IEI Centenary Publication

Bhaikaka Memorial Lecture

A Compilation of Memorial Lectures
presented in

Annual Conventions & Indian Engineering Congresses

35th Indian Engineering Congress

December 18-20, 2020

The Institution of Engineers (India)
8 Gokhale Road Kolkata 700020

Background of

Bhaikaka Memorial Lecture

Taking into consideration the unique contribution of Late Bhailal Bhai Patel, popularly known as Bhaikaka, towards engineering, particularly rural engineering in Gujarat, the Council of the Institution decided to institute an Annual Lecture in his memory. The first lecture was delivered at the 56th Annual Convention held in 1976.

Shri Bhailal Bhai Patel was born at Sersa, Gujarat, in 1880. He saw the famine of 1900 and his heart was filled with grief at the sight of abject poverty, widespread hunger and stark ignorance of people of the ways to mitigate the crisis. His intense desire to remove poverty and ignorance of people arose out of the sad memories of the famine and was the source of inspiration to him in the creation of Vallabh Vidyanagar.

Shri Bhailal Bhai Patel went to Poona in 1908 for engineering studies and took the LCE diploma in 1911. After working for a short period in the then Baroda State, he joined the Public Works Department of the Bombay Presidency. After working for about 12 years in Maharashtra, he was appointed Engineer in the Canal Section of the Sukkur Barrage Plan. An efficient and adventurous young man, he had several opportunities to show his originality of ideas and prowess. He became Executive Engineer of the project in 1936. The successful completion of the Sukkur Barrage Canal brought him an invitation from the Government of Afghanistan to work as Engineering Adviser. However, Sardar Vallabh Patel insisted on his shouldering the responsibility as Chief Engineer of Ahmedabad Municipality and he accepted the post.

During 1942, he resigned from the job of the Ahmedabad Municipality and came to Anand to put into action his plans for education and village uplift and to dedicated the rest of his life to these goals. He became the President of Charter Education Society, Anand — an ideal educational institution established by late Motibhai Amin. The Charter Vidyamandal and Charter Cramoddher Sehakeri Mandal Ltd were established in 1945. After many years of hard work, he could established Sardar Vallah Bhai Vidyapeeth in 1955. As the first Vice-Chancellor of the University, Bhaikaka managed its affairs with least possible expenditure and laid a strong foundation for the Vidyapeeth. Bhaikaka breathed his last in 1970. A man of vision and devoted service, Bhaikaka set-up many educational institutions and administered them ably and honestly.

Bhaikaka Memorial Lectures

delivered during Annual Conventions & Indian Engineering Congresses

The First Bhaikaka Memorial Lecture was delivered during the Fifty-sixth Annual Convention, Ahmedabad, January 19, 1976

Appropriate Technology in the Present Indian Economic Situation

Shri Nanubhai Amin

Chairman, Jyoti Ltd., Baroda

I am very grateful to the Institution of Engineers (India), for the great honour done to me by inviting me to deliver this first Bhaikaka Memorial Lecture. This Lecture series has been instituted to perpetuate the memory of a very extraordinary and remarkable man who was greatly concerned with the engineering technology as required by our rural population so as to provide it with the basic necessities of life. Bhaikaka, as most of you know, was not only a very sound engineer, but also a great social worker who devoted the last 30 years of his life in the field of education and rural welfare. In his later life, inspite of his age, he moved from place to place to encourage people to rely on self-help and to assert their rights as he was convinced that unless rural population itself woke up to its needs and became more vocal, the process of urbanisation and gigantism in industry will create social and economic problems — problems which no administration can solve without misery to the rural population.

With his innate and incisive common sense, Bhaikaka knew the value of applying technological know — how to the needs of rural masses. He kept his feet down to earth while talking of technology — unlike many of us who get carried away with sophisticated and capital intensive technology developed in industrially advanced countries.

Only a few people — the most notable being Mahatma Gandhi have understood the value of appropriate technology for the Indian situation. Curiously enough, many of us who call ourselves engineers and scientists fail to recognize the need of appropriate technology for the development of our economy. We tend to be carried away in this sensational space age by technological advances in other countries in such fields as Rocketry, Atomic Energy, Electronics, Communications and sophisticated Chemical Engineering technologies. We forget that without advancement in the agricultural field and without improvement of living conditions in our villages, the base of a prosperous national economy can not be built and without this base, progress in other fields can not mean much for the large population of our country.

Application of technology has tremendous effect on the economy and social life of a community. I would therefore like to mention here a few parameters of the Indian economy and the prevailing technologies in our country. My remarks, I am afraid, will be inevitably general. but they would put my view point in the perspective of our national situation.

India is a country of continental dimensions. We have abundant labour, but not much capital. Not all the employable individuals are at work; and a good deal of even those who are at work are not fully employed. This is true of highly trained manpower such as engineers. Scientists and technicians as indeed it is true of skilled and unskilled workers. A predominant reason for this lack of full utilisation of the manpower resources is the lack of complementary resources of capital in an adequate measure. While labour and capital are on the one hand substitutes. This complementary relationship on the other hand should not be overlooked. Not only this. but as a welfare state. we have not been able to provide basic necessities of food. clothing. Shelter and medical aid to a vast majority of our people. It is clear that it is the intelligent application of appropriate technology that can provide a solution to our basic problems.

But, what is Technology? At this stage, I am reminded of a very good definition of technology I read recently:

"Technology is the knack of doing things by means of objects that are not parts of your ow body. If you try to crack a nut with your teeth, you are being natural. If you place the nut on a rock and hit it with another rock, you are being technological."

Another way to put this. is that technology is the application of fundamental laws of nature or basic science to meet our felt needs. The needs of us all are many — almost limitless — and can be met by one or more kinds of technology, depending upon the possibilities of combining capital and labour in the respective technologies. Take, for example, farms in India. Generally speaking, a typical farm is tiny, rain dependent and bullock ploughed. The modern farm on the other hand in developed countries is large, irrigated, mechanized and uses inputs such as Synthetic Fertilizers. Insecticides, etc. Another example is Cloth making. Here. the technologies vary as between the hand-spun and hand-woven cloth of the Cottage unit on one hand to the super-fine cloth spun and woven under highly mechanised operations in a modern mill. A third example relates to the transport sector, where the technologies vary from the one embodied in the wooden-wheeled bullock cart in the villages to the one embodied in the latest jet planes seen at the airports in India. Such examples can easily be multiplied. But I hope the point is clear. Namely, that the technologies vary widely from the primitive to the modern. In between these two extremes lies the large intermediate area of products and processes in almost all the fields where technologies are neither that primitive nor that up-to-date.

How appropriate are various technologies for the Indian situation? This morning neither do we have the time nor do I have the necessary competence, to permit a detailed review to answer satisfactorily this question. I shall, however, attempt to answer this question generally, and I trust that this attempt does not answer too unsatisfactorily this question.

A characteristic feature of technology is that an advanced technology embodies, generally speaking, more capital per worker than a primitive technology. The former is a child of the western world, and therefore, naturally inherits the economic properties of its parents, by being more capital-using and less labour-using, reflecting broadly the typical pattern of capital-abundance and labour-scarcity. What is good for these countries is therefore not only not good for India, but may be positively harmful. If we, therefore, copy the highly capital-using Western technologies or pattern our technologies on their models, we would not be having technologies appropriate to the Indian situation of labour-abundance and capital shortage. On the other hand, if we were not to move away from the primitive technologies, we would remain in a static world of no progress. Surely, there ought to be a way out in the direction of an appropriate technology.

Let me hasten to add that appropriate technology should not be construed as backward technology. As a matter of fact it needs a real technological grasp and courage to innovate and apply appropriate technology that is warranted by our overall national interest.

As far as technological and industrial development of our country is concerned, many of us have not yet appreciated Gandhiji’s ideas. I am convinced that his understanding of our national economic and social situation and the type of appropriate technology which he wanted us all to employ, was beyond doubt far better than those of us who claim to have been trained in various fields of technology. A foreign commentator has very succintly described Gandhiji's ideas.

“Gandhi had a different “Time frame” for his country. He believed that for a poor country like India the road to economic development lay in an agrarian rather than an industrial revolution, and so over the years he developed a program for regenerating the bleak, disease-ridden villages in which most Indians live, by revitalizing the old relationships between the cultivator and the soil, the herdsman and his animals, the craftsman and his craft. His idea was simply to provide Indians with the opportunity to live in modest circumstances with a certain amount of dignity and decency - to make it possible for hundreds of millions who were going naked or in rags. Were hungry or undernourished, and could find little or no work to be clothed, fed and given useful occupations. Gandhi called on all Indians to breed cows and bulls, so that there would be milk for nourishment. dung for fertilizer and fuel, and bullocks for pulling the plows and for drawing water from the wells; to take up some form of handicraft, so that no one would be a burden on society; to rediscover man's original relationship with nature, because Gandhi saw divorce from nature as the source of all ills. To educate themselves in the rudiments of sanitation and hygiene, so that they could halt the spread of filth and disease; to engage in such activities as forestry and bee-keeping, pottery and papermaking, so that no one could be without food. utensils or school books; to form elementary work-and-study schools so that children would grow up knowing how to read and write and do manual labour; to raise cotton and to spin and weave it, so that there would be no shortage of khadi. or homespun cloth; to participate in village assemblies and thereby learn to solve local problems; to form economic cooperatives, so that no one would profit unfairly from another's labour; to extend equal rights to the tribal peoples oppressed for centuries as Untouchables; to accord lepers the respect due to them as human beings and to work for the eradication of leprosy; to abolish hereditary bars to learning. So that knowledge would not be preserve of an elite like the Brahmans; to work for the total prohibition of alcohol, which was the curse of the poor, and especially of the Untouchables; to abolish purdah and grant equal rights to women; to overcome religious prejudices so that Hindus, Muslims, Sikhs, Christians, and members of all other faiths could live together in harmony; and to learn Hindi, so that there would be a common language for the whole country, This was Gandhi’s constructive program, “his revolution, which the Indian Government. almost from the day of independence, summarily dismissed as utopian, without seriously testing it.” (“The Talk of the Town, The New Yorker, June, 1974, New York”).

Looking at our country and particularly when we discuss appropriate technology, we must remember what Gandhiji had in mind — a down to earth appropriate technology. Many would argue that all this means use of only backward technology. May be backward, but certainly appropriate.

Shri Bhaikaka was one of those who understood Gandhiji's basic ideas on this subject and devoted a major part of his life as an engineer in applying technology for the benefit of large, number of our people living in villages.

Modern technologies, as are in vogue, have been developed to match the resources and the needs of the industrially advanced world. Since the conditions that generate and foster technologies social needs and conditions, natural and human resources, capital, climate, etc, — are so vastly different in countries like ours as compared to the same in the Western world, their technologies can not be regarded as appropriate.

Reasons for this are several. Firstly, technologies of developed countries are capital intensive whereas we need labour-intensive technology. Technologies developed abroad assume the availabilities of mass markets, highly skilled and trained personnel both for production and maintenance, etc. Since these assumptions often do not hold good in countries like ours, such technologies are often less meaningful and more costly.

Since most of the developing countries like ours are usually short of foreign exchange, the matter is further aggravated.

Secondly, equipment developed abroad makes use of latest materials of construction available there which are not available indigenously. As a result, due to restricted or irregular availability of such materials in our country, production and productivity are affected adversely and raise costs.

Thirdly, the equipment and machinery developed require skilled manpower for start up of manufacture and later on for its maintenance. As such skills are not always readily available, in case of breakdown of sophisticated equipment production capacity remains unutilized for long.

Finally, quite often people talk of durability and extra fine quality of the products produced by these technologies. In many cases, however, where technological changes are rapid, durability beyond a point may become a liability. A more durable product is exposed to a greater risk of being out-of-date. And the company has to carry this half-dead weight for long. Similarly, the quality argument also will not hold much water when it is considered that the critical raw materials and skills which contribute to the core of quality are not readily available and the local ones have to be used as substitutes.

Be that as it may, it is a matter of fact that such modern technologies do occupy pride of place in our country. It may be of interest to explain their prevalence and expansion. Let me offer a few explanations in this behalf.

Ours is not a well integrated economy like that of the USA or the UK but a mixture of pluralities. The terms “well integrated” and “pluralities” are used to indicate the movements or the mobility aspects of economic factors of goods and services. We have a wide range of needs. Methods to satisfy this wide range of needs lie in between the extremes described earlier. And very often there is no necessary inter-connection or bridge between these groups of needs and technologies. Thus, various technologies and needs can co-exist for long.

Thus, for example to the Directors and the Top Executives of large companies, or to the top civil servants or to the top politicians, nothing less than the most comfortable and speediest of the planes would suffice their needs or be good enough to make the best utilisation of their time. On the other hand, to a landless labourer or a marginal farmer in the village, even a bullock cart is a comfortable vehicle and it will carry him quicker to his farm than he cares to reach.

Here I am reminded of a situation wherein all of us make use of planes or fast mode of transport and after using this quick mode of travel and after having made quick survey, the decisions for which people are waiting are not made for months. One could have travelled by less speedy mode and used the available time in arriving at the decisions after digesting the facts and observations.

Similarly, a coarse cotton cloth is all that a poor man would wish for, whereas even the best of synthetic cloth indigenously produced may be regarded by the rich a poor substitute of foreign cloth, the import of which is prohibited.

The moral of these examples is that an apparently similar service such as transport or a commodity such as cloth is a service or commodity which gives differing satisfactions to different individuals who are prepared to pay different prices for their use. And they can be produced only by different technologies making greater or lesser use of capital and labour in different lines.

We have been having a policy of welcoming rather indiscriminate imports of foreign capital. While there is no doubt that the peculiar character of foreign technologies that follow these imports makes them less promotive of employment than we would like them to be. The reason for this phenomenon is plain. Foreign technologies are based on the factor proportions obtaining in their respective countries, most of which in comparison with India, use more capital and less labour than indigenous technologies would have done. A peculiar characteristic of these technologies is that in the Indian market, they have an advantage in that very often they produce the products at lower costs and of better qualities.

Such an advantage is to be found even in respect of indigenous capital-intensive technologies, so that often on the market criterion such technologies are preferred to labour-intensive technologies even where such a choice does exist. This of course neglects entirely social and human costs in terms of unemployment and all the ills and hardships it brings to individuals and families.

In the export markets quality of products and competitive prices of products matter most. This consideration also often goes to make our technology in the export sector more capital intensive.

We have thus a world where things done in the fields of technology make sense at the microlevel, but what is good at that level is not good at the larger national level.

These explanations account for the prevalence of Western technologies in developing countries like ours. But these reasons can not be used as excuses to permit a further spread or propagation of such technologies without first establishing the necessity of their use from an overall national consideration. Since, unlike most of us, Gandhiji was concerned more with national level, he gave a great deal of thought to the question of appropriate technology. He exhorted all concerned to use technologies which were often labelled as backward. Gandhiji's conclusion on appropriate technology is reinforced when one considers that the modern technology has often been accompanied or followed by undesirable features such as concentration, dominance of foreign capital, regionally unbalanced distribution of industry, neglect or slow growth of indigenous capital and initiative, undue drain on foreign exchange and at the micro-level sometimes high prices to the domestic consumer and conspicuous luxury consumption.

This is not to deny the prevalence of the appropriate technology in some products or processes in different sectors of the Indian economy. But the burden of the point made so far by me is that neither the primitive, nor the most up-to-date technology is appropriate for the overall Indian situation today. I am convinced that even the large field of intermediate categories of technologies, while better than these extremes, is a world which offers a lot of scope for experimentation and adoption of appropriate technologies.

While it is easy to enunciate the general principles in this respect, it is difficult to put them in practice. Let me however, give a few illustrations which suggest a good deal of scope for incorporation of appropriate technologies.

a. In building construction, a great possibility exists of using bricks, lime, etc, for load bearing members as compared to R.C.C. The adverse effects of weather, rain, wind, etc, can all be taken care of, if intelligent use is made of the construction materials other than Steel and Cement which are in chronic short supply in the Villages and even Taluka towns in our country. Steel and Cement could then be spared for other uses which need them more and for better reasons.

b. Development and use of small animal drawn implements is desirable against use of large tractor drawn implements. Manufacture of small animal drawn implements can take place in rural areas which will avoid unnecessary transportation and encourage employment of local artisans. It will also avoid many problems of spare parts. services. etc.

c. Use of Capstan and Turret Lathes instead of automatic lathes avoids very high tooling costs. The production lots can be small. Maintenance of equipment is not difficult. Costs of idle time due to breakdown or absence of skilled operative is much less. This applies to all automatic equipment as compared to other equipment used in engineering workshops.

d. We are short of Fertilizers in the country, particularly Nitrogen. Must we depend only on Synthetic Fertilizer for Nitrogen? Plants for manufacture of Synthetic Fertilizers are complicated and to a very large extent still we are dependent on developed countries for raw materials for construction of high pressure vessels, large compressors and many other equipment. Why not think of some intermediate technology which with some R&D effort can make Nitrogenous Fertilizer available to small farmers easily ?

With all the advanced technology, at the present moment, production of nitrogenous fertilizer by industrial plants in the world is 30 million tonnes of nitrogen. Compare this with 180 million tonnes of nitrogen produced by Rhizobium bacteria in crops like pulses, etc. To this must be added about 10 million tonnes of nitrogen which nature provides by way of synthesis taking place during monsoon through lightning as well as through absorption of nitrogen while rain falls.

In other words, even now only about 16 per cent of the nitrogenous fertilizer is produced by Fertilizer Plants whereas 84 per cent is provided by nature. Could we not therefore think of devoting some R&D effort for making use of Rhizobia for other crops? Also could we not think of simple devices to extract nitrogen from the air as fertilizer right at the door of the farmer?

At this stage, may I illustrate the example of an appropriate technology as developed and used by Russians in the late twenties? I owe this example to a competent and highly experienced British Engineer Mr. Allan Monkhouse who was working in Russia at that time as an expert for constructing and manufacturing electrical equipment. During this period, in view of shortage of foreign exchange and for want of big equipment and other facilities. Russians used to construct big turbines with very crude equipment. Even around 1927, Russia did not have large boring mills or lathes. So they machined their large Stators and rotors by Simply laying a small rail track around the rotor with a tiny locomotive to which cutting tool was attached. This method of machining, you would agree, was rather inaccurate and inefficient compared with the standards even of those days. But they could get along and construct initially Power Houses to provide for the basic necessities of power for the Russian population. What other alternative did they have at that time but to go ahead with whatever was available with them? Let me immediately mention here that I am not suggesting that we should copy such crude methods. All I am suggesting is that national self-reliance is imposing on us a large number of problems and we as engineers should look at these problems in the national perspective. In this difficult task, it may encourage us to know that many other countries have found their own solutions in their own distinctive styles. I trust I have established sufficiently clearly the point that the sophisticated technologies are not necessarily appropriate technologies in our context. I have also explained the reasons, why, inspite of this inappropriateness, they rule and thrive. The case, however, is not one of despair, as would perhaps be clear from the several examples of appropriate technology cited by me just a moment ago. But the big question is: How does one move about on this frontier in a more general way?

Here, three questions come to mind immediately.

First, How is one to judge the appropriateness of the technologies in different fields in a more concrete manner ?

Second, How can such appropriate technologies be developed?

Third, What is the role of various parties in encouraging research and development efforts for the development of appropriate technologies?

I shall devote the remaining part of my speech to answering these questions.

Since we must evolve criteria to judge which technology is appropriate, we must look at a given technology not in a narrow sense, but as a part of a total system of national, technological, economic and social development needs.

We can always substitute use of labour by automation, but then, we must assign a value i.e. a social cost of maintaining unemployable manpower either by way of providing doles or by way of generating frustration which can bring about violence only. We must also work out a cost of not using abundantly available national resources in the form of labour and using imported resources in the form of imported technology and equipment.

While we consider the first question namely, the criteria for judging appropriate technology, we have to consider two aspects. These are,

a. Choice of products and processes
b. Choice of technologies in the given products and processes.

As regards (a), searching questions ought to be asked in regard to whether the products are at all necessary to be produced, and if so. in what quantity ? These questions are necessary, primarily because the choice of products and volume of production often dictate the technology, so that here the question is more one of appropriateness or the need of the product rather than one of the appropriateness of technology. The question in this context would be of the following kind. Is it necessary to produce more motor cars or more synthetic cloth or to build more luxury houses, when the need of the hour on several considerations may be to produce more buses and trucks or more of coarse and medium cloth or to build more one and two room tenements? The latter are justified on egalitarian considerations as well as on other considerations such as less pollution. less foreign exchange. more use of labour and less use of capital in their production.

Having chosen the product, we need not borrow or imitate capital-intensive technologies. There are many processes in the production of a commodity where we may be able to make use of more labour, without adversely affecting the quality or the price of the final product. Even though in some cases, there are some adverse effects on these counts, these should be balanced against overwhelming benefits by the use of appropriate technologies. This point is particularly valid for the products meant for sale in the home market.

An important objective of Indian planning is self-reliance. To achieve this objective, exports have to be augmented and imports cut. As argued earlier, nothing but the best quality at competitive prices may do in the export markets. The scope of introducing labour-biased methods of production which may have the effects of affecting adversely the quality or the price of the products would therefore naturally be limited. In fact, very often the export sectors of Indian economy may need to be modernised. Such sectors may therefore perhaps become more capital-intensive. But this should be more than compensated by the import-substituting production at home fostered through protection. Indeed, the latter throws open vast opportunities for introducing appropriate technology.

Another area where willy-nilly we have to use an advanced technology is in the field of computer technology. It is true that in a way a computer is a certain multiple of labour. But a mass of labour is a poor substitute of the computer in a situation where quickness and reliability arc the essence of things. On this principle, if I may tread on a controversial subject. use of computers in the LIC, Railways, etc, must be welcomed. I am convinced that the number of customers to be served, and the speed and the reliability with which they deserve service from these institutions warrant computer technology in these areas.

Computer Technology has to be used by LIC simply because in the end what is important is the satisfaction that LIC can give its policy holders by way of proper storage and retrieval of information. Lack of this facility has put thousands of policy holders to unnecessary hardship and it is time that our Labour Unions understood that they have a responsibility towards the customers of the Corporation which they serve. No amount of employment of large number of clerks can solve the problem of LIC in so far as information storage and information retrieval is concerned. Only sophisticated computer technology can do this.

Again, considering the size of the Railway system and considering the necessity of people all over the country who move from one place to another with various transhipment points, it is just notpossible to give quick, efficient service unless intelligent use is made of computer technology.

What I have said so far should not be construed to mean that all is well with the primitive technologies. They too need to be made more appropriate by introducing innovations which make a little more use of capital than at present. Such innovations will help remove drudgery of work, raise the wage-level from their present dismally low levels, reduce their present high costs of production and improve the quality of products. Not only this but judicious use of scarce resource of capital and abundant resource of labour by employing appropriate technology will benefit the nation in the long run by the forces of dynamism let loose by technological progress.

Let me now turn to the second question regarding the development of appropriate technologies. For the export sector as well as in the field of Computer technology this does not really pose much of a problem. The most up-to-date technology which has been developed in the West and which also produces the products of good quality and at cheap prices should by and large be all right. This does not mean that there is no scope for introducing more labour-using and or less capital-using technologies in the production. To the extent, however, such technologies, make for inferior product or higher price, they will have to be ruled out. The appropriate technology for the export sector may therefore perhaps not be far off from the extremes of the most up-to-date technologies.

On the other hand, the large Indian home markets offer almost a limitless field for modifying the technologies — sophisticated as well as primitive — so as to make them appropriate. The modifications in the direction of appropriateness have naturally to come from both ends. The primitive, low-capital and more labour-using technologies with poor remunerations of capital and labour, and with high cost of production, will have to be modified. Primary consideration here must be firstly to lower the costs and secondly to give more reasonable rewards to the labour without creating unemployment. On the other hand, the modern technologies would have to be more indigenously based. Therefore technologies developed abroad when applied here will have to be modified so as to use less capital and more labour. The action programme on such lines would begin either from the end of primitive technology or from the end of highly sophisticated technology. This action programme will necessarily have constraints in regard to set of conditions for the use of labour and capital, quality of product, cost, use of skills, foreign exchange, etc.

Finally, I will briefly mention the role of Research and Development efforts in arriving at appropriate technologies. This is clearly a field, by and large, of applied research. It involves two stages: first, the research stage with particular applications in mind at foreseeable future, with reference to the broad principles discussed above. And second: the implementation stage when the decision to proceed to the full scale operation has been taken.

This is not to deny the role of fundamental research in the development of appropriate technologies. But at present this role appears to be fairly marginal. In any case, such fundamental research as may be necessary for this purpose by and large would have to be financially supported by the Government, and will have to be carried out in Universities, other institutions of higher learning and research, national laboratories, etc.

In view of the fact that the development of appropriate technologies is warranted more by social considerations, all of us will have to remember that appropriate technology is the technology which makes use of manpower resources more and depends less upon scarcely available capital resources. We must also remember that, fortunately for us, the communication channels through literature and various seminars and conferences make available to us most of the fundamental research work done abroad for study and application for our national needs. We should take advantage of this situation and see that our efforts particularly of young engineers go towards learning the techniques of applying this knowledge keeping in view the national constraints which I have mentioned before. By doing this, we will be able to use existing knowledge towards better utilisation of our resources and improving existing products and services required by various sections of our society-particularly, 70 to 80 per cent of the population which live in rural areas. As a nation, we cannot hope to go ahead until the economic conditions for this vast majority of our population is improved. There is no use of having pockets of affluence both in terms of money as well as in terms of intelligent trained manpower only in few urban areas. This will only create conflicts and jealousies. The available funds for R&D should be earmarked on a high priority basis, for such technologies rather than for sophisticated technologies such as Atomic Energy, Space Technology, Magneto-Hydrodynamics development, etc. Although these new technologies must be kept in view by us, for the present we will have to put them in a rather low gear.

Before I conclude, I would like to express my gratitude to the president and members of the Council of the Institution of Engineers (India) for inviting me to deliver this first Bhaikaka Memorial Lecture. I also thank all of you for giving me a patient hearing.

JAI HIND.

Imagineering and Rural Development

Dr Y Nayudamma

Director General,
Council of Scientific and Industrial Research, Government of Intlia

I am deeply conscious of the honour done to me in inviting me to deliver the Second Bhaikaka Memorial Lecture. I chose to talk to you on 'Imagineering and Rural Development'.

Imagineering is imagination plus engineering-the vision and imagination to be engineered, translated and transferred to the people for their benefit. I do believe that this topic is appropriate to speak in memory of Dr Bhailalbhai Patel who coupled vision and wisdom with pragmatism and engineering; character and courage with determination and drive to achieve so much in a single span of his life towards the cause of people and self reliance.

Self-reliance is not self-sufficiency. Self-reliance is the feeling of self-confidence, self-competence and the ability to stand on one's own legs. It is the duty of any society to provide every opportunity for every person to develop his own capabilities and to utilize these capabilties, talents and skills to be self-dependent and self-reliant to live with a sense of values of human dignity and to live in harmony with his environment. It is towards this cause of self-reliance, particularly to our Indian people, who live mostly in the rural areas that Bhaikaka has done so much in establishing educational, industrial and other institutions.

From the beginning of mankind, the growth of man has been influenced by nature and physical environment around him. Till the 19th century, growth was dominated by nature and roughly followed an arithmetical progression. However, with the advent of industrial, scientific and technological revolution, there has been an exponential growth. This is clearly seen by these data. 'In the last century we have increased our speeds of communication by a factor of 10^7, our speed of travel by 10^2, our speed of data handling by 10^6, our energy source by 10^3, our power of weapons by 10^6, our ability to control diseases by 10^2, and our rate of population by 10^3, by what it was a few thousand years ago.'

Exponential growth has led to increased affluence; affluence led to more aspirations and wants; wants lead to consumerism. This consumer civilization is in a perpetual motion. It is like this — Rags make paper; paper makes money; money makes banks; banks make loans; loans make poverty; poverty makes rags and rags make paper .... one is not sure whether this exponential growth and perpetual motion have brought any happiness to man. The net result however is depletion of resources; degradation of environment and irreversible harm to the land and the seas.

Consumer civilization has led to increased wants and increased production leading to production explosion in advanced countries. In developing countries one more child is considered as an additional investment leading to reproduction explosion.

The predicament for mankind is Production Explosion versus Reproduction Explosion. The other predicament is two-thirds of human beings live in a state of poverty and misery while the remaining minority feel the effect of over-consumption and indigestion.

Modernism and consumer civilization have landed us in an era where there is a basic conflict between man and nature. Earlier, nature controlled man. Today man controls nature. The ideal is for man not to control or conflict with nature or controlled by it but to live in consonance and harmony with nature.

The time has come therefore for alternative lines of development and growth. The alternative model is increased production with distributive justice and growth with social justice. Aspects like social justice, quality of life, a humane society and a kind of shift in societal values and priorities are called for. It will be a society where services loom much larger than goods; where the focus is more on education and less on higher income; more on decent housing and transportation and less on keeping up with the Joneses.

In such a growth new and alternative technologies may be developed and used requiring less use of energy, low energy agriculture transportation system with low energy demand, more use of solar and other energies; household and industrial appliances with long life and recyclability; extensive recycling of minerals and other materials; full utilization of wastes; emphasis on conservation, and exploration and utilization of ocean bed resources.

We have to ask ourselves what kind of society we wish to live in-consumer society or an egalitarian society. We need not copy the advanced west. We need not wait for advanced countries for benevolence and to nobly renounce their exponential growth pattern at the cost of the resources of developing countries. We have to decide for ourselves the type of growth and the quality of life.

The important thing therefore is first to set the societal values and life styles which in turn will decide the type of technologies to be generated and used. Technology should thus be coupled with social technology to achieve the value systems and the type of society we wish to live in. It requires vision. Imagination must be coupled with engineering to bring it down to the level of people to do maximum good to maximum number of people. Coupling of imagination with engineering is called IMAGINEERING.

Since independence, India has made rapid strides in every walk of life. Phenomenal progress has been made in industrialization, international trade, technical education, scientific and industrial research and economic, industrial, managerial and technological competence and self-reliance.

However, there is something amissin the Indian canvas. About 40 percent of our people still live below the minimum subsistence level; 86 percent of such people live in our villages. It only proves that rural people have not been brought into the mainstream of our national endeavour to contribute to the progress and share the fruits of our economic and industrial growth. It is true that a large number of these rural folks are illiterate, but not ill informed. These people have learnt that a better life is not only possible for us but they have a right to better life. They cannot wait in line indefinitely for the better days to come. We have to plan and work in this direction so that better days for them could come sooner than expected.

This then is the challenge for engineers like you and indeed for all thinking Indians. The question is how can technology and engineering help to fulfil the expectations of people? If the development is for people, it should be centred around people and people should be involved. And what makes people involved?

To people seeing is believing. If only we could practically demonstrate as to how through engineering and technology, their living and working conditions could be improved, they would have faith in us and in technology.

Anything for an extra dollar may or may not work in this country. There are plenty of people who do not wish to move from their native place in spite of higher earnings outside. But by and large people however accept change if only they could get extra earnings for the work they do in the same set of conditions; similarly if their living and working conditions could be improved, and if the drudgery of their work could be reduced, or removed. Pride and jealousy are also motivating factors. A sense of challenge and adventure, a sense of achievement and pride are other factors.

Obviously technology should be coupled with social technology. Human resources and skills, and national resources to be coupled with modern tools, techniques, technologies and management methods. An integrated approach, keeping people in the centre of the things, is called for. The aim of this exercise is to see that the capabilities of men are realized and utilized; and to see that every person stands on his own legs. Benevolence, subsidy, doles, aid, etc only lead to more dependence and not self-reliance.

Rural development has all along been considered synonymous with agricultural development. Development is not development of soil and crops; development is development of people, the quality of life of the rural poor in particular. Such a development calls for participation of people and coupling of their human resources and skills with modern technologies and methods of management.

This then is the vision-the imagination. How do we engineer it?

A few examples will show. Drinking water is a must for all people. More than a lakh of villages do not have the most elementary facility for drinking water. It is reported that 70% of the diseases in India are mainly due to bad drinking water. Provision of clean potable drinking water would mean less hospitals, doctors and medicines and investments thereon. People's health will improve and so do the working hours resulting in increased production. Drinking water problem therefore deserves to be brought into sharp focus. Top priority should be given in our plans, programmes and funding.

Once this goal is set, the task is defined, relevant technologies should be generated, transferred and utilized. Technology for providing potable drinking water could be different for different sources of water supply.

Hand-pumped water may not require any treatment. A simple treatment with bleaching powder or alum lime may do in some cases. Chlorine ampoules and tablets for disinfection may also be used. Inexpensive water filter candles which can be fitted with domestic water containers including earthen pitchers may meet the daily requirements of drinking water for an average family.

Brackish and salt waters may require a different treatment of desalination. Solar water stalls are needed in some areas. Where water contains flourine, a special treatment is called for. Deep-water hand pump using non-metallic materials of construction; bamboo-well, etc, come in handy for the rural needs.

This is one aspect. Let us look at supply and distribution of drinking water in rural areas. Let us take a village well. The geophysicists should first tell us about ground water resources, water tables in that area; quality of water where a well is to be dug and the strength of the spring. Weather and wind data over the past should help to decide the possibility of setting up a windmill. The windmill is to be designed not by plumber and carpenter but by experts in aerodynamics, material sciences for light weight material resistant to water weather, etc, physicists studying problems of friction and engineers to construct and set up the windmill. Along with the windmill to pump out water provision has to be made for water storage tanks and tanks for treatment; provision for excess water flowing back into the well or into channels for use in agricultural fields, etc. In the supply of drinkirig water by pipeline, it is not uncommon the tap is open and nobody closes it, there will be puddles of water. The roads become muddy and the puddles become the breeding ground for mosquitces, etc, similarly with the water from the bath-rooms and the wash-water from the kitchens in the individual houses. Technologists should think of how to avoid wastes, to treat, recycle and use water wastes. An integrated water management system and relevant technologies are called for. If on the other hand, each department in all sincerity and anxiety to serve the rural people, go about each in its own way, e.g., one department digging wells for rural drinking water supply, another department digging bore-wells for agricultural purpose, public health engineering group having its own style, will only result in not getting adequate water for the village and surrounding villages.

Let us take a different example-the common rice plant. Basically it is soil-water-crop management coupled with appropriate inputs of better seeds, fertilizers, weedicides, pesticides, etc. How to get greater yields for the same acre, the agricultural scientists should say. Even today cultivation of rice require a large amount of water. Can it be reduced? Lot of water is also wasted by seepage in the channels, etc; covering the channels with polythene may save water. Similarly, evaporation of water in the lakes and fields may be reduced by spreading a thin film of ceryl or cetyl alcohol, etc. With the new varieties of rice, paddy slips become bulky and rough making it difficult to hold it in hand and cut by a sickle. For planting the paddy slips, for harvesting the paddy plant, the job is back-breaking. The engineers should give us newer, simpler agricultural tools, techniques and equipment. Post-harvest technology for drying, storage, distribution require further attention as the losses in these operations are reported to be anywhere between 15-30%.

Agricultural development should be integrated with industrial development. Agricultural produce should become the raw material for the industry. Paddy becomes the raw material for processing into food and food delivery and other industries. Mini-rice mills, rice mills fitted with rubber rollers would give increased yields of unbroken rice. Rice may be packed in pre-treated bags resistant to rodents, etc, and the quantity, quality and price stamped for delivery to customers. Rice is a good source for starch arid starch based industry and for breweries and wineries.

The by-products of rice become raw material for other industries-rice bran, rice bran oil and edible oil or fatty acids therefrom and animal fodder; rice husk for the manufacture of sodium silicate, activated carbon, particle board, detergent, cement, oxalic acid and others; paddy straw for straw-board, apart from animal fodder and for growing mushrooms.

When the farmer sees in front of him a number of industries growing around his rice plant, when he gets greater yields per acre of land and the paddy and byproducts fetch him higher economic returns; when he sees there is nothing like waste and wastes are converted into wealth, he would develop faith in science, technology and engineering instead of pundits, mullahs and astrologers. He would put his savings into the industry in front of him and he would participate in this adventure of development around him.

Such a process would mean decentralized dispersed industry; agricultural produce serving as a raw material for the industry; people's active involvement and gainful employment; and development of self-reliance. To the engineers it would mean going to villages, understanding the needs and demands of the rural people, recognition of social responsibilities and bringing the technologies to the doors of the people that need it.

Such an integrated rural development demand imagination and engineering-imagineering.

Role of Steel and Heavy Industry in the Rural Development and Creation of More Employment Opportunities

Shri Mantosh Soridhi, *Fellow*

Secretary to the Government of India
Ministry of Steel and Mines, New Delhi

It is indeed a privilege for me to be in the midst of this galaxy of engineers, technologists and others and to be asked to deliver the Third Memorial Lecture for this year, founded in honour of the distinguished Bhaikaka, Shri Bhailalbhai Patel's yeoman service to the cause of engineering will long be cherished not only in Gujarat but all over the country.

The organizers of this function were considerate in allowing me to choose the theme of this talk, I wonder whether, in the time allotted, I would be able to do full justice to this panoramic and fascinating subject which has great national relevance today.

At the outset, I would like to remove any fancies of a hiatus or contradiction in the theme which might linger in some minds on the nexus between heavy industry and rural development and employment generation. For some time now there have been some misgivings expressed on the future of heavy industry; an extreme apprehension is that it will be allowed to languish; another view is that at best, it may be allowed to carryon a holding operation without growth or at best a very marginal growth; yet another fear is that the role of public sector will be considerably diluted.

To allay these apprehensions or misgivings, I can do no better than to refer to the recent industrial policy statement made by the Minister of Industry in the Parliament which makes it clear that while heavy industry would have a continuing role to play in the national economy, we cannot afford to continue to tread the same beaten path without a new sense of direction and purposiveness with the necessary adjustments.

What are these adjustments in direction and emphasis that we require? I think the answers would flow if we have, in the first instance, a bird's eye view of our historical development process and then highlight the new pastures which we need to tread, keeping in mind that economic progress can and should be achieved within the framework of democracy in its truest sense.

It is well to remember that we are living in times when our poeple are not only politically aware but are also demanding, as they should be, and that any increase in production must make room for distinctive justice and lead to quick and tangible improvement in the living standards of the mass of our poor people. This means that disparities in incomes must be narrowed down and that ostentatious spending should have no place in an egalitarian society where the mass of people do not have the basic and minimum of food, clothing and shelter.

In more specific terms we may ask ourselves why is it that a country, with a population of 600 million, cannot consume per capita more than a paltry 12 kg of steel or 13 m of cloth or 30 kg of cement? Or how is it that we have over 20 million tonnes of stock of foodgrains and at the same time some of our people are going without two square meals a day? The answer is obvious; a majority of our people do not have the necessary purchasing power. It is this absence of purchasing power which, in the ultimate analysis, has been coming in the way of accelerating industrial growth, because there are close backward and forward linkages between heavy industry — metals and equipment, on the one hand and consumer goods and agriculture on the other. The recession in industry in the recent past is therefore symptomatic of this situation. Unless this situation is corrected at the grass-roots, i.e., by improving the purchasing power of our people, further growth of industry with corresponding draft on our meagre resources would neither be relevant nor meaningful.

Let us look at agriculture and the rural sector where the majority of our people live. With the rising population, the pressure on land is increasing and land is getting fragmented into smaller holdings, unable to provide sustenance to the teeming masses. The industry as it has developed so far in this country has not succeeded in providing sufficient employment opportunities and to the extent it has, these have been mostly centred in and around metropolitan towns and urban centres. It has led to some migration of rural population to cities and towns where the living conditions have, by and large, gradually worsened in the process; the abounding slums in our cities have their own tale to tell. This flow of our people from villages to urban areas is the crux of the problem of economic progress.

I recall what Gandhiji used to say that, however difficult or enormous a problem may be, it can always be broken into simple components and solutions found. If what is involved is clearly understood by the industries, I am sure they would know what to do and what is required and expected of them. Before leading you to some of the corrective measures which the industry could perhaps take, I would like to dwell on the aspect of inter-dependence of heavy industry and rural development in the grand design for economic progress.

Firstly, whatever be the segment or sector of economy, the wherewithal for its growth or development is invariably ultimately linked up with steel, non-ferrous metals and engineering equipment and products. Ignoring this linkage would not serve any purpose. For, example, to meet the requirements of power for industry, agriculture or home, we need dams, boilers, turbines, generators, transformers, switchgears, transmission towers, cables and hundreds of other different items. For improving agriculture, even if it is accepted that the pace of tractorisation is to be slowed down, we require distribution lines, motors, pumps, pipes, diesel engines, improved implements and fertilizers, which must come from large and modern fertilizer plants set up with heavy investments on plant and machinery. For rail transport we require rails, points and crossings, locomotives, wagons and coaches and, in the making of locomotives, wagons and coaches goes steel and hundreds of complex items of equipment and components to be produced by the engineering industry. Defence and communications require a wide and complex base of engineering industry ranging from planes, frigates, tanks, submarines, radar to most sophisticated electronic equipment and so on. Similarly, whether it is petroleum products, coal, or chemicals, drugs, or mass consumption items, or consumer durables, sugar, cloth, paper, soap, edible oil, leather goods, sewing machines, bicycles, and fans the plant and equipment required for their manufacture must come from capital goods industry. The latter, in turn, must depend on steel and non-ferrous metals industries to provide their bask raw material inputs.

We have indeed made a lot of progress in these industries since independence and we are now ranked among the first 10 nations of the world as far as our industrial production is concerned. We have also built up in the process the third largest cadre of professionals in the world after the USA and the USSR; similarly the large reservoir of manpower resources in terms of skills in this country is well known.

All this should be viewed in the context that this has been achieved in only three decades-a short span indeed in the history of any nation! When we gained our independence only a generation back, there was hardly any industry; the total power generating capacity was 1.3 million kW; the steel capacity was about 1.5 million ingot tonnes and aluminium around 5000 tonnes; production of coal was only to the extent required by the railways. There was no heavy industry worth the name and the question of producing capital equipment was a far cry. The use offertilizers and lift irrigation was hardly known, with the result that our agricultural production was low.

Today, we have a power generating capacity of over 23 million kW with an extensive network of thousands of kilometers of transmission and distribution lines and regional grids. Installed steel capacity taken together in the integrated steel plants as well as in the mini-sector is over 13 million ingot tonnes; aluminium 250 000 tonnes; copper 45000 tonnes; zinc 90000 tonnes and coal over 110 million tonnes. Whereas for the Bhilai, Durgapur and Rourkela steel plants, 90% of the equipment was imported, the position in the case of Bokaro Steel Plant 15 years later was exactly the reverse. You are aware that in this plant the second stage cold rolling mill complex, with all its doves and controls, would not only be manufactured in India but also fully designed by our engineers. Similarly, till the end of the Fourth Plan, 85% of the power generation capacity was equipped with foreign power plants. As against this, during the next five years, 85% of the equipment for additional generating capacity will be of indigenous origin and this would include turbo-generator sets upto 210 mW capacity and later upto 500 mW capacity. Whereas the first atomic power plant at Tarapur and Rajasthan were set up with completely imported equipment, the Madras plant would have 50% indigenous component and Narora much higher. This is a measure of the self-reliance that we have been able to achieve in the last 30 years. In fact, we are now in a position with our own resources to design, engineer, fabricate and commission plant and equipment for a wide range of sophisticated industries such as fertilizers, petro-chemicals and refineries, cement, sugar and paper, etc. Our engineering consultancy organizations have also grown in their capability and status. It is also no mean achievement that we have now put our steel and engineering equipment on the world map with an annual rate of exports from these sectors running at over Rs 800 crores. A large work force of our engineers, technicians and workers, well over one million now, are engaged in other countries building power plants, dams, transmission lines, sugar and cement plants, housing complexes, airports and various other projects. Our consultants are helping to set up steel plants, railway and various industrial units the world over.

These capabilities have given us the sinews of strength to formulate independent national policies without being buffeted in the turbulent international political streams. They have enabled us to gain the respect of other countries. A number of developing and developed countries are now keen to develop closer economic co-operation with us. The World Bank has been appreciative of our progress. Less than two weeks ago, President Carter of the USA said:

> 'What is less understood is the degree to which Indian social and economic policy has been a success. In a single generation since your Independence was gained, extraordinary progress has been made.
>
> 'India is now a major industrial power. Your economy: ranks among the ten largest in the world. It is virtually self-sufficient in consumer goods and a wide variety of iron and steel products.
>
> 'There have been notable increases in the production of nearly every important sector of industry-increases which reflect an economy of great technological sophistication'.

and later, in his speech he mentioned:

> 'We are pleased that our space technology together with India's superb space communication capability will serve the cause .... .'

While saying all this, we have to keep in mind the well known axiom that God helps those who help themselves. In a world where altruism is rarely a fact of life, it is good to be in a position to help ourselves. Left to themselves, the industrial and rich world will be much happier to buy our raw materials and agricultural produce at low or depressed prices and sell us the finished goods and capital equipment at inflated prices. Only if our requirements of imports of these goods are residual, can we afford to buy them, and only if we have options, can we get them at competitive prices.

As I have said earlier, we now have a highly diversified industrial base which covers a wide spectrum. It is incumbent on us to continuously develop and improve this industrial base if we have to remain competitive in the world market. This requires a multi-pronged strategy but one of the most important aspects of this, which I have been mentioning in every forum for the last few years-you can call it my obsession-is the need for higher and higher utilization of our existing capacity so that we can get better and better returns from the investments which have already been made.

To illustrate this, I believe that, in the field of steel production, it is within the capability of the steel plants to increase their output, by value, from the existing capacity by about Rs 250-Rs 300 crores per year. If we can improve the availability of power from our existing power plants by 5% and reduce transmission and distribution losses by 4-5% the gain to economy in terms of additional power would be of the order of Rs 200 crores in monetary terms. An additional 10 million tonnes of coal, within the existing capability, would mean an additional Rs 70 crores and with better availability of power and other inputs, an additional half-a-million tonnes of fertilizers worth about Rs 50 crores and an additional Rs 300 crores of heavy engineering equipment from our existing capacity cannot be considered as being over ambitious. These enhanced outputs from existing investments would add up to over Rs 800 crores of materials and products in the national economy. Since, these inputs would have a high multiplier effect, the net gain to all the sectors of our economy including industry, agriculture and transport would be very considerable indeed.

We have to harness modern technology towards the same objective of increasing capacity utilization through higher productivity. It is with this objective that our current emphasis in the blast furnace operation in the steel plants is on the use of more sinter burden, higher operating temperatures, high top pressure and at least a small proportion of low ash content coal. These productivity improvements alone will raise production from the existing blast furnaces, by as much as about one million tonnes of hot metal or pig iron. More use of oxygen in open hearth furnaces and use of better lining in LD convertors can likewise give a spurt in the production of the steel melting shops.

It is also as a part of the same strategy, that we are now planning to step up the production of higher value steel products in our steel plants, such as the boiler quality and high tensile steels; forging quality and deep drawing quality steels; niobium and copper alloyed steels, and more of stainless steels. It has also been decided to set up capacity for the manufacture of CRGO and CRNO sheets at Rourkela with an investment of over Rs 110 crores; similarly we are going ahead with the setting up of the Salem plant for the production of stainless steel sheets.

We shall also have to constantly review the need for balancing equipment to be added to the existing plants to the extent feasible. I might mention here that a small investment of Rs 10 crores in the existing Alloy Steel Project at Durgapur is expected to give an additional 55000 tonnes of alloy steel blooms and billets and bring about a cost reduction or at least Rs 500 per tonne over its entire production range. Similarly, in the engineering sector, constant attention to modernization rehabilitation and introduction of balancing equipment can yield returns many times over in comparison to the investments made.

Another area which needs our constant and intensive attention is plant maintenance. I am told that as much as

Rs 1000 crores worth of production is being lost every year due to avoidable down time of plant and machinery. If we go about this matter systematically, provide scheduled shutdown or repair time with adequate backing of spare parts and resort to preventive maintenance, there should be no reason why we cannot cut down loss of production on this account very significantly.

Whereas, by and large, we have been able to acquire manufacturing capability, our efforts in research and development, which is a very critical area because in the final analysis this is the only way of establishing technical superiority, have been quite insignificant. In developed countries, R&D has been-and continues to be-a major area of corporate and national investment. Thus the USSR spend about 4.25% of its GNP on research and development; other countries like the USA, the UK, Germany and Japan spend equally high proportions. More than the percentages, it is the absolute amounts which are staggering. Even in the corporate sector, to take the electrical industry as an example, General Electric (USA) spends nearly Rs 1000 crores annually on R&D, ie, some 5.5% of its turnover; Siemens spend about Rs 800 crores, or 7% of its turnover on R&D. Both the organizations have been doubling their R&D expenditure every five years. If we compare these figures with the total amount of Rs 1500 crores spent by the whole of India on R&D effort in the past decade, and a present annual R&D expenditure of about Rs 300 crores in the country (representing only 0.5 % of the GNP), it shows the leeway we have to make up in building up a strong R&D base in the country.

We must, however, realize that our own R&D effort has to be given a sense of direction keeping in view our economic and environmental conditions. For instance, our country, where the rural economy plays a vital role, provision of power in remote isolated villages is a challenge. With our high level of sunshine round the year, our priority and economics in developing solar electric power will have to be different from those of a Western environment. The economic cost of providing thousands of km of distribution and transmission lines for power, their maintenance, and the economic cost of their breakdown in this country will justify development of small solar power stations for an individual village or a group of villages. Similar is the case with bio-gas, even in areas like coal gassification and MHD, the cost effectiveness may be different from developed countries.

Similarly, a good amount of our R&D effort could be directed towards indigenization of materials in products. This could be both by developing indigenous materials to suit the designs developed or adapted from the advanced countries, and in developing designs and manufacturing processes to suit the materials available. This will go a long way in reducing the import content on account of raw materials and intermediate parts. Similarly, either through improved designs or through the use of better raw materials, or both, our attempt should be to save on raw materials. I am told that the electrical industry alone can save as much as 10% on raw materials through better designs.

We must also make every effort to put our industrial scrap and waste products to optimum use. The ferrous and non-ferrous scrap arisings, if properly segregated and kept free from avoidable contamination, cannot only fetch higher prices but also bring down the costs of those using them. Similarly, the coke oven by-products should be converted to higher value products and the entire arising of blast furnace slag used for production of cement. If Japan can import mill scale from India and put it to use, we must find out why we cannot use it here. When we do ditinning for making scrap suitable for melting, we should examine why we cannot fully recover tin. Pickling liquors must be continuously recycled and the tonnage oxygen plants made to recover argon. These are only a few examples.

I am not digressing from the theme as to the extent to which basic materials and heavy industries build up their further viability and competitive strengths through optimization of their in-built potential; productivity of assets, technology and R&D, they are poised for the better to serve the objectives of rural development and employment generation. Firstly, through such means, they can increase the infrastructural availability of materials and equipment implied in the very process of rural development itself, as I had explained earlier. Secondly, as such productivity improvements call for considerably less financial outlays than new investments in Greenfield plants, the savings can be productively employed in rural development.

Coming back to my main theme, it is self-evident that the lack of purchasing power on the part of the mass of our people is the real reason for the tardy industrial growth and production. An improvement in the purchasing power of our people would create its own chain of economic reactions. While the new economic and industrial policies are directed towards this objective, the organized industry has also its social obligations to the rural and village communities. We must recognize that it is the organized sector of the industry which has been the recipient of modern technology. In the process of acquiring technology and modern tools of production, it is the organized industry which has developed a high order of management capabilities available in the country. They have also the resources. Unlike in the past when industry, with few exceptions, was exclusively preoccupied with itself and its immediate problems, it is now necessary, in fact imperative, that it must use its technology and management capabilities towards rural development and employment. There is no denying the fact that change, particularly of the magnitude contemplated, can only be brought about by a drastic change in rural management. A necessary corollary is that a job environment will have to be created in villages which not only retains but also attracts managerial talent. Furthermore, it is imperative that management capability percolates down to the lowest small scale farmer, as it is ultimately his capabilities of managing capital and human resources that will yield the results.

If the focus is shifted, the tasks would get identified and solutions would follow. To achieve this, the main planks of our strategy should be:

(i) Setting up of industries in backward areas;

(ii) Adoption of villages and taking up programmes for rural works, provision of potable water, improvement of wells, link roads and educational facilities;

(iii) Provision of seed expertise in the organization with regard to agriculture, horticulture, dairy farming, poultry, handloom and cottage industries;

(iv) Setting up of maintenance and small workshops at the block and district levels;

(v) Development of ancillary industries and the use of small sector industries for the supply of less sophisticated components.

What I have mentioned above is only illustrative; but, perhaps I could briefly elaborate on some of the points.

As you are all aware, Government is already giving considerable fiscal and other incentives for taking industries to the backward areas. The response, however, is not satisfactory. Perhaps the mobility of labour, and the non-availability of infrastructure facilities, including communication, might be some of the factors coming in the way. Even so, atleast in stages, going farther away from the towns should be possible if the industry really makes a concerted effort. In so far as the raw material based industries are concerned, the task should, in any case, be simple where raw materials are located in backward areas.

In the last budget, certain measures by way of tax relief were announced on expenditure incurred by the companies for taking up rural uplift work. Certain associations and industries, including some of our public sector units, are already doing good work in this direction but their efforts still look like drops in the ocean. The industry must go all out and wholeheartedly, in a much bigger way, in adopting villages to the extent they can stretch their resources.

Another example has been brought to my notice. I am told that a company has been able to achieve very good results in rural uplift by employing a few dedicated experts such as on agriculture, horticulture, dairy farming, and poultry. They have also employed one expert familiar with Government procedures in order to help the villagers to secure whatever assistance they can from the district authorities but which require certain procedures to be followed and forms to be filled. These experts have gone into the villages working assiduously to build confidence in the rural population in their advice and methods. Guidance on treatment of soil, on the choice and use of fertilizers, use of better seeds, on growing and tending fruit trees and their advice on dairy farming and poultry has I am told, yielded excellent results. In fact, the small expenditure on engaging the services of these experts, who have nothing to do with the regular operations and functions of the unit, is understood to have yielded results much beyond their own expectations.

Quite often the villagers have to go long distances to have their electric motor, pumps or implements repaired or buyout their needs from the cities. It should be our effort to set up small stores and workshops at the block level to facilitate meeting their requirements. For example, in the Ministry of Steel & Mines, it has been decided that there will be a village level workshop to cater to a group of villages, a block level workshop to cater to a group of blocks and a steel and technical ervice centre to cover the blocks selected. The service centre will provide guidance for the work to be done at the workshops. It is visualized that certain facilities would be provided in these workshops to manufacture some items but basically the idea is to take parts and components made elsewhere, particularly in the villages themselves, and have these assembled at these workshops besides providing necessary service and repair facilities for the equipment and implements that are being used in the rural sector.

I am given to understand that the Department of Heavy Industry with the help of Hindustan Machine Tools has also decided to set up such workshops at the district level, about 25 to start within the next few years.

It should also now be our endeavour to take the jobs to the people in the rural areas rather than bring them to the jobs in the urban areas. Most of the villages would have traditional artisans engaged in blacksmithy, carpentry, or working as masons or making pottery, leather goods or footwear. Soms effort and guidance to help them in the choice of better materials and slightly better handling and processing technology with guaranteed offtake of their entire production could be one of themost important planks for improving the rural economy. For example, some of our large plants have fairly large requirements of simple tools, such as hammers and chisels, crow bars, pick-axes, and shovels. Their production could be developed in a decentralised manner in the rural sector by giving necessary guidance to the village blacksmith in the choice of steel or in its processing. All these items can be bought back for use in the organized engineering plants. Likewise, simple wooden furniture, doors and windows required in the organized industry or in the schools and hostels could be procured from villages following the same technique and approach. Production of uniforms and simple clothings as also footwear, particularly where these are distributed by the management to their workers, could easily be organized in the villages in the same manner. Many more such areas could be easily identified. If such activities pick up, it will not be surprising if some of the villagers who have migrated to the cities voluntarily decide to go back and take up their work in their natural habitat of villages, which is exactly what we would like to happen.

Similarly, there has to be a much more concerted effort in the development of ancillary industries. There should be a total systems approach in this respect in the sense that development centres could be organized and these should be given the necessary guidance with regard to plant layout, choice of machinery, raw materials and processing or fabrication technology. A good proportion of their production should be guaranteed to be bought back. Some headway in this regard has already been made both in the private and public sectors. Today there are 650 ancillary units around the heavy engineering public sector units giving direct employment to over 18000 employees and with a turnover of over Rs 20 crores. This approach could be accepted and carried forward by everyone of the major industries. This would not only result in the dispersal of the industries to the ancillary units and spread of entrepreneurship but it would also help the industry itself to increase their production. The Tiruchy Boiler Plant of BHEL is a typical example of the success of this approach. It has been farming out about 25-30% of its work to ancillaries with the result that its production is now in excess of its rated capacity.

What the steel plants and the heavy engineering units can do, the other. units in the public and the private sector can also do. The cumulative impact of such an effort, considering that there are over 4000 such organized units in the steel and heavy engineering sectors alone, can be dramatic. As this movement picks up momentum, rural life in our country is bound to get transformed. The opportunities ahead are so vast and varied that each and every organized industrial unit which seizes them would have a sense of participation in this national transformation. Let it not be said that the organized industry has failed to respond to this national challenge because if functions in its own ivory tower of profits and preoccupations and does not see the warning signals of rural poverty and backwardness.

Selection of Technologies for Development

Mr S Santhanam

Managing Director
AMCO Batteries Ltd., Bangalore

I deem it an honour and privilege to be invited by the Institution of Engineers (India) to deliver the fourth Bhaikaka Memorial Lecture for this year before this august gathering of eminent public men, engineers, technocrats and managers. My illustrious predecessors in earlier years have talked on subjects like "Appropriate Technology in the Present Economic Situation", "Imagineering and Rural Development", "Role of Steel & Heavy Industry in Rural Development", etc. It is quite fitting that emphasis has been truly laid on various aspects of technology and rural development, in keeping with the ideals set by Dr. Bhailalbhai Patel during his remarkable life and in his practical acts of wisdom. For this year's talk, however, I have chosen the subject "Selection of Technologies for Development" and I hope this is in tune with the spirit of Bhaikaka's life's work. Today, it is impossible to ignore the fact that the conventional capital and energy intensive technologies, which still form the main currency of development programmes, are by no means always in harmony with the needs and aspirations of poor countries. This is most obvious in relation to employment.

The ILO has estimated that in the developinq countries alone, about 40% of the total work force, i.e. some 280,000,000 people, are unemployed or underemployed, condemning them to lives of continued poverty. More than 75% of this large number live in rural areas where seasonal unemployment is often extreme. The result is mass migration from the rural areas to the cities, many of which already pose insoluble social, economic and environmental problems.

Large scale, capital intensive technologies aggravate these problems. Being city centred, they are in the wrong place; the kind of goods they produce are generally of the wrong kind to meet the needs of the poor; and by their very nature, they cannot provide jobs on anything like the scale required. More importantly, capital intensive technologies make heavy demands upon special types of infrastructure facilities, influence consumption patterns and dictate import requirements.

Therefore, It ISnow well recognized that an appropriate industrial technology was the one that aimed at solving the problems facing the people. It could either be big or small, sophisticated or intermediate or a judicious blend of different elements in various sectors. The primary objective was to bring about a technological revolution in the entire country, be it rural or urban, backward or advanced. For this, there was urgent need for a close link between the modern and traditional technologies. The concept of technology, therefore, must be viewed as the technology which contributed the maximum to the economic, social and environmental objectives relating to the development goals, resource endowments and the economic and social environments in our country.

Contrary to general belief, technology was relevant not only to heavy and medium scaled industries, but also to the small scale and cottage sector units. It was, therefore, urgently necessary to have an awareness for the most appropriate technology in each area and then apply it to various sectors of production. It is our responsibility to ensure that there was no ultimate loss of employment as a result of the application of such technology. While no country, however advanced it was, was free from total unemployment, the problem in India was quite serious and, therefore, needs special handling.

It is my submission that technology should help in providing the means, methods and tools for gainful jobs for as many persons as possible. The purpose of technology should not be merely for the sake of its own perfection but by and large, to help man to have a better life or improve the quality of his life.

The special needs of the people and society should be understood. In the USA, they were facing manpower shortage whereas in India, we had an abundant supply of people ready to work. Therefore, blind transplantation of technology would be most undesirable.

In areas where we now have no application of technology whatever, perhaps a simple technology would be most appropriate because it would be easily understood better by the persons employing it. Therefore, the needs of a developing country are quite different to those of advanced countries and we can and should find appropriate technologies to suit our requirements-right from very simple ones to the most sophisticated technologies in selected fields.

Take the handloom sector-it provides jobs for over 10 million people while the entire mill sector employs about a million people. However, it is possible and necessary to effect improvements in this sector so that better and more consistent quality textiles could be produced at lower cost and thereby the workmen's remuneration and living conditions could be significantly improved.

While we cannot slow down our efforts in adopting high level technology in those areas where it is relevant and necessary, we have simultaneously to look for technological inputs and systems which can meet the requirements of better geographical redistribution, decentralization of the production processes, upgrading the skills of the workers and thereby elevating his dignity. Quite often, traditional efforts at promoting economic development by imbibing the technology of highly developed countries have not resulted in the proper assimilation of such technology in the economic blood stream. The concentration of scarce investible resources in high capital intensive technology had raised the output and increased gross national income in the short run. However, it had not helped to affeetivelv solve the problems of poverty and unemployment in India with a high population density.

We should make a deliberate choice of a technology mix based on a definite development strategy evolved through a mature political judgment of the socio-economic environment and needs at a given point of time. The choice could take care of the country's resources and needs and match them in an effort to increase production and productivity without losing the perspective of ,geographic dispersal, capital and labour intensities of production and economic and social advancement of the rural poor.

There was need for international co-operation and co-ordination in this endeavour. We can visualize an institutional mechanism through which international institutions and agencies concerned with technology transfer as between developing countries on the one hand and developed and developing countries, on the, other, could provide a clearing house and delivery system.

A review of the development efforts made by developing countries showed clearly that the economic growth had not always resulted in adequate social development and the vast majority of people had not necessarily benefitted from the development strategies so far.

The application of industrial technology in several developing countries had created a dichotomy between modern and languishing traditional technologies. A dualism in industrial technology existed as between the modern and traditional sectors and no developing country may be able to completely do away with it, neither would it appear necessary or desirable to do so. The technological transformation of developing countries had to be urgently effected and for this a marriage between modern and traditional technologies should take place for their mutual reinforcement.

In all the developing countries, there is a great debate going on on what technologies would be most appropriate to meet their particular needs. The search to find new ways to use technologies as instruments to accelerate development has been at the centre of all such debates on a new international economic order. They seek to eliminate constraints that hinder their full access to an efficient use of modern technologies and to obtain them at better financial terms. To lessen their dependence on imported technology, they wish to create and share their own technologies that are "appropriate" to their distinct ways of economic and social growth.

A point that is being continually debated is the priority given to modern capital intensive technologies compared to less expensive labour-intensive technologies. These latter have come to be known by various terms, such as "intermediate", " rural" or "appropriate". Developing countries tend to reject the proposition that they should so concentrate on labour-intensive forms of activity as to leave the high technology pursuits to the industrialized world, thus widening the gap further. But, on the other hand, expensive technology has drained the financial resources of the developing countries without producing the hoped-for results. The search for new technological "mixes" that are appropriate reaches to many areas and subjects in which relevant technical co-operation can only or best stem from other developing countries as the highly developed countries do not face similar needs nor are they in a position to offer apt technical tools for handling such problems and needs.

At the ILO World Employment Conference in 1976, a resolution was passed as follows:

"There is an urgent need for appropriate and optimal technology, that is management and production techniques which are best suited to the resources and future development potential of developing countries. Such technology should contribute to greater productive employment opportunities, elimination of poverty and the achievement of equitable income distribution."

Again, the Kuwait Declaration on Technical Co-operation resolved in 1977 as follows:

"Provision of skills and technologies readily available with public and private companies of the industrialized countries in a traditional way must be replaced by identification and evaluation by the developing countries of all, available techniques and technologies. The developing country concerned will then select and adapt if necessary the one regarded most appropriate to it."

Like in any type of debate, there are more than one side to a coin. Those who urge the use of the most advanced technology argue that:

1. modern technology is more efficient and will close the development gap more quickly;

2. they provide economies of scale, result in capital saving, provide surpluses for more investment to further increase output;

3. only they can provide highest quality standards neededfor international markets;

4. modern technology provides optimum utilization of scarce managerial and technical skills;

5. relying on obsolete, labour-intensive technologies would condemn developing countries to perpetual technological backwardness and stagnation;

6. any employment problems created by use of modern technology should be taken care of by Government's socio-economic employment-creating programmes.

On the other hand, protagonists of labour-intensive technologies argue that :-

1. technical efficiency is not necessarily economic efficiency; what is economic in one socio-economic setting may not be so in a different set of circumstances;

2. modern technology is developed in industrialized societies whose circumstances are much different from the emerging nations in terms of land, labour, capital availability, size of markets and enterprises, consumer income and tastes, skill levels, distribution structure, transport facilities and so on;

3. developing countries need technologies that require little capital per worker; that operate efficiently on a small scale, that do not call for a high level of education and that use locally available materials;

4. the benefits of using resources to develop and adapt suitable indigenous technologies outweigh the costs-economic, social and political - of the continuing dependence upon imported technologies;

5. technology should provide for economic growth as well as for equitable sharing in that growth;

6. the high capital intensity of advanced technology combined with limited available funds would mean only employment of a small part of the available labour force. The majority would be condemned to unemployment or underemployment and, therefore, economic growth would mean nothing to them.

When this serious problem is discussed in such extremist ways, consciously or otherwise, a new point of view presents itself. By adopting "intermediate technology" or labour intensive techniques, some argue that a new international division of labour will emerge which would reserve labour-intensive forms of economic activity to developing countries leaving the affluent world to concern itself with the much more rewarding high technology pursuits. Such a system will condemn the developing countries to a permanent status of second-class citizens in the economic sense and therefore basically unjust. This will perpetuate and consolidate the injustices inflicted on them over the past decades.

The other main problems facing developing countries are, as we all know:

a) the high and rising costs of acquiring technologies because of patents, licensing, trade marks and so on ;

b) the limitations on the use of technology by various types of restrictions that are imposed-tied purchases, export market limitations, unwillingness to provide the full product range, etc.

c) the inadequacy of available technologies-because they are too automated and capital intensive; they require highly qualified labour, often use synthetics, and aim at too high a volume of production; they create dependence on the supplier of technology for years on end.

It is, therefore, very clear that the choice of technology should be consciously made on the merits of each individual case and situation. Such choice can thus only be realistically seen as part of a ipolitical strategy aimed at liberating the population of the developing country from political domination and economic exploitation, whether coming from the industrialized nations or from its own often over western-oriented elites and bureaucracies. Intermediate technology on its own will not be able to tackle the real causes of under-development nor bring about a viable solution unless there is complete unity and integration of various technological practices and political decisions.

The Intermediate Technology Development Group in the UK founded by Dr. E. F. Schumacher completed a survey in 1976 and have identified several organizations in developing countries whose principal objectives are to mobilize knowledge on appropriate technologies, to promote relevant research and development work and to get field-tested information on technologies into the hands of people who can use them. The approach of Dr. Schumacher and his supporters may be summed up as follows:

a) The source and centre of rural poverty lies primarily in the rural areas of poor countries which tend to be bypassed by aid and development as practised now.

b) The rural areas will continue to be by-passed and unemployment as well as the flood of migration into cities will continue to grow unless efficient small-scale technologies are made available with assistance in their use.

c) The donor countries and agencies do not at present possess the necessary organized knowledge of adapted appropriate technologies to be able to assist the developing countries on the scale required.

d) In matters of development, there is a problem of choosing the right level of technology to fit the given circumstances; in other words, there is a choice of technology. It cannot be assumed that the technology used by affluent societies is the only possible one, let alone that it is necessarily the best for poor countries.

e) The technology most likely to be appropriate for development in conditions of poverty would be in a sense. intermediate between say, the hoe and the tractor or the panga and the combine harvester.

In talking about technological choice, we must make it clear that there is a distinction between science and technology; between scientific knowledge and its application. There is no question of intermediate knowledge or intermediate science. But the application of the best knowledge can take many different forms and can lead to many different types of technology and modes of operation. There are certain conditions in which the most sophisticated technology is the most appropriate and there are others in which intermediate technology would serve the purpose best.

As more and more people enter the discussion about appropriate technology, the terms used to describe it and to distinguish it from large-scale sophisticated technology are increasing. The most common terms used to describe such alternative technologies are — intermediate technology, appropriate technology, village technology, ancient technology, soft technology, low-impact technology and so on depending on who uses them. The most surprising thing is that advocates for these appropriate technologies are to be found both in the developing and industrialised countries. For instance, in the USA, Theodore Roszak says "we deal now in a technology that alters the climate of entire continents and threatens to murder the flora and fauna of whole oceans. Compulsively optimistic technicians may continue to talk of finding a quick technological fix for every problem; but does it not grow clearer by the day that they are woefully out of tune with the environment they claim to understand". Mr. Amulyakumar Reddy of the Indian Institute of Science, Bangalore, has stated in an article that the pattern of industrialization adopted in most developing countries over the past few decades with Western technology has only accentuated the inequalities and the sharp polarization of their societies into haves and have-nots ... a dual society, the elite representing the top 10% to 20% consisting of industrialists, businessmen, doctors, engineers, scientists, bureaucrats and the bulk of organized white-collar labour and the bottom 80-90% consisting primarily of the rural poor.

Let us see what are the characteristics of an "appropriate technology". These are low investment as compared to local income, easy maintenance; high employment potential; high local content; compatabilitv with local ecological and sociological conditions; low dependence on complicated infrastructure and, above all, better productivity than existing technology in the same field. It must be suitable to the economic, physical and cultural endowment of the country. It must be a technology with a human face, which instead of making human hands and brains redundant, helps them to become far more productive than they have ever been before. Such technology making use of the best of modern knowledge and experience, is conducive to decentralization compatible with the laws of ecology, gentle in its uses of scarce resources and designed to serve the human person, instead of making him the servant of machines. Schumacher says that he names it "intermediate technology" to signify its vast superiority to the primitive technology of bygone ages but, at the same time, much simpler, cheaper and freer than the super-technology of the rich.

Despite such sharp differences in approach and philosophy, those who propose newer, more appropriate technologies are in the vanguard of a technological reformation that is seriously questioning the monolithic dogma of big technology. They are demanding for a new age of technological pluralism in both the industrialized and the developing countries. This does not imply a rejection of the countributions made by technology nor the use of such technologies in the future. The thinking persons of the world are asking that new elements be put into the equations and decisions that determine how villages, towns, cities, nations and continents will develop. Among such new elements are - a concern for the priority of people's needs, the protection of the environment and the right of a nation to political, social and economic independence. What is basic is the attitude that embodies such concerns and not the appropriate technologies in themselves.

Let us take some examples where the most up-to-date and sophisticated technologies are called for even in a high population, poor country like India.

The use of modern computers appears most appropriate in our Railways, Airlines, the Life Insurance Corporation of India, by our Defence services and in our scientific laboratories for Research & Development. If I may say so, our Trade Unions are doing a great disservice to the travelling public and the millions of policy holders by opposing the use of computers in these organizations.

These are primarily meant for providing service to the large mass of our poor people and by preventing the use of computers, the whole system has become inefficient, very expensive and time consuming. I need not elaborate on the importance of computers as an aid to prompt decision making process in the strategic areas of defence and research.

Similarly, in the fields of petrochemicals, oil drilling, synthetic fibres, electronics, etc., it would be in our best interest to obtain and use the most advanced technology that is available to us. The question to be considered in these fields is not so much the generation of employment but to use the one which yields the quickest and most economical results, keeping always in mind the maintenance of accepted standards in pollution control and ecological balance.

Thirdly, there is the question of exports assuming great significance and importance in our balance of trade situation. While traditional products like tea, coffee, jute and cotton textiles will continue to provide the base for many years to come, the fact remains that India has been increasing its exports in a dramatic mannet of engineering goods, marine products, handicrafts, garments, manufactured leather goods, gold jewellery and diamonds. Atleast in the area of engineering and some aspects of large scale fishing, etc., it has been well recognized that the very latest technology is essential for maintenance of high quality standards, prompt deliveries and keep the prices competitive in international market's.

Having talked about the most advanced technologies in selected fields, let us now consider other areas where appropriate technology should be used. There is a growing body of literature of case studies of appropriate technoloqies under actual operation conditions. The Appropriate Technology Development Association of India covers a wide range of technologies including some highly sophisticated ones. Let me give a few illustrations:

I. Scaling down of large scale technology

a) cement making
b) paper making
c) cotton spinning
d) jute spinninq and weaving
e) wool spinning
f) chemical fertilizer manufacture
g) improvement in efficiency of mini-sugar technology

II. Scaling up of village technologies

a) handloom weaving
b) blacksmithing
c) carpentry
d) extraction of vegetable oil
e) village pottery
f) village tanning
g) rice milling, etc.

III. Home living and community technology

a) village sewer disposal system & sanitation
b) village transport
c) bio-gas
d) solar cookers
e) animal husbandry
f) forest based industries, etc.

In India, even though we have over 630 million people, the market for most consumer goods has been estimated at no more than 60 million people, i.e. hardly 10% of the population. Nearly 50% of the population are below the poverty line and the remaining 40% just make out a bare living. This is an intolerable and explosive situation and in the democratic set up of adult franchise we have people will not have the patience to wait for the millennium to come. It is, therefore, urgently necessary for all thinking persons in Government, industry and the professions to concentrate on this single most urgent problem of providing rural employment on a priority basis.

The present Government is highly seized of this problem and several steps have already been initiated in respect of increased power generation, improved road communication, expansion of rural industries with the help of district industrial centres, improved agricultural practices, encouragement of agro-based industries and so on. Programmes for housing for the poor, improvement in drinking water supply and health services have also been accelerated. The ruling party has set the ideal objective of providing employment to all able bodied persons within a period of 10 to 15 years. These may sound utopian if we look at the past record of performances, but, friends, there is hardly any choice. As I mentioned earlier, the position is most explosive and if we do not find a solution by which people will have the confidence that they can look forward to a better quality of life in the foreseeable future, things may get completely out of hand.

Let us look at it from another point of view. If by a judicious selection of appropriate technologies for our rural industries and for our agricultural inputs and practices, we are able to create massive employment opportunities and increase the purchasing power of these large dormant masses of people, the demand for consumer goods will escalate so enormously that there would be increasing need for all types of products and services-transport, housing, clothing, steel, cement, consumer goods and so on. It is therefore obvious that priority No.1 should be given to generation of massive employment opportunities and the most appropriate technology should be used to suit each product or service, be it indigenous or imported, simple, sophisticated or an adaption of both.

In the ultimate analysis, it is the availability of choices of technologies that is important so that we can choose the ones which are most relevant. I must also mention that while too often we emphasize the hardware aspects of technology, the management aspects such as the human dimension and optimal utilization of human and material resources are neglected. Japan has done a magnificent job in, screening carefully the imported technology as to its labour, capital and energy contents and made appropriate changes which resulted in the better management of existing resources. Therefore, it is most important that the "innovative process", which is the core of technology and industrialization, is fully understood by our decision makers. It is equally important that full attention is given to proper education, organizational forms and, above all, the management concepts of developing motivated persons who can effectively utilize the available resources.

Technology must be so selected and applied that it will remove the drudgery of work, improve quality, increase the workers' earnings by better productivity, reduce costs and obtain optimal use of the limited capital used in such industries. Research & Development work has to go on continuously for making available technology appropriate to the situation. If, as I hope, all of us consciously practice what is considered to be good for us, I am sure the multiplier effect of tapping the energies of the long-sleeping giant that is our rural population would indeed be staggering by the turn of the century.

Finally, I wish to say that technology and its exploitation, innovation, the creation of new products and services to meet the needsof different sectors of people is as complex as human nature itself on which it so closely depends. For assessment and making choice, knowledge, sympathy and competence are needed. The emphasis is on human capacity to ask the right questions, to select and manage the most suitable mix, the maximization of social goals, given the resource endowments of our country. Government and Industry have enormous opportunities to influence both its scale and its direction for economic growth and the welfare of our 630 million people.

Once again, I wish to thank the President and Members of the Council of the Institution of Engineers (India) to have given me this honour and opportunity to express my views on this topical subject.

Thank you for listening to me with patience.

The Fifth Bhaikaka Memorial Lecture was delivered during
the Sixtieth Annual Convention (Diamond Jubilee), Calcutta, February 19, 1980

The Irrigation Engineer and the Farmer

Dr Y K Murthy, *FIE*

Consultant, World Bank, New Delhi

INTRODUCTION

Irrigation Engineers in India have been playing a vital role in the development of tho water resources for good of the people. Since independence, the development of irrigation in the country has made phenomenal progress. The irrigated area was only 22.6 million hectares: (9.7 million hectares, from large surface water works, 6.4 million hectares from minor surface water works and 6.5 million hectares from ground water). Since then the irrigation potential has gradually increased and how it is about 54.6 million hectares (26 million hectares from large surface water schemes and 7.7 million hectares from minor surface water works and 20.9 million hectares from ground water).At the beginning of the plan period, there were 190 irrigation schemes in the country and storage was 13 milliard cubic metres. Since then 614 dams creating about 146 milliard cubic metres of storage have been completed. Many more projects are under planning and execution. Earlier, to the plan period, areas irrigated from storages accounted for only about 85.5% whereas, the new areas afforded irrigation facilities, nearly 90% due to storages.

Thus, the Government has recognized the importance of the development of water resources and has continually encouraged the implementation of a large number of irrigation projects by providing the highest priority. The irrigation engineer has used the latest technology in developing these resources. The rate of investment has been increased at an accelerated rate from plan to plan. Dams and diversion structures of higher and higher magnitude are being constructed for utilizing the waters, of our river systems of the country for irrigation. High level expertise in the design research, construction has been developed and the country is in a position to export this technology to the other developing countries. Large canal systems such as the Rajasthan Canal and the inter-linking and inter-basin transfer of water has also been successfully implemented for augmenting the irrigation facilities to the cultivated lands. We have utilized nearly 40% of our usable water resources for the purposes of irrigation.

The progress of hydraulic research and design has also kept pace very closely with the development of water resources. Most intricate hydraulic and structural problems have been resolved by resorting to the new research and developmental practices. Some of the outstanding contributions have been made in the research on irrigation structures and this has made tremendous impact on the efficiency of the irrigation systems. No doubt, the irrigation engineer has made remarkable progress in creating the water potential and has won laurels and his work has been recognized all over the world.

Similarly, the modern agricultural development has also made rapid strides in the country.

The intensive area approach acquired new dimension with the emergence of exotic high yield varieties of cereal crops and technological improvements. In fact, the high yielding variety programme became the king-pin of the new strategy of agricultural development in 1966-67. Research support was provided by the Research Institutes both at the Centre and the States and the Agricultural Universities. The new crop varieties, most of them early maturing made it possible to use the land intensively. More crops could be grown on the same land in a year. Water management for efficient agriculture was initiated.

In spite of the high level of expertise attained in the field of water resources development by the eminent irrigation engineers and revolutionary advance in the agriculture technology, the crop, yield in India is one of the lowest in the world (Table 1).

TABLE 1 CROP YIELDS IN IRRIGATED AREAS
((Yield of some important crops in different countries (1969))

Country	Yield (Kg/ha) Paddy	Cotton	Wheat
France	-	-	3580
India	1610	120	1170
Japan	5550	-	-
Pakistan	1820	310	1070
Taiwan	3510	-	-
Thailand	1840	-	-
U A R	5511	790	-
U S A	4700	490	2060
U S S R	-	770	-

Further, the yields also vary considerably over different parts of the country. The yields are erratic. The up-to-date data for 1970-71 indicate the range in crop fields in the irrigated areas and are approximately as follows:-

Paddy	850 to 2350 kg/ha
Cotton	90 to 45 kg/ha
and Wheat	640 to 2800 kg/ha

Though this variation could be attributed partly to non-uniform availability of other inputs such as good seeds, fertilizers etc, the crucial factor responsible for low yields is the non-availability of reliable and adequate water supplies even in the irrigated areas. The timing, frequency and adequacy of irrigation supplies varies widely from place to place.

WOES OF FARMERS

The farmer, who is the king-pin in the process of agricultural development of the country is faced with a. number of woes, which he is not able to overcome, unless there is a revolutionary change in the approach of the engineers. Let us look at the woes of the farmer.

The irrigation engineer feels satisfied that his work is completed, when he constructs the large project and the canal system to the point of an outlet which could normally cover up to 40 hectares. The responsibility of the irrigation engineer stops at this point and the farmer is supposed to take over the responsibility for excavating the field channels and leading the water to the farms. There is no direction to the farmer as to how he could go about in accomplishing the objective to ensure fair distribution of the available irrigation water.

At present, there is overlapping of the responsibilities in the mechanism of distribution of water beyond the outlet. The practices followed are different in different states. Revenue Department, Agricultural Department and Irrigation Department work in different directions. The ultimate sufferer is the farmer.

A farmer does not know as to when the water will be made available. So he has to wait and take the water whenever it is available to the field. Sometimes he has to wait for a number of days for getting his share of water. If he is a tail ender, he hardly gets any water. Many a time the sowing period is over when water is made available and he is forced to adopt entirely different crop calendar. This would naturally reduce the yield from his field, which works as a disincentive.

Farmer close to the outlet has the advantage of using as much water as he wants and only after he is satisfied, the lower farmers are able to irrigate. This system is wasteful, Further, farmer at the tail end has no incentive nor the funds to invest sufficiently in the inputs for Increased production. Thus his lands produced little or were even kept faIlow. The problem is further aggravated by the fact that water charges are levied evenly over the command area, which gives rise to considerable unrest within the community.

The farmers face great difficulties in arranging the water distribution amongst themselves. Sometimes the construction of water courses traversing through the cultivated lands will lead to long drawn disputes. Sometimes, co-operative farming have helped to sort out these disputes.

Since there is no systematic schedule for release of water, the farmers have tendency to draw unauthorized supply from the canals by breaking the bank or by introducing additional pipe outlets nearer to their lands. Further, sometimes the distributaries passing through his land or near his land carries water to the next area, because it is declared as wet, whereas he cannot get the water since his area is declared as Irrigated Dry area.

The problems of the farmers get accentuated further during a draught period. All his programmes get completely upset since timely information is not given to him by the irrigation engineers. He again struggles hard to grow some crop or other to make a living.

Another major hurdle before the farmer particularly the small and marginal farmer is his inability to undertake on farm development of all lands under an outlet as a unit. Willingness of all the farmers under one outlet to take up the work together and to finance the relatively high cost of development is necessary. Without land development, the farmer is unable to get the water to his farm.

In some cases, it has been experienced that the peak discharge required at the outlet is not available due to a wrong assumption made in the design of the minor.

The Government of India has been making earnest attempt to alleviate their problems by providing facilities for the farmers to borrow money from the rural bank for making purchases of the inputs like fertilizers, seeds, pesticides but all these inputs would become useful only if there is a timely supply of water to the fields. Experience with intensive agricultural programme has shown that the irrigation as practiced in most of the command areas of major projects could not provide adequate support to intensive farming. Irrigation supplies to the fields are very often neither available in time nor adequate in quantity. Wasteful use is practiced, particularly where paddy is grown. The responsibility of the irrigation engineer should, therefore, go beyond the outlet. The canals should be taken down to the farmers' lands. The recent trend in the country has been to extend the canal system up to 5 hectares in some of the World Bank financed projects and the responsibility for the construction of water courses beyond this outlet is that of the farmer. The farmer should be imparted adequate know-how to carry out the alignment of the field channels beyond an outlet so that it is possible for the farmers to take the water at convenient places.

The farmers who have been traditionally accustomed to only kharif irrigation should be trained to use water when it is required. The tendency of the farmers to use water when it is required. The tendency of the farmers is to take water from the canal when available and flood his areas. This tendency will not only reduce the yield but also result in excessive wastage of valuable water. In the new areas that are coming under irrigation where rabi cultivation has to be practiced by the farmers, there should be periodical training to the farmers by which they would know when to take the water for their lands.

In consultation with economists, soil scientists, the irrigation engineer should work out the water requirements and prepare a schedule for release of water to the fields.

The time table of release of water to be made available in the right quantity at the right time to the farmer should be made well in advance so that he can plan out his programme for growing crops. This has been practiced in many countries like Taiwan, Japan and Phillipines. With a little more effort, it is possible to work out the requirements of each farmer and the schedule of releases from the canals arranged accordingly.

ROLE OF IRRIGATION ENGINEER

Many of the woes of the farmer discussed above, could be handled effectively by the irrigation engineer. There is an urgent need to review the present system and introduce basic changes in the approach.

Generally the irrigation is practiced through three major sources, namely,

i) Major and medium irrigation project
ii) Minor irrigation projects and
iii) Dugwells and tubewells.

It has been observed that the supply of water from wells and tube-wells are more properly regulated, whereas the major and medium irrigation projects show perhaps the poorest results an there is considerable scope for improvement.

But let us look at these aspects with particular reference to the utilization of the water potential that has been created with the efforts of the irrigation engineer. The studies made from time to time have revealed that there has been a wide gap between the creation of potential and utilization. Who are the people to utilize this water? These are the farmers. Unfortunately, the major deficiency in agricultural planning arise from the fact that the agricultural activity, which was carried out by millions of our farmers, are not given due importance. The farmers were left to take independent decisions. It is well recognized that the success of agricultural planning lies in influencing decision of the farmers in a given direction and in successfully impressing on them to adopt the advanced agricultural technology and the inputs on the desired scale. Farmers have to be motivated first through appropriate incentives to utilize the potential created. The farmer in our country has also a rich tradition and long experience in the agriculture practices. He has done yeoman's service to the country by striving hard in increasing production of food in sufficient quantity. He is dedicated to his work and is intelligent enough to organize and work on the fields with the minimum facilities. Many a time, he has to depend entirely on the mercy of raingod. The gambling of the farmer is going on for times immemorial. With the advent of the development of water resources in the country, the farmer is looking forward for assured water supply for his lands.

The unique feature in our country is that the farmer has mostly a small area to cultivate. There is considerable diversity found in respect of family or cultural practices followed by farmers in different villages and also in between various categories of the farmers in the same village. These variations do not have any order or trend, good enough to try any conclusion therefrom. It seems that in spite of introduction of innovative practices in respect of the use of high yielding varieties, seeds fertilizers, pesticides and other scientific means, farmers are yet in an unsettled state of mind as to whether or not to adopt or continue – if adopted already – the new scientific and innovative practices deviating from the age – old traditional practices. Since most of the farmers are either small farmers of marginal farmers, they cannot afford to invest large sums of money for these sophisticated materials required for using these innovative practices. Further some farmers have developed wrong notions in the use of fertilizers and pesticides about their being harmful to the soils and crops. The new technology also needs adequate irrigation facilities. Since this is not assured, the farmers become complacent.

All these tribulations have been reflected in the low rate of production from the land.

Looking at the other aspect, since rates of construction materials and labour and other inputs are going up, the cost of irrigation projects have increased manifold, thus, making the water available for irrigation more expensive than before. We are, thus, faced with a major problem, that is, on one hand the cost of water has increased tremendously and on the other hand the farmers, particularly the small and marginal farmers, who constitute a major portion of the cultivating in all the rural areas of the country have no facility to improve the method of use of water for the cultivation. The only way to sort out these problems is to examine in depth, these problems and identify the deficiencies and try to improve the relationship in the relevant areas between the irrigation engineer and the farmer so that there is a mutual understanding and benefit. Let us, therefore, look into the various problems for which the irrigation is fully or partly responsible. How the irrigation engineer could help the farmer to improve the production of food and fibre. Some of the important aspects are briefly discussed below:-

i) In many storage projects, the reservoir is drawn down to the minimum at the end of the season before the commencement of the monsoon. As a result of that, there is hardly any water available in the reservoir for releases, if there is a delay in the commencement of the monsoon. Farmers will have to wait till the rain commences, in spite of the irrigation project. These storages should have some ‘carryover’ storage to tide over such critical situations.

ii) A comprehensive on-farm planning and development is essential before the farmers take to growing of crops on the lands to be irrigated. This is possible only if the topographical and the soil surveys of the command areas are available. Similarly, land consolidation also becomes easier if we have the detailed surveys. In the irrigation projects, these are not included. This makes the farmer difficult to start deriving the benefit from the irrigation water. In other words, major irrigation projects, for agriculture will have to be planned and designed to provide the best facilities for the project operation and maintenance. The project should incorporate the canal system down to the farmer’s field.

iii) At the planning and design stage judicious management of water should be considered as an essential input for production. The irrigation field should be the focal point from where the design for the canal system, irrigation blocks with the required control structures and conveyance canals up to the required headworks. At present, the practice is to design according to the flow of water from the source to the distributaries. The old practices followed by the irrigation engineers limit their responsibility to the headworks and the main canals should cease and the distributaries, water courses and field channels up to the farmer’s field should be executed by the irrigation engineers.

iv) Basic question whether to spread the available water thinly over as large area as possible or to use it on a smaller area at a higher intensity should be decided as a policy. Water being more restricted than the available land, optimum allocation would be to spread it thinly over a large area and also to achieve the social goals by giving water to as many farmers as possible. But the modern agricultural production technology to increase the yields lays emphasis on increasing the water supply per unit of crop area.

v) It is imperative to decide at the time of planning itself as to what method of water distribution will be used once the irrigation system starts operation: (i) whether it will be supplied to the farms on a continuous basis as in the many rice growing areas or (ii) on a demand basis as in the case of areas with relatively abundant water and fewer farmers, or (iii) rotation basis as in the areas of scarce water resources with large number of farmers.

Major complication occurs when the irrigation system is planned on one basis and operated differently.

vi) Water management in irrigation means efficient use of water, which is synonymous with the efficient use of investments. Irrigation planning and water management are the obvious measures to obtain the best results from an irrigation project.

vii) The canal system should have sufficient in-built flexibility to allow for expected future changes in the operation as a result of new cropping patterns and increase in the intensity of irrigation. The system should have sufficient capacity to meet peak seasonal demands for water.

viii) The density of the canals, that is, length of the canals per hectare of the irrigated area deserves serious consideration. Irrigation water cannot be distributed evenly throughout a field if the canals are inadequate. One portion of the irrigated area may not have enough water and another area may be over-irrigated wasting a considerable amount of water. The optimum density of the canals (main, lateral water courses and field channels) should be about 50 to 80 m/ha depending on the topography of the area and the irrigation adopted.

ix) Efficient drainage is as important as irrigation. Adequate emphasis to drainage should be given in planning irrigation projects when natural drainage conditions are not available. In fact, similar to irrigation plan, a drainage plan on a map of appropriate scale should be prepared. To stress the importance of the close relationship between irrigation and drainage, some irrigation experts have suggested a new term 'Irrinage' for irrigation and drainage.

x) Canal networks layout in the field should fit to the field boundaries rather than following desirable field arrangement pattern to fit the irrigation network.

xi) At the planning stage of the canal system, rough draft of operation and maintenance plan of manual of operation should be developed which explains the requirement of staff, farming support and the equipment facilities required for operation and maintenance.

xii) Trial runs of the canal network should be made before the commencement of regular operation. This is mainly to check the reliability of canal works to ensure proper functioning of all the components of the canal system.

xiii) The ultimate object of irrigation project is to distribute the water conserved for irrigating the agricultural lands. Unfortunately, under the present system, the irrigation engineers confine themselves with various aspects of construction of the main canals, branch canals and distributaries. But no attention is given to the vital problems of water management, which is the basic need for optimum utilization of the potential. Irrigation engineer along with agriculture experts and extension workers should plan out a strategy well in advance of the completion of the creation of the potential so that farmers keep themselves prepared to plan out their cropping pattern and crop calendar. Senior agriculture and extension officers should be appointed in the project to work closely with the irrigation engineers of the project for the purpose.

In certain under developed cultivated areas, demonstration farms should be started well in advance to educate the farmers in the new methods.

xiv) Efficient management of water use for irrigation depends largely on the measurement of water. The distribution and application of right amount of water to the farmers at the right time can only be achieved with the use of various control and measuring devices along the canals. It is obligatory to provide these devices in order to regulate the distribution and delivery of water.

xv) Organization required for effective water management should be set up, for Indian conditions, a combination of Governmental agency up to the outlet and farmer's organizations below the outlet could be tried in the first instance and gradually the farmer's organization could take over the entire management including maintenance. Farmer's associations, once they become established, will provide convenient focal points for receiving farm supplies and sharing common resources, for receiving and disseminating information and advice on improved water management and agricultural practices.

xvi) To establish effective liaison between farmers and the Government organization concerning the adequacy and timely supply of water and other related matters, it is necessary for the representatives of outlet committee to form further committees at higher levels, for example, at minor, distributary and project levels.

xvii) The Government organizations should be streamlined and must be able to understand problems of the farmers and deal with them sympathetically so that they could be benefitted by mutual exchange of ideas. The staff working in the organizations should be loyal and dedicated and helpful to the farmers. The strength of the organization should be worked out according to the requirements of the irrigated area. Training should be imparted at all the levels at a specified time intervals.

xviii) Agricultural uses of water should be brought administratively under a unitary control. If this is done, water administration aided by suitable legislation could easily give priority to irrigation or agricultural policy.

xix) Education system should be re-oriented such that the young engineers should not only acquire sufficient knowledge about irrigation and drainage but also rudiments of agriculture, crop water requirements and water management. Similarly, agriculture engineers should learn at least the elements of irrigation and drainage engineering. In course of time, a separate cadre of officers for water management should be established as has been done in some countries like Israel and Taiwan.

xx) To meet the immediate needs, a training programme should be worked out to be imparted to the in-service irrigation and agriculture engineers. The training programme should not be too elaborate or ambitious.

xxi) In each of the major irrigation projects, it is highly desirable to establish small pilot projects to educate the farmers to the new technological developments in water management and crop planning, etc. The information gathered from these pilot projects should be judiciously used for planning of new projects.

xxii) A model Irrigation Bill evolved by the Union Department of Irrigation in 1976 should be adopted by State Irrigation Departments with suitable amendments. With the introduction of this bill, the legal problems connected with land development activities like Land Acquisition, Land Consolidation of Holdings, land leveling and construction of field channels could be sorted out expeditiously.

Water is likely to become a scarce resource and the most effective way of optimizing the use of water is to fix consumption rates, according to the volume of water consumed. Volumetric measurements of irrigation supplies have to be progressively introduced. In the initial stages of introducing the new concept, the rates charged per acre of irrigated crop at present should form the basis to calculate the rate to be charged on the volumetric basis. Encouraging the establishment of the water and charging them by volume for the bulk supplies could be tried in the first instance.

CONCLUSION

After recognizing these uncoordinated functioning at the grassroots level, the Planning Commission has introduced recently the concept of command area development. It was proposed that in the first phase whole time development authorities would be set up in areas covering about 14 million hectares in the commands of 51 irrigation projects. A few of them have already been set up and have been functioning. But the experience derived from the working of these Command Area Development Authorities have been far from satisfactory. The co-ordination between the various departments through the Command Area Development Authority remains to be the crux of the problem. Inter-departmental rivalries and jealousies tends to make the concept unworkable. Suitable legislative measures will have to be taken to enforce this concept to be followed effectively in all the irrigation systems. A number of seminars and symposia are being held from time to time for organizing the water management. But actual application of these water management practices will require a large amount of infrastructure which, if not provided, would result in the continued chaotic conditions. We should not forget that the farer plays a pivotal role in the country's economy. Irrigation engineer too is in an enviable position but both are working independently in their own orbits without coming face to face with each other. The irrigation engineers should take the initiative and play a vital role keeping in line the ultimate objectives of major irrigation projects launched in the country. Farmers in our country are industrious and intelligent; what they need is the direction. The irrigation engineers should give a lead and bring farmers closer so that they will derive the benefit of the high deals of irrigation engineers.

Bhaikaka, the Root — Rural Engineering, the Branch

Dr V Kurien, *FIE*

Chairman
National Dairy Development Board

Shri Ramachandran, President of the Institution of Engineers (India), honoured guests –

When the President of the Institution did me the honour of writing to me to tell me that the Institution's Council wished him to invite me, on its behalf, to deliver this, the Sixth Bhaikaka Memorial Lecture, my surprise and pleasure at being so honoured was, I must admit, tinged with apprehension: firstly, because I have not practised engineering for so many years, as I have been employed as a manager of a rural milk producers' cooperative for the last thirty years or so, and I fear that I have forgotten whatever engineering knowledge might have entitled me originally to be a Fellow of this respected Institution ... but there was also another, equally strong reason for my apprehension, which was quite simply that I once had the honour to know Bhaikaka and his work, as I worked next door to him — and I apprehended that I could not really do justice to his memory ... then, however, I realised that I had a duty to try to honour his memory appropriately, by using this occasion as I believe Bhaikaka would himself have wished: namely, to start the process of finishing what I believe he would have considered a piece of unfinished business — that is, the founding of a new, formal branch of our profession, which I shall propose today be called "Rural Engineering."

I hope that this Institution will agree that a Bhaikaka Memorial Lecture is an appropriate vehicle whereby to "launch" Rural Engineering as a new branch of engineering. For if, as is often said, the function of the scientist is to add to our knowledge, while the function of the engineer is to apply that knowledge to practical problems then Bhaikaka was both a scientist and an engineer. He certainly added much to our knowledge — and he applied his knowledge to very practical problems.

Bhaikaka did not merely say that engineering is "the application of science to the conversion of resources for the benefit of man" — in fact, personally, I never heard him indulge in such grand-sounding generalities. Instead of lecturing people about his principles, he concentrated on practising them and turning them into useful realities.

As is the case with all those who are fortunate enough to be born engineers, Bhaikaka intuitively saw problems in terms of improved, scientific application of available resources. When Sardar Vallabhbhai Patel plucked Bhaikaka from his beloved city of Ahmedabad and asked him to apply his knowledge to the benefit of the rural people in the Charotar Tract, he addressed himself to the task set for him by the Sardar with a sure, intuitive perception that the nub of the problem of rural poverty was then, as it is today, the nation's need to enlarge the resources available to our villages — and to improve the conversion of those resources into the goods and services which rural people need.

Sardar Vallabhbhai Patel saw the task of achieving independence not only as a political task — he knew that our rural majority could never be truly free until they were freed from the extortions of money-lenders and middle-men and also from the indignity of bias based on social abuses of privilege and prestige by an elite without a conscience. In other words, the Sardar saw independence not only as a political state, but as a social and economic state — and he chose Bhaikaka as one of his instruments for translating this social and economic vision of freedom into a practical reality for our country's rural majority.

Inspired by the Sardar, Bhaikaka set about building institutions which would both increase the human and material resources available to the people in the villages and which would also enable the rural population to make better uses of those resources. He built rural institutions for research and teaching — and he built rural factories, literally to produce more for the farmers. In short, he added to his engineering skills a skill which can be described as "institutional engineering," which he applied with devotion to the betterment of rural people's lives.

Clearly, there could be no more fitting monument to him than the establishment of Rural Engineering as a branch of the profession he practised so brilliantly, devoted to the application of engineering skills in our villages. This is the proposal that I shall outline here today. I do so with some hesitation, partly because I share Bhaikaka's dislike of the idea of "lecturing" anybody — and partly because I am very much aware of the limitations of my own engineering knowledge, particularly before such an audience. I have the temerity nevertheless to propose the establishment of Rural Engineering as a new branch of our profession, despite my own limitations, because I do believe that it is something which Bhaikaka would have wanted — and that he would have done the job himself, had he lived a few years longer.

Part I: Bhaikaka, progenitor of rural engineering

Before I come to the main outline of my proposal, I should perhaps explain how it came about that I had the privilege of seeing Bhaikaka at work. This will serve also to explain why I refer to him as the "progenitor of rural engineering."

Sardar Vallabhbhai Patel was born and raised in a village called Karamsad, close to Anand, which was then a small town in the fertile area of the Gujarat Plain which is known as the Charotar Tract. Sardar was an unusually wise chooser of people who could build the institutions with his vision of what independent India required. He had seen Bhaikaka's drive and practical engineering skills in Ahmedabad, where Bhaikaka had put into effect what was, in those days, a very advanced approach to town planning, which included provision of adequate water supplies and electricity, as well as the broad roads of new Ahmedabad, with its well laid out zones for educational institutions, for industry and for commerce.

Sardar saw that Bhaikaka was the man that his beloved Charotar Tract needed. So he persuaded Bhaikaka to leave Ahmedabad and to stay at Anand.

The farmers of Charotar wanted their institutions of learning: institutions which would be suited to their needs. So Sardar determined that, first, there should be a College of Agriculture at Anand, then a College of Science and then a College of Engineering. He gave Dr Maganbhai Patel, a distinguished agricultural scientist, the task of building the College of Agriculture and he gave Bhaikaka the responsibility for building the Science and Engineering Colleges — and he knew that Bhaikaka would carry out this task so that the educational institutions which the farmers needed would have a proper rural bias.

In the same way — and with the same good judgement — Sardar chose Tribhuvandas Patel and gave him the responsibility for building up the milk producers' co-operative based at Anand.

This is how it came about that, when I (quite by chance) was posted by the Government of India to Anand in 1950, Mr Tribhuvandas was the Chairman of the Kaira District Co-operative Milk Producers' Union (now better known by its brand-name, "Amul) — and, when I obtained my release from Government service, Mr Tribhuvandas persuaded his co-operative's board of directors to appoint me as the co-operative's manager. That is how I came to have the opportunity to see, at close quarters, these three men the Sardar had selected at work. I came to realise that the greatness of the Sardar was his ability to choose men and to apply their special skills constructively to the task of nation building.

And they did work! Bhaikaka convinced the farmers of Charotar that, before they had an engineering college, they should have a science college — and, ultimately, he built Vallabh Vidyanagar University, which I believe was the first rural university to be built in independent India. As part of the same master plan, Sardar established an Agricultural Institute at Anand, of which he became the first Chairman (an honour which ultimately became mine briefly).

You may be wondering how all this institution building, which is now part of independent India's, early history can be relevant to our concerns today. It 1s relevant not because Bhaikaka did literally "build" the physical plan of Vallabh Vidyanagar and institutions but what is more relevant to us today is the way in which Bhaikaka based the development of these institutions on the active support of the Charotar farmers themselves.

For example, when the farmers said that they wanted these institutions of learning, he called five hundred of them together and asked them to pontribute their land for these projects. He said that if all of them gave him their land free he would give back to them half the land after developing it fully with roads, water-supply, electricity, drainage etc — and he explained that this half would be worth more than double its original value, so that all of them would gain by donating to him half their land!

At the same time, Bhaikaka was too practical to believe that great institutions could be developed entirely out of the farmers' limited resources. So he established the Charotar Vidya Mandal for building the rural university – and the Charotar Gram Udyog Sahakari Mandli, a co-operative venture for building rural industries and he collected around him some dedicated, able men to execute this task. But while he gave these men every facility, he himself set up his office under a mango three.

Thus, Bhaikaka brought together the support and the work of the farmers and his own very significant engineering skills, while also ensuring the autonomy of his new institutions by endowing them with income from viable, productive enterprises, which he established right in the heart of the Charotar Tract.

That was a real piece of "rural engineering"! It was a brilliant venture and one which makes it appropriate, I believe, to name Bhaikaka "the progenitor of rural engineering."

Part II: A rural institutional structure: the necessary condition for the practice of rural engineering

Just as we can draw lessons from the way in which Bhaikaka developed his institutions, I believe that we can also draw some important lessons from the way in which Tribhuvandas Patel developed the institution which Sardar had made him responsible for, the Anand Milk Producers' Co-operative Union, which became ‘Amul’.

The basic approach adopted by Mr Tribhuvandas was first to establish milk co-operatives in the villages. These co-operatives were literally the nbasen of the entire venture. Mr Tribhuvandas insisted that each village co-operative should be open to all milk producers in the village, regardless of caste, creed or community. He placed equal emphasis on the principle of none man, one vote,n regardless of each member's social and economic status.

All members of each village co-operative elected their own Managing Committee and the elected members of each Managing Committee elected their Chairman. The village co-operatives were all affiliated members of the Kaira District Cooperative Milk Producers' Union — and the Directors of the Union were elected from among the Chairmen of those village co-operatives. In other words, the milk producers' co-operatives in the villages were not only the union's "base," but their elected representatives were also literally in command of the Union. This is how Mr Tribhuvandas carried out the task which Sardar had given him: namely, to "put the milk producers in charge of their own milk business."

Once he had started this process of developing the co-operative base in the villages, Mr Tribhuvandas' nest step was to secure for his members the services of professional managers and technically qualified personnel, such as dairy technologists, engineers etc. Thus, the co-operative became the rural milk producers' own instrument for obtaining the services of professionally trained personnel who, up to that time, had worked primarily for urban enterprise and government.

As I mentioned earlier, I had the privilege of being the Kaira Co-operative's first manager and, when I saw the magnitude of the task, I sought the assistance of a fellow student of mine, Mr H.M. Dalaya, whom I knew to be a brilliant dairy technologist. We were fortunate in obtaining his services for our co-operative — and today, he is the Managing Director of Amul.

Back in those early days, however, we soon found that we first had to learn the art of cooperation from our Chairman, Mr Tribhuvandas. It took us some time to appreciate the skill with which he could draw together the people of a village and imbue them with the desire to work together, through their village milk co-operative, for their economic and social betterment. Once we started to understand how our Chairman had developed the concept of making the co-operatives an instrument for social and economic change in the villages, we technical employees of the cooperative also learned how to enable the co-operative to be a better vehicle for making our skills more useful to our milk producer-members.

Amul hired its own veterinary doctors and put t-hem into jeeps (which became known as "mobile veterinary clinics") so that each village milk cooperative could be visited by a veterinary doctor once a week. But this reaching out of professional veterinary services to the villages is only one side of the coin. Of equal importance is the development of para-veterinary personnel in each village itself... We found that the village milk producers could select a person, usually from the village itself, and that the co-operative's veterinary doctors could train that person in "animal first-aid." This trained "animal first- aid worker" would then be available, in the village itself, day in and day out, to treat the producers' milch animals' minor ills and chills, cuts, broken horns etc. This para-veterinary services proved to be a very economic adjunct to our professional veterinary doctors' work. So much so, in fact, that, when the co-operative decided to establish its own artificial insemination net-work, one person, usually from the village itself, was trained to be that village's "lay artificial inseminator." Again, we have found this a very economic and decentralized way of establishing a comprehensive artificial insemination service, which ensures the availability of an inseminator, in each village, whenever a milch animal comes on heat.

The principle which can be derived from this experience is that the Anand Pattern Co-operatives are not only a vehicle whereby rural producers can hire their own professional personnel, but also that these professional personnel can multiply the impact of their skills greatly by providing training to the farmers themselves. The people in the villages so trained provide invaluable "feedback" to the co-operative's professional staff, reporting out-breaks of diseases, monitoring the timing of milk collection trucks etc – apart from automatically weeding out those who had neither the required skill nor the inclination to perform their duties.

These principles, on which the Anand Pattern Co-operatives are based, are now being extended to many more fields than milk. The Government of India has, in fact, now made it a policy that the rural producers should have their own institutions to handle the procurement, processing and marketing of all their produce co-operatively, including, for example, vegetable oil, cotton and, now, fruits, vegetables and jute. Perhaps of equal relevance to our concerns here today is an interesting extension of the Anand Pattern in another direction. The National Dairy Development Board and Amul are now engaged in promoting a maternal and infant health care service, through an autonomous Foundation set up for the purpose, whereby the infrastructure of the village milk co-operatives and their co-operative union can be used to provide the services of training nurses, who visit the villages once weekly and who train a woman from each village to be a "village health worker".

The same Foundation (which is called the Tribhuvandas Foundation, after its Founder, Mr Tribhuvandas Patel), also includes in its objectives the improvement of the village environment, creation of productive and remunerative employment for families whose incomes are inadequate — and the establishment in the village of a young farmers' centre, where the young farmers can obtain training in improved methods of cultivation and milk production.

Now, it is interesting — and perhaps rather sad that, when the Tribhuvandas Foundation wanted to start on the task of improving the environment in the villages where it operates, it had first thought to recruit some young engineers. Then the question arose, "What kind of engineer should the Foundation recruit?" What the Foundation needs, it believes, is some well trained young graduates in rural engineering, but no such graduates exist. There are no graduate programmes in rural engineering, as far as I know, neither in this country nor in any other.

Thus, we have a paradox. In this case, the infrastructure which is the necessary condition for effective deployment of rural engineers, is already being established. There are Anand Pattern Milk Co-operatives in 40 Districts already and that number will probably grow to one hundred Districts, at least, by the end of this decade. At the same time, the Anand Pattern is spreading into more Districts, to handle the procurement of oilseeds, processing them into vegetable oil and de-oiled cake — and marketing the vegetable oil and cake thus produced. No doubt, the producer-members of these co-operatives will want their own "Tribhuvandas Foundation," so that they can obtain the edical services they need, especially for mothers and infants, as well as other professional services for income generation and improvement of the village environment. But when it comes to finding young engineers who could be deployed through this rural infrastructure, we find that there is no course of education and training which really equips a young graduate to serve village people this way.

That is why I am taking this opportunity to propose that rural engineering be established as a new branch of our profession.

Part III: <u>Rural problems as engineering opportunities</u>

Defining a new branch of a profession is a difficult task. I doubt whether anyone individual is capable of doing it by himself. So I certainly will not claim that what I can say about rural engineering is in any way definitive. On the contrary, I believe that the best way to approach the task of deciding what should be the content of rural engineering is to look first at the problems which the young rural engineers will have to tackle in the villages. These problems can then be viewed not as problems, but rather as opportunities for young rural engineers to apply their skills for the benefit of rural society.

Traditionally, academic courses in engineering subjects are supposed to qualify the young graduate for a number of functions, which are usually described as research, development, design, construction, production and the operation and management of engineering processes. Most of us will agree, however, that we actually learn to carry out these functions only when we get practical experience which enables us to "learn on the job".

One can see intuitively, however, that our young rural engineers will have to be capable of carrying out most, if not all of these engineering functions.

Perhaps I should say at this juncture that I am not making yet another call to redesign the bullock cart! That call has been made so often that it has unfortunately become a cliche, even though a truly improved bullock-cart would be a blessing to most of our rural people.

However, I believe that the scope for rural engineering in our village is far wider than the problems involved in improving the bullock cart. After all, the very substance of engineering is the improved use of energy and materials – and it is the need for improved uses of energy and materials which underlies so many of the problems which beset our villages today.

Probably one can best start to define the scope of rural engineering by looking at examples of the problems most commonly encountered in our villages. Usually, these problems have to do with the improvement of the environment, the provision of utilities, the procedures of cultivation, the exchange of communications — and of goods and services between the village and the outside world.

The most common environmental problem, for example, in most villages, stems from the inadequacy of traditional systems for disposal of human and animal wastes. The traditional methods of dealing with these problems are often found today to have become inadequate, in the face of the doubling of our human population since independence. The treatment of human and animal wastes in "gobar gas" production units is frequently advocated, of course. But so far as I know, these units cost some Rs. 4-600 per human served and only a few of our rural population can afford such an investment. To tackle this set of problems, the young rural engineer will need good knowledge of sanitary engineering, as well as of fermentation processes and and the bio-chemistry which underlies them.

To take another example, in the area of the provision of utilities — ever since independence, we have heard a lot about rural electrification. Yet, at least half of our villages remain without electricity supply and I am told that the point has now been reached when a kilometre of rural electricity supply line costs as much as Rs.7500. In many. if not the majority of our villages. The demand for electricity — and the opportunities for using it productively — are too small to permit a reasonable return on an investment of Rs. 7500 per kilometre of line. Probably, some of our young engineers will have to start looking afresh at the task of developing small-scale generating units of low capital cost. Perhaps an extension of a gobar-gas system will ultimately provide the answer ... Certainly, any young rural engineer who has to tackle this set of problems will need to be well grounded in physics and to have a practical understanding of heat-transfer processes and of thermodynamics.

It is difficult to choose a single example of the many problems connected with procedures of cultivation. A good job has been done, I understand, on improvement of traditional ploughs but the motive power-source which pulls most of our ploughs (that is to say, the draught bullock) is often a tractor which has to be kept idle for one or two hundred days of the year "... In these days of population pressure on the land, relative scarcity of fodders and forages etc., one cannot help but wonder how long our agricultural systems will be able to sustain a source of motive power which has to be "fuelled" (that to say, in the case of the draught bullock, which has to be fed) twice daily, even though it is kept idle for so many days of the year ...". There is no doubt in my mind that, sooner or later, our young rural engineers will be pressed by the farmers to help them find some other form of motive power which, when idle, can simply be switched off.

Finally, the exchange of communications — and of goods and services between the village and the outside world: the most common factor in such problems is probably that of providing allweather roads. The traditional methods of road building still in vogue in our country are very costly by village standards. It is no doubt true that "cheap labour" is all too readily available in many villages for many days of the year, simply because there is too little productive work for so many rural people. But this, in any case, still leaves the problem of materials. Gravel and broken stones are costly to move over significant distances. Tar is usually a derivative of coal — and coal is a non-renewable resource ... Probably, the problem of road construction boils down to yet another example of the need to find better ways of using locally available materials.

It may well be that the technique known as the "compacted soil technique" could be developed further for use in areas where road construction would otherwise call for long-distance haulage of stones and other materials. These (and a host of related problems) indicate that our young rural engineers will need to have a sound knowledge of the structure and composition of soil, for example. After all, in many of our villages no doubt the only material which could be said to be plentiful is rather infertile forms of mud, which continues to to be the only building material in most of our villages.

I have described briefly a very few of the problems which professionally educated young rural engineers should be qualified to tackle. Even from this short list, however, one can intuitively see that the approaches of Bhaikaka, Maganbhai and Tribhuvandas Patel to increasing agricultural productivity will doubtless prove relevant — or, indeed, essential. Bhaikaka's education-cum-industry approach, for example, suggests itself for the education and practical training of the young rural engineers. Mr Tribhuvandas' practical approach to letting the farmers' own organisations handle the processing and marketing of the farmers' produced, and the marketing of technical inputs to enable farmers to increase their production — including, especially, the Anand Pattern method of implanting new technologies in our villages by using professionals to train village people in modern techniques all these approaches suggest themselves as practical means of both training' young rural engineers and also of deploying them effectively and enabling them to multiply the impacts of their skills on our villages.

Part IV: <u>The functions and content of rural engineering</u>

As I have said, I do not believe that any individual can single-handedly specify the functions and content of a new branch of our profession – and I shall not attempt anything so ambitious here. Instead, I shall only briefly outline the subject on the basis of my experience and observation in the hope that this may provide a basis for detailed examination of the subject by others more qualified for the job than I.

First, then, the functions of rural engineering. The rural engineers we are looking for must be educated and trained to work in the villages with the people of the villages. There will be a need for the research-and-development function, no doubt, but there are already many institutions in the country doing "R&D". So far as rural engineering is concerned, what is lacking is practitioners, young professionals, who are educated and trained to be the link between engineering institutions and the villages.

We can draw a lesson here from agriculture. There is strong evidence which indicates that, when the western countries invested in institutions for agricultural research — and in costly extension systems, with trained agents to take the results of agricultural research to their farmers — things did not really work out the way they expected at a all! For the first fifty years, most of their significant advances in agriculture came from the farmers themselves! Competent extension agents, by talking with the farmers and observing their fields, identified crop varieties and cultivation practices, used by the more successful farmers, and research institutions then worked to make these improvements available to wider sets of farmers, using the extension system to disseminate them ... Only after about fifty years were significant innovations in crop varieties and cultivation practices originated in those countries' agricultural research institutions.

We can expect the same sort of development to take place in the early years of rural engineering. Young rural engineers, working in villages and talking with the farmers, will observe, say, a better-than-usual way of making bricks with mud -- or, say, a cheaper-than-usual field latrine — and because they are educated and trained in the relevant sciences and technologies, they will understand why these things work better. They will report the news back to the concerned R&D institutions, where the improved technology (or whatever) will be analysed and generalised — and then the network of rural engineers, working in the villages, will disseminate these improvements in the wider set of villages.

One can see, therefore, that rural engineers if they are to play their part in this process will have to be keen observers and good communicators. Also, their education and training will have to equip them for practical work, in the villages, on design, construction, production and operation of improved technologies, systems and materials. R&D will continue to be done by the synthesis of specialists' knowledge — and rural engineers will provide invaluable feedback to R&D institutions — but the rural engineers will be practitioners — and it is clear that their education and training will have to cut across the traditional specialisations of engineering.

This means that rural engineers will have to be unusually well grounded in the basic sciences of physics, chemistry and biology, as well as in mathematics and statistics. These subjects will have to be taught in ways which constantly enable students to relate them to the functions of rural engineering. Probably, this will have to be done in two ways: (1) by placing great emphasis on the unifying laws of science, such as the law of conservation of energy — laws which teach us how to synthesise our knowledge of physics, mathematics etc — and (2) by provision for students of ample opportunities for sustained practical field-work, in the villages, under the guidance of experienced field-workers.

This emphasis on field-work leads one to another conclusion on the content of the curriculum for rural engineering: that is, the curriculum will have to include more of the social sciences than is usually included in programmes of engineering education. There is, after all, a significant body of systematised knowledge of rural society, its structure and dynamics — and there is a growing body of knowledge of rural management. It would be wrong if we were not to expose young rural engineers to this knowledge, so that they will be better equipped to understand the society with which they are to work — and so that they will be more skilful in communicating with rural people, thereby enabling them to be more effective in the feedback process and also more effective in dissemination of new technologies.

I have only limited experience in the organisation and conduct of teaching programmes, but I would guess that the first part of the rural engineering curriculum — concentrating on the basic subjects of physics, chemistry, biology, mathematics and statistics, as well as rural social studies — will have to be a three-year programme for students entering immediately after taking their higher secondary examination. Probably, it could be reduced to one or two years for students entering after they have obtained a bachelor of science degree.

After they have completed this preparatory programme of basic studies, rural engineering students will be well prepared to study the engineering sciences of materials, mechanics, thermodynamics, transfer and rate processes and electrical science as well as irrigation and sanitary engineering etc. Also, to prepare them for the coming age of the micro-chip, students of rural engineering will have to be taught at least enough about information processing and computerised analysis to enable them to know what can be done with computers and how such analysis can help them as they work in the villages.

During the first part of the programme (concentrating on basic studies) and also, especially, during the second part of the programme (concentrating on the engineering sciences), rural engineering students must be given opportunities to do supervised field-work in the villages, in order to help them relate their studies to their future work.

Such field-work is difficult to organise. Too often, in other fields, it is more touristic than instructive. In order to make sure that it is instructive, field-work by rural engineering students must enable them to study a practical problem in a village, to experiment with original alternative solutions and to analyse their experimental results.

These practical exercises in the field need not (and probably should not) be "sophisticated". On the contrary, it is often the most simple-looking problems which prove to be most intractable in the villages.

For example, in the Charotar Tract, there arc hardly any stones in the soil, to a depth of two or three hundred feet. This means that the milk producers find it difficult to construct well drained stalls for their milch animals. Over time, the ground around the stalls becomes permeated with the animals' urine and this pollutes large parts of the villages.

Yet, over all these years, we have never found an economical way of dealing with this problem. Amul did produce pre-cast disassembled concrete stalls — but the co-operative could not afford to give them to the producers and most producers could not afford to buy them ... This is one example of the type of problem which rural engineering students should tackle during sustained periods of supervised field-work (which will be instructive to their supervising faculty, also).

Altogether, I would expect field-work in the villages to take up, say, three-to-four months during each academic year of a rural engineering programme... but of course, before any such syllabus could be finalised, many important decisions would have to be made. For example, what should be the place of soil chemistry in a rural engineer's education, considering the complex interactions between the chemistry of soils and plant nutrients, on the one hand, and the mechanics of cultivation procedures, on the other hand? ... How such issues could be resolved, I shall propose a little later. Let me first briefly summarise my own tentative conclusions on tbe functions and content of rural engineering, viewed as a new branch of our profession:

(1) Rural engineering cuts across traditional engineering specialisations;
(2) Rural engineering therefore requires a very strong grounding in the basic sciences;
(3) Rural engineers will have to be familiar with the social sciences which relate to their work —and
(4) Rural engineers will have to be committed to the betterment of rural life and confident of their ability to use problem-solving logic for the purpose of improving the living conditions in our villages.

Part V: <u>Developing a programme in Rural Engineering: a suggested agenda</u>

As I have said, I do not believe that any individual can single-handedly specify the functions and content of a new branch of the engineering profession. What I have tried to do on this occasion is simply to demonstrate the need and opportunity for rural engineering to become a new branch of our profession.

This is not a mere academic exercise. Our rural people are on the march. They are no longer willing to accept a position subservient to the urbanised minority in our country. Anyone who is fortunate enough to be a qualified engineer in this country is, by definition, a privileged member of the elite. Surely, it is high time that we engineers should make a more determined effort to be more useful to our country's rural majority?

Our training and education as engineers give us some practical advantages in tackling the task of establishi~g a subject, such as rural engineering, as a new branch of our profession. For, as engineers, we are accustomed to "learning by doing." I personally believe that, if a competent and qualified set of scientists and engineers addresses itself seriously to the task, they could quite quickly develop at least a pilot programme of education and training in this new branch of our profession, which I have suggested may be called Rural Engineering.

As I have had the temerity to make this proposal, Mr President, may I cap it by suggesting that our Institution of Engineers could well consider setting up a small panel to consider how best to construct a curriculum in Rural Engineering. The Institute could then make an appropriate recommendation to the Government of India and the Indian Council of Agricultural Research Institute, who I am sure would welcome it.

I am not, however, suggesting that any new or grandiose "institution" should be erected for this purpose. The country has, after all, already made huge investments in institutions of research and teaching. Instead of building any more institutions, at least for the time being, I believe that a somewhat different path could be considered, using existing institutions.

For example, to my own knowledge, there is a already, in Vallabh Vidyanagar itself, thanks to Bhaikaka, an excellent engineering college. We also have nearby, at Anand, the College of Agriculture and the Institute of Rural Management. I wonder whether, if suitably approached, the engineering college at Vallabh Vidyanagar might consider establishing, within the college itself and using its existing facilities, a pilot programme in Rural Engineering. The faculty members involved, might, perhaps, like to draw on the resources of the college of Agriculture and the Institute of Rural Management for that part of the pilot programme's content which will draw on the existing body of knowledge in the social sciences, management studies and agricultural sciences.

The supervised field-work of the students could no doubt be organised with the aid of local co-operatives such as "Amul," and with integrated rural development projects, such as that which I have mentioned of the Tribhuvandas Foundation.

Of course, there may well also exist, in other parts of the country, appropriate configurations of colleges of engineering and institutions working in the social sciences and management — and where there are also programmes of rural development going on in the villages which would provide opportunities for constructive field-work for students of Rural Engineering. Perhaps pilot programmes in the subject could be started in the other such places, where the required facilities also exist.

Certainly, I am confident that, if the concerned authorities get together, a useful pilot programme in Rural Engineering could quickly be established. It would be very much in the tradition of Bhaikaka — and a fitting, living monument to him — if the first such programme were to be established in the engineering college of Vallabh Vidyanagar, which Bhaikaka established with so much loving care and professional skill.

May I close, Mr President, by proposing this agenda for the development of Rural Engineering as a new branch of our profession. May I also propose that our Institute of Engineers may take the lead in implementing this agenda, so that we engineers may make our skills more useful in the villages, for the betterment of the lives of our rural population.

Thank you.

The Seventh Bhaikaka Memorial Lecture was delivered during the Sixty-second Annual Convention, Bombay, January 31, 1982

Ecological Security

Dr M S Swaminathan, *FNA, FRS*

Member, Planning Commission

Ecological security provides the foundation for effective food and water security systems. Land and water based occupations consisting of agriculture, animal husbandry, fisheries and forestry constitute the most important sources of renewable wealth in the world. However, agriculture will be no different from a profession based solely on non-renewable resources of energy if we do not protect natural eco-systems and prevent gene erosion in plants and animals. Similarly, water security will very much depend on our ability to conserve rain water and to harness surface and groundwater resources. Soil health and structure will influence the extent of recharge of the aquifer. It is, therefore, essential that the concept of ecological security is converted at the micro-level into detailed operational programmes involving the active participation of the people.

AGRICULTURAL BALANCE SHEET

The starting point for agricultural advance is a clear understanding of our agricultural assets and liabilities. In drawing up a production balance sheet in agriculture, animal husbandry, fisheries and forestry, we can take advantage of modern techniques of resource surveys based on remote sensing and aerial mapping. Frequently in the name of appropriate technology, developing countries are asked to remain content with obsolete technology. Obsolescence is as much to be abhorred in developing nations as in developed ones. Therefore, there has to be a pluralistic approach in technology choice and transfer. The only criteria in determining technology choice should be human happiness and welfare and harmony between the long and short term goals of development.

We have in the past consciously or unconsciously done much damage to basic life support systems. Careless technology, the greed of the rich and the genuine needs of the poor have all resulted in varying degrees of desertification, deforestation and environmental pollution. Instances of eco-disruption have become frequent. Rich resources of flora and fauna are tending to dwindle. In the past man had depended on a wide range of food sources. With the progress in civilization, the vulnerability of world food production systems has increased partly because of our dependence on too few crops to meet our calorie needsand because of too few countries having surplus foodgrains to sell to others on commercial or concessional terms. Visceral analysis of Tollund man from the stone age studied in Denmark has shown that the diet then consumed consisted of grains from plants like Chenopodium which we now regard as weeds. In parts of the Himalayas people still eat such grains. Our Prime Minister once quoted a story about Charaka, the ancient physician when asked by his teacher to bring plants which were quite useless, he returned after a few days empty handed remarking that there was no such plant. The preservation of the flora and fauna of every country is, therefore, a matter for priority concern. Fortunately, the poor people seem to be aware of this even more than the commercially minded elite. In the Himalayan region where we are deeply concerned about the aftermath of the so called development programmes, it is the illiterate women who started a movement to protect the forests with the slogan: "This forest is our mother's home; we will defend it with all our might".

The Indo-Gangetic plains have been described by several agricultural experts as a potential bread basket of the world. I am, however, apprehensive of the damage that could be caused to the agricultural potential of the Indo-Gangetic plains by the damage happening to Himalayan eco-systems. We should arrest irnmediately further damage to fraqile mountain ecosystems and restore such eco-systems to their original state by the end of this century. In the Sixth Five-Year Plan of India covering the period 1980-85, ecological security has been recognized as the foundation of the National Food Security System.

The growing awareness of the ecological interdependence of countries will probably be the ultimate cementing factor which converts the 'one world' concept into reality. Among the problems which are likely to assume significance in the future with regard to agriculture are:

(i) Growing desertification leading to a destruction or diminution of the biological potential of land and water because of denudation of forests, soil erosion, unscientific irrigation and different kinds of pollution;
(ii) Gene erosion due to monoculture and habitat destruction; and
(iii) Climate changes arising from the burning of fossil fuels.

Desertification can be contained tt rough appropriate measures in afforestation, control of soil erosion and scientific land use. Steps have been taken through agencies like the International Board for Plant Genetic

Resources and the National Bureau of Plant Genetic Resources which can help to preserve for posterity the fruits of thousands of years of natural and human selection. Bhag Singh (1981) has described in detail how the citrus wealth of Meghalaya is proposed to be preserved through a gene sanctuary.

By the middle of the next century, the continued burning of fossil fuels as a source of energy is likely to result in a doubling of CO_2 content in the atmosphere relative to the amount present in 1860. The present CO_2 level of about 335 parts per million per volume (ppm) is expected to increase to about 380 ppm by the end of the century (Bach, 1981). Such an increase will have two kinds of consequences: (i) an effect on photosynthesis because of the greater quantity of carbon available to plants from the atmosphere, and (ii) changes in climate. Computer models indicate that on a global basis, average temperatures upon the earth's surface will rise between 2°C and 3°C with a doubling of atmospheric CO_2. Both evaporation and precipitation may increase by about 9%.

Given adequate solar radiation, soil nutrient availability and irrigation, increased atmospheric CO_2 should act as a fertilizer for crop plants, raising both photosynthetic production and water-use efficiency. Greenhouse experiments have indicated that a doubling of CO_2 under good crop management can increase biomass yields by about 40%. Structural adaptations in farming systems will be necessary both to take advantage of the favourable consequences of CO_2 increase and to face its negative repercussions. The CO_2 effects should be especially important for crop plants such as rice, wheat, millets and potatoes which have a C_3 photosynthetic pathway. Corn, sugarcane and sorghum, with a C_4 pathway, are likely to be limited by solar radiation and nutrient and moisture availability rather than by CO_2.

Plant breeders in India should aim at development of varieties that will have higher net photosynthetic production and use less water as the atmospheric CO_2 content increases. The strains should not, however, respond to a warmer atmospheric temperature by an increase in respiration that would cancel out the effect of CO_2 fertilization. There is an opportunity for pushing forward with attempts to increase total photomass production in the major crop plants.

Herman Flohn (1981) has recently estimated the changes in average surface temperature and precipitation that may occur in different latitude belts if atmospheric CO_2 goes up to 560-580 ppm tie, about twice the 19th century value).

Latitude	Average annual change in surface temp. (°C)	Change in precipitation
60°N	+ 7.5°	+ 18%
50°N	6°	+ 4%
40°N	+ 6°	- 14%
30°N	+ 4.5°	0%
20°N	+ 2.5°	+ 20%
10°N	+ 1.5°	+ 20%
Equator	+ 3°	0%
10°S	+ 4°	- 20%
20°S	+ 4.5°	- 5%
30°S	+ 4°	+ 5%
40°S	+ 4°	+ 12%
50°S	+ 3°	+ 12%
60°S	+ 2.5°	+ 12%

If the above estimates prove correct, major change in surface and underground water supply could occur due to altered precipitation and evapo-transpiration patterns in several parts of the world. Some of the agriculturally productive areas of the USA, Canada and the USSR may be adversely affected. The USA, the USSR and China have about 90% of the world's coal reserves. Since higher CO_2 concentrations may affect these countries adversely, they may be unwilling to develop an export trade in coal and this in turn will have implications for the energy-short countries (Revelle, 1981).

As far as India is concerned, the kinds of projections made by Herman Flohn would imply more rain in some of the drought prone areasand more floods along the Ganga and Brahmaputra. Expansion in major and medium irrigation works as well as extensive denudation of vegetation may also influence weather, particularly the micro-climate, in different ways. Hence, the plant breeder with the help of climatologists and environmentalists will have to assemble diverse genotypes which will profit from increased CO_2 and precipitation or alternatively, withstand the adverse impact of higher temperature and enhanced evapotranspiration.

In order to develop an ecologically sound agricultural strategy, it is necessary to identify the major factors which lead to eco-destruction. The natural liabilities largely relate to the inherent properties of soil, water and climate. What is, however, more serious is the damage being caused to basic life support systems either intentionally or unintentionally by the human population. The growing destruction of our ecological endowments is partly the result of demographic pressures. The genuine needs of the poor for fuel and fodder and the greed of the rich for exploiting forests for commercial and industrial purposes both contribute to eco-destruction. In a report to the President of the United States on 'Global Resources, Environment and Population', there is a vivid description of the kind of world we are like to witness at the beginning of the next century, in case the current trends of damage to soil and water, flora and fauna and the environment continue. The Global 2000 Report depicted a world more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now. It projected that world population would increase from 4 billion to 6.35 billion in just one-quarter of a century; that the gap between rich nations and poor would widen; that per capita food consumption would rise somewhat worldwide-but would not improve materially in the poor countries of South Asia and the Middle East, and would decline disastrously in Sub-Saharan Africa; that the real cost of food would rise everywhere; that the real cost of fuels would also rise everywhere; and that fuelwood would fall far short of need; that many currently productive grasslands and croplands would turn to desert-like conditions; that as much as 40% of the world's remaining tropical forests would be lost, and that as many as 20% of the species of plants and animals now inhabiting the earth could be extinct-all by the end of the century*.

**Global Future: Time to Act. Report to the President of the United States of America on Global Resources, Environment and Population. Council on Environmental Quality, U.S. Department of State, January,1981, 209 Pp.*

The report noted that the burning of fossil fuels is already causing damaging increases in the acidity of rain and snowfall, and it is raising the concentration of carbon dioxide in the earth's atmosphere. Continued into the next century, rising CO_2 levels could cause a warming of the earth sufficient to alter substantially the world climate-with possible serious disruption of human activities, especially agriculture.

These findings and conclusions are a description of what may be expected if present trends continue.They are not predictions of what will occur, but projections of what could occur if the nations and people of the world do not respond to their warnings.

Resource impoverishment, environmental degradation and soaring population growth have not just rbeen discovered for the first. time as global problems. All nations have long recognized them and made serious efforts to deal with them. The United Nations Environment Programme has in particular been drawing attention to the need for arresting further damage to natural eco-systems. While awareness and analysis are improving, commensurate action is conspicuous by its absence, particularly in poorer nations. This is where the prophets of doom serve a positive purpose by generating a 'do or die' atmosphere.

In the past decade, a great deal of international attention has been focused on whether global supplies of finite non-renewable resources, especially oil and gas, can continue to be used in an exponential manner. The US report stresses the need to mainlain the productivity of the earth's systems-the air and water, the forests, the land-that yield food, shelter, and the other necessities of life. These resources are renewable if they are kept in a condition of health. But they are susceptible to disruption, contamination, and destruction. Even agriculture which is the most important source of renewable wealth can be made no different from non-renewable sources of wealth if desertification continues.

In some areas, such as sub-Saharan Africa and South East Asia, a vicious cycle of poverty, accelerating population growth, and erosion of the resource base are visible. Here, the earth's capacity to support life is being seriously damaged by the efforts of present populations to meet their immediate needs, and the damage threatens to become worse. People who have no other choice for getting their living plant crops on poor soils that will soon wash away, graze their stock on land that is turning to desert from overuse, cut trees that are needed to stabllise soils and water supplies, burn dung needed to fertilize and condition agricultural soils. According to World Bank, some 800 million people today are trapped in conditions of 'absolute poverty', their lives dominated by hunger, ill health, and the absence of hope. So long as their situation does not improve, trends toward impoverishment of the earth's renewable resource base are likely to worsen, making the plight of the poor even more desperate. There is therefore an immediate need for every poor nation developing a 'Basic Human Needs' programme designed to provide every rural family in the country the minimum essential requirements of water, food, fuel, fodder, fertilizer and work. The Basic Human Needs programme and the Agricultural Development programme will have to be developed in a mutually supportive nature.

These stresses, while most acute in the developing countries, are not confined to them: For example, in recent years the United States has been losing over one million hectares of rural land annually — including about 400000 hectares of good agricultural land — due to the spread of housing colonies, highways, shopping centres, and the like. Each year the USA is also losing the equivalent, in production capability, of as much as 400000 hectares due to soil degradation — erosion and salinization. The Global 2000 Report emphasized the serious worldwide nature — in rich countries as well as poor — of the degradation and loss of agricultural land. Pollution of water supplies by toxic chemicals and the physical destruction or pollution of essential habitat for fisheries are also common threats to natural systems throughout the world.

It is hence essential that every country takes steps to avoid the diminution or destruction of the biological potential of land caused by man-made factors. For this, each component of the eco-system will need both separate and integrated attention.

ECOLOGICAL SECURITY

Steps for achieving ecological security would include measures for protecting all the basic assets of agriculture and minimizing the liabilities. This can be achieved through the establishment of a National Land Use Board which could foster through appropriate scientific analysis and public policies, land and water use practices which are compatible with the concept of sustainable development. Ecological security, however, cannot be promoted by Government alone. It has to be a joint sector activity involving the people and government agencies. Local level Eco-Development Associations should be organized with the involvement of schools and colleges. Such Associations could operate 'Waste Exchanges' to collect and re-cycle all organic wastes. The economic benefits from eco-development and waste re-cycling could provide the motivation necessary for attracting public attention and participation. For example, in the United States it has been calculated that an estimated 300 million trees could be saved annually if the amount of paper recycled is trebled. Besides steps at the-national level regional and global level action plans to conserve our genetic and environmental heritage need to be developed.

Ecological security in the ultimate analysis means living in harmony with our environment. It implies an awareness of the finite resources of our spaceship 'Earth'. Operationally it involves the promotion of a value system which results in reducing wants and promoting productivity advance through recycling principles. Consumerism will have to be curtailed and the basic minimum needs of every human being will have to be assured. Only then we will have lasting ecological security. History teaches us that when man exploits the nature and natural endowments with greed, civilizations vanish. It has been rightly stated that the soil has been a silent spectator of the rise and fall of civilizations. The best tribute we can pay to such a great Indian as Bhaikaka is to emulate his example of thift, dedication, compassion and a vision for the future.

The Eighth Bhaikaka Memorial Lecture was delivered during the Sixty-third Annual Convention, Madras, January 10, 1983

Some Aspects of Rural Development

Dr S K Mukherjee

Member,
State Planning Board, West Bengal

THE RURAL SCENE

The rural area, by common understanding, is backward. The absence of such urban amenities as electricity, means of quick transport, good drinking water, sanitary and health measures, medical care and education is common in the rural sector. It is, therefore, characterized by malnutrition, disease, poor transport, slow movement, illiteracy, massive unemployment and underemployment and lack of industries. A steep wall of distinction divides the city and the village. There are, however, grades amongst cities and villages. As a result, the rural area may even merge with the urban area. Even then the composite of social, economic, cultural and political scenes in the urban and rural sectors is distinguishable. Moreover, there are relatively affluent sections in the village, just as there are the poor sections in the city. This is perhaps the general picture of society throughout the world.

Conceptually, we seem to have accepted the urban development model as the one for rural development. The desirability and feasibility of this step will be questioned at the appropriate place. There are developing countries including India where the bulk of the population is in the rural areas. Amongst these, the degree of backwardness varies. It is the number of the absolute poor, both in the rural and the urban, that is a measure of development, the yardstick by which developed, developing or less developed countries are distinguished. It is estimated that over 900 million people live in rural areas of the world as a whole, nearly 60% being categorized as absolutely poor. About 200 million of the same category live in crowded cities. It is by sheer number, if not for anything else, the consideration of improving the lot of the poor becomes imperative. In this process, the rural area deserves greater attention, because of the simple fact that like any dynamic system, a sizeable part of a country cannot be left out of the orbit of development without jeopardizing its overall balanced growth. There is hardly any country in the world that can claim cent percent development in the sense that not a single instance of human tragedy in terms of exploitation, injustice and obsolute penury exists. As the number and magnitude of such instances increase, the very root of the country's stability is likely to be shaken, because there is undeniably an organic relationship between the more developed and the less developed areas located under one administration. For a healthy set up, this relationship is of mutual good, but if the less developed area, having usually more potential resources of development, is exploited for its own by the more developed area, tension ensures. The success with which this tension is kept at a low level determines the stability and character of administration. Rural development has, because of such visible or hidden tensions, figured in some form or the other at the national level.

At this stage, the question may be raised: Development, of course, but of what kind? Without discussing this important issue in detail it may be stated that two broad criteria, namely, satisfaction of minimum needs which includes food and removal of unemployment, underline any developmental activity. Food, being one of the most important primary needs, its production has received the greatest attention. Food production activity is conducive to unemployment reduction, no doubt, but opportunity for this should be made available to all rural unemployed. In the absence of such a measure other avenues have to be thought of in order to reduce unemployment and increase income.

RURAL INDUSTRIES

Some of these avenues are based on the setting lip of industries, the so called rural as well as agro-based industries being most important for tbe rural sector. It may be worthwhile at this stage to examine the steps taken by our planners in this direction in the Five-Year Plans (FYP) and the results obtained thereby.

In the First FYP, a substantial outlay was proposed for setting up small industries in rural areas with a network of organizations and boards dealing with handloom, khadi and other village industries related to handicrafts, coir and agricultural production. As a result, production did increase. But development was not uniform, there being statewise as well as regional imbalances.

The Second FYP emphasized rural industries more than the first. The Karve Committee which went into the pros and cons of rural industries recommended that progressive extension and modernization could be achieved by setting up small scale industries, together with service centres located in large villages and small towns.

A still greater emphasis was laid on rural industries in the Third FYP, the main thrust being on the reduction of imbalance. This Plan paid special attetstion to the supply of such elementary needs as drinking water. However, owing to power shortage and transport difficulties, the achievements were at a low key. Agriculture was given the highest priority in this Plan, which holds the key to rapid growth and stable economy. In spite of tall wishes and efforts made to remove the imbalance in growth pattern, nearly 65% of the small scale industries were located in five States only. Even in these States, the concentration of industries aimed at benefiting the rural areas was in and around the metropolitan cities!

The Fourth and Fifth FYPs did similar exercises but the net effect was not commensurate with the efforts made and money spent. The question of uneven regional development loomed as large; disparities caused thereby continued to pose serious problems. An RBI study reveals that the richest possessed 164 times as much assets as the poorest.

Case studies undertaken of industries in Maharastra, Tamil Nadu and Punjab reveal that in the first two having mostly heavy industries the average investment for each employment varies from Rs 28000 to Rs 48000, whereas in Punjab having mostly small scale industries in the same investment is about Rs 18000. For Bihar, according to a 1970 survey, about Rs 38000 was needed to employ a person. The jobs per unit of industry are respectively 52, 56 and 8 respectively for Maharashtra, Tamil Nadu and Punjab. The conclusion drawn from the survey is: 'It is unrealistic to expect any significant regional development from this type of heavy industrialization'. It is also to be noted that whereas in Tamil Nadu and Maharashtra the major emphasis is on chemical, textile and steel industries, that of Punjab is on food processing industries. It is not clear from the descriptions of these industries as to how much of the employment is genuinely rural.

Village industries have, by and large, constituted an insignificant segment of development programmes. By the token of about 2% of the outlay sanctioned for these programmes, they may at best be treated as a welfare measure. The potentialities that lie ahead in the matter of generating employment and consumer goods have never been seriously appreciated. Frankly speaking, properly trained persons having the right attitude towards rural development problems are lacking. The sophisticated institutes of technologies, bearing one perhaps, are of little service in this direction. One of the ways of promoting such attitude seems to be to follow the strategy of the Karnataka State Council for Science and Technology which offers Rs 1000 to each selected engineering student to live in villages and work on rural technology.

A justified apprehension prevails in the matter of making rural industries viable and spread on a wide front; unless they are set up, for obvious reasons, on a cooperative basis. In matters of cooperatives, a number of States have recorded miserable failures. There seems to be no alternative to cooperatives where people of small means are to survive in the face of competition.

One of the surest keys to the removal of rural unemployment seems to lie with rural industries, the setting up of which is be sought with some difficulties. There is no fixed pattern, but a long list of more than a hundred may be prepared covering a wide range, out of which a few are to be chosen according to pressure of social needs and the availability of resources, both internal and external, as well as of raw materials.

In any industrial enterprise-whether big or small, urban or rural-a few essential prerequisites must be assured, namely, power, transport, and market. Power need not ordinarily be electrical; it may be manual, animal or mechanical or at best thermal or a suitable combination of these. Research efforts have to be intensified to solve this problem which is most likely to be location specific. In this connection the utilization of solar energy, biomass, biogas technology and windmill should receive primary attention. Market means not only magnitude of demand, but also competition and quality awareness, whether the market is internal or external.

RECYCLING

One effective way of utilizing biomass is recycling. Recycling is nature's way of economizing energy and meterial resources. Man has so long been exploiting nature without caring for recycling. In view of the almost irreversible depletion of resources and certain forms of energy man has suddently found himself in a quandary. He has tried to learn nature's way and inflict on himself her principle of austerity. This awareness has been most poignant in the face of all-round environmental insult and pollution. The high potentiality of biomass production in the rural sector may be taken advantage of to solve the energy and power problem. Biomass is nothing but solar energy converted mainly into cellulosic materials. There are umpteen kinds of celluloses. Those having very high molecular weights, e.g., wood, may be converted into thermal energy; those having low molecular weights, especially the hemicelluloses may be converted into biogas, and also ultimately converted into thermal energy. The biogas residue contains unconverted carbonaceous matter together with nitrogen, phosphorus, potash and a host of micro nutrients, which are essential for plant growth. The entire residue can be used as excellent manure. The recycling process can be extended to human and animal wastes. On a rural scale the mobilization of these natural resources may not pose a difficult problem. In fact, on a somewhat larger scale recycling may give rise to a moderately economical rural industry. At the same time, environmental pollution will be largely prevented and sanitary condition considerably improved without incurring cost.

RURAL EDUCATION

The next but equally important prerequisite is the availability in adequate number of trained personnel. They may not be locally available, but training facilities available in the nearest place should be taken advantage of. But the trained persons must not be sucked into the urban sectors, as it happens in agriculture, say. The farmers' children trained in agriculture become adverse not only to farming but in course of their training become attracted to the comforts and amenities of city life, and are eventually lost to the villages they are required to serve. The training should be as far as possible locally arranged and under rural conditions.

At this point a question may be raised: Do we envisage rural education to be the same as or different from urban education? It is found that the tendency to modernize the course content by the city-bred academic community puts the rural students into unequal competition. The teachers in rural areas are not also equal to the task; moreover, teaching aids, equipment, books, etc are in short supply. In spite of some of these constraints almost every year talented students from rural areas compete and do well in public examinations. But they are tempted to leave their villages and find in some way or the other a place in a city institution of higher learning. Their movements are always irreversible. The city thereby lures away the best in the villages and impoverish them in the quality of human resources. Because of unequal competition, those who are less capable in remote schools and colleges find themselves useless. They increase the number of drop outs and unemployed in the rural sector. But the heaviest burden and the deepest pain the rural sector has to bear is that of illiteracy. None of the programmes of non-formal andlor adult education are going to remove this deficiency. The success of development programmes of any kind will be to a great extent dependent on the degree of literacy. Low degree of literacy is closely related to poverty whether it is of the rural or the urban kind.

In the context of development of rural industries and the need for trained personnel, preferably to be available locally, the question of a different type of education of the rural students becomes pertinent. The Radhakrishnan Commission recommended the establishment of rural institutes, as distinct from the, existing city oriented educational institutions, to take care of the educational needs of the rural sector. Surprisingly, the import of this recommendation fell flat on the central and state education ministries. Instead, agricultural universities have been set up which have hardly anything worthwhile to do with rural development. To fill up the lacunae, the Indian Council of Agricultural Research, which is the principal funding body for these agricultural universities, compels them to carryon such programmes as Krishi Vigyan Kendras, Lab-to-Land, training and visit, etc, in order to transfer results of research to the farmers. But this is a different story, and the less said the better.

INEQUALITY

From what has been briefly stated above one of the main objectives of the Five-Year Plans has been to achieve rapid economic growth with social justice, it being realized that development is ensured if growth is balanced and distributive. Three decades of planning and expenditure of large sums of money on programmes targeted to the rural sector, inequality, unemployment, poverty and backwardness have not diminished at all, even though the country's economy has shown a remarkable upward trend. Science and technology have given in the hands of the few who can afford to use them with advantage to enhance their prosperity several-fold leaving a vast majority much too poor by comparison.

The Government have no other way but to take corrective measures. Accordingly, the Sixth Five-Year Plan document has proposed targets aimed at amelioration of the condition of the weaker section of the rural population. The much vaunted integrated rural development programme in its current form aims at uplifting the poorest 600 families per year per block from below the poverty line. In the long run such a programme is not going to touch more than the fringe of the problem.

Land being the main means of production the income level and poverty of the agrarian sector will be revealed from the land ownership pattern. The inequality of the economic condition is further highlighted by the analysis of consumption expenditures. A similar picture emerges from a study of the All India Debt and Investment Survey (1971-72) of the Reserve Bank of India. It is, therefore, quite understandable that the basic inequalities in rural assets can only be reduced by distribution of land which accounts for the bulk of the assets. If this vital issue is ignored and solution to the problem is sought by equalizing the technological inputs alone, no headway can be made. Development in the true sense of the term will be unachieved so long as the problem of land reforms remains unresolved.

RURAL UNEMPLOYMENT

It has been estimated that if all the foods the farmers produce were consumed by them, they would certainly satisfy their needs, but there will be no surplus to feed the urban population. The farmers are forced to sell their produce at prices, fixed conveniently by the urban officials, to enable them to buy other needs, but ultimately remain starved or half-fed. They have to borrow money or mortgage property for bigger expenses. The rural indebtedness is colossal and a heavy burden. These factors in turn tell upon the performance of the farmers .

Agriculture, exclusively devoted to food production does not provide full employment, even if every person has got a piece of land to work on. Consequently, other avenues of employment have to be devised. On this, the National Commission on Agriculture (NCA, 1976) states: "The approach towards the problem of creating additional employment opportunities in the rural sector has not been very systematic in the past. A number of schemes of pilot and ad hoc nature have been sanctioned but an effort towards the orientation of the entire plan towards larger employment opportunities and basic needs has been lacking. Employment in developing countries with a vast number of rural unemployed cannot be left as a residue of development or a by product of economic growth".

The agricultural and non-agricultural rural sectors which are likely to provide additional employment have yet to be identified. Because of the presence of a heavy backlog of under-employment it is desirable to provide employment to the weaker section of the rural area, namely, the poor farmers and agricultural labourers. The estimate of the total number of unemployed persons will not be helpful, but a knowledge of what has been termed as the anatomy of unemployment will be required.

Several estimates have stilI been made to quantify the magnitude of unemployment. Before the First FYP, the estimate of rural unemployment was 2.8 millions on the basis of the first Agricultural Labour Enquiry in 1950-51. The emphasis on agriculture in the First FYP was aimed at containing, if not reducing, this figure. The Second Plan assumed the same figure of unemployment, but at the end of the Plan period the unemployment figure rose to 9 millions. During the Third and Fourth FYPs the backlog has, without doubt, continuously increased. The Dantwala Committee of the Planning Commission in 1968 observed about the futility of these estimates, and as such no estimates of unemployment and its backlog feature in the Fifth Plan.

The Committee on Unemployment (Bhagwati Committee) estimated in 1973 that rural unemployment for 1969 was 9.12 million man-years including 7.82 million as totally unemployed. According to Raj Krishna, the figure for rural unemployed and under-employed were respectively 8.3 and 17.9 millions in 1971. The large number of under-employed, or may be the disguised unemployed, becomes a crucialfactor. Those employed partially on land are required to increase the productivity, while the agricultural labourers must have wage paid labour opportunities. Seasonal fluctuation of farm employment is in reality the main cause of underemployment. The higher proportion of female unemployed is partly due to their limited mobility. Increased crop production, agrarian reforms, irrigation work and land formation, soil conservation and land development works, animal husbandry, fisheries, forestry, if planned and acted upon with a purpose are going to provide additional employment and wipe off under-employment. According to Dandekar and Rath, the change in the pattern of rural employment can be brought about "if by means of additional works programme, together with other than Plan projects we could create a certain amount of secure and dependable employment, that is, a regular full-time employment throughout the year for all those who need it''. In course of third FYP and continuing up to the fourth, a number of special employment programmes were worked out. Whatever the original intentions of these programmes, the target groups have not got the full benefit. In fact, in all such governmental schemes implementation is tardy and the expenditure often proves infructious.

The development of infrastructure and services in the tertiary sector including credit, electrification roads agro-service centres and farmers organizations is attended with the continuous opening up of employment opportunities of a varied kind. Most of these services are located in the urban sector, which make them more expensive; moreover, the wealth generated in the rut al sector is mopped up into the urban sector, without any chance of a substantial part returning to the service of the rural sector.

The NCA has estimated that out of the 111.3 million persons needing employment in 2000 AD, the programmes envisaged so far can account for 52 millions directly in the agricultural sector. In the non-agricultural sector there is the possibility of creating adequate number of jobs, but they should not be very far from the farmers' land and homestead, so that they can tend both. In addition, a number of jobs will have to be created for the rural women.

AGENCIES OF RURAL DEVELOPMENT WORK

A variety of agencies have come into being and are engaged in rural development work. These include some set up by central and state governments, a fairly large number by voluntary organizations, and some by business houses. Each is trying in its own fashion to 'do good' to the poor and the deprived sections of the rural community. The primary concern of most of them is production of food crops. This is a logical concern. But as already mentioned, agricultural production is but one of the many facets of rural development. Moreover, because of limited funds available to most of the non-governmental agencies, the number of beneficiaries is small; as a result, discrimination, though not intentional, becomes apparent. Overlapping amongst various agencies is often avoided, but even then their individual achievements do not add up to something significant.

The attitude, approach and objective of each agency vary, although the goal is apparently same. The governmental machinery has its own bureaucratic, hierarchical and impersonal set up in which spending money according to rules amounts to development. The voluntary agencies vary in their outlook according to leadership. Most of them start with the devotion and sacrifice of a few dedicated individuals as the capital and derive funds from external sources; some, unfortunately, of dubious nature. When the external leadership is withdrawn and for the fund shrinks the developmental work stops. The business houses have funds but neither leadership nor devotion. Their motivation stems from the fact that a developed region is a potential market. Moreover, so long it is a form of rural development work, the government policy of tax relaxation acts as an incentive to them. To date, none of these agencies have been able to move the wheels of rural juggernaut in the forward direction. None of the programmes and projects created any momentum either for its own progress or for settingup another ot its kind. The external push is always needed. In other words, there is no element in any of the existing programmes to generate enthusiasm, leadership and a sense of participation in the people of the area concerned.

MODEL OF RURAL DEVELOPMENT

A study of the activities of these agencies reveals that ad hocism prevails in the formulation and implementation of most of the projects, including thoseonginatmg at governmental level. On the basis of the nature, location and size of the target groups, the projects are usually drawn up. Excepting the governmental projects, the rest are short-term ones, not exceeding five years at a time and not normally extending beyond ten years. As such there is no model, except certain loose goals and objectives, which do not take a long-term view of things. As a result, achievements are recorded in certain disjointed sectors, and the oveall development remains an engima. The current programme of integrated rural development is a truncated one of the original. It is estimated that out of 5 100 blocks in the country about 3000 are covered by one or more of thespecial programmes, such as Small Farmers Development Agency, Drought Prone Area Programme, Command Area Development Programme, Food for Work Programme, and the remaining blocks are likely to be covered in the FYP period starting in 1983. In most or all of these programmes as implemented, benefit accrues to a small portion of the total population. "A recent study", observes V C Koshy (NCAER, Margin, October 1978; Vol II, No 1, P 50) has come to the conclusion that the benefits of planning in India over the last three decades have almost bypassed some 60 million, agricultural labourers, 35 million landless labourers, and another 40 million marginal farmers. On the other hand, the study found that rich farmers were able to exploit the facilities extended to the small and marginal ones. Land owned by households accounts for bulk of assets; this basic inequality is, therefore, removable only through land reforms. The deficiency in this respect cannot be counteracted by any amount of technical inputs". Dantwalla observes in his report on block level planning as follows: 'It is now generally accepted that enhancement in the allocations to agriculture and rural development in successive FYP has not made much impact on reduction of poverty and unemployment.' The denial of a large section of the rural population from participating in production activities has been caused by failure to implement agrarian reform programmes laid down by the government. The Task Force set up by the Planning Commission on Agrarian Relations underlines this failure by saying: 'in no sphere of public activity in our country since independence has the hiatus between percept and practice, between policy-pronouncements and actual execution, been as great as in the domain of land reform.'

By giving the security of land and means of production, howsoever small that may be, a sense of self-reliance is instilled in the rural workers, a sense that is absent in the urban workers and that which cannot be imparted through the existing development programmes. Unlike the urban industrial workers, those in the rural industries will have a sense of participation and belonging, a necessary prerequisite for self-reliance.

The rural conditions in China before 1950 were hot different from India's. The pattern of land ownership in China and the political system are such that project planning and implementation can proceed in the same fashion throughout the country. There are four stages, namely, village or cluster of villages, production teams, production brigades, and communes in production, pricing, distribution and marketing. Incentives for higher production is provided by higher price for surplus over quota fixed for each production team. The system has worked well in China. What China has achieved in respect of rural development is summed up in these words: 'There is no Chinese, man or woman, today whose basic needs of food, clothing, housing, education and medicine are not met'. This does not mean that India may follow the same model and achieve the same objectives because China's and India's rural conditions are similar. No model, however, attractive, can and should be implanted as it is elsewhere. Each model should evolve from where it is to be applied. China has put more emphasis on rural industries, such as those of cement, chemical fertilizers, iron and steel, machinery and energy. Mechanization of apriculture has been pushed up at a tremendous rate. China realized that heavy industrialization on the Soviet style introduced in 1950s at the cost of agriculture was hardly conducive to development of the areas where 80% of the people live.

OUTLOOK FOR A TENTATIVE MODEL

Many years of experimentation with ad hoc schemes and projects should open our eyes and conclusively show that they are hopelessly unsatisfactory. But no one protests against their continuance and suggests rethinking, which failures normally provoke. In fact, whatever new often suggested is one of a rehash of the old ones with a new name, and again on an ad hoc basis. A total analysis and comprehension of rural development is somehow missing.

In the rural sector land is the most important primary asset. Each one should have this primary asset if any effective land use plan involving the rural population is to succeed. The next step is to remove factors standing in the way of land contiguity or land consolid ation. These two essential steps are exclusively political measures. It is quite apparent that since government has been incapable of taking these two measures, it has taken recourse to ad hocism and half measures.

The tendency of the Central Government to plan a project hurriedly and include it in the Five-Year Plans without ensuring cooperation of participating states is very commonly noticed. This is particularly so in the case of rural development projects.

The fate of NREP is an instance in point. This programme is an essential component of IRDP, but has not taken off in practice. The main reason is perhaps the condition laid down that the states must provide the matching contribution. NREP is a successor to the Food for Work Programme which made an impressive start. But by changing its character, namely, by reducing the grain component from 2 to 1 kg per day and by asking the States to share 50% of the cost, this programme can hardly succeed.

As a result, other schemes under NREP, namely, minor irrigation, social forestry, soil conservation, other works of rural reconstruction are going to be set at naught. Barring a few states, others with meagre resources are unable to cope with the burden of the NREP. It is either to be centrally aided in full or not at all, it seems. Or else, the States must realize the extreme urgency of rural development and strain their resources to the utmost in this direction.

Rural development has not proceeded on any model, nor has any been concretely proposed. It is argued that the prevailing ad hocism in the absence of a model has resulted in poor performance. The question is not of one model, but it is possible to have several models appropriate to specific conditions. A very broad one laying down policies and principles rather than details may be attempted. This is mainly intended to raise some debate.

It is proposed to choose a town, a metropolis almost at a central location, so that distances from villages to that town is more or less radial. In the suburban zones which constitute the outer periphery of the rural sector should be located appropriate small industries — primarily — agrobased supply the needs of both the village and town people. What should be a viable complex and what should be the nature of such industries will be decided on the basis of local resources mostly.

Such amenities as drinking water, energy and manure from biomass in the form of biogas plants and social forestry and power from windmills should be provided free initially. They may be levied in course of time. The local labour, manpower and resources will form part of the capital. The R and D investment for the rural sector should be much larger, in view of higher returns, than what is provided now, and on a long-term basis.

The pattern of education for the rural people may, of necessity, be somewhat different from what obtains for the urban people and appropriate to the rural people. This is a sensitive and debatable proposition, but in the face of unequal competition the rural people are handicapped by the urban-oriented education, and are unable to utilize it for their benefit and for the amelioration of their lot. The pattern has to be carefully designed to meet the needs and aspirations of the rural people.

INTER-RELATIONSHIP BETWEEN TECHNOLOGY DEVELOPMENT AND SOCIO-ECONOMIC STRUCTURE

In order to understand this interrelationship, let us go back to the rural scene and examine it in some detail. It is characterized by more or less easily identifiable groups, namely, the landless agricultural labourers, marginal farmers, artisans, small and big farmers. The first three are the disadvantaged groups and constitute nearly 80% of the rural population. The landless agricultural labourers are ominously growing at a rapid rate. Theil' aspiration as human beings is to own a piece of land for security and identity, pending which to have high living wage and low food cost. For the whole of India they constitute 36% but there are regions where the percentages are much higher. The marginal farmers constituting 25-35% of the rural population own one hectare or less of land on an average, which is inadequate for subsistence. Their aspiration also is to have a little more land and inputs at reasonable cost, so that production may meet their needs. The artisans, once an important and useful component of the village community, are back to the wall in view of the languishing market for their goods and in the face of competition with organized industry which is invading the rural area, but of which they cannot be a part. The small farmers owning 1-2 ha of land are alsoa poor lot. They constitute 10-15% of the rural population and are in a position to engage labour and sell foodgrains surplus. Consequently, they stand in opposition to the above three groups in the matter of wage rise and foodgrains price lowering. They are, however, not going to lose as a result of equitable land distribution, and would definitely favour inputs at lower price and favourable market. The remaining 'big' farmers constituting barely 5-10% own two hectares of land or more. Out of these, the relatively small holder of land generally go for personal farming, and produce foodgrains surplus. Most of them can afford to use inputs and have access to assured irrigation. The relatively big ones do farming but not always personally and not also with the same seriousness for their entire holding as the small ones do, they almost always have other avenues of income usually from non-agricultural pursuits located in the towns and cities.

The percentages of each group as identified above vary from region to region. Consequently, the interaction between the groups having contrasting interests and aspirations assumes different dimensions. It is presumed that development is achievable through the application of science and technology. Science is universal but technology is not. Technology ought to be appropriate to specific conditions. Apart from supply of inputs, the socio-economic structure determines the nature of the technology to be applied. So there has to be added the political will. A favourable combination of all these factors makes a technology appropriate. Wisdom dictates that under these varying conditions one should be ready with alternative technologies with adequate flexibility for adaptation.

The technology of high yielding varieties of crops for instance, has not proved as much advantageous to the smaller farmers as to the bigger ones. The introduction of the new technology has, therefore, widened the disparity between the big and small farmers. As a consequence, development in its true sense has not taken place. In the circumstance, two possible suggestions come to mind. Either the technology is replaced or the socio-economic structure is altered to suit the technology or both are done in such a manner that the weaker sections of society may improve their lot and do not suffer by default. In carrying out the former proposal, the scientists have to shed their ego and rethink. In the matter of increasing production and productivity in the vast canvas of agriculture crop husbandry is just one, though a very essential facet. Others include animal husbandry, poultry, fishery and forestry. For doing all these political will of the right kind is called for to support the technologies. The distribution of land to the tiller is not enough; means to make credit, inputs and marketing facilities available to the weaker sections have to be worked out. Past experience shows that neither of these two have made any headway. No doubt, every now and then fresh moves are being proposed to make the new technology acceptable to the weaker sections by means of such programme as Lab-to-Land, Krishi Vigyan Kendra, training and visit, etc. They make a lot of noise which is good for propaganda but constitute drops in the ocean, of misery and destitution. Only a small proportion of the rural population derives benefit, and that too for a short period. Rural development is a gigantic problem and needs a gigantic step. That step is yet to be taken.

THE CULTURE

The virtue of looking at technological development in the holistic context of society and culture has been much eulogised but has never been put into practice. The tendency to go for technological development without understanding the social and cultural interactions is quite common. Rabindranath Tagore and Mahatma Gandhi strongly expressed their views on the maintenance of the indigenous rural culture, and not letting it to be subordinated to technological culture which overwhelmingly makes its inroad in the form of bringing succour to the hungry and the poor and supplying physical amenities and comforts. This is perhaps agreeable with the urban culture, which has lost its indigenous nature, but not with the rural culture, where old tradition and culture are valued high. It is that culture which is known to thrive spontaneously in a climate free from oppression. Such technological developments as are capable of amalgamating with the rural culture are likely to stay and spread by the pressure of indigenous needs. Only those having experience of the sociological and cultural behaviour of the rural people can be entrusted with the slow but steady process of absorption and assimilation. Forcing the process for quick results may end in nonacceptance of a technological development, howsoever beneficial it may be. The creative and cultural forces of more than 500000 rural communities are suppressed, so to say, by the gentry. This was the situation long back before independence. But a survey can ied out in a village 5 km from Santiniketan where Rabindranath began his pioneering rural reconstruction work 45 years ago, the situation has not, surprisingly, much altered. The change of mind has to come which may be speeded up by the force of political will of the country, but here also problems may arise.

The cultural forces have generally a unifying role to play in society because they originate from the concept of society as one unit. Divisive forces make their inroads through multiple political ideologies and parties. This is quite common in India and cuts at the very root of a harmonious growth of society. The need of a slogan for integration is indicative of the existence of divisive forces. Any developmental activity which creates disparity in the rural sector is likely to encourage further dissension. It stems from the problem of sharing the fruits of development and credit for bringing them into being amongst the various factions and groups in society. These divisive forces are merely the prototypes of the country's political scene. In fact, this kind of malignancy has invaded every walk of life, including educational, social and cultural organizations, whether private or public. Basically, therefore, we must act quickly to reform the land ownership system, and gear up at the same time the. political system to the concept of the village as an important component of the economic, social and cultural development of the country. Or else, rural development will ever remain a far cry.

ACKNOWLEDGMENT

I am indebted to Prof A N Bose of the Rural Development Centre at lIT, Kharagpur, for criticism and suggestions.

REFERENCE

1. V C Koshy. Margin, vol 2, no 1, October 1978, p 50.

Biomass Energy: Scope and Limitations

Dr T N Khoshoo

Secretary to the Government of India
Department of Environment, New Delhi

Ever since human being discovered fire some 150000 years ago, firewood provided him with warmth when it was cold, protection from predators, more digestible food, higher survival rate and colonisation of habitats which were inhospitable earlier. Firewood soon became the principal source of energy and even today 50% of wood is still used for its original use as fuel. Firewood an charcoal gave way to coal, coal to electricity, and since 1859 oil became the major source of energy.

Two important points emerged from the first energy crisis in 1973. First, all nations suddenly became aware of their total dependence on only one form of energy and realized that they were, in fact, living in a petroleum society. Secondly, it became clear that such a crisis would not have affected any nation if a broad energy policy involving many sources were adopted. There then followed the second energy crisis due to scarcity of firewood for cooking and heating. This crisis has been far more serious, as it affects a very large rural population in the entire developing world. In India, 68.5% of the energy used in households is in the form of firewood and 64.2% of it is collected from natural sources. For a variety of reasons, wood is still the principal source of energy in rural areas and nearly half of the world's wood production goes into its original use, cooking and heating. However, on account of population pressures, the demand for firewood has outstripped natural regeneration and planting, so much so that in some areas, though there is food to eat, not enough wood is available to cook it. At present, there is a big gap between demand and supply of firewood, resulting in depletion of the forest cover which, in turn, has proved to be ecologically disastrous as it leads to floods, soil erosion and, ultimately, shortage of water.

One of the important methods of insulating the country against such an impending disaster is to take to the Photosynthetic Model of Development through large scale use of biomass, particularly firewood. Such an option, apart from meeting energy needs, would help restore the relationship between man and his environment. Therefore, a very massive tree plantation programme is necessary both for energy needs and overall eco-development.

In our country, the shortfall in firewood production by 2000 AD has been estimated to be of the order of 137 Mt, which would require 34 Mha of land, at about four oven-dry tonnes of wood per ha/year, and a minimum annual outlay of Rs 5000 million for 17 years, to be made good. Once such a programme is successful, dung and plant-based residues would become available as organic fertilizer and as industrial feed stock respectively.

Among the renewable alternatives, solar energy, captured by the plants through the process of photosynthesis is the most important, especially because photosynthesis is a key process in the life-support system of this planet. Furthermore, the plant-based energy systems are not only renewable but they remove carbon dioxide from the atmosphere before turning it back, with no overall quantitative increase, as also help to contain environmental pollution. Photosynthesis is at the base of all biomass production and food chains. It converts physical energy into chemical energy and generates oxygen, the life sustaining gas. While net photosynthesis uses only 0.1% of sunlight, it produces organic matter of which only 10% accounts for the total energy used by man and only 0.5% accounts for the entire food requirement of the human race. Increase in photosynthetic efficiency automatically increases production of organic matter. Various types of biomass and/or bio-fuels available are firewood, agricultural alcohols, vegetable, oils, hydrocarbon plants, particularly those yielding rubber and petroleum-like materials; fresh weeds sewage-grown algae; algal hydrocarbons; and biological production of hydrogen using halobacteria, algae, azolla and even higher plants. Every feedstock or bioconversion process has its own merits and demerits, and the different routes available to generate solid, liquid and gaseous fuels are: anaerobic and enzymatic digestion and thermochemical conversion.

The basic premise for raising firewood plantations is that firewood needs cannot and should not be met from the natural forest stands as it would reduce the forest area, which is now only 23% in India, although 33% is envisaged under the National Forest Policy Resolution of the Government of India, and the effective plant cover is only about 12%. The destruction of forests will not stop as long as fuel for cooking is either not provided free to the rural poor, or is not made very cheap. In fact, the time has come for planning towards meeting timber and wood needs for industrial purposes from plantations captive to industry and not from natural forests. In order to obtain maximum productivity of firewood in minimum time, high density and short rotation biomass of fast and hardy species of deciduous trees and shrubs should be raised exclusively on non-agricultural or marginal lands, so as to avoid competition with food crops. The yields of firewood reported so far are indeed overoptimistic and there is a need to conduct meticulous scientific experiments, because estimated yields are a very crucial factor in planning firewood plantations for domestic use and for generation of electricity. The numerous advantages of large-scale firewood plantations range from the strictly local to environmental and social imperatives.

Another dimension to the problem is that the degraded lands proposed to be used for biomass production are at present used free of cost, for grazing. If used for firewood biomass, such lands will have to be closed to grazing immediately. To meet the situation thus created, either tree species with a fodder value will have to be grown or fodder legumes and/or grasses will have to be grown in conjunction with firewood species.

The immediate research needs are:

1. Tree/shrub species should be selected for wide genetic variation and adaptabilitv to marginal or low nutrient soils. Thus, the selected species should be hardy and require low inputs of water, fertilizer and plant protective measures.

2. The selection should be for species with multiple uses, like fuel, fodder, fertilizer end fibre and high regenerative potential and/ or coppicing ability, without loss of vigour under conditions of competition; minimum amount of bark wood with high calorific value and ability to burn without sparks and toxic smoke, etc.

3. Nitrogen-fixing ability of the species is an additional advantage and other methods of biological soil fertilization for deficient soils need to be worked out in view of the fact that high density and short rotation cause high drain of nutrients from soil with hardly any shedding recycling.

4. Agro-technological package of cultural practices for individual species and specific habitats should be worked out in combination with appropriate fodder legumes and/or grasses.

5. Standardization of tissueculture techniques for production on a mass scale in a very short time, of elite clones will be required to meet a very large demand for planting material (10000 and above per hectare).

6. Germ plasm collection of all the relevant species and their variants will have to be made for purposes of location specific adaptability trials as also for incorporation in breeding programmes.

7. Breeding procedure for genetic upgrading for the parameters listed above will need standardization.

Agricultural alcohol, though a successful transport fuel in Brazil, is not relevant to India as it may be more economical to use it as an industrial feedstock. Furthermore, it may be wise to displace sugarcane and/or tapioca as food crops. Sugarcane, besides, is now a 'political' crop. However, the future feedstock for alcohol is ligna-cellulose and R&D has to be intensified in order to make it a commercial raw material. Similarly, although vegetable oils are a promising fuel for diesel engines, due to acute shortage of edible oils, as also their higher price than that of petroleum in India, these oils do not have an immediate future as fuel.

New hydrocarbon plants such as guayule and euphorbias are hardy and most relevant to India and can be grown in arid regions. The demand for natural rubber is unabated, because it is preferred to synthetic elastomers; besides, the latter are based on petroleum feedstock. To meet a shortfall of 65000 t of natural rubber, guayule need to be grown in over 26000 ha in arid zones by 1985.

Among aquatic biomass, water weeds like water hyacinth, common in water-bodies, are already being used. Sewage, though an environmental hazard, can be a source of biogas as also a culture medium for single cell protein for poultry. During the process sewage itself is rendered benign.

Algae are a very promising source or hydrocarbons and deserve attention for production and processing by catalytic hydrogeneration. The whole area of marine biomass has been badly neglected and requires considerable attention in view of the fact that the sea constitutes about 71% of the Earth's surface.

Production of biological hydrogen through biophotolysis, as also bio-electricity, involves the use of hydrogenase and halobacteria with purple membranes, respectively. Both of these merit considerable attention and have a long-term potential.

There is an urgent need to domesticate as also genetically upgrade all the new and upcoming energy crops, microbes and algae, which are at present wild and have low productivity per unit area, per unit time. This is only possible if there is a heavy input of high science. The area of biomass energy is indeed multidisciplinary and requires R & D in subjects like botany, photochemistry, microbiology, agriculture, fuel research, heat physics, different branches of engineering, etc on plants as alternate sources of diverse types of energy.

In general, energy requirements of the rural poor, who often have food but not enough fuel to cook it, have been so far neglected. In view of the acute shortage of firewood, they perforce poach on forests, plantations, etc. It is, therefore, necessary that, like other basic needs, such as food, shelter, clothing and medicare, energy for cooking and heating should also be considered a basic need and guaranteed by the State. This has become all the more necessary on account of the very wide regional disparity in energy use. In fact, affluent nations are using energy in such a reckless manner as to lead to a highly disproportionate use of this finite resource and increased pollution. One way to meet this situation is to follow a broad energy policy in which many forms of energy are utilized, each supplying not more than 20%-25% of the total energy requirement. In a country like India, which has achieved food self-sufficiency to an extent but is deficient in energy, non-agricultural lands will tend to be used for energy crops, in contrast with those countries which are deficient in both energy and food, and have little or no land to spare.

Obviously, biomass, agriculture and animal husbandry form an integrated and symbiotic system. To meet the energy crisis, and the increased demands for food, fibre and feed, the only option for the country is to widen its agro-forestry base. Since agriculture is indeed a dynamic, living and continuing system, the role of agro-forestry is to maintain land in a living and productive form so that human life is sustained for a long time to come.

While agricultural waste residues are a very valuable feedstock for biofuels which can be utilized in a number of ways for productive purposes, it is necessary not to collect all the available waste residues to enable natural soil enrichment by their degradation by soil micro-organisms to continue.

Although even enlightened people think that wood is a fuel of the past, it has steadily been gaining in importance as a source of energy in developed countries, as important as in developing ones. Since there are several economic, social and environmental advantages accruing from biomass. It must receive greater attention from policy makers, planners and funding agencies in the developing countries. Although biomass is a dire necessity for the developing world, there is greater awareness about its importance and R&D in the developed countries. Obviously, the latter would make far greater use of biomass in time to come than the developing world.

While biomass goes well with the social, cultural and economic milieu of the country, there is a wide difference between the perception of a villager and a national planner about the firewood crisis: the former sees it as a local problem and feels that wood is a gift of God and he has a right to it even by poaching; the latter sees it as a problem of denudation of forests, leading to ecological disaster. However, for the success of the programmes of firewood plantations, the most critical factor is the villager who is both their guardian and the end-user. Unless he is made aware of the dire implications of destruction of forests and plant cover in general and the fact that it is in his own self-interest to preserve and make rational use of the plantations, poaching will never stop. Associated with this is a need to evolve and popularize cooking stoves which are energy efficient and smokeless. Smoke itself sometimes contains toxic materials. There has to be a mass-awareness programme encompassing all aspects with people's participation, For such participatory forestry programmes, there is needed, apart from the Forest Departments, a cadre of trained 'barefoot foresters' who can work with the people.

Biomass may not be the panacea for all our energy problems but it will, no doubt, help reduce substantially our dependence on fossil fuels. Being socially and environmentally relevant, biomass enables us to keep our air, water and land clean and manage our life support system in a sustained manner. Two things are needed: first, in view of our country being predominantly agricultural, a perceptible tilt in favour of plants and plant sciences in our planning process by adoption of the photosynthetic model of development; and, secondly, India has to be made increasingly greener. Among other things, such a model envisages revegetating, the uncultivated half of the country and make the country more greener. This would have distinct environmental, social and economic benefits and will help in :

- Conservation and improvement of soil and water by reduction of surface runoff, nutrient. leaching and soil erosion, and increasing soil nutrients by addition and decomposition of litter fall; abatement of dust pollution;
- Stabilization of catchments and watersheds;
- Control of floods;
- Better microclimate by decrease in soil surface temperature and decline in evaporation of soil moisture on account of mulching and shading;
- Conservation of biological diversity;
- Resolving energy crisis in a decentralized manner;
- Reduction of pressure on forests;
- Employment generation;

- Creation of aesthetic and pleasing landscapes;
- Better health;
- Better quality of life;
- Halting influx of rural population into urban areas; and
- Decentralized economy.

The only way to restore the forest cover is to take tree and fodder planting programmes on a priority basis under the National Rural Employment Programme (NREP) and/or the recently announced Employment Guarantee Scheme (EGS) of the Government of India. In fact the people involved in such programmes could be organized into a Conservation Corps. Meaningful results can be obtained only if tree and fodder planting are taken up on a war footing and work started as expeditiously as possible. Even if this programme is started today, the first results would not be discernible before five years. Besides, this would instil in the young people a work ethic and a sense of pride.

The advantages of producing and utilizing biomass in a social, cultural and economic milieu of India may now be enumerated thus:

- It is essentially a decentralized energy system, being basically local and utilizing locally produced materials. Thus, it is immune to international political pressures;
- Biomass offers clean fuel/energy and more or less keeps the environment clean, there being no significant environmental pollution as compared to large-scale use of oil, coal and nuclear power. Biomass also helps to correct eco-imbalances:
- Due to fossil fuel based energy systems, CO_2 contentof the atmosphere has increased nearly 10 times during the past 100 years. Burning bio-mass, or fuels derived from it, does not alter CO_2 concentration in atmosphere; in fact, it helps to recycle CO_2, The importance of photosynthesis which is the basic process involved in the pfoduction of biomass, can be gauged from the fact that every year 300 billion tonnes of carbon are fixed by this process in the form of terrestrial biomass and it stores 10 times more energy than the world consumes in a year;
- Biomass provides, besides fuel, a wide range of feedstock for organic chemicals industry which, at present, is mostly petroleum based;
- Bioconversion of biomass is less energy intensive and involves high science, but, not necessarily high and capitalintensive technology;
- Biomass will utilize marginal, arid/semi-arid and uncultivated land at present lying fallow;
- Production of biomass on such land will improve soil and its water retention capacity and there is likely to be reduction of erosion by wind and water; and biomass is socially relevant, being labour-intensive, with opportunities for generation of employment/income for the poorer sections. Furthermore, the quality of life in rural areas would improve and women and children, who spend most of their time in gathering firewood, would use their time more profitably, including for their education. It may also help in halting or reducing the rate of migration from rural to urban areas. The over-ridding consideration is the provision of energy to a large number of poor people very quickly and inexpensively.

Before considering one of the major disadvantages of utilizing agricultural and forest residues for fuel purposes, it may be pointed out that, while a good portion of crop plants is harvested, root and some of the above ground portions as also the leaves are left in the field. Similarly, in the forests, a lot of plant residues — roots, bark, branches and leaves, flowers, and fruits that fall from the trees — rernain on the ground. All the crop and forest residues contain considerable proportion of plant nutrients. All the nutrients in the residues are recycled to enrich the soil. In this way, a sizeable part of organic matter fixed each year is returned to the soil; besides, humus is also formed. There is, thus, a biological turnover in the soil and the cycle operates continuously, depending upon the availability of substrates (residues). Thus, the nutrients are released in soil through a highly efficient decomposer chain, depending upon biochemical composition of litter, microbial flora and fauna inhabiting the area and hydro-thermal conditions of the soil. However, with the removal of the residues from the field and forest, the soil would become depauperate as there would be depletion of nutrients and lack of humus formation as also conhitioning process of the soil. Because of chronic shortage of fertilizer and other agricultural chemicals, it will not be advisable to remove the entire crop and forest residues for utilization as feedstock for energy. In add it ion to the foregoing constraint, the collection and transport of residues, which are dispersed over a large area, to the utility sites for processing would reduce energy gains.

Although biomass may not always be profitable on technoeconomic considerations, this energy is most relevant, both socially and environmentally, due to many intangible benefits enumerated above. The technoeconomics will change materially as soon as productivity per unit area, per unit time is increased by improving plants and microbes involved in biomass production and conversion through induction of genetical and agronomical research and developmental component. One way to reduce the cost of biomass fuels is to aim at total utilization of biomas, eg, rice husk is not only used as fuel, but also as a source of a number of chemicals for a variety of uses.

Research Needs: Oil was discovered in 1858 and was initially valued only for kerosene for lighting purpose. Later were developed from it natural gas, liquefied petroleum gas, gasoline, fuel oils, lube oils, asphalt, paraifin, etc. By 1975, a stage of complete utilization of a barrel of oil was reached. Now that oil is fast running out, and biomass is regarded among the promising alternatives, complete utilization of a tree to meet with the requirements of sugar, natural and synthetic fibres, lumber, wood chemicals (like rubber, terpentine, lignin, phenols, etc), synthetic chemicals and fuels (methanol, methane, ethanol, ethane, gasoline), etc has not been possible so far. Technologies to accomplish the same are expected to be developed by 2025 AD. Here then lies a challenge for scientists, and a radical research and development approach is needed not only for conversion and utilization of biomass, but also for its production. The latter, among other things, requires improvement in photosynthetic efficiency. Plants with high energy potential can be cloned and grown in an unheard of plant densities as feedstocks for cleaner fuels and energy.

As stated earlier, the R&D on energy from biomass is at a far advanced stage in developed countries, because they have the requisite wide scientific base, capital and manufacturing capability for its complete utilization. Obviously, they would reap the benefits of such researches much earlier than the developing nations for whom it is indeed a dire necessity.

Keeping in view some of the foregoing points, the immediate, research needs are:

While data on commercial energy are reasonably reliable those on biomass are rather speculative. There is, thus, a need for organization of a data base regarding location-wise pattern of biomass availability and consumption. This also includes availability and use of firewood and agricultural residues/wastes, animal dung, etc together with information on, specific energy plants.

Before embarking on the 'fuel from crop and forest residues programme', it is necessary that critical investigations are carried out on the possible consequences of biomass removal from agricultural fields, and forests in respect of possible depauperation of soil and degradation of the environment. The amount of biomass to be left in the fields and in forests for enrichment of soil by natural processes needs to be estimated location and species-wise.

An R&D programme on identification and development of silvicultural, agronomic and management practices for maximizing biomass production under cultivated conditions is urgently called for.

First-tier performance trials in specific locations with specific plant species, having multiple use, need to be undertaken as a prelude to massive afforestation/plantations for fire/fuelwood and non-agricultural land.

Methods need to be evolved to compensate for the faster depletion of nutrients from soil due to short rotation and high density plantations.

Research on the utilization of agricultural residues as also aquatic biomass and municipal wastes for biogas generation needs to be undertaken.

Research on bioconversion of ligno-cellulose needs to be taken up.

The micro-organisms involved in bioconversion as also energy plants need to be genetically upgraded for high productivity and photosynthetic efficiency; thermochemical processes/technologies need improvement for higher yield of products.

The energy and non-energy use of biomass needs integration and by-product utilization requires improvement so as to enable utilization of complete biomass.

Wood burning stoves need improvement for attaining higher heat efficiency.

A trained cadre of scientific and technical personnel in the area of production and utilization of biomass needs to be created in order to enhance capabilities in this area.

Demonstration and awareness programmes need to be organized.

Production of energy from biomass being a multidisciplinary area, there is an urgent need for cooperation between concerned R&D agencies and Departments of Environment, Science and Technology, Energy, Forestry, Agriculture and Community Development. There is also needed a circumscription of the role of biomass energy for continued growth so as to achieve better balance among rural, urban, agricultural, forestry and industrial needs. It may, however, be emphasized that biomass can provide most of the products now obtained from oil and, in time to come, cellulosic materials will be increasingly utilized as feedstock for this purpose.

In the end, let us hope that R & D on biomass ushers a new society in our country which will rely more on renewable energy sources like biomass and solar technology, with smaller and more widely spread industrial establishments that utilize biomass based fuel/energy systems. This will help us to manage our life support system better so that existence of human kind as also associated ventures like agriculture, forestry and the relevant industry are not threatened. To achieve this, India will have to be made greener in years to come.

The domestic energy problems, particularly of the rural community and the urban poor, in a developing country are, indeed, very complex. They are closely linked with poverty and inequality. There are no magic solutions, but, given a sustained commitment of the people, they are not insurmountable. If we do not give the highest priority to these questions now, the price we will have to pay in future will be colossal — ecological disaster and an economic crisis. Let us remember, good ecology is good economics.

Prospects, Perspectives and Problems in Irrigation

Shri M G Padhye, *Member*

Secretary,
Ministry of Irrigation, Government of Indie

Friends,

I am grateful to tne Institution of Engineers (India) and its Council for doing me the honour by inviting me to deliver the Tenth Bhaikaka Memorial Lecture. During this lecture I intend to draw upon my personal experiences and perceptions, mainly relating to the activity of development with which I was intimately associated in the last 35 years of my professional career, namely water resources development in relation to irrigation and hydropower. In this process, I might express views or even appear critical on some aspects. Since presently I am the Secretary, Ministry of Irrigation, these views are liable to be incorrectly interpreted as Government views. I must clarify that these will be my personal views and the apparent criticism introspective thinking aluud, which is quite justified in such a lecture which is being delivered about $2^1/_2$ months before retirement from Government Service.

2.0 On an occasion like this, one is tempted to look back to the engineering profession as a whole and attempt to take a stock of the achievements and the shortcomings. I am proud to say that the Indian engineering fraternity has given a good account of itself in all areas and has made effective contrtbution about which the country should be proud. The various magnificient development projects in the country which are being planned, designed, executed and successfully operated by the Indian Engineers, on their own initiative and efforts, are an eloquent testimony of their excellent performance in this regard. Whereas this excellence is realised by many and at many times, if one asks a question as to whether the image of the engineer as a group in the society has reflected this excellence the answer may be in the negative. On one side we have a picture of the engineers occupying positions of eminence in the various fields, may be as an Industrialist, as a Project Manager, as a Technocrat or as an Administrator, as a Politician or as a statesman, on the other side the engineer is being cunventionally projected and presented before the society, even percieved by the society, as an individual whose delivertes are not to the standard, are always delayed and are at higher costs. In addition many undesirable attributes are also attributed to the engineers. I feel and I earnestly hope that I am wrong, that inspite of all the food work done by engineers, as a group we have not been able to make an impact on the society. As a group, we must introspecitively examine the cause of such a situation. I am not sure that apart from the other causes, that there is no single forum which takes up the causes of the engineers as a group, is one of the main causes. In the early post-independence period Institution of Engineers (India) was the only such forum. However, during the course of time, numerous groups belonging to the various engineering disciplines with separate institutional identities have come up with the result that no single institution can now claim to represent the interests of the engineering fraternity. I feel that Institution of Engineers (India) can, and should represent all the groups. One wonders as to why this Institute cannot work as a focal point for all such matters of general professional interest on behalf of all the other discipline oriented engineering associations. I would urge to all of you and also the other engineering associations, to seriously consider this, so that the engineers as a group would be able to speak on matters affecting the profession with one voice. The extent to which this multiplicity of associations goes will be evident from the fact that we have two associations in closely related field of Water Resources Development in the same town with the Secretariat for both the associations drawn from working members of a single professional Institute. While I realise that with increasing specialisation in every branch of technology, interests of the professionals would differ and this would require intensive exchange of technologibal thoughts, information and experience in relavteily narrow areas of specialisation, but this should not constitute an insurmountable barrier when issues pertaining, the profession as a whole are involved. While I would personally welcome an integration of all such groups under the common banner of the Institution of Engineers (India) with appropriate decentralisation for one specialised groups, a second best alternative would be to have a federated structure of the individual associations under the banner of Institution of Engineers (India) so that the Institutinn of Engineers (India) would work as a strong champion of the honour of the profession as a whole.

3.0 When I raise the question of impact on the society, I am quite aware o.f the odds against us. In the first instance the work of the engineers largely does not require them to come into direct contact with the members of the society. Also, individuals in the society are not always the direct beneficiaries of the engineering projects except perhaps in case of Irrigation, Power, Water Supply and Communication Projects. For various reasons, some of which could be attributed to the professional aspects, but many of which are attributable to other aspects, there are some shortcomings in these services and it is based on their shortcomings that the members of the society and in turn the society forms the impressions about the engineers as a group. Many success stories such as creation of irrigation facilities for as much as 68 million ha, large dams and canals which have provided irrigation facilities to large number of people, implementation of engineering projects which have brought definite benefits to the community such as the various hydro-thermal, atomic power projects, gigantic industrial projects around the country, can be pointed out. These are scarcely noticed and what are noticed are the failures that have directly affected are individual or a group of them. Therefore, if we have to improve our image we have to take great care in implementation and operation of facilities which have a direct interface with the members of the community. Along with this, it is also necessary for, us to project the good aspects of work that we as a group have done. We engineers appear to be a fraternity who keep on doing their good work whether it is appreciated or not. While this attitude of a Karmayngi is commendable. In the modern World, we may have to project our achievemerrts adequately. I recognise and am aware there are quite a few capable engineers amongst us who have the capability of projecting the good that we engineers have done to the society. I very much wish that their tribe may increase. Perhaps, it may be necessary for us to assiduously cultivable such a tribe.

IRRIGATION DEVELOPMENT: PROSPECTS

4.0 I shall now turn to the main topic of my lecture which will deal with the Prospects, Perspective and the Problems of Water Resources Development in relation to Irrigation. I intend to give emphasis on irrtgation as we percieve that a large percentage of our available and utilisable water resource, around 90 to 95%, is expected to be used for irrigation. In the situation as we have in the country not all the available surface water can be used. On the basis of the present day assessment we expect to use about 40% or 70 Mham of the surface water and these are expected to provide water to irrigate an area of about 73 million ha (Mha). About 70% of the assessed ground water resources of 40 Mham is expected to be utilised for irrigation and this may contribute another 40 Mha of irrigation facility. We will have developed facility of about 68 Mha, about 60% of the ultimate of 113 Mha, by the end of Sixth Plan or more accurately by June 1985. Depending on the resources made available, hopefully? We intend to add during the 7th Plan between 12 to 16 Mha. We may continue this development rate through tho successive plans with an objective of achieving the target of, 113 Mha by about 2005 A.D.

5.0 At this stage, I must make a mention of the prospect of hydropower development somewhat briefly. It is very rarely that a WRD project is likely to be planned as a single purpose project. In the context of the energy crunch, maximum use of renewable resource, in the present case the water, will be made for energy generation. In this context even where hydropower generation is not economical, provision will have to be made in the layout of structures, by providing blanked penstocks for generation of power at a future date. Considerable emphasis is also being placed of recent, on micro and mini-hydel stations at the foot of dams, on canal falls and the like. This is a welcome sign. The total hydro-electric potential of the country is estimated at 75000 MW. At the end ef the Sixth Plan about 15000 MW or 20% may be expected to have been harnessed. Subject to availability of financial resources the entire hydro-electric potential will have been harnessed by 2015 A.D. In future we will have to construct some imposing hydro-power dams urider the most complex geological conditions. We have in the early phase of development, a 1000 MW Multi-purpose project with a 260 m high rock-fill dam. We have in the planning phase a 20000 MW multi-purpose project with a 4.7 Mham (about 38 MAF) reservoir behind a 300 m high dam.

PERSPECTIVES

6.0 I have already indicated that we intend to exploit the available water resources by 2005 A.D. and this will provide facility for irrigating 113 Mha. Under irrigation conditions, it will be reasonable to assume that on an average 50% of the area will be double cropped or the irrigation intensity would be 150%. Thus, the physical area that would be served by the facility of 113 Mha would be about 75 Mha. This would mean that out of tbe culturable area of the country, of about 186 Mha barely 40% would receive irrigation facility leaving a very large area of about 110 Mha dependent on rains. Since quite a large nunber of population will be dependent on this rainfed areas and since a large part of these areas, about 1/3rd the area of the country, will also be drought prone, it is necessary to consider as to how benefits of this limited but valuable resource could be maximised. This could be done in two directions.

(a) By witholding the surface water which otherwise runs to waste in appropriate storages, above ground as well as

(b) By making more efficient use of the available resources so that it can cover larger areas.

7.0 Towards ensuring the first, it will be necessary to harness the surface water storages capabilities to the maximum extent by creating as many and as large storages as possible. The storage sites cannot be available as we want them as these are location specific. Therefore, this will require an overall water resources planning of the basins adopting the systems approach. The modern tools that are now available for such analysis have to be used for such a study. So far this tool does not appear to have been used for studying the planning options that may be available for large river systems. A small I beginning in this direction is made in the conntry by taking up such a studys for 'Mahanadi' Basin. Even in such a study there are problems that are both technical and non-technical. While the technical probloms such as inadequate data base analysis thereof, choice of methodology etc, can be taken care of reasonably, resolution of the other non-technical problems may pose some difficulties are these are largely dependent on value judgements which each area or state places on its needs for water use. Such a study for optimisation would also require that the present day criteria for planning of water resources for 75% success as may have to be changed. As the water resource starts getting scarce, gradual changes in approaches in his direction may be expected to take place. However, one aspect is clear that there is need to plan and also create as early as possible, as much storage capacities as may be available in the country. At present, we have built or we are in the process of building storage whose aggregate capacity may be around 18 Mham. A search for more storage sites will have to continue. Suitable storage sites to harness the supplies of the Ganges are available in Nepal. Development of these sites may require active co-operation of Nepal. Storage sites are available on the Brahmaputra and its tributaries. A potential site on the Brahmaputra will have a storage capacity of 4.7 Mha has been mentioned eartier. This is not to say, that there are no problems of exploitation of such sites. These will have to be tackled with determination.

8.0 The possibility of creating underground storages needs further examination. In a limited way recharging the ground water is being practiced in the country. Sometimes this is deliberate though, in a small way such as by construction of percolation tanks, construction of contour bunds and terracing of fields etc though some of these activities are taken as catchment area protection measures rather than ground water recharge activities and for valid, reasons. Many a times this is merely incidental, such as in the case of surface irrigation schemes which recharge, the ground, water table, which at times is advantageous or at times is disadvantageous as it causes problems of salinity and waterlogging. It will be necessary to examine more carefully, whether a deliberate attempt to recharge ground water can be made, either by over-exploiting the ground water during the fair weather season, thus glowing an additional recharge during rainy season or by pumping in of excess surface water into the deep acquifer where such recharge is possible. The former would require careful studies on ground water behaviour models, which studies can now be undertaken in the National Institute of Hydrology, the Central Ground Water Board and other Institutions in the country. An experimental artificial recharge prolect for the latter is already under way in Mehasana District of Gujarat as a UNDP assisted project. There are some imponderables in such an approach such as possibility of pollution of ground water, which needs careful study.

9.0 In India many of the rivers are Inter-State in character. They carry large amounts of flow. The table below will indicates the surface water available in some of our river systems:

River	Geographical Area M.h.a.	Culturable Area M.h.a	Water M.h.a.m.	Equivalent Delta m
Krishna	25.89	20.30	6.28	0.32
Godawari	31.28	18.93	11.8	0.62
Cauvery	8.79	5.80	2.07	0.36
Narmada	9.88	5.90	4.4	0.75
Tapi	6.51	4.42	1.8	0.41
Indus (Indian)	32.13	9.64	7.69	0.80
Ganges (Indian)	86.14	60.6	25.0	0.41
Brahmaputra (Indian)	19.5	5.•7	33.7	6.64
Meghana (Indian)	4.7	1.55	6.5	4.19
Mahi	3.48	2.21	0.77	0.35
Mahanadi	14.16	7.99	6.66	0.83
Sabarmati	2.17	1.55	0.37	0.24
West Flowing Rivers (South of Tapti)	11.21	6.28	21.79	3.47
All India	328.78	156.36	178.00	0.95
		Utilisable	70.00	0.42

Even a cursory look at the quantity of water available per ha of CCA, in the table would inducate that the available water resources in the country are unequally distributed and that some areas are fortunate in having somewhat large resources. However, this is not an unmixed blessing as this large resource many times causes some serious flooding problems. Some of the chronic drought prone areas of the country are also located in the otherwise water short basins such as of the Krishna. Therefore, in overall national interests, it may have to be considered, if the waters of the otherwise water surplus or water satisfactory areas could be transferred to the otherwise needy areas. In the seventies some interesting proposals in this regard were being made in the country. These were the well pulicised 'Garland Canal' of Capt Dastur and the Ganga Cauvery Link of the Engineer-Statesman Dr K L Rao. The former was an idea which had serious technical, technological shortcomings to render it impractical whereas the latter was a plari which was technically and technologically a well concieved plan but was costly and required large amount of power about 5 to 7 GW for lifting the 40000 cusecs of water through a lift of 550 m (1800 ft). In 1980, Central Water Commission and Ministry of Irrigation formulated a conceptual National Water Plan, which aims at diverting some of the surpluses from some of the rivers by long distance mass-transfers of water to the needy water short areas. The Plan is expected to create an additional potential of about 35 Mha and generate about 40000 MW of hydro-power. The feasibility surveys for the Peninsular component of this National Water Plan have been taken up. The National Plan envisages of uses of waters more efficiently in the existing systems, creation of large storage reservoirs to store the monsoon run offs which otherwise goes to waste and transfer and exchange of water over long distances from one river system to other river system.

10.0 The exercise of the perspective of development of water resources shows that, at present, these are not efficiently used. Presently, the overall water use efficiencies may be of the order of 25% to 30%. Concerted efforts, may have to be made to improve them. This can be done by providing lining to the canal system, adoption of better water management, procedures on the system, adoption of Warabandi system for equitable distribution of water, conjunctive use of groundwater and the like. Concerted efforts in this direction are being made in the country and it can be said that during the last few years a consciousness about better water, management is created amongst all concerned. In order to orient the thought processes of persons in charge of operation and management of irrigation towards water management, suitable training programmes, seminars, workshops, etc have been arranged. To impart training to the operational staff in water management and also to orient them towards the requirements of modern irrigated agriculture, training institutes for Water and Land Management, popularly known as WALMIS have been created in a few States and are in the process of creation in others. The Command Area Development Programme being in implemented in the country is also giving emphasis on better water management. In addition, emphasis is also being given on use of devices such as sprinklers and drip irrigation which are expected to improve water use efficiencies. It is realised that these are costly irrigation systems and would take some time to take firm roots. Where water is scarce as in the drought or desert areas or where it is, costly as in the case of lift irrigation schemes or where the soils are sandy and hence highly permeable, cultivators have started taking recourse to sprinkler irrigation. There are a few instances, mainly for high value crops, where drip irrigation is being used. It is expected that for irrigation from ground water where the cultivator is required to bear the full expenses of irrigation, sprinklers will have considerable scope, as this would save his costs on operation of the scheme with better control on water. If and when the water rates on the Government owned and operated flow irrigation schemes are charged on volumetric basis at economic costs, sprinkler irrigation may be expected to find extensive use even on these systems.

11.0 The above perspective of development of Irrigation is also need based. As per demographic studies, the population of the country is expected to be between 900 to 1000 million by 2000 AD. Some estimates also indicate that India will be the most populated country in the World by 2050 AD when her population may stablise at 1500 million against the world population of 10 billion. For a country of the size of India, it is obligatory to continue to remains self-sufficient in food. The food requirements of India in 2000 AD may be of the order of 250-300 Million Tonnes. In 2050 AD these may be 375 to 400 Million Tonnes. It may be reasonable to asume that by 2000 AD the average productivity level from irrigated areas may be around 3 Tonnes per ha and about 70% of areas under irrigation about 80 Mha, would be covered by food crops. This will mean a food production of about 240 Million Tonnes by 2000 AD from the irrigated areas. The un-irrigated areas may contribute, if monsoons are favourable, and additional, 50 - 60 Million Tonnes. Thus, we will be able to manage the race between the increasing population and, self-sufficiency in production. The race has to continue further and this increased production would have to come mainly out of better water management and increase in productivity from irrigated agriculture. This also brings to the fore-front the need for finding out ways and means to maximise the benefits from the limited water available. The National Water Plan would be one of the means. Foundations for this plan will have to be laid during the next 10-15 years.

12.0 There is yet another perspective which has a global context. When and if Indian productivity records higher gains than our needs, we could be one of the exporters of food grains and other agricultural products to the other needy countries. Even this might be for a limited period in the context of the pupulation projections for India for 2050 AD.

PROBLEMS

13.0 With internal capabilities for planning, design, construction and operation of WRD Projects built up in the ceuntry during the post-independence period, no major difficulties in implementation of the perspective programme of irrigation development may be anticipated. However, as some of the WRD structures such as dams for storages in the Himalayan Region or in the North Eastern Region may rank high up amongst tallest WRD stuctures of the World and may have to be planned, designed and constructed in areas where geological and seismological conditions are expected to be rather complex, some specific advice on specific problems of complex nature may have to be sought for from those who may be knowledgeable in this regard in the world. At times this advice may have to be in the nature of a second opinion on the solutions formulated by Indian Engineering fraternity. Construction of such large structures may be expected to pose some problems of planning of the construction as also during construction. Use of expatriate consultants for advice on such complex problems may have to be done.

14.0 The scale of investment for creation of irrigation facility is expected to increase from plan to plan. The present rate at which we have been creating irrigation facility 2.3 Mha per year, may have to be increased. This is expected to place considerable strain on the existing implementative organisation which may have to be strengthened. Some simplification of administrative procedures, by appropriate delegation of authority to lower levels, may have to be considered. At times, new procedures will have to be evolved to take care of special situations. Modern tools of management may have to be used extensively. Financial targets based on physical targets may have to be adopted as an approach to implementation. This may also mean a basic change in the methodology of sanction to the projects by the Planning Commission and adoption of a more rigorous financial discipline by the States who implement the irrigation projects. Perhaps a two stage sanction, first based on the techno-ecomic aspects and the second for its implementation which should be based as a firm programme of completion of the projects, and thereafter for a commitment of all the resources for a time bound completion of the project, may have to be adppted. The approach paper to the 7th Plan, which has been adopted by the National Development Council in its meeting held during July 1984, spells out some of the strategies. What is now required is the political and administrative will and also a mechanism to rigourously implement these.

15.0 Increase in productivity of irrigated agriculture from the present level of about 1.6 to 1.7 Tonnes per ha to about 3 Tonnes per ha or more on an extensive scale in the country, will require an all-out effort on the part of all those who are concerned with irrigated agriculture. Water is the prime input for irrigated agriculture. It has to be delivered in right quantities and in right time to the farmer. The Engineers will have to shoulder greater responsibilities in this regard using of improved technology for operation of canal systems. To enable this to be done, the programme of the construction of field channels as also the land levelling, land shaping may have to be accelerated. There are some difficulties in implementing this programme with the desired speed. These may have to be overcome. Engineers will have to ensure that the systems that they plan, design and construct and operate are able to deliver the supplies as required by the farmers and also as per requirements of the crops, the latter to the extent practicable. While this is done they should recognise that the crop pattern that develops on a project cannot remain static and will depend on the farmer's responses to the agro-economic situation as he percieved. Alongwith this, the farmer must also have easy access to all the inputs such as quality seeds, fertilizers, pesticides, ths necessary credit and the necessary agricultural advice required by him. The most important of all aspects will be to enthuse the farmer to increase his agricultural productivity. The Remunerative prices of the agricultural produce, would work as a great incentive to the farmers. However, the social objective of irrigation development of maximum agricultural production per unit quantity of water, at times is seen to work at cross purposes with the farmer's objective of maximum production, per unit of land. It will, therefore, be necessary to involve the farmers in all the processes of management of irrigation. Perhaps the best course would be to consider involving him through Water Users' Association Co-operatives operating initially below the outlet level and progressively involve him fully in operation and maintenance of channels of increasing discharge. This would require that engineers will also have to take the initiative and play a leading role in nrganising the farmers.

16.0 The Command Aread Development Programme instituted in the country since 1974 envisages almest all the above activities in relation to the irrigated command. Presently, the activity is limited to 102 large and medium sized surface irrigation projects in the country involving a potential of about 17 Mha. The scope of the Centrally sponsored CAD programme is limited by the finances that the Centre may be able to provide for the CAD Programme. What is required is adoption of CAD approach to all the irrigation programme of the States, on their own cover all the surface irrigation projects. CAD organisations are required to be multi-disciplinary in nature. However the core activities such as construction of field channels, land levelling, planning and construction of drainage works, roads in the Command areas, Construction of marketing Centres and O and M of the Canal System will be largely engineering activities. These activities will have many interfaces with other disciplines. For the success of the projects, therefore, the engineer will have to develop not only the engineering skills but the skills required to deal successfully not only with such interfaces, but also with the non-engineering activities related to irrigated agriculture.

17.0 Development of irrigation facilities over years has not remained an unmixed blessing. It has created problems in the environment. One of the oft-quoted and publicised disadvantage of the irrigation is the waterlogging and saline or alkali soil conditions which result as a result of excessive seepage from canals, over-irrigation, lack of drainage etc. It cannot be denied that irrigation has not caused such damages, but many times there is a tendency to attribute all such damage to irrigation which may not to be correct. As engineers we should be alive to the situation and ensure that such situations do not develop in the first instance and take steps to avoid these while formulating the projects; and keep a watch over the status of the area in this context and plan and implement, well in time, before the adverse effects are noticed. Somehow this does not seem to happen, for many reasons, some of which are not under the control of the engineer incharge of management of the system.

18.0 Yet another important environmental problem which is attributed to irrigation projects and more particuarly to large storages is the submergence of lands, the flora and the fauna. Often, it is also suggested that the catchment areas of such projects should also be protected against erosion by extensive afforestation and other measures such as terracing, contour bunding gully plugging at the cost of the project. This has to be considered with some circumspection. At the outset it has to be realised and acceptad without hesitation, that there is a great need to preserve the environment, the forest cover, the soil cover and even the flora and fauna. The plea of the environmentalists should not be brushed aside as a mere fad. If the project causes any damage to the environnent, measures should be taken, at the cost of the project, to mitigate its adverse impact. While this is done, it should also be recognised that no development can take place without affecting the original environment, and therefore, care has to be taken to ensure that no progressive degeneration of environment takes place due to the project. The environment cannot be static and a new equilibrium has to be established in the changed circumstances. Removal of poverty has been one of the main obiectives of development in the Indian context. I would like to remind what the late Prime Minister has said. She said 'poverty is the greatest polluter'. The Engineers should however, be receptive to the environmentalists' suggestions anu analyse them in their proper perspective in relation to the projects they may propose so that the positive and negative aspects of the proiect could be examined and if on an overall assessment the project is considered advantageous to the country consider a decision on implementation of the project. The engineers will, therefore, have to develop an attitude of pragmatism in this regard.

19.0 Another area in which the Engineers in charge of Irrigation Management should get involved more deeply is that of water management. The term water management, should not be understood in the limited sense of merely using the water more efficiently. It has a wider connotation which implies increased productivity from irrigated agriculture for maximising the benefits. The Irrigation system thus cannot be isolated from the agricultural system. The two have to go hand in hand with a common objective. Therefore, it is necessary for the irrigation management engineer also to have a clear perception of the agronomical requirements of production from irrigated agriculture so that he can manage the system in tune with the requirements of irrigated agriculture. This will require that he should also be agriculture oriented though not necessarily an agricultural specialist. This can be done by appropriate orientational training to the engineer in charge of irrigation management. Specific steps in this have been taken in their country to impart this as an in-service-training through seminars, workshops or through formalised training in the Water and Land Management Institutes (WALMIS) some of which are established and some are in the process of being established. A conscious effort is being done by the Ministry of Irrigation in this direction. In due course formalised education in Water Management at the post-graduate level may be a regular feature when a formal cadre of Irrigation Management Engineer as separated from the present combined engineering cadre for planning, investigation, construction and O and M may also be established.

NEW ROLE FOR ENGINEERS IN IRRIGATION

20.0 Under the caption 'Problem' I have tried to review the multi-facetted activities that the Irrigation Engineer may be required to handle as of now and also in year to come. These will show that over years the role that the engineers incharge of irrigation systems will have to play in the field of WRD with special reference to irrigation is changing both in content and quality. No longer the engineer in the field of irrigation development with the Government can remain merely a planning, or designing or a construction engineer as in the earlier times. The environments as we have in the country as of date, the needs of the work which will have to be handled, require that apart from being a good engineer one will also have to be a multifacetted entity which will enable him to play the role also of agriculture oriented social analyst, of a social worker and to a certain extent even an agro-economist. It is necessary for all of us to understand this changed requirement and attune ourselves to this new direction. Whether the engineers in the Irrigation Wing will be able to make a mark in the society will largely depend on how effectively he will be able to do so. This will require a deliberate and conscious effort on the part of all who are engaged in the irrigation activity.

21.0 Friends I have placed before you some of the problem that the Engineering Fraternity may have to face in the field of irrigation in times to come. For obvious reasons a more detailed analysis has not been possible and was not practicable. I hope this will be of use to all. I am also confident that the members of the Engineering fraternity will be able to give a good account of themselves to the challenges that they will have to face in the changing circumstances.

22.0 Before I close, I again thank the Institution of Engineers (India) and its Council for giving me this opportunity to be with you for delivering the Tenth Bhaikaka Memorial Lecture and to all those in the audience for giving me a patient hearing.

Thanking you all.

Resource based Planning of Irrigation Systems

Dr A M Michael, *Fellow*

Director,
Indian Agricultural Research Institute, New Delhi

The rapid increase in the development of irrigation potentia1 in India since the mid-sixties has been recognised as a landmark in the history of agricultural, development anywhere in the world. There is no other country, which has attached, so much importance to the development of irrigation as India has in recent years. The aim is to create a gross irrigation potential of 113 million hectares, by 2000 AD. It must, however, be realised that the land and water resources of India are limited. In spite of the rapid rise in population and the consequent increase in the demand for food and fibre the availability of land and water will remain nearly the same. The only solution to meet the challenge of tomorrow is to increase the efficiency in the utilisation of land and water resources.

The total geographical area of India is 328 million hectares. The net area sown is about 142 million hectares which is about 43.3 per cent of the total geographical area. The area under forests is 65.75 million hectares which is about 20 percent of the total area. The uncultivable and fallow lands amount to 100.45 million hectares.

The dependance of India's agriculture; principally on the south-west monsoon and its consequent vulnerability have been realised since the earliest times. The south-west monsoon is confined essentially to the period, June to September while the rest of the year is practically dry in most parts of the country. The east-coast of South India, however, receives rain mostly from the north-east monsoon, during tho months of October and November, with prolonged dry spells during the rest of the year. Intensive agriculture will require the development of irrigation facilities through the conservation of the monsoon rainfall in surface reservoirs and as ground water and its utilisation in the non-monsoon seasons. There are also critical dry spells during the monsoons when supplementary irrigation will be required, especially for crops like paddy which occupies about 40 percent of the irrigated area in India.

ROLE OF CLIMATE IN PLANNING FOR EFFICIENT WATER MANAGEMENT IRRIGATION COMMAND AREAS

Climate, especially rainfall, is a dominant factor influencing water management and other agricultural operations. The analytical developments on predicting the characteristics of rainfall, based on statistical models adopting probabilistic approach, provide information on the date of onset of effective monsoon, the incidence of critical dry spells during the monsoon and other rainfall characteristics.

A knowledge of the probable date of onset of the southwest monsoon in the command area enables the planning for seed bed preparations and raising of nurseries for rice and other transplanted crops at an optimum time. The success of the monsoon crop depends to a large extent on taking advantage of the available rain at the right time. Monsoon predictions enable planning for alternative strategies in crop production, including possible modifications in crop management canal regulation and the conjunctive use of surface and ground water. The ill effects of the vagaries of monsoon can be mitigated to a large extent if the irrigation system management could be adopted to meet the contingencies arising from the abnormalities in the monsoon.

Irrigation is essentially a means of supplementing the amount of moisture available to crops through precipitation. Hence, the knowledge of characteristics of rainfall including its amount, intensity, frequency and distribution are essential in planning crop and water management practices. Reliable predictions of the weekly normals of rainfall and expected evaporation losses provides satisfactory means of estimating the soil moisture availability to meet the requirements of the crop. Scientific managemsnt of the canal system provides for the releases of water in right amount sand during the periods when there is deficiency in soil moisture for the optimum growth of the crops.

The annual rainfall in an area is of comparatively less consequence in crop production, than its frequency and distribution in time and space. In spite of a normal monsoon from the point of view of total amount of rain received in the season, there may be critical dry spells when the canal water is to be released especially to raise wetland rice and provide supplemental irrigation to other moisture sensitive crops. The prediction of critical dry spells holp greatly in planning the operational schedule of the canal system to tide over the dry periods during the monsoon. Similarly, information on wet spells is important in the reglulation of escapes and spillways and the filling of system reservoirs and tanks as well as the design of soil conservation structures in the command area.

Soil moisture storage in the crop root zone is essentially a function of the characteristics of the soil and the rainfall. Superimposition of the information on rainfall on appropriate soil map provides valuable information on the amount of soil moisture in the crop root zone which could be derived from rainfall and the extent of its availability to the plant. This will enable the selection of suitable crop planning and supplementary irrigation required in terms of amount and time of application.

Rainfall characteristics have profound influence on design of drainage system in the command area. Crops vary widel in their tolerance to surface ponding and depth to water table both of which are influenced by rainfall. The criteria for the design of surface and subsurface drains are developed on the basis of the information on rainfall. For instance, one-day rainfall values with different return periods will be useful for such planning.

Climate is the dominant factor influencing the adaptability of crops to a region. The principal climatic factors influencing crop growth and yield include rainfall, temperature, relative humidity, wind velocity and solar radiation. Information on these factors aid in the adoption of appropriate cropping pattern and crop management practices in the command area.

Crop water requirements are influenced mainly by the climatological factors, namely, solar radiation, temperature humidity and wind velocity. Information on these factors form an essential part of efficient water management in the command areas.

SOIL AND LAND IRRIGABILITY CLASSIFICATION

The interpretation of soil and land conditions for irrigation is concerned primarily with predicting the behaviour of soils under the greatly altered water regime brought about by the introduction of irrigation. The soils are first grouped into soil irrigability classes according to their limitations for sustained use under irrigation. Then the land classes according to irrigability are determined. Special attention is given to three factors in classifying lands for irrigation, namely, the costs of land development, the drainability of the area and the effect of irrigation water on the salinity and alkalinity status of the soils.

The nature of soils and land conditions in an area proposed to be brought under irrigation and their suitaibility for irrigation are determind by preirrigation soil survey, together with drainage investigations and other studies which may be needed. Soil irrigability classes are used to group soils according to their suitability for sustained use under irrigation. The classes are defined in terms of the degree of soil limitation.

DRAINAGE OF IRRIGATED LANDS

In the design of an efficient drainage system in an irrigated area the provision to remove the runoff water accumulated at the ground surface fast enough to prevent damage to the standing crops and maintained the water table at a level which is conducive to the normal growth of the crop in the arid and semi-arid climate zone. It should also provide for the removal of excess salts accumulated at or near the ground surface. The major factors influencing the design of the drainage system are the drainage, requirements of the crops grown, topography of the land, characteristics of the soil, water table situation, rainfall and other climatic factors, methods of water application, type of lining in the canal water conveyance system and the extent of use of groundwater for irrigation. Drainage is essentially a situation specific problem and the design of the drainage system should conform to the requirement of the specific area which forms a distinct unit or block. The design criteria for the system can be developed on the basis of detailed investigations on the causes and extent of waterlogging and the drainage requirement of the crops.

Design of the drainage system in an area is made to meet the requirements of the crops to be grown. Alternative cropping patterns could be developed depending on the limitations imposed by the physical conditions such as the availability of outlets. The two major considerations in the design of the drainage system are the crop tolerance to surface ponding and depth of water table. Both these conditions are detrimental to plants but different crops have different tolerance limits to the above conditions.

Rooting characteristics of the plants vary due to their genetic characteristics. However, plants may be limited in their rooting by factors other than genetics. High water table is one of the factors that restricts the depth of rooting in reduced production. The drainage system is so designed as to maintain the water table below the average rootzone depth of the crops included in the cropping pattern in a particular crop season.

The tolerance of different crops to surface ponding vary widely. Maize and leafy vegetables are the most sensitive crops to surface ponding. Maize is seriously effected by surface ponding extending upto 24 hours or more. Wheat crop can tolerate surface ponding upto almost 3 days. Paddy, though a wet crop, can tolerate complete plant submergence for a period of 5 to 7 days only. Most other drops have their tolerance periods ranging from 1 to 3 days.

The drainage systems in most of our irrigation projects are inadequate to control the water table or remove the surface water adequately.

The following are the factors contributing to the inadequate performance of the existing drains:

1. Low intensity of drains
2. Silting of the drains
3. Blocking of drains through excessive weed growth and manmade obstructions
4. Absence of sub-surface drains.

The design of surface drains consists of the determination of the intensity of the drains to effectively drain the surface water and control the water table, location of the drains and their specifications. The accumulation of surface water and major contributions to ground water are confined essentially to the monsoon period. Inadequate land grading and lack of outlets from fields to surface drains are contributing to the ponding of water in the fields for prolonged periods.

FILLING THE GAP BETWEEN DEVELOPMENT AND UTILIZATION OF IRRIGATION POTENTIAL

The performance in the irrigation sector is usually evaluated on the basis of the potential which is created. This often results in an erroneous assessment. The actual situation is that only a part of tie potential which is created at such an enormous cost is actually being utilized. There is a wide gap between the development and utilization of irrigation potential in major and medium projects. The available figures from major irrigation projects which were commissioned during the past two decades show that in many cases the utilization is less than half the potential created. A detailed study conducted by the Water Technology Centre of the IARI in 1983 revealed that in the Mahi Canal Command Area of Gujarat not even the half the potential could be utilised even after a lapse of over 20 years of the operation of the canal system.

The major lacuna in the development and the utilization of the irrigation potential is due to the lack of attention on the command areas while the irrigation system is planned and constructed. There is also very little involvement of the farmers in the utilization of water. Another lacuna is in the planning of canal systems for surface water development without integrating it with the ground water and accounting for rainfall in the command areas. It is estimated that ground water potential of the canal command area nearly doubles after commissioning of the canal system due to contribution from canal seepage and deep percolation. Hence, to prevent serious problem of waterlogging it is essential to proportionately increase the number of shallow wells and deep tube wells in the command.area. On the contrary, in many cases many wells remain unutilised after the canals are commissioned since the farmer can get his supplies at a nominal cost from the canal. Proper proportioning of the water, would result in considerable saving of the canal water to irrigate larger areas and avoiding misuse. Presently there is no well organised agency for the maintenance of the drains in the irrigated areas. This has resulted in most of the lands getting blocked by weeds and other obstructions. Consequently there are problems of waterlogging in the irrigated areas, especially during kharif season. Arrangements for inputs like quality seeds, fertilisers, farm power and machinery and credit facility to farmers are often not integrated with the irrigation development programme. All these result in the under-utilisation of the irrigation potential and associated problems including low returns from the investments and environmental hazards. A change in the planning of the irrigation projects is suggested to substantially improve agricultural productivity and minimise environmental hazards.

As a first step, information relating to the availability to the irrigation potential and their utilization including the number of irrigations available in different crop seasons (kharif and rabi) should be collected at the district level by combining available information from Irrigation, Agriculture and Revenue Departments. The information should be collected by the Collector/Deputy Commissioner of the concerned district. Soon after the information is available plans are to be developed for bridging the gap between the availability and utilisation of potential to the improve crop production and forestall waterlogging.

The limiting factors in the full utilisation of the irrigation potential could be identified as follows:

— indiscriminate release of water in the kharif season resulting in deficiencies in the rabi season.
— excess application of canal water during kharif season without taking into account the rainfall available in the command area
— non-availability of field channals and water control structures
— inadequate arrangement for farm power and machinery through Argo-Service Centres
— inadequate farmer support to land levelling and land development

— inadequate arrangement for the supply of quality seeds and seedings
— inadequate extention support to farmers on fertilizer requirement and application techniques
— inadequate arrangement for fertilizer in the irrigation command area
— inadequate plant protection cover especially for cash crops including oilseeds and pulses
— lack of farmer participation in irrigation management
— inadequate organisational set up for the maintainance of the fill drains.

ON-FARM DEVELOPMENT

Integrated development of an irrigation system comprises of the construction of the reservoir and/or the diversion works, the canal system and the development of the command area of the system. Command area development is essentially an on-farm development programme which includes the provision for efficient conveyance of water from the canal outlet to the irrigated fields, land levelling and field layout, provision of drains and the build-up of soil fertility. The following are the major on-farm development activities:

1. Consolidation and rectangulation of the fields.
2. Construction of water courses to carry water from a canal outlet to the holdings of the farmer.
3. On-farm water cohveyance through field channels
4. Construction of structures for diverting water from water courses to field channels, erosion control and crossing roads and obstructions.
5. Land levelling to provide efficient distribution of irrigation water, soil-moisture conservation and removal of excess rain water.
6. Field layout to suit the method of irrigation to be adopted, the existing/proposed field boundaries and the limitation imposed by soil and topography.
7. Adoption of appropriate irrigation methods for efficient water application.
8. Development of soil fertility through manuring application of fertilizers and adoption of suitable crop rotations.
9. Construction of field drains for the removal of excess surface/subsurface water and its linkage with suitable outlets.

SOIL FERTILITY MANAGEMENT

Soil fertility management forms an essential component of efficient irrigated agriculture. The different management procedures include the selection of proper crops and the introduction of proper crop rotations to maintain the soil, fertility. These include the growing of green manure crops and incorporation of suitable leguminous crops in the crop rotation. Application of fertilizers, based on proper soil tests, is essential to supply the efficient elements in the macro-nutrients.

CROP PLANNING AND IRRIGATION MANAGEMENT

The basic objective in the development of an irrigation system is to increase agricultural production on a sustained basis. Plants vary greatly in their requirements for water and adaptability to environment. Irrigation systems are planned to meet the water requirement of crops under a specified cropping pattern. Alternatively, cropping patterns can be modified to suit, to a large extent, the availability of water in a project and its distribution in space and time. In spite of the large investments made in the irrigation sector and the phenomenal growth of irrigation potential since the year 1951, the return from the investment, both in terms of crop yields as well as finance are certainly not commensurate with the investments on irrigation projects. Irrigated land, should normally yield at least 4 to 5 tonnes of grains per hectares per year. However, at present it is hardly 1.7 tonnes on an average; The actual yield levels are much lower than the level of 4 to 5 tonnes achived in farmers fields under programmes of transfer of technology. Figures 1 and 2 show the impact of transfer of technology programmes of the Indian Agricultural Researh Institute at the locations one on paddy and the other mustard.

One of the primary ways of increasing crop yield and water use efficiency in a particular envirornment is to select plant species adapted to the total amount and distribution of water. The plant characteristics influencing water requirements include the length of growing season, extensiveness of the root system, leaf area, angle of inclination of leaves and the number, distribution and size of stomata. Species selection, plant selection, plant selection and plant breeding have contributed greatly to increasing the efficiency of the water available in the given area. Plant breeders have contributed greatly by increasing the yield potential of crops and by protecting crop plants from insects or diseases through breeding. With the aid of suitable prediction or moisture available from rainfall, ground water and surface water sources, it is possible to arrive at suitable cropping patterns to make the maximum use of the avai1ab1e water.

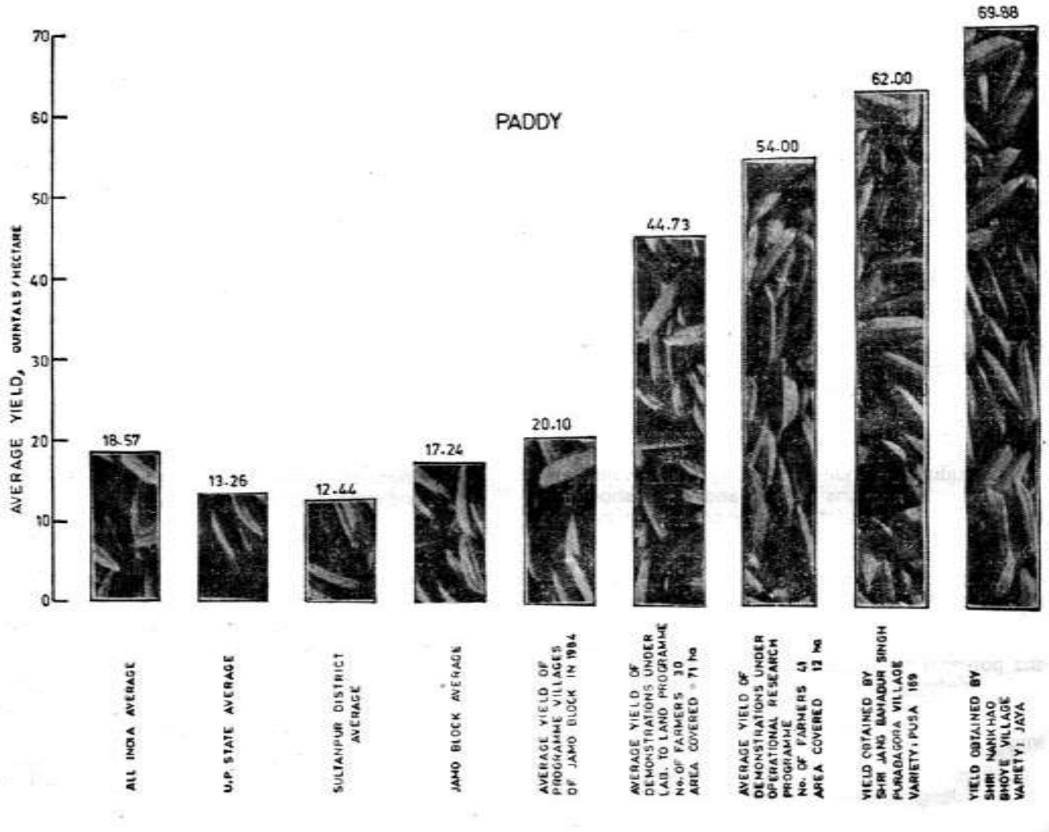


Fig 1 Impact of transfer of technology in farmers' field

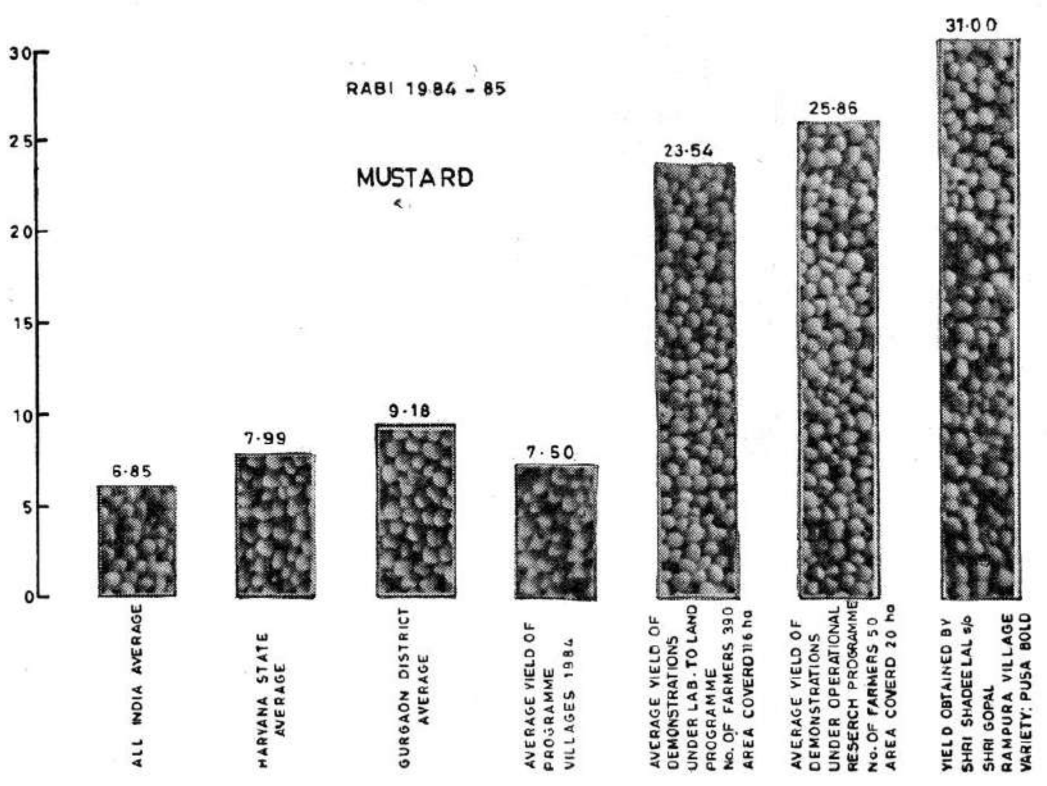


Fig 2 Impact of transfer of technology in farmers' field

Cropping pattern in a region is determined by a multiplicity of factors like types of soil, climate, rainfall, farmers' requirements of food grains for self-consumptions and net rate of returns on various alternative crops that can be grown in that region. Assured water supply will induce the farmer to change over to more water consuming crops which could not be grown earlier, provided the soils are suitable and the expected rates of net return on such crops are higher. It may be reasonable to assume that all farmers are motivated by a desire to maximise their farm incomes and will, therefore a adopt a cropping pattern which in their judgement will ensure maximisation of income. In many irrigation projects the authorities, as a matter of policy, have restricted the area in which heavy-water consuming crops like paddy and sugarcane can be grown. This would permit light irrigation that can be spread to a large area.

IMPACT ON ENVIRONMENT

Any direct human influence on environment shall have a positive objective, namely, to raise the living standards of a given group of human beings. However, certain activities could cause undesirable side effects, leading to unexpected changes in the environment, unless they are carefully planned and executed. They may also give rise to irreversible processes, causing deterioration of the desirable balance of nature.

All water resources development projects have social and environmental implications. The environmental impacts of irrigation projects in India vary greatly with the physiography, climate, soil, the characteristics of river flow and the size of the irrigation project.

Irrigation projects invariable change the river flow characteristics and eco-system regimes of the command areas. Different types of ecological impacts may be observed in the areas occupied by the reservoir at the headworks of the project, downstream from the headworks in the original river course, along the routes of the canal system and in the extensive irrigation command areas. It is essential that all these factors are properly assessed and suitable safeguards and provisions are incorporated in the design of the irrigation system.

The analysis presented in the various sections of this paper reveal an urgent need to improve the performance of our irrigation systems. There is a vast scope for increasing the efficiency of on-going projects and ruture ones. It should be realised that irrigation system planning and management can no longer be considered to be confined within the traditionally established organisational framework on the structural and hydraulic aspects of storage and diversion of water and its conveyance through a network of distribution systems upto the outlets. It is actually a multi-disciplinary programme aimed at increasing agricultural production in a region without any adverse influence on the productivity and or the environment of the region. The core disciplines in a well planned programne of irrigation development are civil engineering, agriculural engineering, soil science, agronomy, climatology, economics and social science. The supporting disciplines are plant and animal sciences, including plant protection and forestry. Unfortunately, the lack of appreciation of the inter-disciplinary nature of irrigation has been one of the major factors which have contributed to the poor performance of irrigation systems. A break-through in increasing through efficiency can be achieved only through deparature from traditional methods and adoption of modern scientific planning and management techniques, giving due importance to the various agencies which could contribute in this important endeavour.

Economic Growth and Innovative Entrepreneurship in Rural Development: Issues in Rural Energy

Dr S G Ramachandra

Past President,
The Institution of Engineers (India)

The Bhaikaka Memorial Lecture has for the past eleven years provided an opportunity for professional engineers to look at the country's development process from the point of view of the engineers role and involvement in development. Distinguished scientists and technologists have been invited to deliver the previous Memorial Lectures. They have extensively covered subjects such as appropriate technology, rural engineering, choice of technologies, importance of irrigation, the impact of ecology, biomass energy, etc. I have been personally present to listen to those distinguished speakers on most of these occasions. All these lectures have set in motion a process of introspection on the role of the professional engineer and his attitude towards economic development. Some of the activities of the Institution have also been influenced by these lectures. A continuing debate has resulted in organising national and international programmes on the subject of low cost sanitation, organisation and water management, rural engineering, etc. To some extent, these Seminars have brought together large number of Indian scientists and technologists working in the areas of rural development.

The Early Efforts:

My mind goes back to the history of rural development. India was always a confederation of large number of rural settlements politically, culturally and economically self reliant, the national spirit however, manifesting itself more on account of the cultural commonalities. Politically, the country suffered setbacks in the 18th and 19th centuries. The beginning of the 20th century, however, brought a few stalwarts into the Indian political and administration scenario. I would like to refer particularly to the concept of economic development as was visualised by the father of the nation Mahatma Gandhi. Just before Gandhi started propagating the concept of decentralised rural development, we in South India had the unique experience of being ruled by a benevolent ruler who entrusted the responsibilities of running the administration to an Engineer Statesman Sir Mokshagundam Visvesvaraya.

Sir M Visvesvaraya joined Mysore service as Chief Engineer on 15th November, 1909. Later in November 1912, he assumed office of Diwan of the State. He continued in office till the end of 1918 and later he was actively involved as adviser to the State Government on many important issues. All of us engineers are familiar with the importance Sir Mokshagundam gave to organising rural industries and technological education based on the needs of the country. His inter-action with the political leadership of the times particularly with Mahatma Gandhi and Pandit Jawaharlal Nehru brought into focus the concept of planning for economic development. In this planning process rural development assumed great importance after the country became independent. The basic object of growth in the country has been to improve the living standards of the rural poor. After nearly 40 years of independence and six plan periods the country is struggling to evolve a satisfactory planning model to achieve the basic object of planned development. The best brains in the country have contributed to the formulation of policies. However, at the current moment,we find that in implementing our plans we do not appear to have obtained the required degree of success.

The Current Situation:

Many economists have looked at the problem of rural development both in India and abroad. Planning models in many countries have been influenced by such studies. Experts like Peter Drucker and Professor Schumacher have proposed their own concepts of planning for economic growth. I would like to quote Peter Drucker "Contrary to all the expectations, global agricultural output actually rose almost 1/3 between 1972 and 1985 to reach an all time high. It rose the fastest in less developed countries. Similarly production of practically all forest products, metals and minerals has gone up between 20 to 35 percent in the last 10 years, gone up again with the greatest increase in less-developing countries. There is not a slightest reason to believe that the growth rates will slacken despite the collapse of commodity prices. Indeed, as far as farm products are concerned, the biggest increase at an almost exponential rate of growth, may still be ahead".

The spectacular developments in the field of agriculture and diarying have been the results of concerted planned activity with well monitored technology input. The current scientific trends in the field bio-technology may provide further impetus for the growth rate of the countries with a strong agricultural base.

During the same period technology has influenced a process of change in the industrial economies of the world. Product design today has resulted in dropping the raw materials intensity of manufacturing process and also the energy intensity of the process. To quote one classic example, to produce 100 pounds of fibre glass cable used in telecommunication requires no more than 5% of the energy needed to produce 1 ton of copper wire. Similarly, new materials have reduced the demand for steel. The new materials are less energy intensive and consequently have brought down the prices of manufactured goods.

The structural change of this nature is bound to effect the economies of the developing countries, Our growth strategy cannot be based on low labour costs. The industrial policy alongwith our agricultural strategy needs a new look so that we can sustain higher productivity on the farm without disturbing the price stability. In this context, the sensitivity of the market for price fluctuations may have to be regulated. Two examples that I can quote in this context are the distress in our agricultural operations concerning cotton, collapse of the cotton prices and sickness of the textile industries. Similarly the agricultural operations connected with sugarcane, the health of the sugar industries are matters to be reflected. Keeping in mind the international trends and technology it would be necessary for us to review our entire strategy for maintaining sustained growth rates in our agricultural economy and establish strong linkages with industries, processing agricultural products.

The country has built an organisation structure for the last 40 years to have an effective control over the economy. The entrepreneurs of early 50s and 60s experienced an atmosphere of growth and the entrepreneurs of today are entering the field in a more competitive enviroment. More risks are involved in today's enterprises. Better management skills are required to manage the complex situation of today. The solution to some of our complex problems may be less and less governmental interference. We see this process of change already set in motion.

The Basic Issues:

Let us examine some of the basic issues arising out of this situation. The process of modernisation which the country has chosen to adopt — Where will it lead us? What kind of economic change will it bring? How will it affect the society? Will the kind of institutions we have, the skills and attitudes and value systems help us achieve our goals?

The 7th plan document declares "Government has to play a major role in the development process in order to promote the interests of the poor, reduce disparities in income and wealth, curb regional inequalities in the level of development, protect the environment, strengthen the scientific technological base for long term growth and safeguard the interests of future generations. These are matters which cannot be left to the free play of market force. Purposive Government intervention in these crucial areas is central to our growth strategy".

Rural development has succeeded only where the entrepreneurship of the individual coupled with innovative skill had an opportunity for a free play. The role of the Government should be limited to a catalytic action. Agriculture and Diarying are two examples where at the lowest operating level of the management there has been no governmental interference of operations in the production process, I hope the policy makers will not miss this essential feature of our success stories. There is hope that the Government will keep this in mind for in the same document states 'Planning for an accelerated growth in a country of India's size and diversity, must have built-in flexibility to cope with the many sources of uncertainity which characterise modern economic life. To add to the effectiveness of the planning process, there must be an adequate emphasis on decentralisation to provide the needed element of built-in flexibility as well as greater involvement of people at all levels".

The Seventh Plan Perspective:

The data provided in the 7th plan documents brings into focus the rural urban dichotomy. India today has an estimated labour force in the age group 15-59 of 269 million persons — 77% of this labour force is in rural areas. In addition,we have potential labour force of 193 million people below 15 years age excluding children below 5 years. This figure is projected to grow by the turn of the century to about 380 million in the age group 15-59 years and 417 million in the age group 5-15. At the turn of the century, the rural population would be only 65% of the total labour force. Such movements of population will create difficulties in urban planning also. Rural development therefore, becomes a vital issue to regulate the population shift.

The plan document also brings out another important issue — the disparity and the inequalities between Rural India and Urban India. This is an explosive situation. It can one day burst into a major conflict. The Institution of Engineers (India) in the early 80's, was involved in serious debate-in the planning commission on this vital issue. The then Deputy Chairman of the Planning commission Dr. MS Swaminathan invited the President and few of his Council colleagues for examining the question of making our plan investments far more productive in the rural areas. A major part of the plan investments was on rural development projects whether it be agriculture, water resources development, rural communication, organisation and water management, rural housing, rural public health, etc. The planning commission was trying to analyse the issue of total involvement of the people and the agencies in improving the effectiveness of the programmes. These discussions could not be continued due to the reorganisation of the planning commission. I would however like to suggest the Council commission an independent study to find out the extent to which a professional engineer is involved in the implementation of development schemes? What is his current goal? Can he change his attitude and approach to make our investments more productive and in the process try to find out whether there is a need for any structural changes in the engineering organisations at the state level. There are a few more related issues which a study of this nature can bring about. In this context, I would like to quote Sri RN Haldipur, a distinguished civil servant who after retirement headed an Institute of Rural Management: "Does rural development lead to employment making people a part of the production process? What kind of institutions emerge and how can we refurbish them? Do the programmes subserve the interests of those for whom they have been conceived? Can the very small surplus generated by the rural poor be processed and marketed by their own organisation, giving the individual members a stable and remunerative price and not expose them to distress sale. When we survey the development scene, we find that benefits of economic growth hardly trickles down to the poor. On the contrary, it has often been accompanied by a rapid rise in the cost of living".

Technology: Technology has no power to transform their lives. The fact of life is such innovations — which certainly deserve notice and need to be promoted — add value to things and therefore even the throw away articles which were valuable to the poor have now become inaccessible. Further, technology has become one more unmanageable factor in their life". Such views reflect the anxiety of the thinking people of this country about the inadequacy of our development process with particular reference to rural development.

With the background that I have discussed so far, I would like to examine whether there are any alternative models which would result in our achieving our objective faster. Inspite of the very highly centralised organisational set up the Government has in our country, India continues to be a very highly decentralised structure of society in which the individual's entrepreneurship and innovative skills have given results. In fact, it will be correct to say that the progress we have achieved so far is only due to this spirit, which has stood the test of time.

Role of Technology:

The future development of both agriculture and industry, will require increasing application of science and technology so as to increase factor of productivity. Arrangements for access to technology, adaptation and absorption of technology in practice, linkages with sectional R&D facilities need to be improved. Changes in the pattern of education to make it more vocation oriented to help absorption of technology is also essential.

Agriculture coupled with water resources management, development of industries allied to processing of agricultural produce and our mineral wealth, development of the infrastructure in environment, public health, energy, habitat, improvement of communication to markets are all areas where technology input can upgrade quality and productivity. The different divisions and disciplines in the Institution are no doubt looking into several aspects of these issues for many years.

For purposes of discussion, I will choose only one area - Rural Energy.

Rural Energy Scenario:

A system approach to Rural Energy Scenario has so far not been attempted. The studies done so far have concentrated either on the present pattern of consumption by types of fuels, sectorwise or concentrated on the domestic or house-hold sector, which is dominated by the use of non-commercial sources of energy. The studies done by different sample surveys, NCAER, the planning commission, the development economists all reflect the concern for the inadequacy of the data base. However, the available data point out to some action in planning energy development for rural use.

The four dominant segments of energy use in rural areas are:

1. House-hold or Domestic Sector
2. Energy used in agriculture including water pumping, fertilizers, farm mechanisation and other inputs to agriculture
3. Energy used in industries and establishments in rural areas
4. Energy consumption in transportation.

In the total consumption of energy in the house-hold sector, the share of non-commercial energy is very high — as high as 80%. The Advisory Board on energy has made estimates based on the assumption that a minimum of 620 K. Cals are required for cooking, 30 K Cals for space heating and 30 K Cals for lighting. Based on these assumptions, the requirements of non-commercial forms of energy by 2005 for an estimated population of 1000 m is as follows:

Estimated Energy Requirements for 2005 AD of Non-commercial Fuels

Fuels (mil.Cu.m)	Millions of Tons
Fuelwood	300
Veg/Agri waste	90
Animal Dung	199
Gobar Gas	169

These figures show that in physical terms the requirement will be 21/2 times the current level of consumption.

As a result of policy changes and the changes in the economic levels, interfuel substitution is taking place. The commercial fuels are slowly replacing the non-commercial segment. The present pattern of use of commercial energy in rural areas is as follows. Kerosene is preferred for lighting, soft coke and charcoal for cooking and space heating. Electricity is more economical for lighting in view of the subsidised tariff of the State Electricity Boards.

The Agricultural Sector:

The bulk of the energy used on the farm today is made up as follows.

Draught Animals ;	20%
Human Labour ;	6.5%
Diesel Operated Equipment — including sprayers, etc:	32.5%
Electric motor operated devices ;	41%

In this sector, the interfuel substitution is taking place — draught animals being replaced by tractors and tillers and diesel pumps being replaced by electric pumps. The pressure on increased supplies of kerosene, diesel and electricity in rural areas is an indicator of this trend.

In the rural industries and transport sector, it has not been possible for any of the research groups to make a realistic forecast. However, the emphasis on decentralisation of industries and dispersal to rural areas, the expanding markets for LCV's and the commercialisation of the activities in small towns. Spread of technical education are all resulting in innovative entrepreneurs going to rural areas for establishment of service centres. The spread of diary farming, sericulture, automobile service centres, agricultural machinery service centres, all these are increasing the demand for skills and commercial energy in rural areas. The village blacksmith is slowly being replaced by a village mechanic. As industry also begins to move into non-urban centres, there will be an increasing demand for construction activity including housing, public health facilities, resulting in demand for commercial energy, particularly for electricity and petroleum fuels. This trend will continue during the next two decades, if our agricultural production keeps growing and alongwith it our GDP.

The Official Line

Sri Hiten Bhaya, Member, Planning Commission in his Mokshagundam Visvesvaraya Lecture last year stated

"Meeting the burgeoning requirement in both fuel wood and animal dung of such magnitude is a formidable task. As most of the non-commercial and nonconventional sources of energy will primarily be in rural areas, there are problems other than technological. As long as the purchasing power of the rural people remains low, any form of commercial energy will need subsidization which the country can ill-afford for a long period. It also needs acceptance of a changed pattern of life. Community biogas plants have not been a great deal of success so far. Individual biogas plants have not been viable for persons owning less than four heads of cattle and such households are very few in rural areas. Energising rural India has, therefore, both socio-economic and technological challenges".

Where do we go from here? Do we accept the official line and let the situation take care of itself?

The complex total rural energy system is indicated in Chart I and Chart II. The transition from the existing usage pattern to the possible future usage pattern would involve strategic planning and injection of technology and innovative skills in energy using methods and hardware. In addition changes in energy organisations become necessary.

Non-commercial energy today is available to the end user directly by his own organisational effort. He locates the source, collects it and uses it. It has no assigned commercial value except in kilo calories. But we can value it by equivalent quantum of commercial energy for equivalent kilo calories. The user will have to acquire that much purchasing power, either through wages earned or sale of his produce or services. In other words if there is a correct assessment of the value of the services rendered by the rural poor for the productive sector, his wages should be adequate for him to enable him to buy an equivalent commercial energy for his level of survival. We must determine this value. Otherwise we will be compensating him through subsidies.

The rate of substitution to commercial energy is also a function of the level of compensation to the rural labour. When we are talking of the rate of growth of demand for electricity or petroleum products we are essentially coping up with the rate of growth of GDP due to economic development.

Do we want to accelerate this rate of Growth? Yes — that is our goal and that is the area for technology innovation. Enterpreneurship, innovation is possible only when an environment is created for this. The highly centralised management system of the commercial energy organisation of today does not initiate a process of change. There is no accountability for the inefficiencies of the system and consequent losses. Can we build a decentralised energy organisation which will be responsible for supplying to the village all forms of energy in an integrated system? This organisation can develop local resources and if they are inadequate arrange to procure the energy from another supplier and distribute it to the consumers at a price. The experience of rural electric co-operatives, milk co-operatives give us hope that such a system works. In an integrated rural energy system, the management concepts will be service oriented and will lead to more interaction with the consumer.

Conservation: Efficient use of existing energy sources will have to be a part of our culture. The present methods of energy use need review. The innovative work of a few heat transfer specialists in the country has resulted in improving the convertion efficiencies of cooking stoves. These designs are now being adopted by a large number of users saving over 50% of the fuel they were normally using. As contrast to this, the organised industry has supplied pumping systems, both run by diesel or by electric motor, where energy conversion efficiencies is less than half of what they should be. There is no organisational mechanism to initiate a process of change to prevent further proliferation of installations of inefficient pumping units. This is a typical example of our inability to handle change. This is partly due to multiplicity of agencies involved in engineering of the system and procurement of the system. The resulting energy losses and consequent financial losses are borne by the tax payer. There is no accountability in our present management structure. If however, a decentralised agency with accountability for profits, would tackle these, the country would derive enormous benefits.

Biogas technology is another area where the Indian experience is not very satisfactory. Too many designs without adequately taking care of local conditions have resulted in large number of installations which are inefficient. The recent audit report of the KVIC highlights this aspect. Biogas plant needs a very hard look by the designers so that more efficient operations of this unit is made possible under varying regional conditions.

Kerosene is a highly inefficient source of lighting energy. Substitution of the use of kerosene by electricity should be encouraged. For this purpose, development of decentralised source of energy supply should be designed, installed and serviced as a national programme. The present practice of providing electricity for lighting from the national grid is resulting in wastage of energy due to transmission and distribution losses. Also the system is not reliable in rural areas.

Development of local resources:

The local energy resources, if any, such as mini /micro hydels, use of local wood waste for running gasifiers, generation of electricity through co-operative schemes, should all be developed with the involvement of the community. The maintenance of the system should also be the responsibility of the local community. Such organisational set up would result in optimisation of resources and give better economic return.

Energy for water pumping could also be provided from a decentralised source generating electricity. Where renewable sources of energy afford economic options, they must be adopted. The present capital intensity of the photovoltaic route does not give much hope of its adoption in the next two decades. However, mini hydels, wood gasifiers, biogas units for purposes of electricity generation have broader chances of economic viability.

Organisation Structure:

One of the basic reasons for slow adoption of new ideas is the organisation structure that the country has built. Over a period of time,a highly centralised structure has developed. There is a case for considering a single organisation for meeting of rural energy needs at the taluk level to begin with. It is also desirable that this organisation is managed by the local co-operatives so that the concept of ownership and accountability will help achieve better operational results. Some of the rural co-operatives for electricity distribution have done their given work.

Strategic Planning

The success of our development efforts,to a large extent,depends on strategic planning by which we are able to generate better economic resources. This plan would call for higher productivity on the farm, stabilised agricultural prices, assured market for agricultural products, introduction of industries based on agricultural produce as a raw material, better vocational education and training in rural schools, etc. To achieve significant results we may have to have a hard look at the loose structure of the present organisation. I suggest that the Engineering Staff College of India undertakes a serious system study and suggest different organisational modules which will integrate the efforts of the various development agencies. While governmental funds will continue to be the main source of financial resources, the organisation, planning and initiative must be left at the local level. Some of the studies done during the last few years by many of our research workers in the area of rural management provides adequate data for analysis of this nature. The ultimate objective should be to develop adequate surplus for reinvestment.

In the model adopted for development in the past we have made one assumption that the consumer market is dominant in urban areas. While this is true in terms of volume, the potential however exists in rural area. To tackle the twin problems of providing employment at the local level and also generate increases in purchasing power, we should seriously consider shifting our units of production which are labour intensive to the source of the raw materials and transport only, the finished product to the nearest market. Just as we produce our food on the farm the processing of farm products, forest produce and mineral wealth, should all be done very close to the source of raw materials. The concept is not new. We generate electricity at the pithead and transmit it to consumption centres. Our strategic planning should bring about this change.

There are many individuals who are not only attempting but initiating change in rural area. I have read reports about some of our engineers setting up in rural areas, hitech assembly units for assembly of Television sets and in the process create employment and purchasing power bringing about a perceptible change in the quality of life. People in West Bengal must be familiar about the Rangabelia experiment initiated by a school master Sri Tushar Kanjilal with the active support of a very dynamic official in the state agricultural directorate. A few individuals working together highly motivated have been able to establish a chain of non-formal education centres spread over 28 villages. In 1976 the per capita income of Rangabelia was Rs. 500 and today it is Rs. 1040/-. Rangabelia today has schools, roads, hospitals, sanitary latrines, piped drinking water all built by villagers, who had not even heard of many of these things decades ago. I quote this example of a success where entrepreneurship, individual initiative of a few individuals has brought about desired change.

Similarly, the example of the work done by Sri Vilas Balwant Salunke, an engineer, in the drought prone district of Pune needs to be mentioned. His work relates to water management and soil conservation on a 16 acre barren land taken on lease from a temple. He adopted a strategy of optimising the use of water in both good rainfall years and poor rainfall years, by construction of tanks, reservoirs, barrages and percolation tanks. He harnessed the water directly from these storages and also by digging open wells fitted with pump sets. In three years the food grain production increased from 10 quintals to 200 quintals. Number of crops per year also increased.

The success of this experiment led to formation of co-operative projects involving local people leading to 62 schemes, with 1800 families over 1500 hectares. He has been recognised by the society by conferring the Jamnalal Bajaj Award for this year. We need more engineers of this type, in the tradition of Sir M Visvesvaraya.

The decision of the Institution of Engineers (India) to set up a rural development forum and a water management forum, will enable engineers all over the country to initiate similar process of change. This can happen provided our engineering education and training focus the attention of our young engineers on the harsh realities of our rural economy. Our new education policy, I regret to say, completely overlooks these linkages with any vocation, entrepreneurship and innovation. I plead that the authorities of the Engineering Staff College to develop a suitable education and training module with a view to initiate change in rural areas. I trust, such an approach will make the rural economy self-reliant for resources for development, reduce the cross subsidies and accelerate the development process.

Let me conclude by quoting Peter Drucker from his recent article.

“Can we learn something from India? Everyone knows of India’s problems — and they are a legion. Few people seem to realise, however, that since independence India has done a better development job than almost any other third world country. It has enjoyed the fastest increase in farm production, and farm yields......... , the emergence of a large and highly entrepreneural middle class and arguably, the greatest achievment in providing schooling and health care in the villages..... India has followed a policy of strengthening agriculture and encouraging consumer goods production. India and its achievements are bound to get far more attention in the future”.

Thanking you.

CHART I

RURAL ENERGY SYSTEM

SOURCE			
Solar Heat Animal Power Diesel Power Human Power	Animal Power Diesel Power Human Power Electricity Power	Animal Power Diesel Power Electricity for Industry	Solar Heat Firewood – Wastes Dung – Cattle Kerosene Electricity
END USE			
Agricultural Operation	Water Pumping	Transport Industry	House-hold
APPLICATION			
Ploughing Harvesting Thrashing Drying			Heating Cooking Lighting
OWNERSHIP			
Individually owned system	Individual or Group	Individual or Commercial Service	Individual System Community System

CHART II

Technology Options for Rural Energy Development

1. Renewables – **Resources**

Photosynthesis	– Solar Route
Afforestation	– Energy Plantations Social Forestry
Conversion	– Direct – use – Charcoal – Gas – Tar – Bio mass – Gasifier – Electricity – Engine – Mechanical Power
Solar Thermal	– Low Grade Heat – Concentrated Heat – Conversion to Steam – Electricity Route
Photo Voltaic	– Electricity – Storage Devices
Wind Energy	– Direct Pumping – Pumped Water Storage – Electricity Route
Hydro	– Large Systems – Mini/Micro decentralised system
Agro Wastes	– Bio-mass – Animal Fodder
Animal Dung	– Bio-gas
Animal Energy	– Optimization – better breeding – Veterinary Science

2. Technology for Energy Storage

- For making Solar, a continuous Source, Absorption – Chilling
- For Wind, continuous source
- Tidal a continuous source
- Parallel operation with large systems
- Battery technology – Solar – lighting

3. Non-Renewables

- Coal/Lignite
- Low Grade Oils
- Refined Petroleum Products

Kerosene	Direct use or Convertion to
Diesel	Mechanical Power/
Petrol	Electricity
Naphtha	Fertiliser
– Gas	– Fertiliser – Electricity

4. Electricity

– Secondary – Accepted as most convenient form of Energy
Feeding from the grid
Decentralised Systems
Good System design – Transmission, Distribution and utilisation

5. Technology for Efficient Energy Conversion & use

- Chula – Use of low grade heat
- Gasifiers, sterling engine
- I.C. engines, efficiencies
- Electrical apparatus/systems
- T & D Systems
- Conservation of all types of Energy
- Solar heat to Reciprocal motion
- Good System design for high efficiency and Reliability in service

6. Economic options

Economic Viability
Capital Intensity
Rate of return on Investment

Improve purchasing power to make transition to commercial Smoother
Development of Decentralised Systems for servicing rural energy needs managed by consumers
Attach Value to all energy – Kilo Calories
– Rupees/Unit

7. Technology

is successful only when Economically viable
– This can happen with Entrepreneural Skill – Innovation – Technovation
– Our efforts should not stop with prototypes to prove Scientific Principles of energy conversion.

Farmers Participation in Irrigation Water Management

Shri Amarsinh Chaudhary

Chief Minister
Gujarat State

Dear friends,

At the outset, I must express my deep sense of gratitude to all of you and the Institution of Engineers (India) the organizer of this coveted Bhaikaka Memorial Lecture series. I have chosen to talk on a subject in which Bhaikaka took keen interest. The subject chosen is “Farmers participation in Irrigation Water Management’. The name and fame of Shri Bhaikaka is very well known to everyone at least in the engineering fraternity of our country. He was a great Engineer and builder of massive irrigation projects during his active service and thereafter his contribution for building up full-fledged Sardar Patel University in Gujarat is of immense value to all of us even today. He was an engineer as well as politician of his time. He was also an ardent scholar of ancinet history and he loved rural life style being himself basically, a farmer. It is a very happy coincidence that the year 1988 i.e., the current year happens to be a centenary year of Shri Bhaikaka.

During this year, the Bhaikaka Foundation, a charitable trust has decided to launch a massive Action Plan for uplifting the rural life of the country, a cause for which Bhaikaka lived. Being myself also, an engineer, farmer and politician, it is my proud privilege to be with you who represent the best engineering talent of the country.

(2) The subject on which I have chosen, to share my thoughts with you, is really thrilling because it directly relates to water, source of all living being. The major portion of utilisable water resources of any country is consumed by agricultural activities for producing food, fodder and other crops. Since ages, man is very conscious about efficient use of water for his own survival and it is common experience that even severe most scarcity and drought conditions which occur more frequently in recent times have been successfully tackled by man. Irrigated agriculture has been assigned very high place in our national planning. As you are aware, only recently i.e., in September, 1987, Govt. of India has come out with a comprehensive document on National Water Policy. I am happy to bring it to your notice that out of 20 points short listed in this policy documents, ‘participation of farmers and voluntary agencies in Water Management’ is also included as one specific point. This shows the high level of recognition this issue has acquired even at the national level. The said document interalia categorically mentions that;

“Efforts should be made to involve farmers progressively in various aspects of management of irrigation systems, particularly in water distribution and collection of water rates. Assistance of voluntary agencies should be enlisted in educating the farmers in efficient water use and water management’.

(3) It is in this national context that we have now to evolve an action plan for implementing the policy decision in this regard. I would therefore urge all of you to bear with me for some time during which I wish to deal with some details about the action plan which all of us can consider together.

(4) Much has been talked about this aspect of farmers participation in irrigation water management, but very little is really done to implement the same. There is no doubt that all the schemes for use of water which Govt. undertake are for the benefit of the people and if people participate in such schemes more effectively, the benefit of the schemes will definitely increase manifold. We have therefore to consider the reasons why the beneficiaries’ participation is not coming forth. Once such diognistic analysis is made, the real remedies can be evolved. It is common knowledge that for any group activity to sustain itself for a long enough period, there must be a common interest. Water for Irrigation is one single input which can serve to provide a common interest for group formations. Therefore, we should keep this precious water in central focus all the time and consider how it can be profitably utilised as an effective tool for promoting and fostering farmers’ participation. In other words, farmers will have to be made to realise the importance of water which is a very very scare national resource. Farmers should also be made to realise the value or price of this input for which huge public investment‘is made by Govt. Thus irrigation pricing policy finds direct relation to the farmers. participation on flow irrigation schemes which consume lion’s share out of utilisable water resources of the country, because the present method of charging irrigation water rates on crop area basis is not related to the volume of water consumed by the farmers. Besides the water rates are also very heavily subsidised. The consequential effect of these two factors is that the farmers tend to waste water more than they really need or use for their crops. Therefore, the first and foremost requirement for bringing farmers’ participation in irrigation water management on a mass scale is (a) to increase the level of irrigation water rates so that the farmers feel the pinch if the water

is wasted by them and (b) the method of charging the water rates should be directly related to the volume of water supplied for irrigation. Now it is very well known to all of us that because of the very nature of our large and small flow irrigation systems, it is almost impossible even to think of precisely measuring the volume of water consumed by each individual irrigator. The average farm size being less than a hectare, the number of irrigators is also so large that rendering irrigation service to individual becomes almost impossible. Therefor, it is out of dire necessity also that we are called upon to think of making irrigation service available only to small or big groups of farmers and not to individuals. It is pertinent to note here that small ground water schemes of private sector which are owned and operated by farmers themselves, cover at least fifty percent of total irrigated area and on these schemes, the farmers spend almost ten times more on water charges compared to flow irrigation schemes and therefore their efficiency is also very much higher. In these schemes owned and operated by farmers themselves, they care for every drop of water and because of their total involvement in management, the operational cost is also much less compared to flow irrigation schemes run by Govt. It is this vexed problem with which we are all confronted today and for the solution of which | would now like to offer a few concrete suggestions for your consideration, for bringing about farmers participation in large and small flow irrigation schemes of public sector.

(a) It is said example is better than precept. Implementation phase of any policy is, therefore, crucial and most imporiant of all phases. The strategies for implementation deserve more serious consideration. It calls for more active participation at all levels in Govt. Depariments and also of the farmer beneficiaries. This process of involvement of all concerned should therefore be a first and foremost step for designing the strategy for people's involvement in management of large irrigation schemes. Since we are at the initial stage of massive experiment, unparalleled in size and complexity in any part of the world, we should be cautious and alert all the time to ensure that we are not tied down by any preconceived notions or rigid rules or guidelines. We have to deal with a variety of situations and we must allow full freedom and flexibility both at the stage of consideration and also for implementing even on trial basis.

(b) Conviction about the necessity to bring about a change is a must at all levels. This should begin at home because those who possess some authority in water management today will be called upon to part with it either wholly or partially and transfer the same to groups of farmers. This is not an easy task at all. In fact, it is this inherent tendency to stick on to power, which has so far acted as a deterant in making any appreciable progress in devolving the management of irrigation schemes to farmers. Even those who are at the helm of affairs in deciding policies have to exhibit will to shed and share their power and authority with others. Only then the policies containing all good ideals would not fail in implementation phase. A large number of subordinate officers are apt to follow the generally implicit or explicit behavioural pattern of their big bosses. Many times various institutions or organisations are created and thereafter they deteriorate and stagnate over time for want of adequate authority or autonomy. A well designed extensive training input for all in service personnel should therefore be considered essential for developing a. sense of dedication and devotion amongst politicians, social workers, administrators and members of farmers community as well.

(c) No where in the world, except India, Government has undertaken responsibility of making irrigation service available individually to lakhs of small holders of land — of about half hectare on an average. Even in most developed nations, this service from Govt. or any such Federal body stops at 500 or 1000 hectares within which the farmers manage irrigation supplies on their own. In Our country it is now becoming increasingly difficult to continue to manage upto each individual field without loss of efficiency and quality. The funds available for maintaining the quality of service are also thinned out because of very poor returns in direct monitory terms from the service provided to the beneficiaries. Until recently, we used to deliver water upto an outlet covering about 40 to 50 hectares and farmers used to manage on their own within this 50 hectare block. The responsibility of construction 42nd maintenance of the system below 40 hectares was also on the users. Of late, particularly after the advent of World Bank loan assistance becoming available on large scale for such projects, we are extending canal net work upto 8 hectares. Some States are also constructing water courses or field channels upto individual fields at project cost. The responsibility of not only of construction of system below 40 hectares but also of maintenance upto 8 hectares has come to Govt. The length of the system has more than doubled. The attention needed in terms of staff, and monetory inputs for proper maintenance has also increased substantially. To ensure supply of water to each field, we have engaged a large fleet of persons. Now a stage has come, when it is difficult to set apart any appreciable size of funds for the proper upkeep and maintenance of the project because almost 70% of the total fund available as per the set norms for operation and maintenance of such projects, get consumed only on wages and salaries of establishment leaving hardly anything for maintenance of the assets created through massive public investments. On the other hand, farmers are reluctant to shoulder any responsibility because they are getting irrigation at almost no cost and without any effort. More particularly those who are in the head reach of canals not only take away lion's share at the cost of all others in the middle and tail end commands, but they also oppose tooth and nail any effort to form farmers groups with an objective of ensuring equitable Supply of irrigation to one and all under the command of each outlet. These farmers who receive lion's share are not prepared to forgo the same. Though they are very few in number, they command a very strong hold in the poor community. Govt. subsidies in irrigation alone are of the order of Rs. 3000 per hectare every year which only a few continue to enjoy. It is a concealed subsidy which everyone fails to reckon and realise. Such is the paradoxical situation we are in today and we must realise that it is the result of wrong practice of spoonfeeding a few for a very long time. It is the result of a very heavy overdose of almost free irrigation and therefore its corrective measure must be a bitter pill. But it has to be sugar coated to be palatable. In their enthusiasm of bringing about any change, the policy makers should not be dragged in any illusion of granting more and more incentives in kind or cash beyond reasonable proportions for formation of farmres groups for water management. A stronger dose of disincentives can be equally or even more effective than direct incentives. Therefore in addition to withdrawing concealed subsidies, we must start forcing disincentives with a view to motivating the farmers to form groups, which ultimately will result not only in individual gain but also for the entire farmers community and the people at large. Economic use of water will thus spread the benefits to more number and to a larger area.

(d) In the initial years, massive and well coordinated effort will have to be planned and put in for inducing farmers to manage the systems. Some norms for having dialogues within the departmental all levels and with specifically preidentified group of farmers will have to be evolved. These norms should provide broad guidelines for conducting these meetings and also the frequency and duration for all levels of interaction. Engineers are not always suitable for this purpose. A catalyst is however a must and even if he is recruited from outside, he should be thoroughly trained for this specific job before he goes out to farmers and wins their confidence. Even canal karkoons and village level extension workers with proper training could be useful. Some voluntary organisations and institutions or cooperatives already established in villages for any other activities can also be profitably utilised to develop linkages to form farmers groups for irrigation.

(e) Hetrogenity is a basic consideration for formation of good groups. However, from the point of view of efficient land and water management, hydraulic boundary determined by canal net work should be considered in preference to a village boundary.

In both the alternatives, objective is common and therefore, one has to strike a balance judiciously in each case. This calls for not only thorough and indepth study of existing and planned net work of the entire canal system both at macro and micro levels, but is requires thorogh and intimate knowledge of socio economic pattern obtaining in each village or in each different group of people in a village which can be classified for its capabilities to work together for a common goal. In hard cases, the social scientists may have to struggle for bringing about desired level of harmony between otherwise warring groups of people.

(f) The necessity of administrative reforms and legal backing for enforcing group behaviours and discipline in irrigation water management should also be given due recognition. The existing procedures and rules should be simplified and made compatible with the objective of involving farmers in water management. The farmers should be given power and authority also and not only the responsibility.

There may be cases where people are not willing to take responsibility even when powers are given. One can come across cases when even powers without responsibility may not be welcome by the people. But still one has to persue and work up to meet the goal.

The amount which is spent normally for O&M by the department can also be passed on to the farmers groups either fully or partially depending on the degree and extent or nature of responsibility passed on to them. Flexibility should be inbuilt in all such modified provisions of rules and administrative orders. Equity in water allocation to all farmers in the command area would perhaps need to be enforced through statutory provisions. The provisions of rules should be clear straightforward and without any ambiguity. No options should be provided to enable continuing the existing practice, otherwise, like any one else, the farmers may always prefer soft options and never adopt new concepts. Law should specifically stipulate that irrigation water shall be given only to groups and never to individuals. Group of about 500 hectares is desirable. However, where it is not possible to begin with, minimum size of such groups should be stipulated as about 40 to 50 hectares or a block under command of each outlet of the canal system. Detailed provisions should also be made in the rules to enable formation of second tier organisations either at a village level or at minor level commanding about 500 to 1000 hectares. Similar enabling provisions should also be made in the rules for an Apex body or Federation of second tier organisations to be formed at the project level commanding an area of about 10,000 hectares. For still larger projects a Union can be conceived to govern various apex bodies or three tier organisations. Even a corporate body under the Campanies Act, can be envisaged with all flexibility and freedom to determine and recover the water rates from the beneficiaries coupled with responsibility and accountability for ensuring social equity in terms of water allocation in proportion to the holding of land under the command of irrigation schemes entrusted to such corporations or similar organisation, on a long enough lease of say not less than 30 years.

(g) In new projects, Farmers' involvement is desirable from the stage of preliminary investigations, survey, design and planning and it should not only continue but should be made more and more intensive as we run through all the subsequent phases like construction, operation, maintenance, etc. throughout the life of the project. Norms and detailed guidelines need to be laid down in consultation with farmers for their effective and lively interaction with officials at all levels and also with policy makers. Consultation with farmers for selecting the best alignment of field channels and water courses and for deciding water allocations to ensure equity are likely to yield good results. Likewise they must have their say in preparing schedules for Rotational Water Distribution under each outlet and also in deciding the overall running of the entire canal system in each season in accordance with crop pattern and crop intensities best suited from agroclimatic and socio-economic considerations. In old projects as well as for projects which are in progress at various stages, the involvement of farmers has to be introduced as an inbuilt component of implementation plan.

(h) With new technologies and hybrid varieties of crops pouring in, the farmers should also keep pace in adopting them. Otherwise we will lag behind in the race, compared to other developed and developing nations. The component of farmers training should therefore be reckoned as an integral part of the programme of involving them in water management. The farmers have a crucial role to play in improving the water and land. The technologies like lift, sprinkler, drip and drop irrigation which consume less water for same or even more production will have to be adopted in large areas even in command areas of canals. Direct irrigation through canals will have to be minimised as it involves lot of waste of water. Even with the best canal system and it’s operation with excellent — infrastructure of onfarm development works, the optimum efficiency of water use can not be expected to rise above 60 to 70%. Water use of efficiency of other methods like lift, sprinkler, drip and drop is high compared to flow irrigation schemes. The farmers will have to be trained to adopt new methods of irrigation and appropriate land preparation for each one of them for different crops. Massive adaptive research need to be launched to demonstrate the effects of these techniques, as farmers would believe what they see. All these call for a well organised and coordinated effort. Awareness amongst the have-nots about their legitimate expectations from the irrigation schemes would also help in accelerating the process of cooperation.

(i) Implementation strategy will be incomplete without the most important component of performance monitoring and concurrent evaluation. The work load norms and qualitative norms should be considered at very senior levels and finalised in consultation with the groups of all operating levels down below the line. A time table should be drawn out well in advance for reviewing and monitoring the progress of all activities. Similarly a separate programme and expert organisation should be chalked out for overseeing the performance and also for suggesting remedial measures based on concurrent evaluation. These norms and programmes should essentially be hibly flexible, live, and dynamic in character. Rigidity brings stagnation and the system may collapse.

(j) The degree of success in achieving farmer's participation in irrigation management will largely depend also on assured and timely supply of water at all outlets. In order to enable proper water budgeiting and maintaining accounts of water allocated and utilised, measuring devices will have to be installed upto all outlets in the entire canal system. The irrigation engineers must discharge this responsibility and they should be considered accountable for the same. Some norms, checks and counter-checks should be devised to ensure that they do this job without fail even within the budgetary constraints. Each section officer should be given a target every year to adopt some area in his jurisdiction where priority should be given to make good the inadequacies of the system. He should also adopt this area for concentrating his efforts to establish more frequent interaction with farmers. The village extension worker also must cooperate for which his jurisdiction should be made co-terminus’ with that of irrigation karkoons.

(5) The task ahead is very difficult, yet it is not as complex as we are used to think it to be. If our approach is totally unbiased, it would unfold its real nature which is very simple. Let us therefore shed all our preconceived notions and then begin denono on a clean slate. Let us develop a habit of tallying how far the theory applies in practice in each case. Updating our know-how of theory is also equally important as the application of theory in practice; because all such theories are concluded only after thorough and critical analysis of long term data of many similar field experiences or case studies. In the background of what I have discussed so far, it should be easy to realise that farmers participation in large and small flow irrigation schemes run by Govt. is a compelling need and necessity of the day; but to bring about such total involvement of farmers, one sided efforts of only irrigation engineers would not succeed. It is essentially a joint responsibility of many sectors like irrigation, agriculture, public administration, cooperation, rural sociology and such a joint responsibility will have to be shouldered not only by Govt. departments but also by non-Govt. agencies and voluntary organisations. through a well knit and coordinated preconceived action plan or strategy. The entire field is enchanging, challenging and very very full of life. Let us resolve to enter this field with dedication, devotion, sincerity and with all humility.

At the end, I thank you all and the organisers of this memorable event.

JAIL HIND.

Water Availability and Use

Dr C C Patel, *Fellow*

Chairman & Managing Director,
C C Patel & Associates (P)Ltd, New Delhi

INTRODUCTION

Water is an integral part of man's environment and the extent to which it is abundant or scarce, clean or polluted, beneficial or destructive, determines, to a very large degree, the quality of his life.

Rapid development of human civilizations and galloping advances of scientific and technological developments are changing the face of our planet giving rise to fundamental transformation of the environment in which water resources play a crucial role.

The relentless increase in the demand of water for various purposes brought about by population growth, and agricultural and economic development combined with poor efficiency in water use and increasing pollution of water supplies have raised serious problems. Water can no longer be taken for granted. It is a limited and valuable resource. Available water must, therefore, be optimally developed and used most beneficially under appropriate priorities of use consistent with the requirements of the region.

ASSOCIATION WITH BHAIKAKA

I had the good fortune of working under late Bhaikaka immediately after I graduated in civil engineering. I was attracted by his noble objective of setting up the Rural University in the midst of a predominantly rural area at Vallabh vidyanaqar, in Gujarat. Right from the beginning, the project was conceived, planned and executed in such a way that funds were generated from within through various consultancy services and small scale manufacture of building products for meeting the construction needs of campus and surrounding area. Land was not acquired. It was taken over by private negotiations. But for the selfless service of Bhaikaka Vallabh Vidyapith (University at Vallabh Vidyanagar) would not have come up. Its benefits to the surrounding rural area are Immense. Especially, it provides unique opportunity for the rural girls to get university education staying at their homes. I would rate this venture of Bhaikaka as one of the greatest successes since it did not receive government funding. Bhaikaka was an irrigation engineer. After retirement from government service in Sind (from Bombay Presidency in British period), he took keen interest in irrigation and water development in Gujarat. He highlighted various deficiencies in planning and Implementation of major canal systems and ardently pleaded for rapid development of the Narmada water resources for the most beneficial uses. The subject of my talk today, therefore, bears good resemblance to the objectives of late Bhaikaka. .

WORLD'S WATER RESOURCES

It is now generally accepted that the total supply of water neither grows nor diminishes and is believed to be precisely the same now as it was three billion years ago water, unlike other natural resources, is not depleted through consumption. While to the inhabitants of a planet that is running out of natural resources, it is reassuring that this vital substance is not being depleted. Two factors, nevertheless, cause some anxiety: the rapid increase in population and pollution.

What is this supply of water? A number of estimates have been made of the world's total water resources. To give an overall picture, some commonly accepted estimates are set forth in Table 1 as the various elements which comprise the hydrosphere, the hydrosphere being defined as the aqueous envelope of the earth, including the oceans, polar ice, terrestrial waters, and and atmospheric waters. The terrestrial waters include the waters of the land: groundwater, lakes, rivers and streams and soil moisture. It is important to note that while the estimates of surface waters are reasonably accurate, the total amount of groundwater is much more difficult to estimate and, because of this, even the order of magnitude is in considerable doubt. One recent estimate of the world supply of groundwater, to a depth of 4 000 m, is 8.35 Mkm^3 far different from the 64 Mkm^3 noted in the table.

The terrestrial waters of an estimated 64.3 Mkm^3 include about 64 Mkm^3 of groundwater, 230000 km^2 of water in lakes, 1200 km^3 of water in rivers, and 82000 km^3 in soil moisture.

By, far most of the world's water 95% (approx) is contained in the world oceans or is locked up in polar ice. Though the remaining 5% (an estimated 64 Mkm^3) is an extremely large amount of water, virtually all of this is groundwater, a large part of which is quite deep and not readily obtainable, leaving only 0.016% in lakes and an even smaller amount (0.0001 %) in flowing streams and rivers.

TABLE 1 THE WORLD'S WATER RESOURCES

Element of the hydrosphere	Volume in 1 000 km^3	Percent of the total volume
World oceans[1]	1 370 000	93
Polar ice[2]	24 000	2
Terrestrial waters[3]	64 000	5
Atmospheric[1]	13	0.001

All this relates to the total quantum of water available. In actual practice, it is the hydrological cycle which provides fresh water for meeting various needs on the planet.

Experts have pointed out that, in the operation of the hydrologic cycle, 400 Tm^3 of water are taken up by way of evaporation (1 Tm^3 = 1 × 10^{15} I) of which 340 Tm^3 are taken from the sea and about 60 Tm^3 from the land. The amount returned to earth after precipitation as rain, hall or snow, is estimated at 440 Tm^3 of which 340 Tm^3 fall over the seas and 100 Tm^3 over land. It follows, therefore, that 40 Tm^3 which are received on the land surface find their way to sea and evaporate in the next cycle. The world river systems, therefore, are estimated to have a constant yearly supply of about 40 Tm^3 or 40 × 10^{15} I. In terms of a more familiar unit, one Tm^3 equals 1000 km^3 or about 800 Macre-ft. This constant supply of water should be juxtaposed against the ever-increasing rate of world population, currently estimated to be 5.0 billion and projected to rise to almost 10 billions by about the year 2050. It has been pointed out that even under the most optimistic assumptions, the population will more than double in the next 50 years.

Mounting population and improved standards of living are pushing up demand for food and fibre. Irrigation must. therefore, play a crucial role in increasing food supplies. The available water resources will therefore have to satisfy the increasing demand for irrigation. Irrigation already accounts for the larqest use of water withdrawals (about 90% in India). According to a United Nations estimate, withdrawals for irrigation by the year 2000 are likely to be twice as large as for the year 1967. Furthermore, the process of urbanization, which is likely to see over a half of the world's population concentrated in urban settlements by the end of the 1980s, would in turn demand greater water supplies. But the rise in population and the consequent increases in water use are not the only contributing factor to this expected shortage. Pollution poses an additional hazard,

One unique quality of water is to cleanse itself in the hydrologic cycle. But although fresh water is a renewable resource and may be sufficient for current human needs, increased use of commercial fertilizers and pesticides, and generation of new and complex wastes are adding more and more to the dimensions of water pollution. The demands for industrial uses of water are already outpacing the demand for domestic uses. Pollution is thus becoming a problem almost in all rivers, lakes and estuaries. Even deep sea waters are not free from it. If the present water pollution continues unchecked, it is feared even enough potable water for domestic consumption may not be available in future,

The United Nations Water Conference of 1977 held at Mar del Plata, described as the 'most important and all-embracing world wide inter-governmental meeting' on water resources so far, has emphasized the accelerated development and orderly administration of water as a key factor to avoid 'a water crises of global dimensions within the next few decades.' The UN Water Conference recognized that persistent and recurring problem in many countries is the mobilization and the obtaining of adequate financial resources to implement necessary improvements in the numerous aspects of planning, development and management of water resources,

AVAILABILITY OF WATER IN INDIA

The prime source of water is precipitation. In India, rainfall is generally confined to 3-4 months in a year. Its distribution over the country is highly skew, viz, 100 mm in West Rajasthan to over 11 000 mm at Cherapunji in Meghalaya. On the top of all these unfavourable features annual variation of rainfall is also highly uneven. The areas receiving less rainfall has a very high coefficient of variation.

Assessed surface water resources of India are around 1780 Bm^3 (1 440 Macre-ft) which is about 3% of the world's surface water resources, whereas the country's population is about 16% of world population. Present consumption of water is around 310 Bm^3 (250 Macre-ft). Thus, only 17.4% of surface water is being used while the rest flows down into the sea, often causing disastrous flooding and drainage congestion.

Needs for Water:

There are two categories of water use: (i) Consumptive use of water for irrigation is regarded as consumptive use; and (ii) Non-consumptive-use of water for hydro-power, recreational use, etc are nonconsumptive. Water is required for the following uses:

(1) Rural and municipal water and industrial use. These include requirements of livestock.

(2) Irrigation: This is the largest consumer requiring as much as 90% of water being used at present. In India, this possition is likely to continue for a long time to come. Production of one tonne of wheat may consume 2000 t of water while that of 1 t of paddy may require as much as 4000 t water. Even water intensive industries do not need that much water for production of one tonne of finished product. We must also appreciate that industrial use is largely non-consumptive/though the effluent usually calls for treatment for rendering it usable, Irrigation use includes requirements of forest and pasture lands.

(3) Hydro power generation: Hydro power stations can quickly respond to changing loads and are ideally suited for peaking. A healthy mix of hydro and thermal/nuclear power in the national grid is highly desirable. Unfortunately, due to various reasons, percentage of hydro power installations has been falling progressively from Plan to Plan. It has been assessed that hydro projects (planned and/or executed) can generate 95 MkW at 60% load factor, Hardly one-fifth of this capacity has been developed. Generation of one kW of thermal energy requires about 0.67 kg of coal. When full hydro potential is developed, the country could save over 250 Mt of coal every year. Apart from conservation of coal reserves, the relief which the transport sector could get would be immense since at present we are using less than one-half of this quantity for entire thermal power generation in the whole country.

(4) Cooling for thermal/atomic power stations: This requirement is increasing very fast. If thermal stations use cooling towers, the requirement is substantially reduced. Where feasible, thermal and nuclear power stations may be located near the sea coast so that sea water can be used for cooling.

(5) Other uses comprise dilution for pollution control, navigation, recreation, etc.

SOCIO-ECONOMIC BACKGROUND

India is a large and diverse country with a population of over 750 millions and the per capita income of $(US) 250, which is very low compared to even other developing nations. Population of the country, of the other hand, is mounting. Agriculture plays a predominant role in the economy of the country. About one-third area of the country is drought-prone, with 70% of the country's population living in rural areas and depending mainly on agriculture. Our Five-Year Plans have laid great stress on development of rural areas providing safe and adequate drinking water supplies, increasing the irrigation facilities especially in drought-prone areas, and better and more efficient water management.

About 40 Mha of area (about one-eighth of total) suffers from recurring floods. The pattern of economic growth of the country is now largely influenced by good or bad monsoons. The country suffers from a 'floods-drought floods syndrome'.

LEGAL FRAMEWORK

Water is a State subject. Under Article 246(3) of the Constitution (Appendix 1) and Entry 17 of List II of the Seventh Schedule, every state government has power to legislate and exercise authority in respect of water. Under entry 56 of List I, the central government can legislate for the regulation and development of interstate rivers and river valleys.

Article 262 of the Constitution authorizes Parliament 'by law' to 'provide for the adjudication of any dispute or complaint with respect to the use, distribution or control of the waters of, or in, any inter-state river or river valley.'

ADMINISTRATIVE FRAMEWORK

All state governments have primary responsibility for use and control of water. However, the administrative control and responsibility for development of water rests with different departments and corporations. Major/ medium irrigation is handled by the irrigation department. Minor irrigation is handled by Zilla Parishads and/or agriculture departments. Water supply is handled by public health department and Zilla Panchayats (for rural water supply). Government tube wells are handled by the Irrigation Department, or, Tube Well Corporations. Water quality is looked after by the Pollution Control Board. Urban water supply and sewage disposal is handled by municipalities/corporations. Hydro power is handled by the State Electricity Board. Similarly, in Government of India, CWC and CEA scrutinize medium/major/multipurpose projects on behalf of the Planning Commission for inclusion in the Plan. Water supply and sewage disposal is handled by the Ministry of Urban Development. Hydro power is handled by CEA/NHPC. Pollution and environment control is handled by the Ministry of Environment. There is thus a multiplicity of agencies handling water both at state and central levels. In Hungary, which is a small country, entire subject of water is handled under one authority. Such an arrangement ensures rational and coordinated development, control and use of water with adequate quality control and monitoring. In India also, at the central level, the Ministry of Water Resources ought to handle overall planning and policy framework for all aspects of water development and use and at state level, the

Department of Irrigation should look after similar aspects of water.

PRIORITIES OF USE

The country has reached almost mid-way towards development and use of water resources. Present water utilization may be roughly assessed as 250 Macre-ft. Under the existing legal framework, we cannot hope to reach a total utilization of more than 670 Bm^3 (540 Macre-ft). That too if environmental impact assessments do not affect the feasibility of some water development projects. In practice, some of the projects may have to be dropped on environmental grounds. Groundwater potential is estimated as 420 Bm^3 (340 Macre-ft).

A rough assessment based on information collected from the states by the Central Water Commission places the total irrigation potential of the country as 113 Mha (73 Mha from surface water and 40 Mha from groundwater). Higher requirements of water for cooling water required by power plants, pollution control and other requirements which were not fully accounted for, are likely to lower this figure by 5%-10%.

Irrigation schemes have been constructed in the post-independence era on a large scale while reservations for rural and urban water supply were not made in water planning. We have for some time reached a stage when drinking requirements of rural and urban populations have to be met from established irrigation uses.

In Gujarat, particularly in Saurashtra and Kachchh, several water storage schemes meant for irrigation have been converted to water supply schemes, many of them after irrigation benefits started accruing. There are several other such instances in the country. The four metropolitan cities and other fast growing urban areas suffer from acute water shortages. There is thus great competition among different uses of water. There is also competition among users within the same category of use.

Priorities of use must therefore be laid down. Reasonable requirements of water supply for drinking for rural and urban populations must enjoy the highest priority. Irrigation at present enjoys priority over hydro power generation though optimization of both irrigation and hydro power benefits by systems approach and flexibility in planning irrigation supplies on more uniform basis in a year appears a preferred alternative.

We have also to remember that priorities fixed now may have to be changed in future. There are several examples that water projects yielded altogether new benefits which were not contemplated when the projects were approved.

Inter-state priorities among irrigation, industrial use, cooling water for power plants, pollution control, etc have to be determined after study of the situation, present and future, from area to area. Best available technologies must be used for achieving highest efficiency in all connecting uses.

WATER

Water is required for survival of life on our planet.Water supply enjoys highest priority. Sanitation, quality of water, spread of water-borne diseases are all important issues for municipal and rural water supplies. Re-use of sewage water for agriculture is becoming more important as water shortaqes for irrigation grow. Water planning cannot be looked in isolation. It is intimately linked to land use planning and social and economic needs in accordance with perspective development Plans of the country. We are almost at the end of the International Drinking Water Supply and Sanitation Decade (1981-90) and still we are far from reaching the goal to provide potable water to our population especially in rural areas. Groundwater is the important source for rural water supplies. Quality of water, dissolved salts, fluorides, iron, etc are important considerations. Groundwater assessment assumes great importance. During drought, dug wells dry up depriving the dependent rural areas of water. Regional water grids based on reliable water supply sources would go a long way. An important task is to find sources of water for villages classified under 'no source' or 'difficult' from the point of water supply. In irrigated areas, the problem of supplying water to rural/urban communities usually does not exist. Sometimes, however, quality may pose problems. Water supply plans should form part of the overall water resource development plans for the region.

In India improving the life of rural areas is a high priority area. Rural activities comprise irrigation, agriculture, small scale industries, dairying, etc. Rural areas require infrastructure of electrification, water supply, irrigation facilities, roads, communications, etc. Water and energy play important role. There are over 5 million pump sets. These have very poor operational efficiency. As a result, there is waste of energy and fuel. There is urgent need to implement the recommendation made by the committee under Ministry of Water Resources in this connection. Unconventional sources of energy such as wind, biomass, solar energy, etc should be popularized for improving the rural economy. More efficient devices such as drip and sprinklers should be promoted. Drainage of irrigated areas are equally important for increasing the yields. Formation of cooperatives for development of agro-industries is a very promising activity especially in irrigated areas.

Floods and flood control programmes should form part of the overall strategy or total water resource development. Silt for sediment, which is a constituent of flood waters plays on important part in river morphology and flood damages. Soil conservation can help in releasing silt free waters downstream which would lower the river beds, thus increasing the discharge capacity of natural river channels. Soil conservation measures in upper catchments would help significantly in reducing silt and preserving soil nutrients.

Urban and metropolitan areas deserve special attention for water supply. Their perspective water needs for next 50 years should be assessed and plans prepared for meeting them progressively. Water should earmarked so that other consumptive use such as irrigation does not develop based on earmarked supply.

High-tech solutions using distillation, reverse osmosis, etc may be resorted to where conventional sources for meeting drinking water supply needs are not available. Quality of water and pollution resulting from manmade activities are posing major problems. Industries must strictly adhere to water treatment norms in accordance with IS codes. They should economize water use by recycling and adoption of water efficient processes. Water-intensive industries should be located in water surplus areas with satisfactory arrangements for effluent disposal. There is need for continuous monitoring of water quality in selected basins through autonomous authorities empowered to initiate action under Pollution Control Acts and to impose penalties.

Hydrologic and quality modelling of river basins is an important tool for monitoring the quality and ensuing integrated operation of water resource systems and flood control.

Systems approach, similarly, is an important tool for preparing master plans of total water resource development. CWC has established a unit trained under on UNDP project for carrying out system studies and giving advice to the state governments.

SCENARIO IN ULTIMATE STAGE

For the purposes of evolving broad policy initiatives in the field of water planning, I have analyzed the situation regarding irrigation use only (which comprises 90% of the water being used). Urban and sub-urban water supplies yield about 75% effluents which, after treatment, can be reused for irrigation.

PRESENT AND FUTURE SCENARIOS— IRRIGATION USE

	END OF 1987-88				Ultimate Stage		
	Potential, Mha	Use, Mha	Use of water, $10^9 m^3$	Surface storage, $10^9 m^3$	Potential or utilization, Mha	Use of water, $10^9 m^3$	Surface storage, $10^9 m^3$
Surface water							
Major/medium	31.6	27.0	216	150	58.0	547	400
minor	10.6	9.7	87	30*	15.0	120	40*
Sub-total	42.2	36.7	303	180	73.0	667	440
Groundwater	31.7	29.6	120	–	40.0	200**	–
Total	73.9	66.3	423	180	113.0	667	440

* No data available. Figures assessed on very approximate basis.
** Figures assessed on approximate basis.

In the above scenario, it is assumed that there is no competition amongst major, medium or minor schemes. Fullest scope is given to all schemes. In fact, they all supplement one another. It is often said that major projects give rise to a host of environmental problems and should be replaced by smaller schemes. This, in effect, is tentamount to giving up a major scheme altogether since the studies have revealed that a group of smaller schemes, in most cases, would not be a substitute for even the quantum of benefits from major reservoir storage project. So far as costs are concerned, they are most likely to have much less attractive cost/benefit ratios. Minor surface irrigation works involve around 100% losses in evaporation and soon get silted up. Check dams, underground dams with impervious barriers and soil conservation programmes for conserving water in the fields are all useful but they all can tap or harness only a small fraction of rainfall and would not by themselves be able to prevent overflows from the cultivated fields. Water must therefore be conserved through surface storages.

With this position, new major water storage projects is the only means to harness additional surface waters. In order to examine their economic viability, positive and negative environmental impacts must be evaluated and incorporated in the cost/benefits analysis. No doubt, each benefit can not be evaluated in monetory terms but suitable norms can be evolved which account for such intangible impacts.

GROUNDWATER

This is an important source of water. Usually it is cheaper than surface water brought through a canal system. It constitutes the main source of drinking water supply for most of the rural communities. Even urban supplies are dependent, to a varying degree, on ground water.

LOCATION

Modern technology has provided tools which greatly increase he probability of finding water through successful drilling.

Sattelite imagery and aerial surveying have been a great help in locating aquifers and favourable geological structures for groundwater in remote regions. Areas of jointing in hard rocks show up in vegetation changes due to the presence of near-surface groundwater. Springs become visible in infra-red imagery due to the temperature difference in the water they produce. Vegetation differences and visual contrasts produced by different rock formations may show boundaries of aquifers and large scale geological structures which control the distribution of groundwater.

Remote sensing methods may locate aquifers or favourable areas for locating water boreholes but the precise position on the ground requires the use of geology and ground geophysics as well as an analysis of the most socially acceptable location.

Geophysical surveys where ground properties are evaluated by indirect measurements are of increasing importance in developing countries where detailed geological information may be limited. A resistivity survey is the most frequently used method, since it is the only technique which actually locates water by measuring the electrical resistance of the ground.

Electromagnetic methods are often used in hard rock regions where areas of jointing and associated weathering zones have to be located. The VLF (very low frequency) method is especially suitable; it uses the ground penetration properties of very low frequency radio waves transmitted from a few high powered stations around the world. When areas of high conductivity exist, such as a weathered jointed zone containing water in a hard rock, the interference of the primary low frequency radio waves and the secondary waves produced from the conducting area allow the limits of the conductive zone to be defined below obscuring surface materials.

Seismic refraction surveys are sometimes used to determine water table depths and aquifer limits. Magnetic surveys using proton magnetometers are useful in areas where igneous dykes and sills control the distribution of groundwater by means of their low permeability.

Exploratory test boreholes are always needed, especially in a new area, to assist with the interpretation of all geophysical data.

I may mention that various authorities have assessed the groundwater resources in India such as the Department of Agriculture, NABARO, World Bank, Planning Commission, Irrigation Commission and CGWB. The assessments vary from 17.7 Mha-m to 41.8 Mha-m. It may be mentioned here, that adequate data regarding orientation and extent of aquifers, withdrawals of water, and water fluctuations in existing groundwater structures, quality, etc are not available. It is hoped that in future, more realistic estimates may be possible after requisite data become available.

It is noteworthy that irrigated areas in Punjab, Haryana, UP and Bihar ae major contributors to groundwater potential mainly due to recharge from surface irrigation.

So far, apart from groundwater supplies for drinking and some industrial needs, a groundwater irrigation use of 29.6 Mha has been built up (75% of potential). The ultimate irrigation potential has been assessed as 40 Mha by Planning Commission and the Ministry of Water Resources. CGWB has estimated that overall development of groundwater for the country is hardly 25% of the potential. This indicates that either irrigation potential is grossly underestimated or groundwater potential is overestimated. This anomaly needs to be settled after thorough review of groundwater assessment. Conjunctive use of ground and surface water which is practised on a large scale in states like Haryana, Punjab, etc needs to be promoted. The groundwater potential of irrigated areas needs to be reviewed and irrigation intensities and command area boundaries may be refixed, where necessary, after study of conjunctive use. Groundwater modelling is a good tool for controlling groundwater withdrawals, and groundwater-table for optimization of groundwater use both from the point of view of quantum as well as economics of pumping. Groundwater legislation has been passed by the Government of Gujarat and recently it has decided to enforce the same. It is high time other states also enact suitable legislation. Overexploitation of groundwater has resulted in salinity ingress from the sea along the coasts. Recharge of groundwater by spreading, construction of check/percolation dams, water conservation in fields having premeable surface and aquifers below, injection wells, etc may be useful.

Quality of groundwater needs to be determined especially for drinking water supplies. Even irrigated lands can be badly affected by salinity and alkalinity. Dilution of saline groundwater with fresh canal water may augment irrigated areas.

Database on a countrywide basis, is rather poor. This is a major impediment in studies of groundwater regime, water-table movements, groundwater recharge, etc. There is an urgent need to have requisite database for balance studies on sub-regional basis throughout the country.

STRATEGY

Present and future scenarios of water use are given above within the existing legal framework. It may be noted that even after full potential from surface and ground water is realized, over 55% of surface water would continue to run waste into the sea. This estimate allows a very liberal allowance for additional soil conservation and contour bunding programme intercepting and recharging as such as $300 \times 10^9 m^3$ or 30 Mha-m of surface water.

What is then the scope, if any, for realizing larger benefits from available waters? A two-pronged strategy should be aimed at for realizing maximum benefits from water resources of the country: (1) Improved water management and modernization of existing water projects; and (2) New surface water projects.

IMPROVED WATER MANAGEMENT AND MODERNIZATION PROGRAMMES

Majority of existing irrigation systems are not capable to meet the water requirements of the entire irrigation command, particularly during peak demand periods. Head reaches receive much more while tail reaches are starved. Regulation and control of supplies also leave considerable scope for improvement. In unlined canals and field to field water supplies (particularly for paddy) there are considerable seepage losses. Maintenance is inadequate. Performance evolution should be taken up for a few selected projects. This would highlight major deficiences.

MAJOR DEFICIENCIES IN IRRIGATION SYSTEMS

The ultimate objective of creating irrigation facilities is the maximization of crop production per unit of water supplied for each unit of land. For achieving this objective, however, continuous co-ordinated efforts by the departments in charge of irrigation, agriculture, co-operation, banking, marketing, etc on the one hand, and the active involvement of the farmer on the other, are pre-requisites. There should be good back-up agricultural research to enable newer varieties of crops to be evolved. Universities and various related research institutes could help significantly if good interaction among executing government agencies and themselves is built up. In the past the inter-linkages even with government agencies were not adequate. Happily, this position is slowly showing. The setting up of command area development has improved the situation. However, the command area development authorities are limited to larger projects. They need extended coverage. In order to identify the deficiencies in existing projects and recommend the measures for their rectification, the Government of India set up a multi-disciplinary central water utilization team, to review the working of selected irrigation projects in India and to recommend suitable measures. This team visited many projects and assessed the scope for their improvement. The deficiencies noticed as a result of these in-depth studies may be categorized under three broad heads, namely; (i) Engineering, (ii) Agronomy, and (iii) Administration.

Engineering

On some old systems, there is need for replacement by old headworks where they have outlived their usefulness. Others will have to be suitably remodelled for improved energy dissipation and water tightness of structures. Provision of gates for higher pond level or additional pondage might also help. Remodelling of head regulators for increased capacities is also justified in some cases. In several cases, canals and distribution systems cannot carry adequate discharge due to silting, weed growth, etc. Similarly, water regulatory structures are not adequate. Additional escapes and water measuring structures may need to be provided. Good communication by telephone and wireless would also help considerably. Canals should be built from reservoirs/headworks to the command areas to reduce river losses where rivers are used to transport supplies. There should be arrangements for temporary storages of escape waters and balancing storages along the canal systems and facilities should be provided for re-use of drain waters by lifting in lower parts of the commands.

Operation of irrigation systems leaves considerable scope for improvements both in terms of total area irrigated and equity in water supply.

On-farm development works need special mention. Furrow irrigation or basin irrigation (depending on crop) should be planned with accurate levelling of the fields. Paddy fields generally need a small bund along its border and also within to prevent waste of water. Field channels should be designed to supply water to each farm. Outlets should be permanent and controlled by gates and be of reasonably small size. Water courses and field channels should be lined, where necessary, or pipes used for these purposes where land is expensive. Drainage facilities should be provided or remodelled and augmented as also the structures across the drains. Farm drains should be provided where necessary with pumping facilities to improve drainage of low lying pockets having no gravity outfall. Drainage planning should be done on the basis of irrigability and land classes. The irrigation and drainage systems should be separate. Land shaping should be done on each farm and water control structures built.

Project performance (in terms of water used, crops irrigated, agricultural produce, etc) development of cropping patterns, and development of on-farm works should be monitored regularly. Feedbacks from the users should be organized and measures taken to make operation and maintenance more responsive to needs. There should be conscious and continuous effort to promote increased participation of farmers in the control and distribution of waters.

Many of the projects when formulated did not have enough hydrological data. The yield figures actually available are found to be appreciably short of the figures forecast. The result is that the available water is not able to cater to the entire command. There is a urgent need for re-appraisal of the hydrology of many projects.

The canal systems are not lined in old projects. At the same time, losses by seepage are empirically assumed to be about 2.42 cumecs/Mm^3 (8 cusecs/Mft) of wetted surface. In actual practice the losses may be much higher. Thus, therefore, is a serious cause for not enough water being available particularly in the tail reaches of canal commands to meet crop requirements.

Many old irrigation systems do not have sufficient cross-regulators with the result that the offtaking channels cannot draw their full supply, unless consistently high level is maintained in the main canal to ensure the required discharge in the off take channels. Many of the projects still practise field-to-field irrigation. This practice should be discontinued and a programme for construction of field channels has to be undertaken. Water short systems should consider crop diversification for increasing production per unit quantity of water. Coniunctve use of groundwater should be encouraged. This would keep groundwater low enough to prevent waterlogging.

In many of the projects the canal system is run to supply water to perennial crops located over isolated patches. Using groundwater in such situations will enable the system to be closed for sufficient length of time, thus resulting in avoidance of sizeable seepage or other losses. Groundwater can be used to supplement irrigation in summer for other periods of shortages. Groundwater use is particularly important for raising nurseries for rice so that the crop is grown and transplanted within appropriate time schedule, making best use of rainfall, and the harvesting is done at the most optimal time.

The life of reservoirs is estimated at the planning stage based on assumed or observed (generally short-term data only available) rates of sediment deposition. The actual rates of sedimentation in reservoirs are found to be much higher than assumed. Accelerated erosion brought about by development activities and deforestation in catchment areas, has also contributed to the increased sediment load. It is very essential to conduct sedimentation surveys of reservoirs and speedily take up corrective conservation measures over the problem areas of the catchment. Several states have undertaken this exercise. CWC is implementing UNDP project for updating technology of sedimentation surveys and interpretation of results thereof.

Integrated operation of all reservoirs in a river system can also significantly increase the aggregate utilization of river supplies and provide carryover for use if the onset of the succeeding monsoon is unduly delayed. This requires inter-state cooperation for inter-state rivers.

In many of the projects contour survey maps of suitable scale are not available. Such maps showing contours at close intervals, 0.15 m-0.25 m, say, are very necessary to plan micro-canalization and field drainage for new projects or for designing a modernization scheme.

Night irrigation is not popular in several irrigation systems. Adequate water control and water measuring devices are not available.

The Warabandi system (rotation of supplies) is necessary on all systems including the rice systems to effect equitable distribution of water and economy in water use.

Agronomy

Irrigated agriculture is mainly judicious management of soil and water to ensure that the cultivated land maintains its optimum productivity levels. The foundation for such management programmes lies in the knowledge of physical and chemical properties of the soil. Soil survey of the command area has to be carried out prior to irrigation and the soils have to be indentified for their irrigability levels. The type of crops and the extent of land levelling required have to be based on such surveys. At periodical intervals, the survey should be repeated to find out the effect of irrigation on the soil properties physical and chemical. Many of our irrigation projects do not have soil survey data and, even if they have, they are scanty. National Bureau of Soil Survey and Land-use Planning has standardized the method and formats for survey and classification of soils. Soils in the command area of irrigation projects have to be surveyed in detail and standard soil maps should be prepared for use in the planning of the system.

The cropping patterns are often assumed without due regard to the capability of soil for growing a particular crop. From the point of view of maximizing crop yield,the crop calendar should be so devised as to make the most effective use of natural rainfall and other agroclimatic factors thereby economizing irrigation water. Crop rotation should be such as to avoid nutrient exhaustion in the soil and to fix as much natural nitrogen as possible. The inputs like fertilizer and pesticides should be applied at the specified doses and at specified times. Diversification of cropping patterns to enable maximum production per unit of irrigation water should be the foremost consideration.

Adoption of high yielding varieties whose growth period best suits the climatological conditions will reduce the incidence of diseases and increase the yield. Reduced crop periods of new high yielding varieties can also facilitate more crops to be grown per year on the same land. For wider adoption of these varieties the activities of agricultural extension and demonstration farms have to be intensified.

Puddling operations in paddy cultivation use large amounts of water. Provision of adequate labour to carry out the operation over as short a period as possible can afford considerable economy. The reduction in the present depths of standing waters on rice fields to the minimum feasible will also be conducive to economy.

Administration

Construction of field channels and field drains sometimes get delayed due to lacuna in legislation and/or enforcement. Legislation has to be amended suitably to accelerate such activities. A model irrigation bill has been evolved by the Ministry of Water Resources which has been sent to all states for adoption with modification wherever necessary. States should take steps to modify irragation laws so that the various developmental activities are not retarded or obstructed.

The pesent irrigation rates in many states are too low. These have to be raised so that the revenue collected could at least meet the maintenance cost of the project. Water is a scarce resource and requires to be paid for according to the volume used. Volumetric measurement of irrigation supplies has to be progressively aimed at. To begin with, the rates charged per acre of irrigated crop should have close relationship to the water used by it. Establishment of co-operatives of users for bulk distribution of water within their service area would be quite useful. Some larger project commands are developed in stages. In the earlier stages farmers used to go in for high water-consuming crops like sugarcane and paddy though the project did not envisage and soil conditions do not warant it. Such a practice has either led to under-irrigation or no irrigation at all in the tail reaches. Supply of water to farmers at head reaches at much higher quantum than envisaged becomes something of an established right. Unauthorized irrigation also needs to be effectively penalised. Strict administrative action is required to enforce planned crop patterns and equitable distribution of irrigation water.

On the organization side there should be adequate arrangements for timely supply of good seeds, fertilizers, pesticides and agricultural equipment. One of the major deficiencies in our country is highly inadequate technical input which should be remedied by increasing the number of water managers at lower levels to more than three times and giving them training in water management' practices. Other disciplines such as agromony, social sciences, economics, etc need to be injected for more efficient water management. There should be a good network of experimental and demonstration farms and extension services and information transfer organizations. Facilities should be easily available for farm soil testing and obtaining advice on cropping patterns and agricultural techniques. There should also be adequate facilities for transport, processing and marketing of agricultural produce. Command area roads would considerably help.

APPROACH TO MODERNIZATION

Each irrigation system has distinct characteristics and has its own problems arising not only from the peculiar physical conditions such as climate, soil, topographical features, capacity of irrigation system to supply water, degree of development of ground water, etc but also from the manner in which the system is operated. It is, therefore, necessary to formulate modernization proposals taking due account of all relevant aspects.

In the first instance, a water balance should be worked out between the quantum of water supplies available at the headworks, (based on up-to-date hydrological data) and the volume of water required to be diverted, represented by the accepted details to be applied to the actual irrigated area plus reasonable allowance for losses in transmission. Careful assessment should also be made of the water being wasted at present through escapes or tail regulators and in drainage channels to assess the efficiency and potentiality for conjunctive use of ground and surface water. These studies will indicate whether available supplies are adequate or not and might quite often throw up unsuspected surprises by way of indicating more than adequate availability of supplies in a situation wherein under actual operation, tail areas of the command may be deprived of the needed water. Such cases would call for detailed investigation into the causes of apparent water deficiency and remedial action taken to correct the situation. If surplus water exists, boundaries of the command area may be extended suitably.

The design of a modernization scheme should commence with a detailed soil survey as a tool to classify soils based on the criteria of land soil irrigability and for evolving the most suitable I crop pattern and crop calendar. Such a crop pattern should preferably be adjusted so as to localize the command distributarywise for facilitating streamlined operation of the system as well as for avoiding the necessity of keeping the entire system running in hot weather to cater to patches of land under perennial crops.

Having fixed the crop pattern, water requirements of crops and field irrigation requirements should be worked out outlet -wise and consolidated for each distributary and further on for branches and main canal. The peak requirements thus worked out in different channels would indicate if the existing channel capacities are adequate or need to be augmented. The quantum of water likely to be saved by canal lining should be based on data of losses actually taking place as measured in the system and losses likely to take place from lined channels. Where there is already considerable use of groundwater in the command, care should be taken to see that such use is not seriously hindered while drawing up the lining programme. Equally important is the need for improved controls of hydraulic structures and for construction of additional structures like crossregulators and escapes.

The adequacy of existing drainge systems and any improvement required to be made would also need detailed consideration and planning.

Actual implementation of structural alterations to the canal system required under the modernization proposals could be confined to the normal closure period of canal, extended to the extent possible without seriously interferring with the irrigation programme. If the work involved is only selective lining of specific reaches, this is the best way of going ahead with the work required. Where, however, large-scale lining and canal structures of modifications thereto are involved, this method of execution will need to be spread over a large number of years. On the contrary, if a parallel canal were to be excavated, the work could be carried out at a much faster pace on account of longer working season available each year. The choice between the alternatives is, however to be made based on relative economics.

System operation has to be designed to meet the requirements of the crops under each outlet command in regard to the depths and frequencies of irrigation and, at the same time, enable adequate discipline to be enforced in water regulation. In other words, the turn system or Warabandi should be carefully worked out on this basis and enforced.

The efficient functioning of a system not only depends on good engineering design and construction, but also on regular maintenance. This fact is quite often overlooked. It is not, therefore, sufficient to design the modernization scheme and implement it; it is equally important to ensure regular time-table for satisfactory maintenance. For this purpose, even at the stage of formulating modernization proposals, norms should be laid down by way of minimum funds and technical and other staff needed for operation and normal maintenance, both at the level of workers as well as supervisors.

Effective communication facilities are vital for regular maintenance and emergency repairs. Personnel planning and placement policies should be evolved including in-country and foreign training. With all the measures indicated above improvement in additional irrigation using the same quantum, viz, 667×10^9 m be of the order of 25% on a national scale. Some individual projects can double the area. Thus at best 10 to 15 Mha more can be irrigated. This transition to total modernization is however long and time consuming. I am aware that this programme was launched 10 years back but the progress has been very sluggish. Policy decisions such as criteria for assessment of additional benefits should, therefore, be taken to give a boost to this programme. Although in quantitative terms the programme may not give spectacular results but qualitatively it is most vital and, in fact. a fore-runner to new projects involving long distance transfers.

WATER DEVELOPMENT THROUGH NEW SURFACE WATER PROJECTS

The USA with nearly three times the area and about one-third of population of India the total water resources available is about the same. While we are using around 420 km^3, the USA is using close to 750 km^3 (2/3 surface water plus 1/5 groundwater and rest sea water largely for cooling of power plants and other industrial purposes). Western parts of the USA are water short and there are various schemes of inter-basin transfer-some implemented such as State Water Project in California (cost \$ 2.3 billions) and several at various stages of consideration. Mainly institutional, legal and political considerations weigh heavily before decision is taken one way or the other. Legal considerations arise from the division of powers between the federal government and the states and the environmental protection legislation. Large inter-basin transfer projects are also conceived in China, the USSR, Hungary and others. Water transfers, however, are not ends in themselves but rather means of providing critical resources for all round development of the country and reducing regional inequalities. All alternatives have to be considered before decisions taken for inter-basin or inter-state transfers of water; especially optimum and most efficient use of existing water resources. Each country has its own problems; decisions must be taken project by project since no two projects are similar.

The National Water Commission created by Act of Congress in 1968 in the USA to review national water resources problems summarises the following in regard to water resources development programmes.

The Commission recognizes that Federal programmes for navigation, reclamation, flood control, and hydroelectric power, among others, have made an enormous contribution to national well-being. But demands on the Nation's water supply have accelerated so rapidly during the past century that national policies governing water conservation, development, and utilization have inevitably lagged far behind national growth. New policies reflecting today's needs and the needs of the 21st century are essential to assure efficiency in water use and to sustain a healthful, aesthetically pleasing environment.

POSSIBILITIES OF SURFACE WATER DEVELOPMENT IN INDIA

For better appreciation, this section may be subdivided into three parts: (i) On-going and new projects under the existing legal framework, (ii) Peninsular river development under central legislation, and (iii) Himalayan river development under regional cooperation.

On-going and New Projects under Existing Legal Framework

As mentioned earlier, by the end of 1987-88, a potential of 31.5 Mha was created through major/ medium irrigation projects while utilization was 29.6 Mha. Similarly by the same period, a potential of 10.6 Mha was created by minor irrigation while utilization was 9.7 Mha. Additional potential of 26.4 Mha remains to be created from on-going and new projects (major/medium) while additional potential of 4.4. Mha remains to be created from minor irrigation works.

Both these figures appear optimistic since unaccounted municipal and industrial water supply and requirements of cooling water for thermal/atomic plants would reduce potential from major/medium category and heavy silting would reduce the potential from minor schemes. In all, not more than 25 Mha could be developed under major/medium/minor schemes, by the year 2010, say.

Need for National Planning

In recent years, considerable interest has been evinced both in the press and other public forums as well as in the Parliament regarding the need of a National Water POlicy aiming at optimum and efficient utilization of the country's water wealth for the benefit of the entire nation over-riding narrow regional considerations.

Left to themselves, the states are prone to plan for development of water resources keeping their own needs in view. A large number of country's rivers are inter-state in character. Therefore, if a national view is taken and major inter-state and international rivers in the country are harnessed in the larger interest of the country, the benefits would increase considerably. This could be feasible only by providing storages at appropriate locations and inter-linking of the various river systems for transfer of surplus water to needy areas. While doing so the reasonable in-basin needs will have to be fully provided for. Such a plan providing for storages and transfer of surplus waters will mitigate the human misery and ravages caused by the flood drought- flood syndrome.

CONSTRAINTS

India is a country of monsoons; but the distribution of rainfall is not only highly uneven both in space and time but also erratic, with the result that about one-third area of the country is drought-prone, where even drinking water becomes a problem; whereas over 40 Mha are affected by recurring floods. Availability of potential large storage sites is also limited.

India has so far built storage capacity of 160 km^3 (130 Ma-ft). To enable the country to make maximum use of surface water resources a much larger storage capacity is required. In this effort close cooperation with neighbouring countries where suitable sites for storage to be used for multi-purpose benefits are available will be necessary. Such storages will also be for mutual benefits.

There is hardly any scope to increase the cultivated areas as such conservation and most efficient utilization of the water resources for beneficial uses such as irrigation, hydro power, flood control, water supply, navigation and other purposes through storage reservoirs and water transfer system have assumed importance.

Under the Constitution, water is a state subject. Ever since the start of planned development of the country in the fifties, the states have been formulating and implementing several river valley projects for harnessing the water resources for irrigation, hydel power generation and domestic and industrial water supply, inland navigation, etc. As is known, investments on these activities are growing from Plan to Plan. Large projects involvinq inter-linking of rivers and long distance transfer of waters such as Beas-Sutlej Link, Rajasthan Canal, Kurnool-Cuddaph Canal, Parambikulam-Aliyar, Periyar Projects have been implemented/are under implementation. Proposals of the nature of linking the rivers Ganga and Cauvery had also been under contemplation at the national level.

Dr K L Rao's Proposal of Ganga-Cauvery Link

Dr K L Rao, an eminent engineer and a former Union Irrigation and Power Minister, in his proposal had advocated the Ganga-Cauvery link along with a few other links including the Ganga-Brahmaputra link. The proposal essentially envisaged the withdrawal of about 60000 cusecs of the flood flows of the Ganga near Patna for about 150 days in a year and pumping about 50000 cusecs of water over a head of 1800 ft (548.6 m) for transfer to the peninsular region and utilizing 10000 cusecs in the Ganga basin itself. The Brahmaputra link envisaged transferring 40 000 cusecs from Dhubri in Assam to Farakka via Bangladesh involving a lift of 40 ft (12 m). Alternatively, Dr Rao also mentioned the possibility of taking this link canal through Indian territory in which case the lift involved was to be 300-350 ft (91-106 m). The proposals envisaged creation of an additional irrigation potential of 4 Mha. Dr Rao had estimated his proposal to cost about Rs 125 billion.

These proposals were examined by the Central Water Commission which was of the opinion that the proposals are grossly underestimated both in capital aid recurring cost and would in addition require a large block of power for lifting water. The scheme will also have no flood control benefits. Therefore, the proposal was not further pursued.

Garland Canal Project of Captain D J Dastur

Captain D J Dastur, a former pilot, came up with his proposals/suggestion for a 'Garland Canal Project' which essentially envisages construction of two canals with the integrated reservoirs as indicated below:

(i) A 15000-mile (24140 km) long Himalayan canal aligned along the southern slopes of the Himalayas from the Ravi River in the west to the Brahmaputra River in the east and extended beyond Brahmaputra towards the south by another 1100 miles. The canal was to be 1000 ft (304.8 m) wide and have a depth of flow of 400 ft. The bed of the canal was to be fixed at a constant level which may be between 1000 ft (335 m) and 1500 ft (457 m) above mean sea level. The canal will be fed from the waters of the Himalayan rivers which will be stored in 50 integrated lakes; each 30 miles (48 km) long and one mile broad and 90-100 ft (27-30 m) deep on the northern side of the canal. There will be another 40 such lakes on the southern limb. The integrated lakes will be created by cutting the hill slopes of the Himalayas to the same level as the bed of the canal.

The total capacity of all the integrated lakes of the Himalayan canal including its southern limb will be 250 km^3 (200 Ma-ft).

(ii) The central and southern Garland Canal which is about 5800 miles (6115 km) long and aligned at constant elevation (zero hydraulic gradient) between 800 ft and 100 ft (244 m and 30 m) above mean sea level. It will have the same size as the Himalayan canal. This Garland canal will also have about 200 integrated lakes as in the case of the Himalayan canal with a capacity of the order of 400 Ma-ft.

Captain Dastur's proposals also include the construction of a reservoir at Nagaur in Rajasthan with a capacity of 250 km^3 (200 Ma-ft) and a reservoir in the Sone Valley with a capacity of 125 km^3 (100 Ma-ft).

The Himalayan canal and the Garland Canal were proposed to be inter-connected at two points, ie, (i) near Delhi, and (ii) Patna by means of pipelines, five 12 ft (3.6 m) diameter each, to transfer waters of the Himalayan canal to the Garland Canal. Alternatively, these were to be connected by linking canals running on high bunds across the plains. A further alternative to this arrangement was to let down the stored water from the Himalayan canal into the natural courses of rivers and pump it up from the Indo-Gangetic plain into the central and southern Garland Canal.

The proposal was examined by two committees of experts comprising senior engineers of the Central Water Commission, state governments, academics and scientists of the Geological Survey of India and the India Meteorological Department.

According to the studies, the cost of Dastur's proposals worked out to about Rs 120 billion, which was nearly 500 times the figure indicated by Captain Dastur. The experts were of the opinion that the Dastur proposals were technically unsound and infeasible and economically prohibitive, and, therefore, were not pursued further.

National Perspective Plan

In view of the fact that the two proposals described above were techno-economically not feasible, the Department of Irrigation evolved a perspective plan in consultation with Central Water Commission which was based on conventional technology and which did not involve lift (except for small quantity of water). The national perspective comprises development Peninsular and Himalayan Rivers.

Peninsular Rivers Development

At the outset, it must be made clear that this is a conceptual plan based on paper study like the other proposals. It is based on optimization of available waters and their use disregarding state boundaries in the best national and regional interests. Full reasonable requirements of water within a basin have been reserved. Amongst the peninsular rivers, the rivers Mahanadi and Godavari would appear to have sizeable surplus after meeting the existing and projected needs of the states within these basins. It was, therefore proposed to examine diversion of about 19 km^3 (15 Ma-ft) of surplus flows of Mahanadi River to the Godavari system and to further transfer 38 km^3 (30 Ma-ft) from Godavari and its tributaries to the Krishna River and downwards south to serve water short areas. The link from Mahanadi to Godavari can run along the east-coast and will not involve any lift. The links between Godavari and Krishna could be partly by gravity and partly, in the ultimate stage, by lifts of the order of 400 ft (122 m) (maximum). The link canal would fully meet the requirements of Godavari, Krishna and Cauvery deltas. Thus waters presently being used by the above delta areas would be available for irrigation in upper areas in Karnataka, Andhra Pradesh, Maharashtra and Tamil Nadu. The transfer of waters would thus provide additional irrigation in drought-prone areas of Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu.

Another part of this proposal is to divert a part of the surplus waters of the west flowing rivers of Kerala to the east for irrigation the drought areas of Tamil Nadu apart from bringing new areas under irrigation in Kerala and generating hydro power and providing flood control benefits.

The third segment envisages construction storages and to inter-linking small rivers flowing along the west coast north of Bombay and South of Tapi. This will provide additional water from numerous west flowing rivers for extension of irrigation to Saurashtra and Kutch areas. It will also provide extra water to meet the growing needs of the metropolitan area of Bombay as well as providing irrigation in the coastal areas in Maharashtra.

The fourth part envisages inter-linking of southern tributaries of the river Yamuna like the Ken and the Chambal in addition to construction of small storages on intermediate tributaries and a dam on the Yamuna at Panchnad. This can provide irrigation in Ujjain-Indore areas of Madhya Pradesh as well as upper Rajasthan.

The proposal of peninsular river development could enable additional use of 75 km^3 (approx) of water to benefit the states of Orissa, Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu, Madhya Pradesh, Gujarat and Rajasthan. This can provide additional surface water irrigation benefits of 13 Mha and generation of 1.5 GW of power. In addition, about 3 Mha area could be irrigated with groundwater due to recharge of irrigated areas.

Cooperative Development of Himalayan Rivers

The river system Ganga-Brahmaputra-Meghna (GBM) constitutes a major basin. The total water resources of the GBM basin is about 1 000 Ma-ft. Less than 10% thereof is being consumptively used at present (largely in the Ganga basin). The rivers Brahmaputra and Meghna are almost virgin rivers. It is indeed feasible to conserve and develop sizeable quantum of this huge water resources for beneficial uses of all the concerned countries. There is ample water for one and all and still more than 60% would continue to run waste into the sea till prepetuity (after fullest use of water). Floods, no doubt, constitute the destructive side of the water resource. But the problem can be best visualized in the context of a total and comprehensive approach towards development, conservation, management and use of water and land resources of the region. For such comprehensive planning, river basin is considered as a unit. The area to be considered would thus comprise the sub-basin areas of the Ganga system, those of the Brahmaputra system and those of the Meghna (Barak) system, the sub-basins of which form part of the major Ganga-Brahmaputra-Meghna (GBM) basin. The countries having vital interest in the development are Bangladesh, India, Nepal and Bhutan.

It is a paradox that although this region is endowed with plenty of the water resources and fertile agricultural lands, it ranks amongst one of the poorest regions of the world earning not more than $150 a year per person. The Ganga-Brahmaputra basin in Bangladesh. India and Nepal is among the most populous areas of the world. It is estimated that 450 million people or 9.6% of all mankind occupy 100 Macres (40×10^6 ha) of crop lands in this basin. Willy Brandt Commission has underscored the need for comprehensive development of land and water resources of this under-developed region to alleviate the poverty and miseries of the people. The area is afflicted by flood-drought-flood syndrome. Often during the same monsoon has large areas in the basin have been affected by floods while extensive areas in other reaches suffered from drought. Sometimes even the same area has suffered from floods and droughts during the same year.

Hitherto the basin countries have been planning water development and flood control measures keeping in view only limited interests of their own. In the process their development activities have adversely affected the established benefits being enjoyed by other country/countries or caused significant adverse effects. There are several problems of this nature between Nepal and India and India and Bangladesh. The key to fuller utilization of this vast water resources is creation of large storages and inter-linking of numerous river systems as in a water-grid to enable conservation of water during monsoon months and its release for beneficial uses such as water supply, irrigation, hydro power generation, pollution control and others as necessary. If adequate flood space is provided in the reservoirs, floods can be moderated providing substantial benefits of flood control in the downstream reaches. Ukai, Damodar valley and Hirakud reservoirs are successful examples in this regard. Aswan dam in Egypt and the proposed Mekong dam and other examples on international rivers. About 600 km^3 (500 Macre-ft) of storage is required to fully harness the water resources of the GBM basin. Unfortunately, the feasible harness the sites are few. As against this, at best about 215 km^3 (170 Macre-ft) of storage could be provided in India, Nepal and Bhutan on the GBM system.

All the four countries, viz, Nepal, Bhutan, India and Bangladesh stand to benefit. If a regional view is taken India can get benefits of additional irrigation of 30 Mha (approx) after fully meeting the needs of water in the other three countries. Besides, the region can benefit from hydro power generation of 50 GW apart from flood control and other benefits.

National Water Development Agency

As the Himalayan rivers development component involves international implications and cooperation from neighbouring countries, Government of India has decided initially to undertake surveys and investigations for the peninsular rivers development component of the National Perspective. For this purpose, a separate organization, namely, the National Water Development Agency has been set up in 1982 under the Ministry of Water Resources, under the chairmanship of the Union Minister of Water Resources. This scheme of surveys and investigations is estimated to cost about Rs 1070 million and the work is expected to be completed in about 7-10 years. The Secretary, Ministry of Irrigation is the Chairman of the governing body of this agency which has representatives of all the states concerned both at official and political level. The Director-General, National Water Development Agency, is the Cheif Executive Officer. The agency has started the work in right earnest and made some progress. However, work is hampered for want of cooperation from some states.

National Water Policy

Transfer of water from one river to the other has always been a sensitive issue amongst the states; more so because water is a state subject. It is gratifying to note that the Government of India constituted the National Water Resources Council with the Prime Minister as its Chairman and Union Minister of Water Resources as Vice-Chairman and the Chief Minister of the states as members. The Council in its first meeting deliberated upon certain, national water policy issues. It was agreed that planning and development of water resources need to be governed by national perspectives. It was also agreed that available resource should be brought to utilizable resource to the maximum extent. It was also agreed that water should be made. Available to deficit areas by transfer from surplus areas including transfers from one river basin to another, based on a national perspective, after taking into account the requirements of the areas/basins. It was also agreed that the irrigation intensity should be such that benefits of irrigation are extended to as large a number of farm families as possible keeping in view the need to maximize production. Quality and environmental aspects were also stressed.

These principles should provide a good basis for preparing the National Water Plan. However National Water Policy has still to make considerable headway. Some pertinent issues must be examined for enabling NWDA to prepare meaningful perspective plans for water development. What constitutes reasonable requirements for a basin? What factors such as irrigated intensity, cropping pattern, etc should be considered in arriving at such reasonable requirements? How far we should go into future while arriving at future water requirements for various uses? What priorities should in basin areas enjoy in years of distress? What levels of water use efficiency and quantum should be adopted for consumptive uses (in basin and outside basin) for planning a water resources project? What minimum requirements of drought-prone areas should be aimed at? Another vital issue is the rehabilitation of displaced persons. Although more and more liberal compensations and benefits are being offered, planning and implementation of rehabilitation need considerable improvement. A national consensus on this issue will go a long way in accelerating water resource development.

Of course, any development scheme must satisfy the basic criteria of techno-economic feasibility taking into account all positive and negative impacts on the environment. The benefits should exceed the costs.

Once a broad consensus is reached amongst the states regarding the National Water Policy, the central government could introduce legislation declaring wateras a national resource to be developed within the framework of the National Water Policy evolved by the National Water Resources Development Council. Water Development Plans could be prepared by NWDA or Regional Commissions and after scrutiny by experts from various disciplines such as engineering, agriculture, economics, environment, planning, etc can be forwarded to the state governments concerned and finally discussed at the National Water Resources Councils meetings.

Plans involving inter-state transfer of waters require huge outlays and call for participation and cooperation of all concerned states. The central government may have to participate in their implementation by way of funding, monitoring of progress and, later on, in water management with a view to ensuring co-ordinated operation of the supply and distribution systems for equitable distribution with the framework of water planning of the project.

High- Tech Applications

Like many other areas water has many applications using computers. A large number of software programmes are available which can be used on IBM compatible PCs for graphics, statistical analysis, complex computations, solution of equations, hydrologic modelling, groundwater modelling, finite element analysis, digital terrain modelling and many others.

Automated and semi-automated canal system operation from a centrally located computer based on sensed data regarding inflows, outflows at various locations, crops dependent on canal irrigation, rainfall in command, soil moisture data for root zones of irrigation crops, etc is one of the recent applications. The Sardar Sarovar Project in Gujarat has planned such semiautomated canal system operation.

There is large scope for sprinkler and especially drip irrigation in India. If power for pressurization is available considerable economy can be achieved.Similarly elastomeric bearings for very high loads, prestressed anchorages for large sized tainter gates, inflatable water seals and many other devices are available for economizing in water related structures. Plastics have numerous applications such as lining, pipes and tubes.

REFERENCES

1. T G Chapman, S Dumitrescu, R L Nace and A A Sokolov. 'World Water Balance: General Scientific Framework of Study.' UNESCO, Technical paper no 6, 1970.
2. S Orvig. The Hydrological Cycle of Greenland and Antartica.' International Association of Scientific Hydrology (IASH), Publication no 92, 1970.
3. M I Lvovitch. 'World Water Balance: General Report.' International Association of Scientific Hydrology, publication no 93, 1970.
4. S Caimcross, I Carruthers, D Clerits, R Feachem, D Bradleky and G Baldwin. 'Evaluation for Village Water Supply Planning.
5. CBIP Total Catchment Management, Journal of Soil Conservation, New South Wales, vol 42, no 1, 1986.
6. 'Developing World Water,' Grosvenor Press International.
7. 'National Water Policy.' Ministry of Water Resources Government of India, September 1987.
8. Proceedings of the First National Convention, Central Board of Irrigation and Power, October 1987.
9. Proceedings of International Seminar on 'Environmental Impact Assessment of Water Resources Projects.' 1985.
10. A K Biswas and Qu Gepina. 'Environmental Impact Assessment for Developing Countries.'
11. Workshop on 'Assessment of Environmental Impacts: Their Integration for Planning Water Resources Development Projects and Water Quality Modelling.' System Engineering Unit, Central Water Commission, 1986.
12. Dr B0 Pathak. 'Hydrology of India.' Central Board of Irrigation and Power.
13. Irrigation and Power, vol 45, no 3, July 1988.
14. 'Research Schemes in Water Resources.' Central Board of Irrigation and Power, 1988.
15. 'Long-Term Planning OT Water Management.' United Nations.
16. 'River Basin Development Policy and Planning.'
17. C C Patel. 'Modemization of Irrigation Systems in India.'
18. 'River Basin Management.' United Nations, 1971.
19. 'Environmental Impact Assessment.' Interim Mekong Committee, 1982.
20. G N Goluber and A K Biswas (ed). 'Large Scale Water Transfers.' Water Resources Series.' United Nations Environment Programme.
21. National Resources Forum, United Nations, vol, 6, no 2, April 1982.
22. 'New Directions in US Water Policy.' Summary, conclusion and recommendations from the Final Report of National Water Commission.
23. 'Integrated River Basin Development.' United Nations, 1970
24. D C Major. 'Multi-objective Water Resource Planning.'
25. 'Water Resources Policies for Development and Management.' Department of Economic and Social Affairs, United Nations.
26. 'Australian Surface Water Resources.'

The Next Phase of Irrigation Planning in India

Dr Yoginder K Alagh

It is my privilege to deliver the Fifteenth Bhaikaka Memorial Lecture. Vidyanagar at Anand is a great compliment to Indian engineering since it is technology diffused in a rural area and Bhaikaka was the spirit of this development in the Charotar. Unless technological issues are properly integrated with socio-economic and production system relations, different kinds of water devolopment strategies can and do lead to environmental costs and may not be sustainable in the long run. But the challenge is to see that technological, agronomic and socio-economic aspects are properly integrated into water development planning, such that environmental costs do not arise. The issue is not surface-vs.-groundwater development or dams-vs.-watersheds, but planning with sutainability concerns and without it. The argument that large water transfer projects have unacceptable environmental costs and low benefits arises, we will see only if major planning failures are postulated. But with poorly planned and executed projects, low or negative returns to investment, land degradation and environmental problems arising out of use of poor quality water in relation to the soil can and do also arise with groundwater use. Similarly small watershed projects need very careful planning strategies and in fact raise important concerns of popular participation in local planning. It is important therefore to face up to some of the real issues of land and water development, rather than discussing the problem only on general first principles and with impressionistic data.

2. I propose to address myself to questions of planning for the use of water, particularly those areas where the engineering aspect impacts on economy and society and, therefore, there is the requirement of a wider range of skills to be brought to bear on the solution of purely technical and structural problems.

3. It is true that we have in the past not been the best conveyors of water. Our skills in dam designing and construction are recognised globally, but questions of planning and a management of water conveyance system have received much less attention. Conveyance losses are high, in many cases 40 to 60 per cent higher than the designed standards. In some areas, improper water regulation and drainage has also led to water-logging. This is socially extremely wasteful in the context of the land water scarcity of the Indian economy. The issues involved in water conveyance are, therefore, of very high priortiy.

Agricultural Regions and Water Use

4. Let us begin at the level of the agricultural field irrigation engineers have to learn to design water delivery systems differentially for the different regions of a canal-command. For too long, commands of large irrigation projects have been treated as homogenous and uniform entities. Soil conditions, temperature and its distribution, rainfall and its distribution, the ground water regime, existing forest cover and existing tanks and minor rivers and drains are all features which need to be paid very detailed attention. This will normally requre that a command is regionalised into components. In Annexure-A, data is presented on a large project in Western India where while the initial intention was to provide for a uniform pattern of irrigation through the command, after detailed consultations with geologists, demographers and land use planners, meteoreologists and agricultural scientists, the command was broken up into 13 regions (Sardar Sarovar Narmada Command).

5. Even in the Indira Gandhi Nahar area, where the initial feeling and intuitive sense was that of regional homogeneity of the proposed command in the Phase II area. The available data showed that the average annual rainfall varied only by 40-42 per cent as between different rain gauge stations in the period 1930/1960, but there was years when this variation could be in the range of 928.24 per cent. While a considerable part of the command had a depth to below ground water table of over 40 metres, area with levels below 20 metres was not unsubstantial. Also there were pockets of critical hard pan areas. Regionalisation, aquifer and other studies have now been completed for this purpose. The IGNP Stage II area, for example, has now been divided into three areas. Zone I area above Nachno and Phalode has more than 50 m alluvial cover and variability of rainfall is low. Zone II is the area below this zone. Rainfall has high coefficient of variability and low soil cover. Zone III is the Lift Command Areas with higher rainfall and loamy sand soils. Hard Pan areas coverage varies in the three zones. Thus irrigation planning will have to be different in each sub-zone (Annexure-B).

6. I would like to bring to your attention that this phase is important for irrigation planning. This phase has to be seen not just as a question of regional studies. The association of the irrigation engineer with the wide disciplines of geography and land use, meteorology and ground water will from the beginning sensitise the irrigation planner to the diverse agro-climatic and agro-ecological environment in which the water system has to operate and this sensitivity is extremely important for planning the physical features of the irrigation structures.

Cropping Patterns and Farmers Behaviour

7. There is the much vexed question of cropping patterns and the problems that arise when the 'design' cropping pattern does not materialise on the field on the 'sanction' for the crop(s) is violated in practice. The practice uptil now has been to consult agronomists and to fix these parameters into the design of irrigation projects. Much depends on the seriousness of the agronomist who gives the projection. In one particular case of a project which used to be singled out by Prime Minister Indira Gandhi for critical comment. I discovered on a field visit that the cropping pattern in the project area was taken from the 'Second Five-Year Plan o,f the particular State in which it was located. The project area is less than 5 per cent of this large paddy growing State. Paddy is totally unsuitable as a crop for the black soil in the command area. But somehow paddy was recommended as a crop for this project. Irrigation system design for paddy of course created considerable havoc in the subsequent phases of development there.

8. Here again, there is considerable need to understand and quantify the behaviour of the Indian farmer in the agro-climatic regime being studied. Economists have for long worked on this problem and have developed 'acreage response models.' These essentially postulate that the acreage allocation of the farmer follows profit maximising behaviour and depends on rainfall and its distribution, irrigation, the agricultural technology available and relative prices. The use of these models for irrigation planning would mean that the farmer's behaviour is studied and statistically estimated through acreage allocation models for an area of the kind with due consideration of the agro-climatic characteristics of the region in the command.

9. For the different possibilities of water availability, it would be possible to estimate alternative crop sets that the farmer would consider once irrigation is available to him. The model would be of an econometric variety as follows:

Formal Models of Water Allocation

1. We take a big irrigation command. With some simplification the same principles will apply to ground water development. The command has 'r' regions and 'c' crops. First take the obvious fact that regionalisation should be done with irrigation characteristics namely rain fall and distribution, soil characteristics, water aquifer characteristics and the possible layout of delivery systems. Administrative and/or general economic development categories are not important. Assume that potential crops for the command are worked out with agronomic studies.

2. For any region 'r' the potential crops 'c' are defined.

Now we can first work out

(i) $A_{rc} = f(R, I, P_{rc})$

Where,

A_{rc}	=	area in the rth region under crop 'c'
R	=	rainfall (mean = variability can also be tried)
I	=	irrigated area
P_{rc}	=	relative price of cth crop (or relative profitability can be tried).

(i) can be estimated with distributed lags. Work out a relative price configuration for the future. Then for alternative levels of irrigated area, alternaitve crop sets combinations can be worked out (A_{rc}/A_r). In the next step for each crop set work out water requirements in peak period W_r. Now with an aquifer model, limit surface water delivery such that water logging is ruled out. This gives alternative combinations of ground and surface water delivery (totalling to W) which can be used potentially in each region.

3. For each possible crop set in each region, using potential crop yield (Table II) and cost of cultivation data for each crop, value added in agriculture can be worked out. Work out separately for wages (hired or imputed) and surplus. Given the estimates of costs of delivering water, maximize value added for all regions applying a social wage criterion which is derived after examining inter-regional irrigation possibilities.

4. The important issues, therefore, are to use farmer's behaviour patterns to work out cropping possibilities; to atlocate water subject to ecological constraints (water-logging and drainage parameters); and to explore in details the benefits arising from spreading water through the command rather than concentrating in a few areas to avoid the tail ender problem. Technological aspects like distribution systems with sufficient capacity, control (for regulation) and efficiency (to avoid losses) are as important as the use of appropriate economic machanisms, eg, pricing of water and incentives for groundwater use.

An estimate of possible crop sets for one region of an irrigation command in which this method has been applied, given in Table - I.

Table – I Projected Irrigated Crop Sets (Fraction of Cropped Area) for Region – 1

Sl No	Crops	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Paddy	0.16	0.18	0.20	0.17	0.17	0.12	0.10
2	K Jowar	0.01	0.00	0.01	0.00	0.01	0.03	0.05
3	K Bajra	0.03	0.03	0.02	0.03	0.02	0.03	0.03
4	K Groundnut	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Wheat	0.14	0.14	0.14	0.12	0.12	0.12	0.16
6	Vegetables	0.03	0.02	0.02	0.04	0.04	0.04	0.02
7	R Pulses	0.04	0.04	0.03	0.03	0.03	0.03	0.03
8	S Bajra	0.04	0.03	0.02	0.03	0.03	0.04	0.02
9	S Groundnut	0.01	0.00	0.00	0.02	0.02	0.05	0.00
10	R Jower	0.00	0.04	0.05	0.04	0.04	0.05	0.05
11	Tobacco	0.09	0.09	0.05	0.04	0.09	0.05	0.02
12	Cotton	0.31	0.35	0.38	0.34	0.33	0.42	0.40
13	Sugarcane	0.00	0.00	0.00	0.02	0.02	0.00	0.00
14	Perennials & Fruit Crop	0.02	0.02	0.02	0.02	0.03	0.02	0.02
15	Other crops (including lucerne)	0.06	0.60	0.05	0.05	0.05	0.05	0.05

The method essentially reduces the theoretical cropping sets from infinite possibilities to a set of alternatives which need to be considered for irrigation design purposes. It also sensitises the water resources engineer to the possibilities of alternative agricultural development in the area in which he is working.

Conveyance Capacities for Conjuctive Use of Water

10. The design for conjuctive use of surface and ground water has to be planned from the beginning. experiment is conducted and the number of watering in the field in the crop season. This requires emphasis on ground water investigation. Given the kinds of crop sets discussed above, the peak requirements of water can be worked out, for each crop set. Once the possibilities of safe withdrawal of ground water are known, the requirements of each crop set for the balance surface water can be estimated. If this kind of planning is considered from the beginning and institutionalised either by promoting use of tubewells by the farmer or by integrating ground water into the project, the possibilities of water logging would be eliminated from the beginning.

11. I would only like to note two further features namely that systematic monitoring of ground water and the construction of water balance models at the level of an aquifer are in fact not very expensive propositions and can be followed through fairly easily with modern computers, once the basic information is available. Given preliminary estimates which can generally be built with easily available bore hole data, soil characteristics and land use information, more refined models can be developed as the investigation of soil characteristics and the ground water regime proceeds at micro levels.

12. At this stage of planning, the whole question of allocation of water to different regions becomes critical and would in turn then determine the design of the conveyance system. Too little attention has been paid uptil now on both the costs and the benefits of irrigation development. It is not generally known, for example, that crop cutting experiments which are the base of Indian agricultural statistics, contain data at the level of each field on which the experiment is conducted and the number of watering in the field in the crop season. Thus, with a little effort and marginal expense on computer money, it is possible to generate estimates of the kind indicated in Table-II, generated for Gujarat.

This Table shows that the returns to irrigation with 6+ waterings are quite high. Incidentally, information of this kind would nail the critique that productivity of surface and ground water irrigation in India is low and also that 'benefits' are overestemated.

13. Now if information on alternative crop sets of the kind discussed earlier is available and the yield from irrigation can be estimated with the degree of precision indicated in Table - II for a recent period and the costs of building conveyance systems to the field can be estimated accurately, a very precise estimate of the benefit of irrigation conveyance estimates can be derived (Table - III). Such calculations have in fact already been made for some advanced projects which are off the design board and we now have the techniques to replicate them on a much larger scale. With these kinds of calculations, if an explicit weight has to be given to generate more

employment in some poverty stricken region, this could be done in a quantifiable manner.

Table – II

Sl No	Crop	5 Year Average 1969/70 – 1973/74
1	Paddy HYV/6+ Irri.	2845
2	Paddy Av/6+ Irri.	2180
3	Wheat HYV/6+ Irri.	2489
4	Wheat Av/6+ Irri.	2379
5	Bajara HYV/3–5 Irri.	1861
6	Bajara Av/3–5 Irri.	1843
7	Tobacco Av/6+ Irri.	2337
8	Cotton HYV/6+ Irri.	1312
9	Cotton Av/6+ Irri.	1308
10	Groundnut Av/6+ Irri.	1456

Source : Crop Cutting Experiments – Retabulations.
HYV = High Yielding Varieties.
Av = All Varieties.
Irri. = Irrigation.

Table – 3 Irrigated and Unirrigated Crop Sets for Different Water Allocations for Region 1

Efficiency - 60 %

Uper limit of canal utilisation ('000 Ha)	Peak canal water demand ('000 cusecs)	Peak G W demand ('ooo cusecs)	Value of objective function (Rs Crores)	Irrigation intensity GIA/CCA	Annual G W utilisation ('000 hm)	Canal utilisation ('000 ha) Kharif	total	Irrigated set intensity set N0/Value	Unirrigated set intensity set No/Value
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
65	1.771	0.655	41.583	0.707	25.181	31.519	65.000	4/0.707	1/0.452
70	1.891	0.700	43.113	0.755	26.386	34.236	70.000	4/0.755	1/0.414
75	2.012	0.745	44.616	0.803	27.590	36.952	75.000	4/0.803	1/0.377
80	2.294	0.750	45.966	0.882	28.795	37.730	80.000	1/0.434 4/0.448	1/0.325
85	2.597	0.750	47.305	0.964	30.000	38.243	85.000	1/0.927 4/0.037	1/0.271
90	2.790	0.750	48.632	1.914	31.205	40.518	90.000	1/0.832 2/0.182	1/0.229
95	2.971	0.750	49.959	1.061	32.410	42.966	95.000	1/0.679 2/0.382	1/0.187
100	3.153	0.750	51.286	1.109	33.614	45.413	100.000	1/0.526 2/0.583	1/0.145
105	3.334	0.750	52.613	1.156	34.819	47.860	105.000	1/0.373 2/0.783	1/0.103
110	3.322	0.750	53.269	1.151	31.872	53.152	110.000	2/0.940 4/0.211	3/0.100
115	3.322	0.750	53.686	1.151	27.354	58.152	115.000	2/0.940 4/0.211	3/0.100
120	3.322	0.750	54.103	1.151	22.836	63.152	120.000	2/0.940 4/0.211	3/0.100
125	3.322	0.750	54.105	1.151	22.820	63.170	120.018	2/0.040	3/0.100

14. Irrigation projects have, therefore, now to be designed within the framework of a very detailed understanding of the agro-climatic and agroeconomic regime for which they are being designed. It is possible to take into account the diverse features of the Indian agricultural economy to develop such designs as illustrated above.

Water Management Design is Genuinely Interdisciplinary

15. The important issue that I would like to ernphasize is that studies of the type being discussed have to impact on irrigation design and capacities. The agricultural Scientist and Economist, land use and regional planner, economic statistician and geologist, are not add us to the team. The work has to impact on the day to day work for the design of capacities and regulation of the systems. This has been done in our country already on some projects (Table III). We need to replicate tile selected advances faster. In fact, a Working Group for the Eighth Plan has reviewed the experience under the National Water Management Protect and recommended that a quarter of the area under government canals should be included in a programme, the target of which should be to deliver water in every crop season, to each field in the command.

Surface Water Projects

16. Critiques of surface water projects argue that they are expensive, they do not lead to benefits in relation to costs, they lead to waterlogging and rehabilitation costs.

17. In many cases inter-basin transfer of water attempts to transfer water from water surplus regions to strongly deficit regions. There is no evidence to suggest that schemes which involve the transfer of such water are more expensive than those which provide for ground water lifting, let's say at a depth of 20 metres or more in average soil conditions on dry land conditions, leaving aside more difficult conditions like hard pan or hard rock areas, where obviously capital costs of ground water would be higher. In such areas costs of around Rs 40000/hectare are by now common. Sometimes even experienced agricultural economists work out the running costs of ground water projects without adequately costing the opportunity energy costs of pumping.

18. The standard groundwater aquifer model works out first the groundwater balance in the past and calibrates it with observational data. Such models are used to simulate the land and water regimes in the command given soil conditions like rugosity, hydrogeological conditions and evapotranspitation rates, natural vegetation over the crop regime and the quantity of surface water flow, the number of years and the pace in which the groundwater table rises, can be worked out. Thus, a model of the Mahi Narmada Doab, an aquifer in which at present the water table is between 60 feet to about 300 feet the model works out the number of years in which under alternative irrigation delivery regimes, the groundwater table will rise to say a level of around 10 feet below the surface. It may be noted that at initial phases of an irrigation project, surplus water is available and its seepage through the soil to the aquifer is a sure-shot manner of augmenting the natural resource of ground water. In the new irrigation projects being planned, such models are used to plan canal systems. Groundwater levels in a basin are monitored. Since the surface water is regulated the farmer is encouraged to invest in tubewells to realise his profitable cropping pattern. If he does not do so, State tubewells are installed when the water reaches close to the surface. The canal system is designed to convey this water abstracted from tubewells. The system is failsafe. I had argued that in projects in which this is being done, not a single hectare of land would be waterlogged and have been criticized for making this claim. My only reply is to append in Annexure-C, the groundwater levels in October 1988, in 78 points in the Mahi Narmada Doab in Annexure-C. Thus, groundwater is being monitored with 78 piezzometers 6 to 7 years before the surface water is to became available. The irrigation system has been designed in a manner such that the farmer would be encouraged to withdraw groundwater, since only limited quantities of surface water would be available. If this strategy does not work and the monitored ground water levels show alarming levels, State Tubewells would be installed and water would be pumped back into the canal system, which has been designed to accommodate it. Not a single hectare of land would, therefore, be allowed to be waterlogged and critics have to prove the contrary. Tile Planning Commission has approved the project with tile pre-condition that studies for drainage and ground water balances already completed for the Mahi Narmada Doab must now be completed for regions like the Bahl, Saurashtra, Kutch and Sami Harij, so that the irrigation strategy takes the soil and water balance into account.

19. In Indira Gandhi Nahar Project in the Phase II area, ground water levels are 20 metres to over 100 metres below the surface. Ground water aquifer models have been built up for the area and are being used for devising irrigation planning strategies for the Sagarmal Gopa Branch (CCA of 2.56 hectares) and to a lesser extent the Shahid Birbal Branch (1.01 lakh hectares), two of the largest parts of the system. It may be noted that since the conveyed water would be sweet, quality of the ground water could also improve through blending. The simple point is that conveyance of surface water would in fact augment the availability of water for good and hence the need to plan from tile beginning for conjunctive use. The purpose of ground water acquifer models of course, is to build up computer capatible regimes which precludes waterlogging. Measurement and control systems are installed from the beginning and provision made at the design stage in such a manner that if the farmer does not use the ground water even when the energy cost of pumping it falls as the water table rises, the Project authority would pump out the water and convey it in the distribution system which is designed from the beginning to provide for this eventuality.

20. As regards the benefits of irrigation, quantifiable estimates have been discussed earlier (Para 12 and Table II). It is argued that the benefits of Sardar Sarovar Project are overestimated because the expected yield is high ie around 4 tonnes of wheat and paddy and more than 2.5 tonnes of Jowar and Bajra or around 1.5 tonnes of Pulses, groundnut and cotton, and over 2 tonnes of tobacco. As against this, current yields are lower. The Sardar Sarovar Project would give controlled and assured irrigation. Thus, its outcomes should not be compared with the average obtaining at present or even the average obtaining under irrigated conditions presently, since in large parts of the State, irrigated areas did not get assured water supply. Detailed tabulation of crop cutting experiments have shown that in most cases average yield with 4+ waterings was more than double the average of all irrigated crops showing that 4 assured irrigations were not made available on an average in irrigated areas in the State. Thus, it was clear that when assured irrigation will be given to the farmer, the yield levels achieved will be those approximating to those planned for the Sardar Sarovar system towards the end of the century. Infact, such yield targets would be exceeded on account of technological progress. The benefit cost ratio would be highly favourable making the Sardar Sarovar Project a worthwhile investment. When these have been conveyed to critics, they argue that they relate to a small experimental area. Again this is incorrect since Table II is from crop-cutting experiments: the source of production statistics in India. The argument of course is not that expenditure on irrigation development is by itself a magic wand. The issue really is that poverty and low productivity levels in dryland areas themselves have tremendous social costs. The acute scarcity of water in these areas adds on to the social and economic problems of the inhabitants. Well planned-out transfer of surface water can be a great boon in providing drinking water, removing water-borne disease, raising the agricultural productivity of the region and can in fact lead to highly beneficial ecological outcomes. More than half of themorbidity in India is estimated from water borne diseases. In the Saurashtra Districts of Gujarat to be benefitted from Sardar Sarovar, up to 20 per cent of the morbidity is from scabies, a disease arising from stagnant water. The trade-off is not between a favourable eco-system and development. As Mrs. Indira Gandhi argued in her Stockholm lectures, poverty and ecological degradation normally reinforce each other. The design of development has to augment the sustaining capability of the environment and to provide for a more active interaction between man, technology and the available land and ecoresouces.

21. The argument that surface water development is at the expense of ground water development is not particularly clear. In areas where both are the possibilities, the two are complementary. In others, where they do not compete, they are in their own right each important priorities. To argue that the two are competitive, is to suggest for example that for a student textbooks compete with stationery. The requirements of both have to be met possibly at the expense of other inessential expenditures. However, it has to be emphasised that water should be transferred or conveyed only after socially profitable use possibilities for it have exhausted. Thus only 'surplus' water is to be conveyed.

Water Development

22. Development of ground water and watershed development are very important priorities for the national economy. Watershed development in particular is a concept on which emphasis has been recent. A number of experiments are presently underway. There are centrally Sponsored Schemes. In a few States, externally aided watershed projects are in operation including World Bank, EEC financed and bilaterally financed projects. ICAR is also emphasising agricultural development on selected watersheds. Finally some very exciting work is being done by NGOs like the Society for the Promotion of Wasteland Development and other groups. An interesting feature of the work of some of the voluntary groups is that the cost estimates of feature like contour bunding, check dams, land levelling and digging of percolation tanks and soil conservation work is lower than that in official projects. Also voluntary agencies have interesting proposals of integrating rural development schemes like NREP, RLEGP and IRDP with watershed development schemes.* Finally groups like the SPWD and Pani Panchayat of Shri Salunkea, lay considerable emphasis on contribution from the farmers and beneficiaries and this is of very high importance. Detailed studies are now showing the importance of the involvement of different institutional groups, the farming communities, landless labourers and government agencies, for any serious attack on land use planning problems.**

23. In actual fact, in many rural areas, examples of successful agricultural development or rural development experience particularly under somewhat difficult resource endowment conditions, tend to follow a very different experience path. If sufficient irrigation water is available and the soil regime is suitable for a crop for which technology is well known like wheat or paddy, market oriented prescriptions have great possibilities of success, since almost all the pre-conditions of this paradigm are fulfilled in terms of the atomistic nature of peasant proprietorship and the response of the peasantry to economic incentives. Thinking took place in a somewhat 'linear' direction. The emphasis was on irrigation and the new bio-tech technology and in many cases only on this.

24. In many parts of the country, however, the problem is far more difficult. Land and water resources are meagre. Population pressure is rising. Commercialisation in many cases tends to lead to the short-term

exploitation of resources and costs of soil degradaion and water erosion are not fully reflected in market prices. Traditional, socio-economic systems working at low levels of equilibrium are collapsing and newer methods of sustainable development are not jelling.

25. There are, on the other hand, a number of successful experiences where the basic problems of food and energy requirements of poor rural communities have been resolved through the application of state-of-the art scientific knowledge and technology at the cutting edge of the interface of man with land and water. A fairly massive programme of work has been designed on agro-climatic planning in which the country has been divided in 15 broad agroclimatic zones based on soil, climate including temperature and rainfall, both level and variability and the availability of water, both surface and underground. Apart from putting together such information, an attempt was also made as a part of the development of such plans to document success and failure stories in land and water management and more optimal land use and cropping patterns. Such success stories were under alternative agro-climatic regimes which include low rainfall areas where, for example, the level of water availability on an average is 50 cms and a coefficient of variation of 40 to 60 per cent. In other words, in some years the water availability could be less than 8 inches. A second kind of agro-climatic problematique is that where the availability of water is greater, say around 1000 mm, but the variation is again 40 to 60 per cent. But now the problem is set within the context of a hill slope and a valley. Unregulated commercialisation invariably means soil erosion and precipitation instead of becoming a blessing becomes a curse, since it flows down the hill, erodes the land base of the region and leads sooner or later to a collapse of the socioeconomic system in terms of food and energy. A third problematique can be one where past development of an unplanned type or of a badly planned type has led to resource loss. President Gorbachov, in his speech on 'Soviet Agriculture' pointed out that the loss of land through waterlogging almost equalled the additions to irrigation in the Soviet economy over a period of decades. Waterlogging and soil salinity are examples of this kind.

26. Invariably, the technology to overcome these problems is well known. It is also generally well known in university and research environment not very far away from the area where the particular problematique exists. The interesting point is that just as there are a number of failures of development efforts to resolve such problems of the interaction of the society with a scarce resource endoment, there are also many examples of success. These are no longer pilot projects in the sense of designed attempts on amelioration by the State or by international agencies, but where interestingly almost invariably attempts at local level solutions of problems have been evolved at the level of the community itself. The Planning Commission has had studies initiated on a set of these experiments by independent· social science institutions. The results of these and other studies are interesting in terms of the paradigms involved.*** These experiments have a set of common characteristics which I propose to describe. First, they invariably involve effort at the level of a community but the baisc technology is well known. In the case of a dry area, the question is that of water harvesting techniques. Resuscitation of traditional practices of storing water now require larger economic incentives, since the cost of community labour has gone up on account of commercialisation. Areas with better endowed rainfall required watershed development. This means soil conservation which stops soil from erosion like contour bunding, ridge plowing and also water harvesting like gully plugging on the soil slopes and the use of village and percolation tanks. Once the land development and water harvesting is done, an optimal crop combination is possible. The land reclamation problem invariably involves more complex technology including pumping of water and the use of soil amendments. Since it involves application of the technology at the level of an aquifer, the community aspect is important.

27. The second aspect of these success stories is invariably the importance of leardership. There is no uniform pattern of this leadership. In cases like Sukhomanjri in the Punjab and the Pani Panchayats (water collectives) at Ralegaon Sidhi, voluntary organisations mattered. In others, it was some concerned official who could initiate the process. Generally, the leadership groups invloved younger people, say below 45 years of age. All those who succeeded had an experimental and scientific and technological training, at least a university degree in the sciences. Also initial successes were sustained and replicated.

28. The third feature of these kinds of success stories is the high rates of measurable 'economic' return and at the same time lack of profitability in market prices of each one of these successful experiments. In all the success cases participative methods mobilised the labour resources of the community. At 1986 or 1987 prices when these experiments were evaluated, the investment costs varied between Rs 9000 to Rs 11000 per hectare for land which was made available for agricultural or orchard crops after reclamation and between Rs 2500 and Rs 4000 per hectare for social forestry purposes. (The facts discussed in this and the next Section are based on papers circulated in a Society for Promotion of Wasteland Development Seminar, SPWD, Surajkund 1988 and a Planning Commission sponsored study, Singh and Bajaj, 1988). As far as the economics was involved, between 38 to 53 per cent of these resources were bankable once the community was invloved because many of these efforts were labour intensive, particularly the investments in land development and water management. The

internal rates of economic returns to these investments were in the range of 18 to 27 per cent per annum making them some of the most socially profitable investments in the Indian economy. Yet at going market prices, many of the families ended up in making losses. A counterpart to these losses was a deficit in energy/food requirements of many of the families involved. There is, therefore, no guarantee that with the given structure of international or national markets financially viable development will result. The paradigm question in this kind of development is of an important nature. None of the received methods of thinking correctly interface with the available institutions in the kind of development being described. Decentralised working of markets is important and yet they do not necessarily provide, automatically for the application of the available technology towards sustainable development in terms of the interface of man with the scarce resources of land and water. Also the income levels generated at existing prices may not meet subsistence requirements. A measurable kind of intervention is necessary in the economic or social context and yet it has to be of a kind which does not lead either to the suffocation of local initiatives. or to a neglect of the great vitality of rural markets

29. The question of socio-economic rules which permit this participatory kind of development is a very complex one. It is quite clear that estatist type of cooperation does not solve the problem. Neither does a technocratic regime which relies on the socalled transfer of technology paradigms through centralist auspices. For example. land development projects financed through international financial institutions have led to low rates of returns also. Perhaps the answer lies in social control on a part of the resource endowment. When water is harvested in a water shed a set of community rules has to be evolved. For example, the Pani Panchayats, give rights even to landless labourers on a part of the harvested water. Yet the peasant does not have to give up his rights to land. Socialisation and cooperative institutions do not have to be holistic or either/or propositions with individual initiatives. It is possible for individuals to cooperate for limited and well defined purposes.

Market Functioning: Limits and Opportunities

30. It is being suggested that in many rural/agricultural situations in our country, the application of state-of- the-art technology to develop the slender resource base of the area requires community organisation at the level of say watersheds or aquifers. However, such requirements can be for limited purposes and the "labour institutions" challenge is to mesh such community requirements with the advantages of factor and commodity markets working essentially with functioning atomistic peasants. Such community requirements are a precondition for better use. For example, of lands in hill slopes or sandy areas with dune formation or at the level of an aquifer, either for reclamation of say saline land or the development of water harvesting or aquifer exploitation methods.

31. Will an overall policy framework set in the context of competitive domestic and international markets be consistent with and support the kind of developments discussed earlier? In other words, how will community based systems which meet the technical requirements of resource use relying on the labour endowment of the area interface with the rest of the economy. Experience tends to suggest that at ongoing market prices, many of these experiments are financially unviable at least for those peasants who have a slender resource base. These losses have been estimated both as calorie/fuel gaps from a minimum biologically determined requirement for a section of the labour force (8% to 17.5%) or financial losses if labour costs of development are fully accounted for (13.2% to 27%). The nature of such "losses" can help in appreciating the interface of markets with labour institutions. First such losses can be minimised by development of domestic and international markets. These help by raising the value of agricultural/ forest/ residue produce and also by reducing input costs. The price of a modern water harvesting/ energy saving technology may be lower than a domestic substitute for example, an energy efficient pump set, a modern seed or pesticide. a more efficient sickle, seed drill or power tiller, or the use of photovoltaics for providing energy in remote regions. Second, it has to be appreciated that in many cases. initial costs may be high and so the case for selective non-market forms of intervention may be good, since capital markets are poorly developed. Consider that in many land development/reclamation schemes, generally particular crop combination cycles are technologically recommended for soil consolidation/improvement. For example, a fodder crop or a tree crop may require to be grown in reclaimed land to avoid relapse into degradation. At going market prices, such a crop may be unprofitable. Again invariably under such conditions in initial years input rates are high. for example the number of waterings required, seed rates or soil amendment requirements will decline, as the organic composition of tile soil improves. Thus initial subsidies/public intervention mechanisms may be required.

32. The conventional theoretical answer to such "low" carrying capacity of land features, is to suggest migration and transfer of populations to the non-agricultural or urban sectors. While useful as a long term guideline, the immediate relevance of such advice is not very clear. Also improvement in land productivity is anyway a precondition of such a desirable outcome and in any case if soil improvement is a dynamic process, excessive migration may be the wrong answer. The upshot is that market oriented rules need considerable modification when applied to realistic rural development possibilities. In fact, So called "sub-optimal" policy alternatives, for example. preference to input subsidies over output subsidies, may need to be experimented with given the

fragmented nature of labour markets. Having said this, however, two guidelines are important and may be stated firmly. Generally markets are efficient methods of getting across the farmers and other things remaining the same should be used as the preferred form of delivery of inputs or output collection and processing. Second, development of markets and communication and processing infrastructure must get high priority for rural reform. In fact, the heart of institutional reform is to evolve a policy regime which uses fiscal and investment packages which unleash the power of properly functioning markets for generating higher incomes and employment and wherever necessary, use direct intervention methods also.

33. To sum up therefore, the direct involvement of village level beneficiary oriented organisations is required since:

(i) the experience is that totally officially sponsored schemes have limited effectiveness (around 40 per cent as per the concurrent Evaluations of Indian rural development scheme);

(ii) a part of the cost of land and water development schemes becomes bankable and this really means that through the kind of mechanics described earlier the labour assets of the community, instead of being a drag on employment, lead to asset creation;

(iii) it becomes easier to channel structured subsidies to poorer beneficiaries through this method. Such subsidies are required for land development, water harvesting mefhods, and also for vegetative and crop cover on such lands. At going market prices of outputs and inputs, studies show that such schemes are not financially viable. Instead of accepting such "market failures", tile challenge is to channel public funds to energise the community to also contribute its bit and foster such schemes on a larger scale;

(iv) such organisational changes lead to the very exciting possibilities that assetless persons can share in the rewards of possible community efforts. For example, in the Pani Panchayat landless labourers have a share of tile water saved and in a number of watershed schemes, energy entitlements are given to all. No wonder, in a number of such cases, we are in the somewhat happy state that practive is running ahead of theory, and the practitioners are explicitly unhappy with the social scientist and the planner.

Groundwater Issues

34. Delivery of groundwater to the Indian farmer is another important area of priority. By now the hydrogeological survey of ground water potential in the county is nearing completion. Accelerated programmes of tubewell construction and extraction have been identified in selected districts in the country and funds provided in the Special Action Plan. More generally, it needs to be appreciated that a number of studies are now showing the working of ground water markets in the country. The farmer has shown that he is willing to pay for reliable supplies of water and ground water development policies which take into account the existing markets for such water and increase the supplies of water, ensuring its availability at reasonable prices to the farmer, should be a major objective of policies. In those areas where markets have not developed, the State may have to playa stronger promotional role, particularly through cooperative agencies but in other areas, it should stongly support and provide initiative in maing available this scarce resource in a larger measure. Policies which provide finance on a larger scale, resource development information and specialised advice to field level agencies, need to be devised and encouraged.

35. Assessment of groundwater resource in the sub-surface reservoir entails assessment of both static and dynamic components of the available water in storage. Assessment of tile dynamic component over any space and time frame is best done by water Balance Techniques.

36. Although the concept of safe yield has been widely used in groundwater resource evaluation, there has always been widespread dissatisfaction with it. Most suggesions for improvement have encouraged consideration of the yield concept in socia-economic sense. From an optimization view point, ground water has value only by virtue of its use, and the optimal yield must be determined by the selection of the optimal ground water management scheme from a set of possible alternative schemes. The optimal scheme is the one that best meets a set of economic and/or social objectives associated with the uses to which the water is to be put. In some cases and at some points in time, consideration of the present and future costs and benefits may lead to optimal yields that involve mining of ground water. In other situations, optimal yields may reflect the need for complete conservation. Most of the optimal ground water development lie somewhere between the two extremes of complete depletion to complete conservation.

37. The deleterious effects of isolated development of surface and ground water have necessitated their combined development in a manner such that the resource use is optimised. The difference between combined or supplemental use and conjunctive use is required to be appreciated in proper perspective. Conjunctive use does not mean independently optimized development of surface water resources and ground water resources to serve the same general opjectives in a basin. Rather, it means the complementary use of the many natural sub-

resources of both systems to allow more cost-effective development than could be obtained evena with the optimum plans for independent development. With this definition, many of the "so called conjunctive use projects" planned and implemented in our country are, in fact, not truely conjunctive use projects. They are joint or supplemental use projects.

38. The Planning problems of conjunctive use are formulated as an optimisation model of the water resources system. The decision or control variables of the model are the ground water and surface water allocations. The optimal decision maximises the objectives of development while satisfying the hydraulic response equations of the surface and ground water systems, and any constraints limiting the head variation and the surface water availability.

39. Given the large ground water exploitation programmes initiated currently, for example, the 6 lakh shalloew tubewell programme per annum and the priority proposed for the sector in the Eighth Plan, it is quite clear that we will have exploited the easily available potential in the Nineties. The Planning Commission is now urging that the stage has reached to give high priority to groundwater management systems, rather than only emphasising targets of pumpsets installation. A programme of six studies has been initiated in different aquifers to assess the detailed nature of prototype ground water management problems and to provide pilot solutions. These studies include a coastal aquifer, subject to salinity ingress, a multilevel aquifer with saline and fresh water inputs, both through surface and ground recharge and so on. Mathematical modelling of such systems is generally based on foreign models. Indian agro-climatic and farmers behaviour have yet to be patterned, hypothesised and tested.

CONCLUSION

40. The critics of well planned out large surface water projects are all of the mark. Available data shows that when the farmer is given 4 plus watering in a crop season, his yield is more than twice that of the average irrigated yield and two and a half times to thrice the average yield of irrigated and unirrigated farms. Also cropping intensity goes up. Investments in properly planned out new irrigation projects or modernization projects which give regulated and assured irrigation are some of the most profitable social investments which can be made. And it is now possible to press ahead with an ambitious programme of canal modernisation, watershed development and completion of ongoing schemes. Second, there is now operating proof on the field of aquifer models which ensure the use of water conjunctively and rule out waterlogging. These examples have to become the standard practice. There is not evidence to suggest that for dry areas, groundwater supply is cheaper than surface water plans. In fact both have to be planned together and complement each other. Badly planned out projects of any kind; surgace, groundwater or watersheds, can be economically wasterful and environmentally damaging. We have discussed concrete instances of each, but we have also seen field example where with modern planning techniques, the use of systems models, computer based data information systems and development of solutions to Indian problems, our land and water management problems are being solved creatively. This has to become the average practice in the Eighth Plan. On the groundwater side the emphasis has to shift from "utilization targets in hectares of potential" to groundwater management of aquifiers. The systems studies of the Central Ground Water Board with the National Institute of Hydrology will go a long way in operationalising these concepts. Groundwater markets have to be used more effectively in policy making, since they are flourishing in different posts of India. The farmers' behaviour individually and in groups and interest, particularly of the small farmer, has to be at the centre of the effort to bring modern water and land management technology to him, since widespread agricultural growth is a great equalizer.

**See for example the papers circulated at a Seminar on Wasteland Development through Watershed Development organised by the Gokul Prakalp Pratishthan at Kuve at Ratnagiri from October 26 - October 31, 1987.*

***See the recent work of MV Nadkarni 'Political Economy of Forest Use and Management in the Context of Integration of a Forest Region into the Larger Economy'.*

****See Kanchan Chopra, Gopal K Kadekodi and M N Murty in Participatory Development People and ommon Proper! Y Resources, Sage Publications, London, 1985.*

ANNEXURE–A

TABLE – A1 REGIONS OF THE NARMADA COMMAND

('00 ha)

SL. No.	Name of the Region	Region No.	GCA	CCA
(1)	(2)	(3)	(4)	(5)
1	Saukheda-Savli	1	2531	1619
2	Sinor-Vadodare	2	2731	1876
3	Bharuch-Amod	3	1532	849
4	Vagra-Jambusar	4	1113	368
5	Mehmedabad-Daskroi	5	2957	1923
6	Sanand-Kadi	6	1817	1257
7	Dholka-Dhandhuka	7	4760	2643
8	Limdi-Botad	8	2940	1826
9	Halyad-Malia	9	2684	1680
10	Viramgam-Dasada	10	3446	2421
11	Sami-Harij	11	1917	1152
12	Radhanpur-Vav	12	4628	3197
13	Rapar-Mundra	13	1229	428
14	All regions	14	34285	21239

Climate and rainfall

Maximum and minimum temperatures are known to vary in the command area between 40° during May to 5°C during January

TABLE – A2 ANNUAL PRECIPITATION IN THE COMMAND

SL No	Mean Annual Rainfall (MM)	Regions
1	800-1000	1,2
2	700-800	3,4,5,6
3	600-700	7,8,9,10
4	400-600	11,12,13

TABLE – A3 VARIABILITY OF ANNUAL RAINFALL IN THE COMMAND

SL No	Coefficient of Variation	Degree of Reliability	Percentage of area under Narmada Command in Gujarat
1	above 60	exceptionally	—
2	40 to 60	very low	46.0
3	30 to 40	low	54.0
4	Soils		

TABLE – A4 AREA SUITABLE FOR GROUND WATER DEVELOPMENT (SQ KM)

SL No	Region	Total area	Alluvial area	Hard area	Saline area	Net suitable area for ground-water development
(0)	(1)	(2)	(3)	(4)	(5)	(6)
1	1	2530	550	19800	–	2530
2	2	2730	2730	–	260	2470
3	3	1530	1530	–	650	880
4	4	1110	1110	–	8800	310
5	5	2960	2760	200	170	2790
6	6	1820	1600	220	160	1660
7	7	4760	4450	310	3590	1160
8	8	2940	1580	1360	1150	1790
9	9	2680	2400	280	1650	1030
10	10	3450	3450	–	1650	1800
11	11	1920	1920	–	1070	850
12	12	4630	4630	–	2230	2400
13	13	1230	820	410	820	410
14	Total	34290	29530	4760	14200	20090
15	%	100	86	14	41	59

TABLE – A5 INDICATORS OF AGRICULTURAL DEVELOPMENT IN EIGHTIES

SL No	Region	Average size of holding (HA)	Cropping Intensity	Irrigation Intensity	Pumpsets per 1000 HA.	Tractors per 1000 HA.	Index of value of production per HA. of Net area sown
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	1	2.9	103	9.5	16	0.9	106
2	2	2.5	109	35.5	19	1.9	150
3	3	3.4	101	13.7	15	1.9	87
4	4	4.3	100	4.2	8	0.6	60
5	5	2.0	118	35.3	41	3.8	159
6	6	4.0	110	28.6	36	1.4	125
7	7	6.4	103	10.9	27	1.5	76
8	8	6.8	101	7.7	33	0.3	98
9	9	7.0	105	15.2	62	0.6	97
10	10	6.3	102	5.3	13	1.0	75
11	11	6.2	103	6.5	8	0.0	97
12	12	7.8	106	9.9	9	0.1	72
13	13	4.8	102	6.6	26	0.0	113
14	All regions	5.3	105	15.5	25	1.1	100

ANNEXURE–B

PLANNING STUDIES FOR IGNP STAGE II

TIME CHART

SL No	STUDY TITLE	AGENCY	INPUT FOR STUDIES AT SR. NOS.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	REMARKS.
1	Bench-Mark Surveys	ORG	3,10,13					□				⊗								
2	Soil Surveys: a) Available Reconnaissance & Semi-detailed Surveys	IGNP/CADA	3,7,8,9			⊗														
	b) Semi-detailed Surveys in remaining areas.																			To continue as per stipulated work plan.
3	Regionalisation of the Total Command Area	ORG	8,9,10,11,13			□			⊗											
4	Hydrological/Meteorological Studies	IGNP/CADA through University	3,10,16			□														-do-
5	Groundwater Studies (Generation of basic hydrogeoligical data)	State Groundwater Deptt.	3.8.9			□			⊗											
6	Crop yield Study	IGNP/CADA	10,13			□			⊗											
7	Conveyance loss and other Engineering Studies of Conveyance System	IGNP	13,15					□				⊗								
8	Groundwater Aquifer Modelling & Conjunctive use Studies	ORG	9,10,13,15						□				⊗							
9	Drainage Studies (Possibility of ponding Depressions with canal water)	IGNP	8,13,16							□					⊗					
10	Cropping Pattern & Crop Water Demand Studies.	ORG	13,16								□				⊗					
11	Pilot Scheme on Sewan Grass for Scientific Development of Animal Husbandry.	Rajasthan Agriculture University Bikaner.	13,16								□				⊗					
12	Afforestation & Ecological Studies	Forest Deptt.	16									□			⊗					
13	Inter-regional Water Allocation Policy (Agri. & non-agri.)	ORG	15,16									□				⊗				
14	Operation & Maintenance Study (Water Management in particular)	ORG-CADA	15,16									□				⊗				
15	Conveyace System Design Parameters	IGNP	16										□				⊗			
16	Integration of all Planning Studies & preparation of a detailed Project Report to be posed to the Warld Bank.	WAPCCS														□		⊗		

P.S. — Month (1) in the Chart starts from November, 1987.

□ Submission of Interim Report.

⊗ Submission of Final Report/Recommendations.

ANNEXURE–C

A STATEMENT SHOWING SUBSOIL WATER DATA OF PIEZOMETERS NARMADA MAHI DOAB OF NARMADA COMMAND AREA, GUJARAT

Sl. No	Village	Taluka	District	Water depth below ground level 1984 May	1984 October	1985 May	1985 October	1986 May	1986 October	1987 May	1987 October	1988 May	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Tarsdaja	Sankheda	Baroda	4.30	3.16	5.22	5.00	7.31	5.08	9.51	-	9.76	
2	Dasan	"	"	13.03	12.13	12.88	13.38	14.28	13.43	15.58	-	15.38	
3	Jojwa	"	"	6.58	5.08	6.98	5.03	7.20	5.68		-	7.27	
4	Lavad	"	"	4.70	2.73	4.62	4.46	6.03	4.64	7.40	-	7.4	
5	Malu	"	"	4.36	3.31	5.18	5.67	6.25	6.31				
6	Ambapura	"	"	12.90	11.12	12.65	13.58	14.10	-	16.40	-	18.90	
7	Ankoli	"	"	6.75	4.02	6.33	5.75	8.62	6.67	-	-	7.61	
8	Padvan	"	"	12.59	12.07	12.49	12.62	13.16	12.88	10.71	-	3.63	Filled
9	Boriad	"	"	3.04	1.86	2.62	2.73	4.07	2.72	-	-	-	
10	Limada	Vaghodia	"	7.60	4.61	6.96	7.13	9.96	6.73	-	-	-	
11	Ramdasharpura	"	"	6.60	4.60	6.71	6.11	7.51	7.63	-	-	-	
12	Pancha	Savali	"	33.92	32.60	34.12	34.30	35.20	34.01				
13	Anjesar	"	"	26.30	24.81	26.73	26.16	27.59	26.02	30.65		31.65	
14	Kotambior	Vaghodia	"	6.73	2.70	6.24	6.16	9.41	7.11				
15	Panchdevla	"	"	5.42	4.02	6.03	4.64	7.06	7.17	10.2		-	
16	Sarod	"	"	6.63	2.72	6.20	5.76	6.72	6.11	-	-	-	
17	Zardala	Kalol	Panchmahal	11.67	9.93	10.98	10.62	12.24	11.11	-	-	-	
18	Garadhiya	Savali	Baroda	4.27	2.77	5.00	3.30	5.22	4.09	-	-	-	
19	Samalaya	"	"	6.72	5.41	8.00	5.67	7.70	6.61	-	-	-	
20	Charanpura	"	"	8.23	5.12	6.29	4.74	6.26	5.56	-	-	-	
21	Amrapura	Savali	Baroda	21.70			Abandoned					-	
22	Savali	"	"	9.44	9.26	10.58	10.71	11.68	12.51	14.72			
23	Sarada (Harsiod)	Sankheda	"	-		18.62	16.96	19.63	18.93	-		21.05	
24	Tilakwada	Tilakwada	"	-	-	28.31	25.17	28.24	25.34		-	-	
25	Raika	Baroda	"	33.88	33.10	34.20	34.19	36.27	35.28	-	-	-	
26	Harni	"	"	3.22	2.70	3.40	3.10	3.43	3.38	5.10	-	-	
27	Kesarpur	"	"	8.42	5.70	9.00	7.03	10.36	8.61	-	-	-	
28	Mavli	Dabhoi	"	10.88	9.24	11.27	11.40	12.53	11.98	-	-	-	
29	Angadhan	"	"	10.19	9.62	11.52	10.54	13.37	11.31	-	-	18.40	
30	Hansapura	"	"	4.39	3.11	4.16	3.42	4.13	3.93	-	6.2	6.23	
31	Dabhoi	"	"				Abandoned						
32	Shirala	"	"	30.94	30.90	31.39	31.61	32.00	32.62	-		35.85	
33	Chandod	"	"	35.35	33.53	35.76	34.13	35.50	34.23	35.60	35.17	35.17	
34	Malpur	Sinor	"	34.31	33.77	34.16	34.38	35.14	34.76	38.50	-	-	
35	Barkal	"	"	22.43	19.06	22.07	19.17	22.17	19.51	-	-	-	
36	Surashal	"	"	31.82	29.09	31.74	30.53	32.03	32.93	32.70	-	-	
37	Timbarva	"	"	35.82	35.20	36.00	36.09	39.05	35.84	-	-	39.00	
38	Karvan	Dabhoi	"	21.49	21.68	22.16	22.50	23.70	22.66	-	-	24.00	
39	Samsabad	Baroda	"	21.11	21.07	21.63	22.06	23.60	22.45	26.66	-	-	
40	Palasvani	"	"				Abandoned			-	-	-	
41	Itola	"	"	15.40	16.31	15.69	15.81	16.23	15.79				
42	Alampi	"	"	12.33	12.13	12.70	12.86	13.60	14.63				
43	Ankodia	"	"	26.36	24.47	25.99	26.98	26.77	24.37	28.90		30.60	
44	Jaspur	Padra	"	29.04	27.50	29.41	29.60	30.87	29.12				
45	Dabka	"	"	16.32	16.12	16.38	16.60	16.90	16.90	-	-	22.50	
46	Kamaluva	"	"	26.62	25.76	26.01	26.93	28.09	27.14			-	
47	Kotana	"	"				Abandoned			-	-	-	
48	Bamangam	Karjan	"	27.87	27.66	28.13	28.42	29.72	28.78	30.46	-	-	
49	Litapur (Moti Koral)	Karjan	Baroda	14.66	13.20	15.77	13.66	16.06	13.71	16.50	-	-	
50	Urad	"	"	28.48	28.42	28.23	28.19	27.02	28.62	-	-	29.60	
51	Karjan	"	"	27.32	27.43	27.90	27.77	29.04	29.93	-	-	-	
52	Sarod	Jambusar	Bharuch	12.40	12.03	12.40	12.66	12.93	12.76	-	-	-	
53	Kavi	"	"	6.48	6.37	7.24	7.22	6.31	6.27	-	-	-	
54	Piludra	"	"	10.40	18.26	18.40	17.23	18.70	18.56	-	-	-	
55	Jambusar	"	"	7.10	6.00	7.30	6.60	7.98	7.64	-	-	-	
56	Matar	Amod	"	19.21	19.71	19.50	19.42	20.73	20.07	21.7	-	23.10	
57	Jalalpur	Jambusar	"	11.20	10.88	11.32	11.24	11.64	11.48	12.40	-	12.70	
58	Kamla	Bharuch	"	15.50	15.58	15.03	16.00	16.06	16.36	-	10.0	23.36	
59	Vagra	Vagra	"	8.65	7.48	8.79	8.16	9.37	9.17	10.50	10.66	12.35	
60	Bhorasan	"	"	7.05	6.95	7.96	7.56	9.18	7.63	-	-	10.30	
61	Dehhan	Amod	"	5.40	4.50	5.83	5.40	6.40	5.57	-	-	8.70	
62	Bhadbhut	Bharuch	"	8.50	7.22	8.10	7.43	8.20	7.72	-	-	-	
63	Dasan	"	"	10.50	9.60	10.41	9.91	10.67	10.12	-	-	-	
64	Trasa	"	"	14.00	12.95	14.48	13.57	15.07	13.84	-	16.65	-	
65	Nahipur	"	"	9.60	8.32	10.40	8.55	9.98	8.74	-	11.40	15.20	
66	Nand	"	"	23.60	21.22	23.18	21.29	23.34	21.63	-	22.40	24.35	
67	Shuklatirth	"	"	9.20	6.52	9.29	8.14	9.75	8.21	-	9.50	10.90	
68	Bharuch	"	"	7.05	6.56	7.16	7.20	8.06	8.23	-	-	-	
69	Kishnad	"	"	23.03	23.00	22.46	22.75	23.57	23.10	-	-	-	
70	Samlha	Jambusar	"	6.48	2.66	4.44	3.46	4.46	3.98	-	-	-	
71	Devla	"	"				Abandoned			-	-	-	
72	Mangrol	Amod	"	3.40	2.92	3.73	3.61	4.16	4.22		-	6.05	
73	Nahor	"	"	9.62	9.03	9.58	9.69	10.14	9.97	10.70		11.80	
74	Gandhar	Vagra	"	5.50	5.30	5.93	5.49	6.61	5.81			6.82	
75	Kadodara	"	"	3.55	2.71	3.91	3.67	3.83	3.40			5.07	
76	Luvara	"	"	6.40	5.75	6.13	5.65	5.88	5.69	6.95	6.63	7.63	
77	Atali	"	"	5.65	4.90	6.00	5.65	6.00	5.08	-		-	
78	Chandpura	Jambusar	"	3.95	3.90	4.78	4.60	5.01	5.08	-		-	

The Sixteenth Bhaikaka Memorial Lecture was delivered during
the Fifth Indian Engineering Congress, Kanpur, December 14-18, 1990

Sustainable Development and the Role of Engineers

Shri Mahesh Prasad

Secretary (Environment and Forests)
Government of India, New Delhi

INTRODUCTION

We are a welfare state committed to provide to all our citizens at least the basic minimum needs of food, shelter, clean drinking water, fresh air, health, education, employment, etc. Basic necessities can be met only through judicious management of the natural resources which by and large are non-renewable and are getting fast depleted. The use of living natural resources and their transformation into economically valuable commodities has to be sustainable, otherwise the very base of development would get eroded.

Sustainable development has been defined as:

'Development that meets the need of the present without compromising the ability of future generations to meet theirs'.

Each generation has, therefore, to function as a trustee of the environment for succeeding generations so that their future options are not foreclosed. A development opportunity deferred is better than an irreversible and destructive mistake.

Sustainable development, therefore, presupposes:

Equity and social justice,

Efficient economic system,

Ecological harmony, and

Stable social system.

The Panchabhutas, viz, land, water, air, space and energy are closely interrelated and interlinked and, nature maintains a delicate balance among them. Changes in one set off a chain reaction in the other elements. Exploitation of these resources can be done on a sustained basis by adopting the concept of 'carrying capacity' of a given eco-system. It must be underlined that optimization of our natural resources is the key to sustainable development.

Before going into the concept of carrying capacity and sustainable development it would be worthwhile to examine our traditional development approach and its implications.

TRADITIONAL DEVELOPMENT APPROACH

The development process during the last four decades in India has been clearly characterized by :

- Emphasis on short term gains rather than long term sustained development;
- Over exploitation of the natural resources to the extent of their 'slaughter;'
- Development gains monopolysed by the vested interests rather than reaching the common man;
- Bureaucratization of the development process rather than orientation to achieve results through professional inputs;
- Emphasis on sectoral rather than integrated development; and
- Reliance on obsolete and outmoded imported technologies and approaches.

As a consequence of the development strategy adopted, the environmental problems in India today can be classified into two broad categories:

(a) Those arising from conditions of poverty and under development; and

(b) Those arising as negative effects of the very process of development.

The first category has to do with the impact on the health and integrity of our natural resources (land, soil, water, forests, wildlife, etc) as a result of poverty and the inadequate availability for a large section of our population of the means to fulfil basic human needs (food, fuel, shelter, employment, etc). The second category has to do with the unintended side effects of efforts to achieve rapid economic growth and development. In this latter category would fall the distortions imposed on national resources from poorly planned development projects and programmes, as well as from lack of attention to long term concerns by commercial and vested interests. Thus it is clear that a concern for environment is essentially a desire to see that national development proceeds' along rational sustainable lines. Environmental conservation is, in fact, the very basis of all development.

Consequences of Traditional Development Approach

The major consequences of the development strategies adopted may be summarised as: socioeconomic impacts, environmental impacts, and technological options.

Socio-Economic Impacts

Low Growth Rate: Since proverty reduces the capacity to use resources in a sustainable manner,the pressure on the environment gets intensified. Unfortunately, the absolute number of people below the 'poverty line' has steadily increased thereby threatening the eco-system. The World Commission on Environment and Development in its report 'Our Common Future' has estimated that the developing economies will have to achieve a national income growth rate of 5%-6% per year to eliminate absolute poverty.

Unequal Distribution of Wealth and Produce: Increased agricultural output gives sufficiency in foodgrains which are still beyond the reach of a large population because of the absence of buying power.

Islands of wealth and prosperity exist in an ocean of stark poverty and deprivation. Marked polarization of society into 'haves and have-nets' is the result.

Environmental Impacts

Natural Resources under Stress: The natural resources like land, water, air and forests are under acute stress due to the heavy pressures brought upon them by haphazard development programmes. Water, once abundantly available, has become a scarce commodity. Supply of drinking water is an acute shortage in the urban centres and, in the absence of timely steps, this scenario is likely to spread to the rural areas as well.

Scarcity of land to sustain the ever increasing population is a matter of serious concern.

The accelerated deforestation is not only instrumental in degradation of environment but is creating the socio-economic problems for the poor for meeting the requirements of fuel, food and fodder, etc.

Air and Water Pollution: Since the pace of industrialization is still slow, the problems of air pollution are concentrated in the industrial and urban centres with consequent ill-effects on the health of the surrounding population. The problem will become aggravated if the industrialization proceeds ahead without serious efforts at controlling the air pollution at source.

Water pollution is a consequence of both industrial as well as urban waste disposal. The main surface water bodies like rivers and lakes have become recepients of untreated sullage which could not be purified through the natural process of self-cleansing.

Accelerated Deforestation: The forest cover has been dwindling at an alarming rate in order to meet the requirements of industries, building materials, fuel wood and fodder, etc. The forest cover in India is flresently depleting 1.5 Mha/year according to an FAD estimate (not supported by satellite e pictures) and at present the good forest cover is estimated to be around 12% of the land mass. At this rate of loss even the genetic reserves will soon disappear which are considered to be the basic insurance for the food security of the coming generations. The present generation is also facing the consequences of a vicious cycle of drought and floods as a result of massive deforestation.

Climatic Changes: Modifications in the land use and human interventions in the other natural resources are manifested in such phenomena as ozone depletion, CO_2 concentration giving rise to green house effect, acid rain and overall climatic changes which are expected to have long term consequences for the mankind.

Technological Options

The third world economies are primarily based on the outmoded technologies long discarded by the developed countries. Bureaucratic systems evolved in the colonial times to meet the dictates of the Crown have been perpetuated in many third world countries by an inflexible bureaucracy incapable of launching these countries into technological innovations and excellence. The result is the dependence upon highly polluting, excesswaste technologies requiring considerably higher quantum of inputs compared to the outputs achieved. Indeed, it is ironical that the visible pollution-air, water and/or land-should be considered to be a sign of rapid development at one or the other stage of the industrialization of the developing countries indicating clearly the avoidable over-exploitation of natural resources. Emphasis must be on the clean state-of-the-art technologies.

STRATEGY FOR SUSTAINABLE DEVElOPMENT

Step I: Carrying Capacity

It is clear that the concept of carrying capacity of a region can help in devising a project portfolio to achieve sustainable development through optimum utilization of resources and minimization of adverse impacts on the environment. The carrying capacity is region specific and at a given time is made up of its supporting capacity plus the assimilative capacity.

The supporting capacity provides the necessary natural resources needed to operate a given project portfolio; and the assimilative capacity indicates the capability of the system to absorb the wastes at an acceptable level of risk. The carrying capacity is shown in Fig 1. The system thus comprises of natural resources which support the production actrvrtres and in turn produces residual wastes that are assimilated by the eco-system to a finite extent. It is obvious from the flow-sheet that the resource consumption and the waste assimilation could be optimised through minimum use of resources with maximum efficiency. It gives rise to a strategy which deals not merely with the treatment of wastes of all kinds but also the prevention of environmental problems through the use of renewable resources, pre-emptive substitution of ecologically harmful raw materials and products, low waste technology, waste recyciing and reuse; and bye-product recovery.

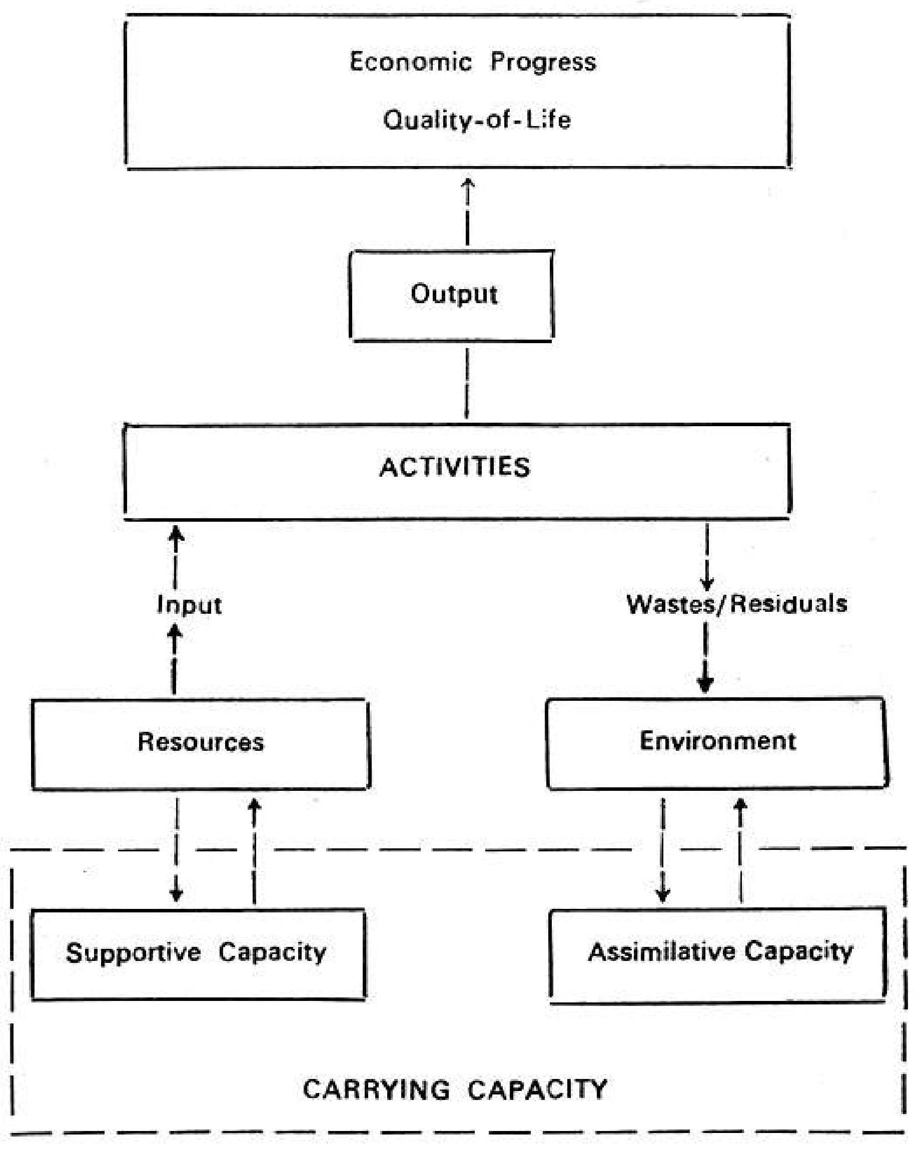


Fig 1 Concept of carrying capacity

Step II: Environmental Strategy

Within the carrying capacity of a given eco-system we have a choice of adopting curative or preventive strategies.

Curative strategy aims at repair of the damage to the natural environment brought about by uncontrolled production process. This is achieved through pollution control measures and restoration techniques. This strategy is characterized by high cost of environmental protection and dependence of regulatory stipulations on end of pipe and top of stack treatment.

The preventive strategy, on the other hand, aims at the modification of production process and products, through technical innovation and structural changes so that the output is environmentally compatible. This strategy relies on clean technology, recycling and use of renewable resources and, therefore, involves lower cost of environmental protection because of:

— use of clean technology;
— reduced use of raw materials with consequent reduction in pollutants generated; and
— low energy inputs.

Development strategy thus must be tempered with overall conservation strategy.

Step III: Waste Management

Waste is a resource wasted which could bring benefits to the industry through innovative use of technology. Approaches to waste :nanagement may include changes or modification in one or more of these parameters-raw material inputs, production process, products, waste discharges, etc.

Step IV: Internalization of Environmental concerns in Project Planning

It is not sufficient to evolve a project portfolio well within the carrying capacity of a given ecosystem unless each project is further investigated in detail to ensure its techno-economic and environmental viability. The process which can give best results for individual projects is one which can ensure that technical, economical and environmental concerns are assessed together right at the project inception stage. Internalisation of the environmental concerns, thus becomes a basic essential.

TECHNICAL AND MANAGEMENT INPUTS BY ENGINEERS

It is self evident that the country's development policy must ensure:

— Welfare of the common man with benefits distributed for achieving the objective of equity and social justice;
— Goods and servicesfor the welfare of the society must be produced through optimal utilization of natural resources;
— Adoption of the best technolcgy and management packages for efficient conversion of natural resources into goods and services and for lowering or even eliminating the wastes/pollutants.

The most crucial component is the improvement of conversion efficiency which presently leaves much to be desired resulting in avoidable waste of resources.

The conversion efficiency is dependent upon:

— Avoidance of inefficient, high waste, highly polluting technologies and processes; and
— Management system geared to efficiency.

The adoption of appropriate technology and management packages calls for high degree of skills, know-how and dedication to the pursuit of professional excellence. This task cannot be performed by anyone but a team of dedicated engineers and technologists.

Let me illustrate with some examples:

We already know that natural resources like water, can no longer be considered to be a free and inexhaustible resource. Therefore, reduction in the total water requirement by recycling is not only cost effective but also helps in resource conservation. Table 1 gives the benefits to be derived from recovery systems in the fertilizer industry. It clearly shows that the pay-back period varies from 0.49 to 8.47 years which is an excellent investment proposition. Studies have indicated that the extent of waste water to be reused is really phenomenal as is clearly indicated in Table 2. In the case of the highly water consuming industries, the reuse possibility varies from 40% to 98% and can contribute greatly to the conservation of precious water resources. In the recycling of waste water, it is not just the utilisation of water itself but a number of other salts and metals that can also be recovered from reuse. The potential of recoverable metals from industrial waste water is shown in Table 3.

Similarly, requirement of energy for metals varies considerably depending upon whether these are extracted from ore Of obtained from recycled metals. This is clearly demonstrated in Table 4.

TABLE 1 APPROXIMATE INVESTMENT ON SUGGESTED MODIFICATION MEASURES

(excluding deep Hydrolyzer Stripper)

Name of Plant	Capital Investment, Rs million	Water Conserved, x 10^5/year	Saving per year, Rs million	Payback Period, years
RCF Thal	5	1092.96	1.749	2.86
Kribhco, Hazira	3	478.45	0.345	8.47
NFL, Vijaipur	3	2082.96	3.562	0.85
IFFCO, Phulpur	5	2871.00	2.87	1.70
FCI, Gorakhpur	10	2589.84	1.556	6.43
FCI, Sindri	10	18128.88	8.883	1.13
GNFC Bharauch	1.5	2790.22	3.07	0.49

Source : BICP, 1990

TABLE 2 WASTEWATER GENERATION AND ACHIEVABLE REUSE

Industry	Average Volume of Wastewater per unit of product	Reuse possible, %
Thermal power	155×10^3 l/h/MW	98
Pulp and paper	250×10^3 l/t	50*
Iron and steel	150×10^3 l/t	40
Pharmaceuticals	4.5×10^3 l/kg	40
Fermentation—		
(a) Brewery	10 l/l beer	25
(b) Distillery	100 l/l alcohol	25
Textile	250 l/kg cloth	15
Tannery	34 l/kg hide	12

**Note :* Water utilization per tonne of paper production in India and the USA is 300 m^3/t and 142 m^3/t, respectively.

TABLE 3 RECOVERABLE MATTER FROM INDUSTRIAL WASTEWATER

Industry	Recoverable Matter
Pulp and paper	Ligno-sulphonate and Sodium salts
Fertilizer (phosphate)	Calcium sulphate and fluoride
Petro-chemical	Acetone and carboxylic acid
Electroplating	Chromium and nickel salts, silver cyanide
Coke oven	Ammonia, tar and aromatic organics
Dye stuffs	Anthranilic acid, methylaniline, sodium and potassium hydroxide
Textile	Caustic soda
Distillery	Potassium salt and yeast
Rayon	Zinc, sodium sulphate

TABLE 4 ENERGY REQUIREMENT FOR METALS WHEN EXTRACTED FROM ORE AND WHEN OBTAINED FROM RECYCLED METALS

Product	Energy requirement, kWh/t	
	Ore, kg	Recycled metal, kg
Aluminium	51 000	2 000
Copper	13 500	1 700
Iron & steel	4 000	1 500
Magnesium	91 000	1 900
Titanium	125 000	52 000

Source : UNEP, Industry & Environment.

The engineer has to play not just a passive but a very active role in making our production processes efficient. We have only two options, that is, either we continue to utilize the imported technologies irrespective of their serious drawbacks as difficient tools of production, or, to utilize our own ingenuity and technical skills to adapt and improve the available technologies and strive to keep abreast of the state-of-the-art technologies. Proper use of even the available technologies can give us much better efficiency. For example, in our construction programmes, there is tremendous scope for reducing the consumption of building materials, and energy, for conservation of space through better design of the structures, quality control of materials, adoption of layouts Textile suiting our climatic conditions and a proper maintenance programme. As the saying goes, a Distillery high safety factor is nothing but a reflection of ignorance and we must strive to bring down, Rayon through better designs and quality control, this safety factor from the adopted level of 2.5-3 in our structures. This could result in saving in the materials like cement, bricks, concrete and steel which, in turn, would further result in saving of raw materials as well as energy in their conservation. The layout and design of our commercial and residential complexes have also been guided not so much by our own climatic conditions but the construction and architectural practices adopted in the Continent and the USA with the result that the concrete modules are totally unlivable unless heavy investments are made for cooling through air conditioning in summer and warming through central heating/blowers in winter. In all these areas, our engineers could make a remarkable contribution through better designs of structures, emphasis on use of local materials and architectural practices so that we may achieve not only saving in the resources but also create a living environment which is compatible with the natural setting.

There is enormous scope for innovations. Utilization of fly-ash poses both a challenge and an opportunity so that this industrial waste could be gainfully utilized as a building material to meet our ever increasing requirements. Similarly, there is a vast scope for developing new equipment for control of air, water and noise pollution not only in our industrial units but also for use in our daily life. The engineer can leave an imprint on every facet of our daily life through his skill, ingenuity and creativity by reshaping, indeed designing and inventing, the tools, plant and machinery-big and small-in such a way that the process technology for converting raw materials into productive goods is efficient as well as environment friendly.

Unfortunately, our administrative and management structure is such that decision making even in technical matters, is not in the hands of technical professionals. This state of affairs leads, on the one hand, to uninformed decision making and, on the other, frustration and dejection among the technocrats and professionals. I am convinced that a thorough organizational restructuring is necessary to overcome this situation.

CONCLUSION

We can no longer afford to waste our finite natural resources in wasteful development programmes. The needs and aspirations of the present generation as well as the interests of the coming generations can be safeguarded only through adoption of strategies for sustained development without destruction. It is a challenging task and on its success depends the future of manking. I am confident that our engineers and technologists will be able to successfully meet this challenge and usher in an era of prosperity.

Policy Options for Environmentally Sound Technology in India

Prof P Khanna, *Fellow*

Director,
National Environmental Engineering Research Institute, Nagpur

PREAMBLE

The socio-cultural roots of the present environmental crisis lie in the paradigms of scientific materialism and economic determinism which fail to recognize the physical limits imposed by ecological systems on economic activity. The economies must expand within ecosystems which have limited regenerative capacities. Contrary to the neoclassical theory of continuous material growth, economic activities directly undermine the potential for development through over-exploitation of natural resources, and indirectly compromise future production through the discharge of residuals. The entrenchment with quantitative growth as a major instrument of social policy is thus quite paradoxical.

The emergence of the concept of sustainable, development in recent years has brought in the general realization that societal perceptions must shift towards ecological determinism so as to achieve qualitative growth within the limits of the ecosystem's carrying capacity. The carrying capacity based planning process, innovative technologies for ennanced material and energy effectivity of production and consumption, structural economic change towards less resource-intensive sectors, and preventive environmental management through increasingly interventionist· policies are some of the strategies for reconciling developmental goals with ecological capabilities.

This paper analyzes the existing and future environmental issues emanating from developmental objectives and policies in various economic sectors in India and suggests agenda for action, with focus on environmentally sound technology, to ensure discernible positive movement towards the overall aspirational goal of sustainable development. It first analyzes the economic sectors in India from environmental perspective and then elaborates the agenda for sustainable development to draw an action plan at national level.

ENVIRONMENTAL PERSPECTIVE OF ECONOMIC SECTORS

Population

India accounts for 2.2% of the global land and 16% of the world population. The country's population has nearly doubled in the four decades of its independence and is estimated to reach the billion mark by the year 2000 AD, While there has been a decline in average birth and death rates and increase in life expectancy, the country is far from a emographic transition to population equilibrium. There is also a predominance of young age structure with 31.6% of the population expected to remain below 15 years of age by the year 2000 AD.

Population planning in India must, therefore, be based on the realization that, even with the most stringent control measures, the population will continue to increase at a high rate in the next few decades resulting in increased demands for food, energy, shelter, employment and other infrastructural needs.

Control of numbers alone is not sufficient to achieve equilibrium between population and environmental carrying capacity. Efforts should be madeto link population planning with developmental planning and environmental action to ensure equitable distribution of the benefits of economic growth.

Food, Agriculture and Forestry

India witnessed a record production of 179 Mt of food grains in 1988-89 and, with continued developmental efforts in the agriculture sector, it is estimated that the country will be able to meet the demand of 240 Mt by the year 2000 AD.

The quest for meeting rapidly growing food needs with insufficient attention to the environmental impact of agricultural policies and practices has, however, resulted in large-scale environmental degradation and depletion in the fbrm of soil erosion; deforestation; drought and desertification; loss and deterioration in the quality of surface and ground waters; reduction in genetic diversity; waterlogging, salinity and siltation; and eutrophication caused by excessive use of fertilizers.

Despite heavy reliance on irrigation, high-yielding varieties and fertilizer, Indian agriculture is witnessing the familiar phenomenon of diminishing returns. A recent study reveals that the inputs to agriculture has increased at a rate of 4.2% per annum between 1970-80, whereas the yields increased at only 2.3% per annum.

Industrialized agriculture has promoted an extraordinary use of chemicals in the form of pesticides and fertilizers. The country uses nearly 100000 t of pesticides annually and almost 70% of this is contributed by compounds banned or severely restricted in therdevelopec countries. Excessive use of pesticides has resulted in destruction of predators and non-target species, and enhanced resistance in target pests beside contaminating water and soil thereby creating hazards for human health and animals.

The consumption of fertilizers in the country has increased from almost a negligible figure in 1950-51 to 39.4 kg/ha in 1984-85. This has indeed given a boost to agricultural output. However, sustained yields are possible only through balanced fertilizer use. Excessive use of chemical fertilizers adversely, affects soil fertility and causes degradation of the quality of surface and ground waters. Use of organic manures to supplement chemical fertilizer, on the other hand, could enhance soil fertility by improving soil structure and changing its physical properties like water-holding capacity, porosity and hydraulic conductivity.

India presently has 143 Mha of arable land of which 85 Mha suffers from varying degrees of soil degradation. Further, as per latest satellite data, the country is losing 1.3 Mha of forests a year. Widespread deforestation has brought about far-reaching chanqes in forest ecosystems which can no longer perform adequately the essential functions of water retention, climate control, soil conservation and provision of livelihood to contiguous population.

The major causes of deforestation in the country are the increasing demands for fuel wood, grazing land and timber; raw material for paper industry; and the construction of large multipurpose dams. The current availability of green fodder in the country is estimated at 434 Mt whereas the minimum requirement is 882 Mt. The gap has resulted in unrestricted grazing in forest lands. As against a demand of 27 Mt, the current permissible removal of timber from forests is only about 12Mt. Packaging and paper mill requirements account for most of the demand for industrial wood. These demands have indeed spelt disaster for the forests.

Nearly half a million hectares of forest land in the country have been lost to large dams. Further, nearly 25% of the land under irrigation in the country has been rendered non-productive by salinity and waterlogging problems resulting from inadequate and improper command area development.

On an average, the country loses 5 000 Mt of top soil per year through water erosion which, in terms of NPK alone, constitutes an annual loss of Rs 7000 million. The total area subjected to periodical floods has increased by 100% in the past 10 years. Floods have caused loss of significant quantities of water to the sea which would have otherwise joined subsurface aquifers.

Energy

India's per capita consumption of commercial energy at 208 kg oil replacement units is only one-eighth of the world average. The energy intensity of growth, on the other hand, is extremely high while energy efficiency remains low. With one unit input of energy, India produces only a half of what is produced in the developed countries. Further, for 1% growth in GNP, the country requires 2.02% energy growth.

The energy policy has always laid emphasis on expansion of capacity. Subsidized prices, which even fail to cover the costs, have discouraged energy saving and technological innovations. Some of the power stations in the country operate at efficiencies of barely 25%-30%.The loss of energy in electricity transmission is nearly 22%. As a result, despite annual increase in energy production to the tune of 8.9% in the 1980s, there continues to remain a gap of about 10% between demand and supply.

Another significant aspect of the energy scenario that is often overlooked by planners, is that cooking energy constitutes nearly half the energy used in the country, of which almost 90% comes from non-commercial sources such as firewood, cowdung and crop wastes. Further, farms and transport systems employ nearly 80 million work animals that just about match the country's vast electricity network in energy generation.

Commercial energy accounts only for a little over 50% of the energy use with industry as the major consumer of electricity and coal (62% and 78% respectively), and the transport and household sectors as the major consumers of oil (56% and 29% respectively).

Increased reliance on coal is the single major cause of air potlunon and land spoilation in the country. Despite reg~latory measures, the levels of air pollution in many regions have far exceeded permissible concentrations resulting in increased health risks and larger environmental threats such as global warming and acid deposition.

The combustion of non-commercial fuels as a source of cooking energy in the country has resulted in excessive exposure to indoor air pollutlon while depriving the soil of important nutrients that would otherwise be recycled through biomass decay. Moreover, the replacement of these nutrients with synthetic fertilizers is an energy-intensive process representing the debit side of energy balance when biomass is combusted for energy recovery.

More than 80% of the hydroelectric potential in India still remains untapped primarily due to adverse environmental consequences of large-scale hydropower development such as deforestation, undesirable changes in riverine ecology and massive displacement of human communities.

Decentralized, small-scale hydropower schemes are not yet used on a significant scale, although they possess the potential of providing economical, efficient and environmentally benign sources of energy.

With an installed capacity of 1 350 MW in 1987, nuclear energy constitutes 2.43% of the total power capacity. The nuclear energy programme aims at 10 000 MW of installed capacity by the turn of the century, contributing 10%of the total energy mix.

Biomethanation, which is an energy efficient and environmentally compatible process and could provide five times the energy yielded by combustion of non-commercial fuel sources, has been exploited only for substrates such as cowdung. The potential for biogas generation from other substrates largely remains untapped.

Industry

Since the inception of planned development in the early fifties, India has established a well diversified industrial structure with a sizable capacity in basic and heavy industry. The share of value added to the GDP by the manufacturing sector is expected to risefrom 14.6% in 1984-85 to 20% by the year 2000 AD with an average annual growth rate of 8%.

The expansion in industry sector, however, has been towards capital and energy intensive sectors which are alsomost polluting sources.

Nearly 50% of the total industrial output in monetary terms is contributed by over 2 million small scale industries which also account for 60%-65% of the total industrial pollution. Also, the use of toxic chemicals in industry has grown phenomenally. As per estimations of OECD derived from correlation between hazardous wasre generation and economic activity, nearly 0.4 Mt of hazardous waste was produced in the country in 1989.

The mining sector has grown from Rs 850 million worth in 1950 to over Rs 84.64 billion in 1986. Coal production constitutes the bulk of mining output with iron and limestone predominant amongst the metallic and non-metallic minerals respectively.

Only about 50% of the large/medium scale industries have provided complete/partial emission control systems and many of these do not achieve stipulated effluent standards. The small-scale industries (SSIs) have not yet been subjected to rigorous pollution control. Despite joint treatment of wastes in case of few industrial estates, the SSIs, by and large, have not availed the financial incentives introduced to enable small entrepreneurs to deal with pollution problems.

Health and Human Settlements

India's urban population of 160 millions is the fourth largest in the world. In the four decades after independence, while the total population has doubled, the urban population has tripled and is estimated to reach a staggering figure of 315 million by the year 2000 AD. Thus, nearly a half of the total addition to the country's population between 1981 and 2000 AD is expected to occur in urban areas.

Inadequate shelter and basic amenities, lack of access to clean water in adequate quantities, poor sanitation, environmental pollution and resource depletion are some of the major problems of human settlements that continue to pose unsurmountable health and environmental risks in urban as well as rural areas.

Nearly one-third of the total urban population in India lives in slums. While the problem of shelter is more visible in urban areas because of high population densities, it is no less acute in rural areas. The total housing requirement by 1990 is estimated at 40.9 million units out of which 31.2 million units will be required in rural areas. In order to deal with the problems of shelter, the Ministry of Urban Development has recently formulated the National Housing Policy.

The National Commission on Urbanization built a case for dispersal of urban centres and identified 329 settlements as Generators of Economic Momentum (GEM) to bring about a dispersed organization pattern.The commission also identified 49 Special Priorty Urbanization Regions (SPUR) on the basis of their potentialfor socio-economic development. Similar attempt was made during the Sixth Plan period by initiating a programme on Integrated Development of Small and Medium Towns (IDSMT). These programme, however, have largely failed in meeting their objectives due to multiplicity of agencies and absence of an integrated approach to the problems.

Several health problems in the country are associated with environmental factors, particularly in combination with malnutrition and poverty. The largest single cause of infant mortality in India has been digestive disorders that are closely related to waters supply, hygiene and malnutrition.There is a commitment on the part of the country to attain the UN goal of 'Health for All' by 2000AD. The attainment of this goal requiresan objective review of the existing approaches to heath for bringing about qualitative improvements in the health care services.

The targets for International Water Supply and Sanitation Decade (1981-90) in India were fixed at 100% coverage for urban and rural water supply, 80% for urban sanitation, and 25% for rural sanitation. The erstwhile Ministry of Works and Housing proposed an outlay of Rs 198.8 billion to achieve the decade objectives but resource constraints permitted an outlay of only Rs 65.2 billion. As a result, targets for urban water supply and sanitation were curtailed to 90% and 50%, respectively.

The growth of vehicular traffic has posed a veritable nightmare not only on the roads but also in the atmosphere. From merely 0.3 million in 1950, the number of vehicles in the country increased to 8.8 million in 1985. Automobile emissions in Bombay and Delhi account for nearly 70% of carbon monoxide, 50% of hydrocarbons, 30% to 40% of particulates in the atmosphere. There is also a severe problem of indoor air pollution arising from the use of non-commercial energy for cooking, inadequate design of cooking stoves and poor ventilation in dwellings. Women who cook on hearths for three hours inhale carcinogenic benzopyrenes equivalent of 200 cigarettes.

SUSTAINABLE DEVELOPMENT

Premises, Preconditions and Agenda

Sustainable development is a process in which the exploitation for resources, the direction of investments, the orientation of technological development, and institutional changes are all made consistent with future as well as present needs.

The concept of sustainable development has following underlying premises:

- Symbiotic relationship between consumer human raceand producer natural systems
- Compatibility between ecology and economics

The following entarged Constitutional preconditions must be satisfied while working for the goal of sustainable development:

- Equity and social justice
- Endogenous choices
- Economic efficiency
- Ecologic harmony

These preconditions have been overlooked in our quest for scientific materialism as illustrated by an example from the industry sector in Fig 1.

PARADIGMS IN POLICY

* Industry or environment/Industry and environment
* Economic accountability/Ecological accountability
* Private property/Common property
* Reaction and cure/Anticipation and prevention
* Pollution control/Structural economic change
* Externalization of environmental concerns/Internalization
* Adversarial approach/Cooperative approach
* Penalties/Incentives

PARADIGMS IN TECHNOLOGY

* Rehabilitation of damage/Conservation of resources
* End-of-pipe treatment/Low polluting technology
* Disposal of residues/Recycle-reuse
* Individual treatment for pollution abatement/Joint treatment
* Engineered EIA/Objective EIA

Fig 1 Paradigms in policy and technology for industry sector

The concept of sustainable development is closely linked to the carrying capacity of ecosystems as depicted in Fig 2. Accordingly, the underlying correlation between population, poverty and pollution must be analyzed against the backdrop of the ecosystem's capacity to provide supportive capacity for development and assimilative capacity for maintenance of acceptable quality of environment. With these preconditions, following agenda for sustainable development ensue:

- Carrying capacity based developmental planning process Preventive environmental policy including technology
- Assessment Structural change in economy
- Environmental impact assessment.

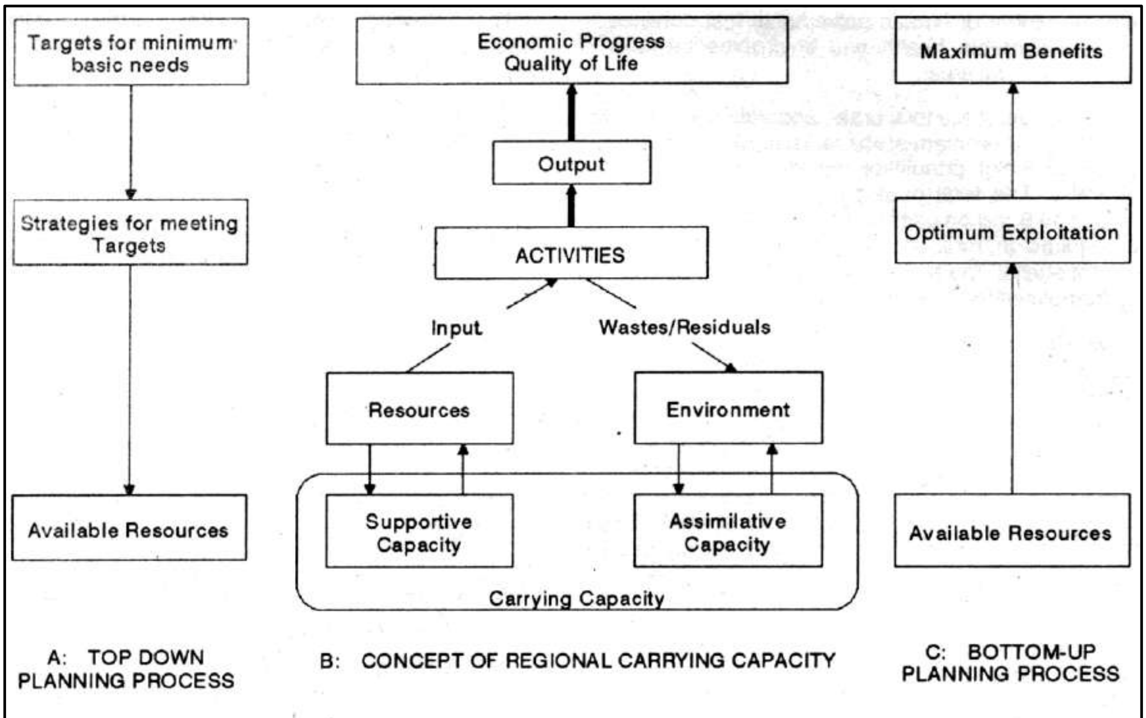


Fig 2 The planning process — Traditional and proposed

Carrying Capacity Based Developmental Planning Process

Developmental planning in most countries has been traditionally based on the concept of minimum needs in which the planning priorities and activity targets are established to meet certain basic minimum needs of the poorest sections of the population. This approach, if anything, has led to greater inequality in the societies of developing countries as it overlooks the basic requirement of availability of resources that form building blocks in developmental process. In contrast, the developmental planning process based on regional carrying capacity takes cognisance of the fact that the environment, with its biotic and abiotic components, provides the basic resources that support production-consumption activities and assimilates the residues produced during the course of these activities.

Sustainable development calls for trade-offs between the desired production-consumption levels through the exploitation of supportive capacity and environmental quality within the assimilative capacity of regional ecosystems. The utilization of carrying capacity, thus, requires a series of adjustments to reconcile competing aspirations in developmental process. This shift in developmental planning process also brings out the fact that analytical models could be used to answer technical questions whereas value judgements must be made in societal and political domains for devising pragmatic developmental and environmental strategies.

The ecosystem carrying capacity provides the physical limits to economic development and may be defined as the maximum rate of resource consumption and waste discharge that can be sustained indefinitely in a defined planning region without progressively impairing bio-productivity and ecological integrity. While recognizing societal dependence on many ecological resources and functions for its survival, carrying capacity is ultimately determined by the single vital resource or function in least supply. Working within the limits of carrying capacity does not however, preclude some unavoidable environmental damage in the course of development.

The concept of carrying capacity implies that improvement in the quality of life is possible only when the pattern and levels of production-consumption activities are compatible with the capacities of natural environment as well as social preferences. The carrying capacity-based planning process thus involves the integration of social expectations and ecological capabilities by minimizing differentials between realized and desired carrying capacity indicator, viz, supply/demand patterns, infrastructure/congestion patterns, resource availability/use patterns and assimilative capacity/residual patterns.

The proposed carrying capacity based developmental planning process is schematically presented in Figs 3-5, which illustrate the flow of resources from- and to- natural systems, regional environmental system model, carrying capacity based planning process, and modelling and analytical techniques in carrying capacity based planning process.

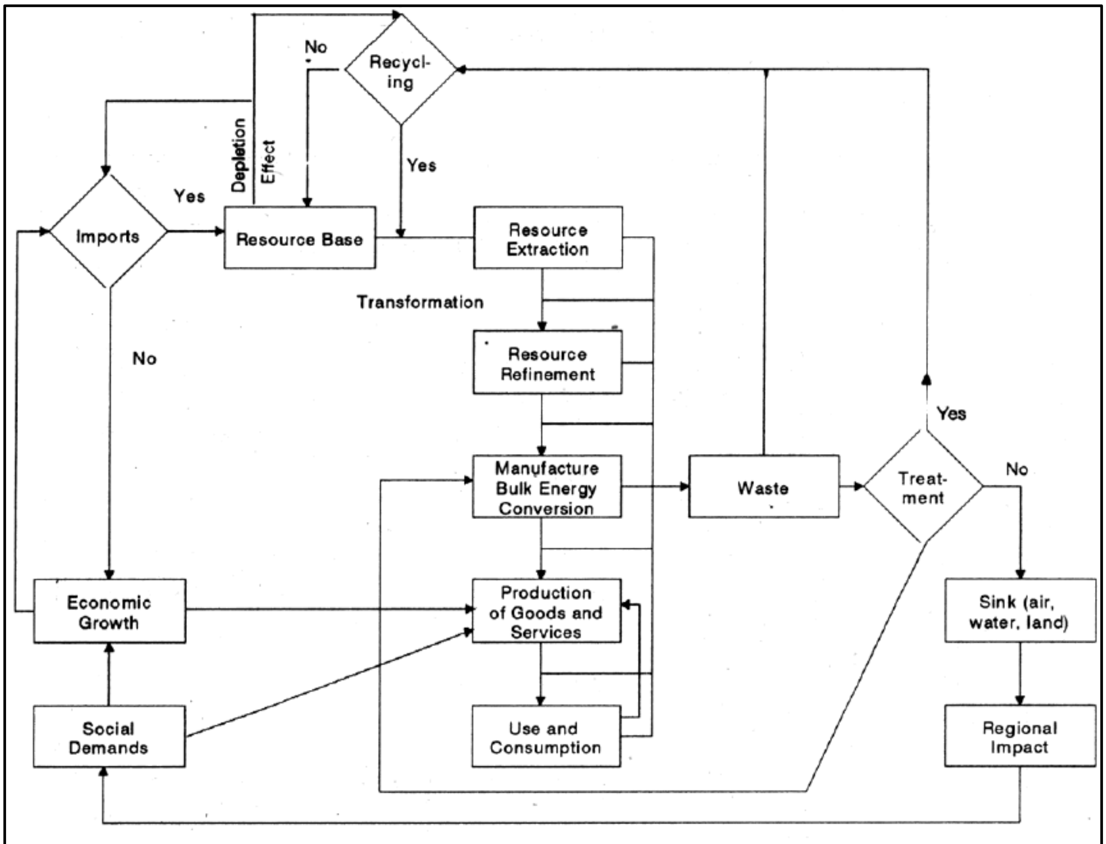


Fig 3 Flow of resources from– and to– natural systems

Given certain inputs of human and natural resources, the carrying capacity based planning process uses a systems approach to estimate the changes in carrying capacity indicators. The differentials between realized and desired carrying capacity are overcome through a combination of institutional, informational and attitudinal strategies aimed at changes in the exogenous driving forces, systems structure, and the aspirations and tolerances that determine the level of desired carrying capacity.

The traditional concept of resources is extended in this process to include:

Natural resources that determine the regional capacity to support production — consumption activities and assimilate the residuals produced therefrom;

Transformational resources that determine economic opportunities and constraints vis-a-vis regeneration rates;

lntrastructural resources that provide or distribute services needed to sustain developmental activities;

Socio-cultural resources that include people and institutions governing human environment;

As both supportive and assimilative capacities can be enhanced through technological advances, albeit to a limited extent, carrying capacity analyses also necessitate evaluation of these technological interventions.

An ideal approach to the validation of the concept of regional carrying capacity based developmental planning process will be hierarchical through the stages of a village, district, region, nation and globe in keeping with existing political and administrative boundaries. It is obvious that the success of this approach depends entirely on planner's participation in the process and its acceptance by administrative and political jurisdictions.

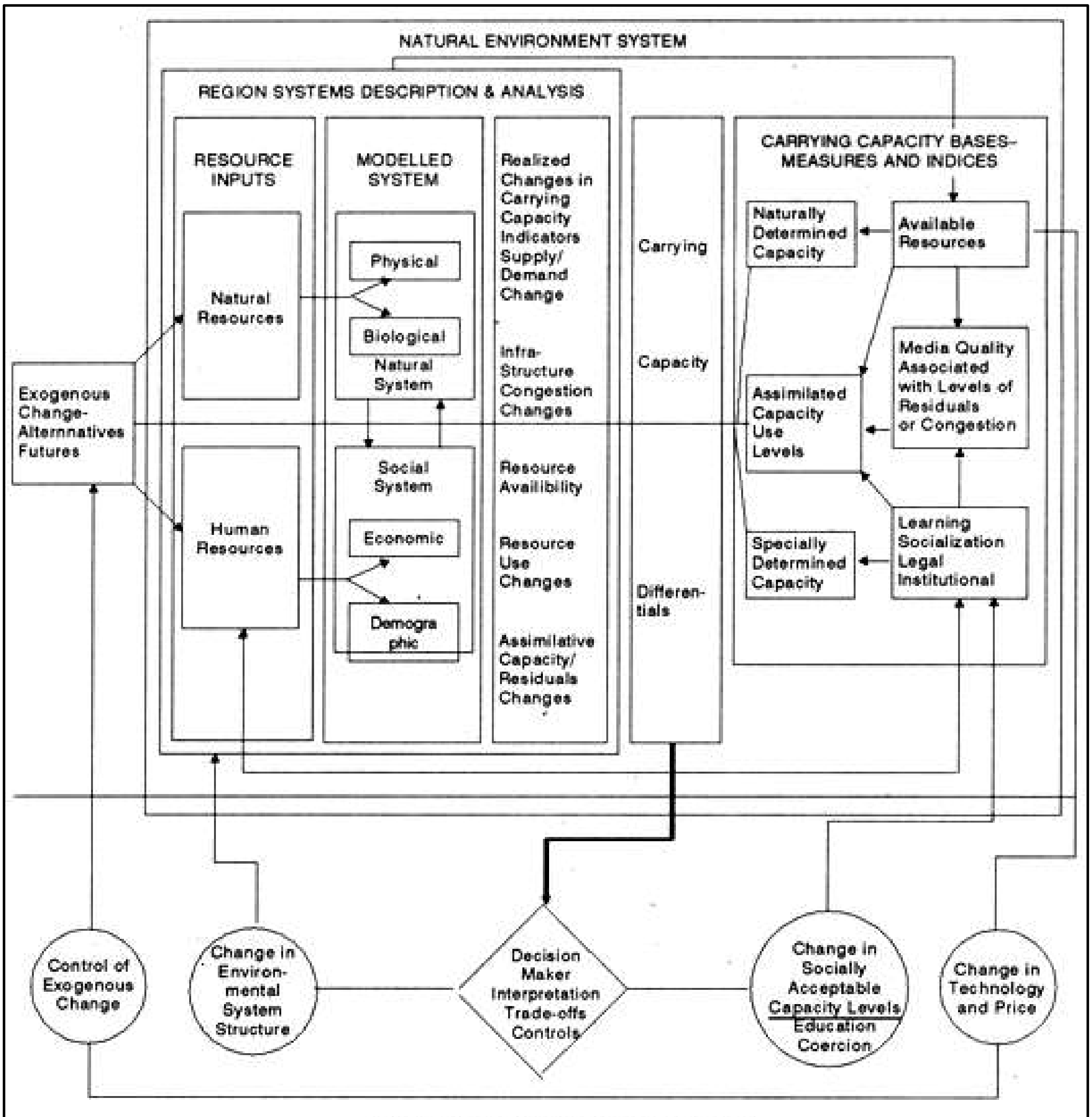


Fig 4 Carrying capacity based planning process

Preventive Environmental Policy (PEP)

Framework for PEP

Present environmental policy is reactive not only with regard to the instruments used but also the legislative and administrative structures. Its focus is on pollution control which inevitably leads to cross-media transfers, second generation off-site pollution, externaliaztion of environmental costs, and cost-ineffectiveness besides being ridden with all the fallacies of a legalistic paradigm.

The inadequacies of reactive environmental policy could be overcome through a preventive policy which influences technological considerations preceding investment decision-making in such a way that resource utilization as also the cost of environmental protection and damage are minimized while economic productivity and innovative capacity of proponents are maximized.

Preventive environmental policy is directed towards the conditions that give rise to environmental problems and anticipatory actions to readjust these conditions so as to prevent potential environmental damage. It must be recognized that preventive strategies cannot avoid future environmental damage totally, but can, at best, limit it more effectively that reactive policy.

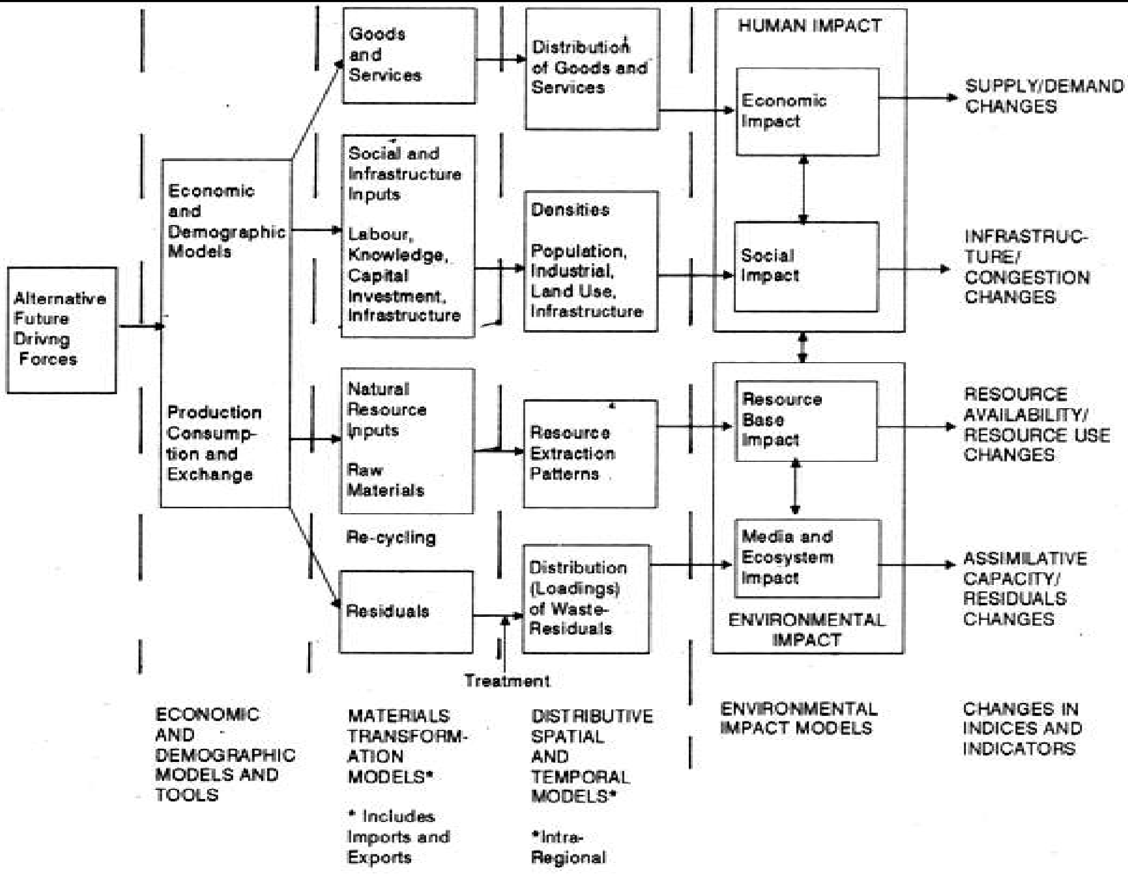


Fig 5 Modelling and analytical techniques in carrying capacity based planning process

Adoption of preventive strategies does not make reactive strategies superfluous as environmental backlogs must be cleared and unforeseen problems dealt with. Pragmatically speaking, the preventive and reactive approaches complement each other and that is how the legislative, administrative, institutional and policy formulations must be devised.

Towards Environmentally Sound Technology

Identification and implementation of environmentally sound technologies warrant evaluation of various feasible options based on economic, environmental and social considerations. While the decisions at the industry level are guided by the economic analysis of resources conserved, pollution control costs avoided, and costs in curred on new technologies; government at the national level must include analysis for the benefits to society, impacts on environmental quality, as also stock and quality of natural resource base.

The methodologies for technology assessment relate to two different and yet inter-linked stages in the overall process of converston of raw materials into finished products, viz, manufacturing process and residue/waste management.

Presented herein is an approach to technology assessment based on the realm of environmental impact assessment. Example is first presented of technology ranking exercise for residue/waste management to illustrate the methodology followed by a framework for ranking of manufacturing technology.

Ranking of Technology Options in Waste Management

The methodology for ranking of technology options in residue/waste management comprises following steps:

Identify feasible treatment processes for meeting the stipulated effluent standards as also processes that facilitate recycle and reuse;

Estimate sizes of individual units in the treatment processes;

Estimate land, power, and staff requirements for each alternative;

Estimate capital and annual O & M costs;

Estimate annual benefits, if any, and calculate net annualized cost;

Identifythe attributes for ranking of alternatives;

Apportion a total score of 1000 between the assessment attributes based on their importance through ranked pairwise comparison technique ;

Develop Efficacy Index Relationships (EIRs) using Delphi technique;

Estimate actual score for each attribute for various technology alternatives using EIRs;

Add the scores for individual alternatives to rank the alternatives based on the score.

The methodology is illustrated through a case study for waste management in ranking of wastewater treatment alternatives in Table 1.

TABLE 1 RANKING OF WASTEWATER TREATMENT ALTERNATIVES*

Attribute	Maxi-mum Score	Score for Alternatives					
		Activated Sludge Process	Trickling Filter	Carrousal Oxidation Ditch	Stabilazation Ponds	Aerated Lagoon	Aerated Lagoon with Settling Ponds
Environmental risks	100	100	100	100	100	50	100
Health risks	200	150	120	175	125	160	140
Aesthetic risks	50	50	20	50	15	30	50
Net annualized cost*	250	17	30	0	140	250	175
O & M staff requirement	100	0	0	65	100	76	76
Land requirement vis-a-vis availability	200	193	193	200	0	194	163
Reliability	100	100	100	100	100	80	80
Total score	1000	610	563	690	580	840	784
Ranking		IV	VI	III	V	I	II

*With resource recovery, wherever possible

Ranking of Technology Options in Manufacturing Sector

The process of ranking of technology options in manufacturing sector will comprise following steps:

Select attributes for evaluation of alternatives, eg, raw material conversion efficacy, energy efficacy, etc.;

Apportion atotal score of 1000 between the assessment attributes based on their importance through ranked pair-wise comparison technique;

Develop efficacy Index Relationships (EIRs) using Delphi technique;

Identify the feasible technologies for the product to be manufactured;

Estimate score for each attribute for various technology options using EIRs.

Add the scores for individual technology alternatives to rank the alternatives based on total score. An example on EIR for energy consumption in steel industry is presented in Fig 6. The methodology is illustrated through a hypothetical case study in Table 2.

Structural Economic Change

Structural change involves large scale technological substitution towards environmentally-benign technologies such as:

Clean technologies of industrial production that conserve resources, generate less pollution, provide direct economic benefits and stimulate the growth of industry as well as national economy;

Recycle and reuse technologies for end-ot-pipe treatment that render the otherwise deemed non-productive activity of waste treatment as a profitable proposition through waste utilization;

Biotechnology for substitution of non-renewable with renewable resource base resulting in wide ranging ecologic and economic advantages;

Integrated technologies that minimize cross-media transfer of pollutants thus minimizing overall pollution-induced risks in all environmental components rather than addressing single types of pollutants in particular environmental medium.

Select examples of clean technology are presented in Tables 3-6.

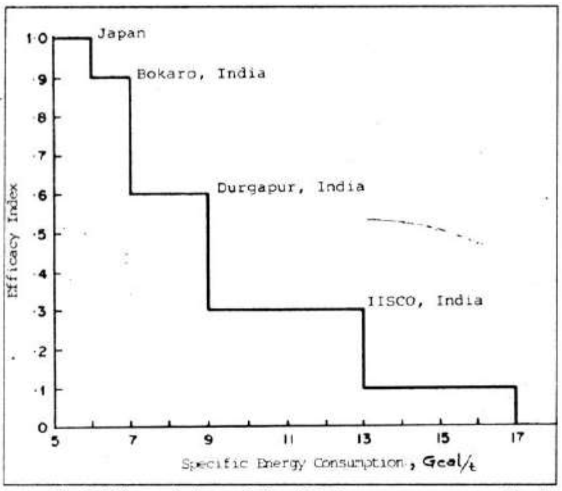


Fig 6 Efficacy index relationship for energy consumption in steel industry

TABLE 2 RANKIING OF TECHNOLOGY OPTIONS IN MANUFACTURING SECTOR

Attribute	Maximum Score	Score for Alternatives A	B	C	D
Raw material requirement per unit of product	100	80	60	70	75
Energy requirement per unit of product	100	80	70	78	76
Water requirement per unit of product	100	70	75	80	85
Quantity and characteristics of residues					
Gaseous	80	70	60	65	70
Liquid	60	50	40	45	50
Solid	60	50	45	48	47
Annualized net cost of producton per unit of product*	300	200	225	210	215
Annualized cost of pollution control per unit of product					
Gaseous	60	40	55	50	40
Liquid	60	50	40	45	50
Solid	60	50	45	45	45
Noise	20	10	10	10	10
Total score	1000	750	725	746	763
Ranking		II	IV	III	I

*With resource conservation and recovery, wherever possible

TABLE 3 CLEAN TECHNOLOGIES OF PRODUCTION

Industry	Steps towards Clean Technology: Process Modification	Recycle/Reuse	Equipment Redesign	Product Formulation
Pulp and paper	Removal of silica before evaporation process in cooking of rice straw	White water recycling for washing of pulp	Press drying technology for paper making	Brightness of pulp regulated to 75%-80%
	Substitution of chlorine with chlorine dioxide or hydrogen peroxide for bleaching of pulp	Recovery of sodium sulphide/sodium carbonate in cooking		Separation of paper requiring permanent brightness
		Separation of lignin in bleaching process for use as adhesive agent and raw material for dyestuffs		
Textile	Thermal printing process for cotton cloth	Caustic soda recovery in mercerizing		
	OMC/PVA to replace starch in sizing	Solid cotton waste separation for use as stuffing for cushions and dolls		
	Counter current washing			
Tannery	Aluminium salts to replace chromium salts in pretanning	Cuttings, trimmings as raw materials for leather boards	Use of drums and mixers instead of pits	
	Batch wasing of hides instead of continuous washing	Green scrappings from sawing for glue production		
	Enzymes to replace sulphate in unhairing	Tail and body hair for carpet industry		
Metal Finishing	Counter current washing for rinsing	Cadmium and cyanide recovery through reverse osmosis		
	Non-cyanide salts for nitriding	Recovery of noble metals through electrolysis		
Chor-alkali	Ion-exchange and electrolysis for production of chlorine and caustic soda			
Iron and steel	Mechanical cleaning to replace acid pickling	Blast furnace slag as construction material		
	Neutral electrolyte process for pickling	Recovery of hydrochloric acid from pickling process		
Fertilizer	Nitrophosphate process for NPK complex production	Nitric acid recovery in ammonia fertilizer plant		

TABLE 4 BENEFIT-COST ANALYSIS FOR SELECTED INDUSTRIES*

Industry	Total Wastewater flow, m^3/d	Total cost of plant, Rs $\times 10^5$	Net annual Recovery, Rs $\times 10^5$	Investment payback period, years	Remarks
Apparel	6 450	4 625	4 375	1.05	Recycle in process house
Alcohol	1 725	2 250	975	2.30	Reuse of energy in process house
Tanning	2 710	3 875	NQ	NQ	Recycle for irrigation
Food Processing	1 460	1 0500	4 250	2.47	Recycle for irrigation /process house and reuse of energy
Viscose rayon	4 500	200	36	5.5	Recovery and reuse of zinc, foreign exchange savings

NQ : Not quantified

* Based on analysis of some recently installed recycle and recovery systems in India

TABLE 5 INDUSTRIAL COMPLEXING AS A SOLUTION TO PHOSPHOGYPSUM FERTILIZER WASTE PROBLEM

Fertilizer industry produces 4-5 t of phosphogypsum (PG) as waste per tonne of phosphoric acid from rock phosphate

Leachates from land disposal of PG poses threat to ground water quality

PG can be used as raw material for production of cement

It is feasibile to locate, construct and operate an industry complex, consisting of a phosphatic fertilizer and a cement plant in keeping with the concept of environmentally balanced industrial complexes

It is possible to develop an analytical model to produce an optimum mass balance for the fertilizer-cement plant complex to arrive at the optimum size of manufacturing plants

Such an industrial complex will result in low production cost of phosphatic fertilizer and cement while conserving resources and minimizing the problem of waste management

TABLE 6 WASTE UTILIZATION OPPORTUNITIES IN INDUSTRY SECTOR

Industrial Waste	Physical Form of waste	Source industry	Present Disposal Method	Potential for use
Fly-ash	Power	Thermal Power Station	(i) Pumped in the form of slurry to near-by lowlying areas in the wet system of disposal (ii) Fly-ash discharged from the precipitators is conveyed for disposal the dumps in the dry method	(i) in portland pozzolana cement (ii) In construction industry (iii) (a) Dam construction (b) Land reclamation (c) Road construction (iv) Cellular concrete (v) Lime fly-ash bricks (vi) Sintered light weight aggregates
Blast furnace slag	solid lumps	Steel industry	Dumping in open area	(i) As a component in blast furnace slag cement (ii) As a component in binding material (i) Road aggregate (ii) Slag wool
Lime sludge	Slurry/ paste	Fertilizer, sugar, Paper and acetylene industry	Stored in large outdoor settling ponds	(i) As raw material in cement manufacture (ii) In lime pozzolana mixture
Chemical gypsum	Slurry/paste	Fertilizer industry	Pumped in the form of slury to the dumping ponds	(i) As a set controller in the manufacture of cement in palce of mineral gypsum (ii) For making gypsum block board
Red mud	Paste	Aluminum industry	Dumped in open area	(i) As a component of raw mix in the cement industry (ii) In the manufacture of building bricks (iii) Light weight structural blocks

These are three broad groups of resources upon which economic activity is based, viz, non-renewable resources, renewable resources and information. The sectors of economy that deal with non-renewable resources are environmentally the most problematic. Branches of the economy working with renewable resources are significantly less problematic in terms of acquisition of raw materials and waste disposal. Information is a non-material resource. It is easily accessible to all stages of industrial development and is ecologically sound.

Restructuring of the economy by substituting environmentally harmful branches with equally productive but environmentally compatible ones could from an important strategy of environmental policy.

Structural change aims at raising the levels of both ecologic and economic efficiency by increasing material and energy effectivity in production and consumption in order to minimize the expense on environmental protection while keeping the cost of natural resource exploitation within acceptable limits. It involves restructuring of economy based on ecological principles.

TABLE 7 PRIORITY AREAS OF ENVIRONMENTAL ACTION

Policy Level	Plan Level	Programme Level
1. Carrying capacity based developmental process	1.1 Supportive capacity based developmental planning	1.1.1 Development and implementation of Village/district/regional/national sustainability model
	1.2 Assimilative capacity based environmental management	1.2.1 Assimilative capacity based location of developmental projects
		1.2.2 Establishment of Centre for studies on policy issues
2. Preventive environmental intervention	2.1 Introduction of environmentally benign technologies and services in various economic sectors	2.1.1 R & D and implementation of low and non-waste technologies of production and recycle and reuse technologies for end-of-the-pipe treatment in industry
		2.1.2 Use of renewable resources in energy sector
		2.1.3 Greater use of biotechnology and ecocultivation in agriculture sector
		2.1.4 Use of fuel efficient engines in transport sector
		2.1.5 Use of renewable and environmentally compatible building materials in construction sector
		2.1.6 Establishment of Centre for Studies on Low and Non-Waste Technologies of production
	2.2 Structural change towards less resource and energy-intensive sectors of economy	2.2.1 Substitution of non-renewable with renewable resource base in manufacturing sector use of biofertilizer and biocides in agriculture use of non-conventional sources in energy sector
		2.2.2 Expansion of tertiary sector of economy
	2.3 Conservation of raw material and energy resources	2.3.1 Environmental audit including resource and energy audits of developmental activities
		2.3.2 Development of resource and energy efficient systems
	2.4 Application of EIA in sectoral decision making	2.4.1 Development of sectoral guidelines for environmental review
		2.4.2 R&D on screening and scoping and computer-aided EIA methodologies
		2.4.3 Preparation of model studies on EMP and DMP
		2.4.4 Development of objective criteria for delineation of environmentally sensitive areas
		2.4.5 Legislative framework for implementation of EIA stipulations
		2.4.6 Establishment of autonomous National Environmental Impact Assessment Agency
	2.5 Inter-sector policy coordination	2.5.1 Review of sectoral plans from environmental considerations
		2.5.2 Creation of infrastructure within MEF for inter-policy coordination
		2.5.3 Creation of environmental cells in various Ministries
3. Measurement qualitative growth	3.1 Development of indicators of qualitative growth	3.1.1 Development of National Ecologic Economic-Database (NEED)
		3.1.2 Development of concept of Gross Ecologic Product (GEP)
4. Restoration of environmental quality.	4.1 Assimilative capacity based environmental standards	4.1.1 Assessment of regional assimilative capacity and formulation of location specific standards
		4.1.2 Implementation of environmental assimilative capacity based standards
		4.1.3 Formulation of standards for industrial sludges materials
	4.2 Operationalization of polluter pays	4.2.1 Introduction of effluent tax

	principle	4.2.2 Introduction of resource cess for industry
		4.2.3 Implementation of standards based on resource consumption and production capacity
	4.3 Damage-cost functions and cross-media analysis as basis for environmental quality standards	4.3.1 Development of damage-cost functions and concomitant environmental standards
		4.3.2 Analysis of cross-media pollution transfer for integrated pollution control
	4.4 Legislative and fiscal measures to induce waste utilization	4.4.1 Collation of information on nature, volume, location and accessibility of wastes, economically viable technologies for waste utilization and potential market for recoverable
		4.4.2 Development of stabilized market support for recovered materials
		4.4.3 Establishment of National Waste Utilization Board (NWUB)
		4.4.4 Establishment of centre for studies on waste utilization
	4.5 Integrated land use planning	4.5.1 Apportionment of land for meeting competitive sectoral demands
		4.5.2 Integration of physical and environmental planning concepts for devising National/regional/district/town land use plans
		4.5.3 Establishment of centre for Studies on Land Environment
	4.6 Reclamation of degraded lands and restoration of fragile ecosystems	4.6.1 R&D and implementation of technologies for reclamation of mining lands water bodies, wetlands, and catchment areas
		4.6.2 R&D and implementation of technologies for restoration and enhanced utilization of forests, mangroves, wetlands, island and coastal ecosystems, arid and semiarid zones
	4.7 Development of wastelands	4.7.1 Identification of wastelands
		4.7.2 R&D and implementation of technologies for development of wastelands
	4.8 Ecosystem compatible and need-based afforestation	4.8.1 Vegetation mapping of the country
		4.8.2 Development of afforestation plans to meet demands for forest based products particularly for rural poor
5. Information, education and training	5.1 Use of integrated ecologic Economic database for sectoral decision making	5.1.1 Creation of nodal agency for establishment of National Ecologic-Economic Database (NEED)
	5.2 Human resource development for environmental management	5.2.1 Introduction of environmental subjects in curricula of schools and colleges
		5.2.2 Introduction of specialized graduate and post-graduate programmes on environment
		5.2.3 continuing education of professionals
		5.2.4 Extension of employment guarantee scheme to environmental restoration programmes
	5.3 Awareness building for enlightened public participation in environmental decision making	5.3.1 Development of mass communication techniques
		5.3.2 Development of centralized facility for acquisition, documentation, storage and dissemination of environmental education material in form of Environmental Resource Centre
		5.3.3 Establishment of regional/local ENVIS centres

A few examples of structural change are presented hereunder:

Manufacturing sector: Transition to production processes which save or recycle raw materials and energy, substitution of ecologically harmful to harmonious products, application of biotechnology for substitution of non-renewable resource base, carrying capacity based planning of industrial estates, ecological grouping of industries.

Agriculture sector: Eco-cultivation and biotechnological improvements, promotion of organic manures and biocides, development of land-use plans compatible with species and ecosystem types.

Energy sector: Rational use of primary energy, greater use of regenerative energy sources, decentralization of supply, improvement in combustion process.

Construction Industry: Use of renewable and environmentally compatible building materials, saving of land and energy, labour-intensive designs.

Transport sector: Reduction in the specific energy consumption of motor vehicles, reduction in total number of motored kilometers, provision of efficient public transport system.

Structural changes in economy could be brought about by de-linking of economic growth from the consumption of ecologically significant resources. Fig 7 illustrates a five-fold de-linking of the growth of GNP from five major indicators of environmental pollution.

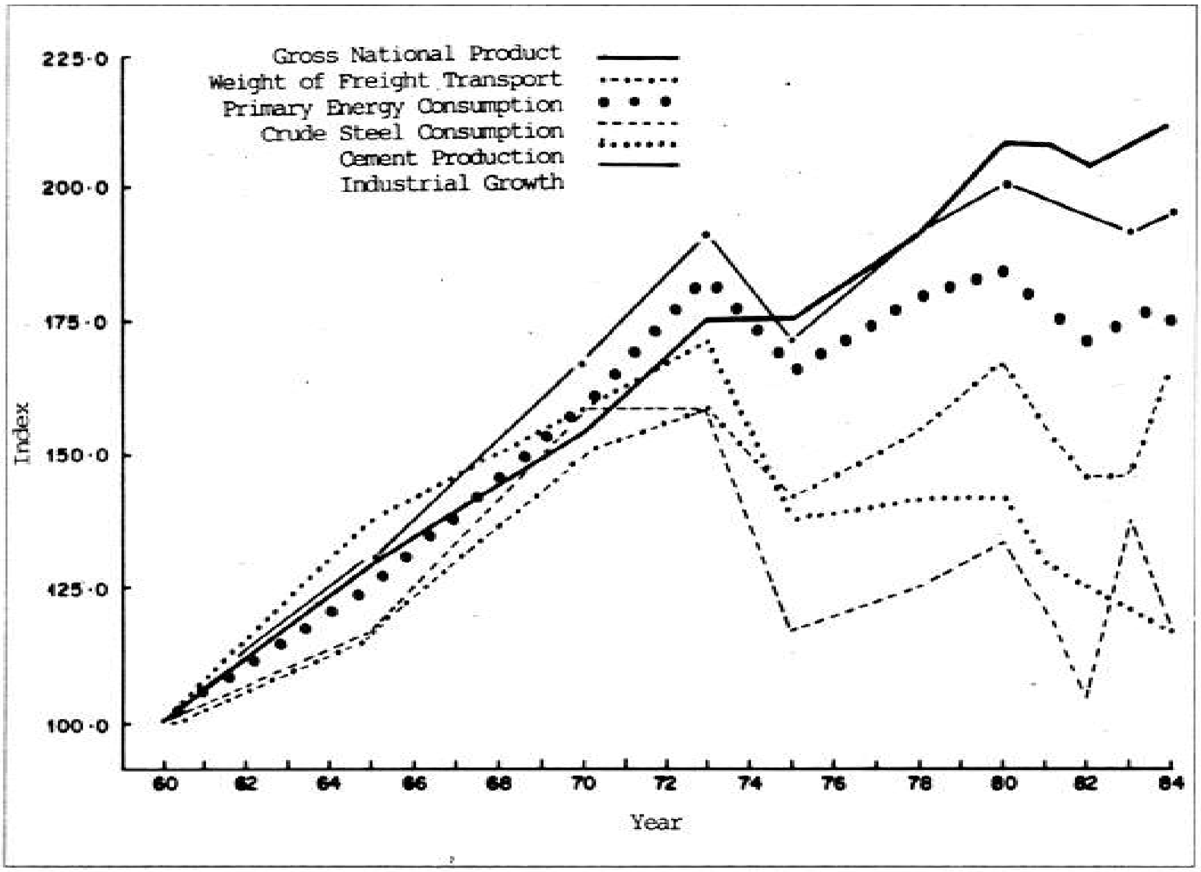


Fig 7 Structural economic change in the Federal Republic of Germany

However, an analysis of Indian economy between 1970 and 1989 shows a marked structural deterioration with negative environmental effects as depicted in Fig 8. The energy-intensity of economic growth has increased substantially.

The available indicators of growth and environmental pollution do not provide environmentally relevant information about the structure of an economy as it ignores the impact of economic growth on the stock and quality of natural resources. A macro indicator of qualitative growth that has been suggested by environmental economists is the gross ecological product (GEP) as illustrated in Fig 9.

ENVIRONMENTAL IMPACT ASSESSMENT

EIA is potentially one of the most valuable, inter-disciplinary, objective decision-making tools with respect to alternate routes for development, process technologies and project sites. It is an anticipatory mechanism which establishes quantitative values for parameters that indicate the quality of the environment and natural systems before, during and after the proposed developmental activity, thus allowing measures ensuring environmental compatibility with economic efficacy.

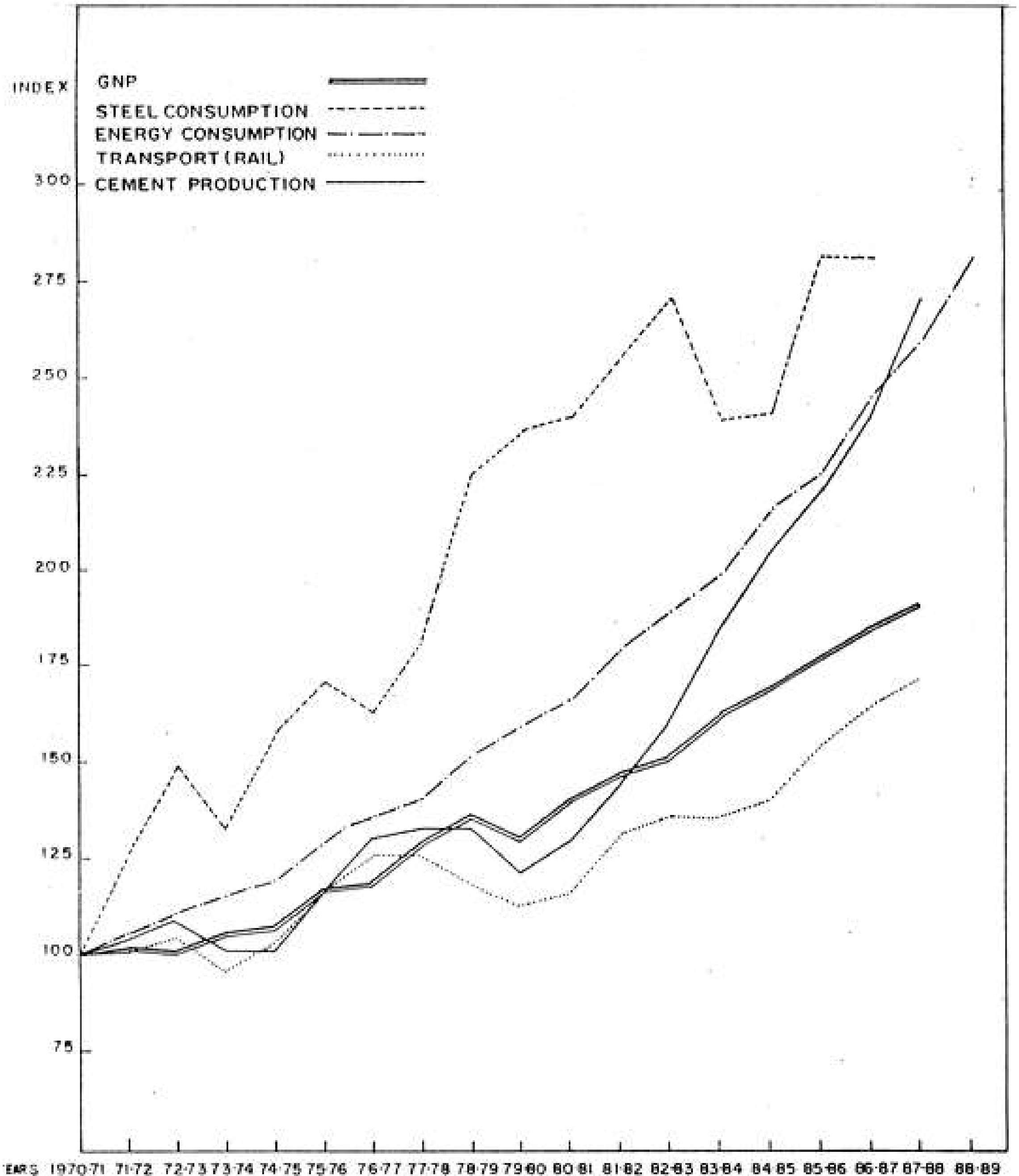


Fig 8 Structural economic change in Indian Economy

EIA could form a major instrument for the assessment of developmental activities in the context of regional carrying capacity, provided the conceptual framework is extended to the cumulative assessment of policies, plans, and projects on a regional basis.

EIA should ideally be undertaken at the policy and planning levels as the environmental consequences of projects often arise due to high level decisions. Policy EIA, however is viewed as an extremely complex issue, largely due to the fact that the potential range of alternatives to achieve a desired goal can be almost unlimited. This problem may be resolved through a hierarchical approach in which the number of alternatives are reduced by defining the problem in terms of a series of choices as illustrated in Fig 10.

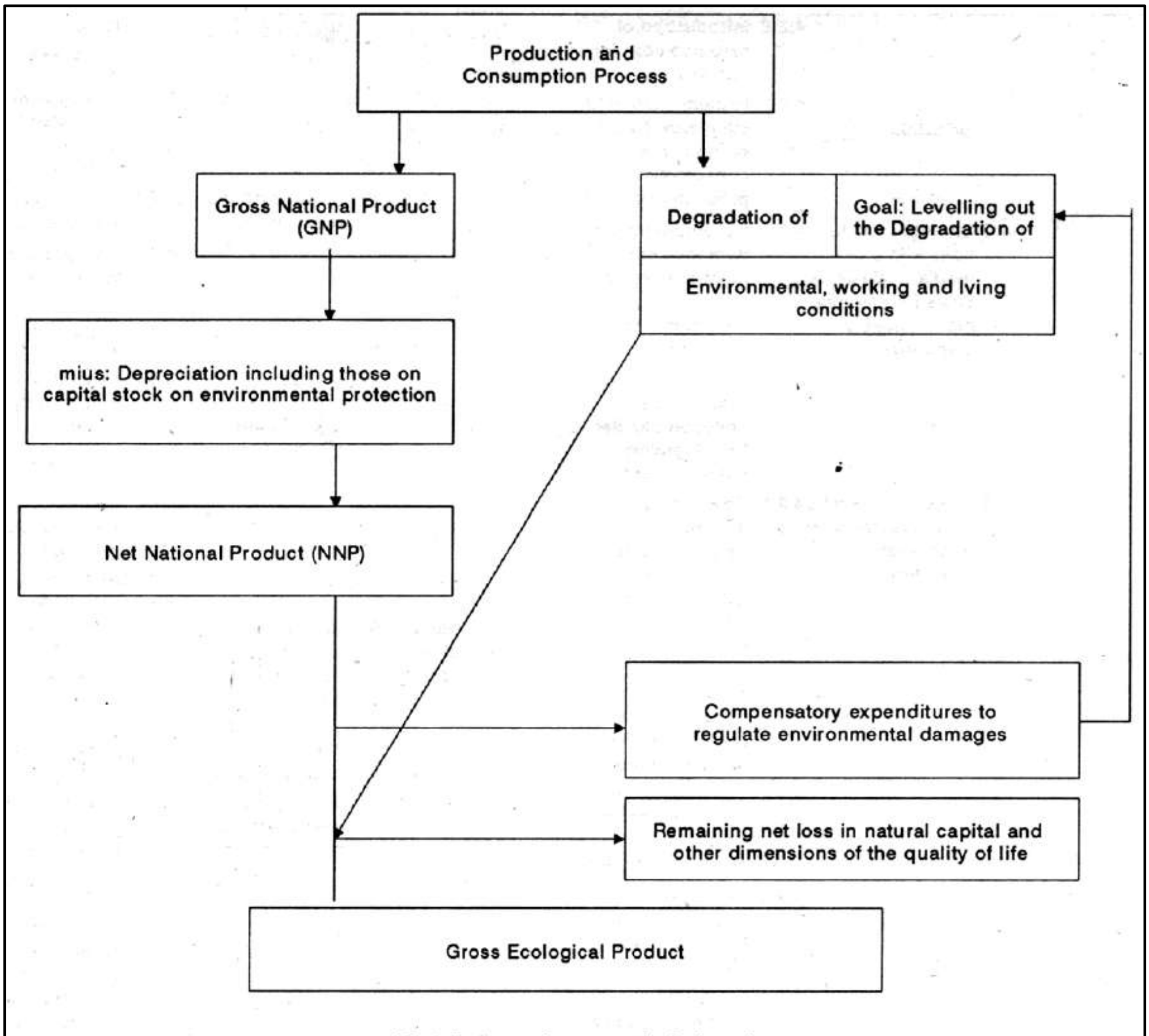


Fig 9 Concept of gross ecological product

The most appropriate stage for implementing EIA is at the level of district planning, since at this stage a reasonable number of alternatives are available to the developer. The assessment of regional supportive and assimilative capacities during formulation of development plans could greatly reduce the requirement for project EIA.

Most ecological problems are the cumulative result of environmental and social impacts of human activity in the region. Planning for sustainable development in the context of ecosystems carrying capacity thus requires systematic identification, quantification and management of cumulative trends in significant environmental variables on a regional basis. Functional planning regions need to be identified based on ecological criteria such as climatic, vegetation patterns and soil classification; airshed and watershed boundaries rather than political jurisdictions.

PRIORITY AREAS OF ENVIRONMENTAL ACTION

The analyses of economic sectors in India apropos the agenda for sustainable development leads to following conclusions:

Aspirational goal for sustainable development demands no less than environmental reorientation of entire developmental process;

There is a need for introduction of a right mix of preventive and curative approaches in environmental policy;

Administrative structures and institutions need to be redesigned accordingly;

Priority areas of environmental action at policy, plan and programme levels need to be tackled on an urgent basis.

The priority areas of environmental action at the policy, plan and programme levels are presented in Table 7.

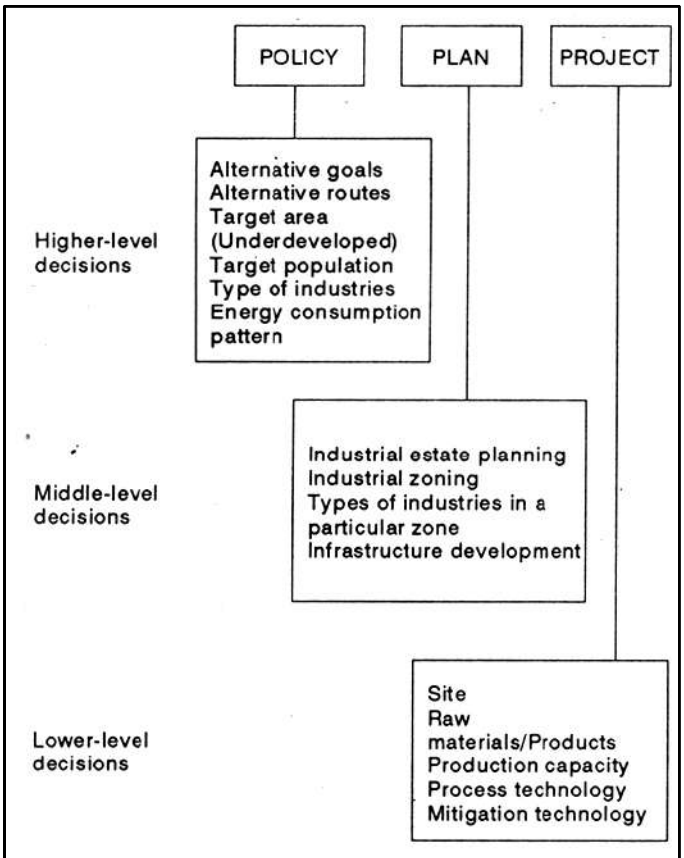


Fig 10 Hierarchy of decision-making related to industrial development

EPILOGUE

Environmental management in present day context warrants a dynamic policy framework in which the time lag between problem awareness, technological solution and remedial action is minimized through a combination of four strategies as shown in Table 7.

- Anticipation and prevention of environmental problems that may arise as a consequence of decisions taken within various sectors of the economy;
- Restoration of environmental quality wherever necessary Structural changes in economy; and
- Inter-policy coordination.

Policy-makers faced with long-term environmental problems often argue that they cannot afford to worry about the remote and abstract when surrounded by the immediate and concrete. The problems which overwhelm us today are precisely those which, through a similar approach, we failed to solve decades ago (Dr Mostafa K Tolba, Executive Director, UNEP).

ACKNOWLEDGEMENT

The material presented in this lecture has been derived from a number of national and international publications. The author is responsible merely for the interpretation of available literature to highlight the emerging role of environmentally sound technology in sustainable development.

Role of Engineering in Housing the Millions with Sustainable Development

Dr H C Visvesvaraya, *Fellow*

Past President, Institution of Engineers (India)
Vice Chancellor, University of Roorkee, Roorkee

PREAMBLE

The population of the whole world, which was just about 200 millions 19 centuries ago, rose to about 2400 millions by the year 1950. Now it is over 5200 millions. Out of this, India's population today is about 875 millions and crossing the billion mark is well in sight. Whatever the demographers, planners, politicians and governments might be doing or attempting to do, the fact is the world population in general and population of countries like India in particular are increasing in millions. Since food and shelter and clothing are essential needs of man, it falls on the shoulders of engineers to play their full role in meeting these needs.

In the matter of food, a variety of engineering activities have enabled increasing food production in India from' a mere 51 Mt at the time of independence to over 180 Mt by now. To achieve this, many hundreds of anicuts, dams, canals and tube-wells have been planned, designed and constructed; irrigation has been expanded from 21 Mha to 80 Mha; agricultural engineering with the manufacture and use of a wide variety of modern farm machinery like tractors, power tillers, threshers, harvesting combines and so on has played its role; fertilizer plants and their downstream and upstream technical activities are some of the other inputs.

In clothing, the production has increased from a little over 3 billion meters (8 m) at the time of Independence to nearly 158 m by now; in achieving this, mechanical engineering, textile engineering, chemical engineering and many other branches of technology and engineering have played their vital role .

Providing shelters has, however, lagged behind as will be seen from the following.

DIMENSIONS OF THE PROBLEM

Even though the total stock of dwelling units has increased from 58 million units at the time of Independence to about 150 million units by now, the present shortage or backlog is as much as 23 million units; by the turn of the century another 64 millions dwelling units comprising nearly 33 millions in rural areas and 31 millions in urban areas are required. In all, 87 million units have to be put up in about nine years if housing needs of the millions have to be fully met by the year 2001. Out of the present stock of 150 million units, as much as 101 million units are still of the kutcha or semi-pucca type; and so the task of taking qualitatively the kutcha category to semi-pucca/pucca and the semi-pucca category to pucca category, poses yet another challenge.

To achieve these two goals massive programmes of housing would have to be undertaken. Such a massive programme in size and speed can be successfully accomplished only after giving indepth considerations to both micro and macro level issues and after formulating a realistic strategy framework. Such a strategy framework has to take into account the following factors:

(a) Unless all parameters are within the regime of sustainable development, the achievement will not sustain for long;
(b) The share of basic resources available per capita is much smaller in a country like India than in most other developed and developing countries; and
(c) Any programme of housing the millions cannot be conceived as mere putting up of houses or dwelling units but of making them shelters which include a range of other supporting facilities, such as water and energy supplies, drainage and sanitation, access to transportation and communication, and enlivening exposure, all of which together provide an acceptable living environment.

SUSTAINABLE DEVELOPMENT

It is by now clear that sustainable development is that Development which is towards meeting the needs of the present generation without compromising the needs of the future generations.

In order, therefore, to achieve the objective of housing the millions within the regime of sustainable development, the following areas have to be particularly studied:

(a) Interlinkages of sustainable development and shelter;
(b) Social value added by each additional shelter in a given situation; and
(c) Economic value added by each unit increase in shelter as the stage of development of a country advances.

These considerations lead to an immediate fact that whatever may be the variations or differences in the share of shelters in the total construction activity in a country, considerations of engineering and sustainable development would both require that the strategy framework for shelters or for housing the millions should be part and parcel of the strategy framework for construction in the region or the country. Whilst the per capita national expenditure on construction could vary from country to country depending on its state of development, the actual total expenditure on construction has been a substantial proportion. In India, the outlay on construction has been 40%-50% in the successive national Plan outlays.

BASIC RESOURCES

The basic resources for construction are:

(a) Human resources,
(b) Eco-system resources,
(c) Energy resources, and
(d) Materials resources.

If the resources situation of some of the countries is seen, Australia has 7.7 Mkm^2 for a population of 17 millions; China 9.6 Mkm^2 for 1134 millions; India 3.3 Mkm^2 for 875 millions; the USA 9.41 Mkm^2 for 251 millions; and the erstwhile USSR had 22.4 Mkm^2 for 289 millions population, Thus, India is rich in human resources but extremely limited in others. The human resources will have to be effectively utilized to bring about an optimum balance between energy and mass to secure a good environment and the strategy framework has to have as its aim such a balance.

STRATEGY FRAMEWORK

The strategy for achieving the above stated goals would be in the framework of the following considerations with all of them being considered simultaneously.

* Environmental Protection including Ecological Balancing
  - in exploitation of raw materials
  - in processes of manufacture and use
  - in disposal when no more needed
* Materials Conservation including Preformance Maximization
* Energy Conservation
  - exploitation and manufacture
  - transportation, placement and treatment
  - utilization
* Durability, Serviceability and Cost Reduction covering both
  - immediate cost
  - life cycle cost
* Safety Assurance both
  - health
  - hazard
* Speed Compatability
* Manpower Optimization
* Ergonomic and Aesthetic Satisfaction

Since elaboration of each of the elements of this strategy framework would be too long, only some aspects of some of them are indicated here by way of illustration.

ENVIRONMENTAL PROTECTION INCLUDING ECOLOGICAL BALANCING

Presently, over 3600 Mt of building materials are consumed in the construction activity every year. To provide this, the Earth's crust in India is degraded every year to the extent of 5000 Mt. For example, it is estimated that last year

* to provide 68000 million bricks, 57000 ha of fertile lands were degraded;
* to secure 2.5 Mm^3 timber, 450000 ha of forest were damaged;
* to win other minerals for steel, cement, etc 30000 ha of land were degraded.

As long as this rate of exploitation continues, there is bound to be serious ecological degradation. So, if sustainable development has to be achieved:

* The quantity of materials consumed has to be reduced so that there is less strain on the resources; and
* Other possible resources have to be explored to supplement earth's crust resources.

The increasing population and the increasing pressures for using the resources of nature no more permits the unrestrained freedom enjoyed by the earlier civilizations in utilizing resources from earth; on the other hand, the continuous advances in science and technology are enabling more to be done with less, the aids of which were not available to earlier generations in the same measure. Thus, the futuristic development scenario for building materials will get its focus from two major factors:

* Nature cannot any more be allowed to be exploited without the restraints of ecological and environmental considerations.
* The scientific and technological advances would have to be harnessed to get the best from what is available appropriate to the socio-economic conditions of the country.

A majority of solid wastes have the same elements as the most abundant elements in the earth's crust and hence their exploitation in the waste recycle technologies for making building materials is increasingly gaining ground. Today, over 2600 Mt of solid wastes are produced a year-about 500 Mt from agriculture, 300 from industries, and 1800 Mt from rural and urban activities.

MATERIALS CONSERVATION INCLUDING PERFORMANCE MAXIMIZATION

Whether it is from the point of view of reducing ecological degradation or of energy conservation of from basic principles of engineering, there is a need to conserve materials. There are three distinct paths to achieve this.

* Maximizing the performance that can be secured from a given natural resource material by applying the latest knowledge in materials science and technology in its manufacture as well as in its use;

* Minimizing the amount of materials used in a construction element by applying the best principles of shape engineering; and

* Minimizing the quantum of structural elements or building materials needed by adopting the best structural configurations and forms.

Conservation of materials by all these methods is all the more urgent and necessary for sustainable development when the fact that the per capita materials resource available in India is relatively quite small as earlier stated.

Building materials are relatively heavy and are used in large quantities in construction. Today, building materials are used 4 to 7 t/year per capita; no other material except water is consumed by man in larger quantities. In view of this, transportation of building materials is a major strain on the national system. And so, it is imperative that building materials are, as far as possible, secured from local resources. Science and technology has to be applied to maximize the performance from a given quantum of material by both the type of processing as well as by the way the processed material is used, such as hollow clay bricks, light weight aggregates, improved cements and concretes, etc.

The final objective of all these would mean securing from any material, component or structure the highest possible

* performance-to-weight ratio
* performance-to-energy ratio
* performance-to-time ratio
* performance-to-utilization ratio
* initial-and-life-cycle-performance ratio.

ENERGY CONSERVATION

Whilst there is a keen awareness to conserve energy all over the world, the need for conserving energy has become more acute in developing countries such as India because of scarcity of utilizable energy. Out of the total utilizable energy available in the world, 21% of the population living in industrialized countries use 76% of this energy; only a meagre 24% is used by the remaining 79% inhabiting the developing world. Any construction activity has to take this reality into account.

In the total energy concept, the energy used (or released) has to be accounted for at all stages such as:

• Energy consumed in the exploitation and manufacture of raw materials, finished products, components and equipment;
• Energy consumed in transportation, handling, placement and treatment;

• Energy consumed in the utilization or by the final construction.

When the final product of construction- shelter, in this case-there are a number of aspects of planning, designing and use which help in saving energy consumption such as through:

• building form, landscaping and orientation;
• hollow walls and roofs;
• thermally designed windows;
• appropriate ventilation;
• appropriate lighting;
• elimination of wastage.

DURABILITY, SERVICEABILITY AND COST REDUCTION

Whilst securing a higher initial performance is the first step, developments in the manufacture, choice and utilization of materials, advances in design and improved techniques in construction have pointed out the importance of looking into the durability as an important aspect of performance during the life cycle. The materials and the constructions have to so perform as to be serviceable over the entire life of the construction. Corrosion of steel in reinforced or prestressed concrete due to presence of chloride in their environment, and reduction in alkalinity protection around the reinforcement due to carbonation and alkali-silica reaction in the body of the concrete are some typical examples relating to adverse effects on durability.

The net immediate cost generally comprises of:

(a) Basic cost of the building material at the source such as at the manufacturing plant
(b) Packing, handling and transportation cost to reach the site
(c) State levies such as excise, taxes, etc
(d) Planning and design costs
(e) Supervision and construction costs

What determines the true measure of cost of a building material is the sum of (a) + (b) and developmental decision relating to alternative materials or new materials will be governed by the relative values of (a) + (b) while the value of (c) will depend on the policies made by the State.

To the net immediate cost indicated as above has to be added the maintenance, repair and replacement costs in orderto get at the life cycle cost. Many times, the largest possible number of shelters have to be provided with meager funds and the best way to achieve this is to use materials design and construction techniques which are least expensive. Sometimes, very high performance materials like stone blocks or good timber elements, may be locally available at very low prices and so real low cost constructions which are of high performance or durability can beachieved; but there are many situations where locally available materials are either poor in performance or costly to the user due to a variety of reasons; there may also be very little choice due to various restraints. Initial low price may not therefore necessarily mean real low cost in actuality. The real cost of every construction has to be evaluated in the given location and circumstances.

The real cust of a building unit can be considered as the sum of the initial cost of constructing the building unit plus the present cost of long term maintenance during the planned life cycle of the building unit plus the present cost of subsequent replacements within the planned duration of the life of the building unit multiplied by a factor related to: (a) the indirect costs based on the extent to which social needs are met and the required strategy is satisfied, and (b) the degree of satisfaction that the user gets.

Constructions which ensure long enough economic and satisfactory life and constructions which are prevented from becoming a liability on future generations are those in which the immediate costs and the life cycle costs are well optimized.

CONCLUSION

In the foregoing, the attempt is only to draw attention to the need for a strategy framework if the millions have to be housed whilst securing sustained development. On this base fabric, delails can be worked out in specific cases.

The first purpose of this endeavour would have been served if an appreciation has been created for looking at the various parameters in an integrated manner for sustainable development through the appropriate role of engineering.

Energy Management in Agriculture and Rural Sector

Prof V L Chopra

Director-General,
Indian Council of Agricultural Research, New Delhi

INTRODUCTION

I feel honoured for having been asked to deliver the 19th Bhaikaka Memorial Lecture on the occasion of the Eighth Indian Engineering Congiess. I have chosen the topic 'Energy Management in Agriculture and Rural Sector' as the subject my lecture today.

India has made considerable progress towards increasing agricultural production and productivity. Her strive to meet the future food, feed, fibre and fuel requirements for the growing population, however, is a continuing one. Commercial energy from oil, coal, natural gas and electricity has been the basic input tor modernization of agriculture and development of industries. The high productivity model of developed nations based on intensive use of commercial energy is not suitable for developing because of the rapidly increasing price of such energy sources, their exhaustible nature and their ever increasing rate of depletion. It is, therefore, important to explore new sources to meet the energy needs of agriculture and agrobased industries. The needs of the rural kitchen which account for over 50% of total energy use in agriculture and industries put together is also an important consideration. Agriculture of the future will be required not only to produce more food but also to generate energy to cope with the increased demands.

ENERGY USE PATTERN AT MACRO-LEVEL FOR AGRICULTURE PRODUCTION

Agricultural productivity is dependent upon improved seed of high genetic potentiai and efficient use of water and energy of chemical or biological origin. An analysis[2] of energy use for agriculture in various states of India during the last three decades (1961-91) shows that while the input through animate enerqy (draught animal energy and human energy) have remained more or less constant, the use of diesel and electricity, agricultural machinery and chemical fertilizers has increased by 24.0, 3.3 and 24.5 times, respectively (Table 1).

TABLE 1 CATEGORY-WISE ALL INDIA ENERGY INPUT IN AGRICULTUREAL PRODUCTION

Category	Input Energy Source	Form and Type of Energy	Year 1960-61	Year 1980-81	Year 1990-91
A	Animate energy (human and animal)	Direct non-commercial	81 568 (22.10%)	116 600 (14.85%)	130 750 (10.39%)
B	Seed and farm yard manure	Indirect non-commercial	237 373 (64.45%)	27[illegible] 245 (3[illegible].30%)	286 600 (22.77%)
C	Diesel and electricity	Direct commercial	10 549 (2.35%)	99 461 (12.66%)	253 075 (20.10%)
D	Farm implements and machinery	Indirect commercial	17 505 (4.75%)	39 349 (5.01%)	57 702 (4.58%)
E	Fertilizer and chemicals	Indirect commercial	21 602 (5.85%)	252 670 (32.17%)	530 682 (42.16%)
	Total		368 597 (100%)	785 325 (100%)	1258 809 (100%)

The highest energy input use in agricultural production during 1961 to 1981 (Table 2) has been registered by Punjab (270%), followed by Haryana (212%), Andhra Pradesh (120%), and Uttar Pradesh (106%). The states which increased energy use by more than 75% are Kerala (92%), Karnataka (86%), West Bengal (84%), Maharashtra (83%) and Rajasthan (77%). States with relatively smaller increases of input energy use are Assam (16%), Orissa (31%), Jammu and Kashmir (37%), Bihar (55%), Himachal Pradesh (64%) and Madhya Pradesh (70%).

The state-wise productivity index and energy use index for the period 1961-81 is presented in Table 3. In spite of variations in factors such as types of soil, cropping patterns, methods and sources of irrigation, cultural practices, sources of power used, etc there is a co-relation between the level of energy use and productivity. So far, the increase in productivity has been realized through commercial energy sources only, ie, chemical fertilizer, diesel and electricity. A study conducted at the Punjab Agricultural University[4] has revealed that during the 15-year period from 1965-66 to 1979-80, the total food grain production in Punjab increased by 175%, 12.5% annually. During this period the total energy input increased by 387%, at the rate of 27.8% per year. Can higher productivity be achieved also through alternate energy sources? This is an important and vital matter deserving serious consideration.

TABLE 2 STATE-WISE ENERGY INPUT TO PRODUCTION AGRICULTURE DURING 1961-1981

State	Level of Energy Input, TJ		
	1961	1981	%
Andhra Pradesh[5]	42 636	94 134	120.8
Assam	9 193	10 672	16.1
Bihar	29 450	45 600	54.8
Gujarat[3]	20 500	62 225	203.5
Haryana[2]	9 616	30 018	212.2
Himachal Pradesh	2 036	3 347	64.4
J and K	2 434	3 328	36.7
Karnataka	23 574	43 778	85.7
Kerala	5 989	11 507	92.1
Madhya Pradesh	37 279	63 354	69.9
Maharashtra	38 348	70 296	83.3
Orissa	17 773	23 240	30.8
Punjab[1]	17 607	65 234	270.5
Rajasthan	25 660	45 508	77.3
Tamil Nadu[4]	24 376	62 643	157.0
Uttar Pradesh[6]	71 286	146 690	105.8
West Bengal	17 302	31 853	84.1

* 1965 Level as these states were formed in 1965.

TABLE 3 STATE-WISE PRODUCTIVITY INDEX AND ENERGY USE INDEX FOR 1981

State	Yield Index	Energy Use Index
	Base: 1971 as 100	
Orissa	81.1	116
Himachal Pradesh	104.8	118
West Bengal	106.7	156
Kerala	107.1	139
Madhya Pradesh	108.9	133
Jammu and Kashmir	116.1	137
Bihar	122.9	128
Uttar Pradesh	127.7	144
Rajasthan	134.8	130
Tamil Nadu	135.4	135
Andhra Pradesh	140.1	171
Haryana	140.4	198
Karnataka	142.5	139
Gujarat	147.8	158
Punjab	158.4	183
Maharashtra	159.0	136
All India	123.8	148

ENERGY SUBSTITUTION — THE ROLE OF BIOGAS SLURRY

Energy as chemical fertilizpr is the single largest input to agricultural production constituting 40%-55% of the total energy input[2]. Recycing of dung through biogas plants provides not only energy for cooking but also plant nutrients for crop production. The requirement of chemical fertilizers can also be reduced to an extent by practices for maintaining soil fertility such as crop rotation, catch cropping, lay farming with legume rotation and recycling of crop and livestock residues. Research has led to availability of a range bio-tertilizers such as rhizobia, blue green algae and Azolla on commercial scale.

Under the All India Co-ordinated Research Project on Renewable Sources of Energy, field exoeriments have been conducted at Indian Agricultural Research Institute (IARI), New Delhi; Central Institute of Agricultural Engnineering (CIAE), Bhopal; Tamil Nadu Agricultural University (TNAU), Coimbatore; SPCW, Courtallam; and UAS, Dharwad; on the use of biogas spent slurry as partial replacement to chemical fertilizer. Different crop rotations and different treatment methods were tried both in Kharif and Rabi seasons. Results have shown that the chemical fertilizer can be replaced to the extent of 50%-75% for achieving the same yield. Besides, residual effect of the slurry gave comparatively higher yields and resulted in improved soil conditions.

Alternative Energy Sources for Motive Shaft Power

The pumping energy is the next largest energy input for crop production. There are over 400000 diesel pumpsets and an equal number of electrical pumpsets. Such pumps consume about 150×10^8 units of electricity and about 500 million litres of LDO/HSD. The supply of electricity is erratic in rural areas. The pump sets can be energized with biogas engines and gasifiers working on agriculture residues as feedstock. Atleast four designs are commercially manufactured in the country. However, there is need to improve the technology, after sales service and repair and maintenance services for these gadgets. Alternate sources of energy are encouragingly becoming cost competitive. Mittal and Ohawan[5] have reported that irrigation accounts for up to 60% of the total energy requirement for crop production.

Improved Tools and implements for Energy Saving and Enhancing Production

It has been shown that 15%-20% increase in food production can be obtained by timeliness of operation made possible by improved tools and equipment.

The increased production is realized at lower cost and savings in energy consumption. In one study on the use of improved animal drawn implements led to a saving of 44.3%, 37.7%, 56.7% and 60.3% in energy for production of wheat, mustard, cotton and pear millet, respectively. Average increases in yield of 5.4%, 17.4%, 14.8% and 16.3% and saving in cost of operations up to 51.6%, 28.3%, 40.5% and 59.4%, respectively, were observed by adopting improved technology for energy utilization in the agricultural sector.

ENERGY USE PATIERN AT MICRO-LEVEL — CASE STUDY OF A VILLAGE

The example of the village Islamnagar in the District of Bhopal, Madhya Pradesh, which has 224 households with a total population of 1529 and livestock population of 1436 is instructive. An Energy Census and Resource Assessment Survey revealed the following:

(i) Among the four major activities in the village, energy for crop production accounted for 14.5%, post-harvest operation about 0.5%, cattle raising about 1% and domestic activities (mainly cooking) 84% (Fig 1).

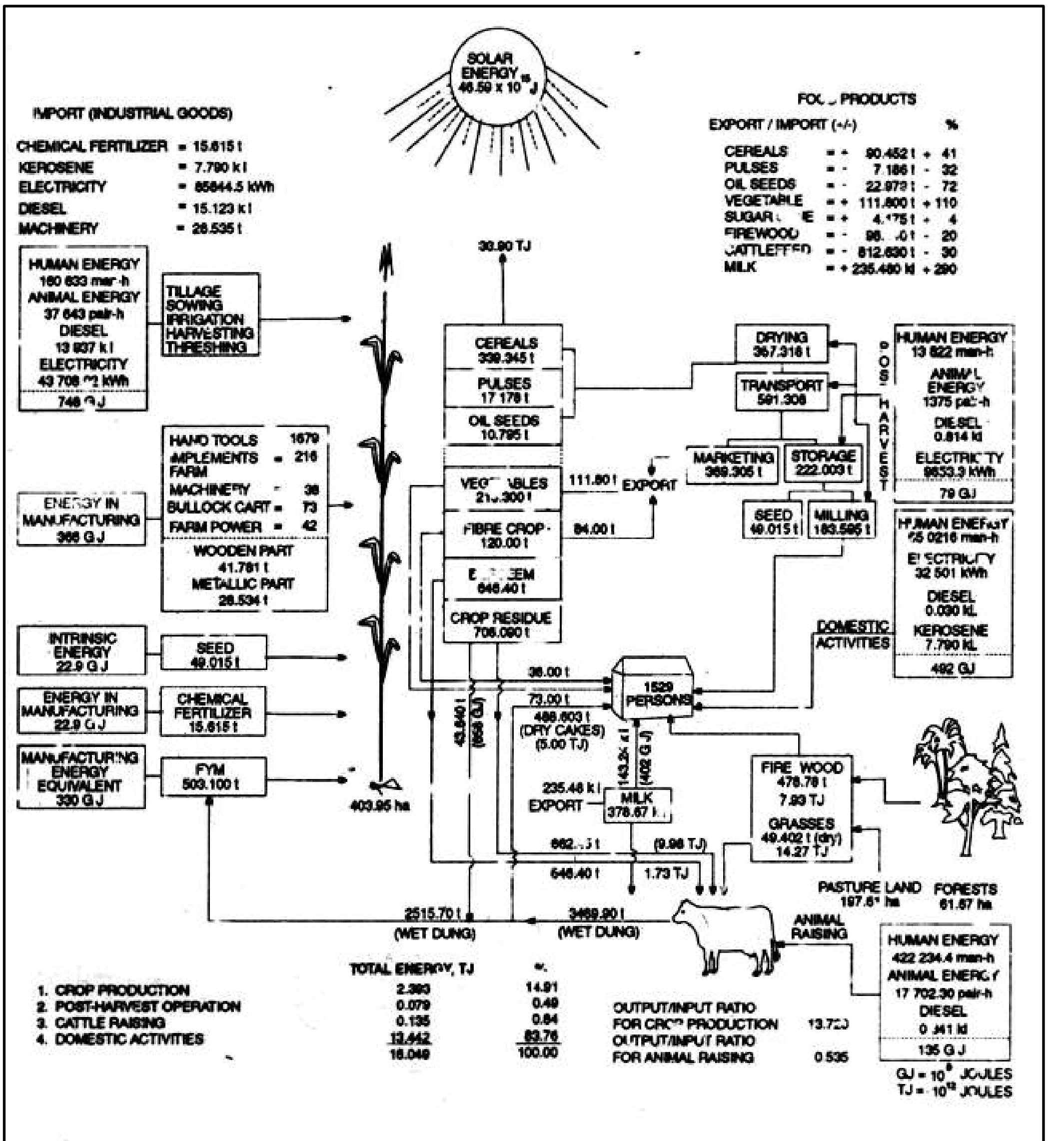


Fig 1 Annual energy flow in village ecosystem

(ii) Landless people form 36% of the population (the largest category). This group accounts for 30% of total energy use in the village. There is no agency which plans for the energy supply to the landloss people.

(iii) Out of the 46000 TJ of solar energy that is received annually by the geopraphical landmass of 717 ha of this village, only 40.44 TJ is converted into food, feed, fuel and fibre indicating an overall photosynthetic efficiency of only 0.0867%, as compared to the world average of 0.16% (Fig 2).

(iv) The village was surplus in cereals, vegetables, sugarcane and milk. However, there were annual deficits: for fuel wood by 20% (98.8 t), cattle feed by 30% (812 t), oilseeds by 71% (23 t) and pulses by 32% (7.2 t)(Fig 3).

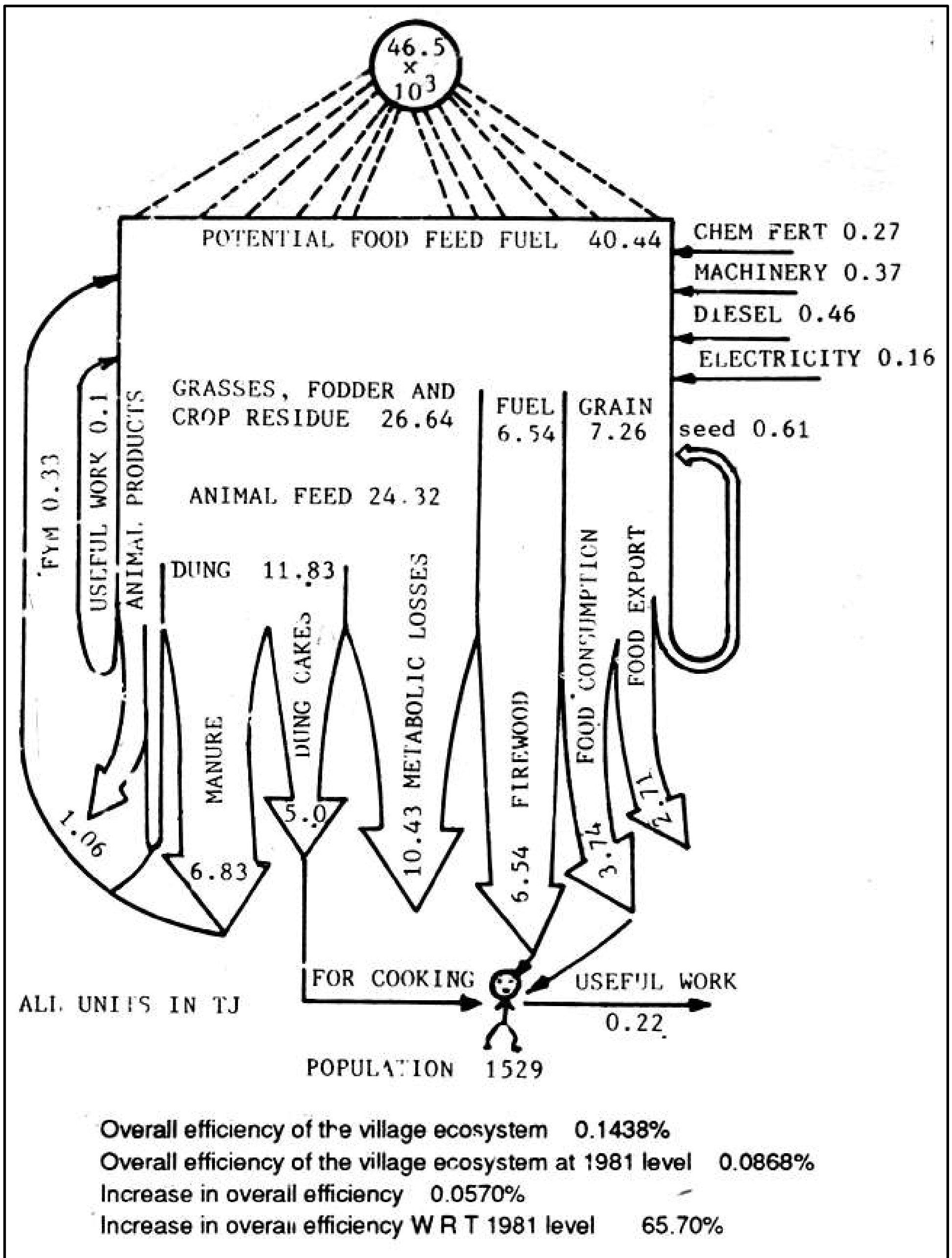


Fig 2 Sankey diagram illustrating solar energy flow in the village ecosystem

(v) The village has 61 ha of wasteland and 133.6 ha of pasture land which have the potential to make the village self-sufficient and even surplus with regard to firewood and cattle feed.

PLANNING FOR DECENTRALIZED ENERGY SUPPLY SYSTEM

The aforesaid enorgy census survey was used as basis for planning and implementating a scheme of development for achieving self-sufficiency in fuel wood, fodder, pulse, and oilseed production and its processing at the village level. The inspiration was the Gandhian concept. The reallocation of land, based on soil survey and land use planning as prepared by the National Soil Survey and Land Use Planning Bureau, Nagpur,[8] has led to self sufficiency in planning pulse and oil seeds production by taking into account an efficient soil and water management plan[9] and a package of improved tools and implements. The cropping intensity which was 98% in 1981 had gone up to 130% in 1986. The fuelwood deficit was eliminated through plantation of 34940 trees of 24 species on 38 ha. In addition, 10800 tree of 20 existing rootstocks were regenerated. The ecosystem was enriched in number and a variety of birds and wildlife animals such as wild pigs, a pair of wolves, etc. If all the 61 ha of forest land could be brought under aftorestation, the village would have become surplus in fuel wood production. Growing of grasses on the wasteland and pasture land can reduce cattle feed deficit to the extent of 77%. The village has 132 ha of pasture land mostly under illegal encroachment which can be retrieved through social action. Installation of 50 individual biogas plants and three community biogas plants of 35, 35 and 85 m^3/day capacity led to the production of 72 000 m^3 of biogas and 570 t of FYM from the biogas slurry which could take care of 50% of the cooking energy needs of the village and 28% of nitrogen requirement of the village for achieving self-sufficiency in cereals, pulses and oilseeds.

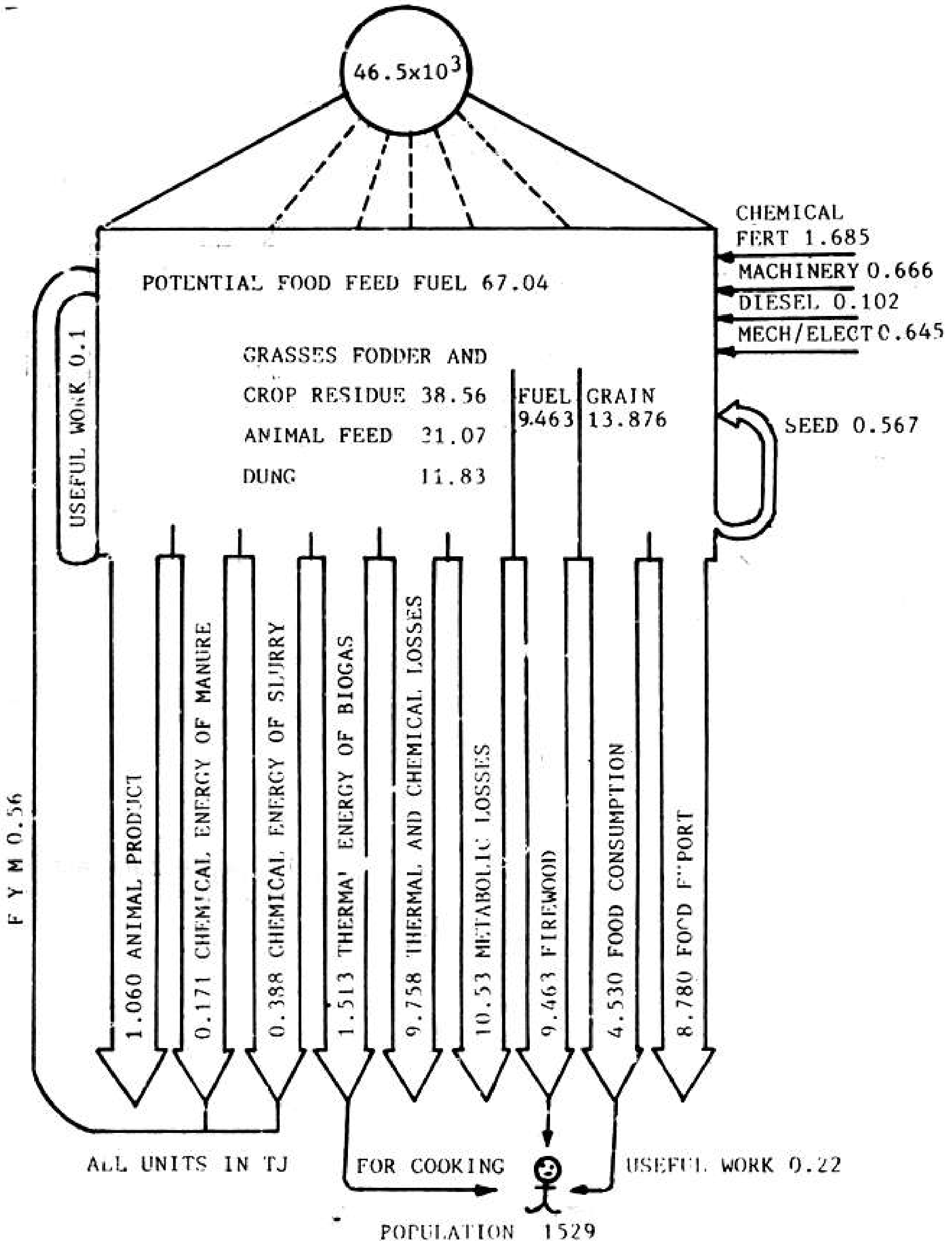


Fig 3 Sankey diagram illustrating solar energy flow into village ecosystem at the level of self-sufficiency

Implementation of various programmes for making the village self-sufficient can lead to better resource utilization and increased harnessing of solar energy for conversion into food, feed fuel and fibre. It is important to note that when the ecosystem becomes self-reliant snd sustainable, the actual energy requirement of the village goes down, from 16 TJ to 15.5 TJ annually. The production efficiency increases by (i) reduction in wasteful use of thermal energy through traditional stoves and achieving higher thermal efficiency through biogas burners, and (ii) harnessing of solar energy for additional food, fuel wood ad grass production. The solar energy conversion qoes up from 40 TJ to 67 TJ leading to overall photosynthetic efficiency to an average of 0.144% against the original 0.0868%. The new agricultural production, post-harvest operations and afforestation programmes generate additional 100000 man-h/year (12500 man-days). In other words, 40 persons could be gainfully employed for 300 days a year.

It is, thus, obvious that alternate energy sources play an important role in agriculture. The example can become a trendsetter for other sectors and a way to profound changes in the life style and living standard of the people.

REFERENCES

1. C P Bohra and R C Mahesnwari.'Effect of Energy Input on Productivity of Various States of India During Last Two Decades'. National Seminar on 'Contribution of Agricultural Machinery and Power in Increasing Production and Productivity; CIAE, Bhopal, 1985.
2. N S Randhawa and R C Maheshwari. 'Energy Management for Farming Needs: Sources and Technologies'. Journal of Society and Science, vol 5, no 4, October-December 1982.
3. R C Maheshwari (ed). 'Annual Report of AICRP Old Renewable of Energy for Agriculture and Agro-based Industries.' CIAE, Bhopal, 1980.
4. B S Pattak. 'Energy for Indian Agriculture.' Key-Note Address at the 20th Annual Convention of the Indian Society of Agricultural Engineers, G B Pant University, Pantnagar, March :'-7, 1983.
5. J P Mittal and K C Dhawan. 'Energy Parameters for Raising Crops under Various Irrigation Treatments in Indian Agriculture.' Journal of Agriculture Ecosystems and Environment, vol 25, 1989, P 11.
6. N K Bansal, M K Garg and M L Jain. 'Effect of Improved Implements on the Pattern of Energy Utilization in Agriculture 'Journal of Agriculture, Ecosystem and Environment, 0167-8809/89.
7. R C Maheshwari, et al. 'Energy Census and Resources Assessment at Village Islamnagar in the District of Bhopal.' CIAE Techniccl Bulletin,, no CIAE/81/28, 1981.
8. S N Deshmukh, et al. 'Soil Survey and Land Use of Village Islamnagar District (MP), NBSS Report no 453 NBSS and LUP, Nagpur,1983.
9. D N Bhandorbai. 'Efficient Soil and Water Management Planning for Village Islamnagar.' CIAE Technical Bulletin, no CIAE/CPE/86/48, 1986.
10. R C Maheshwari, et al. 'Planning and Implementation of an Integrated Energy and Nutritional Security Systems for Village Islamnagar.' CIAE Technical Bulletin, no CIAE/88/83, 1988.
11. A Alams. 'National Policies and Programmes on Development of Renewatle Energy Sources.' Proceedings, ICAR Summer Institute on 'Energy Management in Agriculture and Rural Sector', CIAE, Bhopal, 1984.
12. R C Maheshwari and C P Bohra. 'Village Prosperity as Effected by Energy Use.' Journal of Changing Villages, vol 5; no 1, January-February 1983.

Post-Harvest Management of Perishable Agricultural Commodities — Engineering Considerations

Dr Jayant Patil

Member
Planning Commission, New Delhi

Mother nature has blessed India with diverse agro-climatic conditions that are conducive to grow a variety of crops almost round the year. This forms the basic ingredient for healthy growth to provide competitiveness in agricultural sector. The Indian economy is agro-based and the future of the economic growth of the country is closely linked to adoption of modern technologies and tools for increasing agricultural production. In a country where more than 70% of the labour force is directly or indirectly deployed in agriculture and allied activities, it is important to ensure that in developing and adopting of the technologies, efficiency of labour force also increases.

Indian agriculture has made major strides' in the last four decades following independence. Foodgrain production has increased from 51 Mt in 1950-51 to over 180 Mt in 1993-94; this has been possible through modernization cf agricultural production processes in which our scientists and millions of farmers have played a key role.

The country faces the major challenge of feeding its burgeoning population which is to be over one billion by 2000 AD and 1.4 billion by 2010 AD. With the average per capita foodgrains consumption being barely sufficient to minimum daily nutritional requirements, we face a formidable task to satisfy the hunger of millions besides maintaining and improving the health standard as also quality of life. The potential of increasing the area under crops is limited as agricultural land, resources are inelastic. However, there is scope to increase productivity utilizing inputs like sunlight, seeds, fertilizers, pesticides, technologies and labour force. In case these potentials are harnessed, our productivity can increase substantially in the next few years.

Development of application packages for increasing production and yield level of various crops, though very important, the post-harvest management of these crops plays a vital role. Reduction in post-harvest losses and improving the quality of produce results in additional production thereby increasing the income of the producers.

The post-harvest management operations involve improving harvesting of agricultural commodities and handling the produce ex-farm to final consumer, either in fresh or processed fonn. In case of most of the agricultural crops, which are non-perishables, cereals, oilseeds, pulses, sugarcane, cotton, etc we have considerably improved our technologies in developing harvesters, winnowers, packing; processing - primary, secondary and tertiary as also ginning in case of cotton through research and development in which the engineering aspects played a crucial role. The primary processing sector which takes care of milling of foodgrains and oil extraction should consider the need for reduction of milling and nutritional losses, cost efficiency and economic by-product utilization. In the secondary and tertiary sectors of processing the main focus should be on domestic markets and export demand. There is wide scope for research and development in improving the post-harvest handling of agricultural produce and products. Development of milling technologies for wet paddy having higher moisture content where the percentage of broken rice is more, needs adequate attention. The domestic pappad industry is still semi-automatic. I learn that a semi-automatic chapatti rolling machine has been developed and the Punjab Agro-Industries Corporation has taken a licence to manufacture the same. Several new technological developments have taken place in the field of food processing sector also.

In this august gathering of scientists, engineers and planners who have assembled here today under the aegis of the Institution of Engineers (India) to pay tribute to Bhaikaka, a great engineer whose major interest was in rural development, I would like to focus their attention to relatively new promising and upcoming field, horticulture, fruits, vegetables and flowers, which has direct impact on our rural masses.

All our attention in the past mainly has been towards cereal crops, pulses, oilseeds, sugarcane and cotton which are not perishable in nature. However, horticultural crops not only are perishable in nature but also highly nutritious, more remunerative, labour-intensive and having immense export potential. From subsistence level to meet the local and to some extent regional needs, fruits and vegetables now have assumed industrial overtones. Food security being our main focus, emphasis on nutritional security, post-harvest management of horticultural crops has yet to catch up in terms of material and infrastructural facilities.

India is the third largest producer of fruits and vegetables after Brazil and China, accounting for 8% of the world fruit production and 11% in vegetables. The FAG estimates put the country at top in case of mango and banana. We are the second largest producer of onion, third in case of potato, fourth in case of green peas and pineapple. The per capita availability is, however, much below recommended minimum daily dietary requirements. To meet the basic nutritional requirements of our increasing population we have to take necessary measures to increase their production. Alternatively, we can salvage fairly large quantities by reducing the post-harvest losses which are estimated to be varying between 20% and 40% depending upon perishability of crop. Pre- and post-harvest aspects of these crops, particularly packaging and handling, have engineering considerations.

The design considerations have immensely been helpful in case of other perishable agricultural commodities like milk, meat, fish and poultry and I am sure if horticultural crops also receive due attention, this sector is also bound to be rewarded. My suggestion would be that an immediate action needs to be taken to cut down losses. However, before initiating action we must know where the losses occur in the chain of pre- and post-harvest management so as to enable you identify the measures available to reduce such losses.

I would only like to make a passing reference to some important aspects of pre-harvest operations where engineering considerations are important, though our major topic of discussion is on post-harvest management.

Greenhouse

With growing emphasis on micro propagation of pedigree seed/planting material, off-season vegetables, cut flowers, having domestic and export market potentials, the design and fabrication material needs to be standardized and improved to make these relevant to our conditions and to develop technologies which are cost-effective.

Irrigation

Irrigation has a direct effect not only on production but also on quality of produce also. Tensiometers are used in several countries to measure the irrigation requirements, these need to be locally fabricated at affordable price.

Maturity of Fruits

The picking maturity of fruits is usually made by an eye judgment or by touching the fruits. Fruit pressure testers apart from the eye judgment can be useful in ascertaining the right picking maturity along with TSS through refractometers.

Harvesting

Mostofthe fruits are harvested manually. A mechanical mango harvester has been developed by Konkan Krishi Vidyapeeth, Dapoli. Efforts are required to be made to develop mechanical harvesting appliances for other major fruits and vegetables like tomatoes.

Field Boxes

Usually, fruits and vegetables are harvested in the field and brought for packing and transport in gunny bags, baskets, etc. Depending upon the -type of conunodity and its perishability and to reduce the losses suitable field boxes of various types needs to be developed.

Pre-cooling

Field heat in case of fruits, vegetables and flowers, a living material, is required to be removed immediately after harvest. It prolongs the storage life and helps in maintaining the quality of produce, particularly when the produce is required to be transported to distant markets. Several methods are being used: forced air cooling, vacuum cooling, hydro-cooling and top icing. The former is probably the best suited, if the air is first humidified to near 100% for which air handlers to ensure such high humidity are to be developed.

Grading

The usual practice is to jumble pack fruits without proper grading. Size grading is usually done manually, except in some fruits like apple and citrus where some, of the progressive fanners and public sector organizations have recently resorted to mechanical grading, In developed economies almost all fruits are being graded mechanically keeping in view the size and quality parameters including colour. The concept of on-farm packing houses with grading and short-duration storage needs to be developed.

Packaging

Although the Central Food Technological Research Institute, Indian Institute of Packaging, CSIR and the ICAR have done quite useful work in the field, however, we are still far from standardization of packs for different fruits, vegetables and flowers for local and distant markets within the country. The packaging requirements for export market, air freight and ocean freight are quite different. The number of handling in transit have to be minimal for which palletization is a must. Considerable improvements are required in conventional packaging, wooden or corrugated fibre board (FB). Even the permeable PVC/polycarbonate film to prevent moisture loss is not available. Cost-effective technologies need to be developed. Sulphur and ethylene pads to prolong shelf-life are now available in India. Shrink-wrap and over-wrap machines though developed in the country, however, several improvements are required in these systems for fruits and vegetables. It is heartening to note that the Central Institute of Agricultural Engineering has recently designed a Modified Atmosphere Package (MAP) for tomato. Efforts in this regard need to be intensified.

Refrigerated Transport

Perishable commodities for domestic and export markets are required to be transported under controlled conditions of temperature and humidity. Meat, fish, ice cream, frozen fruits and vegetables are now being transported through specially designed trucks, and the railways have recently introduced refrigerated wagons. However, fruits and vegetables require high humidity which, in the present case, are lacking. Filacell technology is being adopted world over to ensure high humidity.

Storage

Perishable agricultural produce needs to be stored under refrigerated conditions with high humidity. Most of the cold storages in India are for storage of potatoes, barring a few for frozen products, meat and fish. The concept of controlled atmosphere (CA) storage though has come to India on a limited scale. Technologies in the world have changed and most of the new cold storage are on 'K span' system, which is cost-effective. Various types of insulation materials are being used. However, the most important consideration apart from being cost-effective should be:

(a) Low thermal conductivity,
(b) High water vapour resistance, and
(c) Durability at low temperature.

Similar is the case with regard to refrigerants for cooling. Evaporative cooling system for short-duration storage and on-farm storage is cost-effective and solar cold storage system is energy-saving and needs to be standardized.

Processing

Processing of fruits and vegetables is a very vast subject and time may be too short to go into detail. However, the major considerations for any technological adoption would be

- Lower capital investment
- Minimum operating cost
- Lower maintenance
- Simplicity of operation
- Operation automation possibilities
- Easy availability of raw materials, packing material and spares
- Energy efficient
- Multiproduct
- Convenience of product and market potentials in domestic and export markets

These would involve food process engineering, development of food processing systems including machinery and equipment and food waste/processing management.

Advance technologies for processing, aseptic packaging, concentration, freeze drying, etc are now being increasingly adopted in the country. There are over 4000 fruit and vegetable processing units in the small and cottage scale sectors. Many of these find it difficult to adopt advance technologies and equipment in view of the high cost. The processed food industry in other countries, where over 60%-70% of the produce are processed acts as a cushion in stabilizing the prices of these perishables during peak harvest period. However, in India the industry is yet to develop, as it hardly utilizes even 1.2% of production.

Improvements are also required in processing and packaging of traditional foods. We still do not have mechanical peeling equipment for mango - our national fruit - dehauling equipment for walnuts, one of our major export items; walnut kernels, mechanical decortication machines for cashew nuts. The CSIR laboratory Merado at Cochin has developed a semi-automatic decortication machine recently but it is yet to catch up the market. Even small equipment for pricking of 'petha' are not available what to talk of 'Ginaca' machine for processing pineapple fruit.

Quite useful work has been done by National Institution of Design Development, Central Institute of Agricultural Engineering, Regional Research Laboratories of CSIR, and the Indian Council of Agricultural Research. Under its All-India Coordinated Project on Post-harvest Technology, Central Foud Technological Research Institute, Indian Institute of Technology and other organizations. However, a lot of work still remains to be taken up which do have engineering considerations. The primary objective of future course of action should be to analyze where losses occur, what methods are available for reducing losses and how to cut these losses further. Close linkages between research, producers, commercial enterprises/manufacturer and marketing would be a pre-requisite for the success of any technologies offered for adoption.

I am sure that the Institution of Engineers (India) being a pioneer and focal organization would look into several of the aspects I have touched upon. We should in the coming days work in a coordinated manner leading to development of sound pre- and post-harvest management for the diverse horticultural crops the country produces. This would enable the farmers to realize more remunerative prices, create large employment opportunities on the non-farm side and thus contributing to the economic betterment of all segments of the rural society. We would help in this process to realize the dream of Bhaikaka to usher in alround rural development and progress.

Ocean and Industry

Dr S Z Qasim

Member,
Planning Commission, Yojana Bhavan, New Delhi 110001

INTRODUCTION

I am grateful to the President of the Institution of Engineers (India), Shri P M Chacko. for his kind invitation to deliver the 21st Bhaikaka Memorial Lecture.

First of all I would like to pay my homage to Shri Bhailal Bhai Patel (popularly known as 'Bhaikaka') whose contributions in the field of engineering and, particularly, rural engineering, are well known. In fact, it is because of the work and dedication of persons like Bhaikaka that the State of Gujarat has progressed so well in its industrial development and today it displays a visible change in the quality of life of its rural masses.

The theme, 'Ocean and Industry', which I have selected for this lecture, seems appropriate and relevant to the economic development of the coastal areas, where 30% of the country's largely rural population lives, and most of them, either directly or indirectly, are dependent on the sea and its resources. This is particularly important in the context of rural engineering — a field very dear to Bhaikaka.

During the last three decades, spectacular advances have taken place in the ocean sector. The sea which was being used since ancient times for two main purposes — shipping and fishing — is now being used for a variety of activities to fulfil the growing needs of mankind. Thus the ocean is called 'our last frontier' and mankind is looking towards the sea as our future hope.

The economic importance of ocean resources is determined basically by two main criteria: first, the kind of resources actually or potentially available for exploitation, and second, by their accessibility determined by such factors as depth, location and the available technology. The resources broadly fall under the category of: (a) food (fish, shellfish, seaweeds, etc), (b) fresh water, (c) chemicals and drugs, (d) minerals, (e) oil and gas, and (f) energy.

Besides these resources, the knowledge of the ocean provides us with many kinds of services on which our life is so much dependent: for example, climate, recreation, tourism, etc.

Major industries related to the ocean in India, like anywhere else in the world, are: (a) shipping, (b) fishing, (c) offshore oil and gas, and (d) tourism. Apart from these, there are other industries of minor nature such as (a) chemicals and drugs, (b) fresh waterfrom sea water, (c) exploitation of minerals, and (d) extraction of energy. In addition to these, such services are derived from the oceans on which the livelihood and survival of millions of people depend. One of them is the monsoon forecast. The entire agro-industry of India is dependent on normal monsoon, and any deviation from good monsoon leads to a crisis situation.

The different types of industries related to the ocean sector can be described as follows.

MAJOR INDUSTRIES

Shipping

Shipping is one of the-most important industries in the economy of a nation. Since ancient times, shipping in some form or the other for the transportation of men and materials, using the sea-route flourished from the days of the Mauryas. It got accelerated with the advent of the Arabs who were mainly traders.

During the British period, very little progress was achieved in India in the shipping sector, as the transport of goods and cargo was carried out by foreign ships, largely European, to and fro India. In 1862, the British India Steam Navigation Co was founded which soon developed into a large shipping venture. Subsequently, several Indian companies came into existence, the most notable among them was the Scindia Steam Navigation Co. This had a fleet of several vessels. In 1927, a training ship 'Dufferin' was commissioned. In 1961, the Shipping Corporation of India (SCI) was formed and within a short time it became the leading shipping company in the country. It started with only 15% of the nation's total shipping and reached 51% in 1975. Its growth till today has been phenomenal.

The shipping industry has two other important components, namely, shipbuilding and ports and harbours.

Shipbuilding

There are historical evidences available to suggest that the Indians had enough ingenuity in applying methods to keep themselves afloat. Logs of wood and rafts formed the basic material to transport things over short distances. Sea currents and direction of the winds provided the means for propulsion towards the destination.

During the Indus valley civilization (3500-3000 BC), the Mohenjadaro and the Harappans undoubtedly had sea-going capabilities. This is clear from the carvings on the stones of floating crafts taken from that period. During the Nandas and the Mauryas, shipbuilding prospered as an imperial undertaking. The Ajanta paintings (6th century AD) also show vessels tossing in the sea (painted in Cave II). Ships of different sizes were built during the 13th and 14th centuries in Cochin, Calicut, Mauslipatnam and Calcutta. However, during the 17th century, the Indian shipbuilding industry received considerable thrust. With the coming of the Portuguese and the British, the Indian shipbuilding industry flourished further. Shipyards were established in Calcutta and Visakhapatnam and many ships of different sizes began to be built in these shipyards. In 1952, the Hindustan Shipyard was formed. In Bombay, the Mazgaon Dock Ltd has a history of its own. It was created by the British in 1769 as a repair and refitting facility. After 1947, the capabilities of this shipyard were enlarged considerably and it expanded as a primary shipbuilding yard in the country.

In Goa, a shipyard was founded by the Portuguese which was taken over by the Government in 1961 after the liberation of Goa. This yard was given on lease to Mazagaon Dock. In 1960, the Garden Reach Workshops Ltd (GRW) in Calcutta, which was a private yard, was acquired by the Government. It was renamed as Garden Reach Shipbuilders and Engineers (GRSE) in the mid-seventies. In 1972, another shipyard was established at Cochin. It was named as Cochin Shipyard Ltd.

In addition to these Govemment-owned shipyards, there are many private shipbuilding and boatbuilding yards in the country and these are building barges and fishing boats of different sizes. Today, India enjoys self-sufficiency in the manufacture and repair of ships of almost all sizes. Capabilities also exist on building the offshore structures and oil platforms in the country.

Ports and Harbours

Ports and harbours provide the sea-bome vessels some basic services such as dock, berthing facilities for the ships and landing facilities for the passengers and cargo. Apart from this, ports provide cranes, warehouses, labour for cargo handling and transport.

There are 11 major ports in India, namely, Kandla, Bombay, J L Nehru, Mormugao, New Mangalore, Cochin, Tuticorin, Madras, Visakapatnam, Paradip and Calcutta/Haldia, 163 minor ports along the 7000 km coastline and at sea islands. Four of the major ports (Bombay, Calcutta, Madras and Marmugao) are more than 100 years old. Cochin and Visakapatnam have celebrated their golden jubilees. The others were bom after the Independence. J N Nehru at Sheva became operational in 1989.

Each major port has a Board of Trustees representing various interests connected with the port operations and the shipping industry. The Chairman of each major port is appointed by the Central Government. The Port Trust Board comprises Deputy Chairman, representatives of Customs, Railways, Defence, State Government Shipowners, Shippers, etc. All members of the Board, other than Chairman and Deputy Chairman, are part-time members.

The Central Government provides resources for modernization and development of major ports. The major port trusts are empowered to receive loans from the Government, raise loans in the open market and levy rates and fees for the services rendered. Ports largely derive their revenue from the cargo handled in their port areas, charges on the ships visiting their areas, and other related charges. The main sources of revenue from cargo traffic are wharfage/landing fees, cargo-related charges, crane hire charges, rental from warehouses; demurrage charges; charges for various services done to the visiting ships, port dues, pilotage; berth hire, survey fees and ship repair in dock areas.

The main activities of the port are maintenance of port approaches, navigable channels and alongside berths, dredging, conservancy, hydrographic surveys, light-houses and light-vessels under the port, pilotage, towage, berthing and unberthing of the visiting ships, handling, warehousing, transportation of goods in port areas, civil, mechanical and electrical engineering and maintenance of labour crafts and plants, fire-fighting, fumigation, stores, medical, welfare, housing and management of port properties.

Fishing

Fishing industry is one of the largest industries in the country. It provides employment or gainful economic activity to nearly 10 million people. There are nearly 30000 mechanized boats and more than 100000 non-mechanized boats operating along the 7000 km coastline. Other infrastructure includes a large number of processing plants, canning factories, ice and refrigeration plants and many other ancillary industries. It contributes to the seafood production, which consists of capture fishery from the sea and culture fishery from estuarine and enclosed backwaters. In 1947. fish production in India was about 0.4 Mt. In 1979-80, it had increased to 1.4 Mt. Today, our fish production is of the order of 2.16 Mt. India ranks sixth in the list of fish-producing countries. Fish constitutes only about 4% of the world's food production, but in Asia, it supplies about 45% of the total animal protein to the people. During the last few decades, substantial inputs have been provided for sea fisheries in the form of intrastructure, institutional base and manpower. Within the last 30 years, India has also emerged as one of the foremost exporters of seafood in the world. The export of seafood from India has reached more thai) Rs 3000 crore per annum in value.

Fishing industry is constantly getting enlarged and much of the investments in this sector are coming from the private sector. The list of exporters of marine products is increasing rapidly, and with this the inspection and quality control measures are also getting more and more stringent. With the export of new products, such as squids and cuttlefish to Japan and shark fish to several other countries, the possibilities in this sector are immense. However, shrimps form the bulk of the export. Quality food fishes such as pomphret, king-fish. perches, etc are being exported to Gulf countries. Similar is the case with by-products and the processed foods such as fish meal and dehydrated seafood. Expansion of the industry is associated with the enlargement of canning, freezing, refrigeration and transport industries.

Seaweeds form another resource for industrial development. In the early fifties, dried seaweeds were exported from India. However, when agar-agar, alginate and other products began to be harvested in India, the export of seaweeds was stopped. Factories in Gujarat, Maharashtra and Tamil Nadu began to multiply but because of the shortage of seaweeds as raw materials, many factories had to be closed down. Culture of seaweeds in the sea can generate considerable extra resources and the technology for their rope culture has been well demonstrated in India.

Offshore Oil and Gas

India has mounted a major effort to increase its exploration, exploitation and development capabilities for hydrocarbon and during the next few years, this effort is likely in increase rapidly. The present activities related to offshore production of oil and gas are confined to Bombay High areas on the west coast and the Godavari Basin on the east coast. However, further exploration activities are going on intensively on both the coasts. This is largely being achieved through the efforts of several national organizations. The two agencies. namely, the Oil and Natural Gas Corporation (ONGC) and the Oil India Ltd (all) are largely responsible forthe entire oil and gas production. In 1993, the total oil production was 27 Mt against a demand of 58.7 Mt, but the indigenous production is expected to reach 38.3 Mt mark in the year 1995-96, because of the onset of production from three new Bombay High oilfields, namely, Neelam. L-11 and L-111 and from the Godavari Basin.

This industry also includes large refining capacity of hydrocarbons. In 1993-94, there were 13 refineries, the total capacity of which was 53.4 Mt. This is not enough to meet the ever-increasing domestic demand. Additional capacities are being achieved through plant expansion and new investments.

Many supply vessels, inspection vessels, helicopters, crew boats will be added to the existing fleets. A large number of drilling and process platforms, including submarine pipelines, have already been installed and more of them will be constructed in the future. There are substantial reserves of oil and gas in the ocean. A large part of our continental shelf is still unexplored. Further technological progress in the methods of drilling at depths beyond the shelf edge will enhance the potential of oil production from the offshore areas considerably. The production of oil and gas from the Bombay High oilfields has gone up many times during the last 10 years.

Our country has a large petrochemical industry. The petrochemical complex in Baroda known as Indian Petrochemical Ltd (IPCl) is well known. In addition, there are many other industries in the country producing raw materials, intermediaries, and products such as plastics, polymers, synthetic rubber, synthetic detergents and industrial chemicals which are based on hydrocarbons.

Tourism

Tourism has become a major industry along the sea coast. It has made excellent progress during the last decade and many tourist resorts and luxury hotels have come up all along the coastline providing considerable income and prosperity to places of tourist attraction such as Goa, Cochin, Bombay, Madras, etc.

One of the most common uses of the sea all over the world is recreation and holiday-making. People from far away places go near the sea for rest and relaxation. They also enjoy a lot of water sports such as diving, surf riding, boating and underwater photography. Sea air is known to be fresh and rich in oxygen.

In the Maldive achipelago, tourism is the major revenue-generating industry. The country includes some 1190 islands forming a double chain. The total land area of all these islands put together is about 300 km^2. There are only three islands with an area of about 4 km^2, The total combined human population of all the islands is about 200000. There are 58 tourist resorts with a capacity of 5789 tourist accommodation. In 1992, more than 200000 tourists visited the Maldives. The Lakhshadweep islands also provide a great potential for tourism. At Bangaram island, there is a popular hotel for tourists with only limited accommodation. The islands of the Andaman and Nicobar group are also providing facilities for tourists.

Successful tourism requires a lot of infrastructure to meet the needs and demands of every class of tourist. The first and the most basic requirement is the accessibility of the place by air, rail and road. Second priority is accommodation (hotels, guest houses, etc) to cater to the needs of all classes of tourists. The third includes facilities for good catering sight-seeing, recreation such as boating, surfing, surf-riding, diving and underwater photography. On most of our islands, the facilities are still very inadequate. Goa perhaps provides one of the best facilities for tourists in the country. Because of this, special chartered flights are coming directly from London, Frankfurt and other European cities to Goa with full tourist packages.

MINOR INDUSTRIES

Chemicals and Drugs

There are 60 or more elements present in sea water. Of these, only six are recovered commercially. Sea water is 96.5% water and 3.5% salt. The total salt content in all the oceans, with a mass of 1419×10^{18} tonnes is 50 000 trillion tonnes. This huge mass of salt is said to contain almost all of the naturally occurring elements of the Periodic Table. Since ancient times, the chemical industry has been closely associated with the sea water. Sodium chloride, sodium carbonate, bromine, magnesium and potassium and their salts are being recovered in industrial quantities from sea water. One of the first large-scale industrial process attempted by man was the manufacture of salt from the sea by solar evaporation. However, only a small part of the salt produced is used for dietary purpose, the main bulk upto 95% is used in many chemical industries. Magnesium is used in the form of its compound, while bromine, calcium and sulphur in the form of calcium sulphate (gypsum). Because of low concentration, the recovery of potassium directly from sea water is not considered economical. However, it is possible to recover potassium in substantial quantities from bittern, which is a thick concentrate of common salt. Efforts are being made to recover many other useful elements including uranium and gold from sea water. So far, owing to the availability of cheaper extraction methods employed from land deposits, the technology of obtaining some of these valuable elements either from sea water or from seaweeds is not economical. Japan, however, has announced that by using their new technology, they are able to recover uranium from sea water in economic quantities. It is almost certain that research in this field will accelerate considerably and a large number of elements will be recovered in commercial quantities in the future.

The utilization of marine plants and animals in India, as raw materials for drugs and pharmaceuticals is of recent origin. Of the 200 or more organisms that have been screened so far, many have given promising results. The most remarkable feature is the antifertility properties shown by the extracts of several organisms. Recently, prostaglandins, which play a major role in controlling biological reproduction, have been isolated from the seaweed Gracilaria sp. Studies in India indicate that all those species of marine algae which exhibit antifertility properties may also contain prostaglandin. For this work, scientists of the National Institute of Oceanography, Goa; and the Central Drug Research Institute, Lucknow are to be congratulated because they took the initiative to establish a team of scientists capable of handling this project successfully.

Minerals

Practically all those minerals, which are found on land, are also found in the seabed. This is because seabed is simply an extension of the same land on which we live, the only difference is that it is covered with water. And since we do not see those minerals with our naked eyes and yet we have to find them, the science of oceanography becomes very exciting.

Marine minerals are broadly classified into: (1) Placer deposits, (2) Minerals from the offshore zone areas. (3) Phosphorite, (4) Polymetallic nodules, and (5) Oil and gas (described earlier).

Placer deposits are seen on the exposed beaches in the form of black sand. Deposits on the west coast are largely concentrated as high grade ilmenite, rutile, zircon and monazite, with varying proportions of magnetite and garnet. Several of these are being exploited by the Indian Rare Earths Ltd. From ilmenite, titanium is obtained.

The offshore zone includes minerals like coal, gold, diamond, tin, iron, phosphorite, potash, sulphur and many other minerals which are being mined by several countries. Mining from the sea is either done by tunnelling, pumping or dredging.

Phosphorite (phosphate deposits) occur on the sea floor either in the form of nodules or grains or pellets away from the coast. These are found in association with volcanic areas. in areas with cold water currents or where the biological productivity is high. Although phosphorites are generally found at depths of less than 1000 metres, the nodules have been dredged at 3400 m depth also. Some authors believe that some of the phosphorite deposits are so large that these can serve as the cheapest fertilizers to be utilized for agriculture.

Polymetallic nodules constitute perhaps the largest marine resource known to man from the seabed. Nodules form a carpet over the seabed and exhibit varied physical and chemical properties and occur in different sizes. Most of them are potato-shaped. They form a rich source of copper, nickle and cobalt in addition to manganese and iron.

In 1980, India initiated an exploratory programme on polymetallic nodules in the Indian Ocean. The research vessel R V 'Gaveshani', in January 1981, collected the first few samples of nodules from the Indian Ocean. The most promising area for nodules deposit was found to be the Central Indian Ocean. Thus the National Institute of Oceanography, with financial assistance provided by the Department of Ocean Development, and with the cooperation of other organizations, intensified the exploration of nodules in the Central Indian Ocean and demarcated an area of 300000 km^2. The abundance, grade and the potential reserve of nodules were also evaluated. Sampling was carried out by freefall grab samples initially at an interval of 100 km, which was reduced to 50, 25 and 12.5 km. The samples collected were analysed for their metal contents and grade. Based on the data generated till 1986, two areas, each of 150000 km^2 were demarcated. The demarcated areas were applied as pioneer areas to the United Nations for the award of rights for the development of a mine site. Our application was approved by the Preparatory Commission of the International Seabed Authority. Thus India became the first country in the world to obtain an exclusive right over an area of 150000 krn^2.

Two pilot plants have been set up in India: one at Bhubaneswar and the other at Jamshedpur for extraction of copper, nickel and cobalt and to work out the economic feasibility of the project.

Fresh Water from Sea Water

In terms of population growth, the world supply of fresh water is dwindling very rapidly every year. Therefore, all measures are being taken to obtain drinking waterfrom different sources. There are many areas in India where potable water is in short supply and thus people resort to drinking saline water, very often containing objectionable chemicals. For example, the presence of fluorine in drinking water causes what is commonly known as fluorisis – a disease leading to painful symptoms of bone deformity. Several desalination technologies are being employed to generate fresh water from sea water.

The first method is by solar stills. These are well suited for small and isolated communities where fresh water is limited and where power is either not available or is in short supply and transport of large quantities of water from neighbouring places is not practicable. The solar still consists of a glass chamber in which the sea water gets heated by the sun rays and is made to evaporate. The vapours are condensed as fresh water. Solar stills are ideal for small coastal villages, as they run on a non-expendable energy source. These are simple to construct and their operating and maintenance costs are quite reasonable. Improvements in the solar still design have been made in India for better yield. A solar still of 5000 l capacity has been installed in Avnia village of Gujarat where 500 families obtain drinking water from this source.

The other method of obtaining fresh water from sea water is by flash distillation. In this process, heated saline water is allowed to flow through a series of chambers which are maintained at different pressures below the atmospheric pressure, and progressively decrease towards the end of the series. Saline water thus evaporates in each section of the chamber, the vapours are released and then condensed over a bundle of tubes cooled by circulating sea water inside them. The distillate of fresh water thus produced at each stage is gathered either separately or collectively to be used as fresh water.

The third method is by electrodialysis. This technique employs ion-selective membranes for desalination of brackish water. Electrodialysis is more economical for salinities below 5000 ppm. The energy cost of the process is directly proportional to the salinity; thus beyond 5000 ppm, the process is not very economical. Significant contributions towards the development of suitable ionexchange membranes for desalination have been made in India. A sea water desalination plant based on electrodialysis (capacity 5000 l/d) has been installed in the Lakshadweep. Both flash distillation and electrodialysis are being used extensively in Gulf countries.

The fourth method is by reverse osmosis. This is the most widely used desalination technique in India. In this process, suitable osmotic membranes are used which reject salts and allow water to pass through when the sea water is put under high pressure. Several plants with capacities of 50000 to 100000 l have been set up in Indian villages to supply potable water to the villagers. The institution which has contributed very richly to this field is the Central Salt and Marine Chemical Research Institute, Bhavnagar (Gujarat). This institute has refined and updated the technology of reverse osmosis and has passed it on to the Bharat Heavy Electrical Ltd, which is now supplying plants of different sizes and capacities in the country. In 1986, a plant, based on the technology of reverse osmosis, of 50000 l/d capacity was installed in a harijan village called Puthagaram in Tamil Nadu. There was an acute shortage of potable water in that village with the result that people were drinking saline water. The effect of this plant on the health and hygiene of that village has been tremendous. Later on, it has been upgraded to 100000 l/d capacity.

In the furure, desalination technology of different types will playa distinct role particularly in India's rural development programmes for the supply of potable water. However, it is not certain that desalination technology can produce enough water to meet the demand of the growing population. It can only supplement other technologies but will not provide a substitute.

Energy

It is well known that the vast seas around India have great potential for renewable sources of energy available in the form of ocean thermal energy, waves, tides and salinity gradients. The time is not far off when the extraction of energy from these sources will become economical because of the increasing cost of power generation from the depletable sources of energy such as coal, oil and natural gas.

A major research and developmental effort is being undertaken in the country to develop the necessary capabilities in this frontier area. More research and developmental efforts are required in connection with the data collection, analysis, environmental modelling, selection of materials, design of various components, fabrication, sea trials, environmental impact studies, etc. India has been carrying out intensive studies on the extraction of energy from waves at the Indian Institute of Technology, Madras, and I would give my highest appreciation to the scientists and engineers of the Ocean Engineering Centre there for providing a major breakthrough in this field. Within a short span of less than ten years, the young team at Madras has developed a design of 150 kW wave energy plant to be built in India. Based on the principles of oscillating water column (OWC), this plant has been completed at Vizingham in Kerala. This is the first plant of its kind in the world, completely designed, built and managed by Indian scientists and engineers.

METEREOLOGICAL SERVICE

Monsoon Forecast

The word 'monsoon' comes from the Arabic word 'Mausam' which means season. What it really signifies is the seasonal wind pattern along the shores of the Indian Ocean, particularly the Arabian Sea. A half of the year the wind direction is south-west, that is towards the land, and in the other half it gets reversed and takes the north-east direction, away from the land, and towards the Arabian Sea. Thus it has two distinct phases — the wet phase and the dry phase. The wet season is the monsoon or the rainy season and it comes with fair accuracy each year. Towards the end of May, it normally reaches the Lakshadweep and in the first week of June it comes over the Kerala coast and in the second week of June it normally hits Bombay forcefully. From there it travels inland in early July and the wet or moist winds go over Punjab, Delhi, Uttar Pradesh, Bihar making an island over the Rajasthan desert.

From the Bay of Bengal side, the monsoon reaches the Andaman Islands first in mid-May and then it hits the Chittagong Hill tracts during late May. A few days later it goes over the West Bengal region producing rain. According to the India Metereological Department, Delhi, has on an average 70 cm of rain spread over a period of 52 days. Calcutta, with an average rainfall of 158 cm, has 242 rainless days per year and Bombay whose annual rainfall is 188 cm has 257 rainless days. The number of rainless days in Madras is 270 while the average rainfall is 110 cm. Except South India, July is easily the wettest month, although in some places, there is more rain in June or August than in July. From Madras and Kodaikanal, November is the wettest month, while Bangalore, Coimbatore and Visakhapatnam receive the highest rainfall in October. Poona and Sholapur have the maximum rain in September.

The dry season refers to the other half of the year when the wind reverses, bringing cool and dry air from the Himalayas and spreading over the land mass. Thus, for the monsoon climate, the winds must blow in reverse directions between summer and winter. The term monsoon usually refers to the winds that blow over India from June to September and the rainfall during this period is called as 'south-west monsoon' and the reverse winds that blow from No- vember to January giving rain of moderate intensity in parts of South India is termed as 'north-east monsoon.'

Causes of Monsoons

During May, June and July, due to high temperature caused by the sun's radiation, the vast plains of the northern sub-continent and central Asia get intensely heated and the air above the entire region also gets hot and expands causing a low pressure belt all over. At this time, the Indian Ocean is relatively cool and the air above it is also cool and highly moist. Because of the low pressure above the land mass, the sea winds are driven towards the land. In the land, the Himalayan mountains form a barrier and prevent the winds from escaping. Blowing from the south, these get turned in a westerly direction because of the rotation of the earth known as the 'Coriolis Effect'. The winds thus blowing from the Arabian Sea reach the Himalayas resulting in heavy rainfall.

During the winter months, the plains of northern India get rapidly cooled. The air above these plains also gets cooled. It becomes heavy creating a high pressure zone. The winds over the sea are lighter. Therefore, the cool air from the high pressure zone blows towards the sea as north-east monsoon. This monsoon coming from land is dry and brings little rain here and there. While the south-west monsoon over the peninsular India is well defined, the north-east monsoon is not dis met. In fact, on many occasions, there is no clear distinction between the withdrawal of south-west monsoon and the onset of north-east monsoon. The two get merged with one another. Only the State of Tamil Nadu gets a substantial amount of rain from the north-east monsoon, approximately 46.5 cm which represents 47.7% of the total rainfall of Tamil Nadu. The reason for Cherrapunji getting enormous rainfall is that it gets two streams of air, one coming from the Arabian Sea and the other from the Bay of Bengal. Both these coincide over Cherrapunji resulting in enormous rainfall with an annual average of 1087 cm, nearly half of it falls during June and July. At present the highest rainfall (1141 cm) occurs at a place called Mawsynram, not far away from Cherrapunji in Meghalaya. Some of the characteristics of the monsoon are as follows.

(a) Normal and Abnormal Monsoon

Normal monsoon means not only the total quantity of rain falling over India, but the even distribution of rain in various climatic zones is what determines the quantum of monsoon. Similarly, either too much rain at one place or too little in different parts is what is often termed as abnormal monsoon. This leads to either floods in certain parts or drought and famine in other regions. Therefore, forecasting of the monsoon season becomes an important aspect of metereological service because the entire agriculture in the country will have to be geared accordingly.

(b) Fluctuations of the Monsoon

In north-east India and southern parts of Kerala, there is either no or little fluctuation in the rainfall from year to year. Similarly, in Assam the variability in the rainfall lies within 10%. The average rainfall in India for the whole year is about 115 cm, of which nearly 88 cm occurs frorrrt st June to 30th September. The regions where high variability occurs in the rainfall area are West Rajasthan (49%), and Gujarat, Punjab and Haryana (30%). As a rule ofthumb one can conclude that in those regions where there is high rainfall, the variability is least and where there is scanty rainfall the fluctuations are maximum. An interesting exception, however, is found along the west coast of India and the plains of Maharashtra. The west coast gets 250 cm of rainfall and the plains of Maharashtra 65 cm, the variability in both cases is about 18%.

(c) Monsoon Failure

Failure of monsoon is attributed in two ways. First, when the rainfall is not sufficient, and second, when there are long gaps in the rainfall, even though the total rainfall may be average or more than average. Thus the drought seasons could be of three types: (i) meteorological drought when the rainfall is significantly lower than the average over a wide area; (ii) hydrological drought when there is a depletion of surface water leading to drying up of lakes, ponds and rivers. It is often manifested into cracking up of the top soil; and (iii) agricultural drought when the moisture in the soil is not enough to support the growth of crops. The India Metereological Department has indicated 21 major drought years in India during the past 111 years (1877-1987).

(d) Special Features of the Rainfall

Very often there is little or no rain in the plains. On the other hand, there could be a heavy downpour in the Himalayas leading to floods in many parts as a result of flooding of the rivers. People often get a surprise when floods appear at a place without any rainfall in that area or in its vicinity. Similarly, when there is no rain in the coastal area, it does not mean that it is not raining in the sea. There is, normally, a considerable amount of rainfall occurring in the sea in almost all the seasons but this is of no use to us.

Monsoon Forecasting

In real terms, accurate forecasting of the monsoon is an extremely difficult task, because there are so many variables and factors which change from year to year. Even in the same year, unless they get properly synchronized, we cannot get an accurate prediction. However, it is very important to forecast such a unique phenomenon on which the livelihood of millions of people depends. Forecast for the rainfall is done in three different ranges — short, medium and long.

(a) Short-range Forecast

This is done as a weather forecast for the next day or for the next few days such as we hear on the radio or see on the television. The validity of this forecast lasts for one day with an outlook for the next two days. It is done by subjective and objective methods. The two methods include synoptic charts taken on a continuous basis and on the basis of satellite pictures. These methods also make use of statistical and numerical techniques to predict fore- I casting of the rainfall.

(b) Medium-range Forecast

This forecast includes 4-10 days of weather and it is considered important for agricultural operations (farmers) or water resources management. Various methods are used for the medium-range forecasting and the most promising being the numerical weather prediction (NWP). This method involves heavy computation of global data. High speed computers are used for this purpose. A new centre has been established for this purpose in Delhi which makes use of the super computer.

(c) Long-range Forecast

Forecasts for a period of more than 10 days or more are classified as long-range forecast. Two types of models are in use by the India Metereological Department which provides forecast before the start of the monsoon season-the parametric model and the power regression model. The parametric model makes use of the data from 16 regional, global and oceanic parameters. The parameters are those which have a direct physical linkage with the monsoon rainfall. The power regression model has been developed by arranging the parameters according to their decreasing correlation coefficients of monsoon rainfall over India. Using these two models, the actual rainfall for the past several decades are compared and new predictions are made. The reliability of power regression model is found to be better than the parametric model.

The results of analysis of these models for the past 37 years indicate that almost on all occasions, except very few, the forecast was correct. During the last six years (1989-95), the forecast for the normal or above normal monsoon has come true.

CONCLUSION

Since 1947, and more intensively since 1960, considerable work has been done in the ocean sector by different agencies and institutions which have laid the foundation of newer and more sophistication in the industrial growth. However, as we approach nearer to the 21st centry, new thrust and priorities are needed in the light of global scenario.

Ocean technology cuts across the technologies of almost all sectors because it is at the centre and has direct linkages both vertical and horizontal with all other technologies leading to the new industrial revolution in which we are entering now. Moreover, the new regime of the ocean has added 2 Mkm^2 of ocean area to India's 3 Mkm^2 of land area. This is a wonderful resource at our disposal to be exploited. Therefore, it is very necessary for planners and policy-makers in India to progressively follow and take note of global development and formulate appropriate steps to usher in a new era of marine revolution in the country.

Iron and Steel Technology and Rural Development: Some Reflections

Prof P Ramachandra Rao, *Fellow*

Director,
National Metallurgical Laboratory, Jamshedpur

At the outset, I would like to pay my respectful homage to Shri Bhailal Bhai Patel, whose untiring efforts towards rural upliftment have been well recognised. It will not be an exaggeration to state that his efforts have gone a long way towards creating an awareness amongst the rural population of Gujarat and paving the way for its rapid rate of development. In this lecture, I wish to dwell upon this very need, the need to build upon our traditional skills and technologies, for achieving rapid growth even in complex technologies like that of iron and steel. Towards this end, I propose to briefly recall the glorious past of the Indian iron and steel technologies, the present and future scenarios and compare the same with the experience of Japanese to assess our present position in the chain of technology development. I shall conclude by briefly recalling the efforts made by the National Metallurgical Laboratory, CSIR, in helping the ancient rural technology to upgrade itself and serve the needs of society.

Iron and Steel Making in India: Pre-modern Times

A large number of investigations have been carried out to understand the advent and growth of iron and steel usage in ancient India. These studies based on an examination of artefacts found at various excavation sites and study of dated literature suggest at least three distinct stages in the evolution of iron technoloogy.

These are:

(a) Phase I: The beginning	: c. 1300 – 1000 BC
(b) Phase II of adaptation	: c. 1000 – 600 BC
(c) Phase III of expansion	: c. 600 – 200 BC

Professor V K Thakur [*Radhakrishna Chowdhary Memorial Lecture, Dharbanga, 1992*] has evaluated the available evidence and critically discussed the social impact of the growth of iron technology in ancient India. While the first iron findings at Ahar date back to 1300 BC, later findings at Nagda, Prakash and Bahal are of 1200 BC. By 1000 BC, iron appears at various sites spanning a large geographical domain. The following years seem to have been one of realising the potentialities of iron. The period 1000-600 BC was also one of a transition from a nomadic existence to a settled agrarian society and the emergence of agriculture as a means of livelihood. Further, there are valid arguments to suggest that the proliferation of iron might have been responsible for the creation of standing armies by about 700 BC During the period 500-350 BC, use of iron became very widespread and by the 3rd century BC iron age in India has reached a stage of culmination. With advent of urban life towards the end of the 7th century BC and their subsequent growth, there appears to have been a greater demand for iron and Prof. Thakur opined that iron technology-based rural settlements must have been providing support to the urban economy.

Prof. A K Biswas [*Indian Journal of His tory of Science, 29, 579(1994)*] has also reviewed the state of iron and steel in pre-modern India and recorded that by the 3rd century BC some forms of heat treatment of steel and carburisation of iron were also known in India. He noted that Rasa Ratna Samuccaua of 13th century AD described types of iron and steel that ranged from the soft wrought iron [Kania Loha] and different grades of high carbon steel [Tikshna Loha] to varieties of cast iron [Munda Loha]. The invasions of Babar, the Dutch and the British brought their own methods of iron-making and by the 18th and 19th centuries AD small blast furnaces using charcoal were in operation. Some of the furnaces used in Kathiawar were like the European reverberatory furnances.

Professor Biswas has also reviewed the available evidence and schools of thought concerning the nature of the old Indian enterprises in iron and steel. These could be classified into three types:

Type I : Tribal household industry as practised by the iron-melting tribe of Agarias

Type II : Market-oriented craft groups with two subdivisions viz.,

(a) migrant groups like Santhals and Munda Kols

(b) settled Bengali-speaking populations

Type III : Protocapitalist enterprises such as the iron-smelting workships of Karnataka which were financed by merchants and employed skilled labour with wages being paid in cash or kind.

By the latter part of 18th century, it is estimated that there were about 10000 iron and steel furnances in operation producing about 200000 tpa of iron and steel! Most importantly, these enterprises were mostly rural based and supported the rural and urban economy as they did centuries earlier and at the very beginning of the growth of urban civilisation in India. These distinct categories of enterprises faded into oblivion for reasons which were both technical and social. Amongst the technical reasons may be mentioned the use of charcoal in place of coke, non-utilisation of fluxes in smelting, lack of suitable refractories, lack of powerful bellows, etc. Prof. Biswas is of the view that it would have been necessary to introduce all these changes at one time (rather than piecemeal) for the survival of the iron and steel technology. Some of the prominent social factors that led to the demise of the technology are: (a) lack of awareness of technology advances in the West; (b) near absence of innovation; (c) dumping of British steel; and (d) absence of governmental support during the British regime.

The above listed factors and their influence can be gauged from a study of the gun barrels employed. Gun founding came to India in the early part of 16th century after Babar's invasions. The cannon were made of cast-bronze or brass. Even though the Marathas acquired cast-iron cannon from the Europeans, casting technology for steel was never developed in India. At the same time, however, fagging technology for steel reached great heights. The Delhi pillar, the Konark temple beams and the swords of royalty represent the zenith of Indian fagging technology. In short, the near extinction of Indian technology was essentially a result of lack of innovation, failure to adapt contemporary European or Chinese methods and a deliberate suppression of indigenous technologies during the British regime.

Steel Industry in Modern India

Modem steel-making in India originated with the establishment of the Tata Iron and Steel Company at Jamshedpur in 1911.The great success of this venture in supplying steel for the First World War effort encouraged the Company to strive to increase its production until it faced what is presently known as 'dumping' from the steel producers of Belgium and England. On the recommendations of the Tariff Board, the Steel Industry (Protection) Bill was introduced in the Central Legislative Assembly in May 1924 and was finally passed in June 1924.The umbrella of State protection thus started continued till recently. This was partly due to the large investments made by the State in establishing several state-of-the-art steel plants starting with Bhilai,Durgapur and Rourkela in the 1950s and Bokaro in the 1970s.The intervening three decades were characterised by rapid expansion in the absorption of technology, low cost of production and subsidised pricing to promote demand for steel. By 1980s,however, the installed technologies became outdated and Indian steel became costly and uncompetitive due to its being highly energy intensive. The oil crisis of 1973 highlighted these issues and demanded considerable modemisation and upgrading of technologies.

The recent economic liberalisation programme has had considerable impact on the growth of the Indian steel industry. Deregulation and removal of licensing in 1991, elimination of pricing and distribution controls in 1992 followed by the abolition of many levies and cess this year, have given the necessary impetus for its growth and the Indian iron and steel industry is poised to be a prime player in the nation-building exercise. Economic liberalisation has also brought to focus not only the great need but also the accelerated growth in infrastructure, transport and consumer goods sector. There is a great demand to improve the availability of electrical power, national highways, irrigation network, ports and housing. Consequently, the Union Ministry of Steel has forecast a shortage of steel to the tune of about 13 Mt by the end of this century. This assured demand for steel has prompted the existing public sector (SAIL) and private sector (TISCo) steel plants to modemise their facilities and go in for expansion. SAIL's modemisation programme is more than half way through while TISCo is beginning its last phase of an equally ambitious modemisation programme at Jamshedpur besides embarking on the erection of a new plant of 2.5 Mtpa capacity of saleable steel at Gopalpur in Orissa. These modernisation programmes have led to the replacement of the open hearth furnace process by the more energy efficient BOF process, an enhancement of the continuous casting capability and installation of modern hot strip mill etc.

The existing scenario with respect to the raw materials needed for the industry is somewhat cloudy. Decentralisation of the coking coal sector has resulted in 15%-25%increase in the cost of coking coal. The deteriorating quality of coking coal has also enhanced the import content of the raw material mix. For example, in SAIL plants the percentage of imported coal was 20% in 1992, 21% in 1993 and close to 35% in 1994. Steel is also a highly energyintensive industry with energy accounting for almost 40% of the cost of steel production in India. This is nearly 1.5 times that in developing countries. While the switch over to continuous casting from the ingot route will undoubtedly reduce the contribution of the price of power to the cost of steel many other options require to be explored and exploited. The cost of power has also greatly affected the secondary steel industry and the ferroalloy industry. The rising costs of scrap and sponge iron have also contributed to the decline of the mini steel plants based on electric arc furnance (EAF) route. Over 50% of about 9.5 Mt installed capacity remain idle or have been closed down. The competitiveness of the integrated steel plants and the high cost of power have clearly demonstrated that production of mild steel by the EAF route is not a viable proposition. Devaluation of the rupee has made the import of another raw material, shredded scrap, dearer and has forced the mini steel plants to substitute scrap with sponge iron. This has automatically resulted in an increase in demand for domestic sponge iron which is marketed in the form of hot briquetted iron or directly reduced iron. Between 1994-95 and 1995-96, there has been about 25%-30%growth in demand for sponge iron. The total projected demand for sponge iron and scrap is expected to be about 14 Mt for 1996-97 and 17 Mt by 2000.

Notwithstanding the problems associated with various raw materials and power, the next decade will witness a phenomenal growth in the production of steel in India. Proposals have already been made for setting up 22 new steel plants at a total cost of US $ 9 billion over the next six years a longe. Many of these proposals are backed by financial institutions and expert partnership from companies in the USA, China, Mexico, Italy, Japan, Korea and some of the Gulf countries. Some of these ventures have already begun. Apart from these, about 400 proposals with an outlay of Rs 900 billion have either been commissioned or about to be completed by the end of 1997. This could very well mean doubling of the present production capacity of steel by the turn of a century. Taken together with a competitive price per tonne of our steel [Table I], it augurs well and progressively India should become a global player.

Table I: Comparative cost of steel at various stages of production, US $/t

Country	*Hot Metal*	*Liquid Steel*	*Hot Rolled Coil*
U K	133	176	233
Germany	130	172	242
Japan	128	177	273
South Korea	112	158	213
India	83	131	222

Source: A. Chatterjee and T. Mukherjee, Tata Tech, No. 20, May 1995

Having made a brief survey of the current trends in steel production in India, let us now compare our performance with that of our Asian neighbours and other developing countries. The per capita consumption of crude steel, like many other indices of prosperity, is very low [Table II] and the rate of growth as also the volumes of production have been far from satisfactory [Fig 1]. There can be many reasons for the sluggish growth of this sector.

Table II : Per capital consumption of crude steel

Country	*1980*	*1985*	*1990*	*1992*
Industrialised countries	436.9	384.6	415.5	374.0
Developing countries	44.4	49.6	58.0	62.4
Republic of Korea	160.0	277.2	501.0	532.3
Brazil	117.9	88.5	67.8	65.5
Mexico	148.7	98.7	99.4	111.0
China	43.6	67.8	59.3	71.3
India	16.5	19.2	26.2	21.7

Source: Steel News, Vol 1, No. 1, 1996

The Japanese Experience

The United Nations University conducted a project on Technology Transfer, Transformation and Development: Tire Japanese Experience during 1978-82. The process of technological development of Japan and the role of infrastructure, human resources development and social conditions in technology transfer, transformation and development was analysed. The findings were summarised by Takeshi Hayashi. The analysis demonstrated that technology has five important elements:

1. Raw Materials and resources;
2. Machines and equipment;
3. Manpower;
4. Management; and
5. Markets for the technology and products.

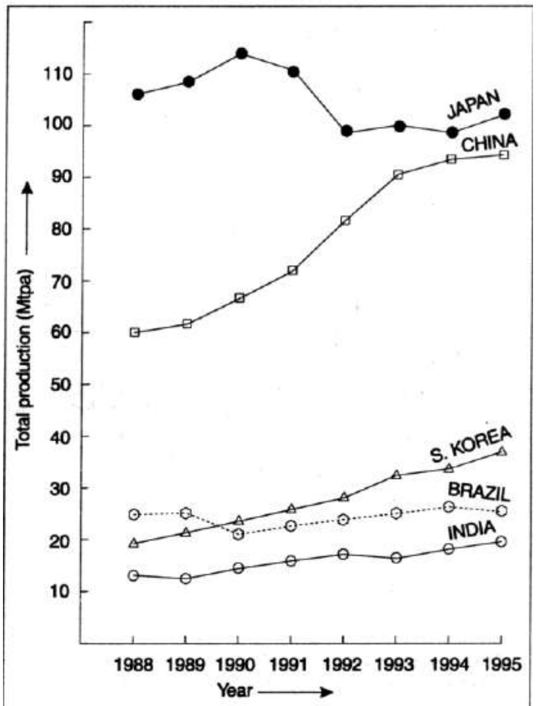


FIGURE 1

These are the 5 Ms of technology. These were used to study the origin of problems in technology transfer and development. It transpired that, irrespective of the specific cases, development occurs also in five stages:

1. Acquisition of operational techniques
2. Maintenance of machines and equipment acquired
3. Repairs and modifications of the foreign technologies and equipment covering both the system and operation
4. Designing and planning
5. Domestic manufacturing or the evolution of self-reliance in technology.

While there could be differences in the order of priority of the above five stages depending upon the specific technology under discussion, none of the stages can be bypassed. It was also stressed that when a technology is transferred from one country to another, the culture of that technology is not transferred.

Let us now consider the Japanese experience in iron and steel technology. It took about 40 years before Japan could attain independence in this technology and 100 years for it to export its own technology. The first blast furnace in Japan was constructed in 1854 but had the same problems as discussed in the Indian context viz., use of charcoal and a water-wheel to blow air. The Meiji government in Japan received two proposals for the construction of modem iron works at Kamaishi mine site; one from a German and another from a Japanese. The government opted for a 25 tpd furnace suggested by the German and ignored the Japanese proposal to set up several 5 tpd furnaces. The furnace could not be run due to several technical problems and ceased operation within a year of installation. The furnace was eventually restarted by the efforts of Japanese workmen, academics and engineers in 1894. In spite of Kamaishi iron works producing as much as the iron produced by all the foot-bellow mills, all the traditional mills survived. In retrospect, it was found that the success of the Japanese effort in reviving the German furnace was more to do with the selection of an appropriate scale of operation for easy management and transfer of technology. The story was once again repeated on a larger scale when the Yawata Works started in 1901 with a foreign design failed soon after and the Japanese were again called in to alter the designs to suit local conditions. The works were successfully restarted in 1904.The Japanese thus had gone through all the five stages of development of technology.

A Comparison

We are now in a position to evaluate our own experience in relation to that of Japan. It may be recalled that about 200 years before Independence, India had an annual production of 0.2 Mtpa of iron and steel, and blast furnaces of about 3.05 m (10 ft) height were in operation. However, no attempt was made to find a solution to the problems of using coke, devising powerful bellows and improving the productivity. Attempts were also not made to obtain technology and adapting it to Indian conditions. The situation persists even today. Much of the modernisation of the steel industry is effected through the acquisition of technology from abroad. In most cases, we have completed only the first three steps in the development of modern technology. Step 4 of designing and planning with originality has been confined to only a few subsystems in the total technology package with the parameters being specified by the foreign technology supplier. We have a long way to go before reaching the final step of self-reliance in technology.

The question arises as to whether we would have been more successful if we had continuity in our iron and steel technology and evolved our own systems based on our long experience. There could be arguments both in favour and against such a suggestion. I believe that it would certainly have been very beneficial to have developed an appropriate technology based on centuries of our experience in making iron. China has demon strated such a possibility.

Another step which has remained unattended to is the last stage in the five elements of technology viz., creating a market for technology and its products. This also demands innovation in that special and characteristic markets have to be created rather than depend upon conventional uses for steel as reflected by Western experience. It is heartening to note that the steel manufacturers have already recognised this need and are establishing an institute to promote the use of steel. With the success of such a venture, we would have completed all the steps in the technology for steelmaking.

Efforts of the National Metallurgical Laboratory in Upgrading Traditional Metallurgical Practices

The laboratory has concentrated its efforts in three areas:

(i) Brass and bell metal casting,
(ii) Development of a mini cupola; and
(iii) Improving agricultural tools.

The laboratory participated in a project on 'Village Artisans and Science' co-ordinated by National Institute of Science, Technology and Agricultural Development Studies (NISTADS), a constituent laboratory of CSIR. The programme related to the artisans of Bankura, West Bengal, who produced castings of household items using processes which suffered from high fuel consumption, severe metal loss and defective castings. A furnace capable of melting 8 kg-12 kg of the metal was devised and provision was made to utilise waste heat for pre-heating of moulds. The artisans were also taught the use of fluxes to prevent metal loss and better pouring methods to avoid defects. Very recently, in a training programme conducted at the laboratory, a batch of artisans were introduced to the relatively recent technique of evaporative pattern casting. This enables the artisans to produce more lucrative castings of art objects for a given amount of metal.

In the area of iron casting, efforts were directed at developing a small capacity cupola to replace the obsolete pit furnaces in use in the rural areas. The furnace, capable of prod ucing 250 kg of molten metal/h provides employment to four persons and enables them to produce grey iron castings from foundry grade coke, limestone and pig-iron or cast-iron scrap. The products that can be marketed with the aid of the furnace range from soil pipes, drainage covers, bends, tees to small household equipment. The furnaces were not only adopted by rural artisans in our country but also exported to nearby developing countries. The furnace is portable and enables the artisans to make the castings at site by carrying the furnace and raw materials in small trucks/three wheelers. The quality of iron is comparable to that produced by standard industrial cupolas.

The poor quality of plough shares available to our farmers is a matter of concern. The small holdings in many geographical locations of the country are not conducive to tilling by tractors and there is a continued need for developing reliable and wear resistant agricultural tools. A survey conducted in tribal areas of Bihar has revealed that handtools used by farmers are made from mild steel leading to rapid wear and tear and require frequent replacement. Our laboratory developed alloy cast irons with 3%-4%of chromium and manganese for making plough share. It was observed that these elements retard graphitisation and increase hardness by refining pearlitic structure. The basic raw materials for the cast-iron production consisted of mild steel, ferrochrome, ferrosilicon, ferromanganese and carbon. The compositions were optimised for best wear resistance and hardness after a number of trails. Subsequent to the development of the material, a training- cum-demonstration centre was set up at Bishnupur, Ranchi in collaboration with Vikash-Bharathi. A forging unit and heat treatment facilitieswear set up for the demonstration and training of artisans from nearby villages. Work is continuing to achieve further improvement with other additions.

The 'Father of the Nation' pondered over the upliftment of our villages and has said "As a moderately intelligent man, I know that man cannot live without industry. Therefore, I cannot oppose industrialisation ..... Dead machinery must not be pitched against the millions of living machines represented by the villagers scattered in the 700,000 villages of India." We will do well to remember Gandhi and his advice in our plans in developing our technology in general and in finding markets for steel.

Education — Enlightenment or Information

Shri A K Bhattacharyya

Vice-Chairman & Joint Managing Director,
Development Consultants Limited

I am grateful to the Institution of Engineers (India)for inviting me to deliver the 23rd Bhaikaka Memorial Lecture. I feel different to speak today for two reasons. First, I suffer from comparison with the eminent men who graced the occasion in the previous years. Secondly, with this lecture is associated the name of an illustrious son of India who can be a role model for all of us and Iam apprehensive that I may fail to do justice to his revered memory.

The late Bhilalbhai Patel, or Bhaikaka as he was popularly known, was an engineer by training - a profession in which he was a success. But today, we remember Bhaikaka more as a social scientist, an educationist and a humanist.

I think it would be quite proper if I speak today on education, a subject which was so dear to the heart of Bhaikaka. One of his lasting contributions was the establishment of educational institutions and administering them ably.

Like all other developing nations, India has given primacy, at least in theory, to education since the Independence, 50 years ago. We took a vow to remove the curse of illiteracy. Compulsory primary education for every Indian child was an important part of our national education programme. But this objective still remains a dream. The Union Human Resources Development Minister admitted a few months ago that

> "It is unfortunate that even after 50 years of Independence India, far from achieving total literacy, has only reached a level of literacy below 50% in the rural area in 1991."

The record indicates that in 1991, female literacy was as low as 20%-30% in the populous States like Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan which account for 40% of the country's total population. It may be noted that definition of literacy is so elastic that if somebody can write his/her name, the person is considered as literate. This record also indicates that socio-economic factors coupled with education deviates from its objective and resulted in a high drop-out rate. In 1991, drop-out rate was 40% in the Class I-V range and more than 52% in Class I-VIII range.

But it is not enough that we admit our failure. We have also to ask why has it been so? The reasons are many. Yes, the allocation of money for education has been inadequate but the root causes of failure are :

(a) planning has been lopsided, and

(b) implementation insincere.

In many cases, even this meagre allocation of money could not be spent due to faulty planning. Grimness of the picture is further revealed when one takes into consideration the diversion of funds to channels other than its intended purpose viz. education. Relatively speaking, a higher amount has been allocated for higher education. However, in this field, our inability to crystallize our objectives together with the lack of clear idea of the implementation procedure has resulted in infructuous expenditure of national resources.

It may not be out of place to mention that we are yet to reach the goal of spending 6% of our national income on education whereas the enclosed Table 1[1] indicates that expenditure on this account is as high as 6%-7% of the Gross National Product (GNP) in western countries where the literacy rate is near 100% and the higher education is oriented towards not only professional 'training but also creation of institutions of higher learning for fundamental research. Even in China where literacy rate is also near 100% and whose institutes of higher education are better equipped the expenditure on education as percentage of GNP is of the order of 2.3%. It should be noted that expenditure as percentage of GNP does not necessarily mean much as GNP itself is of a much higher order in western countries and even in China. As a matter of fact, GNP of India has fallen even below the countries of Sub-Sahara region of Africa. Table 2 and Figs 1 & 2, indicate the rise of literacy rate, rise of a number of illiterates in the country and rise of GNP from 1951 to 1991. The number of illiterate were 295 million in 1951 and rose to 401 million in 1991.

Table 2[2] Growth of Pupulation, Number of Literate (Literacy Rate), Number of Illiterate & GNP

Year	Population (million)	No. of Literate (million) & (literacy rate, %)	No. of Illiterate (million)	GNP at Market Price, 1995 Rs (billion)
1951	361	66 (18.3)	295	933
1961	440	125 (28.3)	315	1613
1971	548	189 (34.5)	359	4288
1981	684	299 (43.7)	385	13636
1991	839	438 (52.2)	401	52797

Table 1 UNESCO Statistics on Education (Selected Indicators)

Country	Circulation of daily newspapers per 1000 inhabitants, 1995	Gross enrolment ratios at 1st and 2nd level*, 1995			Public expenditure on education as % of GNP, 1995	As percentage of Govt expenditure on education
		MF	M	F		
Denmark	332	106	106	107	8.3	11.8 (1991)
Finland	512	110	105	115	7.6	11.6 (1992)
France	205	106	105	106	5.9	—
Hungary	282	90	89	90	6.6	7.7 (1992)
Norway	607	108	109	107	8.3	14.1 (1992)
Sweden	511	100	100	100	8.0	12.7 (1992)
UK	383	104	105	103	5.5	13.8 (1990)
Canada	166	104	105	103	7.3	14.3 (1992)
USA	218	100	100	100	5.3	12.3 (1990)
China	43	94	97	92	2.3	12.2 (1992)
India	31	72	82	61	3.5	11.9 (1992)
Israel	271	94	94	94	6.6	10.5 (1992)
Japan	576	100	98	101	3.8	16.5 (1990)

*Gross enrolment ratio : Total enrolment in primary and secondary education, regardless of age, expressed as a percentage of the population age-group corresponding to the national regulations for these two levels of education.

Source : UNESCO Yearbook 1996, 1995

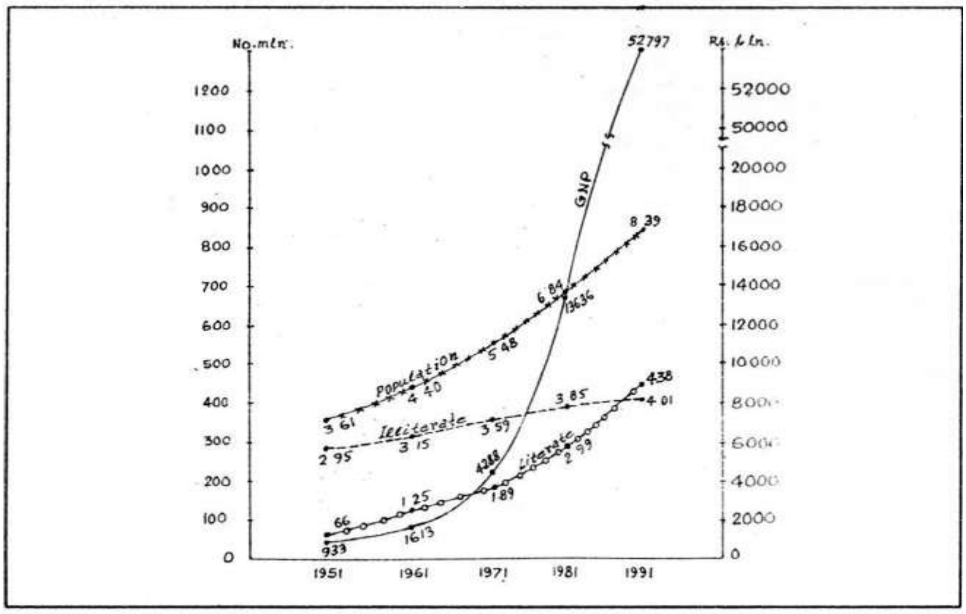


Fig 1 Growth of Population, Number of Literate, Number of Illiterate & GNP

The dismal aspect of the education scenario, with which most of us are familiar, has been delineated above. Though I have great doubt as to whether the present structure of administration will ever be able to modify the outdated and defective system. I sincerely hope that our planners and educationists will, at least, make sincere effort and devote necessary time and energy to find out a pragmatic way out of this impasse, and accordingly, our national educational policy will be re-framed and re-structured by a team of experts free from bureaucratic control. The implementation of the policy should be completely taken out from the hands of politicians and subservient bureaucrats. This should be entrusted to an autonomous body conversant with the management of education including its financial aspect.

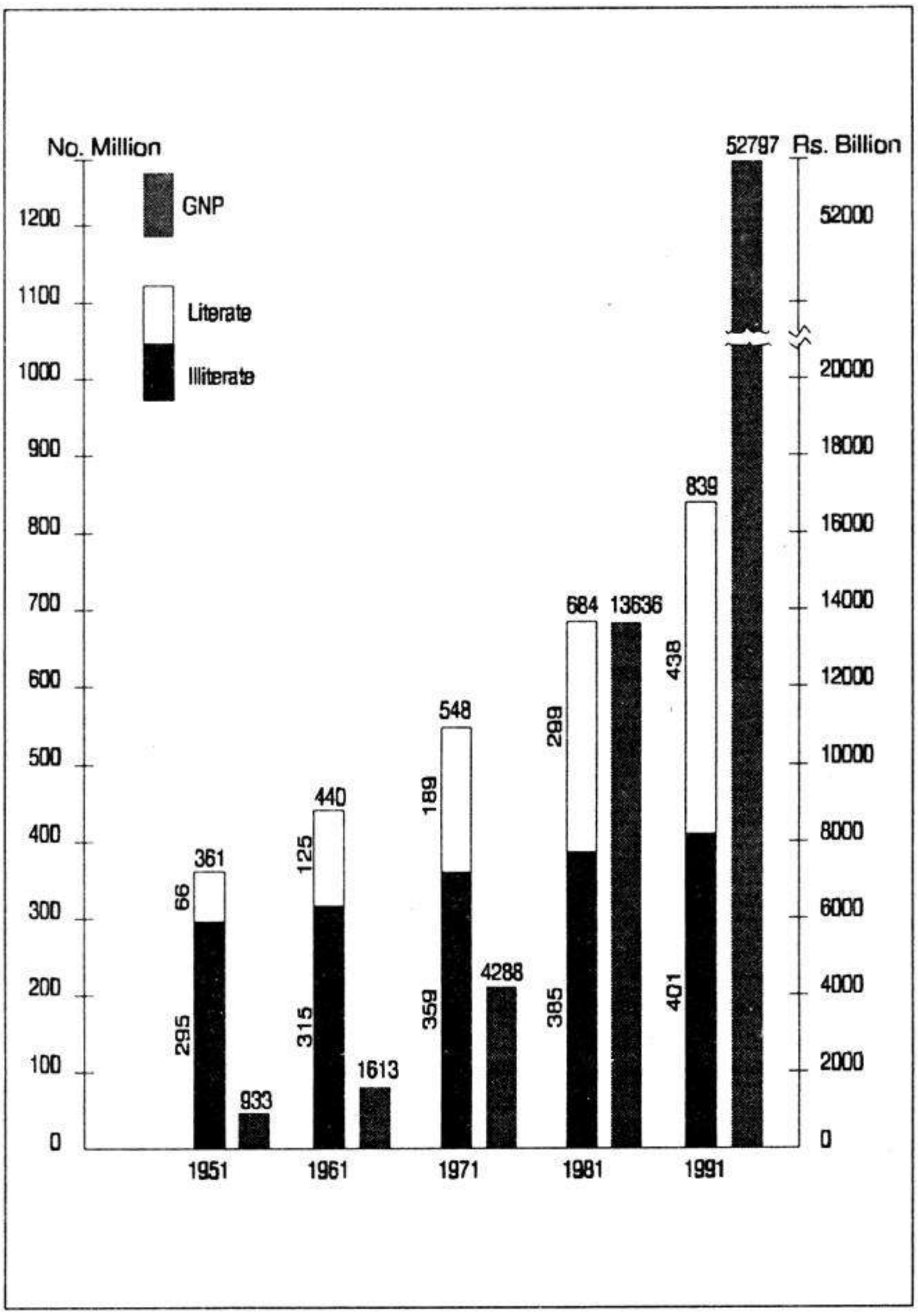


Fig 2 Histograph shows the Growth of Population, Number of Literate, Number of Illiterate & GNP

The second aspect, which bothers me more, is the qualitative deficiency of the education that is being imparted. What kind education are people receiving? Is this the kind of education they need? Does the present system of education fulfil either of the two major requirements viz. awakening of the spirit of enquiry in the pupil and preparing them for making a living by value addition type profession? The present education system has miserably failed in fulfilling any of the two requirements mentioned above. The present system is a machine for mass-production of so-called educated unemployed; it does not help them either to acquire the necessary skills that are in demand by a productive profession or to create in the minds of the students the necessary spirit of enquiry which alone can motivate them to acquire knowledge. Obviously, when one analyses the above mentioned deficiencies, one begins to ask a more fundamental question; what is the purpose of education and why should a person be educated at all? C E M Joad[5], a leading British thinker of early 20th century, listed three objectives of education :

(a) to enable a boy or girl to earn a living;
(b) to equip him or her to play his or her role as a citizen in a democracy;
(c) to enable him or her to develop all the latent powers and faculties of his/her nature and so enjoy a good life.

T S Eliot[6], the renowned British poet of early 20th century, considered this list as quite comprehensive. It is obvious that our present education system falls far short of the requirements of the above-mentioned objectives. On the other hand, to most of us, the aim of present-day education is possibly what was stated by T S Eliot who foresaw the shape of things to come-

> "The individual wants more education, not as an aid to the acquisition of wisdom, but in order to get on; the nation wants to get more in order to get the better of other nations, the class wants it to get the better of other classes or to hold its own against them. Education is associated, therefore, with technical efficiency on the one hand, and with rising in the society on the other."

The same sentiment has been echoed by the French scholar, Jacques Elluf[7 i], who also could sense the social decay, when he stated-

> "Instruction must be useful in life. Today's life is technique. It follows that instruction must, above all else, be technical. Education is becoming oriented towards the specialised end of producing technicians." He lamented that "education will no longer be an unpredictable and exciting adventure in human enlightenment, but an apprenticeship to whatever gadgetry is useful in a technical world."

Are we not trying to ape this kind of education? Difference being that our education is not even imparting instruction that is useful in life in the sense it is used by Jacques Ellul.

The concept of universal literacy is a concept arising of the philosophy of the democratic form of government. The democratic idea states that everybody should have a legitimate opportunity to become educated and this is considered as one of the essential steps to prosperity. Advancement of industry and technology is supposed to be intimately related to the expansion of education and as such, present-day democracy considers expenditure on education as a good investment.

However, political pundits avoid defining both the words 'democracy' and 'education'. They also avoid stating whether different types of education are required for different groups of people at various stages particularly at the primary stage. It is obvious that all people are not going to indulge in the same type of activities in life. The question that is being raised is not of imparting relatively lower quality of education but of different types of education.

Dr Robert M Hutchins [7 ii], a noted American educationist thinks –

> "That an educational system directed to economic growth will regard the people as an instrument of production and teach them to regard themselves as such. The emphasis is on the jobs. The tendency is to relate education to job."

According to this philosophy, freedom of thought and freedom of the pursuit of knowledge are not the basic criteria. Such freedom has to be justified by showing some kind of dependence on the basic criteria of training people as instruments of production.

Aristotelian[7 iii] idea was that all men by nature desire to know. Not only do all men desire to know,' but they also have the requisite capacity to know. Every child can learn the basic subjects unless it has sustained some damage to the brain. All sections of a community can be taught things which were earlier suspected as not feasible. You cannot any longer say that man is uneducable. Man has been defined in many ways, one of them being "Man is a Teachable Animal." However, our object of education should not be to prove either man as a teachable animal or he can be induced to learn anything. Our object is not only to make him feel a productive member of the society but also to make him proud of his knowledge of the profession due to which he has become productive. In this connection, may we recall the statement of Winston Churchil "I am willing to learn but I do not like to be taught." Education should not become a product of persuasion but should be a result of pursuit. Education should be a motive force due to which a man will pursue knowledge relentlessly whatever may be his field of enquiry.

If one analyses the above mentioned statement of Dr Hutchins, then it becomes obvious that the statement "tendency is to relate education to job" requires a clear definition of the word 'job'. Does this mean that by and large different types of jobs should have different types of educational orientations?

To give an example, a man may decide that his ward will not pursue the forefathers' profession, say agriculture, but would like to follow an urban oriented profession, say he wants to be a member of Indian Administrative

Service (IAS). In this case, he should have the freedom to send his ward to such an educational institute which prepares him for such a profession. In a country where more than 75% of its people are pursuing rural professions such as agriculture, fishery, weaving, animal hunsbandary, etc. the educational system of the neighbourhood school should be highly biased towards knowledge required for these prefessions. Presently, rural boys develop an inferiority complex because they are unable to absorb the education which is basically aimed to produce a candidate for an urban profession. Unsuccess leaves them under the shadow of self-pity, whereas with a neighbourhood school education oriented towards their rural livelihood, they may be able to discover themselves as men knowledgeable in the trade they practise and be proud to be so.

I regret that most of the supportive quotations given above are drawn from the writings of western scholars, reason being one of the characteristics of our present-day education system is that if any statement is supported by western sources of knowledge then it carries more weight with the socalled literate public to which I belong.

Great Indians like Swami Vivekananda, Rabindranath Tagore, Rishi Aurobindo, Madan Mohan Malavya also expressed their unhappiness over the state of education in our country in no uncertain terms. Their finding was that the prevalent system of education was not helping in bringing out the latent potential qualities of a man. They were highly critical of the system introduced by our colonial rulers, formulated to serve their limited aims. Definitely, full development of human faculties of the subject-race was not of the aims. Rabindranath Tagore, Madan Mohan Malavya, Rishi Aurobindo, Vivekananda and other thinkers tried to formulate a pragmatic educational system. However, it is most unfortunate that after gaining Indendence, we chose to continue with the system of education formulated by colonial-rulers for subject-race with superficial tinkering done here and there.

The present-day examination-oriented education has effectively stifled the spirit of enquiry, the desire to know. Memorizing large volume of information is being peddled as knowledge by the modern merchants of education. Obtaining a degree by any means and getting some kind of employment, whether it is connected with the knowledge acquired or not, has become the sole objective for attending a school, a college or a university.

'Homo sapiens' are supposed to be superior to other animals. It has been said that the pursuits of an animal are nourishment, reproduction and sleep. According to the great anthropologist Richard Leakey, some features which we value in homo sapiens are self-awareness, consciousness, language, artistic imagination and technological innovation. It seems that the objective of the present-day education is now restricted to advancement of the last mentioned quality - 'Technological Innovation'.

May I take the liberty of stating the experience of one of my friends who was travelling from Delhi to Calcutta recently. A family of three, the child and his parents, were co-travellers in a four-berth compartment. Right after the train left Delhi, the child approached the parents asking such question as 'where am I', 'the name of the station' or 'the name of the river'. The parents attempted to reply to the queries in the beginning but their patience did not last long. When the enquiry was repeated, the child was bluntly told that if he went on asking questions any more, this would be his last opportunity to travel with them. This effectively silenced the child. He never asked any questions during the rest of the day. The next morning when the train was approaching Calcutta, the child forgetting the earlier warning, repeated similar types of questions. This time my friend took change and explained to him the route of the train from Delhi to Calcutta, the names of the major stations, rivers and states it crossed. This little conversation added to the joy of travel for the child. It appears what was witnessed in the train compartment is happening on a national scale in which one can compare the school system to the parent, the child to the student and I regret to state that the co-traveller is an extinct animal.

Killing the spirit of enquiry, stifling the desire to know, seems to be the objective of present-day school education. At a very early age, the child comes to know that it is better to keep quiet and receive with grace the information that is being handed over as knowledge and commit it to memory and vomiting out the same in the examination. It is better to forget the famous lines of T S Eliot : "Information is no knowledge, knowledge is no wisdom." The result is that our education system is failing to produce first rate minds who could make original contribution. Instead; first grade students are forced to identify themselves as raw material for machine of producing job-seekers devoid of any sense of responsibility either to the nation or to the mankind; driven only by the selfish desire of material prosperity for themselves and their families. The evil effect is now showing increasingly. Throughout the country, administrators, analysts, scholars and thinkers are complaining that R&D activity in any field is so insignificant that it has place in the world of advancement of knowledge and ideas.

Up to this point I have tried to delineate the scenario on the education-front as it exists today, its limitations and its shortcomings and its disturbing effects on impressionable minds. I would now like to dwell for a while on the background in which in the late 19th century and early 20th century India produced galaxy of literateurs, scientists, scholars, social workers and captains of industries. The sole purpose of education introduced by the colonial-ruler was to create a band of people who would be educated enough to perform the task of native administrators and functionaries who would have a 'mindset' for administering the dictates of the superior ruling-race. The other important purpose of this education was to create market for products manufactured in the country of origin of the ruling class. Roads, railways, etc. were developed so that cycles, cars and railway accessories could be sold. Textile factories and jute mills were opened so that machinery could be sold. There is no end of such examples. For this type of education they did import educationists from Britain. Unfortunately for them, some of them were really educated. To name a few, Sir William Jones, David Hare, D W Bethune, eminent Vice-Chancellors - Stephen, Urquhart and so on. They went beyond the limits introduced by the ruling-class and imparted the scientific temper and spirit of enquiry as a part of education. The student community with a background of oriental-learning together with the occidental input was instrumental in producing literateurs, scientists and social workers like Rammohan Roy, Rabindranath Tagore, Vidyasagar, Bankim Chatterjee, Jamshedji N. Tata, Lokmanya Tilak, Lala Lajpat Rai, Pt Madan Mohan Malavya, H R Ghokhale, Dayananda Saraswati, Archarya Jagadish Chandra Bose, K S Krishnan, S Radhakrishnan, C V Raman, Meghnad Saha, Satyen Bose, Ramesh Majumdar, Munshi Premchand and a galaxy of other luminaries who did not have the benefit of foreign education on foreign soil.

One may ask why the product of post-independence system of education became anaemic. I have often heard people saying that to cope up with the expanding field of knowledge, the school curriculum has become too heavy . To meet its demand there is no time to entertain the luxury of asking questions and meeting the demands of an enquiring mind. Is it true that the course is too heavy? For your ready reference a Curriculum of Study covering the range from Class II to FA standard is being presented in Table 3[3]. This curriculum of study was followed during the last decade of the 19th century and early decades of the 20th century. It may be noted that the curriculum of the single stream included both the disciplines - arts and science, subject-matters were of high standard and were considered essential for cultivating a civilized mind. The curriculum covered the range from Class IIto FA. Single streams of FA were replaced by the two streams viz. Intermediate - Arts and Science, in the second decade of this century. A review of the curriculum will indicate that the load was at least equal to, if not more, than the present curriculum. The basic difference between the two curricula is that the earlier system did give food to the brain and inducement for thinking as against the bitter medicine of injected nutrient of the present-day education system.

May I now draw your attention to the unusual item in the curriculum in the early 20th century termed at 'library'. It was an optional item which one could select as a subject he felt worth pursuing. One of the luminaries selected philosophy in the first year of his FA in 1850 which is equivalent to Class XI and got first-class securing 100% marks. A present-day student cannot even dream of taking such an optional subject of study which will not enhance his standing in the competitive type of education he pursues in schools and colleges.

As the present curriculum is information-oriented, quite often the imparted education gets obsolete even by the time the individual has reached the age of productive working. One of the significant differences in the method of dispensing education. between the present-day method and the method of the earlier period was that the role of memory was related only to numerical tables and grammar and similar topics. As such, the teacher had a bigger role to play in the formative age during the primary classes in the school where verbal medium of imparting knowledge was prevalent. The present-day method of learning is painful. It deprives a person of the joy of knowing. People in the field of education are worried about why all of a sudden the tap which produced such eminent personalities in the later part of 19th century and early part of 20th century dried up? What happened to the great tradition of Indian universities where up to AD1200, the scholars from the Middle East, the Far East and the Central Asia used to come in search of knowledge?

Will the re-introduction of early 20th century method be of any use now? The answer is 'No'. Up to the first quarter of 20th century, education was mandatory for a particular section of society. The so-called democratic doctrine of mass-education was yet to be recognized as a requirement of the society. It is therefore obvious that reintroducing the method which produced such a galaxy of luminaries in early part of the century, will not be effective under present milieu.

I would now like to dwell upon the possible methods that can meet the demands of the emerging society in India which suffers from continuous population growth. In Europe, population growth is on the decline and as a matter of fact, in some countries it is negative.' In the emerging world, the growth is such that in every 40-year, the population is doubling itself.

In this connection, I am appending a letter from Jamshedji N Tata to Swami Vivekananda dated 23rd November, 1898. At that point of time Jamshedji was thinking of setting up an institute of fundamental science as he felt that unless the nation develops such an institute, our country would never be an honourable member in the comity of nations. Jamshedji had a chance of encounter with Swami Vivekananda as a co-traveller en-route to the USA from Japan. Swami Vivekananda was yet to become internationally famous as this was prior to his addressing the Parliament of Religions at Chicago. The "letter" which I am about to read now and is amazing.

Table 3 Curriculum of Study

19th Century Education System Class/Std.	Equivalent Present-day Class	Expected Age (Years)	Course of Study
Primary	Infant	5 8	One (1) Year 1st Year — Writing by chalk 2nd Year — Wring on Plam leaves 3rd Year — Writing on Banana leaves 4th Year — Writing on Paper Note : A. First 2 years - Handwriting only. There were no text-books. Learning through verbal lessons from teacher. B. After 'A' lesson is over, the student starts writing on paper — writes letter pertaining to income & expenditure — etc. Morever, memorizing lessons like addition, multiplication, story-telling, etc. — through verbal instructions only.
7th	IV	10	Homer's Iliad, Murrey's Grammar, Playfair's Geometry, Goldsmith's Rome, Arithmetic.
6th	V	11	Pope's Essay on Criticism, Couper's TASK (Richardson's Selection), Drama — Venice Preserved; Bell's Euclid, Stewart's Geography; Wood's Algebra; Goldsmith's Rome; Keightley's India.
5th	VI	12	Course complete - Junior Scholarship Exam.
1st-year College	VII	13	Shakespeare's King John; Vanity of Human Wishes; Spectator (1st half); Euclid—I-VI & XI; Hindman's Plane Trigonometry; Wood's Algebra (up to Binomial Theorem and Summation of Series); Hume's History of England, Stewart's Mental Philosophy.
2nd-year College	VIII	14	Shakespeare's Hamlet; Bacon's Essays; Scott's Lay of the Last Minstrel; Potter's Mechanics; Geometrical Conic Sections, Algebra; Guizot's History of the English Revolution; Physical Geography; Stewart's Mental Philosphy.
3rd-year College	IX	15	Shakespeare's Mecbeth, Henry VIII; Milton's Paradise Lost I-II; Bacon's Advancement of Learning; Dugald Stewart's Mental Philosophy; Analytical Conic; Differential & Integral Calculus; Hydrostatics, Adam Smith's — Wealth of Nations, Smith's Moral Sentiments; Mill's Logic; Mecauley's History of England, Arnold's Lectures on Modern History; Spherical Trigonometry & Newton's Principia.
4th-year College	X	16	Shakespeare's Merchant of Venice, Othello, Tempest, Novum Organum; Dryden's Macfleckndе; Dryden's Absalom and Achitophel; Young's Night Thoughts; Mill's Political Economy; Optics, Astronomy; Calculus.
FA 1st-year	XI	17	1st year — Fifth number Reader; Second number Reader; Stewart's Geography; Chamier's Arithmetic; Gay's Fables; Goldsmith's History of Rome; Third number Prose Reader; Aesop's Fables; Rev. W. Essays (the essays were meant to teach European customs and etiquette). Mills's Logic, Adam Smith's Theory of Moral Sentiments, Reid's Inquiry, Arnold's History of Rome, Elphinstone's History of India; History of England Mathematics — Arithmetics and Integral Calculus (pure & mixed), Richardson's Selection (Poems of Dryden, Pope, etc. Sanskrit optional). Library — Chosen subjectwise — a number of books extra to prescribed books. An optimal additional exam. of distinction.
FA 2nd-year	XII	18	1. Bacon's Essays. 2. Shakespeare—Macbeth, King Lear, Othello, Hamlet. 3. Milton—Paradise Lost, Lycidas, commas L'Allegro, Il'Pensoraso, Sonnets. 4. Pope's Essays. 5. Young's Night Thoughts. 6. Gray's Poems. 7. History : i. Hume's History of England ii. Gibbon's Roman Empire iii. Mitford's History of Greece iv. Fergusson's Roman Republic v. Elphinstone's India 8. Mathematics : i. Euclid's first 6 books and IInd Book ii. Algebra iii. Plane & Spherical Trigonometry iv. Analytical Conic Sections 9. Mixed Mathematics : i. Whewell's Mechanics ii. Berkley's Astronomy iii. Webster's Hydrostatics iv. Phelp's Optics v. Calculation of Eclipse

A LEDER FROM JAMSHEDJI N. TATA TO SWAMI VIVEKANANDA

Dear Swami Vivekananda,

I trust you remember me as a fellow traveller on your voyage from Japan to Chicago. I very much recall at the moment your views on the growth of the ascetic spirit in India and the duty, not of destroying but of diverting it into useful channels. I recall these ideas in connection with my scheme of Research Institute of Science for India of which you have doubtless heard or read. It seems to me that no better use can be made of the ascetic spirit than the establishment of Monasteries or residential halls for men dominated by this spirit, where they should live with ordinary decency and devote their lives to the cultivation of sciences-natural and humanistic. I am of the opinion that if such a crusade in favour of an asceticism of this kind were undertaken' by a competent leader, it would greatly help asceticism, science and the good name of our common country; and I know not who would make a more fitting general of such a campaign than Vivekananda. Do you think, you would care to apply yourself to this mission of galvanizing into life our ancient traditions in this respect? Perhaps, you had better begin with a fiery pamphelt rousing our people in this matter. I should cheerfully defray all the expenses of publication. '

With kind regards, I am, dear Swami,

23rd November, 1898 *Yours faithfully,*

Hiplanade House, Bombay *SdI- Jamsedji N. Tata*

An industrialist willing to create an institute for which there will be no immediate financial gain, thought of utilizing the service from an ascetic as head of the institute of science of the highest order. This was because Jamshedji felt the need of the hour was, to quote him -

"Galvanizing into life our ancient traditions."

This letter is a clear guideline to the nature of education which India should look forward to. Paths indicated by Malavyaji, Tagore and more recently Bhaikaka should be studied with care. The education policy should be framed by analyzing the meaning of various words such as 'trade', 'job', 'education', etc in the context of our present requirements.

The dual requirements of bringing up an individual as a worthy citizen of a country with diverse culture and tradition on the one hand and achieving the uniform standard of excellence for any particular profession on the other hand should be an important criterion.

Elements of history, geography and the culture of the country should form a part of a child's education in the primary stage so that he or she can honour the commitment of the constitution of the country by recognizing the secular, multi-lingual, multi-cultural character of India.

'Elementary science, mathematics and knowledge of gadgets that are bound to be used in the rural sectors should also form a part of the core education. The curriculum should include ecological knowledge such as the use of insecticides, chemical manure as well as a knowledge of the ecological cycle by the insect and animal life. Hygiene, both general and sexual should also be a part of the education to ensure the health of the society. Sex education should be introduced only after studying its effect on the traditional society and, conditions permiting, should be introduced as early as possible.

Last but not the least, moral science and aesthetics should form a part of the academic activity whether in the form of verbal communication and/or through printed medium. If we are to arrest the alarming decay and aberration of value and deterioration of behaviour of individuals and groups which we are witnessing today, then introduction at primary stage of education of the topics mentioned above is essential.

The present society is already suffering from the effect of distortion of the meaning of words, such as 'secular'. 'democracy' and 'justice'. The word 'secular' now stands for irreligiosity. 'Democracy' stands for mob rule or party rule in place of rule based on collective decision-taking. 'Justice' stands for protecting the rights of the ruling-class only. At a very early stage in the education system, a clear concept should be implanted in the mind of pupils.

I would like to close with the following comment -

It is paramount importance in the light of growing population that the public is made aware of the disastrous effect of population growth. Furthermore, education system should teach the people that contentment is not a linear function of consumption. Delinking of these two is essential for creating a healthy environment. The education system which honours people who are either pursuing productive professions or helping in advancement of learning and knowledge will automatically be able to establish a balance in the society and secure for our country its rightful position in the league of nations.

References

1. UNESCO Statistics on Education: (Selected Indicators) UNESCO Yearbook 1995, 1996.
2. Growth of Pupulation, Number of Literate (Literacy Rate), Number of Illiterate & GNP.
3. Curricuhuu of Study. Courtesy - Sri Sitansu Sekhar Ghosh.
4. A Letter lrom .Iamshedji N Tata to Swami Vivekananda.' Prabudha Bharat, Courtesy- Sri Sitausu Sekhar Ghosh.
5. About Education - C E MJoad.
6. Notes towards the Definition of Culture - T S Eliot.
7. The Learning Society - An Eassy on Education in Britannica Perspectives Vol II, by Robert M Hutchins.

   i. Jacques Ellul;

   ii. Dr Robert M. Hutchins; and

   iii. Aristotle.

Higher Education in India — A System that Resists Change

Prof V C Kulandaiswamy

Former Vice-Chancellor
Indira Gandhi National Open University, New Delhi

Introduction

It has become an established practice to avail oneself of a memorial lecture to make a few observations on a theme that may be of immediate, as well as long term, relevance to the nation. Such themes may be many, but I make my choice from an area of my acquaintance; I mean higher education.

The 20th century, on the edge of which we now stand, is a period of momentous developments in human history. Notwithstanding its two major wars, numerous conflicts all over the world and the display of crudeness, cruelty and a certain degree of vulgarity in the behaviour of individuals and nations that we witness and have witnessed, it has made enormous contributions towards civilising, refining and facilitating human life. There have been many developments that represent a break from the past, or a radical departure from accepted traditions.

The concretisation of human dignity, human rights, individual freedom, democracy, socialism and communism have brought about a metamorphosis in human society. Science and technology which was essentially a tool for economic development in the industrial economy has emerged as a major force and exerts an all pervasive influence in every sphere of human life. Possession of relevant knowledge, creation of new knowledge and capacity for its application have become the determinants in the strength of a nation. Consequently, education has come to the centre stage and is today the most important agent for change and development. The dominance of education and the emergence of the concept of human resource development are most significant developments of this century. The new role that education might play, the new gates it might open, and the unknown world it might bring to light, are in the womb of the future. We need the highest of education for a few to master existing knowledge, as well as creating new knowledge, and basic education for all for a society to be able to absorb and apply knowledge to social, political and economic development.

Added to the general trend of the century, certain policy changes of our Government in the nineties have brought new compulsions to keep our education system in good repair. We have, with whatever reservations there may be, accepted liberalisation and globalisation of our economy. It means that we open our market to the world and we gain access to the world market. Employment opportunities have transcended the state boundaries, national boundaries and have become global. If we are to take advantage of these changes, we have to improve our competitiveness which in concrete terms means excelling in productivity. In this context, education faces three challenges, ie, universalisation, equity and ability to be on the frontiers of knowledge. Higher education, therefore, has a decisive and dominant role to play in keeping our competitiveness high in every sphere of activity.

Condemnation: not a Contribution

Higher education is a subject on which every one feels qualified to express as opinion; but unfortunately often highly critical and damning. Higher education in this country has been condemned almost uniformly by political leaders, administrators, journalists, parents and what is worse, by the students and teachers as well. Surprisingly, political parties - which are not in position, and therefore, in the opposition and those in position - who never agree on any issue, are agreed in delivering harsh and adverse verdict on higher education. Berating it has even become a fashion and a practice with many. Every one who passes by an educational institution, pauses for a while, picks up a stone, hits at it, making an already bleeding institution to bleed more and walks ahead with the supreme satisfaction that he/she has made a great contribution to education. We seem to be developing in this country a culture of condemnation and a philosophy that condemnation is by itself a contribution, complete and adequate. We have many to demolish, but a few to construct. Demolition of anything without replacement is no reform, it is vandalism.

I may, on this occasion, declare that we have made great strides in higher education since independence. We have today one of the largest systems of higher education in the world with over 230 universities, 9300 colleges, and 6.4 million students and teachers (1995-96)[1] The country has produced scientists, engineers, technologists, managers and doctors who are in demand all over the world, both in developing and advanced countries, and who have distinguished themselves in every area of knowledge. The scientific and technological capability of India is far above that of any developing country, and is above that of some of the advanced countries as well. These and many other achievements bear testimony to the contributions of higher education. The system has today the necessary infrastructure, the tools and the manpower; it has a tremendous potential. We can certainly have faith and confidence in the higher education system we have developed and the potential it has. Having said this much, I may come to our failure in the past, the inadequacies that have developed, the issues and challenges we face today.

The Indian Scene

Education is not a static phenomenon, it is an organic entity that recognises the changes in the environment, responds to new demands and keeps growing with the society of which it is a part. The advanced countries have responded adequately to the new demands and new challenges; their education system has incorporated such changes, effected such improvements, made such departures and brought about such reforms as to serve the emerging requirements of a competitive world. One may naturally ask as to what our response has been, and how well is the antenna directed to receive the messages of the modern world and respond appropriately. A review of this aspect leaves us sad and somewhat perturbed.

The facts are as follows:

i. The system has expanded considerably in all aspects. We have drawn heavily from the experiences and curriculum models from advanced countries. However, we have not developed a management system capable of making such changes, as may be needed to relate it to the social and economic needs of the country, and even to bring about the necessary structural and pedagogic changes to keep pace with the reforms taking place in advanced countries. We have not reformed as much as we expanded.

ii. It is said that the 19th century was known for transportation revolution and the 20th century for communication revolution. It may be safely stated that the communication revolution which has broken all geographical and national boundaries has not entered the class room in India. Any academic who might have retired half a century back can enter the class room and feel quite at home with the tools of instruction now in use in an average class room. The curriculum no doubt has changed beyond recognition, but the conduct of instruction remains the same.

iii. Since the advent of industrial revolution, there has been continuous application of science and technology to transform craft into technology and thereby increase productivity. The major difference between an advanced country and a developing country is ultimately in productivity in every field. In India, the productivity in education remains constant. The modern tools and methods have not entered the class rooms. Our academics are not as advanced in pedagogy and education technology as they are in the knowledge of their subjects.

iv. A system when advances, sheds gradually its rigidity, increases its flexibility, and becomes increasingly capable of adapting itself to new developments. But the higher education system in India, not only remains unchanged but has resisted consistently all attempts to bring about changes.

v. In the age of knowledge that we are in, progress depends on innovation and its application. Services and contributions of persons with expertise and exposure to developments in the field are needed in any area of activity. It is more so where we had to transform a system designed by a colonial power to meet its needs of maintaining law and order and revenue collection, to fulfil the requirements of development — social, political and economic — in independent India. But unfortunately, policy formulation and decision making have remained with the bureacrats of the Government and outside the domains of academic leaders, especially in the states which are entrusted with implementation of educational programmes. This is a major deficiency in the system that has resulted in the continuation of a system, condemned on the platform, but entertained and expanded in practice.

vi. It may appear strange but true, that we do not have the category of persons who are acknowledged as academic leaders. We have our scientists, historians and economists in our universities. We do have professors of education, but we do not have many educationists. We have not established the necessary institutions that will help the development of leadership in education. Academic leadership today is the desideratum.

Some Anachronisms

Since Independence, consistent efforts have been made to bring about desired changes in education. Many committees and commissions have gone into the issue. Our shelves are full of scholarly and comprehensive reports, often quoted, but unimplemented. The Government have brought about two National Policy documents on education, one in 1968 and the other in 1986. The National Education Policy of 1986 (NPE 86) ushered in heroic efforts to bring about changes. What we have achieved by way of changes in higher education is precious little.

• The most objectionable component is the affiliating practice. It is an anachronism which does not exist any where in the world except the Indian sub-continent. It has done and continues to do enormous harm to higher education in our country. It has changed the university into an examining body, converted the colleges into tutorial institutions, and the academics into tutors. It has taken away all initiative, leadership and sense of participation from the academic community and rendered the academic atmosphere anaemic. All over the world higher education is on the university campus. Since we could not convert all the colleges into universities, the Kothari Commission came up with the idea of autonomous colleges. The NPE 86, set a modest target of 10%, ie, 500 colleges to be granted autonomy. But even today the number is around 110, of which nearly 40% happens to be in Tamil Nadu.

• The academic year concept is another -fossil on our campus. The delay in starting instruction, leisurely drift over a major part of the year, near absence of seriousness in the campus atmosphere, slow and indifferent pace of instruction, intensive last minute study, fear and nervousness on the eve of the examination, (since the final examination is the only deciding factor) are the characteristics of the academic year system[2]. These are mostly absent in the educational campuses of advanced countries and in some institutions of our own country. We must more over to the semester system which normally means a shorter academic term and continuous internal assessment and a final examination.

• Modular approach has come to be accepted in every area of activity. It is a symbol of flexibility and provides scope for enormous manoeuverability. Credit system in the choice of subjects is now a universal practice and is in vogue in some campuses in our own country. It makes mobility easier and gives the learner the freedom to acquire the kind of competence he chooses to acquire. In a single step we can impart into our system enormous flexibility and end the stifling rigidity that we now have.

The administration and management of the universities are in the hands of university bodies like the Boards of Management, the Academic Council, the Senate, the Planning Board and Boards of Studies. The composition of some of these bodies as well as powers and functions remain, by and large, as they obtained in the preindependence days. We continue and expand a structure devised for educational objectives far different from those that we have now set before us. Attempts have been made since the sixties to devise a more appropriate structure, but nothing significant has happened in the State universities. The university system is invariably identified with the Vice-Chancellor. Whether it is the fall of standards, poor performance in research, delay in publication of results or unrest on the campus, whatever the breakdown, the debris falls on the head of the Vice-Chancellor. But he runs the university as the chairman of bodies, in the composition of which he has no say. In some States he holds office at the pleasure of the Governor who is the Chancellor. The position of Vice-Chancellor has been devalued gradually over the years and has lost the prestige it had even under the colonial rule. I can think of no parallel office with so brief a term, so insecure a tenure, so limited an authority and so many demands.

As we stand at the end of the 20th century and are about to knock at the door of the next, we find that we carry on our shoulders the burden of arrears of reforms that we, have failed to bring about in the second half of this century. There is an urgent need that we take bold and decisive steps to come level with the modem world in academic practices and administrative structure. They are intellectually, politically and economically well within our capability. What is needed is the will and conviction to sweep off the obsolete and enter the race with endowment of a system that is modem and has its antenna well directed towards the new challenges.

Inefficiency of the System

However good the curriculum and syllabi, however rich the library and well equipped the colleges, they serve no purpose if the academics do not teach and the students do not study. The UGC has prescribed 180 contact days in an year, less than 50% of an year; certainly not an ambitious target. With our system of vacation, two weekly holidays, a large number of authorised holidays and the interruption of work because of strikes, it has become difficult even to fulfillthis modest target.

The Rajasthan Government, in consultation with the VCs and principals of colleges has officially, by a Government Order, fixed 153 contact days in a year. But discussions indicate that what is realised may not exceed 130 days.

The survey conducted by the UGC Pay Committee covering 76 universities and 1095 colleges showed that 22.1% of the universities and 5.6% of the colleges reported less than 100 contact days in a year[3].

The Working Group on Education constituted by the Planning Commission for preparing the proposals for the

IX plan was headed by the UGC Chairperson and it states as follows :

'New universities particularly suffer from infrastructure deficits as the grant formula is generally unfavourable to them. On the other hand, the physical plant is not utilised optimally ... some institutions barely work for 100 days to 140 days'.

While the contact days are so limited in number, the question also arises as to how many classes are engaged on these days without being cancelled and how many students attend the classes held. The institutions mostly work between 10.00 am and 5.00 pm and for the rest of the 17 hours in the working days and all the 24 hours in the holidays the class rooms the laboratories remain idle, excepting the hours when examinations are held. Take into account the fact that the minimum percentage of marks prescribed for a pass is only around 35 and the ?ercentage of successful candidates may be about 60. If all the additions and subtractions are made and if one reckons the net utilisation of manpower resources and physical facilities and the performance of the system, the efficiency status leaves us sad and highly perturbed.

Since educational institutions have a long vocation they must have their own regime of holidays and they need not be common with the administrative offices. The unutilised facilities in the higher education system constitute a luxury that even the affluent countries cannot afford.

New Institutions

We have come to realise that institutions play a major role in the developmental process. New developments invariably require new institutions or reorganisation of existing institutions. In the domain of higher education, the New Education Policy (1986) suggested, among others, the establishment of two new institutions, one at the state level and the other at the national level. These are :

i. State Councils for Higher Education;
ii. National Council for Higher Education.

Though education is in the concurrent list, the responsibility for setting up universities and colleges, funding, administering and maintaining them rest with the State Governments. While the Central Government has such bodies as the UGC, AICTE, ICAR, ICMR and NCTE for guidance in policy formulation and planning, there is hardly any expert body at the State level to take a comprehensive view of the higher education system in the State and its strength and weakness. To meet this requirement, the State Council was recommended; but it has not been set up in most of the States, and even the few that have been established are not in accordance with the Model Act formulated by the UGC, Andhra Pradesh being one exception.

At the GOI level, higher education remains fragmented since UGC, AICTE, ICAR, ICMR and NCTE are independent bodies. In order to co-ordinate their activities the NPE suggested a National Council for Higher Education. This again has not been set up though the NPE and Programme of Action containing this recommendation have been approved by the Parliament.

Funding Higher Education

The Education Commission headed by Prof Kothari recommended as early as in 1966 that allocation for education must be about 6.0% of GNP. This was reiterated in the NPE 86. However, the allocation according to the IX Plan document stands at 3.2% of GDP. It is even lower than the average of the developing countries of the world which spend about 3.9%. The world average is 5.1% and that of the advanced countries 5.4%[4] There has been a sudden decrease in the plan allocation for higher education as seen from the following :

Five year plans	Share of education in the total allocation, %	Share of higher education in the plan allocation, %	Share of higher education in the allocation for education, %
I Plan	7.86	0.71	9.0
II Plan	5.83	1.02	18.0
III Plan	6.87	1.01	15.0
IV Plan	4.90	1.24	25.0
V Plan	3.27	0.52	22.0
VI Plan	2.70	0.49	18.0
VII Plan	3.70	0.53	14.0
VIII Plan	—	—	8.0

Here again, the world average of expenditure on higher education as percent of total expenditure on education is 21. 0; that of the developing countries is 18.0 and advanced countries 22.0 (1992)[4]. It can, therefore, be seen that limiting the expenditure on higher education in the VIII Plan to 8.0% is an extremely unwelcome and unimaginative step. Increased outlay for universal primary education is stated as the cause for this reduction. Failure to pay adequate attention to primary education in the past is a great blunder and a sad lapse. To economise on higher education to promote primary education will be another blunder at the other end of the educational spectrum.

We have adopted a policy of liberalisation and globalisation of our economy which will demand higher competitiveness on our part. We see no tangible steps in the field of higher education to augment our competitiveness. On the other hand, one sees an attitude of withdrawal from the domain of higher education which will be disastrous.

Another disturbing feature is the note on subsidies prepared by the Department of Economic Affairs of the Ministry of Finance which classifies higher education as non-merit service and for non-merit services Government subsides may be reduced (according to the note) from 90% to the level of 25% over a period of five years. The subsidy for higher education now is at the level of 90%.

The arguement of the authors of the note is that:

'...benefits of subsidies accrue primarily to the recipients'

'A significant portion of subsidies in higher education is appropriated by the middle class to high income groups. because shortages of seats in this sector are cleared by quality based clearing in the shapes of entrance examination, interview, group discussion etc, where the poorer sections of society are competed out'.

It is the inference of many that the authors have been influenced by the thinking of the World Bank and its specialists. The World Bank generally has been against developing countries investing in higher education.

The presumption that benefits of subsidies to higher education accrue primarily to the recipients is unsustainable. Higher education provides the leadership in every area of activity. They are the researchers, the academics, the designers, the builders, the administrators and the entrepreneurs.

This talent can neither be borrowed, bought or imported. Without the assistance of the Government-subsidised institutions of higher education, even the richer sections of the society, not to speak of the middle class, could not have afforded higher education and contributed to provide this level and size of manpower. If it is true that adequate number of boys and girls from the poorer sections do not gain admission, we may devise methods to remove whatever blocks that may exist-social, economic, even academic. Without higher education and by diverting funds to primary education, we may have literate but no learned citizens. A nation needs both the categories.

Some are of the view that too many in this country go in for higher education; this again is an unsustainable presumption. Only 6.0% of the age group is in tertiary education in India. The average for developing countries in the world including African countries is 6.8%, and the average for the advanced countries is 47.0%[5]. If we consider the S&T manpower (1991), the figure per 1000 in India is 3.5. It is 9.0 for the developing countries and the world average is 25.0[6]. There are grounds for opening up more opportunities for higher education in India. The problem of higher education in India is not the problem of numbers, but is one of quality and relevance.

While I plead for more allocation of funds, I must clarify two points:

• There is room for enhancing the tution fees with adequate safeguards for deserving poor students.

• Unless some of the academic and administrative reforms are carried out, additional funds may not produce commensurate results.

• The crisis in higher education is not merely the crisis of inadequacy of funds, but of anachronistic academic practices, unsuited administrative structure and total breakdown in accountability.

What is needed is a major change bordering on revolution and it warrants the earnest attention of all the political leaders, transcending party differences as well as the academic leaders and enlightened members of the public.

Urgent Reforms

Before we can find a level ground in the next century for competitiveness based on knowledge, we must carry out the following reforms.

i. Granting autonomy to all good colleges.

ii. Granting deemed to be university status to as many good institutions as possible.

iii. Introduction of semester system and continuous internal evaluation.

iv. Promotion of modularity and credit system.

v. Revision of holidays and vacation pattern.

vi. Establishing in every state, State Council for Higher Education under the chairmanship of an academic.

vii. Introducing a high degree of professionalism in policy formulation, planning and management.

viii.Conscious steps to be taken to promote academic leadership.

A Vision of the Future

It is necessary to visualise the developments that may take place in higher education in future. Considering the rate at which changes take place and progress is made in science and technology, and its impact on the content and conduct of education, it may not be possible to look far into the future. It may be desirable to aim at a period of 20 years. We already have Vision 2020 documents for many sectors though education explicity is not one of them.

Whenever we consider the possible developments in education we are often tempted to produce an impressive and all embracing document, irrespective of the availability, or otherwise, of the institutional machinery, political will and resources for implementation, and more than that the preparedness of the society to absorb and benefit by such developments. While higher education has a universal component, and employment opportunities are global, we prepare manpower for our need and not the kind of manpower who might complain that opportunities do not exist in India for the kind of expertise that they have. The most important requirement that education and training must satisfy is to be able to substantially improve national productivity, starting with, and improving upon, whatever level of technology and management practices we may have. We need produce a designer or planner who could do the job with whatever data are available or could be gathered; and not declare that he could make a beginning only if all the data to suit his theory are made available. It must be clearly understood that in every country the education system prepares manpower for its economy. If we decide to prepare consciously a class of manpower, necessarily limited in number, for international market, or if the manpower we produce for our need has an international demand, it is a different issue.

With these introductory remarks we may consider the future prospects for higher education. There are two branches in technology that march forward incredibly fast and they are information technology and communication technology. There is a distinct possibility that there will soon be a congruence of these two. The impact of the possible future developments in information technology and communication technology may have to be assessed. We must remember at the same time that however fascinating, they by themselves will not do the job of a plough on the field or the machine tool in the workshop. The two major sectors of the economy, agriculture and industry may continue to play their role. The farmer, the worker and their tools may gain in productivity; nevertheless they have to produce. Access to knowledge will improve, dissemination of knowledge will be enormously facilitated, creation of new knowledge could be accelerated to the extent that one may command input to one's research work from many sources at an incredibly fast rate, but the creative mind has to be there, it can neither be replaced nor produced by any of these technologies. The limitations on the ability of a society with 40% illiteracy at present, to avail itself of these developments must also be borne in mind.

The rays of following developments are seen on the horizon; some may evolve on their own and some may have to be brought about by appropriate intervention and initiative.

i. Our institutions function as individual units in isolation of each other; the culture of horizonal co-operation for combining the strength of partners, complementing each other and ensuring better utilisation of the existing resources, does not exist. Hierarchical set up is what we have been accustomed to; we look up and look below and never sideways. Even interdisciplinary studies are more praised and preached than practised. It is necessary to take concrete steps to promote networking either at the component level or at the institutional level as the case may be. A trend in that direction is seen; it has to be nurtured and encouraged.

ii. We, as a nation, are engaged in transforming an agricultural society into an industrial society. It is not a matter of establishing a few large industries; it is a question of developing an industrial culture which will enable the widespread use of technology to increase productivity in every activity. The productivity of every square centimeter of land, every cubic centimeter of water and every individual must increase. In achieving this objective, every institution of higher education must function as a resource centre; as a development agent. The academic community must interact with the world outside either at the national, regional or local level, depending on its competence; but interact it must. The potential available in an educational institution is much more than what has been realised either by the institution itself, or by the community around. Its capacity must be extended to the maximum. The Canada India Institutional Co-operation Programme (CIICP) has demonstrated how a modest institution like the polytechnic benefit the industries and the community around and derive benefit from them; provided the faculty is given appropriate training and the institution is given adequate autonomy. The models developed have to be replicated.

iii. Communication technology is finding increasing use in education and training. Distance mode as a method of instruction has come to be accepted and the open university as an institution is now well established. As of January 1998, there were 1117 open universities in 103 countries and they were offering 31000 courses 7. It is neither a substitute for, nor a replacement of, the existing face to face system, but a new stage in the evolution of education to cater to the needs of certain target groups not served by the conventional system. We may set up more open universities in future. In addition, every conventional university will add a distance education component to meet its extension activity requirements. I foresee that every university may slowly start operating in dual mode using both face to face mode and distance mode. It will become possible for the students to move in and out of the campus and pursue the courses through face to face mode in some semesters and distance mode in some others. The Governments and apex bodies like the UGC, AICTE and ICAR must perceive the world trend and be prepared to accept, regulate and guide the transition along a healthy course.

iv. Educational institutions will carry their programmes transcending the walls of their campuses and perhaps the boundaries of their nations. We have, today, multinational corporations in industry and business. We see on the horizon the emergence of multinational universities. We have today in a small city like Hong Kong, 18 universities from other countries offering some of their programmes and are operating their centres either independently, or in collaboration with local universities or educational institutions. The UK open university offers its programmes in Europe and in countries in Africa.

In the past, students from developing countries were moving to universities in advanced countries for higher studies; but today the universities in advanced countries are setting up their campuses in developing countries. It is now possible with satellite communication for a university in the USA to offer its programme with the same lectures, assignments and discussions in China or Russia. Academics in India must prepare themselves for international competition right on our soil in the field of higher and continuing education. These developments may appear to be far away in time, but may suddenly explode and descend on us. We need to remain prepared for such developments.

v. Information technology is another area that holds immense possibilities. Virtual class rooms and virtual universities may serve the needs of continuing education and further education atleast for those who can afford to have the computer facilities. Computers and use of CD-ROM for carrying lessons will become popular before long and it will bring about revolutionary changes.

vi. So far, education has been treated as social service and expenditure on higher education was treated as subsidy. Recent studies by the World Bank have clearly established that expenditure on primary education is investment that ensures satisfactory return. Instructional materials in print form, audio- video cassettes and computer programs have become marketable commodities. Continuing education programmes and many degree programmes in Management, Commerce, Computers and certain areas of technology have become self supporting or they yield marginal profit. The natural consequence of this development is the entry of private enterprise in the field of higher education which remained for long as Government effort or Government aided.

vii. As mentioned above, there is bound to be increasing participation of private enterprise in higher education. We have had private colleges for long: but they are Government aided. What is now emerging is a category of private institutions designated as self-financing institutions. There have been and there are a large number of private colleges in advanced countries. The tuition fees there are high, but they yet had the protective hand of philanthropy. What we are witnessing in India is a class of institutions very different from what is obtaining elsewhere in the world. These institutions charge differential fees and the students from well-to-do families pay enough fees to subsidise the education of meritorious students, some of whom may be poor and disadvantaged. It is a case of practicing a new and direct form of socialism on the campus.

The entry of private enterprise in higher education will bring in new initiatives, more enterprising and more innovative experiments and programmes. They are likely to be more responsive to market demands and meet student aspirations more effectively. Their course offerings may resemble a cafeteria with liberal scope for choice. It may become necessary for the university system also to be more flexible and accommodate experiments and innovations without blocking them in the name of rules, regulations and statutes.

In certain States of the country we already have arts and science colleges, medical colleges, engineering colleges and polytechnics, paramedical courses, law colleges and teachers training colleges, all mainly on self-financing basis. These will grow in number and spring up in other states also. The Government may have to go in for legislation which will not stifle these initiatives by over regulation, or allow exploitation by unscrupulous elements by being indulgent.

viii.The Government of India prepared a bill for the establishment of private universities. It was referred to the Parliamentary Committee on Education. It appears that the measure is not under active consideration; but it is bound to come sooner or later. It will add another dimension to higher education. I do not consider it a revolutionary measure since many of the deemed to be universities today are registered societies established by private effort. What is needed is to ensure that persons with appropriate background of service, interest in the welfare of the people and image in the eyes of the public alone are allowed to establish university level institutions provided they satisfy the requirements laid down for land, endowment, buildings and manpower resources. Quinquennial accreditation must be made mandatory and provision must be made for stopping admissions when certain minimum requirements are not met.

ix. We have been talking about life long education since the publication of the UNESCO document, 'The Learning To Be.' We are not fully prepared today to meet the demands that would arise in future. We have made enough progress in science and technology and we have, long before, entered the domain of high technology. We will soon face in a big way the obsolescene of manpower. The policy of liberalisation and globalisation has made it inevitable that we keep our employed manpower adequately updated and to that end organise continuing education programmes. It is a massive task. We have to handle large numbers. Increased number to be handled will demand higher productivity in education. Catering to employed persons will require greater flexibility. Instructing employed professionals will need different kind of competence on the part of the faculty. For the economy of the nation continuing education will become as important as formal education. The institutions of higher learning will have to play in future a major role in continuing education as part of their extension dimension.

x. Development in the past meant, by and large, economic development. Today we recognise three aspects of development.

a. Social Development,
b. Political Development,
c. Economic Development.

Social problems have assumed great importance in all societies. Equity in every field, especially in education is one of the main demands. We do find in India that social justice has become a major factor in the manifesto of all political parties. In the past, we have been concerned with making opportunities available; but availability does not ensure accessibility. The main issue today is making the available opportunities accessible. Since education has come to be recognised as a popular vehicle for upward movement, demand for equity in educational opportunities is on the increase. The education system should adjust itself to reach as many target groups as possible. The higher education system must necessarily use a multimedia approach and the educational campuses must be endowed with facilities for using as many channels of communication as modern technology has provided.

xi. The universities have been the birth place of research and creation of knowledge continues to be one of their main functions. In India today, in the total grants made available for research, the share of the universities is barely 2.0%. This is too meagre when we compare with 19.0% in the USA and 25.0% in Canada. The universities have the unique advantage of a perennial flow of young minds capable of fresh and creative thinking.

It is not necessary that we should encourage research only at Centres of Excellence in advanced studies. The problems that we have in India represent a broad spectrum offering opportunities for research from the humblest of institutions to the most advanced centres of learning. For us, Boeing is important, the bullock cart is also still important. We must endeavour to promote research and innovation in as many institutions as possible.

References

1. U G C, AnnuaJ Report, 1995-96, New Delhi.
2. V C Kulandaiswamy, 9th Convocation Address, Alagappa University, March, 1997.
3. U G C, Report of the Committee to Review the Pay Scales of Unviversity and CoUege Teachers, May 1997, New Delhi.
4. UNDP : Human Development Report, 1996.
5. UNDP : Human Development Report, 1995.
6. M M Ansari: Higher Education and Economic Reforms; Industry and Higher Education, London, December 1997.
7. United Kingdom Open Unviersity : International Centre for Distance. Learning, CD-ROM Data Base, January 1998.

Engineering Management in the Indian Air Force at the Corporate Level

Air Marshal R Ramamurthy (Retd) *PVSM, FIE*

Ladies and Gentlemen.

It is indeed an honour to have been invited to deliver the 25th Bhaikaka Memorial Lecture at the 14th Indian Engineering Congress. It would be my endeavour to highlight the challenges and opportunities faced by the engineers of the Indian Air Force and also to give you an insight into the higher level engineering management in the Indian Air Force.

I am sure you would be pleasantly surprised to hear that the Indian Air Force employs about 5000 engineers — 95% of whom are graduates and post-graduates, Recently we have inducted a number of women who have done their engineering.

INTRODUCTION

At the outset I would like to give you a general idea of the Indian Air Force. We are the sixth largest airforce in the world operating more than a thousand flying machines, apart from missiles and radars. The Indian Air Force operates at the frontiers of technology employing state-of-the art equipment. The inventory of the Indian Air Force consists of

- Aircraft-Fighters, Transports, Trainers and Helicopters;
- Missiles-Surface to Air, Air to Air, and Air to Ground;
- Radars;
- Communication Equipment;
- Airfield aids;
- Specialist vehicles and common user vehicles;
- Ground and Test Equipment.

The IAF mans more than a hundred airfields and helipads which are equipped with modem navigational and landing aids. The cost of the inventory of the IAF will be over Rs 50 000 crores. The IAF has to operate over very hostile terrains in the Himalayas, North-East, Rajasthan desert and coastal India. It is the only airforce in the world which repairs and overhauls many of its flying machines and other equipment. The inventory of the IAF is sourced from different countries-Russia (erstwhile Soviet Union), the UK, France, Europe and the USA. This obviously brings in complexity of standards and approaches to maintenance. Because of its high cost, the inventory has to be maintained, updated and modemised over a period of 25 to 30 years.

The safety of aircraft is paramount. Procedures have to be built into the system to safegaurd against accidents

The spare parts in adequate need to be held for requirments in peace time as well as during hostilities/war. The operational equipment and spares need to be dispersed in various locations to minimize loss by enemy action. At the same time mobility is of extreme importance. The long lead time of supplies, of the order of 18 to 24 months, imposes a tremendous strain and responsibility on the provisioning and procurement group.

The training of engineers and technicians for maintaining the multifarious equipment in itself is a huge task. It needs to be recognised that for best performance it is essential that:

WEAPON SYSTEM CONCEPT

- The flying machine should be capable of performing at its best in terms of speed, maneuverability and weapon delivery.
- The weapons used must be the best.
- The pilots must be highly trained to exploit the capabilities of the flying machines fully. They must be highly dedicated.
- The engineers and technicians must be highly trained and dedicated.
- All other support systems need to function equally efficiently.

To achieve these objectives a weapon system concept has been introduced in the IAF to ensure that all links in the chain are equally strong and the system as awhile performs at its best all the time.

'The More We Sweat In Peace The Less We Bleed In War'

STRUCTURE OF THE LECTURE

It would perhaps not be possible to give a complete picture of the entire gamut of the maintenance activity in a short period of one hour. Hence, I intend to highlight the challenges faced by the engineers at the corporate level. I shall illustrate some aspects with my personal experiences. I shall cover the following aspects:

- Induction of a weapon system
- In service maintenance
- Repair and overhaul
- Provisioning and procurement
- Accident and defect investigation
- Indigenisation
- Quality Assurance
- Organisation

INDUCTION OF A WEAPON SYSTEM

The induction of a new weapon system into the IAF is a very complex process. From conception to planning to induction can take as much as ten years. Since the weapon system will be in service for over 25 years one can visualize a very large number of factors which need to be taken care of. To get the best value for money three or four weapon systems will be evaluated against the ASRs (Air Staff Requirements) and negotiations will be held at Government level after short-listing the firms. This is a very important stage where the following factors playa very important role:

- Performance of the weapon system against the ASR
- Availability of maintenance support including spares and the cost thereof
- Capability of updation and modernisation
- Training of pilots, engineers and technicians
- Proposals to set up manufacture in India
- Guarantees by concerned Governments

Engineers and pilots work together in the department which undertakes this task. A very deep knowledge of the various weapon systems under development all over the world and the capacity to critically analyze all factors and impartially judge goes a long way in the selection of the right weapon systems.

As regards cost one cannot go by initial cost alone-one has to workout the life cycle costs. We have to look into how reliable the support will be not only during peace time but also during hostilities. Having finally selected a weapon system a detailed contract is drawn up encompassing all the above aspects. The process of drawing up a detailed contract and finally being signed by both parties can take upto six months. Considering that the value of the contract can be as high as Rs 2000 to Rs 3000 crores savings of the order of 15% to 20% can be effected. Decision making at this level will have to be very quick.

Once a weapon system has been inducted it has to be maintained in service.

IN SERVICE MAINTENANCE

Firstly I would like to give you an overview of the servicing concept in the IAF. A flying machine's airworthiness has to be certified at different points in time. It involves inspections and interventions at specified intervals. Accountability and traceability are very important. Documentation, analysis of defects, supervision and quality assurance has to be built into the system. At the same time the maintenance man hours are to be kept to the barest minimum.

The servicing of weapon systems are broadly undertaken at four levels — first, second, third, and fourth. The first line encompasses activities which certifies the weapon system fit and airworthy for its operational role and equips it for the same. Launching the flying machine and recovering it comes under the ambit of first line. The second line encompasses activities which certify the equipment fit over larger periods-inspections of a deeper nature, readjustments, prevention against wear and corrosion, and repairs where necessary. Obviously work at second line takes much longer time compared to first line and requires greater expertise. In third line we undertake work which is beyond the capability of second line-mainly repairs due to accidents or defects, and modifications, and updations. Fourth line deals with overhaul of weapon system-essentially giving them a new life-in short rejuvenation. Engineering is at its highest glory at fourth line. Very sophisticated equipment are used. Very high skills are honed. Tremendous savings can be and are effected by meticulous planning and a high level of expertise.

The induction of weapon systems from different countries poses serious difficulties. The servicing schedules which specify what to do, and the worksheets which specify how to do, need to be recast as applicable to the trade structure of our technicians. We have a specific establishment to undertake this work — known as the Central Development and Servicing Organisation. Initial training, particularly abroad, can perforce be given only to a nucleus group. These personnel will not only be required to set up the facilities, and maintain the weapon system, but will also have to train other personnel. Typically the core group will consist of eight engineers and fifty technicians, which is gradually built up to about 1500 consistent with the build up of the equipment. The training is imparted at establishments specifically created for this purpose.

The aim of servicing and maintenance is to keep the weapon system in a high state of operational readiness at all times and ensure that its performance is as per laid down standards.

Since most of the systems are inducted almost off the drawing board, it has to be ensured that the engineers and technicians absorb the technology and maintain the state-of-the art equipment. On condition maintenance, use of built in test equipment (Bite), calibration of test equipment, accurate fault diagnosis, a high level of expertise-all these factors have to be built into the maintenance system in support of operations. While it no doubt puts tremendous strain on those who have to manage these systems, it is indeed a great pleasure to work at the frontiers of technology. For the weapon system manager it is tight rope walking all through. Maintenance costs and man hours have to be kept low at all times.

Calibration of test equipment is given the highest importance. Over the last ten years we have made considerable progress in optimising the master test equipment required for calibrating the in use test equipment. On site calibration facilities have been introduced which have brought about considerable savings.

At the operating units only those who are trained and certified as qualified can work on the weapon system. Continuous training and periodic testing and certification of personnel is an integral part of the maintenance activity. Senior Engineers and Chief Engineers at operational bases undertake this task. Resources have to be provided by experienced managers at Command and Air Headquarters.

REPAIR AND OVERHAUL

A weapon system inducted into the IAF comes up for overhaul after 8 to 10 years of service. Since most of the weapon systems are inducted off the drawing board, the manufacturer himself would not have finalised the overhaul schedule and procedures. He would await feedback from the users. The environment in which the equipment is operated significantly affects the condition of the equipment. In India particularly we have a dusty, hot and humid environment-all are bad for the equipmemt.

Considering these various factors a dialogue is initiated with the manufacturer after four years or so of induction, by which time we have a fairly good idea of the equipment. Likely arising are worked out. Requirement of jigs, tools, fixtures and test equipment are assessed. Where to locate the overhaul — in an existing repair depot or in a new one-is itself a very major decision. Preliminary negotiations, obtaining Government sanctions and final negotiations leading to contract finalisation takes almost five to six years. Some times the initial set of arisings have to be sent to the manufacturer — either because the facilities have not been set up in India, or because the manufacturer wants to examine these systems at the factory to finalise the overhaul schedules. In some cases we have found that it is not economical to set up overhaul facilities in India-because of low numbers and consequently low arisings it is not cost effective.

The process of setting overhaul facilities is again a very complex affair involving very large sums of money. We have to procure a large amount of jigs, tools, ground equipment and test equipment. The range of spares required will at least be 10 times as that required at first and second lines. A large complement of engineers and technicians will have to be trained in narrow areas of specialisation. The overhaul schedules of the manufacturer will have to be recast into simpler worksheets which specify what to do, how to do and what to record. What activities are to supervised at what levels and what information is to be collected for future analysis-will all have to be worked out in advance and updated periodically. The overhaul line takes about two to three years to stabilize, and thereafter, is functional for about 15 to 18 years. When one overhaul line closes down we try to ensure that another line is started-to achieve economies.

As regards aircraft and equipment manufactured by HAL the responsibility for overhaul is also given to HAL. All the resources generated for manufacture can easily be diverted for overhaul and thereby costs can be kept low. Also a large number of technicians becoming redundant on closing down of the manufacturing line can be retrained for working in the overhaul line.

Considering aircraft, helicopters and aeroengines alone the IAF, in the last 50 years has overhauled more than 2000 aircraft, 1000 helicopters and 5000 engines, saving considerable amount of foreign exchange.

One may think that rotation of personnel would have adverse effects. However, in actual practice the rotation of personnel from an overhaul agency to an operational unit, and vice versa, has resulted in skills upgradation of a very high order and has also promoted innovativeness. It has been clearly established that the cost of overhaul in the IAF is definitely cheaper. The emphasis on indigenisation has paid off significantly.

The entire repair and overhaul activity is managed by the Air Officer Commanding-in-Chief of Maintenance Command (AOC-in-C). This is the seniormost position for an engineer in the IAF, equivalent to a Secretary to the Govt of India. Within the IAF only the Chief of Air Staff (CAS) is above him. The policy making and implementation in the IAF is at Air Headquaters. On the engineering side it is managed again by an engineer of the rank of an Air Marshal-Air Officer-incharge Maintenance (AOM) who directly reports to the CAS. These two heads are totally responsible at the highest level for maintenance in the IAF.

PROVISIONING AND PROCUREMENT

A fighter aircraft normally has more than 1.5 lakh items built into it. The major equipment like aeroengines, hydraulic components, electrical and electronic items would be about 2000, the cost of which would be about 70% of the cost of the aircraft. Out of 1.5 lakh items about 25 000 can be used at first and second lines. Out of these not more than 2500 will be fast moving. The rest are termed insurance spares and their requirement though infrequent will have to be some how catered for. During overhaul the scenario is different. Out of about 60000 spareable items 10000 will be fast moving and the rest insurance tems. Considering that the IAF operates 30 types of aircraft and in addition various other equipment, the provisioning requirements of the IAF are indeed very complex, in fact mind boggling. Most of the items are long lead items which have to be ordered 18 to 24 months in advance. Talking the need to keep certain minimum stock levels at all times, one has to take action 48 months in advance. In between this period the equipment will be modified, updated etc.

The responsibility for stocking spares and distributing them to the units has been assigned to Maintenance Command. These stocks are held in various equipment depots and air store parks. Procurement is another very complex issue-particularly since the weapon systems are acquired from different countries. Urgently required items affecting operations are procured on a fast track procedure. In many cases we have to pay a premium for ordering small quantities. The responsibility for procurement has been divided between the AOC-in-C Maintenance Command and the AOM at Air Headquaters. This aspect of maintenance requires expert knowledge of the weapon systems. Laid down procedures will have to be followed keeping financial canons in mind. Close cooperation between the engineering and logistic staff is very essential. Provisioning and procurement have a direct bearing on operational readiness and cost savings.

ACCIDENT AND DEFECT INVESTIGATION

In spite of our best efforts accidents do happen. The cause of the accidents are:

o Technical defects
o Bird strikes
o Human error (aircrew, servicing crew and others)

There is a well oiled procedure for reporting accidents, incidents and defects as well as for investigating them. Remedial action is taken immediately after the cause of the accident is established. Highly qualified experts are associated in the process. Remedial measures can be one time actions, changes to servicing procedures, modifications etc. Repair agencies in India and abroad, DRDO etc are closely associated with the investigations. Whenever the need arises special teams are constituted to go into these aspects in depth. Recently the Ministry of Defence (MOD) constituted one such committee under the chairmanship of Dr APJ Abdul Kalam of which I was one of the members. We looked into the accidents over a 10-year period.

Amongst the many recommendations, one was to usher in simulators in a big way-for flying, maintenance and training. Since we are operating state-of-the art equipment which utilise materials and processes at the frontiers of technology there could be accidents due to technical defects. Employing fail safe designs and a high level of expertise can, however, prevent catastrophic accidents.

QUALITY ASSURANCE

Quality assurance is another important area of focus in weapon system maintenance. Quality assurance wings are independent of the production wings. Quality consciousness is inculcated at all levels. Periodic quality audits are ordered to pinpoint areas which need to be looked into.

INDIGENISATION

The subject of indigenisation has been foremost in the IAF over many years. Non-availability of spares from the manufacturers, foreign exchange crunch etc has been the driving factors. Small and infrequent requirements, stringent test procedures, risk of failure etc have been the main reasons for Indian firms to shy away from taking on this challenge. Ways and means are being constantly thought of to overcome the obstacles. Procedural wrangles are being ironed out to attract the Indian firms. Of late there is a welcome trend towards redesign using modern materials instead of reverse engineering.

A lot of attention is given to indigenisation at the highest levels.

ORGANISATION

In addition to the AOC-in-C at Maintenance Command and the AOM at Air Headquaters we have at the next rung Senior Maintenance Staff Officers at the various Commands who guide and oversee the maintenance activities at the operational bases and at the various repair depots. They are engineers with a rich experience at field and staff appointments.

CONCLUSION

Ladies and Gentlemen,

During this short period of an hour I have attempted to bring about an awareness to the engineering community at large represented by this august audience, the immense responsibilities shouldered by the engineers in the IAF. The engineer in the IAF faces many challenges, particularly at the corporate level. We need the best engineers to join the IAF. A challenging career, full of opportunities and a high level of job satisfaction awaits them.

I thank the President of the Institution of Engineers for giving me this opportunity to share my thoughts and experiences with all of you. I thank you all for your august presence and patient hearing.

The Twenty-sixth Bhaikaka Memorial Lecture was delivered during
the Fifteenth Indian Engineering Congress, Hyderabad, December 18-22, 2000

Managing Speed — an Aspect of E-Governance

Prof P N Murthy

Head, Systems Engineering and Cybernetics Centre
Tata Consultancy Services, Hyderabad

At the outset, I would like to thank the Council and the President of the Institution for inviting me to deliver this lecture in the memory of an illustrious engineer-humanist. People like Bhaikaka have made difference to the social context and surroundings in which they were active. They embedded themselves expansively into their environment. That is why we remember them and try to trace the footprints they left on the sands of time. I join all of you in paying homage to that great soul.

DIGITAL WORLD

We are in a digital world. Speed characterises this world. Ubiquitous information flows around shaking and shaping our physical and mental universes. We have to act, live and survive in this world. We, the humans, are the creators of this world. This world is the logo highlighting the ingenuity of the human being. This world is both enchanting and scaringly demanding'.

All our instincts and ingenuities, physical and mental resources are called upon to make an exciting, meaningful transition into this world of high speed. This world can be beautiful, if we can respond to it with attention, alacrity and alertness. It can sweep us off if one is caught unaware without the right adjustments. It can make us slaves to its charms. It can serve us if we get on top with proper value systems. E-governance is one of the tools of managing this world. One of the important features of e-governance is the 'Decision-making'. I want to explore in this lecture the many facets of decision-making.

E-GOVERNANCE

E-governance is a double edged sword. The usefulness of the tool depends on the user. There are many cases in corporate experience which can be called as failures in the use of e-biz and e-governance attempts. The IBM, GE and Microsoft took considerable pains to get the best out of this most modern concept in corporate administration. The tool integrates many operations and processes within the organization seamlessly. It conveys through its conduits loads of information, processed and raw, coarse and refined, confidential and open. Information can overwhelm if it cannot be handled properly. Information is defined in some contexts as one which changes a context through promotion of action arising out of a decision based on its processing into suitable patterns. It is known that quality of action determines the quality of results. So in e-biz and e-governance, managers must be able to handle the loads of information coming out characterizing multi-dimensional, and complex contexts and make decisions for actions. So the key is decision making. A typical e-governance chain is depicted in Figure 1 wherein one can see that the decision-maker is an important element of the chain. All the operations shown use IT for manipulation.

GOOD DECISION

What is a good decision'? The answer depends upon the emerging action and its goal. Good or right decision is one which leads to right action. Here for right action there is a benchmark laid down in the Indian tradition of intellectual and spiritual experience, ranging over millennia. This right action flows from a right actor. From right action, a universal purpose is served. Each is a benchmark in itself. Since decision flows out of human being, if that human being is a right actor, the decision flowing out of such a person will be the right decision.

Nowforthe benchmarks, the right actor is the divine worker performing divine actions in a mood of 'Yathaprapta Karyam', that is, the unintended, undesired and unexpected action, conditioned, controlled and regulated by his 'Dharma' (of the actor) in harmony with the dharma of the land and the natural law of becoming, that is, swabhava of the actor. The right actor always works as part of the closed loops of Dharma-inquiry-source triad.

Accelerated technological change, induced by the ability for adopting the technology that is created, induces a rapid change in the economic context of the society. The purpose of change masters of society should be to syncronise their action with the axis of developmental configuration. The change masters are to be found in industry, in government, in artists, in culture, in agriculturists and among political executives and law-makers. These change masters are deployed at various levels in the macro-micro cycle of development and at the various levels of a vision pyramid. The decisions and consequent actions of these change masters and the rest of the people in these various professions must be in conformity with the purposes of a society, i.e, development.

FIGURE 1 : A TYPICAL E-GOVERNANCE CHAIN GOOD DECISION

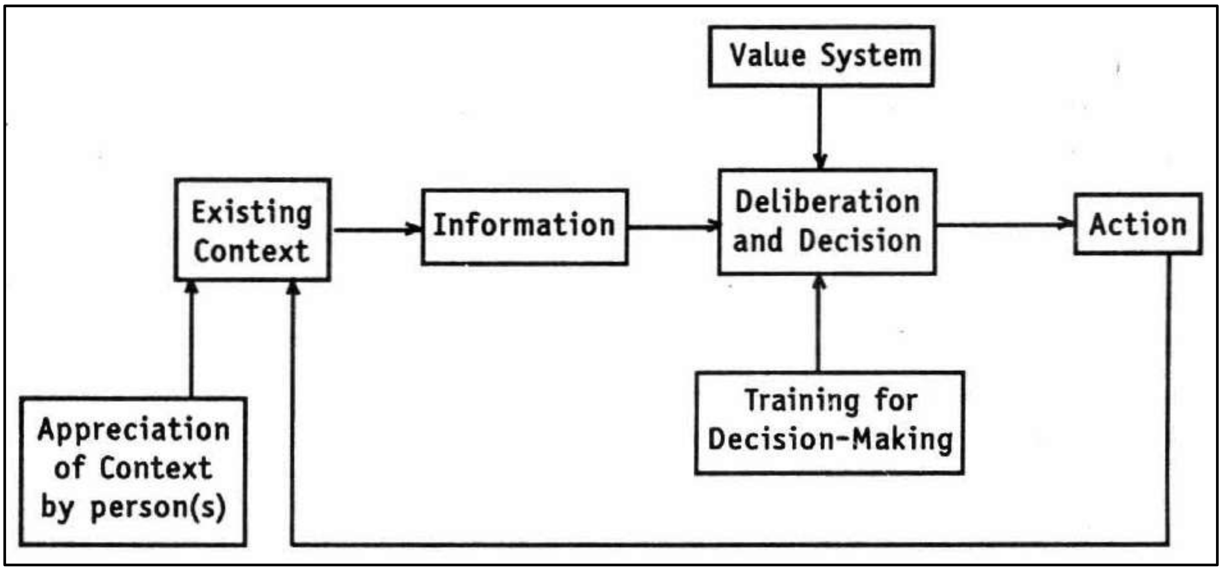
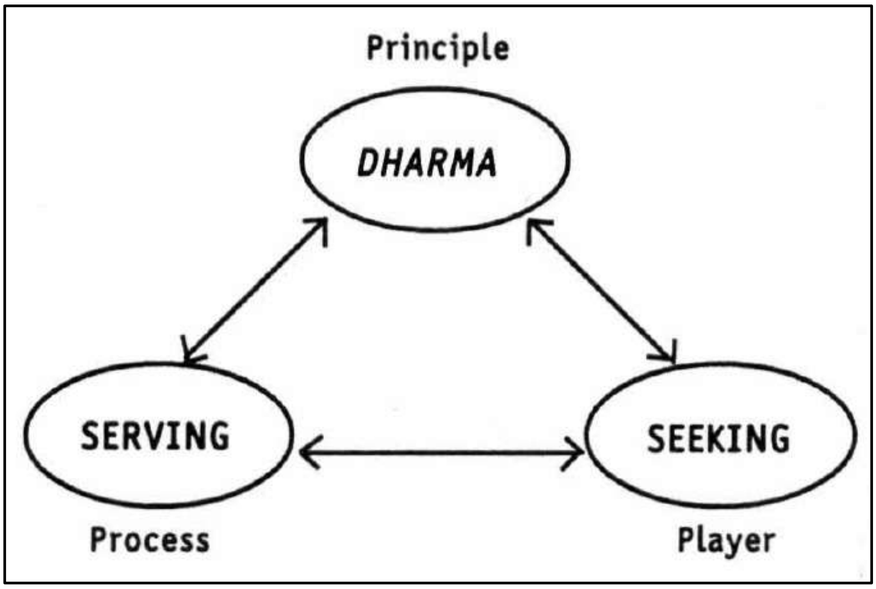


FIGURE 2 : TRIAD OF ORGANISATIONAL AND INDIVIDUAL ACTION



Evidently, social purpose is development: The context is the social complex; methods of understanding and manipulating the context should be in harmony with the purpose. These are the concerns involved in e-way of mastering and manipulating actions. Human being, — the decision-maker — should acclimatize himself to the acceleration impressed by information age and function in this to achieve the purpose of social development.

DEVELOPMENT

There are two aspects of this development (a) the goal of development and (b) the metrics of development.

Goal of Development

The goal of development seems to be the welfare of society. A succinct statement that is familiar to all of us : 'Loka Samstat Sukhlnah Bhavantu' (May the entire world be happy). There is an interesting definition of 'Loka' in the Upanishads (Taithireya). 'Athadhi Lokaml Prthuvipurva Rupam; Dyauruttra Rupam; Akasasandhih; Vayussandhanam; Ithyadhilokam' (Now about the world: Earth is the earlier form, sky is the later form; space/ether is the conjunction; air is the agent of conjunction; this is the world'). This is a holistic statement. Whatever happens to any part of the system affects every other part. A chunk in the ozone layer due to air that is polluted. Earth that is denuded - all these affect each other of the spheres: the atmosphere. the biosphere and the Earth. So anyone who is on Earth, living or otherwise, should be careful and adapt and organize his life with this holistic definition in mind. And so should the decision-makers. But today the word 'happiness' is limited to mean that which is given by money'.

Metrics of Development

There are many definitions and metrics of development floating around like per capita income (PCI), GDP growth rate, human development index, etc. The latter is now promoted by the World Bank. I would like to suggest an understanding of the human development through the idea of 'Purushartha' of Indian social and philosophical tradition. These are Dharma, Artha, Kama and Moksha. From these, one can derive the five qualities of development: Quality of scientific inquiry (including spiritual and religious knowledge); Quality of philosophical debate (including media, etc.); Quality of appreciation of emotive life (culture, arts, literature, institutions like family); Quality of governance (social laws, ethics, political institutions); and the Quality of material concerns and life (PCI, productivity, wealth creation, etc.). One can see that the last is the one on which the most emphasis is laid.

Development Process

Development is a macro-micro interaction process as shown in Figure 4. The arows indicate the processes of their mutual interaction. A government operates at both ends. While at the policy level, it acts to influence and manipulate the macrolevel parameters like GDP. interest rates, etc. Its entire executive machinery intervenes at various levels down to the microlevel, translating the policy into various activities. The effects of intervention will throw up many parameters that are not addressed and the upward influence to the macro-level takes place through again governmental, executives processes and procedures. In a problem solution mode. this can be reprt:sented as in Figure 3. The influence channels in Figure 2 and Figure 3 are the ones which are the e-governance channels. But at every level. They are modified by the human decision-makers except where the decisions are highly quantitative. The micro-level is generally highly quantitative and bears total numerical quantification. Further, the channels can be clogged or weaken or broken as in a developing country. The only way to overcome is by the ingenuity and integrity of the person handling the information.

MANAGERIAL HIERARCHIES

The most generalised managerial hierarchy can be visualised through a vision pyramid as depicted in Figure 5. For an organization to be effective leader, managers are required at every level. Except at the lowest level, information cannot be reduced to quantitative techniques. Also the accuracy and quality of information and data influence the higher level appreciation and policy formulation. So the decision-maker has to contend with fast information arrival and necessity to comprehend and building mental models for action at the rate of the speed of thought. It requires considerable mental training both in terms of knowledge and appreciation of the patterns. and constant need for alignment of decision and action with agreed purposes of the organisation.

FIGURE 3 : PROBLEM SOLUTION LOOP IN A COMPLEX

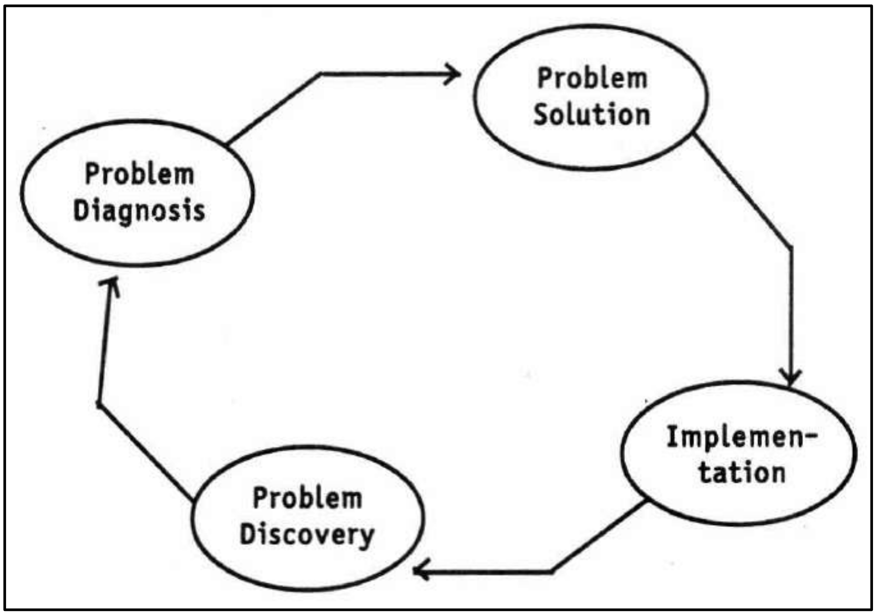


FIGURE 4 : DEVELOPMENT AS A MACRO-MICRO INTERACTION PROCESS

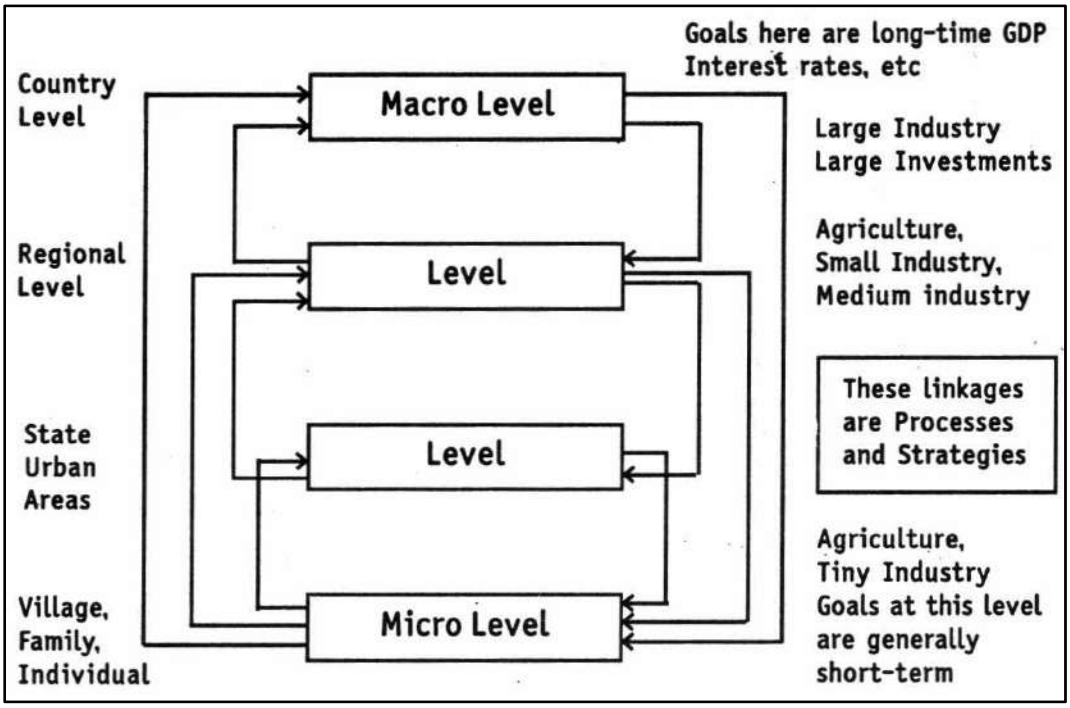
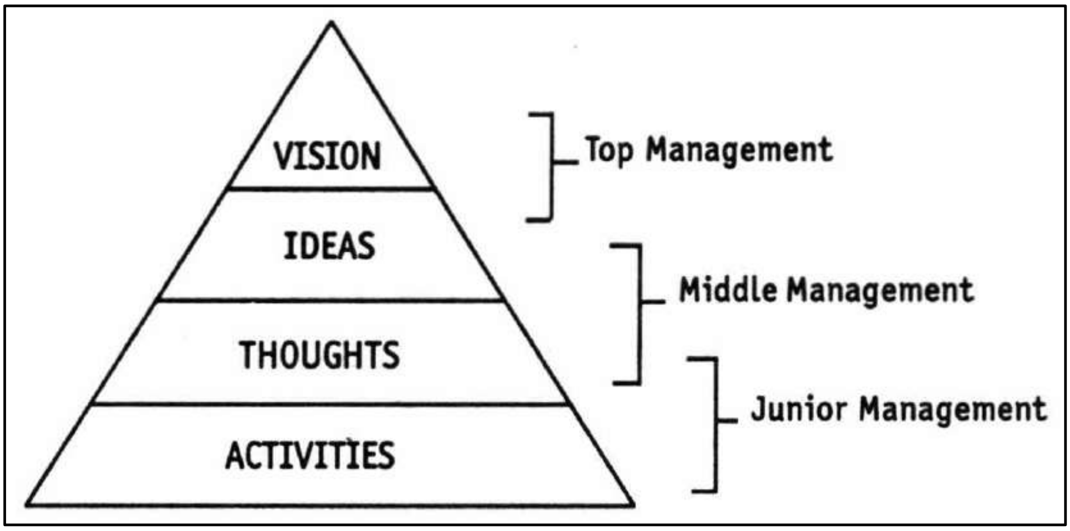


FIGURE 5 : VISION PYRAMID SHOWING A MANAGERIAL HIERARCHY



THE PRESENT CONTEXT

The context in a developing country is different from that of a developed country. The wealth distribution pattern, however, is same in both countries with the difference that the bottom line income levels is very low in a devel oping country. In some cases, like India, the threshold level for self-propelled economic growth is also not reached. In such cases, the manager will find it difficult to create and implement policies. The pattern of wealth distribution seems to be :

Top 5% of population	- 33% of wealth
The next 11% population	- 33% of wealth
The next 84% population	- 33% of wealth

This is true of both USA and India. It is said that this pattern is essentially due to IT industry. So there is a digital divide within a country. Further, there is a digital divide between other countries and the US. So there is a digital divide between countries and digital divide within a country already plagued by inequity. One of the important features of the present-day technology driven economy is that technology creation and technology adoption are almost simultaneous. In a free market, this is a dangerously high speed activity - Business at the rate of speed of thought, which can be self destructive. This is now seen in behaviours of stock markets and dotcom companies. Some of the companies are quoting at high levels on the markets even though they are yet to make profits. So a paradigm shift in investor thinking and shareholder value is taking place. Many heads are rolling on the way too fast for even attempting to perform in the long run. CEOs are forced to running against the stream to catch up.

In this milieu, the case of India is strange. India has the software skills and USA has the software economy. The irony of it is that the short-term goals of individuals and companies are creating short-term, stock-based wealth with long-term effects of inequity in wealth distribution. Money is playing its deceitful role of accumulation at some points leaving many in a highly unequal condition. Stock markets are playing a speculative role instead of being the indicators of the health of markets and economies.

Short-term goals are controlling the society at both ends of the spectrum. At the lower end, too many people chasing too few (high-end) jobs with the result that there is increasing money-power exchange in an already endemically corrupt society. At the higher end, there is shortage of skills.

Further the possibility of American economy slowing down is looming large overthe horizon. This may mean that the US loses its capacity to serve as a marketplace for the goods of other countries.

India's present overall scenario can be defined as follows: India is trying hard to move forward economically; There is a movement for reforms in progress; Environments are becoming increasingly turbulent; Technology is driving the economy; Society has become generally acquisitive; Large lumped groups are active around the world; Small perturbations are causing great global disturbances; and Confrontation, confusion and complexity characteristics are 'individuals environment'.

This is clearly a 'chaos' situation. Order out of this 'chaos' will be through transition structures with several intermediate bifurcations (Society is choosing a new structure of less complexity). So these times are different for both political and other executives. While the e-artifacts and networks help in resolving the issues, they are only conduits of information flow. The stress is therefore, on decision-making.

DECISION AND DECISION-MAKER

A decision will be influenced by the nature of the decision-maker, his value system and short-term and long-term purpose of an organization. A person acts according to his basic nature called 'swabhava', his value systems and beliefs (i.e. what he considers as his 'swabhava') and his ability to react to the contextual computations and his ability to understand and appreciate the organizational cultures. Therefore, a decision coming out of a person will be aligned with his nature.

If one understands the human dynamics, there are three types of persons according to Bhartrihari, 12 major types according to Geeta - refer to the Table 1, and four types according to Human Dynamics Group. In addition in terms of response to context, nearly 60 per cent are fence sitters who act value neutral, even through they hold some value system. About 20 per cent try to fight for their beliefs but will give up soon. About 20 per cent hold fast and act according to their beliefs, good or bad.

The fence sitters are a major problem in any large organisation. They can make or break a system by their ineptitude and unwillingness to commit. They become ineffective and incompetent decision-makers in a high-speed situation like e-governance. If they see a leader, they will immediately fall in line. IT can never reduce the effect of these people. The quality of decision will be a causuality. IT can make these people irrelevant in the large. But they can easily clog the network.

There will always be leader managers at every level. These can enhance the efficiency of the system with IT in place. So what matters is the of quality of decisions that these people can make. A decision-maker has to tolerate the velocity of information and be quick in assessing the inputs and makeup his mind. Can he do that? Many cannot, unless it is routine for which there are precedents, traditions and rules.

This is a matter of great concern, particularly if such people are at the top. They have to deal with three types of decisions involving varying degrees of risk: (a) Decisions with long-range effects demanded in a short time; (b) Decisions with long-range effects allowed sufficient time; and (c) Decisions with immediate catastrophic consequences to meet catastrophic contexts (In a situation of chaos, most of these fall into this category).

CONCLUSION

The main problem in development is to enthuse people, draw them into the stream of ideas and entrepreneurial activity, leaving aside (shedding) their sense and mood of cynicism and despair. To instill a sense of positive approach, to resolve their problems and work towards aspirations, is the main task. IT can stir their ambitions and aspirations and spur them onto the path of building their lives.

In India, everything seems to sink into degrading despair. Common people are moved by some short-term benefit. They are rarely moved by altruistic statements. This is something to be realised. Long-term goals are always supported by short-term steps. These steps must be yielding results which sustain the movement to the long-range goal. In terms of cybernetics, microlevel achievements influence the macro-level broad goals of a society and vice versa. The individual should take the micro-level step for the society to reap the macro-level goal of prosperity, which in turn should generate the right micro-level movement. This is the cycle of development. The IT and the e-governance can help this.

The problem is that the velocity of information about wants with speed of event forces speedy response from these decision-makers. Any wrong move can flare up into a flame of disturbance. Lumpen groups will try to take advantage of situations only. Leader-managers with courage of conviction, with a historic and intuitive appreciation of problems, can handle these situations. Right action will flow only form a right decision.

A qualitative chain of relations is: Speed of occurrence $\rightarrow$ Speed of information $\rightarrow$ Speed of decision $\rightarrow$ To match speed of information.

Those who have operated and handled situations like a calamity would appreciate the above chain. This does not mean that all the time there is a calamity at the doorstep. But the speed of information flow, particularly at the higher levels of management, carrying with it loads of uncertainty gives the character of something imminent. With events moving at speed of thought over the Net, this character is to be expected. Then the manager gets into a situation where he is forced to take a decision with his thinking suspended or ignored. This is a situation close to 'Silencing the Mind'. Most of the strains and the pressures that are felt by managers are due to this need to make decisions at the speed of thought. Furthermore, the complex nature of the problems posed needs a holistic, compassionate, coherent view of the problem. How does one do this? The best way is to bring his intuitive abilities to the force and combine them with the IT help. The style of management has to change.

Managing speed requires managing oneself. To manage resources towards right goals requires value-driven human beings and not mere machine-like human resources.

'JOHAD' — a Structure of Community Self-Reliance

Shri Rajendra Singh

Head
Tarun Bharat Sangh, Jaipur

On the night of 2nd October, 16 years ago, when I got on the bus from Jaipur to Bheekampura with four of my friends, we only had a single agenda, which was 'to fight injustice against the people' and we only knew one way to do it, by spreading literacy in the villages. So we promptly started a literacy drive.

But the people suffered from a severe scarcity of water. The region that once sustained the eco-system of the 'Aravalli' had become barren. It was rare to find young people in the villages, all of them had fled in search of employment, women trudged long distances to fetch a mere pot full of water. Crops failed regularly, lack of vegetation led to soil degradation, monsoon runoff washed away the topsoil. I remember there was not a single blade of grass in the region and we often stumbled on the carcass of cattle. Barely 3% of cultivable area was irrigated. Life was difficult and hardship endless.

One day, Mangu Lal Patel, the wise old man of this village told me 'we do not want your literacy, we want WATER'. But where was the water? I did not know anything about water.

Mangu explained to me about the rich tradition in this region of building 'johads', which were a prime example of the ingenuity of inexpensive simple traditional technology that was quite remarkable in terms of recharging ground water of the entire region. 'Johads' are simple mud and rubble concave shaped barriers built across the slope to arrest rainwater with a high embankment on three sides while the fourth side is left open for the rainwater to enter.

The height of the embankment is such that the capacity of the 'johad' is more than the volume of run off coming from the catchments based on a rough estimation of maximum possible run off that could come into it. Therefore, the height varies from one 'johad' to another, depending on the site, water flow, pressure etc. In some cases to ease the water pressure a masonry structure called 'Afra' is also made for outlet of excess water. The water storage area varies from two hectares to a maximum of 100 hectares.

The water collected in a 'johad' during monsoon is directly used for irrigation drinking and other domestic purposes. The advantage of this structure is that apart from arresting and storing rainwater, is in improving moisture level at the sub-soil level in the field, particularly in down stream areas, which recharges ground water and wells.

The distinctiveness of this structure is that it is based on simple and cheap technology with locally available labor and material. All the estimations are based on villagers experience and intuition, without any physical measurements.

When I went to Bheekampura in 1985, this unique traditional water management system was still alive in the collective subconscious of the people but as ecological management had been takeover by the State, the people remained alienated from the local environment. On the advise by Mangu Patel, we became a catalyst to building 'johads', the local authorities were dead against us as we by-passed all bureaucratic channels and dealt with the people directly to fulfill their requirements in the manner they decided.

The first 'johad' took three years to build, in the fourth year we built 50 'johads', in the fifth year we built almost 100 and this year we built a 1000 water structures and in total we have built 4500 'johads' in 1050 villages.

No engineer was called for consultation; we were guided entirely by the traditional wisdom of the people who have maintained the ecological balance for generations. These water structures were built with the active participation of the community in its construction from identification of the site to the design of the structure and by contribution in the cost of its construction and later in its maintenance, which ensured that all the structures were need based.

As a result, water became abundant; more water meant better crops, better conditions of soil, education and rich community life. It helped forestation in the area and development of wild life. Five rivers of the region started flowing perennially after decades of drought, a direct result of the increase in the water table due to recharging ground water of the entire region through numerous projects of small traditional 'johads'.

Prosperity retuned back to the region, agriculture became productive and due to availability of fodder cattle rearing started, resulting in increased production of milk. Higher water levels also meant less money on the diesel for pump set. In 1985 only 20% of the agricultural land was cultivated, now it is 100%, and villages started selling surplus grains in market for the first time. Studies have shown that an investment of Rs 100 per capita on a 'johad' raises the economic production in the village by as much as Rs 400 per capita per annum.

As villages mobilized themselves to improve their quality of life by contributing in building 'johads', this participation of the people promoted the community to become self-reliant optimizing social cohesion and emotive bonding in the community. Since, people realized that members were responsible not only for individual but also collective action, they becamemore awareof their rights taking on an activist stance to stop employment of children in the carpet industry and fought a legal battle up to the Supreme Court of Indian to stop indiscriminate mining on forest land.

An enlightened and active community also enforced self-discipline for the common good of the village. They strictly enforced their own rules to stop deforestation, hunting wild life and consumption of liquor. The development of community participation through the 'gram sabha' or village assembly, gave each and everyone an opportunity to freely discuss, decide and implement a common decision taken for the general benefit. This process also made them reflect on the problems of others in their community and help each other in solving them. While the community became active in social and economic change, the crime rate dropped in the villages as economic conditions Improved, education and health consciousness was createdand overall quality of life improved of the entire region.

This momentum in the community caused by the construction of 'johads', has encouraged the villagers to go further looking for innovative methods of social change. Now the greatest challenge before them is to sustain those traditional values that started this movement in the face of the transformation of the community due to progress and prosperity.

EMPOWERMENT

When we work on people's priorities one important process takes place. The centre of power shifts from the establishment to the people because people's decisions take front seat. This amounts to empowerment of people. However this empowerment, if it impinges in any way on self-interest of the powerful elite, will be opposed. This empowerment in these circumstances will not take place without struggle or community joint action. We as NGOs cannot fight it out unless the community is fully involved.

Therefore, we can say that for community leadership to be effective among its constituents, this shift, this empowerment, is essential. People should be able to decide on their own priorities znd imp!ement them. This can be illustrated by example of formation of Arvari Sansad.

ARVARI SANSAD (PARLIAMENT)

From 1986 onwards we have been helping people to build johads. These johads are traditional earthen dams. These small scale, low-cost structures do not look like very much, but taken together in hundreds and thousands they have changed the face of our part of India. TBS has helped people build almost 4500 johads, check dams and like structures for water harvesting. In 1995 we were amazed to find Arvari river flowing even at the peak of summer. We had been building these structures over the years in the catchment area of this river without realizing that we were in fact recharging the river through percolation underground. Since then four more rivers have become perennial.

When there was plenty of water in Arvari, there was natural growth of fish which went on multiplying. Seeing this the government wanted to get hold of fish and brought in a contractor. The people resisted and the Government had to cancel the contract. It is not that the local people wanted control over the fish. Far from it, they are all vegetarians and do not eat fish, but they realized that today it was fish and tomorrow it would be water. The government through the contractor was intruding into community's domain, its right over the use of water. Water as a resource was developed by them and they wanted to have full control over it. If they had allowed that intrusion to succeed, the leadership would have failed the community to protect its right aver water. But since they resisted and won, one can see the shift in the centre of power as far as control over use of Arvari water is concerned.

Then there was fear that intrusion having taken place once could take place again. Besides there were differences over sharing of Arvari waters within the community. This led to the formation of Arvari Sansad (Parliament) representing 72 villages and it has framed 11 rules for use of Arvari water. This Parliament meets 4 times a year. God willing, this Parliament will have its own building and a temple before long.

In this example, you see community leadership in action in protecting a resource. First, people work on their priority, ie, water, and develop this resource through rain water harvesting.

Second, when resource is fully developed there is an intrusion to demolish the concept of people's right over water.

Third, community puts up a strong resistance and removes intrusion. Fourth, community consolidates and takes responsibility. It gets a mandate from 72 villages.

Finally, a lesson — the community initiated work unites people and builds bonds of cooperation between different constituent groups.

In all this, workers of TBS function as facilitators with leaders of gram sabhas. The people come out stronger when working through their gram sabhas and their leaders. But all this is possible when every member of village community has a feeling of ownership. This feeling of ownership is very important and is a product of one's contribution, participation and sharing.

CONTRIBUTION

One most critical ingredient in building leadership and management of resources is the contribution the leader and each member of his community makes. When we are making 'johads', contributions of each section of the community has to be decided. As a matter of policy, TBS will not associate itself with any structurel building till contribution aspect is sorted out. Contribution may come in the form of free labour from poorest of the poor or cash from the better off. This contribution determines participation and the ownership of the resource being developed. When we are dealing with very poor communities, it becomes very difficult to convince people to make contribution. There have to be series of dialogues with them, till they agree. Beneficiary contribution used to be 25% of total cost initially, but it now varies between 35% and 75% depending upon benefits that will accrue to the concerned people. And of course there are cases where people have built structures themselves and asked for technical advice only from us. Contribution involves the concept of ownership, of asset created, and if one owns an asset created and if one owns an asset, he will ensure its long term safety and maintenance.

TECHNICAL TRAINING

We have 45 workers on our staff who have responsibility for works in different areas of Rajasthan. We get requests from other States of India for advice and we depute these workers. These workers are picked from villages where we have worked. They are hard core village youth. In the past we tried to employ welleducated urban youth, but since facilities they are used to are not available in villages, they left after a few months. Most of our present workers have studied upto high school in village schools and we provide training, exposure and work experience on sites. Our creed is 'Do not expect others to do what you cannot do yourself', a learning-by-doing technique at the geographical site. They have to examine:

- detailed features of the landscape
- catchment area
- the reservoir for storing water
- suitable site, if a new one
- soil type
- the possible benefits

Some years ago we ran training courses also for our workers to impart technical knowledge. Duration of this training varied from 6 to 9 months. Today these workers are as good as any, if not better, as far as building of water harvesting structures is concerned.

GRAM SABHA AND BHAONTA VILLAGE

Promotion of village institutions to look after works during implementation and maintenance is also responsibility of our workers. And the primary institution in this respect is gram sabha (village representative body). Earlier we had problem with women joining and participating in gram sabha activities, but gradually male resistance to their participation got softened.

In Bhaonta village, gram sabha is very active and women have formed a Mahila Mandai (Women's Committee) for themselves. This Mandai works as an associate to gram sabha and discusses problems specific to women as well as to voice general concerns. The gram sabha of this village is very progressive and received an award of Rs 100000 from the President of India for being most friendly to the environment. A senior worker of TBS belongs to this village. This gram sabha is known for high degree of awareness on water, land and environment issues, and has a development fund of its own for maintenance of structures, etc.

Gram sabhas generally have following functions to perform:

- Meet once a month on Amavasya (new moon night)
- Make rules on cutting of trees, protection of pastures, forest lands, use of water, crop patterns, alcoholism etc
- Punishment for breaking rules
- Building a fund for future development or maintenance needs.

Here TBS may help but does not run gram sabhas. TBS has also instituted a Friend of Trees Award which is given annually to ecofriendly active gram sabhas.

PADYATRA

There are times when you can find workers of TBS and men and women leaders from different villages going round for weeks from village to village carrying banners and shouting slogans about conserving water, saving forests and planting trees. In the evenings where they halt they talk of ways to make gram sabhas effective with local people. These footmarches have become popular and more and more people want to join them.

Where the literacy is low and people poor, this tool is very effective in establishing communication.

JOHADS AND DROUGHT

Rajasthan is a drought-prone state and there are years when rains are half of average rainfall. And one of the main features of our johad building activity is that villages which have built water harvesting structures are able to withstand the rigors of drought much better. When we started working, our area was classified as 'dark zone' by the government. By 'dark zone', they imply it has severe water shortage and underground water table has receded to difficult depths. The same area after 10 years of our work on johads was classified as 'white zone' which means it does not need attention of Government during drought and its underground water levels are satisfactory.

REGENERATION OF VILLAGE NIMBI

Nimbi is a village near Jaipur. Its land had been overtaken by sands shifting from the Thar Desert in last 100 years. About 200 years ago a big tank was constructed but it had become non-functional due to silting. In 1996, after TBS was approached by people from this village, Nanak Ram of TBS took charge of the action plan. The tank was desilted and repaired. The good monsoon of 1996-97 did the rest, leaving a massive reservoir of water. The next three years saw low rainfall but Nimbi's reservoir literally pulled this village out of acute poverty. Moisture content of soil increased and agriculture prospered. Today millions of rupees worth of vegetables and fruits are exported to urban areas, and the Jaipur Dairy sends its van regularly to fetch milk. Till five years ago this village had nothing to sell except its labour to the outside world.

GET RESULTS

Here, I would like to quote an American management guru*.

'Good intentions, good policies, good decisions must turn into effective action ...... Work is not being done by having a lovely plan. Work is not being done by a magnificent statement of policy. Work's done when it's done. Done by people. By people with deadline. By people who hold themselves responsible for results'.

What Mangu Lal Patel told me in 1985 was no different. He simply said, 'Do not talk too much. Dig tanks and build johads. You will get results'. I now invite you to Rajasthan to see the results yourself.

----

*Peter Drucker: Managing the Non-Profit-Organization

Reforms in Hydropower Sector

Shri Yogendra Prasad

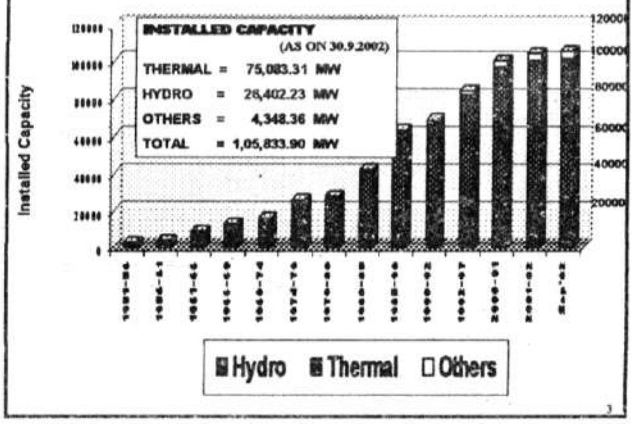
Chairman & Managing Director
National Hydroelectric Power Corporation Ltd

INDIAN POWER SCENARIO

• INSTALLED CAPACITY	1,05,833.90 MW (AS ON 30.09.2002)
• GROSS GENERATION (2001-2002)	515 BUs
• PEAKING DEMAND	81,555 MW
• ENERGY SHORTAGE (2001-2002)	7.5%
• PEAKING SHORTAGE (2001-2002)	12.6%

2

GROWTH PROFILE OF INDIAN POWER SECTOR



3

SECTOR WISE INSTALLED CAPACITY IN MW

As on 30.09.2002

	HYDRO	THERMAL	WIND	NUCLEAR	TOTAL
STATE	22777	39598	63	0	62438
PRIVATE	576	9149	1565	0	11290
CENTRAL	3049	26337	0	2720	32106
TOTAL	26402	75084	1628	2720	105834

SOURCE: CEA

4

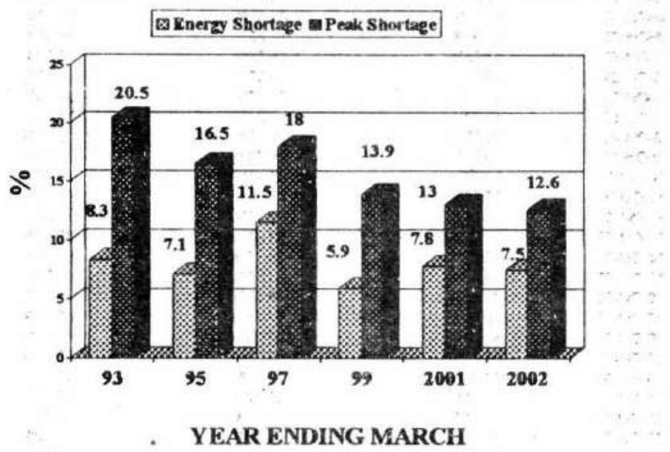
PROJECTED POWER DEMAND IN INDIA

REGION	ENERGY REQUIREMENT (Mkwh)		PEAK DEMAND (MW)	
	2006-07 End of 10th Plan	2011-12 End of 11th Plan	2006-07 End of 10th Plan	2011-12 End of 11th Plan
NORTHERN REGION	220820	308528	35540	49674
WESTERN REGION	224927	299075	35223	46825
SOUTHERN REGION	194102	262718	31017	42061
EASTERN REGION	69467	90396	11990	15664
NORTH-EASTERN REG.	9501	14061	1875	2789
A&N ISLANDS	236	374	49	77
LAKSHADEEP	44	70	11	17
ALL INDIA	719097	975222	115705	157107
INSTALLED CAPACITY REQUIRED (MW)			165293	224439

SOURCE : 16TH EPS

5

ALL INDIA DEMAND AND SUPPLY GAP



6

DAILY SYSTEM FREQUENCY EXCURSION BEYOND THE DESIREABLE BAND OF 49.5 HZ TO 50.5 HZ FOR THE MONTH OF SEPT'2002

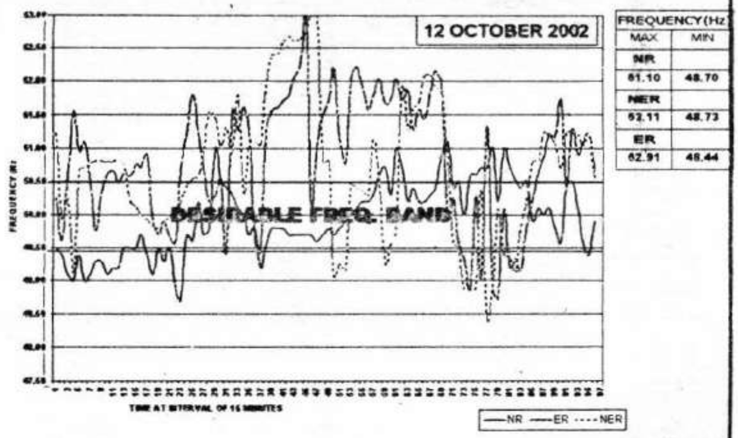
DATE	NORTHERN REGION	NORTH EASTERN REGION	EASTERN REGION
1-Sep-02	17.71%	59.38%	58.33%
2-Sep-02	22.92%	56.25%	59.38%
3-Sep-02	7.29%	63.54%	64.58%
4-Sep-02	27.08%	67.71%	71.88%
5-Sep-02	25.00%	56.25%	57.29%
6-Sep-02	13.54%	68.75%	65.63%
7-Sep-02	19.79%	65.63%	62.50%
8-Sep-02	16.67%	72.92%	69.79%
9-Sep-02	19.79%	64.58%	65.63%
10-Sep-02	18.75%	69.79%	73.96%
11-Sep-02	20.83%	86.46%	82.29%
12-Sep-02	19.79%	71.88%	76.04%
13-Sep-02	34.38%	58.33%	51.04%
14-Sep-02	28.13%	35.42%	41.67%
15-Sep-02	28.13%	51.04%	52.08%
16-Sep-02	20.83%	62.50%	62.50%
17-Sep-02	20.83%	60.42%	60.42%
18-Sep-02	18.75%	43.75%	43.75%
19-Sep-02	29.17%	48.96%	50.00%
20-Sep-02	12.50%	48.96%	55.21%
21-Sep-02	8.33%	81.25%	80.21%
22-Sep-02	44.79%	84.38%	83.33%
23-Sep-02	27.08%	55.21%	63.54%
24-Sep-02	48.96%	68.75%	72.92%
25-Sep-02	47.92%	81.25%	76.04%
26-Sep-02	37.50%	68.75%	66.67%
27-Sep-02	37.50%	81.25%	79.17%
28-Sep-02	57.29%	65.63%	62.50%
29-Sep-02	29.17%	53.13%	58.33%
30-Sep-02	42.71%	66.67%	57.29%
AVERAGE	26.77%	63.96%	64.13%

DAILY SYSTEM FREQUENCY EXCURSION BEYOND THE DESIREABLE BAND OF 49.5 HZ TO 50.5 HZ FOR THE MONTH OF OCT'2002

DATE	NORTHERN REGION	NORTH EASTERN REGION	EASTERN REGION
1-Oct-02	40.63%	70.83%	71.88%
2-Oct-02	17.71%	85.42%	84.38%
3-Oct-02	47.92%	71.88%	75.00%
4-Oct-02	43.75%	65.63%	66.67%
5-Oct-02	65.63%	39.58%	46.88%
6-Oct-02	29.17%	71.88%	69.79%
7-Oct-02	46.88%	57.29%	54.17%
8-Oct-02	81.25%	56.25%	70.83%
9-Oct-02	30.21%	65.63%	71.88%
10-Oct-02	31.25%	65.63%	71.88%
11-Oct-02	62.50%	77.08%	86.46%
12-Oct-02	33.33%	71.88%	75.00%
13-Oct-02	22.92%	81.25%	86.46%
14-Oct-02	16.67%	94.79%	93.75%
15-Oct-02	14.58%	87.50%	90.63%
16-Oct-02	44.79%	68.75%	67.71%
17-Oct-02	45.83%	67.71%	63.54%
18-Oct-02	50.00%	38.54%	43.75%
19-Oct-02	35.42%	58.33%	62.50%
20-Oct-02	26.04%	51.04%	45.83%
21-Oct-02	9.38%	52.08%	47.92%
22-Oct-02	37.50%	61.46%	58.33%
23-Oct-02	19.79%	50.00%	59.38%
AVERAGE	37.09%	65.67%	68.03%

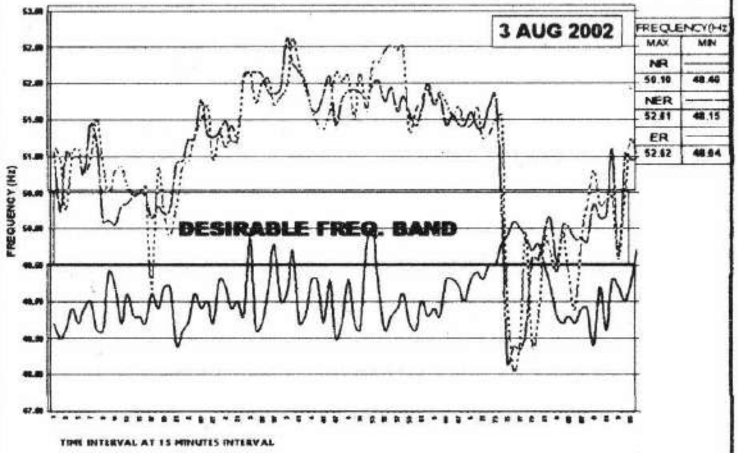
8

TYPICAL OPERATING FREQUENCY CURVES FOR NORTHERN, NORTH EASTERN, EASTERN REGIONS



9

TYPICAL OPERATING FREQUENCY CURVES FOR NORTHERN, NORTH EASTERN, EASTERN REGIONS



10

REFORMS – THE NEED

- PER CAPITA CONSUMPTION OF ELECTRICITY IS ONE OF THE YARDSTICKS OF ECONOMIC DEVELOPMENT
- INDIA'S PER CAPITA CONSUMPTION IS ONE OF THE LOWEST IN THE WORLD – LESS THAN 400 KWH PER ANNUM
- GAP BETWEEN DEMAND & SUPPLY OF RELIABLE & QUALITY POWER INCREASING
- ESTIMATED COMBINED FINANCIAL LOSS OF STATE UTILITIES IS OF THE ORDER OF Rs. 26,000 Cr. PER ANNUM WHICH IS BOUND TO INCREASE FURTHER WITHOUT REFORMS IN POWER SECTOR
- HEAVY T&D LOSSES
- GRID POWER STABILITY NOT SATISFACTORY
- ADVERSE HYDRO THERMAL MIX

11

OBJECTIVES OF POWER SECTOR REFORMS

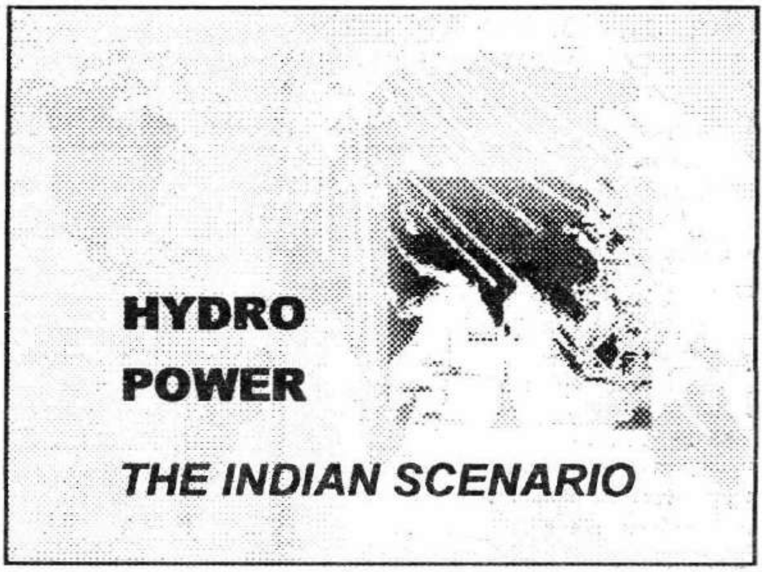
- To Provide Power on demand by 2012
- To make the sector commercially sound and self sustaining
- To provide reliable and quality power at an economic price
- To achieve environmentally sustainable power development

12

REFORMS REQUIRED IN POWER SECTOR

- UNBUNDLING OF SEBs INTO GENERATION, TRANSMISSION & DISTRIBUTION COMPANIES AS INDIVIDUAL INDEPENDENT ENTITIES TO RUN ON COMMERCIAL BASIS
- AUTOMATIC REVISION OF TARIFF WITH TIME
- REMOVAL OF SUBSIDIES
- CONCENTRATED EFFORTS TO REDUCE T&D LOSSES AND THEFTS

13



HYDRO POWER IN INDIA

TOTAL POTENTIAL ASSESSED BY CEA

A) AT 60% LOAD FACTOR	:	84,044 MW
AS INSTALLED CAPACITY	:	1,48,700 MW
B) PUMPED STORAGE SCHEMES	:	93,920 MW
C) SMALL HYDRO	:	6782 MW
TOTAL	:	2,49,402 MW
INSTALLED CAPACITY DEVELOPED	:	26,402.23 MW *(As on 30.9.2002)*
UNDER DEVELOPMENT	:	12,800 MW

SOURCE: CEA

15

HISTORY OF HYDROPOWER DEVELOPMENT IN INDIA

FIRST HYDRO POWER PROJECT

NAME	SIDRAPONG HYDEL POWER STATION
CAPACITY	2 X 65 KW
LOCATION	DARJEELING
YEAR OF COMMISSIONING	1897 (10TH NOV.)

IN FIRST 50 YEARS I.e. UPTO 1947

TOTAL CAPACITY INSTALLED	-	1362 MW
HYDRO CAPACITY INSTALLED	-	508 MW
HYDRO SHARE	-	37.30%
HYDRO SHARE IN 1963	-	50.62 %

AS ON 30.9.2002

INSTALLED CAPACITY DEVELOPED	-	26,402 MW
UNDER DEVELOPMENT	-	12,800 MW
HYDRO SHARE	-	24.95 %

16

REGION-WISE HYDRO POTENTIAL (AT 60% LOAD FACTOR)

As on 30.09.2002 (In MW)

REGION	POTENTIAL ASSESSED	POTENTIAL DEVELOPED	POTENTIAL UNDER DEVELOP.	BALANCE %
North Eastern	31857	522	199	97.74
Northern	30155	4630	2499	76.36
Eastern	5590	1378	331	69.42
Western	5679	1858	1500	40.87
Southern	10763	5797	632	40.27
Total	84044	14184	5161	76.98

SOURCE : CEA

17

HYDRO PROJECTS FOR X, XI & XII PLAN

PLAN PERIOD	TOTAL HYDRO CAPACITY PROPOSED TO BE ADDED (MW) *	LIKELY REQUIREMENT OF FUNDS (Rs. in Crores)	NHPC'S PROPOSED SHARE (MW)
X (2002 - 2007)	10,432	42,000	4,357
XI (2007 - 2012)	21,288	85,000	11,194
XII (2012 - 2017)	23,000	92,000	13,000

* Source:- CEA's Vision paper- March 2001 for development of Hydroelectric potential in the country by 2025 - 26.

18

REFORMS IN HYDROPOWER SECTOR

GOVERNMENT INITIATIVES FOR REFORMS IN HYDRO POWER SECTOR

- IN 1991, GOVERNMENT OF INDIA ALLOWED PRIVATE SECTOR TO SET UP GENERATING POWER STATIONS OF ANY SIZE AND ANY TYPE – THERMAL & HYDEL
- EARLIER PRIVATE COMPANIES COULD BE ONLY LICENSEES BUT NOW THEY COULD BE GENERATING COMPANIES
- DEBT EQUITY RATIO RAISED TO 4:1
- 100% FOREIGN EQUITY PARTICIPATION BY FOREIGN INVESTORS ALLOWED
- IN TARIFF, UPTO 16% RETURN ON EQUITY ALLOWED IN RESPECTIVE CURRENCY
- GOVERNMENT ANNOUNCED HYDRO POLICY IN AUG' 1998 FOLLOWED BY MEGA POWER POLICY

20

HYDRO POWER POLICY - HIGH SPOTS

- EMPHASIS ON BASIN WISE DEVELOPMENT
- RATIONALISATION OF HYDRO TARIFF
  - SALE RATE OF SECONDARY ENERGY SAME AS THAT OF PRIMARY
  - NORMATIVE MACHINE AVAILABILITY REDUCED TO 85%.
  - PROPOSAL TO ALLOW PREMIUM ON SALE RATE OF PEAK POWER
- SURVEY & INVESTIGATION ADOPTING MODERN TECHNIQUES & PREPARATION OF BANKABLE DPRs
- DEEMED GENERATION ALLOWED LIMITED TO DESIGN ENERGY.
- SIMPLIFIED PROCEDURE TO TRANSFER CLEARANCES OF APPROVED PROJECTS IN FAVOUR OF IPPs
- COMPENSATION TO DEVELOPER FOR INCREASE IN COST DUE TO GEOLOGICAL SURPRISES BASED ON RECOMMENDATION OF EXPERT COMMITTEE

CONT ... 21

HYDRO POWER POLICY - HIGH SPOTS

CONT...

- IMPETUS TO PRIVATE PARTICIPATION THROUGH IPPs & JOINT VENTURES
- POWER FROM MEGA POWER PROJECTS AND JV PROJECTS TO BE PURCHASED BY POWER TRADING CORPORATION
- DEVELOPER CAN BE SELECTED THROUGH MOU ROUTE UPTO 100 MW ; BIGGER PROJECTS BY COMPETITIVE BIDDING ROUTE
- TEC OF CEA EXEMPTED FOR PROJECTS UNDER MOU ROUTE UPTO Rs.250 Cr AND THOSE UNDER COMPETITIVE BIDDING ROUTE UPTO Rs. 1000 Cr.
- PROJECTS INVOLVING INTERSTATE ISSUE TO BE CLEARED NECESSARILY BY CEA IRRESPECTIVE OF THEIR CAPACITY AND COST
- STATE GOVERNMENT TO BE RESPONSIBLE FOR LAND ACQUISITION, R& R AND CATCHMENT AREA DEVELOPMENT. DEVELOPER ONLY TO CONTRIBUTE FUNDS; COST TO BE PASSED THROUGH TARIFF.

22

REFORMS AT POST HYDRO - POLICY STAGE

- CONSTITUTION OF CERC / SERCs
- AVAILABILITY BASED TARIFF
- CERC ALLOWED LEVY OF 5% DEVELOPMENT SURCHARGE TO SUPPLEMENT RESOURCES FOR HYDROELECTRIC PROJECTS BY NHPC
- RANKING STUDY BY CEA
- THREE STAGE CLEARANCE PROCEDURE

23

ACCELERATED HYDRO DEVELOPMENT THROUGH THREE STAGE CLEARANCE

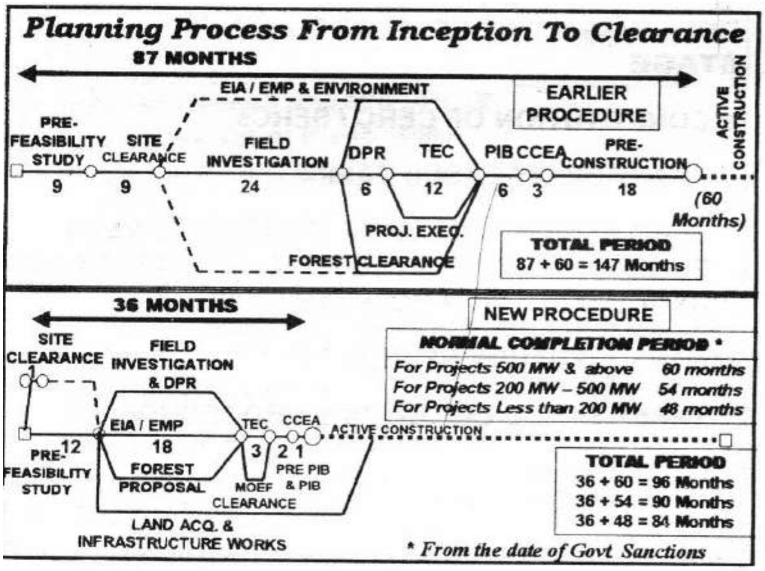
- Three Stage development introduced to reduce time and cost overrun, and better project management.

✓ Stage – I : Survey & Investigation and Preparation of Pre-feasibility Report.

✓ Stage – II : Preparation of Detailed Project Report, Environment Clearance, Development of Infrastructure.

✓ Stage – III : Investment decision, Actual implementation of the project.

Cont 24



CONSTRAINTS IN HYDRO DEVELOPMENT

- DIFFICULT INVESTIGATION
- TARIFF RELATED ISSUES LIKE LOW IRR AS COMPARED TO THERMAL PROJECTS, PEAK POWER SALE RATE, ETC.
- UNCERTAINTIES DUE TO GEOLOGICAL SURPRISES
- ENVIRONMENTAL ISSUES
- DELAY IN LAND ACQUISITION

CONT ...

26

CONSTRAINTS IN HYDRO DEVELOPMENT

CONT ...

- RESETTLEMENT AND REHABILITATION OF PROJECT AFFECTED PEOPLE
- INTER STATE PROBLEMS
- LAW AND ORDER PROBLEMS
- DEARTH OF GOOD INDIAN CONTRACTORS AND INABILITY OF RESOURCEFUL FOREIGN CONTRACTORS TO MATCH LOCAL COMPETITORS
- POOR CONTRACT MANAGEMENT

27

PRIVATE PARTICIPATION - BACKGROUND

- DEVELOPMENT OF HYDRO PROJECTS HAD BEEN PRIMARILY IN GOVT./PUBLIC SECTOR.
- IN DEVELOPING COUNTRIES VARIOUS INFRASTRUCTURE SECTORS COMPETE TO GET PRIORITY IN FUND ALLOCATION
- CONSTRAINTS OF GOVERNMENT FUNDING NECESSITATES PRIVATE INVESTMENT
- IN INDIA, PRIVATE HYDRO POWER NOT A NOVEL CONCEPT
  - IN 1947, PRIVATE HYDROPOWER CAPACITY WAS 276 MW (54% OF TOTAL)
  - TATAS HAVE 426 MW CAPACITY

28

RESPONSE OF PRIVATE SECTOR

- PRIVATE PARTICIPATION IN HYDRO SECTOR IS INSIGNIFICANT
- PRIVATE PROJECTS COMPLETED AFTER LIBERALISATION AGGREGATE TO ONLY 129.5 MW.
  - SHIVPUR (2X9 MW)
  - MANIAR (3X4 MW)
  - TAWA (2X6.75 MW)
  - MALANA (2x43MW)
- 16 MW BHATTAHAMKETTU PROJECT SLIPPED TO X PLAN
- ONLY 400 MW MAHESHWAR & 300 MW BASPA ARE UNDER ACTIVE CONSTRUCTION AND WELL BEHIND SCHEDULE
- 400 MW VISHNU PRAYAG & 330 MW SRINAGAR PROJECTS YET TO ACHIEVE FINANCIAL CLOSURE
- NO FOREIGN COMPANY HAS DONE ANYTHING CONCRETE SO FAR

29

REASONS OF POOR RESPONSE OF PRIVATE SECTOR

- MAJOR UNTAPPED HYDRO-POTENTIAL CONCENTRATED IN REMOTE NORTHERN & NORTH EASTERN REGION CHARACTERISED WITH COMPLEX GEOLOGICAL TERRAIN OF YOUNG HIMALAYAS. THESE STATES DO NOT HAVE DEMAND FOR POWER AND CAPACITY TO PAY
- POOR FINANCIAL HEALTH OF STATE ELECTRICITY BOARDS
- HYDROPROJECTS HAVE HIGH RISK PROFILE & UNIQUE ECONOMIC CHARACTERISTICS
- HYDRO PROJECTS INVOLVE HUGE INVESTMENT BUT INTERNAL RATE OF RETURN LESS THAN THERMAL
- DELAY IN FINALISATION OF POWER PURCHASE AGREEMENTS
- IPPs PREFER TO SIGN PPA WITH ONLY ONE ENTITY WHEREAS POWER IS REQUIRED TO FLOW TO MORE THAN ONE STATE

30

EMERGING HYDRO SCENARIO

- A LEVEL PLAYING FIELD FOR PRIVATE & PUBLIC SECTOR NEEDED
- PRIVATE SECTOR MAY BE INTERESTED IN SMALL & MEDIUM SIZED PROJECTS IN GEOLOGICALLY FRIENDLY TERRAIN
- PUBLIC SECTOR ROLE WILL CONTINUE ESPECIALLY FOR MEGA, STORAGE AND PROJECTS IN DIFFICULT GEOLOGICAL TERRAIN
- ENVIRONMENTAL PROPAGANDA BY VESTED GROUPS OPPOSING DAMS NEEDS TO BE EFFECTIVELY COUNTERED. OTHERWISE IT WILL DETER PRIVATE INVESTORS.
- SURVEY & INVESTIGATION TO BE ON MODERN SCIENTIFIC BASIS. IT IS BACKBONE OF DPR. INVEST TIME & MONEY IN IT. PREPARE BANKABLE DPR .

31

SUGGESTIONS FOR FURTHER REFORMS IN HYDROSECTOR

- ALL CENTRAL SECTOR HYDRO COMPANIES TO BE BROUGHT UNDER ONE UMBRELLA TO ENSURE
  - OPTIMAL UTILISATION OF TECHNICAL, FINANCIAL AND OTHER RESOURCES FOR MAXIMUM BENEFITS
- RATIONALISATION OF TARIFF
  - POOLED TARIFF FOR A COMPANY AS A WHOLE
  - PEAK POWER TARIFF
  - VALUE FOR MONEY
- FREEDOM FOR JUDGING VIABILITY OF A PROJECT WITHOUT ASSESSMENT BY EXTRANEOUS ORGANISATIONS

CONT ... 32

SUGGESTIONS FOR FURTHER REFORMS IN HYDROSECTOR

CONT ...

- SPEEDING UP OTHER CLEARANCES AND SANCTIONS
- SIMPLIFYING AND SPEEDING UP LAND ACQUISITION PROCEDURE
- INTERSTATE PROJECTS TO BE ENTRUSTED TO NEUTRAL ORGANISATION viz. NHPC
- EARMARKING POTENTIAL HYDRPOWER PROJECTS FOR COMPETITION AMONG LOCAL CONTRACTORS AND RESOURCEFUL FOREIGN CONTRACTORS

33

CONCLUSIONS

- ADVERSE HYDRO THERMAL MIX NEEDS TO BE REVERSED
- HIGHER BUDGETARY ALLOCATION FOR HYDRO SECTOR NEEDED
- FASTER CLEARANCES & INVESTMENT APPROVAL NEEDED
- RESOLVE ISSUES OF INTER STATE PROJECTS & GET THESE IMPLEMENTED THROUGH NEUTRAL AGENCIES
- EFFECTIVELY COUNTER THE VESTED GROUPS OPPOSING DAMS

34

- ***DEVELOPMENT OF HYDRO-POWER IS TECHNICAL COMPULSION FOR INDIA.***
- ***LET THIS GIFT OF NATURE NOT GO WASTE.***
- ***REDEDICATE OURSELVES TO THE TASK OF ACCELERATED DEVELOPMENT OF HYDRO POWER IN THE COUNTRY.***

35

Technology and Development

Dr P Dayaratnam

Former Vice Chancellor,
J N T University, Hyderabad

CATEGORIZATION OF DEVELOPMENT

The theme of the Engineering Congress is the role of Engineer for All round Development of the country, so it is worth while to examine the factors that affect the development and also look at different types of developments. Today, the nations are categorized into two major groups: Developed and Developing nations. The development that is talked is normally of the economic development. The development can be in many aspects. however. ultimately the economic development matters for any country. All round development may mean development in agriculture, economy, technology, industry, commerce, defense, optimal utilization of natural resources, education, culture, environment, quality of life, international relations, etc. A nation may be developed in some sectors and lag behind in others. The primary developments are normally classified in to three groups and they are:

- Technological development
- Industrial development
- Economic development

Engineers play vital role in the primary developments. Agriculture is also an important component in the development of a nation, but it intern depends very much on technology and industrial developments. All the three primary developments are interdependent to a limited extent. Industry grows with technology and vice versa. The technology is developed from industry and the industry is developed from technology. Most echnologies are born out of intuition of genius or industrial innovations or scientific discoveries; however, the technology or engineering is built on science. education and industry. There are several exceptions to this rule. The aviation technology was born out of intuition of Wright brothers. Joseph Aspdin who invented the wonder building material Portland cement was a brick layer; and the cement technology has gone through many improvements and transformations since then. Today the world per capita consumption of Portland cement is more than, 280 kg .It is next to production of food grains. Similarly innumerable developments and theories were formulated out of the intuition and innovation. The technology and industry are like chicken and egg situation. Each draws strength from the other for development. Technology is the application of scientific knowledge to variety of activities. It is a force that drives the development of industry and economy of a nation.

Even though there is no rigid yard stick to measure the development, but some basics are available. Practically, all countries that are technologically developed are also industrially developed and almost all of them are economically advanced. Technological development of a nation doesn't depend on the abundance of natural resources. Countries like Japan, Korea and Singapore are the classic examples having the technological cutting edge. Application and export of technology or its products leads to economic advancement. Technology is the most desired tool for economic development. Russia on the other hand even though technologicaIiy developed in many fields but its economic development is not matching with its technology. Further it is a nation with considerable natural resources with relatively small population. There are many blessed countries with abundance of natural resources with least natural hazards. Countries whose per capita income and living standards are high are considered as economically developed ones. Many Gulf countries may not be technologically advanced but are blessed with rich oil reserves, so they are considered in the category of economically advanced nations. India is a nation with reasonable natural resources and with a large population; further natural hazards like draught and floods coexist in the country. The main solution for economic development is the technology development. Technology development in the nation should be for competitive in export of products and trained manpower at the global level. Human resource is our best strength and can be a real resource if the people are trained in technology. Practically all professions such as Agriculture, Engineering, Medicine, Media, Industry, Finance, Management etc are dependent on modem technologies. India to be a developed nation, a dream of the Nation; technology is the key to the solution. The technology is not only involves the industry but very much dominant in the service sector. The percentage contribution Industry to the gross national product is about twenty five percent, similarly, contribution of the service sector to the GDP is of the order of fifty two percent. Considering all these aspects, the direct or indirect contribution of technology to the GDP may be estimated to be more than eighty percent. Therefore, a nation to be a developed one, technology is the key player. A quotation from Ignited Minds by Dr APJ Abdul Kalam, President of the Nation is worth remembering at this point.

"In Assam the sight of mighty Brahmaputra almost mesmerized me. Its vast expanse of water fined me with a strange sense of helplessness too the river's untapped flow was taking a gigantic mass of the water into the sea. It made me think, that as a nation too we were failing to utilize our tremendous energies."

Keys to the Technology Development

There are number of success stories of technology development in the nation. Irrigation and Power, space and missile technology, rural telecommunications, nuclear technology are some of the examples. Important basic tools to be implemented for successful development of technology are:

- In-house technology development and self reliance,
- Free from bureaucracy and change in mindset,
- Treat a failure as a challenge to success,
- Importance to long term goals,
- Speed and reliability of work,
- Accountability with privileges,
- Quality in Technical Education,
- Technology a business and a vicious circle.

There are no short cuts and easy solutions to development of technology in a nation.

In-house Technology Development and Self-reliance

Very often, technology is imported at a lower price compared that of in house development. However, unless one sweats and takes the challenge to improvise the technology at the local revel, it is not possible to grow in the technology. Some imports of technologies are inevitable but total package imports as black boxes, not only kill the initiatives and also make the nation technology dependent. The total dependency of import of a technology leads to bondage. Technology export countries are the main developed nations; therefore India must create the reliable technologies at competitive price. Even if one is not able to export, let there be no total technology dependency on outside sources. India has missed the industrial revolution, so there is a set back in technological innovations. Irrigation, Railways and to some extent low cost recycling of wastages are some of the simple technologies in which India has strengths. Improvisation of modem tools of management and information technology to these technologies helps to reach the global market.

A statement from Dr APJ Abdul Kalam, the President of India taken from his book, Ignited Minds is:

"Knocking at others' doors will be futile. Instead of importing theories and transplanting concepts we need to grow our own solutions. Instead of searching for answers outside we will have to look within for them".

Free from Bureaucracy and Change in Mindset

The governance of many organizations and even the country is influenced by bureaucracy. It succeeded in the pre-independence era for obvious reasons. Support and survival was the aim of the governance at that time but not the development and freedom. Very few departments in India are free from bureaucracy and governed by the professionals. Railways, Space and missile, and Atomic Energy etc are good examples. India is able to maintain the giant network of railways at the lowest cost because of the least interference from the bureaucracy. Some failures are inevitable even though not desirable, but then the successful maintenance of the system is a great achievement. Similarly, the space and atomic energy technologies are the other successful stories that prompt the developed nations to watch the trends in India. Too many rules, long ladders of commands and absolute authority were acceptable in the preindependence era. Such a mindset kills the initiatives and breeds inefficiency. Professional governance based on the knowledge and technical know how is the key to efficiency and advancement. It is well known that work to rule, is no work at all, therefore, too many rules provide easy escapes for non-accountability and may even create chaos. Similarly, great engineers like Sir Visvesvarya, Dr Khosla, Dr A P J Abdul Kalam and the other great engineers who pioneered technology development were free from the bureaucracy.

A Quotation from 'Ignited Minds' by Dr AP J Abdul Kalam

"Scarcity of resources is not the cause of our problems. Our problems originate in our approach to them. We are spreading our resources too wide and too thin. With our resources and the money that we spend we could accomplish three times what we do, in half of the time we normally take, if we were to operate in mission mode with a vision for the nation".

Treat a Failure as a Challenge to Success

Every activity has two faces. An activity has a starting point and finishing point. The activity may be completed successfully or incomplete or may even end up in failure. The incompletion of an activity is also a failure. There is always a probability of not able to complete an activity in spite of the best efforts. Every failure to achieve the target teaches us a lesson. An analytical mind must be able to assess and synthesize the failure and find ways and means of avoiding such failures. Calculated risks must be taken in the unknown zones of activity, otherwise it becomes a no-activity and a failure. Individuals, Organizations and administration need to accept the failure as a challenge to success.

Importance to Long-term Goals

Instantaneous solution to a problem is not necessarily permanent solution. Instantaneous solutions are required at times. However a nation must look for long lasting solutions. Research and development is the primary tool to solve nagging problems and provide lasting solutions. Even though for a given time and environment, a solution may be best suited, however no solution is permanent, especially in the global situation. Global competitiveness makes the process of solutions very dynamic. In such a situation, the technology dependence on other countries makes the nation dependent on others and leaves it far behind others. Research and development within the universities, R & D establishments, or in the industry must be given adequate weightage.

Speed and Reliability of Work

Twenty first century is the electronic century. Computerization of most operations and communications through electronic media has raised the expectations of the common man. Instant solutions are expected by the public. A student appears for an exam and expects immediate announcement of the result; similarly a person buying or selling a product and expects instantaneous returns. Civil engineering projects, in fact most engineering projects needs time for planning and execution. Major irrigation, highway and bridges; infrastructure development and environmental control projects take considerable time. Some of the operations in such projects are not in the hands of the engineer. However, the public expectation of speed of completion of a project must be met by using modern tools of management and machinery. Decision making is often bogged down by formalities and hierarchy. In addition to taking long time of completion, a number of inconveniences are generated to the public during the process. The speed of work helps in minimizing such inconveniences. Reliability of performance of a product or service is vital locally and global.

Accountability and Privileges

Sustainable technology must be supported by Industry and Research and development laboratories. Policies of the Government are important in creating initiatives by the industry and R & D establishments for technological development. Some organizations consider the research and development as a luxury or give a low priority; and are concerned more about production and product acceptability. R & D institutions and laboratories must have the freedom of managing the projects and at the same time be accountable to schedules, quality and acceptability in the competitive world.

Quality in Technical Education

Technical education is the back bone for technology development. Historically, the earlier years of technical education in the country has prepared the students primarily for employment. In the first three decades of independence, most of the engineering graduates or diploma holders were hired by the government or public sector undertakings. Employment in the private sector has grown gradually and now a major and important provider. Further, the technical education was the privilege of elite few till about fifteen years ago. The number of engineering and management institutions got multiplied during the last fifteen; and now the common man has access to such education. The quantity is multiplied at the cost of quality in many institutions. A wide spectrum of quality exists in India, starting from those that meet the international standards to those that are not acceptable for any standard. Engineers must be employment generators rather than seekers. The technical education must have the following characteristics:

• Broad based under-graduate and specialized Post-graduate courses,
• Robust system to withstand perturbations,
• Flexibility in training and opportunities,
• Diversity in curriculum and regulations,
• Reasonable opportunities for upgradation,
• Reasonable industrial exposure,
• Improved management and communication skills,
• Academic autonomy for institutions.

Large numbers of young people are seeking engineering and management studies. Private sector has come in big way to provide the educational facilities. However, the rapid explosion of engineering colleges is not matched by the availability of qualified teachers. To contain the exploitation of the common man in engineering education by the vested interests, the governments and the universities have come with variety of controls, checks and norms. Privatization of education is certainly a welcome thing; and hopefully more initiatives and innovations are likely to come from the private sector. If the business exploitation is the aim of a college, then there is a big danger of the student not getting its share and the poor are put to disadvantage. While the concept of technological university is excellent, but enlarging to an unyielding level is hurting the quality of the education. Further, research and development that is expected of the university is taking the back seat because of the volume of problems in the management of examinations and evaluation of the affiliated college students. Teaching, curriculum, R&D is left behind because of over centralization of the educational policies. Establishment of many colleges brought in certain amount of redundancy in the openings of technical education. This helps in reducing the undue problems of seekers of seats in colleges. However, to survive in the market and attract talented students and teachers, quality and economic viability of a college has to be maintained at an excellent level.

Industry and professional bodies seem to be neglecting the proactive role in the technical education and training of the manpower and R&D activities. Even though the nation may survive with import of technology at reasonable price at this point of time, but dependency leads to helplessness as it was the case witll East India Company, a trading company becoming a ruler. The global and local economies are dictated by the technologically developed nations in another two to three years as the WTO policies being implemented. Unless the quality of technical education is improved, the unemployment situation in the nation is going to be the major problem. Production of food and availability of goods are important, but lack of employment opportunities to the masses leads to poverty and crime.

Technology — A Business and Vicious Circle

Technology has become a tradable product and process, and a service. Ideas and knowledge are playing powerful roles in the business. Communications, information technology and computers have introduced a new dimension to the business. Products and processes become outdated with the dominances of the information technology and computer applications. Developing nations can't afford the luxury of changing models and technology at high frequency. Up gradation of technology even before it picks up, is putting a heavy toll on the developing nations. One buys a technology, and by the time it is operational, a new technology is introduced, spares parts of earlier technologies not available in the market. The words like obsolescence, modernization, up gradation, latest technology and software etc have become catch words in the sellers market. The developing nations have to succumb to the trends setters dominated by the developed nations at high price. Technology is tending to be monster, playing a negative role in the humane values of understanding of the nations, a powerful tool to exploit the technologically developing nations.

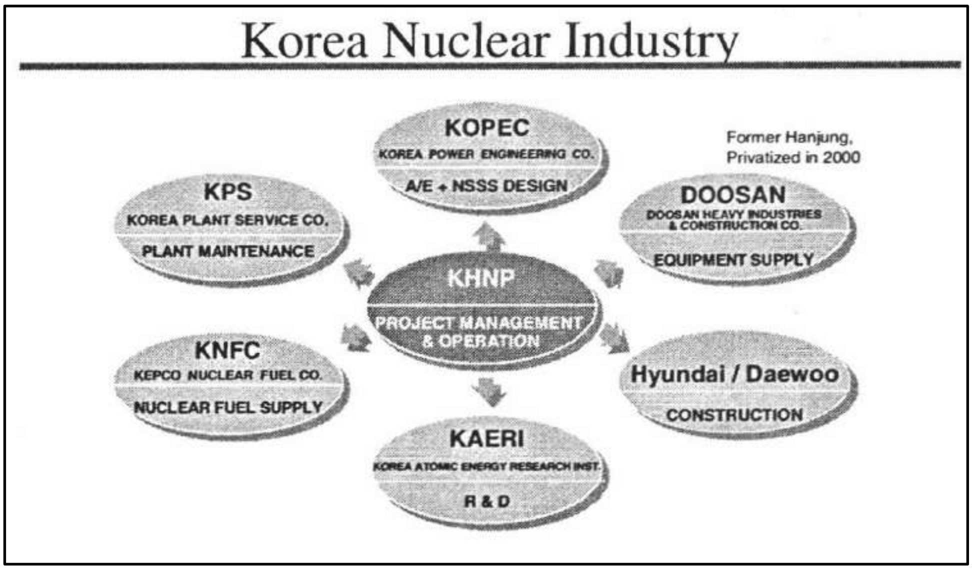
CONCLUSIONS

The key to economic development is the development of technology irrespective of the availability of natural resources. Lack of technological competence of a nation, leads to inefficient use of the natural resources including manpower and environmental degradation. In the ever expanding communications and competitive world of globalization, technology dependence on outside the country leads economic dependence on the technology advanced nations. Indiscriminate purchase of technologies may appear cheaper at this point of time but leads to loss of freedom of a nation. Development of in-house technology is a must for a nation to be independent politically and economically. Human resource is the strength of India, and the growing service sector contribution to the gross domestic product must be recognized and put to the right technology. Technology is not only a tool for economic development; but a tradable product from which wealth can be accumulated, stability can be improved and political global dominance can be achieved. The keys to technology development are: In-house technology development and self reliance. Free from bureaucracy and change of mindset. Acceptance of failure as a challenge to success. Speed and reliability of work, Quality in Technical Education, and Technology a business solution. Scientists, Engineers, Technologist and Professionals play the significant role in the technology development and sustenance which leads to economic independence.

Nuclear Industry and Nuclear Technology — Route of Self-reliance in Korea

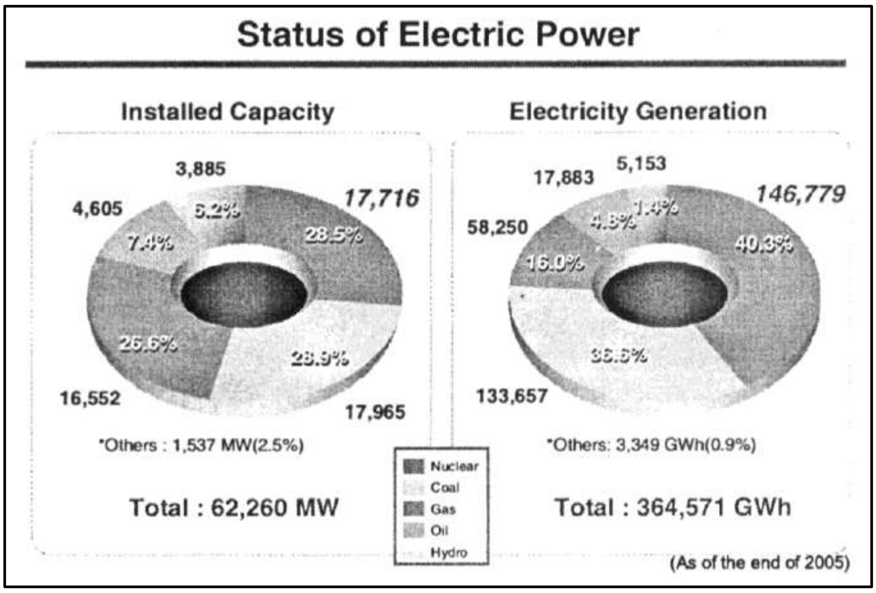
Mr Nam Ho

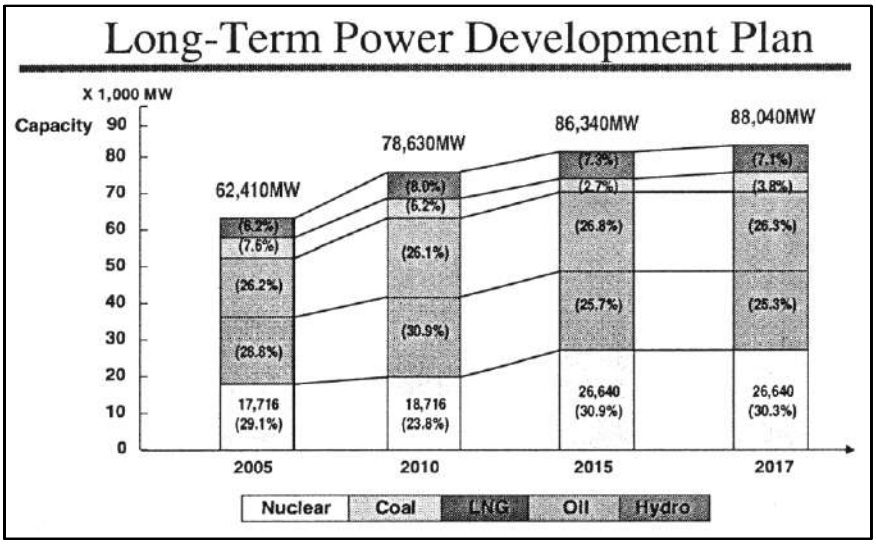
Senior Vice Precident, KPEA
Chairman, Hyundae Nuclear



Brief History of Nuclear Power in Korea

- 1957 Becoming a member of IAEA
- 1958 Promulgation of Atomic Energy Law
- 1959 Construction of 1st research reactor (TRIGA Mark-II)
- 1968 Set-up basic plan for the introduction of 1st NPP
- 1969 Set-up construction plan for 1st NPP, KRN #1 (PWR, 587MWe)
- 1971 Start construction of 1st NPP, KRN #1 (PWR, 587MWe)
- 1977 Start construction of 2nd NPP (KRN #2, PWR 650 MWe) and 3rd NPP (WSN #1, PHWR, 650MWe)
- 1978 Commercial operation of 1st NPP, KRN #1
- 1983 Commercial Operation of 2nd NPP (KRN #2) and 3rd NPP (WSN #1)

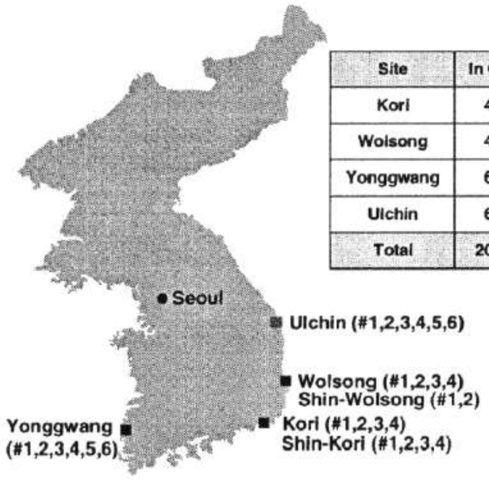




Status of Nuclear Power Plants

(Unit: MW)

Site	In Operation	Under Const.	Total
Kori	4 (3,137)	4 (4,800)	8 (7,937)
Wolsong	4 (2,779)	2 (2,000)	6 (4,779)
Yonggwang	6 (5,900)	-	6 (5,900)
Ulchin	6 (5,900)	-	6 (5,900)
Total	20 (17,716)	6 (6,800)	26 (24,516)



Nuclear Power Plants in Operation

■ 20 units (17,716 MW)

Plant		Reactor Type	Capacity (MW)	NSSS Supplier	Plant A/E	Commercial Operation
Kori (KRN)	#1	PWR	650	W/H	Gilbert	Apr. '78
	#2	PWR	587	W/H	Gilbert	July '83
	#3	PWR	950	W/H	Bechtel/KOPEC	Sep. '85
	#4	PWR	950	W/H	Bechtel/KOPEC	Apr. '86
Wolsong (WSN)	#1	PHWR	679	AECL	AECL	Apr. '83
	#2	PHWR	700	AECL/DOOSAN	AECL/KOPEC	Jun. '97
	#3	PHWR	700	AECL/DOOSAN	AECL/KOPEC	Jun. '98
	#4	PHWR	700	AECL/DOOSAN	AECL/KOPEC	Sep. '99
Yonggwang (YGN)	#1	PWR	950	W/H	Bechtel/KOPEC	Aug. '86
	#2	PWR	950	W/H	Bechtel/KOPEC	Jun. '87
	#3	PWR	1,000	DOOSAN	KOPEC	Mar. '95
	#4	PWR	1,000	DOOSAN	KOPEC	Jan. '96
	#5	PWR	1,000	DOOSAN	KOPEC	May '02
	#6	PWR	1,000	DOOSAN	KOPEC	Dec. '02
Ulchin (UCN)	#1	PWR	950	Framatome	Framatome	Sep.'88
	#2	PWR	950	Framatome	Framatome	Sep. '89
	#3	PWR	1,000	DOOSAN	KOPEC	Aug. '98
	#4	PWR	1,000	DOOSAN	KOPEC	Dec. '99
	#5	PWR	1,000	DOOSAN	KOPEC	July '04
	#6	PWR	1,000	DOOSAN	KOPEC	Apr. '05

NSSS: Nuclear Steam Supply System, A/E: Architectural Engineering

Nuclear Power Plants under Construction

■ 6 units (6,800 MW)

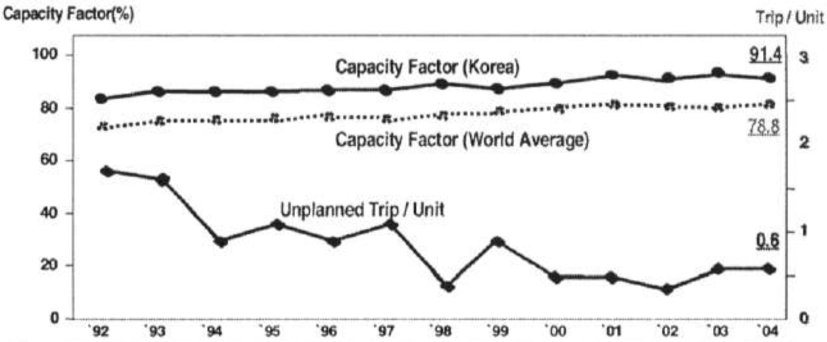
Plant		Reactor Type	Capacity (MW)	NSSS & TG Supplier	Plant A/E	Commercial Operation
Shin-Kori (Shin-KRN)	#1	PWR	1,000	DOOSAN	KOPEC	Dec. 2010
	#2	PWR	1,000	DOOSAN	KOPEC	Dec. 2011
Shin-Wolsong (Shin-WSN)	#1	PWR	1,000	DOOSAN	KOPEC	Mar. 2011
	#2	PWR	1,000	DOOSAN	KOPEC	Mar. 2012
Shin-Kori (Shin-KRN)	#3	PWR	1,400	DOOSAN	KOPEC	Jun. 2012
	#4	PWR	1,400	DOOSAN	KOPEC	Jun. 2013

Nuclear Installed Capacity of Countries

	Country	Units	Installed Capacity (MW)
1	U.S.A	103	97,924
2	France	59	63,473
3	Japan	55	47,700
4	Russia	31	21,743
5	Germany	17	20,303
6	Korea	20	17,716
7	Ukraine	15	13,168
8	Canada	18	12,595
9	U.K	23	11,852
10	Sweden	10	8,938

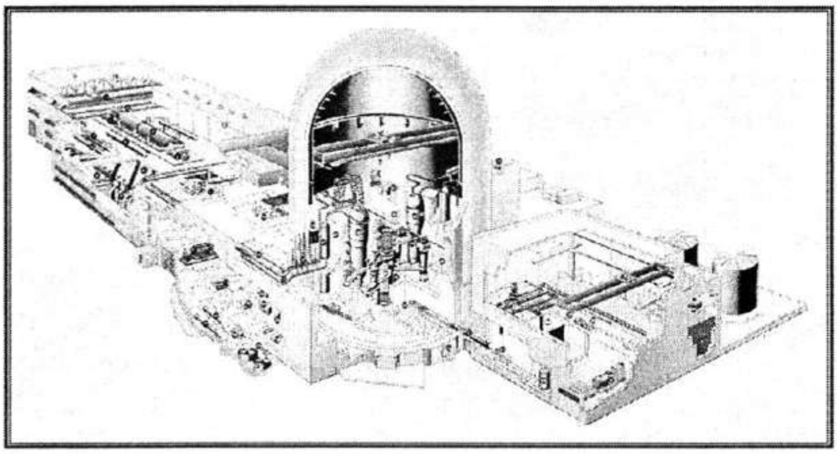
(As of the end of 2005)

Performance of Operation



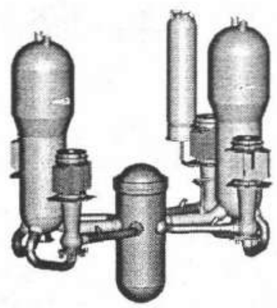
C.F.(%)	84.5	87.2	87.4	87.3	87.5	87.6	90.3	88.3	90.4	93.2	92.7	94.2	91.4
Trips	1.7	1.6	0.9	1.1	0.9	1.1	0.4	0.9	0.5	0.5	0.4	0.6	0.6

Bird's Eye View of OPR1000



Design Features of OPR

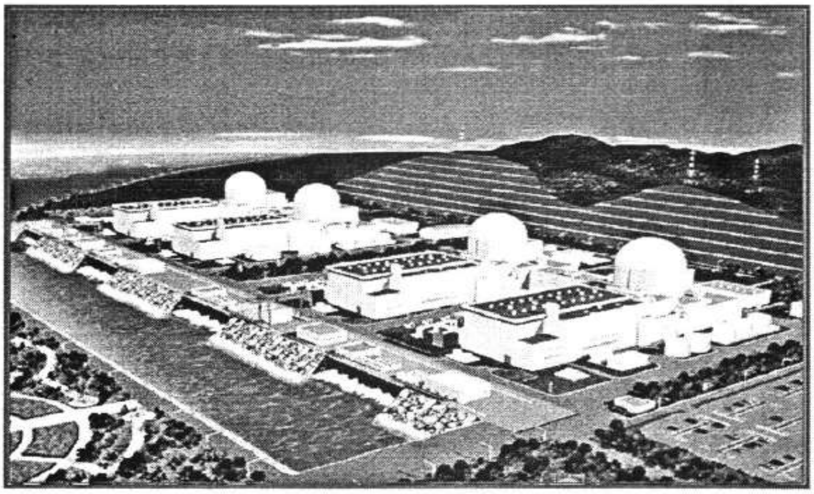
2 Loop, 4 Pump RCS Design
Power Level : 1,050MWe/2,825MWt
Plant Design Life : 40 years
Plant Availability : 80~87%



Advanced Design Features :

- Human Factors Engineering
- Design against Severe Accidents
- Leak Before Break (LBB) Concept
- Increased Operability and Maintainability
- Lower Occupational Radiation Exposure

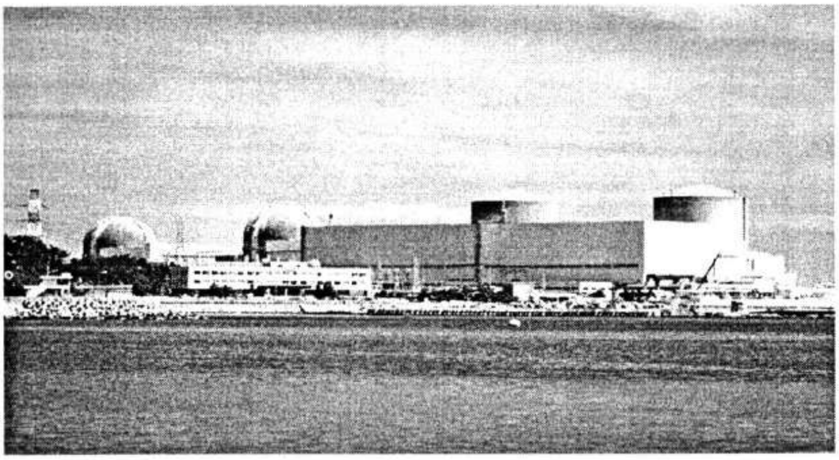
Bird's Eye View of APR1400



Design Features of APR1400

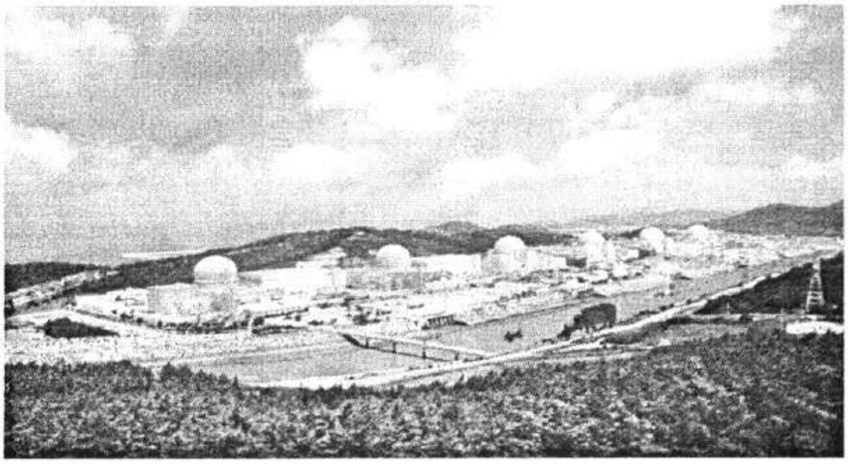
- 2 Loop, 4 Pump RCS Design
  - Power Level : 1,400MWe/4,000MWt
  - Plant Design Life : 60 years
  - Plant Availability : at least 90%
  - Advanced Design Features :
    - Fully Digitalized Man-Machine Interface
    - Direct Vessel Injection
    - In-containment Refueling Water storage TK
    - External Reactor Vessel Cooling System

Site View of Kori NPPs (KRN #1, 2, 3, 4)

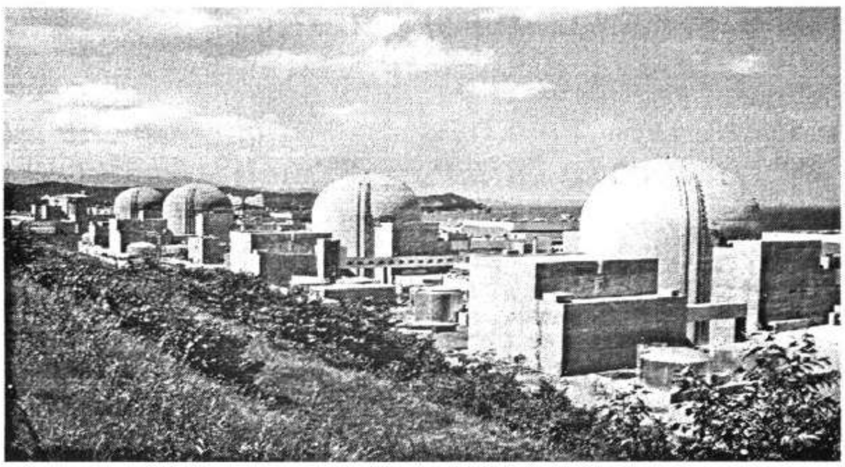


Site View of Wolsong NPPs (WSN #1, 2, 3, 4)

Site View of Yonggwang NPPs (YGN #1,2,3,4,5,6)



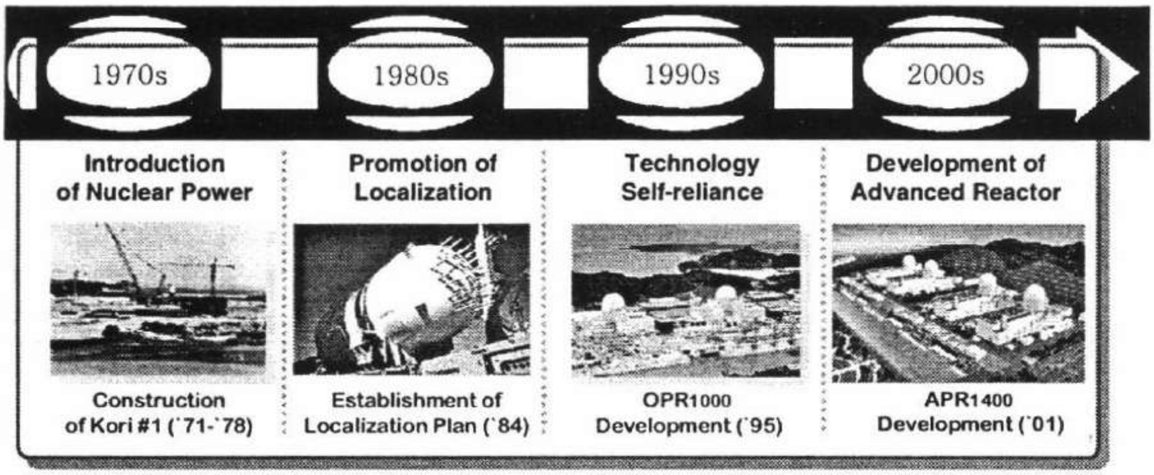
Site View of Ulchin NPPs (UCN #1,2,3,4,5,6)



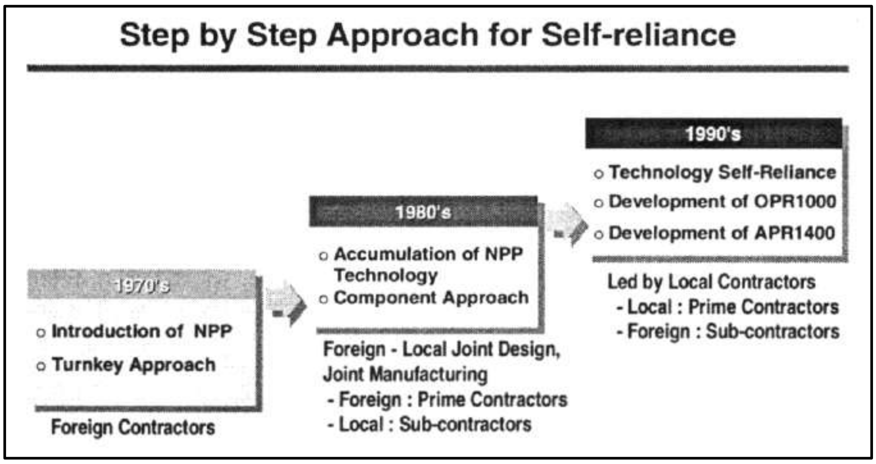
Why Self-reliance in Korea?

- **Accumulation of Technologies**
  - Localization results in the accumulation of the related technologies
  - Set up the self-reliance
- **Increase of the Domestic Participation**
  - Increased the domestic participation improves economy
- **Avoiding Deep Dependence on Overseas Technologies**
  - Establishment of self-reliance assures the energy security
- **Leading to Other High Technologies**
  - Nuclear technology can be the precursor of the other technologies, such as, mechanical, electrical, electronics, civil, chemical etc...

Nuclear Technology Self-reliance History

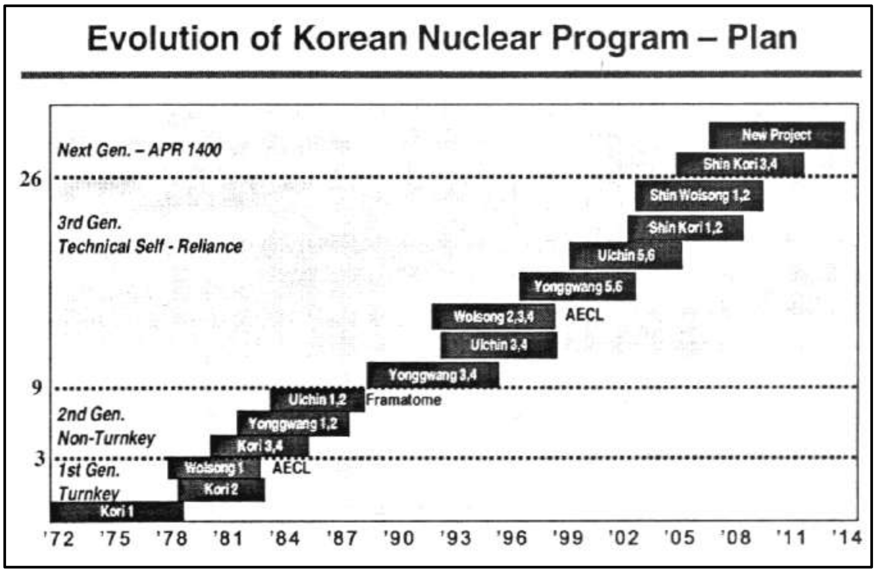


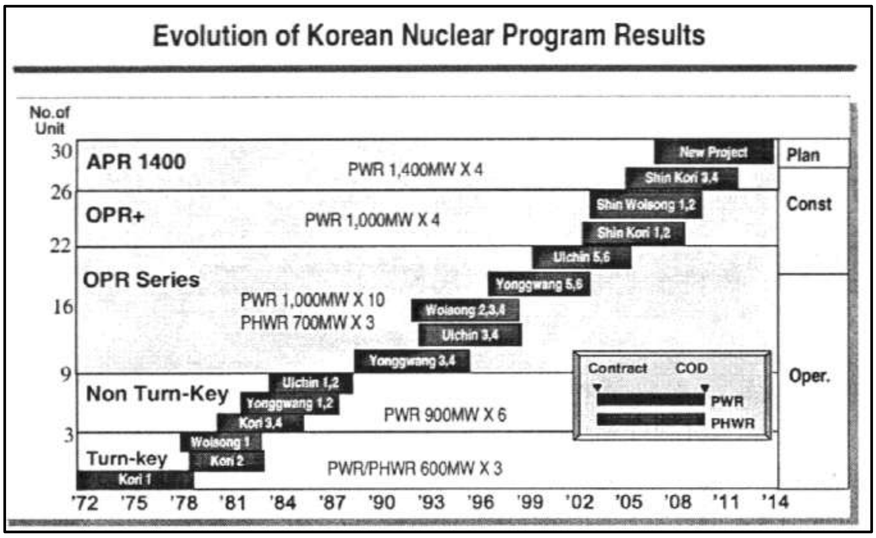
* OPR1000 (Optimized Power Reactor 1,000) is renamed from the former KSNP

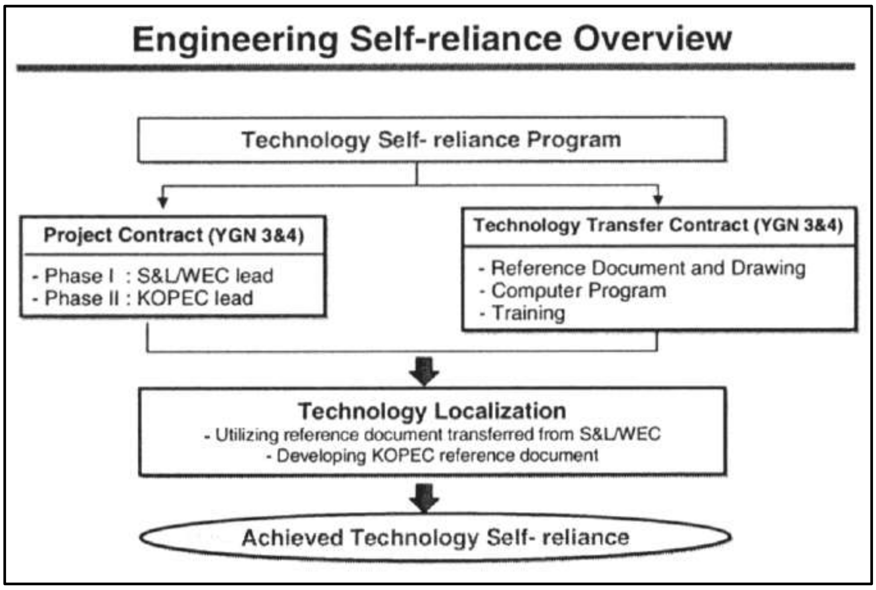


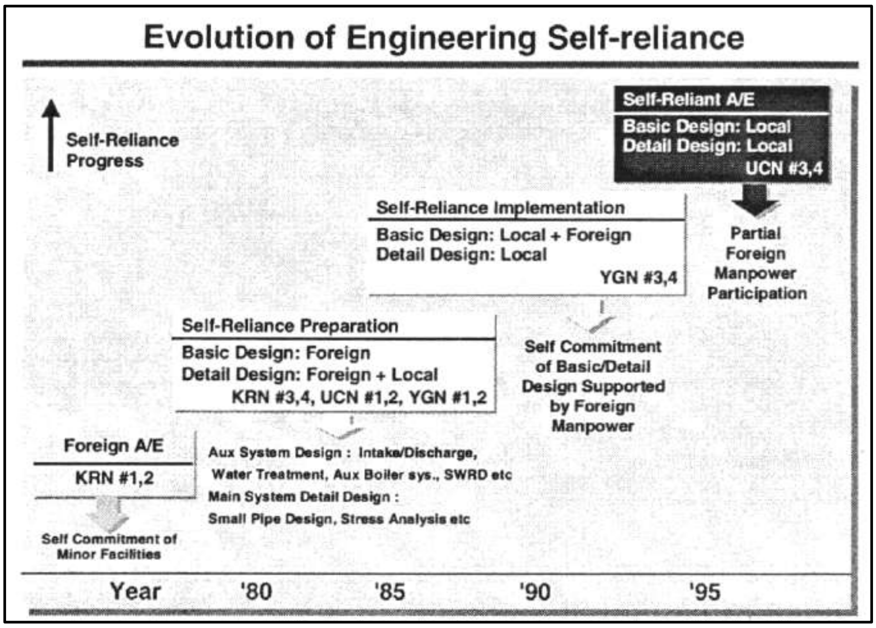
Evolution of Project Structure

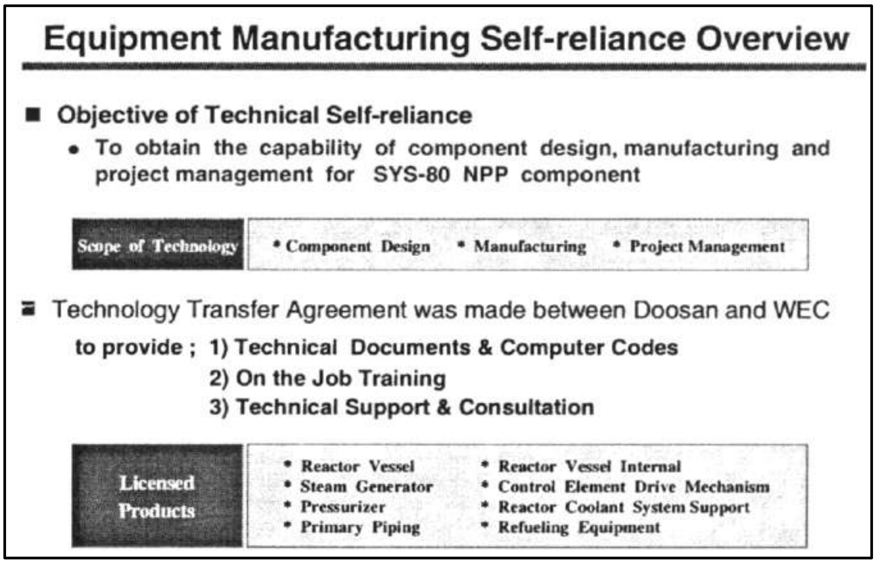
1970's	1980's	1990's
1st Generation	2nd Generation	3rd Generation
Turn-Key	Non Turn-Key	Non Turn-Key
KRN #1,2 WSN #1	KRN #3,4, YGN #1,2, UCN #1,2	YGN #3,4, UCN #3,4
Foreign Contractor Local Labor Supply	Foreign Prime Contractors Local Sub-contractors	Local Prime Contractors Foreign Sub-contractors
Technological Dependency	Technological Acquisition	Technological Self-Reliance

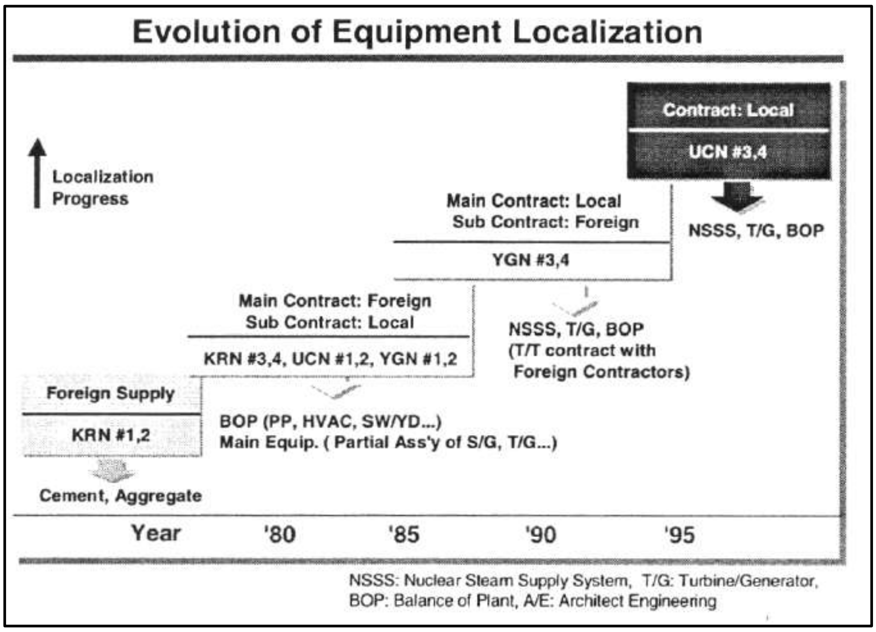


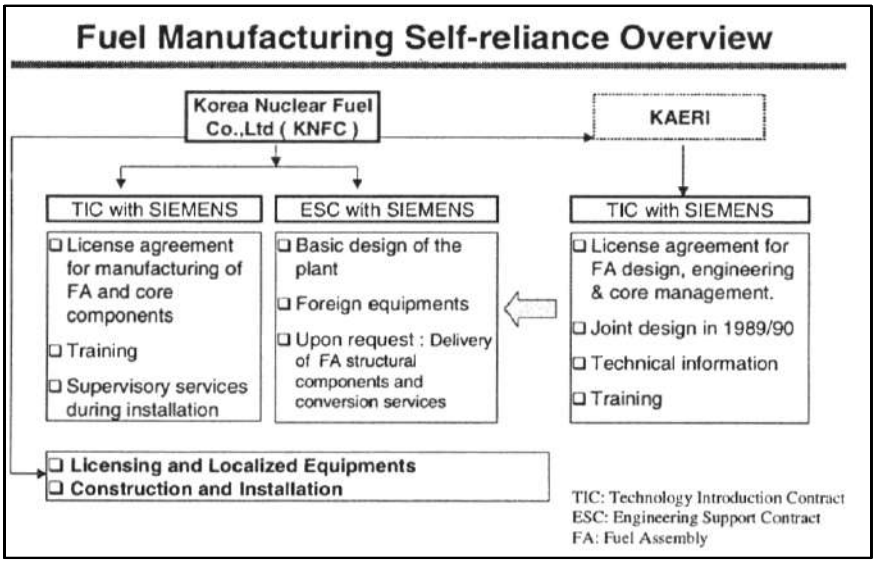

Evolution of Korean Nuclear Program Results
No.of Unit
30
26
22
16
9
3
APR 1400
PWR 1,400MW X 4
OPR+
PWR 1,000MW X 4
OPR Series
PWR 1,000MW X 10
PHWR 700MW X 3
Non Turn-Key
PWR 900MW X 6
Turn-key
PWR/PHWR 600MW X 3
New Project
Shin Kori 3,4
Shin Wolsong 1,2
Shin Kori 1,2
Ulchin 5,6
Yonggwang 5,6
Wolsong 2,3,4
Ulchin 3,4
Yonggwang 3,4
Ulchin 1,2
Yonggwang 1,2
Kori 3,4
Wolsong 1
Kori 2
Kori 1
Contract
COD
PWR
PHWR
Plan
Const
Oper.
'72 '75 '78 '81 '84 '87 '90 '93 '96 '99 '02 '05 '08 '11 '14


Engineering Self-reliance Overview
Technology Self- reliance Program
Project Contract (YGN 3&4)
- Phase I : S&L/WEC lead
- Phase II : KOPEC lead
Technology Transfer Contract (YGN 3&4)
- Reference Document and Drawing
- Computer Program
- Training
Technology Localization
- Utilizing reference document transferred from S&L/WEC
- Developing KOPEC reference document
Achieved Technology Self- reliance


Evolution of Engineering Self-reliance
Self-Reliance Progress
Self-Reliant A/E
Basic Design: Local
Detail Design: Local
UCN #3,4
Partial Foreign Manpower Participation
Self-Reliance Implementation
Basic Design: Local + Foreign
Detail Design: Local
YGN #3,4
Self Commitment of Basic/Detail Design Supported by Foreign Manpower
Self-Reliance Preparation
Basic Design: Foreign
Detail Design: Foreign + Local
KRN #3,4, UCN #1,2, YGN #1,2
Foreign A/E
KRN #1,2
Self Commitment of Minor Facilities
Aux System Design : Intake/Discharge,
Water Treatment, Aux Boiler sys., SWRD etc
Main System Detail Design :
Small Pipe Design, Stress Analysis etc
Year '80 '85 '90 '95

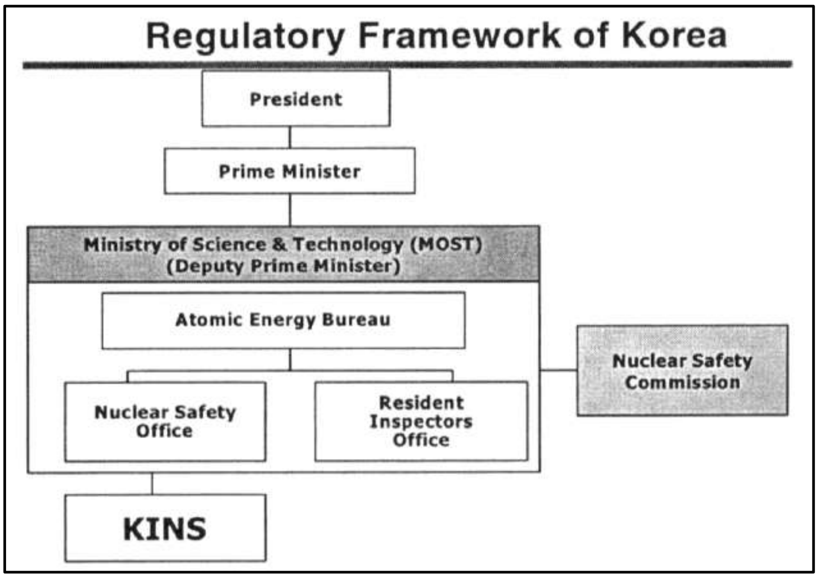

Equipment Manufacturing Self-reliance Overview
Objective of Technical Self-reliance
To obtain the capability of component design, manufacturing and project management for SYS-80 NPP component
Scope of Technology
• Component Design • Manufacturing • Project Management
Technology Transfer Agreement was made between Doosan and WEC
to provide ; 1) Technical Documents & Computer Codes
2) On the Job Training
3) Technical Support & Consultation
Licensed Products
• Reactor Vessel
• Steam Generator
• Pressurizer
• Primary Piping
• Reactor Vessel Internal
• Control Element Drive Mechanism
• Reactor Coolant System Support
• Refueling Equipment

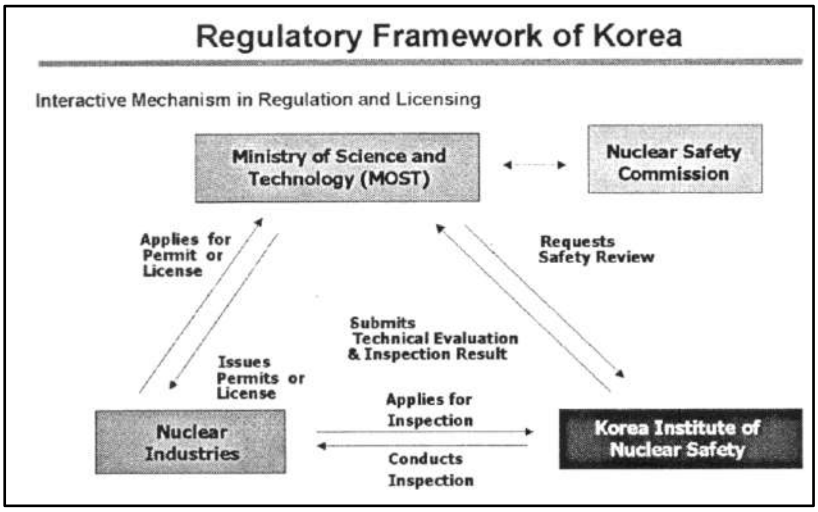

Evolution of Equipment Localization
Localization Progress
Contract: Local
UCN #3,4
NSSS, T/G, BOP
Main Contract: Local
Sub Contract: Foreign
YGN #3,4
NSSS, T/G, BOP
(T/T contract with Foreign Contractors)
Main Contract: Foreign
Sub Contract: Local
KRN #3,4, UCN #1,2, YGN #1,2
BOP (PP, HVAC, SW/YD...)
Main Equip. (Partial Ass'y of S/G, T/G...)
Foreign Supply
KRN #1,2
Cement, Aggregate
Year '80 '85 '90 '95
NSSS: Nuclear Steam Supply System, T/G: Turbine/Generator,
BOP: Balance of Plant, A/E: Architect Engineering


Fuel Manufacturing Self-reliance Overview
Korea Nuclear Fuel Co.,Ltd (KNFC)
KAERI
TIC with SIEMENS
License agreement for manufacturing of FA and core components
Training
Supervisory services during installation
ESC with SIEMENS
Basic design of the plant
Foreign equipments
Upon request : Delivery of FA structural components and conversion services
TIC with SIEMENS
License agreement for FA design, engineering & core management.
Joint design in 1989/90
Technical information
Training
Licensing and Localized Equipments
Construction and Installation
TIC: Technology Introduction Contract
ESC: Engineering Support Contract
FA: Fuel Assembly

Regulatory Framework of Korea

- **Regulatory Body**
  - **Ministry of Science and Technology (MOST)**
    - Regulatory authority
    - Regulatory policy development and rule-making
  - **Nuclear Safety Commission (NSC)**
    - Composed of 8 members
    - Principal function :
      - Decision-making on major nuclear safety issues
      - Supported by four Special Committees (Reactor Systems/ Radiation & Environment/ Siting & Structure/ Regulatory Policy & Systems)
  - **Korea Institute of Nuclear Safety (KINS)**
    - Regulatory expert organization to technically support the MOST





Safety Inspection of NPPs

- Pre-operational Inspection
  - To ensure that the performance of the reactor facilities meets the specifications of the relevant technical standards
- Periodic Inspection
  - To ensure that the performance of the reactor facility is maintained in the state of the pre-operational inspection
- Daily Inspection by Resident Inspectors
  - To confirm whether the plant is operating in compliance with the technical specifications
  - The Office of Resident Inspectors at each plant site is composed of government officials and KINS staff
- Quality Assurance (QA) Inspection
  - To verify annually that the QA activities of the licensee are in accordance with the QA Program approved by the regulatory authority
- Manufacturing Inspection
  - To check the implementation status of the QA program and technical requirements for manufacturing major components and equipment by means of documents reviews and field inspections

Summary of Self-reliance Experience in Korea

- Establishment of long-term localization plan led by Government & Owner
  - Ministry of Commerce, Industry and Energy[MOCIE]
  - Ministry of Science & Technology[MOST]
  - Korea Hyundae & Nuclear Power Co., Ltd[KHNP]
- Establishment of NPP standardization program
- Localization by step-by-step approach
- Importance of owner's overall PM capability
- Close cooperation with experienced foreign companies

Recommended Approach for Self-reliance

1ST STEP

- Technology Accumulation
  - Implemented by foreign supplier with Local participation

2ND STEP

- Foreign - Local Joint Implementation
  - Implemented by Owner with foreign assistance

3RD STEP

- Accomplishment of technology self-reliance
  - Implemented by local prime contractor with foreign assistance as sub-contractor

Technology Innovation in Korea

Prof (Dr) Min-Koo Han

Department of Electrical Engineering
School of Electrical Engineering
Seoul National University, Korea

From fast follower to innovation seeker…

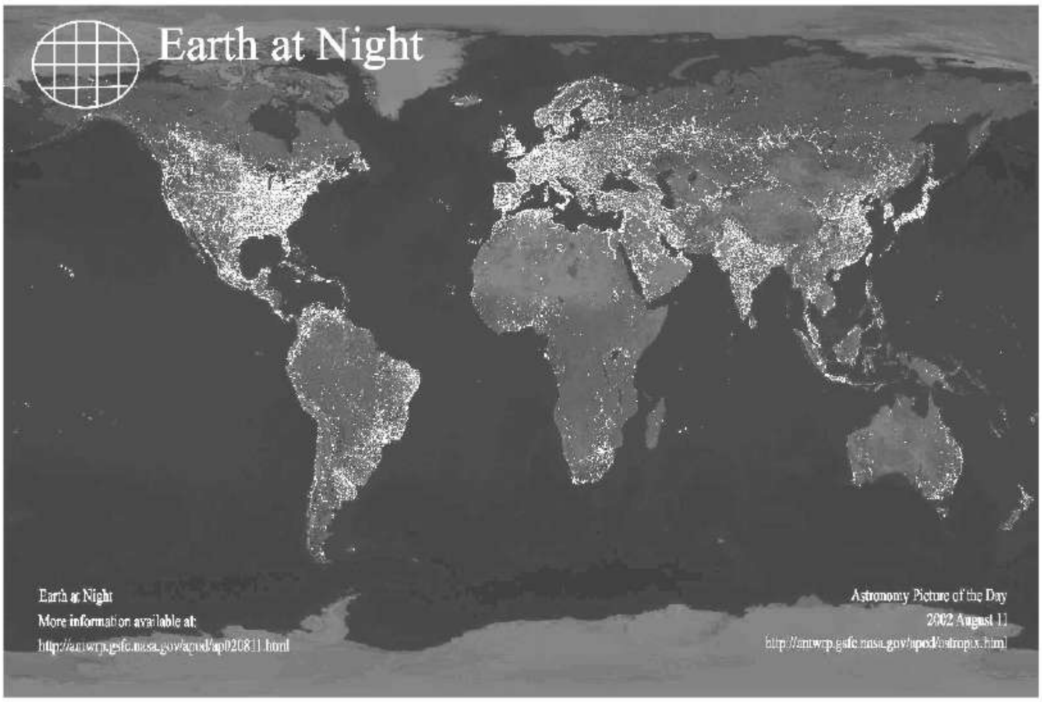


TABLE OF CONTENTS

ECONOMIC GROWTH

- Goal : to catch-up with advanced countries by rapid industrialization
- Market: export-oriented
- Key elements : human resources
- Heavy reliance on foreign capital and technology, not on FDI
- Open system: not self-reliant strategy
- Drastic structural change within a short time
- Rapid growth of high-tech industries
- Government initiated in the early stages, but later private firms became driving forces
- Weak areas : capital goods, SMEs, services, etc

Major Economic Indicators

	1960	1970	1980	1990	2003	2006
Population (1000)	25012	32241	38124	42869	47925	48497
GDP (US$, billion)	2	8	62	253	605	887
Growth rate of GDP (%)	2.2	17.2	21.8	20.6	3.1	5.0
GDP per capita (US$)	80	248	1632	5900	12628	18373
Trade balance (US$, million)	– 65	– 597	– 4384	– 2004	14991	16082
Exports (US$, million)	32	660	17214	63124	193817	325465
Imports (US$, million)	97	1256	21598	65127	178827	309383

Changes of Korean Top Ten Exports

Item 1960s	Percentage	Item 1980s	Percentage	Item 2000s (year 2006)	Percentage
Iron ore	13	Textiles	28.8	Semiconductor	10.2
Tungsten ore	12.6	Electronics	11.4	Automobile	10.1
Raw silk	6.7	Iron and steel product	9.0	Wireless telecommunication equipment	8.3
Anthracite	5.8	Footwear	5.2	Ships	6.8
Cuttlefish	5.5	Ships	3.5	Petrochemical product	6.3
Live fish	4.5	Synthetic fibres	3.3	Computers	3.9
Natural graphite	4.2	Metal product	2.3	TFT-LCD	3.8
Plywood	3.3	Plywood	2.0	Plastic and chemicals	3.4
Rice	3.3	Fish	2.0	Iron and steel product	3.4
Bristles	3.0	Electrical goods	1.9	Automotive parts	3.1

Pivotal Sources of Economic Growth

1960s — Labour (light industry)

↓

1970s — Capital (chemical and heavy industry)

↓

1980s — Internationalisation (international trade)

↓

1990s — Technology (high tech industry)

↓

2000s — Knowledge, information, innovation (high tech industry and knowledge industry)

GROWTH OF SCIENCE AND TECHNOLOGY COMMUNITY

- Rapid increase of R&D resources: investment and manpower
- Human resource development
- Technology import
- Strong application-oriented production process
- Government initiated in the early stages, however, since the mid-eighties private sector has been leading
- Implantation of western systems
- Active role of expatriates
- Pan-national support to S&T

Major R&D Statistics

	1963	1970	1980	1990	2005
GERD (US$, million)	4	33	428	4676	23580
Government against private	97:3	71:29	64:36	19:81	24:76
R&D / GDP	0.25*	0.38*	0.77*	1.87	2.99
Researcher (persons)		5628	18434	70503	234702 (FTE:179812)

Note : * R&D / GNP
Source : Ministry of Science and Technology

Evolution of R&D System, *<ratio of GERD>*, %

	1970	1975	1980	1985	1990	2002
Public institute	84	66	49	24	22	15
(GRIs)	(25)	(27)	(27)	(20)	(16)	(10)
University	4	5	12	10	7	10
Company	13	29	38	65	71	75
Total	100	100	100	100	100	100

Source : Ministry of Science and Technology

Evolution of R&D System, *<ratio of researchers>*, %

	1970	1975	1980	1985	1990	2002 (FTE)
Public institute	43	30	25	17	15	7 (9)
(GRIs)	(9)	(27)	(27)	(20)	(16)	(4) (5)
University	36	44	47	36	30	30 (18)
Company	21	26	28	46	55	62 (73)
Total	100	100	100	100	100	100

Source : Ministry of Science and Technology

Corporate Research Institutes

Year	Number
1978	48
1988	500
1991	1 000
2000	5 000
2003	9 810 (SMEs : 91%)
2004	10 000

Academic Papers, SCI

	1997	1998	2001	2002	2003	2004	2005
Number	7 852	9 684	14 733	15 705	18 635	19 279	23 048
Increase (%)	21.7	23.3	19.6	6.6	18.7	3.5	19.5
Share (%)	0.85	1.35	1.61	1.71	1.85	1.96	2.02
Rank	18	16	15	14	14	14	14

Summary : Major Achievements

- Cultivation of R&D actors
  - GRIs in seventies
  - Corporate research institutes in eighties
  - Universities in nineties
- Increase of R&D investment and of human resources
- Completion of institutional systems
- Rapid structural transformation

Characteristics of SAT Policies

- Goal: support for industrial and economic growth
- Target: private sector-led system from the beginning
- Dominant supply-side policy
- Rapid structural transformation
- Priority setting: centre of excellence
- Growth-oriented investment
- Strong support of the President

CURRENT ISSUES ON TECHNOLOGICAL INNOVATION

- Ability to participate in Global Supply Chain System
- Architecture and platform technology as sources of high value addition
- Possibility of emergence of China's innovation model
- Linkage of technological innovation with macro variable
- Necessity of next generation corporate innovation model in Korea

CORPORATE CAPACITY FOR TECHNOLOGICAL INNOVATION

Input

R&D expenditure gap with global leading firms :

Samsung 2.1, IBM 4.75, Hyundai-Kia 1.2, Ford 7.7 (US$, billion)

Lack of high calibre workforce in firms

Engineering PhDs in firms: Korea 19%, US 64%

Process

Weak cooperation among R&D actors

Firms' R&D fund: university 1%, overseas 1%, inter-firm 9%, internal use 88% (2002)

Output

Initial stage of performance

Technical export/import ratio: Korea 0.23, US 2.36, Japan 2.27 (2001)

MODES OF TECHNOLOGICAL INNOVATION

Stages of Technological Innovation

- The First Generation Model

  Assimilation of Imported Technologies : Examples — textiles and consumer electronics in the sixties and automobile, steel, shipbuilding and machinery in the seventies

- The Second Generation Model

  Production-based Innovation : Examples — new generation products of automobile, shipbuilding, steel, DRAM, CDMA, TFTLCD and DVD

- The Third Generation Model

  Path-navigating Innovation: Examples — SoC, PDA, 4G mobile hand set, fuel cell, BT, NT, optics, next generation vehicles, etc.

The First and Second Generation Models

- Import of basic knowledge and technological learning
- Standardization of items with strength in mass production system: utilizing mid-level engineers
- Development of world-class quality products: increase of export market than domestic market
- Active in-house R&D to match with technology import
- Module-type product development and technological capability building
- Threshold level and technological core formulation process
- Pioneering top management with long-term vision as well as technological insight
- Best practices within the Korean context : no world-class technological novelty and technological breakthrough

The Third Generation Model (emerging stage)

- Developing new products by in-house innovative capabilities
- Initiated by in-house R&D, but the original idea can be borrowed from outside
- Core element : own dominant design and/or architecture
- Technological progress paths are not open and thus technological uncertainty is very high
- Few cases reported in Korea till now

CORPORATE TECHNOLOGICAL INNOVATION : CASE

Performance of Korean Enterprises

- DRAM: world market leader since 1998 (44%, 2003)
- CDMA: world market leader since 1998 (45%, 2003)
- TFT-LCD: world market leader since 2001 (42%, 2003)
- Shipbuilding: global market share (33% , 2003)
- Automobile: global market share (5.5% , 2003)
- Steel: global market share (5.0% , 2003)

DRAM: Samsung and Hynix

Major Performance : Samsung

- World market leader for the last 11 years
- World M/S 30.8% in 2002 > 30.2% (second + third ranker)
- Technological leader in production : at least 0.5 to 1 year ahead of competitors
- Steel : global market share (5.0% , 2003)

Key Success Factors

- Mobilise the best manpower within Samsung and Korean experts
- Long-term commitment and continuous large-scale investment by conglomerates
- High risk-taking in choosing alternative product paths
- Cooperation with US industry: equipments and materials

Sources of Technological Competitiveness

- Economy of speed: concurrent engineering
- Massive resource inputs to technological learning
- Close interface between R&D and production departments
- Abilities to integrate internal R&D and outsourcing
- Massive efforts to fit market conditions including thorough quality control
- Top management leadership to provide favourable environment for R&D activities

CDMA: Samsung and LG

Major Performance

- World market leader in CDMA since 1998
- World M/S of CDMA (23.7%, 2002)
- World M/S of cell phones (9.8%, 2002; 7.1%, 2001 and 5.0%, 2002)

Key Success Factors

- High risk-taking to overcome technological and market uncertainties
- Large and responsive domestic market with strong purchasers — test for new products in the market
- Technology transfer from US (Qualcomm)

Sources of Technological Competitiveness

- Ability to introduce continuously new products with strength in design and timeliness (Samsung introduced 120 new models while Nokia did 30 to 40 in 2002)
- Capability to develop the most advanced production and operation technologies based on its accumulated technological capacity
- Good integration of fundamental technologies imported from Qualcomm Inc, self-developed production and commercialisation technologies

TFT-LCD (Thin Film Transistor Liquid Crystal Display)

Major Performance

- World market leader for the last six years
- World M/S (17% , 2002), LG Philips (16.6%, 2002)

Key Success Factors

- Continuous aggressive investment even in hard times
- Focusing on global standard items rather than niche items as targets from the beginning
- Speedy catch-up and leadership by exploiting latecomers' advantages
- Cooperation with US industry (Corning, 3M)

Sources of Technological Competitiveness

- Effective utilisation of the accumulated technologies and manpower in DRAM area
- Initiatives in developing new products by focusing on two-step ahead critical technologies
- Successful differentiation and competitive advantage over competitors in the function, quality, service and cost of new products
- Massive efforts to keep technological leadership in core technologies of state-of-the-art products

Automobiles: Hyundai and Kia

Major Performance

- The eighth car maker in the world by 2002
- World M/S (3.1%, 2002)

Key Success Factors

- Economy of scale: strengths in mass production
- CEO leadership to overcome several difficulties in its growth path
- Export-oriented growth strategy with its own brand : triggering internal technology development efforts
- Cooperation with US industry (Chrysler)

Sources of Technological Competitiveness

- Strong wish to enhance internal technological capabilities to establish its own brand from the beginning
- Effective 'crisis construction' management to boost up the fast internal learning of key technologies
- Active import of foreign technologies from many sources of different countries
- Strong supports from top management providing favourable R&D infrastructure
- Rapid adoption of new technological trends : early adoption of Multi-Point Injection (MPI) engine with high risk-taking

Steel: POSCO

Major Performance

- The world largest producer since 1998
- Keeping top class operation and production technologies in the world, but not a technological leader

Key Success Factors

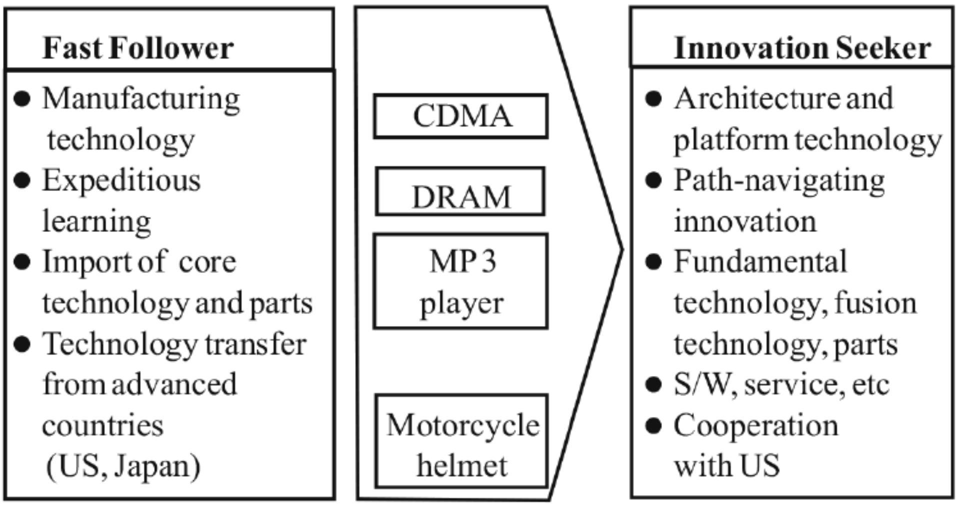
- Economy of scale : strengths in mass production
- Efficient management system and high productivity
- Government's active support at the beginning including sufficient supply of infrastructure
- Adoption of the latest production facilities

Sources of Technological Competitiveness

- Securing long-experienced company engineers and technicians by powerful internal promotion system

- Active technological learning through in-house and overseas training
- Benchmarking and catching-up the Japanese frontrunner
- Acquiring world class operation technologies by skilled engineers in production sites
- Active internal R&D activities to update the next generation technologies

FUTURE STRATEGY FOR TECHNOLOGICAL INNOVATION



Market Leader

- Brand power
- Global standard
- Commercialisation of new technologies
- Digital TV, 4G mobile handset, etc

Technology

- Development of core technology
- Fusion technologies (Nano Technology, Energy)
- Strategic alliance with US
- Intelligent robot, fuel cell, etc

High Value Addition

- Increase of high value added products
- Competitive and unique technology
- Combination with high-technology (US)
- Future automobile, shipbuilding, steel, etc

Innovative Parts

- Participation in global sourcing (US)
- World-class product reliability
- Collective learning with client firms (US)
- Next-generation semiconductor, display, etc

Critical Policy Agenda

Globally Competitive Human Resources

- Restructuring of university education system
- Incentive scheme for inducement to industry

Innovative Small and Medium Sized Enterprises

- Enhancement of SME's technological innovative capacity
- Differentiated policy measurement based on innovative capacity

Innovative Networks among R&D Actors

- Human resource network through national R&D projects
- Promotion of sectoral, regional and functional networks

LESSONS FROM KOREAN EXPERIMENTS

Economy of Scale : Global Standard (resource focusing)

- Strong mass production system in highly standardised items
- Large-scale and massive in-house technological learning
- Producing world class products focusing on international market than domestic market
- Maintaining high productivity by efficient production management system
- High priority to establish in-house manufacturing factories rather than outsourcing

Economy of Scale : Growth for Future (High Risk-Taking)

- Module-type product development and strong integration ability of production process
- Concurrent engineering and parallel product development system
- Close interface between R&D and production departments
- 'Threshold level' and successful 'technological core formulation' process
- Active imports and outsourcing of technological knowledge

CONCLUSION

Korea's Next Model of Technological Innovation

Main Attributes : Path-navigating

- Manufacturing processing technology $\rightarrow$ creation of architecture
- Skilled workforce $\rightarrow$ creative human resources
- Promoting actors $\rightarrow$ innovation networks
- Global cooperation and partnership with US

Policy Focus

- Upgrade of accumulated resources and capacity
- 'Holistic Innovation Policy': Link to the macro policy

Major Political Challenges in the World Today

Mr Lars Bytoft

Chairman
Danish Society of Engineers

INTRODUCTION

Dear President Rear Admiral K O Thakare, dear members of The Institution of Engineers (India), fellow engineers, dear friends –

As far as I know, The Institution of Engineers is probably the world's largest interdisciplinary engineering organisation. Therefore, I consider it a great privilege that you have invited The Danish Society of Engineers to be one of your associates and giving me the honour to deliver the lecture in memory of illustrious engineer and educationist Bhaikaka.

I am also absolutely in no doubt that the future seriously belongs to you. India's economic growth over the last few decades has been extremely impressive and this development is going to continue for many years to come. Today India is the fourth largest economy in the world. You have the world's second largest work force, combined with an exceptionally high level of education. There is no doubt that India, in the decades to come, will undergo significant development, which will result in greater prosperity for your whole population. However, this cannot happen unless you engineers continue to be the necessary and crucial driving force behind that development.

THE MAJOR POLITICAL CHALLENGES IN THE WORLD TODAY

In the last few months, we have experienced a growing anxiety, particularly in the financial markets, an anxiety, which many believed was a thing of the past. Objectively, however, we must conclude that the stable growth, which most of us took for granted, is perhaps not quite as stable as we believed.

The guarantee of stable financial conditions is essential, if we are to guarantee economic development in the future. At the same time, the anxiety on the financial markets must not deter us from making business and exchanging services with each other. Increased commerce is the best guarantee for peace and stability in the world.

It is in this context, the engineers have a very special role to play, in terms of both economic and sustainable development.

The subject of this congress is ‘Environment and Ecological Challenges: Role of Engineers’. I do not believe you could have chosen a more pertinent theme. The creation, in a sustainable way, of increased economic prosperity and development is, in my opinion, the 21st century's greatest political challenge, not to mention engineering !

Over the last ten years or so we have seen that the environment has seriously begun to set limits on the continued growth of our common prosperity. The greatest problem that affects us all is probably global warming. We can now start to see and feel its serious effects. If we do not start to react and thus reduce the emission of greenhouse gases, the ultimate consequences will be of catastrophic proportions.

In other words, we know that it is not a question of whether we will experience climate changes, it is a question of the degree to which they will come to affect us.

In Denmark and the rest of Scandinavia, where there is a temperate climate, we will experience a wetter and slightly warmer climate, which of course will be problematic in itself. But countries such as India will be hit much harder and can expect many more floods, even worse than those of today. You will also be victim to much more drought and water shortage than you are now.

I am the first to admit that it is totally unfair that we, in the so-called “industrialised” part of the world, are by far the greatest emitters of greenhouse gases, while countries such as India are hardest hit by climate changes.

Therefore, I will do my best to see that Denmark and other western countries assume much greater responsibilities for the reduction of greenhouse gas emissions, when, I hope, a new agreement will be signed by next year at the United Nations' Summit Conference, COP 15, in Copenhagen.

FINANCIAL DEVELOPMENT AND ENERGY CONSUMPTION

A reliable and stable energy supply is, and will continue to be, crucial for economic development. History has shown us that there is a close correlation between economic development and the world's energy consumption. A period that sees the industrialisation and modernisation of society requires an increase in energy production. Therefore, it will be morally wrong and a symbol of outmoded, misguided cultural imperialism, if developing countries and emerging economies are not given the opportunity to increase their energy consumption and to achieve the prosperity, which we in more developed economies have enjoyed for many years. In fact, the International Energy Agency predicts that, in about five years' time, those so-called developing countries, who are presently in the process of industrialisation, will have just as great an energy consumption as Organisation for Economic Co-operation and Development (OECD) countries. I will go into this issue in greater depth later.

For the past 50 years, we in the western world have not paid sufficient attention to the environment and the use of resources. This means that today there is increased pressure on the world's resources and increasing number of environmental problems. That in turn compelled us to create a new form of energy supply, which does not lead to the environmental problems we know today.

The UN climate panel IPCC estimates that the emission of greenhouse gases must be stabilised before 2015 and decreased further by 50% - 85% before 2050 in relation to the 2005 level, if the average temperature on the earth is to be prevented from increasing by more than 2ºC - 2.4ºC.

This is an enormous engineering challenge. Certainly viewed in the light of the present trend, in which the emission of greenhouse gases increased by about 1% from 1990 and annually by 3% in the period after 2000. But the challenge should also be viewed in relation to the demographic and economic development we are witnessing.Whereas today there are more than six billion people in the world, by 2050 there will be about nine billion, which represents a population growth of approximately 50%. At the same time, we hope that economic development will continue and we will manage to wipe out poverty. You do not have to be an engineer to realise that this is a gigantic task.

Economic growth also means that the pressure on our natural resources and the discharge of climate gases, all things being equal, will increase, if we do not initiate a radical change in our energy systems. Further, to guarantee a reliable and sustainable energy supply means that we must also develop systems in which the dependence on present geostrategic energy resources, such as oil and gas, is more limited. Those resources anyway are increasingly available for import only from a handful of regions in the world.

This can place us in an unfortunate and dependent relationship to nondemocratic political regimes, resulting in periodic breaks in our energy supply and ultimately threatening global security. Not many nations are going to be interested in that.

In the worst event, the struggle for limited energy, agricultural and water resources, not to mention the consequences of future environmental catastrophes, could lead to large sections of the population being dispelled and increased conflicts and wars between population groups over the remaining resources.

In other words, we risk undermining the very nature that is the whole foundation for our livelihood.

ENGINEERS HAVE A SPECIAL ROLE TO PLAY IN ECONOMIC AND SUSTAINABLE DEVELOPMENT

It is our duty as engineers to do whatever we can to prevent the above scenario from becoming a reality. We must become better at utilising nature's forces and potential. We must work with nature and not against it. We must get better at understanding nature, her strengths, organisation and eco-systems. We must use that knowledge in our day-to-day engineering work for the benefit of mankind.

Throughout history, engineers have always been responsible for guaranteeing economic growth, but our perspective has always been much more than a purely economic one. More often than not, engineers have been driven by a desire to change the world and make it a better place to live in.

There could not be a better illustration of this tendency than the man, whom this Memorial Lecture is named after, Bhaikaka. The will to combat poverty ‘and the service of humanity’ were the vital forces in his work. This will to change the world is absolutely crucial, if together we are to tackle the challenges in the area of energy.

In recent years, we in The Danish Society of Engineers have drawn up a range of plans for a more sustainable future, that includes energy. We set ourselves the goal of reducing Denmark's emission of CO_2 by 50% before 2030 and of becoming, by 2030, totally energy self-sufficient and creating four times as many jobs in the energy sector. People claimed this was impossible.

For 12 months, with the help from our members, we held a large number of seminars and conferences on the subject of energy. We made active use of our members' skills to identify the energy technologies etc, that need to be developed, if we are to live up to the goal to establish a more sustainable energy system.

It was a great success and today our energy plan is central to the crossparty political debate in Denmark. So we believe our work was worthwhile.

Our experience of using our members' professional expertise in this way also led to the establishment of the project “Future Climate-Engineering Solutions.” This is a project in which we are inviting our sister organisations from all over the world to devise national climate plans. We are really delighted to have The Institution of Engineers (India) on board this project.

ENERGY CONSUMPTION AND ITS CONNECTION TO POLLUTION

When we take a closer look at the development in the global demand for energy, we can see that, till now, the OECD countries have had the greatest energy consumption. However, that development is undergoing a change and the greatest demand for energy is now coming increasingly from developing countries and emerging economies. The International Energy Agency has developed a so-called reference scenario, a scenario that shows the development in energy consumption on the basis of political decisions made up to, and including, 2006. According to this scenario, more than 70% of the world's demand for energy in the period between 2004 and 2030 will come from developing and emerging economies. In particular, we can look forward to a very significant demand from India and China. The growth will occur primarily as a result of the increasing demand for electricity and energy in the transport sector. This also means that efforts to reduce greenhouse gas emissions will also encompass emerging economies.

However, it will still be the OECD countries, who have the greatest obligation to reduce greenhouse gas emissions, because, in the future, OECD countries will also have by far the greatest per capita energy consumption. Personally, I also believe that OECD countries have a special responsibility to reduce greenhouse gas emission because of their greater prosperity and because historically we have emitted enormous quantities of greenhouse gases.

The International Energy Agency has recently published a report, Energy Technology Perspectives. This report constructs a scenario, the so-called “BLUE MAP” scenario, in which the emission of greenhouse gases is reduced by half in 2050 in relation to 2005. In other words, it is a scenario that attempts to reduce the emission of greenhouse gases, so that the temperature will rise by a maximum of 2ºC - 2.4ºC.

The good news is that it can be done. It will cost in the region of US$ 45/T. That is an awful lot of money, but, compared to the expected global economic growth, and the harmful effects of greenhouse gas emission, it really is not so scary. And anyway, the fact that it can be done is wonderful to know.

However, what concerns me most as an engineer is whether politicians have the will and the strength to agree on an ambitious and sustainable energy policy. My concern is even greater when one takes into account that the scenario predicts that the greenhouse gas emission will peak as early as 2012. That cries out for political action here and now. The later the emission peaks, the more difficult it will be to achieve the goal by 2030.

If we look more closely at the technologies behind the BLUE MAP scenario, it is crystal clear that the greatest reduction of greenhouse gas emission (as much as 44% in the scenario) must come from improved energy efficiency by end users. Those end users are principally, the transport sector, the building trade and industry, where more effective processes are called for. Power stations must also become more efficient and cut down on the use of coal for the production of energy. 22% of the reduction in emissions must come from the expanded use of renewable sources of energy. 19% must come from carbon capture storage and 6% from the development of nuclear power.

The focus on energy efficiency is due to the fact that they provide by far the cheapest solution in relation to the effect. In fact, it is the case that endues efficiency often has direct economic advantages. In other words, there is big point in picking the lowhanging fruits, which are connected to the improvement of energy efficiency.

As you can also see, improvements in efficiency in the power station sector and the development of more renewable energy and nuclear power are relatively cheap. The expensive technologies are the implementation of carbon capture storage and the change from oil to alternative fuels in the transport sector.

THE HISTORY OF ENERGY IN DENMARK

I will now give you an insight into the ‘history of energy’ in Denmark, because it has, in many ways, been a great success. Denmark is the only country in the world to have enjoyed economic growth over a 35-year period, while at the same time, our energy consumption has been comparatively stable. In fact, for a number of years our emission of greenhouse gases fell. Unfortunately, however, in recent years that situation has changed.

In the 1970s Denmark, like the rest of the world, was hit by a rise in oil prices. That was the beginning of a relatively stable energy policy for a number of years and a great number of long-term energy plans. Whereas, at the begining of the 1970s, oil was by far the most dominant source of energy in Denmark, the Danish government decided to focus on coal and gas for energy supply. At the same time, and just as importantly, they improved energy efficiency by building combined heat and power facilities and developing district heating. They also began to support the development of new, renewable energy technologies.

As a result Denmark has gained a broader combination of energy, which means that we are not as vulnerable as before in terms of the import of strategic energy resources and, at the same time, our energy efficiency has improved radically.

Both combined heat and power and district heating deserve special commendation for this development.

The development of district heating, together with combined heat and power facilities, is definitely the single most significant factor in Denmark's stable energy consumption. Quite simply, it is a question of not wasting surplus heat from the production of electricity, but instead using this heat for the heating of our houses. As you can see, heat and power production supplies almost 80% of the heat in Denmark's district heating and about 50% of electricity.

Regarding the other area of technology, I would like to draw your attention to the great Danish windmill adventure. Today Denmark is one of the world leaders in the use of wind power. It was not only due to the fact that the Danish government who began to focus on the whole energy issue in the 1970s. The Danes themselves also showed great will and interest in developing new energy technologies, particularly renewable energy technologies.

A whole range of citizens, smiths and engineers began to experiment with the development and construction of windmills. Initially these windmills were small and relatively primitive, but gradually the Danish state subsidised their construction and, bit by bit, their quality improved significantly. After a number of years, serious money was invested in research into windmills. In the 1980s, and particularly in the 1990s, the development really took flight and Danish companies developed the windmills, with which we are familiar today.

As you can see from the graph, today windmills supply almost 20% of Denmark's electricity. This makes particular demands on the Danish electricity system, which has to cope with large quantities of fluctuating energy. Twenty years ago, one would not have thought it was possible. But today we are in no doubt that we are able to manage much larger quantities of fluctuating wind energy in our national grid.

The Danish energy system has become much more effective. We have also succeeded in stabilising our overall energy consumption and reducing CO_2 emissions. In addition, our prioritisation of the energy issue has meant that we have developed some of the world's most competitive companies in the field of energy. Of course that includes windmills. Vestas is the world's largest windmill manufacturer, but it also includes areas, such as, energy-effective pumps, thermostats and enzymes used for the production of bioethanol.

As you can see, our export of energy technologies has grown significantly in recent years and energy has developed into one of Denmark's most important industries.

In my opinion there is no doubt that ‘green tech’ will become more and more important all over the world and Denmark's experiences clearly indicate that one must be at the forefront of development, if one is to reap the benefits in the form of growth, in terms of both industry and employment. Countries, who do not take the climate challenge seriously, will eventually be crippled. Their industries will be losers in the future competition to supply effective, climate-neutral technologies to companies and citizens throughout the world.

As I have explained during my introduction, the Danish Society of Engineers have developed an energy plan that shows how we believe the Danish energy system should be developed by 2030. As I explained earlier, the goal was to show that Denmark can reduce the emission of greenhouse gases by a minimum of 50% by 2030, at the same time developing Denmark's engineering industry to the benefit of both employment and export.

The success has far outweighed the expectations. In the plan, we showed that it is possible to reduce CO_2 emissions from the Danish energy system by as much as 60% in relation to emissions in 1990. The most important part of our plan has been the improving energy efficiency, in the same way that the International Energy Agency predicts, and our scenario showed that it is possible to reduce energy consumption by approximately 30%. In our scenario coal is more or less phased out and approximately 50% of our energy supply is based on renewable sources of energy.

Particularly in our study, the calculations of the economic costs involved in the energy plan were interesting, compared to a ‘business as usual’ scenario, in which we imagine that decisions regarding energy policy are not different from those being taken today.

The study showed that the execution of our plan could save approximately $US 3 billion per year, mainly because our plan would involve a lower consumption of fossil fuels. $US 3 billion may be does not sound very much to you, but for a small country such as Denmark, with about 6 million inhabitants, it is a great deal of money. Just try and calculate the sum in Indian terms.

I do not want to use a lot of time on the individual solutions and technologies involved in our plan. I will just highlight some of the plan's most important elements.

Our suggestions include better insulation of houses, which would reduce domestic energy consumption by 50%. We are suggesting that the Danish state introduce an energy saving fund, which would provide subsidy for energy saving in houses. We would also like to see much more restrictive housing standards than the present ones. We are also suggesting that a large part of the country's road transport be transferred to rail. It is especially important to move freight transport on to trains. But this will only happen if there is serious investment in the railway system. At the same time it is important that, in the future, a great number of cars run on electricity. The traditional internal combustion engine is totally uneconomic.

We take for granted that it will be both technically and economically possible to base our present heat and power stations on fuel cells. Fuel cells are much more energy efficient than traditional power stations. However, that is going to need serious investment in the research and development of fuel cells.

The final thing I would mention here is serious development on the windmill front, so that by 2030 windmills will contribute between 50% and 60% of Denmark's electricity consumption.

ENERGY SUPPLY IN INDIA

In many ways our challenges on the issue of energy are very similar. Like Denmark, you import an enormous amount of your oil, I believe, it is 70%, which I am sure you would rather be without. If your present development continues, in 2025 you will be the world's third largest importer of oil after USA and China and you will be dependent on the Middle East.

Today a very large part of India’s electricity production is based on coal, so is Denmark's. But whereas Danish coal consumption is not particularly significant by international standards, India is the world's third largest consumer of coal.

I think it is also interesting that both Denmark and India are home to some of the major windmill manufacturers: Vestas and Suzlon. As it happens, Suzlon has a fairly large development department in Denmark. However, although in some areas we are similar and face common challenges, we must admit that the challenges facing India and other booming, emerging economies are very different from those facing Denmark. So the solutions will also have to be different. Nevertheless, despite the differences, I believe we can learn from each other's experiences and I would now like to share a couple of humble recommendations, based on our experiences in Denmark.

You will have to produce even more energy, if you are to guarantee your economic growth and a good standard of living for your citizens. You will have to develop your electricity system to meet the needs of approximately 400 million people, who do not yet have access to the electricity. However, despite the scale of the challenge, you have the advantage of being able to draw on your own experience and that of others. In other words, you do not have to commit the sins of the past.

If I was in your position, I would do everything to encourage energy saving and energy efficiency. Energy saving and energy efficiency will always be cheaper than building new production capacity. I would also set high standards for electrical products, such as electric bulbs, airconditioning and household appliances, and make great demands on industry to make their processes more efficient.

Another experience I can contribute from Denmark is that distributed local solutions can be just as effective, cheap and flexible as systems dominated by large power stations. Small, distributed electricity systems, in which electricity production is based on biomass, small solar cells and small windmills, could may be provide a solution for the large areas of India, which are not yet electrified.

Why should you construct expensive transmission lines to those areas that are not yet electrified, when today's technology can provide distributed systems? Local solutions could also provide the means of developing employment in the area. For example, in Denmark we have several areas that aim at being based 100% on renewable energy, because it also creates growth and work places for the area.

In India you are in the process of developing your nuclear energy supply and I know that recently you entered into an important agreement with USA to exchange knowledge and technology in this field. Without a doubt this is a step in the right direction. The development of your nuclear power stations will be one of your best options for reducing your emission of greenhouse gases.

Nonetheless, despite the development of nuclear energy, in future, most of the power stations will also be based on coal. Therefore, it will be crucial, from both an economic and an environmental point of view, to work hard to the running energy efficiency of these power stations. I am aware that this is also the ambition of the Indian government in their 2006 Integrated Energy Policy.

On this subject, I would also suggest that, in the future, you build combined heat and power facilities. Whereas, in Denmark we use the surplus heat from heat and power production for district heating, your option could be to convert the surplus heat to cooling for use in district cooling. Today district cooling is, without a doubt, a technological option and cooling based on heat and power production is far more economic in terms of energy than traditional electric air-conditioning.

My final recommendation is that you work heart and soul on the development and distribution of electric cars. I am aware, and delighted, that TATA and REVA from Bangalore have both developed their own electric cars. Besides the fact that electric cars are much more energy efficient than traditional cars, their distribution will also play a vital role in the fight against pollution in India's cities. Electric cars will also help reduce your oil imports. Further, I believe there is no doubt that, in the future, electric cars will dominate the world's motor vehicle market. If Indian companies lead the way in this development, they will also get a large slice of the future global car market.

FUTURE CLIMATE

As I mentioned before, the work of The Danish Society of Engineers on developing a Danish energy plan inspired us to start the project, “Future Climate Engineering Solutions”. The purpose of the project is to bring together engineering organisations from all over the world to develop sustainable climate plans, based on the energy technology solutions of their own countries.

Together we want to present a palette of innovative ideas and technologies, which will prove that it is both technologically and economically possible to reduce the emission of greenhouse gases to a sustainable level. It is our ambition to present the results of our work to the UN at the Climate Summit in Copenhagen in December 2009.

In purely concrete terms, we have set ourselves the target of developing technology-based climate plans, which show the possibility of reducing greenhouse gas emissions, so that the world climate stabilises and the temperature does not exceed 2ºC.

In addition to Denmark and India, the project includes: Japan, Australia, Norway, Sweden, Finland, Germany, England, Ireland and the USA. We started the project with a major conference, followed by a Seminar in September. Now all the organisations have rolled up their sleeves and are ready for work. In September next year each one of us will present a sustainable climate plan at a final conference in Copenhagen. I look forward greatly to seeing the fruits of our collective efforts.

A LACK OF ENGINEERS

As I have emphasised several times, we are faced with an enormous challenge in creating a more sustainable energy system. The question is whether we have sufficient engineering resources available.

We know many of the technologies, but most of them must be developed further and also implemented. I am concerned that we, especially the OECD countries, are going to experience a lack of engineers to contribute to the development and implementation of new and better energy technologies.

The lack of engineers is an enormous problem for the OECD countries, who are going to lack even more engineers in the future. The main reason is that fewer and fewer members of the younger generation are choosing an engineering education. The problems are only exacerbated by the small number of young people today, in contrast to the large number of people who are about to retire.

This development is significant in Denmark, where 25% to 30% of our engineers will be retiring in the course of the next 7 to 8 years, and where, in the same period, there will be a small number of young people. Therefore, the Danish Society of Engineers, together with the government, public authorities, companies and educational institutions, are working to encourage more young people to choose the engineering profession.

It will demand a lot of hard work. Therefore, I am delighted that, in the meantime, we have succeeded in attracting a number of foreign engineers to Denmark.

Of course, many of these come from other EU countries, but approximately half of them come from countries outside the EU. In 2007 approximately 1,400 engineers from non-EU countries came to work Denmark and, of these, two-third of them (940) came from India. Indian engineers find Denmark attractive, while Danish industry gets the benefits.

We, The Society of Engineers are delighted with this influx, because it facilitates the creation and development of competitive development environments and businesses in Denmark. Mind you, at the same time, just as many Danish engineers find work abroad, so one could say that the migration contributes to the creation of development, both for the individual engineer and for our respective societies.

I also regard the association between our two organisations as an enormous benefit for our ‘migrant members’, for whom both organisations will now be able to provide support, advice and guidance.

But, at the end of the day, I continue to believe that we are facing a global problem in terms of solving the world's energy problems. We can point out the technical solutions, but the task is so enormous, that it is going to take a focused and extraordinary effort to train those engineers who can develop and implement them.

So, when we present our suggestions for a solution, I find it important that we also make our governments and authorities aware of the bottlenecks, where a lack of the right engineering skills could easily represent.

CONCLUSION

Global problems require global solutions. Although, broadly speaking, we know the technological answers to the climate challenge, it will be political priorities, not just in one, but in all the countries of the world, which will pave the way so that technology can do its proper job.

It is our role as engineers to show politicians what technology can do. But, when all is said and done, it is politicians who will create the conditions for the effective use of our solutions in the struggle to create a better future for our planet. That is the goal of every single engineer.

Through projects like ‘Future Climate’ we can show politicians all over the world that there are solutions to problems, even global warming. But I also hope that the project will be an example of how much we can achieve together, when we unite the skills of engineers from all over the world. In Denmark there was once a popular advertising campaign for a telephone company. Its slogan was, ‘Conversation encourages understanding.’ I am of the same opinion.

We should, we must, converse much more with one another. I hope this new association between IEI and The Danish Society will mean that we are going to have lots of discussions with one another. We can set an example for others.

We live today in a global world with enormous challenges, but also with possibilities. I believe we can tackle these challenges, if we simply work together openly and honestly together. For as long as both the will to make the changes and the competences to do so are present, then everything is possible. And the engineers have always been known for both, and it is up to the rest of the world to do the same.

Thank you very much for your attention.

Creating World-Class Institutions in India – Some Issues

Prof D P Agrawal

Chairman
Union Public Service Commission, New Delhi

I wish to thank the Institution of Engineers for considering me worthy of delivering Bhaikaka Memorial lecture on the occasion of 24th Indian Engineering Congress. I have been associated with the activities of the Institution of Engineers for a long time and is also a Fellow of the Institution. I have been very proud to have received from the Institution of Engineers, a number of recognition over the years. I profusely thank them for all the kindness and affection shown to me. As we all know the Institution of Engineers (India) is the oldest professional body of engineers in India. It was established (1920) to promote and advance the art, science and practice of engineering and technology amongst the members and the public at large. It works closely with engineers, academicians, research workers and professionals. It had pioneered the delivery of non-formal engineering education programmes in the country. It's AMIE is recognized as equivalent to a graduate degree in engineering by the Government of India.

INTRODUCTION

In the context of quality and its assurance and assessment in higher education, the research revealed that the professional bodies may be entrusted with ensuring the public interest in the absence of any effective checks on the activities of the professionals. The Institution of Engineers may define the specific competencies and underpinning knowledge required for their practitioners and the trend toward standards consistent with market demand.

The Institution of Engineers is also on the forefront for introducing ethical code of conduct to its members. In essence, professional ethics refers to the ethos, rules and principles underpinning professional practice. A professional assuming a professional title, expressly agrees to be bound by the rules of that profession. It is described as a synthesis of minimal legal requirements and statements of ethical ideals, backed up with professional statements. A code of ethics can also be a deterrent: that is, practitioners follow its principles otherwise they could be 'struck off'.

I am privileged to be at the campus of one of the best NITs in the country having great reputation for academic achievements in teaching and research. I am in know of the many a new and innovative steps taken by the institute after attaining Deemed University status in 2002. The institute is in its 50th anniversary year. It is an occasion for rejoicing and introspection. On this occasion, I congratulate them for the high standards they have established for themself and for maintaining it for over five decades. I also wish them luck.

While deciding to speak on this occasion, I considered it my duty to learn about the great man in whose memory a lecture has been instituted. In this regards I recall my visit to Birala Mahavidyalaya, Vallabh Vidyanagar to address their convocation wherein I interacted with a number of academics and senior citizens. I also went to WEB for further Information about this personalatity. Available Information has been very large and presented in glowing terms.

I may summarise by saying that 'Bhaikaka', an imminent civil engineer in the service of government, had earned a great reputation for his sense of values, discipline, dedication to duty and absolute integrity. Once, Sardar Patel, the Iron man of India, advised him to go to the villages and work for their regeneration.

Consequently, Bhaikaka saw that the most potent instrument to improve the sub-human life of villagers was to bring higher learning to their very doorstep and thus the concept of establishing institutions of higher education started taking shape. He was a great institution builder and thoughtful institutional leader. He always chose the best faculty from all over the world and also ensured training to teachers abroad. While setting an institution at Vallabh Vidyanagar, he worked out an ingenious scheme and persuaded the farmers to donate their land free of cost, saying, “Donate your land to us now; we'll develop and use two-thirds and return you the remaining one third in course of time”. The response to it was overwhelming and a total of 555 acres of land was received in donation.

His love for natural environment was unparalleled and to it one can owe the lush-green, stately, shady trees all along the roads in Vallabh Vidyanagar. Bhaikaka devoted himself to create an institute of higher learning for serving the cause of education and through it the development processes of villagers, an outstanding contribution in an area hitherto touched by a few.

It is in this background that I chose to talk to you on a subject which could have been dear to him i.e. "How to build a world class institution". Since we live an age of technology and an environment where acquiring and managing knowledge is niche, I start by discussing the kind of education needed in the knowledge economy.

Education for the Knowledge Economy

The ability to produce and use knowledge has become a major factor in development and is critical to a nation's comparative advantage. Education for the Knowledge Economy (EKE) refers to cultivation of highly skilled, flexible human capital needed to compete in global markets. It requires a strong human capital base to be produced through education systems that impart higher-level skills to a greater share of the workforce. These systems must foster lifelong learning, must offer recognized certificates and degrees through internally accredited institutions.

EKE needs to build a national innovation system, a network of firms, research centres, universities, and think tanks that work together to take advantage of global knowledge–assimilating and adapting it to local needs.

EKE encompasses a wide range of efforts, including secondary education that lays the foundation of a healthy, skilled, labor force capable of learning new skills as needed and higher education that creates the intellectual capital to produce and utilize knowledge. life long learning, science & technology, and innovation and use of information and communications technology (ICT) are some of the aspect of this education.

Institutions, those offer EKE, strength goes beyond research and development, allowing both companies and entrepreneurs a chance to validate their technologies and get them out in the marketplace. The culture of collaboration between academic institutions, entrepreneurs and companies in these business sectors really makes any ambition achievable.

Let us also appreciate that the world continues to get smaller and flatter, and now needs to get 'smarter.' It highlights the need to solve some of the most pressing problems of the world by leveraging technology. Smarter education will reshape learning around two key components of any education system: the student and the teacher. Next wave of efficiency in education will come from adaptability of learning processes instead of inflexibility of university administrative systems.

In such a paradigm of education, setting global academic standards is a complex process and need to keep the following in mind:

- Share promising national and international efforts in the development of world-class academic;
- Share promising practices;
- Highlight ways to improve academic standards, assessments, and accountability systems and to ensure that schools and students actually attain those standards; and
- to keep standards from narrowing the curriculum.

Need for Higher Enrolment

With a growing number of young people, gains in school education and rising prosperity, demand for higher education is rising rapidly. India would have the largest population by the year 2028 and population of its young generation (15-24 years) already exceeds that of China. This would put enormous pressure on the Indian higher education. Thus, improving access without compromising on quality and cost is the most significant challenge before India's higher education.

Consistently we need to develop a critical mass moving from higher secondary to undergraduate institutions and to research universities. Among the millions of students in India who go to school, only 12.4% reach college. By contrast, in the United States, 63% of students go to college; among the 30 member countries of the Organisation for Economic Co-operation and Development, the average is 56%. Therefore, we have targeted 30% of the cohort to get there by pushing an additional 40 million students in higher education, by the year 2020. On top of this is the massive increase needed in postgraduate enrolments catering for the need of education system and also high technology industry.

Increasing access will require the expansion of enrollment at existing institutions and the creation of many new ones at all levels. Let us appreciate that top class universities will only contribute a small fraction of the required increase in enrollments throughout India, but they will play an especially prominent role in India's future development.

Need for a World Class Institution

India is the most populous and vibrant democracy the world has ever known. The value of universities has always been recognised in all societies that they have existed, the oldest being India and China. Modern governments, too, recognise the key value of universities, and more recently realised that increasing mobility of people, demands for advanced study, and the dynamics of the research community, driving forward in areas such as high technology have heightened the role of universities.

The great universities become economic drivers and play a huge role in their region. This is as true for Stanford University in the creation of Silicon Valley in the US as it is for Cambridge University in the creation of Silicon Fen in the UK and the same is about IIT Guwahati which was established for the same thought in view as part of Assam Accord.

India's development context is also unique; its economic agenda is deeply rooted in social issues.

There is no doubt that India possesses a number of educational institutions that have made their mark, and will continue to make their mark, on the world stage. But the dream to become one of world's economic powerhouses calls for expansion in India's higher education system. The need is a striking one.

In terms of quantity, Indian higher education currently the third largest, would surpass the US in next the five years and China in the next 15 years to be the largest system of higher education in the world.

However, in the list of top 500 universities in the world, India has only a few IITs and the IISc. China itself has 18 universities in the list. The US tops the list with 159, all of Europe has 210.

Keeping these issues at centre stage and the quest for making India a knowledge super power, the Government of India set up a Knowledge Commission. It made a number of recommendations for achieving the objectives, which interalia included setting up of a number of world class universities in the country. On acceptance of this report, it was decided by the government to establish 14 innovation universities during the XIth five-year plan (2007-2012) aimed at world-class standards. These Universities would be at the fore-front of making India the global knowledge hub and set benchmarks for excellence for other central and state universities. The first and foremost criterion for a university to be termed world class is the quality and excellence of its research, recognised by society and peers in the academic world. The proposed institutes shall create more reliable and credible admissions processes and autonomy in administration, teaching and research.

Everyone wants a world-class university. No country can do without one as the global war for talent intensifies. In this process, the quest for worldclass status among universities has become more prominent. Like in India, Pakistan announced its ambitious US$4.3 billion project to create nine world-class engineering universities in collaboration with European universities, with 50% of its academics and administrators coming from Europe. King Abdullah University of Science and Technology in Saudi Arabia is also one such ambitious project.

World-Class Institutions in India

For an institution to be world class, there has to be a commitment for it. It must be backed by out of box thinking and innovative approach in all the activities of the institution. We already have examples of IITs and IISc Bangalore, who are considered part of the Ivy league institutions of world for education and research. Research in these institutions is of global standards. The elements that have gone to make them what they are encompass: governance arrangement, full academic freedom and high quality faculty and students and also the exhilarating academic environment. These institutions are publicly funded institutes.

In private sector, Indian Business School has emerged as an inspiration example. Much is written about the tremendous success of ISB model and also about the reservations of this model. It has done things differently than one existing in India and positioned itself as institute of high quality with a price. It has charged much higher tuition, chosen the location in an upcoming metropolis backed by the state government, designed one year programme rather than two years and selected students with work experience only through globally accepted GMAT scores. The faculty was flying global faculty under a visiting faculty model from international schools. The institution also had partnership with global B-schools like Kellogg, Wharton & London Business School which lend their names to it. Fund-raising principals were employed for building world class facilities on campus for academic who required significant upfront cost. ISB case proves that innovation requires relentless conviction to achieve successful execution.

In the early years of technical education in the country, we also have examples of BITS, Pilani and Thapar Institute, Patiala run by large industrial houses as philanthropy.

Proposed Vedanta University has chosen Stanford University, USA as model for an ambitious international institution in the state of Orissa. It aims to attract researchers, staff and students from around the world.

Undergraduates will study diverse subjects including literature, economics, music, arts etc. on the way to earning degrees, rather than focus exclusively on one discipline.

There will also be a research and development park serving as an incubator for spin-off companies. Eventually, it is hoped that this will evolve into a large research-cum-education complex resembling silicon valley, the economic hub that surrounds Stanford.

Global Research Centres in India

Growth of Indian economy and resulting opportunities are attracting more global universities to be a part of this growth story through their academic and research offerings. They believe that research collaborations and dedicated research centres of foreign universities would help Indian universities in developing a culture and approach towards research which is both cutting edge and rewarding. Likewise, foreign universities gain immensely from the research engagement, networking, brand visibility and local presence in India. However, finding effective research collaborations in India is not easy for top-tier foreign universities. This is primarily because Indian universities lack the research culture and enabling environment. Thus global universities, not wanting to dilute their brand, are going beyond research collaborations and establishing dedicated research centers in India. Some examples are as follows.

i. a high profile research academy partnered by Monash University, Australia and IIT-Bombay on the IIT Campus to undertake multidisciplinary research to provide engineering solutions in areas including infrastructure, clean energy, water and nanotechnology.

ii. Founded in 1997, the University of Pennsylvania's Institute for the Advanced Study of India in New Delhi undertakes research projects and engages scholars across a range of institutions in to produce research relevant to the regional needs.

iii. Harvard Business School (HBS) established the India Research Center (IRC) in 2006. It seeks to play a proactive role in the social transformation of India by engaging HBS faculty, sharing knowledge and best practices through research and case studies, encouraging talent and skills among students who are managers in the making and with leaders. IRC works to bring the best of Harvard to India and take the best of India to Harvard.

Concept of World-Class Institution

The modern university is a large, complex organisation with multiple stakeholders, increasingly involved in a world of global competition. It is appreciated that a university is not just classrooms but a live environment for thousands of people.

Few have attempted to define a world-class university. The dictionary defines world class as ranking among the foremost in the world; of an international standard of excellence. At the fundamental level, a worldclass university contributes to the world through research and innovations. A great research university is not built around students and scholars who inhabit it, and the experiences and ideas they share to create advance knowledge and enable young people to become critical thinkers and society's leaders. It develops an environment that facilitates learning and growth in all areas of human endeavor and teach young people how to think not what to think.

Such universities are composed of many things: a distinguished faculty; outstanding resources, library collections; state-of-the-art laboratories and computing resources; and a wide range of extracurricular, cultural and athletic activities, to name just a few essential components.

Researches from these universities develop new ideas feasible to be converted to products for human welfare and the advancement in quality of life in communities across the world. The human capital produce by them are the next generation of leaders, leaders who will be able to tackle new problems and new situations with maturity and flexibility and who see the world with curiosity and an open mind.

World Bank in a report highlights that ‘becoming a member of the exclusive group of world-class universities is not achieved by selfdeclaration; rather, elite status is conferred by the outside world on the basis of international recognition’. For world-class standards require deep commitment to global best practices adapted to the local context.

Academic freedom and an atmosphere of intellectual excitement are central to a world-class university. This means that professors and students must be free to pursue knowledge wherever it leads and to publish their work freely without fear of sanction by either academic of external authority. Some countries permit unfettered academic freedom in the nonpolitical hard sciences, but place restrictions on it in the more sensitive social sciences and humanities.

There is also a view that in addition to starting new institutions, it is important to choose a handful of institutions to nurture and propel towards becoming world class institutions. Efforts should be made to highlight the importance of attracting and nurturing faculty that are research pioneers in the fields: 'India must fund research on a strictly meritocractic basis and integrate researchers into universities.' It may require the universities to 'break egalitarianism in salaries' in order to be able offer competitive salaries to lure back faculty that have chosen to work abroad. Bill Green, CEO Accenture said 'India does need world class institutions but there is also a need to raise the water table in the tank.'

There is no universal recipe or magic formula for 'making' a world-class university. National contexts and institutional models vary widely. Therefore, each country must choose, from among the various possible pathways, a strategy that plays to its strengths and resources.

Some suggested combination of conditions and resources for creating world-class universities as follows:

1. Sustained financial support, with articulated accountability and autonomy;
2. Innovative and differentiated academic system;
3. An effective administration on the of lines of Global organizations;
4. Truly meritocractic hiring and promotion policies for the academic profession;
5. A rigorous and honest recruitment, selection, and instruction of students from world wide.

Some Characteristics of World-Class Institutions

The best universities seek to educate students not to be experts in a particular field, but to be creative, flexible, and adaptive; to approach problems critically and to collaborate with others to solve them; and to be able to understand different cultures and adapt to new environments. Universities train students not for a profession, but for life.

The guiding light in the creation of a course of study should be to stretch the minds of students to the limit which is infinite. Professors must serve as mentors, as sources of inspiration, not merely as lecturers and graders. Students, too, should not find their development limited to the classroom. Students should learn over meals with their peers in university dining halls than they do in classrooms and lecture halls. In addition, extracurricular activities - producing a play, singing in group, writing for a campus publication help teach skills in teamwork, communication, and collaboration that students later put to use as their careers develop.

A world-class university will accommodate a large number of disciplines and areas of study, to ensure cross-fertilisation of ideas which comes from the gathering together of bright, higher-energy people from a variety of backgrounds and traditions.

World-class universities recruit students and faculty without concern for national borders. This enables them to focus on attracting the most talented people, no matter where they come from, and open themselves to new ideas and approaches. Harvard, for instance, has a student population that is 19% international; Stanford, 21%; Columbia, 23%. At the University of Cambridge, 18% of the students are from outside the European Union. The US universities ranked at the top of these global surveys also hire significant numbers of foreign academics. Caltech, for example, has 37%.

A factor of success is a combination of freedom, autonomy and leadership. World-class universities thrive in an environment that fosters competitiveness, unrestrained scientific inquiry, critical thinking, innovation and creativity. Institutions that have complete autonomy are also more agile, because they aren't bound by clunky bureaucracies and externally imposed standards. As a result, they can manage their resources efficiently and quickly respond to the demands of a rapidly changing global market.

The new technology sectors and the venture capitalists have learned from universities and now fund 'incubators' to help researchers take their work toward commercial interest. Startups exist within research clusters Silicon Valley, Silicon Fen, Genome Valley and so on.

The best undergraduates. It is believed that a large and talented undergraduate population offers an uplift to the institution, keeping everyone focused. It is worth viewing universities themselves as having a transforming effect on undergraduates, such that high-school performance may not always be the best indicator of university success it is therefore difficult to select for success at the admission stage as the only viable policy to find the best students. But it is agreed that world class universities may not accept mediocrity of student performance, and utilise all sorts of mechanisms to ensure the fullest possible support to the widest diversity of students.

Why Some of the Universities are World Class

The Principal McGill University: The first and foremost, I attribute McGill University's international standing to the quality of our people. Our distinguished faculty have a long history of success in attracting competitive research funding. And in the global race for talent, smart people attract other smart people. McGill draws outstanding students from around the world.

Robert Zimmer President University Of Chicago: The University of Chicago is driven by a singular focus on the value of open, rigorous and intense inquiry. Everything about the university that we recognise as distinctive flows from this:

- our education that embeds learning in a culture of inquiry and analysis, thereby offering the most empowering education to students irrespective of the path they may ultimately take.
- our commitment to attract the most original faculty and students, who can most benefit from, and contribute to, our environment.
- our recognition that our contributions to society rest on the power of our ideas and the openness of our environment to developing and testing ideas.

Vice-chancellor Australian National University: The reputation of a university depends not on the number of its students or the splendour of its buildings, but on the quality of its members and the nature of its contribution to learning ....

Malcolm Grant Provost University College London: Universities that excel in basic research need also to think about how they can become more relevant to the society around us. That is why we have launched a research strategy designed to facilitate cross-disciplinary interaction — within and beyond the university — and apply our collective strengths to thinking afresh about problems of global significance.

Universities need to be focused and determined in delivering solutions to the challenges the world faces. I believe it is willingness to take risks and push the boundaries of academic Endeavour .

Tan Chorh Chuan — National University of Singapore: At the NUS, we see each of our student as a unique individual. Our globally oriented education offers space, opportunities and challenges for them to discover their talents, pursue their passions and realise their potential. Student exchange, entrepreneurial internships and double-degree and joint-degree programmes with some of the world's top universities. Our partnerships and alliances stretch across the globe.

University of Pennsylvania

How many first the university claim? Benjamin Franklin's vision for University of Pennsylvania of an education balancing the unfettered pursuit of knowledge with its practical application.

Today, Penn focuses on increasing access, integrating knowledge, and engaging locally and globally. Increasing access equalises opportunity, enriches educational experience and educates leaders. Integrating knowledge through joint appointments of faculty and the creation of collaborative centres expedites solutions to our most challenging problems. Engaging locally and globally, we advance the central values of democracy: life, liberty, opportunity and mutual respect.

University of Kyoto

Ancient shrines and temples, traditional craft ateliers and high-tech companies flourish around our campus, and this co-existence in a small space seems to be the source of the university's creativity. The university focused on research rather than the production of government officials. Those principles resonate today, and we are known for our commitment to academic freedom, dialogue and originality. A long lineage of Kyoto scholars has rejoiced over what is unwritten in books, reconsidered their preconceptions and created new ideas and vocabularies, creating a uniquely language-conscious campus.

University of Houston

We are the most ethnically diverse major research university in the United States. That's what makes the University of Houston a great university. Its faculty has received many accolades Such as Nobel Peace Prize, National Medal of Science, Pulitzer Prize, Membership National Academy of Sciences National Academy of Engineering, American Academy of Arts and Sciences etc.

University attracts major research funding from top funding agencies, has cited research, atmospheric research education research, SERCC – The new science and engineering research will help at the forefront of next-generation of research, including nanotechnology, with a static- and vibration- free ‘clean room.’

Student achievements are most diverse. Students work in the surrounding community each year through internships and other course-related programs. UH currently enrolls 72 national merit finalists. Community work include disaster relief summer camps design/build studio each year, this College of Architecture Studio builds, from concept to completion, a new facility for local non-profits such as schools and little league teams.

Vision Care – through the University Eye Institute and offcampus clinics such as the Good Neighbor Clinic, Public School

Partnerships

Most of the alumni are head their own company or are presidents or chief executives of businesses or corporations. Alumni are the US Secretary of Education, congressmen and legislators, the CEO of large companies, astronauts, judges, educators, actors and artists, and many more. UH has the second-most alumni in the Texas State Legislature.

Research Focus and Innovation

As the principal source of basic research, universities play a fundamental and irreplaceable role in encouraging economic development and national competitiveness. That fact, that fundamental research occurs within the university rather than in government laboratories, non-teaching research institutes, or private industry is an essential element of allowing a university to realize its full potential. When researchers are isolated in research institutes, students – especially undergraduates are deprived of exposure to first-rate scientists, their methods, and their research.

The research undertaken in universities must drive national innovation and must move from theory to practice, and the university plays a key role in this process as well commercializing faculty inventions benefits both the university and the broader society. Standard measures of research effectiveness include citation studies but also measures of research funding. Links between universities and sponsors are well-developed, and indeed may include easy movement between academic and commercial work settings.

Excellence in research underpins the idea of world class-research that is recognized by peers and that pushes back the frontiers of knowledge. Such research can be measured and communicated.

In the words of the former President of Harvard University, patents offer universities an incentive to work harder to identify valuable ideas discovered in their laboratories.

World-class research requires substantial resources, and it is important to allocate these resources to produce maximum social benefit through the strict meritocracy of peer review.

It is largely through their research performance, the university will build reputational capital. A university perceived to be world class one generation may not be there in the eyes of the next generation.

I am not in favour of closely targeting research to narrow national objectives instead advocate for global research. Research be focused to the problems of human sufferings wherein students involved in research that leads to practical outcomes gain much from the experience.

Lead scholars are the life blood of a world-class university. They provide vital academic leadership. World-class universities have a coterie of prominent scholars who are also explores the ideas and innovations that will fuel the economy in the next generation. Academic environments, and other settings, which are dedicated to similar pursuits, offer the most conducive environment for innovation to foster without the commercial imperative.

World class universities, as research institutions provide resources to support leading edge research, employ outstanding individuals, and maintain large, diverse and complete libraries. They have modern equipment, often unique.

World class universities are seen a research universities foremost, since it is with these institutions, if you like the knowledge value chain begins; these are the incubators of future possibilities, while other institutions may excel at teaching for instance, they transmit what others have already uncovered.

Academic staff is generally required to make significant contributions in their fields. And they are suitably recognised for their contributions with time and incentive recipients of prestigious awards.

Community Interaction

Integral to the world class University's mission is a commitment to public engagement. University must foster closer links with the society in whose sphere it operates. Residents of the city must participate in scores of conferences, institutes, credit and noncredit courses, and workshops presented on campus and statewide. The University's extension service keep contact with residents. Research and class projects take students and professors outside their classrooms and laboratories to share expertise and technical support with far. The world-class universities also instill in the students social responsibility and an appreciation of service to the community.

It shall be the endeavor to create a comprehensive strategy to engage with surrounding community, partnering with public officials and neighborhood groups to better the city in which we live. Our initiatives could include an internship program to allow students to work in schools community service organizations, and local government. Redevelopment of the downtown retail district. As a result of these actions, our community has been dramatically strengthened.

Facilities

Adequate facilities for academic work are essential–the most advanced and creative research and the most innovative teaching must have access to appropriate libraries and laboratories, as well as to the internet and other electronic resources. Staff and students must have adequate offices as well. Academic resources on campus must be among the finest in the world. The University library must be fully equipped with latest technology support including web based support. It must also house, housing manuscripts, periodicals, and other non-print materials, and periodicals and journals. In addition to the main library, there should be departmental libraries and divisions throughout campus. The library's computerized cataloging system must serve as the primary access to a large academic library. Users worldwide should be able access the online catalog each week.

Students have access to thousands of computer terminals in classrooms, residence halls and campus libraries for use in classroom instruction, study, and research. Students and scholars find the University an ideal place to conduct inter- and multi-disciplinary research. Other major facilities include the multipurpose assembly hall, stadium, big grounds for games, the physical education building, recreational facilities on a university campus and a wide range of cultural activity support to name a few essential components. Many universities do have living facilities too.

Alliances, Networks and Internationalization

The last decade has seen a literal explosion in the signing of exchange agreements between universities in different countries. With a new competitiveness, a new strategy on alliances is needed for universities pursuing the world-class goal facilitating not only the normal array of student and staff exchanges, but is moving quite rapidly to. Further it is imperative for a world-class university to have a forward looking world-view which is progressive and keeping abreast with the development of the world. Inward looking will stifle academic and intellectual growth for no world-class university should be an island, entire of itself.

World class universities are involved all over the world, their students are in other countries, participating in exchange programmes, their academics leading international research teams, or editing the best journals in the world and gather knowledge of many cultures to answer the questions .

The benefits of making effective use of international networks and alliances and form wider participative networks are understood and must be part of every significant academic or business alliance. This requires considerable institutional flexibility, including:

- Mutual recognition of academic programmes for degree progression and graduation,
- Fully-integrated academic programmes often leading to joint degrees,
- Extensive staff exchanges across all university functions, including administration, finance as well as research and teaching and with the private sector,
- Open access to intellectual property, and courseware and
- Benchmarked performance and joint research.

Quality of Faculty

Faculty, not administrators, make a quality university. Thus the First and foremost, a world-class university must have a world-class faculty that, through its research, is making significant contributions to the advancement of knowledge. It will be widely recognised as a place where top staff will wish to congregate. Given the chance, staff from other universities will migrate to the world-class university, and top faculty attract top students said Gandhiji. The process is auto-catalytic.

These institutions act as magnets at a global level, drawing talent from all over. This means that every possible effort is needed to create the right climate for building this sort of environment. This includes not only pay structures, but openness of career progression in particular to higher academic positions, research and teaching support, and sufficient career security to encourage commitment.

And to attract and retain the best academic staff, favorable working conditions must be available. These include arrangements for job security–many countries call it tenure–and appropriate salaries and benefits, although academics do not necessarily expect top salaries. The best professors see their work as a ‘calling’–something to which they are committed by intellectual interest and not just a job.

What could be worrying for future is the acute shortage of teaching faculty in specialised and technical areas. I foresee that the worst sufferers would be the state universities as there could be a migration of good faculty from such universities to the newly established central universities and technical institutions.

The key question is the availability of the quality faculty pool. Three Chinese universities have invited retired or semi-retired American professors and executive officers to staff their universities. Singapore is also doing the same. These countries are paying well. They have the confidence to hire foreigners.

Governance

The governance of the institution is also important. World-Class universities will practice the art of good management. It goes without saying that a truly eminent university will be an excellence in management driving first-rate administrative systems.

My vision for educational administration in India is to equip Indian youth to meet the challenges India faces – including equitable access to education, employment opportunity and community development - and to contribute to addressing the issues of the region and the world. India's rich cultural heritage and diversity, strategic location, thriving economy and huge pool of talent are tremendous assets. Education administrators have great responsibility and opportunity to positively influence the growth of the nation.

Governance structure should be such that truly represents the interested stakeholders. They must all as team have shred dream for the university to serve society and the country. The government should act only as a facilitator through policy pronouncement. The governance must be responsive and accountable to the academic community. It must take decisions and manage funds in unbiased , honest and transparent manner. World-class universities have a significant measure of internal selfgovernance and an entrenched tradition, usually buttressed by statutes, ensuring that the academic community (usually professors, but sometimes including students) has control over the central elements of academic life--the admission of students, the curriculum, the criteria for the award of degrees, the selection of new members of the professorate, and the basic direction of the academic work of the institution.

Funding of World-Class University

Many countries of the world now use fund allocation mechanisms to create competitive environment and leverage change. Experience has shown that clear financial incentives enable public institutions to deliver better on goals set as per national policy objectives. Thus, besides increase in level of funding, its use to ensure public funds are used to direct change becomes important.

Failing to invest in universities undermines long-term economic and social progress, why funding, indeed substantially increased funding, for higher education should remain a high priority for governments: Building world-class university is a Herculean task. Adequate and consistent funding must be available to support the research and teaching as well as the other functions of the university. It can be said that World class status is not achieved on a tight budget.

It is also understood that, a vast majority of public universities enjoying liberal funding even in the USA, where many private universities exist. Over 70% of the universities making the list for engineering sciences are state funded. Even in the private universities, a significant proportion of research funding comes from the public sector. In the middle and low income countries, only state-funded universities are able to do any scientific research of any consequence.

Countries which fund universities solely from the public purse quickly discover that they cannot provide sufficient resources for rising educational demands and research infrastructure investment, and soon must address tuition fees and other top-up charges. Invariably, though, these countries will also need to develop policies to reduce the impact of tuition fees on students, for example, with tax-deductibility of such fees, or easy access to scholarships, bursaries and loan programmes.

The cost of maintaining a research university continues to grow because of the increasing complexity and cost of scientific research. Universities are about the discovery and transmission of new knowledge to students. The cost of research equipment which is at times unique is now a major budget item electron microscopes, NMRs, mass spectrometers, nanostructure fabrication etc all these require planning and special funding. One thing is certain the title of world-class won't come at a discount price, and without world-class funding the goal of reaching, and preserving. The availability of abundant resources sparks a circular chain of events that allows institutions to attract even more top professors and researchers, and thus even more money.

United States and to a lesser extent Japan have private research universities of the highest rank exist. These top universities have sizable budgets. These institutions have several sources of funding: government money for operational spending and research, contract research from public organizations and private firms, and earnings from endowments, gifts and tuition fees. Per student, the richest private universities in the US receive more than

$40000 in endowment income every year, compared with a mere $1000-per-student at top Canadian universities The American tax system, which provides for tax-free donations to nonprofit institutions such as universities, is also a major factor in permitting the growth of world-class private universities. Research universities have the ability to generate significant funds through a variety of means, but there is no substitute for consistent and substantial public financial support. Without it, developing and sustaining a world class universities is impossible.

Fees

More and more Indians are willing to shell out large sums of money for quality higher education, whether overseas or at private institutions in India. The ISB charges four times the tuition of IIMs, the country's most elite. It is gaining international recognition and producing some of the highest-paid graduates in the country. And last year, Indians spent $1bn on education overseas, 60% more than in the year 2005. Very little is being done to put in place an adequately funded scholarship and loan scheme for the poor. Such an intervention is urgently required to promote inclusion in higher education and address equity issues. The evidence that fees have a negative impact on accessibility is mixed, but the highest rates of university participation appear to be found in countries that permit universities the freedom to charge fees.

In recent years, higher education enrolment has shown a healthy growth. A major part of this has come from the private sector. While private higher education based on full cost recovery is expensive, fee levels for professional courses even within the public institutions have risen sharply. Research and teaching jobs in the country is attracting students from middle and lower middle class family backgrounds. They need support for pursuing their studies Thus, there is serious concern about ability of the poor to access higher education. We will have to reverse the trend of rising costs of education and give liberal scholarships even for living expenses.

Conclusion

We are at this time is in the process of taking leadership position in the comity of world nations on many issues of human sustenance. We have to move faster in our interventions. This is possible if our human capital is of highest quality and globally competitive. Also, at the same time we need to accept our own realities of access and inclusiveness. This calls for multi pronged solutions. Thus we not only create large expansion of our academic institutions but also have to address the issue of quality and bring many of our universities in the global to league.

We not only need to strengthen the IIT model but develop new and innovative models of creating research and world-class university. These new initiatives must have improved governance and generously available funds.

I also agree with Prof Dinesh Mohan (He wrote in Business standard) that we should forget the notion, currently popular, that in order to create world-class universities, we need government to get out of education. Forget also the notion that private institutions, motivated by profit and charging appropriate (that is, sky-high) fees will do the trick. Think again about the notion that you need fabulous pay packages in universities in order to attract talent- no, the types who are attracted look for job security, decent pay and a supportive environment.

Technological Challenges for a More Equitable and Sustainable Planet with Special Reference to Power Sector

Mr B Prasada Rao

Chairman & Managing Director
BHEL New Delhi

"We have the moral responsibility to bequeath to our children a world which is safe, clean and productive, a world which should continue to inspire the human imagination with the immensity of the blue ocean, the loftiness of snow-covered mountains, the green expanse of extensive forests and the silver streams of ancient rivers."

Prime Minister Dr Manmohan Singh

Introduction

India has emerged as one of the largest economies of the world, and will continue its rapid urbanization and economic development with the aspiration of achieving double digit growth inthe coming years.This isacause of celebration. But, it has its own share of challenges.

Our society has been built on the notion that economic growth is entirely positive. This made sense as long as we were few people on the planet and the global economy was small compared to the natural system. This is no longer the case where more than two-thirds of the most important ecosystems have been over exploited. The present path of development characterized by never-ending increase in demand-driven consumption cannotsustainmuchlonger.

The 15th Conference of the Parties (COP 15) to the UN Framework Convention on Climate Change in Copenhagen demonstrated that the threats of catastrophic climate change are still not sufficiently perceived as real and urgent. In common with previous civilizations which have collapsed, we see the threats deepening but we are unable to agree on strong action.

Neither Copenhagen Accord nor I profess that growth is not good. But, as our Hon'ble Prime Minister Dr Manmohan Singh has said:

"Our people have a right to economic and social development and to discard the ignominy of widespread poverty. For this we need rapid economic growth. But I also believe that ecologically sustainable development need not be in contradiction to achieving our growth objectives. In fact, we must have a broader perspective on development. It must include the quality of life, not merely the quantitative accretion of goods and services. Our people want higher standards of living, but they also want clean water to drink, fresh air to breathe and a green earth to walk on."

This is both a challenge and an opportunity to lay the foundations of innovative, resource efficient, sustainable and socially-just societies.

In this backdrop, like other countries, India needs to find a way to ensure energy and environmental sustainability without compromising on its economic and social development. Availability of adequate amounts of energy at affordable prices and equitable access to them for all sections of society will be defining characteristics of life in the 21st century. India with 17% t of the world population and just 0.8% of the world's known oil and natural resources is going to face serious energy challenges in the coming decades. Besides energy independence, the devastating impact of climate change has become an issue of critical importance. Energy production using fossil fuels is the major contributor to greenhouse gas emissions. Hence, transition to a low-carbon energy economy is the real solution for mitigating the impact of climate change.

India's Climate Change Mitigation Strategy following the Copenhagen Accord

Since, the Copenhagen Summit (COP-15) did not set-up any legally binding targets and commit the countries to agree to a binding successor to the Kyoto Protocol, whose present round ends in 2012, there isn't any obligation for the countries to take some concrete measures. COP-15 underlines that climate change is one of the greatest challenges of our time and emphasizes a “strong political will to urgently combat climate change in accordance with the principle of common but differentiated responsibilities and respective capabilities”. It is also said that deep cuts in global emissions are required according to science and it agrees cooperation in peaking (stopping from rising) global and national greenhouse gas emissions as soon as possible and that a low-emission development strategy is indispensable to sustainable development.

By 2030, India is likely to have a GDP of USD 4 trillion and a population of 1.5 billion. This will swell demand for critical resources such as coal and oil with parallel increase in greenhouse gas emissions. India is giving serious consideration to adoption of a 20% to 25% reduction in energy intensity (taking 2005 as the base year) for its own reasons, despite no guarantees of compensatory financing. If India moves ahead with this plan of reducing the energy intensity, and if the National Action Plan on Climate Change (NAPCC) released on June 30, 2008 is able to deliver the expected results, it could serve as the backbone of the climate change mitigation regime to be followed by India.

Technology Policy: Pathway for Development of Low- Carbon Technologies

Many of the most promising low-carbon technologies currently have higher costs than the fossil-fuel incumbents. It is only through technology learning from research, development, demonstration and deployment (RDD&D) that these costs can be reduced and the technologies become economical. Thus, governments and industry need to pursue energy technology innovation through a number of parallel and interrelated pathways. Most new technologies will require, at some stage, both the “push” of RDD&D and the “pull”of market deployment.

The role of government in developing effective technology policy is crucial. Policy establishes a solid foundation and framework on which stakeholders, including industry, can build the entire spectrum of RDD&D. In this way, governments can reduce the risk for other actors in the early phases of technology development and then gradually expose the technology to greater competition, while allowing participants to realise reasonable returns on their investments as a low-carbon economy takes hold.

Governments will need to intervene on an unprecedented scale in the next decade to avoid the lock-in of high-emitting, inefficient technologies. They must take swift action to implement a range of technology policies with the overriding objectives should be to reduce risk, stimulate deployment and bring down costs.

In recent years, much attention has been given to the importance of policies that put a price on carbon emissions asa way of stimulating the clean technology development and deployment needed to deliver an energy revolution.

While such policies (eg, carbon trading) are likely to be an important driver of change, they are not necessarily the most effective way to deliver short-term investment in the more costly technologies that have longer-term emissions reduction benefits. Moreover, a truly global carbon market is likely to be many years away. Governments can draw upon a wide variety of other tools to help create markets for the technologies that meet national policy objectives, including regulations, tax breaks, voluntary programs, subsidies and information campaigns.

Governments also have an important role in encouraging others to take the lead in relevant areas. Industry can demonstrate leadership through active involvement in public- private partnerships. Universities can expand training and education to develop and deploy the human capacity needed to exploit the innovative energy technologies. Non-governmental organizations can help engage the public and communicate the urgency of the need to deploy new energy technologies on a large scale, including the costs and benefits of doing so. Finally, all stakeholders must work together to strengthen international technology collaboration to accelerate RDD&D, diffusion and investment. Technology road maps can be an effective tool to help this process.

Technology Diffusion: An Integral Part of the Way Ahead

Nearly all of the future growth in energy demand and in emissions comes from non-OECD countries. Accelerating the spread of low-carbon technologies to non-OECD countries is therefore a critical challenge, particularly for the largest, fast-growing economies, such as, Brazil, China, India, the Russian Federation and South Africa.

Non-OECD countries have traditionally been assumed to access new technologies as a result of technology transfer from industrialized countries, presupposing a general trend that technological knowledge flows from countries with higher technological capacities to those with lower capacities. The situation is, however, becoming more complex, with an increasing multi-directional flow of technologies among and between OECD and non-OECD countries, and emerging economies establishing strong manufacturing bases and becoming exporters in their own right.

To be successful, a low-carbon economy should be based on market principles in which energy technologies spread primarily through commercial transactions. The challenge is to reorient these transactions to support the transfer of low- carbon technologies while also encouraging corporate India to become technology developers. India is rapidly improving her capability to develop and deploy key low-carbon technologies.We need to advance at an even more rapid pace to decouple CO_2 emissions from economic activity.

Progressive Efforts in R&D

Along with the technology transfers, a lot of work needs to be done in the country itself if it wishes to meet the targets that have been set-up for energy requirements, emission levels etc and this is where the R&D kicks in. In house R&D plays a major role as it is easily able to address the problems of the country, like the environmental conditions, working conditions etc and hence the developments in any particular region are readily implementable. This helps in increasing the acceptability of the product considerably. There should be a rapid expansion of energy-efficiency programs, massive scale- up of renewable energy implementation (complete with demonstration projects, enabling legislation and incentivizing tariffs), measures to improve agricultural practices and reforestation initiatives and the creation of a fund to promote national innovation and research into clean technology solutions. But, R&D spend among Indian industries has been abysmally low barring few like pharmaceuticals.We spend all of our energy and resources on various strategy initiatives not giving desired thought to the level of innovation required for future market requirements. BHEL spent Rs.829 crores (2.43% of sales) on R&D during FY2009-10, which was highest among our kind of industries in India. We have pioneered in customizing technology sourced from global technology holders as per Indian conditions with extensive in-house R&D.

SectoralPerspective

About 84% of current CO_2 emissions are energy-related and about 65% of all greenhouse gas emissions can be attributed to energy supply and energy use. All sectors will need to reduce dramatically their CO_2 intensity if global CO_2 emissions are to be halved. However, this does not mean that every sector needs to cut its own emissions by 50%. Each sector has different growth prospects and a different range of low-carbon options that can be deployed to reduce emissions.

For advancing deployment of both existing and new technologies across all sectors, a key message is the need for rapid action that takes into account the long-term goals. Without a long-range perspective, there is a risk that inappropriate and costly capital investments made in the near term could undermine future emissions reduction targets or will need to be scrapped well in advance of their normal life cycles.

I will take youth rough Power Sector perspective in detail..

Power Sector

It bears repeating that decarburizing the power sector will beat the heart of efforts to make deep cuts in global CO_2 emissions. Globally, power sector currently accounts for 41% of energy- related CO_2 emissions. The Baseline scenario of World Energy Outlook 2009 projects a doubling of these emissions over the period to 2050, because of continued reliance on fossil fuels.

Significant policy change is needed to break the current dependence on fossil fuels in the power sector. A key challenge is that, at present, many low-carbon alternatives are considerably more expensive than traditional fossil-based technologies. In addition to expanding RDD&D support and creating market mechanisms to foster technological innovation, governments should adopt policies that encourage the earliest possible closure of the dirtiest and least efficient plants. All low-carbon generation options need to be pursued: excluding any one option could significantly increase the costs of achieving CO_2 emissions reductions from the sector.

Some low-carbon generation technologies raise unique challenges. For example, system integration will be needed to support large quantities of variable renewable (such as, wind, solar PV, run-of-river hydropower and wave and tidal power). There is also an urgent need to accelerate the demonstration of Carbon Capture and Storage (CCS) in the power sector and to develop comprehensive regulatory approaches to enable its large-scale commercial deployment. Nuclear power requires further progress on building and operating disposal facilities forradioactivewaste.

There are signs that the necessary changes in power generation are starting to happen. Investment in renewable energy, led by wind and solar, reached an all-time high in 2008 and stayed at similar levels in 2009 despite theeconomic downturn. In 2009, more wind power was installed in Europe than any other electricity-generating technology. Similar developments have been seen in other parts of the world. In terms of global installed renewable capacity, China now ranks second and India fifth. There is also evidence that nuclear power is undergoing a renaissance. Major expansions of nuclear capacity are planned in China, India and Russia. Several other countries with existing nuclear plants but where no new construction has been launched in recent years are also actively considering new nuclear capacity.

We in India are actively pursuing eight national missions as outlined in National Action Plan on Climate Change (NAPCC). Power sector is at the core of NAPCC touching all aspects generation, transmission and distribution and finally end use. BHEL is leading the country in introducing low-carbon emitting and energy efficient Supercritical Technology at new power plants. We have increased our focus on low carbon path technologies, such as, Ultra Supercritical, IGCC, Solar Power, etc. BHELis playing a lead role in 'development and deployment'of advanced Ultra Supercritical Power Plant under the proposed National Mission for Clean Coal (Carbon) Technologies. Post nuclear treaty with US and other countries, India is expected to significantly increase share of nuclear power in its energy mix in years to come.

Concluding Remarks

There are many existing and emerging technologies, such as, advanced fossil fuel power generation, biomass and bioenergy, wind power, buildings and appliances, and electricity transmission and distribution technologies, that can help achieve a low-carbon future and other environmental goals.

Each of these is at a different stage of the research, development, demonstration and deployment (RDD&D) cycle; however they are not being developed and diffused at the rate required because of a number of technological, financial, commercial and regulatory barriers. Given the urgency of the climate change problem, government, investors and consumers around the world need to take bold, decisive action to initiate and advance change in their respective spheres of influence – and increase their commitment to working together with all sincerity of purpose and sense of responsibility.

I wish to conclude by recalling Mahatma Gandhi's sagacious message:

"The earth has enough resources to meet the needs of people, but will never have enough to serve their greed. This is the spirit which must be the foundation of any strategy for equitable and sustainable development of our planet".

Thank you.

Engineering Advancements and Accelerated Nation Building

Dr N Ravichandran

Executive Director,
Lucas – TVS Ltd Chennai

INTRODUCTION

Ladies and gentlemen,

It is my proud privilege to be here today to deliver the 39th Bhaikaka Memorial Lecture.

Before I begin my lecture, I would like to bring to your attention the unique contribution of Late Bhailal Bhai Patel, popularly known as Bhaikaka, an eminent engineer, educationist and administrator — the first lecture was delivered at the 56th Annual Convention of the Institution held in 1976 for his outstanding accomplishment in the field of Engineering.

I may summarise by saying that 'Bhaikaka', an imminent civil engineer in the service of government, had earned a great reputation for his sense of values, discipline, dedication to duty and absolute integrity. In my opinion, he is a role model for a true Engineer, which defines as follows:

"The qualifications for achieving success in Engineering are intellectual and moral honesty, courage, independence of thought, fairness, good sense, sound judgement, perseverance, resourcefulness, ingenuity, orderliness, application, accuracy and endurance. An Engineer should have ability to observe, to deduce, to correlate cause and effect, and to apply the principles discovered. He should know how to inform, convince and win confidence by skilful and right use of facts. He should be alert, ready to learn, open-minded but not credulous. He must be able to assemble facts, to investigate thoroughly, to discriminate clearly between assumption and crude knowledge. He should have intensive knowledge of the science and other branches of learning besides knowing intensively those things which concern his specialties. He must be a student throughout his career and keep abreast of human progress".

This is evident from his life wherein he started his career in the Public Works Department, responsible for the Sukkur Barrage Plan, where he showed his originality of ideas and prowess which elevated to the position of Executive Engineer of the Project. This brought fame to him and he was invited to Afghanistan to work as the Executive Advisor.

Based on his excellent credentials, Sardar Vallabh Bhai Patel appointed him as the Chief Engineer of Ahmedabad Municipality at the very young age. During his period, he created the Hill Garden as a site for public recreation, from the stones that were left out when an old fort was levelled down.

He did not stop with that He took a career in the academic side as President of Charoter Education Society, Anand, and was responsible for creation of Sardar Vallabh Bhai Vidyapeeth, which was established in 1955 and he occupied the prestigious position as its first Vice- Chancellor.

I am very much honoured to be invited by The Institution of Engineers (India) for this memorial lecture, which I consider as an unique event in my life. Today, I stand before you to deliver a talk for about 40 minutes on the subject which is widely talked and practised in the business organisations in various countries, i.e. Total Quality Management and its relevance to business excellence. I have structured my presentation as Introduction, Indian Economic Scenario, Global Business Environment, Challenges, TQM, The Future Ahead and Conclusion.

I shall try my best in the next 40 minutes to make the session interesting, educative and lively.

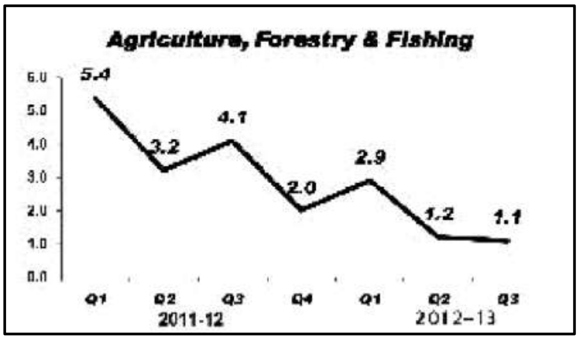
THE INDIAN ECONOMY

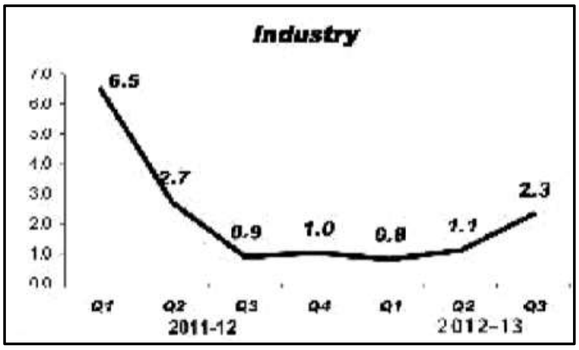
The Economy of India is the tenth largest in the world by nominal GDP and the third largest by purchasing power parity. The country is one of the G20 major economies and a member of BRICS. On a per capita basis India Ranks 141st by nominal GDP and 130th by GDP (PPP). We are the 19th largest exporter and the 10th largest importer in the world. The independence era of Indian Economy (1947-1991) was based on mixed economy combining features of capitalism and socialism. In 1991, India adopted liberal and free market principles and liberalized its economy to International trade. Following three major economic growth reforms and a strong focus on the National Infrastructure such as the Golden Quadrilateral project, the country's economic growth progressed at a rapid pace resulting in relatively large increase in per capita income.

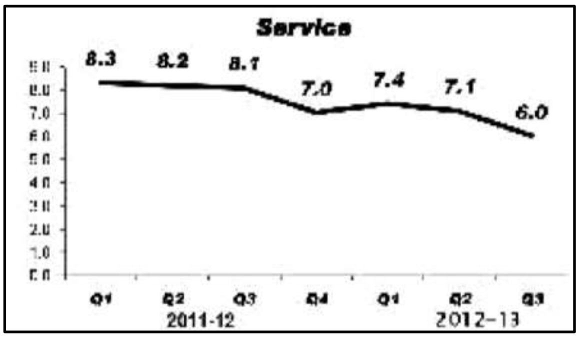
Since 1991 continuing economic liberalization, has moved the country towards market based economy. By 2008 we established ourselves as one of the fastest growing economies. However in the last 5 quarters we are seeing a different situation. The growth of the world trade has been pruned to 3.6% from an earlier of 4%. As a result of pruning of growth estimates for the mature market economies, the export and import growth projections for the emerging economies have also been scaled down. We have to depend more on foreign institutional investments rather than foreign direct investments to finance CAD. The FII flows have hence become more unpredictable leading to rising concerns about the widening trend of CAD.

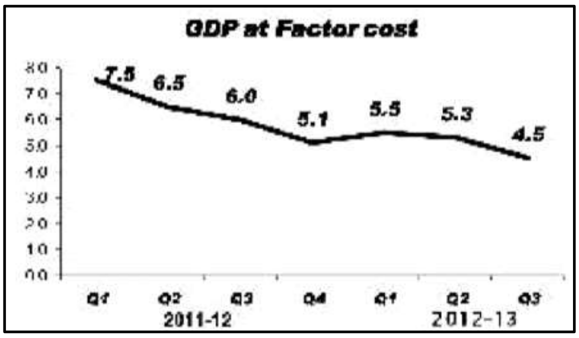
We can have glance at different future growth.

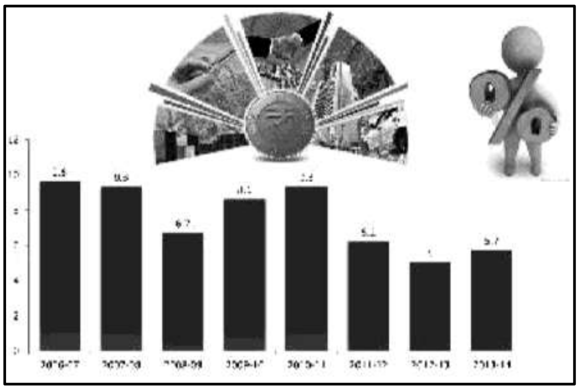
Sector wise growth rates of GDP(Recent Prices) (Percentage)

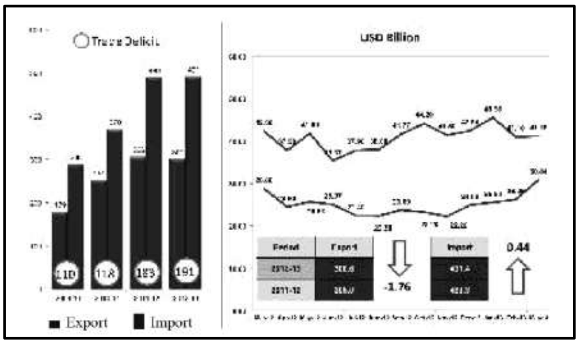










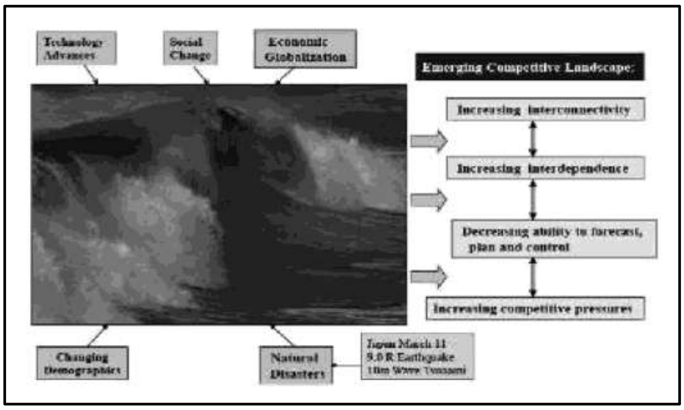


CHANGING BUSINESS ENVIRONMENT

The whole world is becoming a borderless state, we experience the following situations. We witness fast changing business environment as a characteristic of the 21st century. There is a paradigm shift in the very aspect of staging a successful business; some of the points are listed below.

Yesterday	Today
Natural resources defined power	Knowledge is power
Leaders commanded and controlled	Leaders empower and coach
Shareholders came first	Customers come first
Production determined availability	Quality determines demand
Everyone was competitor	Everyone is customer
Value was extra	Value is everything

There are several forces that contribute to the changing business scenario below is a pictorial representation of the forces that affect the business scenario.

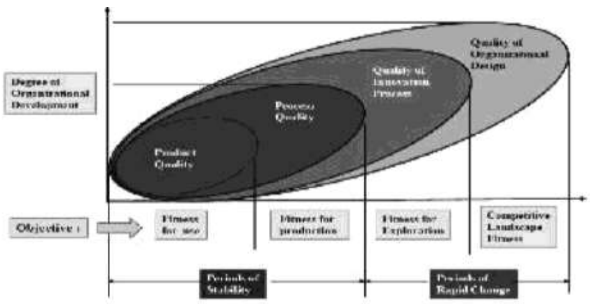


The advancements in technology and globalization have revolutionized every sphere of business and commerce; these advancements have paved way for significant improvements in productivity, quality, technical superiority, product differentiation and thus the bottom-line of business, besides providing customer service. The significant drivers of globalization are

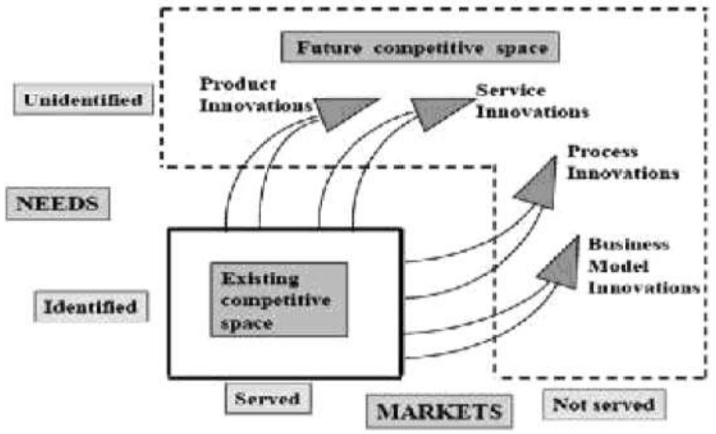
- Market Drivers: Global customers, Global channels, Common customer needs and transferable marketing
- Cost Driver: Global economics, Favorable logistics, Changing technology and Steep experience effect
- Govt. Drivers: Favorable trade policies, common marketing regulations, compatible technical standards and common marketing regulations.

New paradigm in shift in quality definition

Quality over the years has evolved, from Product quality to Organizational design. A graphical representation of how quality has evolved over the years, depicting how product quality has given way to organizational quality.



Organisations are compelled to move from existing competitive space to future competitive space, that means product innovations, service innovations, process innovations and business model innovations.



In today's globally competitive market, knowledge constantly makes itself obsolete with the result that today's advanced knowledge is tomorrow's ignorance. One has to be on the learning curve and continuously move up. All the knowledge workers have to leverage intellectual capital for growth-creative destruction-keep on innovating otherwise someone else will be at the top of the pecking order. Companies function in a world of exponentially shortening product and service life cycles; one must also note that the average life cycle of a corporate company has come down in terms of years.

CHALLENGES

The challenge is to be competitive as a country in the international market place and as an organisation to be innovative. Today we experience very small gap between winners & losers.

So we need to manage things differently from what we were doing all along. A change is needed on the outlook of business and also a different approach is needed in running the business.

TQM (TOTAL QUALITY MANAGEMENT)

In the current business scenario every organisation be it Hospital, University, Bank, Government, Airlines, Manufacturing Industries etc. competitiveness is rife. Today Organisation / Business survives purely on its reputation for Quality/Reliability /Price & Delivery. We just cannot avoid seeing how quality has developed into the most important competitive weapon, and many organizations have realized that TQM and its relatives is the way of managing the future. TQM is far wider in its application than assuring product or service quality, it is a way of managing organisation to improve every aspect of performance both internally and externally.

History of Quality

The history of quality control is undoubtedly as old as the industry itself. During the middle Ages, quality was to a large extent controlled by the long periods of training required by the guilds. This training instilled pride in workers for quality of a product. The concept of specialization of labor was introduced during the Industrial Revolution. As a result, a worker no longer made the entire product, only a portion. This change brought about a decline in workmanship. In 1924, W.A Shewart of Bell Telephone Laboratories developed a statistical chart for the control of product variables. This chart is considered to be the beginning of statistical quality control. Later in the same decade H.F Dodge and H.G Romig both of Bell Telephone Laboratories, developed the area of acceptance sampling as a substitute for 100% inspection. In 1946, the American Society of Quality Control was formed. Recently, the name was changed to American Society of Quality (ASQ). This organization, through its publications, conferences, and training sessions, has promoted the use of quality for all types of production and service. In 1950, W.Edwards Deming, who learned statistical quality control from Shewart gave a series of lectures on statistical methods to Japanese engineers and on quality responsibility to the CEOs of the largest organizations in Japan. Joseph M Juran made his first trip to Japan in 1954 and further emphasized management's responsibility to achieve quality standards for the rest of the world to follow. In 1960, the first quality control circles were formed for the purpose of quality improvement. Simple statistical techniques were learned and applied by Japanese workers. By the middle of 1980 the concepts of TQM were being publicized. Emphasis on quality continued in the auto industry in the 1990's. In addition, ISO 9000 became the worldwide model for quality management system. ISO 14000 was approved worldwide as a model for environmental management systems.

Gurus of Quality

Shewhart

Walter A Shewhart spent his professional career at Western Electric and Bell Telephone Laboratories, both divisions of AT&T. He developed control chart theory with control limits, assignable and chance causes of variation and rational subgroups.

Deming

W Edwards Deming was a protégé of Shewhart. In 1950 he taught statistical process control and the importance of quality to the leading CEOs of Japanese industry. He is credited with providing the foundation for the Japanese quality miracle and resurgence as an economic power. Deming is the best-known quality expert in the world. His 14 points provide a theory for management to improve quality, productivity and competitive position.

Juran

Joesph M Juran worked at Western Electric from 1924 to 1941. There he was exposed to concepts of Shewhart. Juran travelled to Japan in 1954 to teach quality management. He emphasized the necessity for management at all levels to be committed to the quality effort with hands-in involvement. He recommended project improvements based on return on investment to achieve breakthrough results.

Feiganbaum

 Arman V Feiganbaum argues that total quality control is necessary to achieve productivity, market penetration and competitive advantage. Quality begins by identifying the customer's requirements and ends with a product of service in the hands of a customer.

Ishikawa

Kaoru Ishikawa, Studied under Deming, Juran and Feiganbaum. He borrowed the total quality control concept and adapted in for the Japanese. He developed the Fish bone diagram, commonly known as the Cause and Effect diagram.

Crosby

Philip B Crosby authored his first book 'Quality is Free' which is translated into 15 languages. He argued that “doing it right the first time” is less expensive than the costs of detecting and correcting nonconformities.

Taguchi

Genichi Taguchi, PhD, developed his loss function concept that combines cost, target and variation into one metric. Because the loss function is reactive, he developed the signal to noise ratio as proactive equivalent. The cornerstone of Taguchi's philosophy is the robust design of parameters and tolerances.

TQM

Total Quality Management (TQM) is an enhancement to the traditional way of doing business. It is a proven technique to guarantee survival in world-class competition. Only by changing the actions of management will, the culture and actions of an entire organisation be transformed. TQM is for the most part common sense. Analyzing the three words, we have TQM

Total – Made up of the whole

Quality – Degree of excellence a product or service provides.

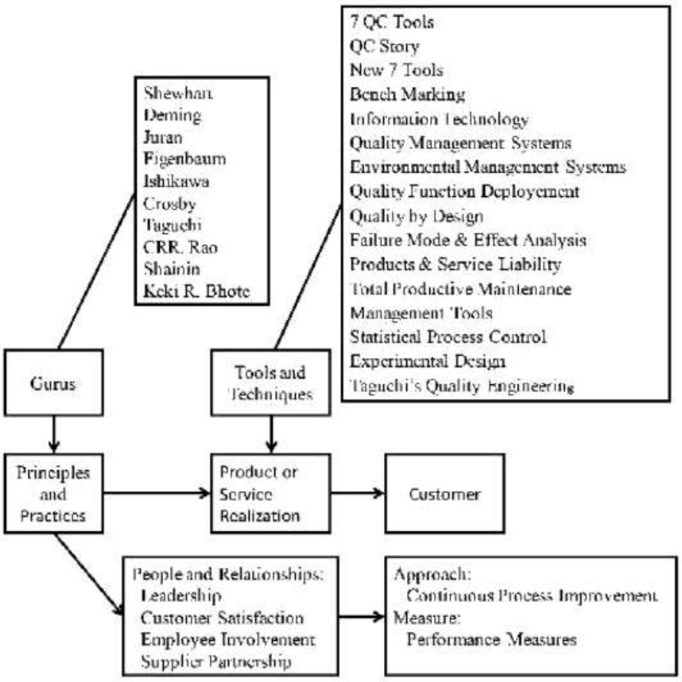
Management – Act, art, or manner of handling, controlling, directing, etc.,

Therefore, TQM is the art of managing the whole to achieve excellence. TQM is defined as both a philosophy and a set of guiding principles that represent the foundation of a continuously improving organisation. It is the application of quantitative methods and human resources to improve all the processes within an organisation and exceed customer needs now and in the future. TQM integrates fundamental management techniques, existing improvement efforts, and technical tools under a disciplined approach.

Basic Approach

- lAcommitted and involved management to provide long-term top to bottom organizational support.
- lAn unwavering focus on the customer, both internally and externally.
- lEffective involvement and utilization of the entire work force.
- lContinuous Improvement of the business and production.
- lTreating suppliers as partners.
- lEstablish performance measures for the processes.

TQM Framework



New and Old Cultures

Quality Element	*Previous State*	*TQM*
Definition	Product-oriented	Customer-oriented
Priorities	Second to service and cost	First among equals of service and cost
Decisions	Short-term	Long-term
Emphasis	Detection	Prevention
Errors	Operations	System
Responsibility	Quality Control	Everyone
Problem Solving	Managers	Teams
Procurement	Price	Life-cycle costs, partnership
Manager's Role	Plan, assign, control, and enforce	Delegate, coach, facilitate, and mentor

The Dimensions of Quality

Dimension	Meaning and Example
Performance	Primary product characteristics, such as the brightness of the picture
Features	Secondary characteristics, added features, such as remote control
Conformance	Meeting specifications or industry standards, workmanship
Reliability	Consistency of performance over time, average time for the unit to fail
Durability	Useful life, includes repair
Service	Resolution of problems and complaints, ease of repair
Response	Human-to-Human interface such as the courtesy of the dealer
Aesthetics	Sensory characteristics, such as exterior finish
Reputation	Past performance and other intangibles, such as being ranked first Brand image

Most of the organisations face the following obstacles

- Lack of Management Commitment
- Inability to Change Organizational Culture
- Improper Planning
- Lack of Continuous training and Education
- Incompatible Organizational Structure and Isolated Individuals and Departments
- Ineffective Measurement Techniques and Lack of Access to Data and Results
- Paying Inadequate Attention to Internal and External Customers
- Inadequate Use of Empowerment and Teamwork

- Failure to Continually Improve.

Some of the tools used in TQM

Today many statistical & management tools are used by organisations practicing TQM.

- 7QC Tools

Check Sheet, Histogram, Pareto diagram, Cause and Effect Diagram, Scatter Diagram, Control Chart & Stratification

- New 7QC Tools

Relations Diagram, Tree Diagram, Arrow Diagram, Affinity Diagram, Matrix Diagram, Matrix Data Analysis Diagram, Process Decision & Programme Chart

- Simple Design of experiments
- Multi Vari Chart
- Basics of Shainin Technique

In addition to the above tools, some of the methodologies used are QFD, Benchmarking, MEOST(Multi Environment Over Stress Testing), Poka- Yoke, TPM, Kanban, Cycle Time Reduction, Value Engineering, JIT & SPF.

Total Quality Management as a Management Tool

TQM is a management approach that aims to succeed in fostering the stable growth of an organisation by involving all of its members in economically producing the quality that its customer wants. The goal is to economically achieve the quality that satisfies customers' demands. This is an objective shared by everyone in the organisation from senior executives to production workers and sales staff. The common language in a TQM organisation is put Quality First, the next process is our customer, speak with facts, give importance to the process, priorities, prevent recurrences, control at the source, and respect humanity. These are some of the slogans commonly used in TQM. One common principle in a TQM organisation is work by rotating the PDCA wheel, employ statistical tools, base judgments on the facts.

The two most fundamental principles of TQM are:

1. Use statistical analysis to identify quality losses based on the facts.

2. Continually improve the work by following the PDCAloop.

The PDCALoop (Deming Cycle)

Deming cycle is the basis on which TQM rests.

The four components of the PDCAloop are discussed below:

Plan

Of the four components of the PDCA loop, top priority should be accorded to the “plan” phase.

Do

On completion of the planning, we move on to the execution, or “Do” phase. The following steps should be taken in order to ensure that the plants are properly executed:

- Ensure that the people responsible for implementing the plans are fully aware of the objectives of the work and its necessity.
- Let the people responsible for implementing the plans know exactly what is in them.
- Arrange any education and training necessary for implementing the plans.
- Provide necessary resources as and when needed.

Check

When checking the results of implementing a plan, the following two aspects should be assessed independently:

- Whether the plans were faithfully followed.
- Whether the plans themselves were adequate.

Act

When taking corrective action, it is essential to distinguish clearly between eliminating a symptom and eliminating its cause.

Quality Training

For a company to implement TQM effectively, each individual employee must have a strong sense of participation in the running of the business. The presence or absence of this feeling of involvment not only affects the company's quality management but also has a profound influence on the management of the company as a whole. Any company implementing TQM must provide companywide quality training and it is best if this training is tailored to specific grades within the company hierarchy.

Normally the training methods practiced are:

On the Job Training (OJT)

It is best to make OJT the basis of any in-company training program. However, developing people solely by means of OJT entails the risk of giving them a short term, narrowly focused perspective on workplace problems and is unlikely to change their ideas or broaden their minds enough to enable them to view such problems from the overall standpoint.

Group Training

Only a limited number of people can be trained by OJT, and this type of training generally takes a long time to complete. Group training in the classroom should therefore be used in addition to OJT.

Outside Training

People working in an organisation are usually well aware of its internal problems but may fail to notice those affecting the organisation as a whole. Employees should therefore be sent on outside training courses as a supplement to in-company training.

Routine Management

This is the most important in the PDCA cycle.

If a repetitive task is improved each time it is done, the way in which it is done will move closer and closer to perfection. In such a situation, it is important to standardize the methods by which the work is accomplished and use the standards to maintain the level of the work.

Policy Management

Policy management effects improvements down the vertical lines of an organization, cross-functional management does so across its horizontal lines and QC circle activities fill in the gaps by tackling detailed, workplace-specific problems that the first two activities cannot address. Policy management consists of the following elements:

Policy Settling

Senior and middle managers must establish policies for quality management and improvement activities. The policies established at this stage must then be deployed down throughout the organsiation and implemented through the remaining stages of the PDCAloop. In policy management terms, a policy consists of an issue, an objective and a strategy.

Set Objectives

Measures for assessing the degree to which objectives have been attained must be devised and target values must be established on the basis of these measures.

Devise strategies and draw up action plans

Strategies are devised by considering the actions that must be taken to attain the targets and clarifying the work that must be done to accomplish those actions.

Deploy Policy

Heads of departments consider what must be done to tackle the issues allocated to their departments, together with other issues specific to their departments, and deploy their policy downward in the same way as described above.

Implementation (Do)

When actually implementing action plans, the necessary resources must be injected and the required training must be given. The state of implementation must also be recorded, progress must be identified, a review must be carried out at the end of the business year.

Confirmation of Results (Check)

It is best to perform two types of check – a regular monthly or other periodical check and a final check at the end of the business year.

Corrective Action and Policy Review (Act)

When a target has not been achieved, the situation must be analyzed in order to determine whether the problem lies with the plans or their implementation. When the problem is in the implementation, the necessary resources must be provided or the relevant personnel must be given extra training. When the problems in the plans, they must be carefully examined to find out exactly what is wrong with them before they are revised, as well as to determine whether or not all relevant factors had been taken into account when the strategies were selected.

Cross-Functional Management (In New-Product Development, etc.,)

The aim of cross-functional management is to improve the overall system of activities spanning an organisation as s whole, not the work done by its individual parts. Cross-functional management is performed by committees. It is generally difficult for the individual components of an organisation to effect improvements covering the organisation as a whole, so an improvement function that transcends the normal organisation is needed. This is an issue for top management, and crossfunctional committees act on its behalf in this respect. The lineup of cross-functional committees may include a quality management committee, a production-volume management committee, a cost management committee, and so on, depending on the purpose to be served.

Across-functional committee takes the following actions :

1. It instructs the secretariat to perform the necessary investigations and analyses. When necessary, it forms a project team to do this.

2. It reviews the results of the investigations and analyses performed by the secretariat. When necessary, it invites people from the departments directly responsible for the problem to attend the meeting and give their opinions. It uses this process to identify the problems and formulate improvement proposals.

QC Circle Activities

As an important element of total employees' involvement, QC circles wildly practiced in TQM organisation.

AQC Circle is :

- A small group of people.
- From the same workplace.
- Who perform quality improvement activities.
- On their own initiative.

The basic philosophy of QC circle activities performed as part of TQM is as follows:

- To exercise people's capabilities and draw out their unlimited potential.
- To create cheerful workplaces that make life worthwhile and where humanity is respected.
- To contribute to the improvement and development of the corporate constitution.

Top-Management Diagnoses

Ensuring that top–management policy infiltrates an organisation right down to its lower echelons is not easy. It is also extremely important for top management to use diagnoses as a means of finding out what is really going on in their company's workplaces and to utilize this information to run their companies more effectively. Also, workplace managers do not usually have a chance to meet senior management on a daily basis and top-management diagnoses are a good way of fostering a sense of solidarity by providing a forum for the direct exchange of opinions on management problems.

The purpose of a top-management diagnosis is to allow senior executives to check how top management's business policies are being deployed and implemented by the company's actual working departments. If done properly, it produces many ancillary benefits.

For top-management diagnoses to be effective, the following conditions must be satisfied:

- They should be performed in conjunction with policy management.
- They should focus more on the process of the activities than on their results.
- Care should be taken to ensure that they do not become too formalized or ritualized.

TQM Introduction

Different organizations have various motives for introducing TQM. Some of the main ones are as follows:

Acompany is facing a management crisis as a result of the emergence of strong competitors, changes in the external environment or an onslaught of quality claims. Improving the company's constitution becomes the supreme issue and TQM is introduced as a means of achieving this. A company's senior management has a strong desire to improve the corporate internal environment and takes the initiative introducing TQM. It is introduced as a result of a parent company's policy or a customer's influence.

The Trial and Preparation Phase

A decision to deploy TQM across the company is usually taken after passing through the following three processes:

- The CEO's office or the company's planning department investigates methods of introducing TQM.
- The CEO, deputy CEO and other senior managers attend lectures by outside experts.
- The company's directors lead discussions of the pros and cons of introducing TQM.

The Introductory phase

- Decide which will be the responsibility for TQM promotion. Many companies appoint their planning office or QC department to this role.
- The company's CEO formally announces that TQM is to be introduced.
- A companywide TQM committee is established and its members are appointed. The members of this committee deliberate and approve the promotion plans proposed by the TQM promotion department.
- Grade-specific QC training is provided.
- Individual departments and sections commence improvement activities. Activities are carried out separately by different levels of the company hierarchy.

The Promotion Phase

- To make individual and departmental improvements more effective, introduce policy management and link improvement activities systematically to top-management policy.
- Keep on expanding standardization activities and maintain the benefits of improvements by standardizing them.
- Introduce top-management quality audits and ensure that quality management becomes established throughout the organization.
- Apply for a Deming Prize and further enhance the above activities.
- The Consolidation Phase.

As the level of quality management rises, the main problem then becomes how to maintain that level. This applies to all kinds of activities, not only quality management.

The following activities should naturally be practiced as part of the company's routine management in order to ensure that TQM continue and the levels achieved are maintained.

- Accurate collection and analysis of market quality information.
- Grade-specific quality training.
- New-product development management.
- Routine management and policy management.
- QC circle activities.
- Top-management diagnoses

Role of Executives

The primary responsibility of a company's top managers in a free-market economy is to make a profit through the activities of the company.

To promote TQM and achieve useful results, senior managers themselves must understand this well and be seen to take the initiative. If they do so, department managers, section managers and others will naturally take notice, activity will begin in individual workplaces and the whole company's health and character will eventually improve.

The Roles of Department and Section Managers

As mentioned earlier, the role of a manager in TQM is not merely to ensure that his or her organisation correctly performs its allotted task. In the process of promoting TQM, department and section managers must do the following:

- Find out exactly what their own department or section managers must supply to subsequent processes.
- Scrutinize the mechanisms and standards of the work being performed by their department or section and recognize the problems they must deal with.
- Coach their subordinates, continually introduce improvements and raise the quality of their departments.
- Support QC circle activities and try to keep their work places lively and vibrant.

Roles of First line workers/ Staffs

Follow SOP, total involvement in raising standards.

The Deming Prize

The Deming prize is one of the highest awards on TQM (Total Quality Management) in the world. It was established in 1951 in commemoration of the late Dr William Edwards Deming, who contributed greatly to Japan's proliferation of Statistical Quality Control after the World War II. His teachings helped Japan build its foundation by which the level of Japan's product quality has been recognized as the highest in the world. It is administered by JUSE (Union of Japanese Scientists and Engineers).

JUSE

JUSE was established in 1946 and authorized as the foundation of a juridical body by the Science & Technology Agency of Japanese Government and the purpose is to promote systematic studies needed for the advancement of Science & Technology, where upon to contribute to the development of the culture and industry. So far, 229 companies since 1950 have been awarded the Deming Application Prize out of which 23 Companies are from India. Deming Grand Prize (formerly Japan Quality Medal) was introduced in 1970 and 27 Companies have been awarded the prize so far; out of which 7 are from India.

THE FUTURE AHEAD

It is seen, in the years to come in the global market place, some of the key forces like consumer awareness, globalisation, shortening product life cycle, workforce of the future, age, population, 21st century quality expectation and innovation clearly stand out, which need to be addressed. Every country & organisation has to look both inwardly and outwardly the way they do business and the 'Mantra' is survival of the fastest. This means fitness is assumed.

CONCLUSION

In the last 50 years, many organisations in the world have adapted TQM philosophies, principles & practices and have seen significant results. Country like Japan is a standing example – from nowhere, they were able to build the country and top industries in the world. In the last 15 years, many organisations have adapted TQM practices and have seen significant business results and able to project themselves in the world market place. Some of the companies include TVS Group, Aditya Birla Group, Tata Group, Rane Group, Sona Group, Mahindra Group and it is to noted that TQM is not only for large industries and organisations but also for very small companies, where they practice TQM and have benefitted significantly. We Indians are not inferior in knowledge, stature and abilities. All we need is a disciplined approach in excelling our performance in whatever field we are. Let us all join together in building a great India by not pointing and projecting only the problems but contributing our mite for productive solutions and creating an atmosphere to excel.

REFERENCES:

- The Economy of India
- TQM Promotion Hand Book – Hitoshi Kume
- Total Quality Management – Dale H Besterfield, Carol Besterfield Michna, Glen H Besterfield, Mary Besterfield Sacre
- Quality Management in New Product Introduction – Hitoshi Kume
- CII Communique – Vol.35, No.11
- Quality World – Vol.X, May-June 2013
- ASQ – 2011Future of Quality Study

Nuclear Power — An Inevitable Option

Mr N Saibaba

Chief Executive
Nuclear Fuel Complex, Hyderabad

Introduction

World at large, is following "Business-as-Usual", and with all the current Pledges of all countries on Climate Change and fail to level-off emissions. The Fig.1 shows burgeoning global greenhouse gas emissions despite 20 years of international treaty negotiations and little progress made. Yet, at current levels of emission, an 80% cut is needed to stabilize the atmosphere at 450 ppm CO_2, and to keep global warming less than 2°C. With no drastic intervention, we are soon doomed to endure a 3-4°C warmer world in this century[1].

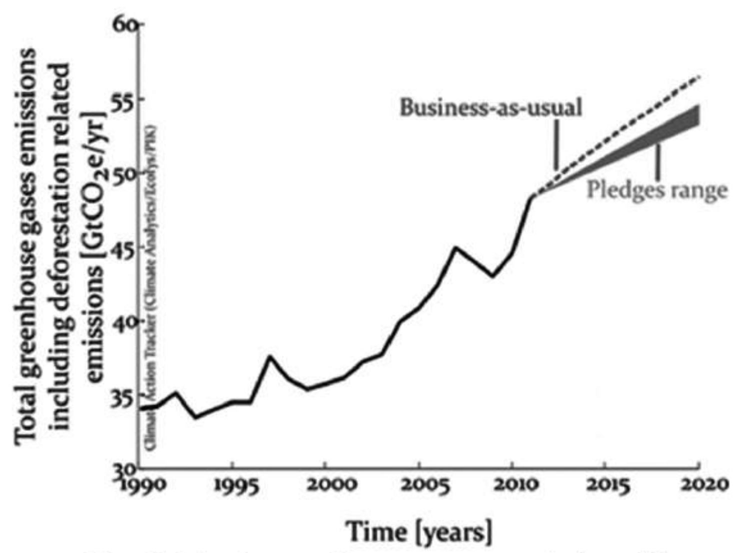


Fig. 1. Total green house gases emissions [1]

The world is threatened with twin energy challenges: that of not having adequate and secure supplies of energy at affordable costs and that of environmental harm caused by consuming too much of it. Global recognition of these issues means the drive for new and clean energy generation, efficient supply, distribution and consumption technologies which are real and here to stay. The challenge is how to achieve energy self sufficiency or strategic energy independence that is consistent with the tenets of social equity and ethics; with elements of sustainable energy culture.

Present Scenario

India is having 2% of world's land but 17.5% of world's population at 1.26 billion people and expected to be 1.50 billion by year 2050. Of the 1.4 billion people of the world who have no access to electricity in the world, India accounts for over 300 million. Prosperity of any nation depends on meeting increasing energy demands for socio-economic growth and quality of life. India is projected to see a power shortage of 5.1% compared to demand in the current financial year with southern and north-eastern regions anticipated to witness high deficits. Annual per capita energy consumption as on March 2013 is 917.18 kWh and the targeted is 500 kWh. Total Installed Generating Capacity from various sources in India as on October 2014 is 2,54,049 MWe and requires 15% growth per annum. So, the question is how to meet this energy challenge.

Table 1. India's Energy Requirement and Availability status [2]

State / Region	Energy				Peak			
	Requirement	Availability	Surplus (+)/ Deficit (-)		Demand	Met	Surplus (+)/ Deficit (-)	
	(MU)	(MU)	(MU)	(%)	(MW)	(MW)	(MW)	(%)
Northern	328944	318837	-10107	-3.1	47570	46899	-671	-1.4
Western	288062	289029	967	0.3	45980	52652	6672	14.5
Southern	298180	260366	-37814	-12.7	41677	32423	-9254	-22.2
Eastern	118663	114677	-3986	-3.4	17608	17782	174	1.0
North-Eastern	14823	12248	-2575	-17.4	2543	2215	-327	-12.9
All India	1048672	995157	-53515	-5.1	147815	144788	-3027	-2.0

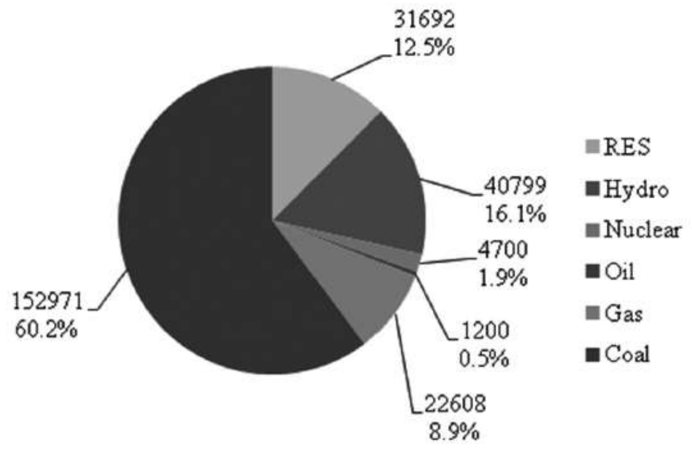


Fig. 2. Installed Generating Capacity from various Sources in India (as on 22-10-2014)

Energy Generation Options

At present, thermal power plants with coal and lignite accounted for about 60% of India's total installed capacity. Thermal power plants convert energy rich fuels such as coal, natural gas, petroleum products, agricultural waste, domestic trash/waste, etc. Into electricity. Other sources of fuel include landfill gas and biogases. In some plants, renewal fuels such as biogas are co-fired with coal. India is endowed with economically exploitable and viable hydro potential assessed to be about 94,000 MW at 60% load factor. Nuclear power share is around 3% with 21 operating reactors in India. India's electricity sector is amongst the world's most active players in renewable energy utilization. As of 31 January 2014, India had an installed capacity of about 31.15 GW of nonconventional renewable technologies-based electricity, about 13.32% of its total[3,4]. These include wind, small hydel power projects, bagasse cogeneration, solar, biomass power & gasification and waste to power. Tidal wave energy and Geothermal energy are potential resources to harvest and India is developing technologies for power generation.

This time around, the main argument is to know the best source for generation of electricity. Nuclear energy is actually excellent replacement for fossil fuels. Nuclear power plants do not pollute the environment and leave no carbon footprint in their operational wake and they provide a lot of energy from a very small amount of fuel. They also generate a very small amount of waste. Compared to this, coal and oil produce a lot of air pollution and waste and they are needed in large amounts to generate electricity. Geothermal energy, solar and wind energy are promising sources but they are lopsided and cannot provide as reliable and powerful a source of electricity as nuclear energy. In addition the technology to use these alternatives on a large scale is still not highly developed. A mix of energy sources with nuclear as major chunk is the best viable scenario for the country like India.

Fossil Fuels

Electricity generation is predominantly (about 70%) fossil fuel based in India. Indian coal is of low calorific value and high ash content. On average, the Indian power plants using India's coal supply consume about 0.7 kg of coal to generate a kWh, whereas United States thermal power plants consume about 0.45 kg of coal per kWh. Fossil fuels are being used about a million times faster than it takes nature to form them. The fossil fuel resources available in India are limited and may last only for few hundred years. Coal reserves are effectively limited — in 2013, 159 million tonnes was imported, and 533 million tonnes produced domestically. Crude oil imports already stood at top costing $160 billion to the nation.

Fossil fuels are detrimental to our atmosphere. The more of them we use, the more we help to destroy any chance ofa clean non-toxic environment. Pollutants that come from the combustion of fossil fuels include sulphur dioxide (SO_2), nitrogen oxides (NO_x), ground-level ozone, particulate matter (PM), carbon monoxide (CO), carbon dioxide (CO_2), volatile organic compounds (VOC) including benzene, some heavy metals and a number of other pollutants and they contribute to smog, acid rain, climate change, and other health, environmental and economic concerns. The Earth appears to have the capacity to absorb carbon dioxide emissions at a level of 3 gigatons per year. Today's emissions total about 9 gigatons, about two-thirds of which is due to fossil fuels. Every day, around 42,000 tons of CO_2, 600 tons of acid gas, 10 tons of fly ash and 1,300 tons ash is being produced from a 2,000 MW thermal power plant burning coal. Impacts of unchecked anthropogenic climate change due to greenhouse gas (GHG) emissions from burning of fossil fuels could be catastrophic for both human society and natural ecosystems. Using historical production data, it is calculated that global nuclear power has prevented an average of 1.84 million air pollution-related deaths and 64 gigatonnes of CO_2, equivalent ($GtCO_2$-eq) greenhouse gas (GHG) emissions that would have resulted from fossil fuel burning[5]. Finally, fossil fuels should be defiantly replaced completely with alternative sources of energy to nurture the humanity and environment.

Hydro and Renewable Sources

Though hydroelectric power produces no chemical or waste heat pollution, It is not a reliable source of energy to meet India's large energy requirement. It is a very limited source as it is seasonal and depends on water elevation. Pumped storage schemes would be in high demand for meeting peak load demand and storing the surplus electricity. They also produce secondary /seasonal power at no additional cost when rivers are flooding with excess water.

Installation of solar power plants require nearly 2.4 hectares (6 acres) land per MW capacity which is similar to coal fired power plants when life cycle coal mining, consumptive water storage & ash disposal areas are also accounted and hydro power plants when submergence area of water reservoir is also accounted. Wind energy has become a popular symbol of clean carbon free electricity. Unlike other sources of renewable energy such as hydro-electricity or geothermal, wind and solar power are variable producers of electricity. Since the wind does not always blow nor the sun always shine, any given wind turbine will never produce its full capacity rating for an extended period of time. For wind power, the average capacity factor is 25%, whereas, the nuclear power plant can run at least at 90% of its capacity factor over a year[6].

Technology is not yet developed to produce large scale electricity from other potential sources like geothermal, biomass and tidal wave energy. However, these sources can only be add-ons to the power requirement of India but don't have capacity for major contribution. Hence, nuclear power is an inevitable option for prosperous India.

Nuclear Power

Nuclear power supplied 20 billion kWh (3.7%) of India's electricity in 2011 from 4.4 GWe (of 180 GWe total) capacity and after a dip in 2008-09 this is increasing as imported uranium becomes available and new plants come on line. India has a flourishing and largely indigenous nuclear power program and expects to have 14,600 MWe nuclear capacity on line by 2020. It aims to supply 25% of electricity from nuclear power by 2050[7]. Because India is outside the Nuclear Non-Proliferation Treaty due to its weapons program, it was for 34 years largely excluded from trade in nuclear plant or materials, which has hampered its development of civil nuclear energy until 2009. Due to these trade bans and lack of indigenous uranium, India has uniquely been developing a nuclear fuel cycle to exploit its reserves of thorium. Foreign technology and fuel are now expected to boost India's nuclear power plans considerably. All plants will have high indigenous engineering content. However, a fundamental incompatibility between India's civil liability law and international conventions limits foreign technology provision. India has a vision of becoming a world leader in nuclear technology due to its expertise in fast reactors and thorium fuel cycle.

Need of Nuclear Power

The world will need greatly increased energy supply in the next 20 years, especially cleanly generated electricity. Electricity demand is increasing twice as fast as overall energy use and is likely to rise by more than two thirds between 2014 to 2035. Nuclear option is the most environmentally benign way of producing electricity on a large scale. Renewable energy sources such as solar and wind are costly per unit of output and are intermittent but can be helpful at the margin in providing clean power.

Both population growth and increasing standards of living for many people in developing countries like India will cause strong growth in energy demand. Fossil fuels have both economic and carbon emission implications. Looking at the needed capacity, due to the variability and low capacity factors of renewable such as wind and solar, capacity must increase even more than the output. This demonstrates the importance of nuclear as it has high capacity relative to other forms of generation. With less than 5% of the generating capacity (about 550 GWe), it produces about 20% of the electricity, indicating its importance in a low carbon electricity system. On a global scale nuclear power currently reduces carbon dioxide emissions by some 2.5 billion tonnes per year.

Coal and other fossil fuels are required in much larger quantities than uranium to produce the equivalent amount of electricity. Nuclear power is very energy dense, an extremely concentrated form of energy and it is very cheap (see Table 2 and Table 3). Nuclear power already has substantially reduced the use of fossil fuels.

Nuclear plants can contribute to the reliability of the power system where they increase the diversity of power generation technologies in the system. India can also reduce the dependence on foreign supplies and limit our exposure to fuel price movements in international markets.

Table 2. Cost various sources of electric power per kWh [8]

Power Plant Type	Cost $/kWh
Coal	$0.10-0.14 - Rs.6-8
Natural Gas	$0.07-0.13 -Rs.4-8
Nuclear	$0.10 -Rs.6
Wind	$0.08-0.20 -Rs.4-12
Solar PV	$0.13- -Rs.8
Solar Thermal	$0.24- -Rs.12
Geothermal	$0.05 -Rs.3
Biomass	$0.10 -Rs.6
Hydro	$0.08 -Rs4

Table 3. Coal equivalent of different fuels [9]

Fuel Type	Coal Equivalent
1 kg gasoline	1.59 kg
1 kg fuel oil	1.52 kg
1 m3 natural gas	1.35 kg
1 kg anthracite	1.14 kg
1 kg hard coal	1.00 kg
1 kg hard coal coke	0.97 kg
1 kg lignite briquette	0.72 kg
1 m3 town gas	0.60 kg
1 kg firewood	0.57 kg
1 kg fire peat	0.56 kg
1 kg crude lignite	0.34 kg
1 kWh	0.123 kg
1 kg U 235	**2700000 kg**

India's Nuclear Power Program

Dr. Homi J. Bhabha in the 1950s formulated India's three-stage nuclear power programme to secure the country's long term energy independence, through the use of Uranium and Thorium reserves. The three-stage power programme of DAE, as shown in Fig. 3, has been planned based on a closed fuel cycle concept, requiring reprocessing of spent fuel from every reactor. The objective is to judiciously utilize mined uranium and thorium resources of the country to a maximum extent in meeting the country's energy requirements. India has only around 1—2% of the global Uranium reserves, but one of the largest shares of global Thorium reserves at about 25% of the world's known reserves[10].

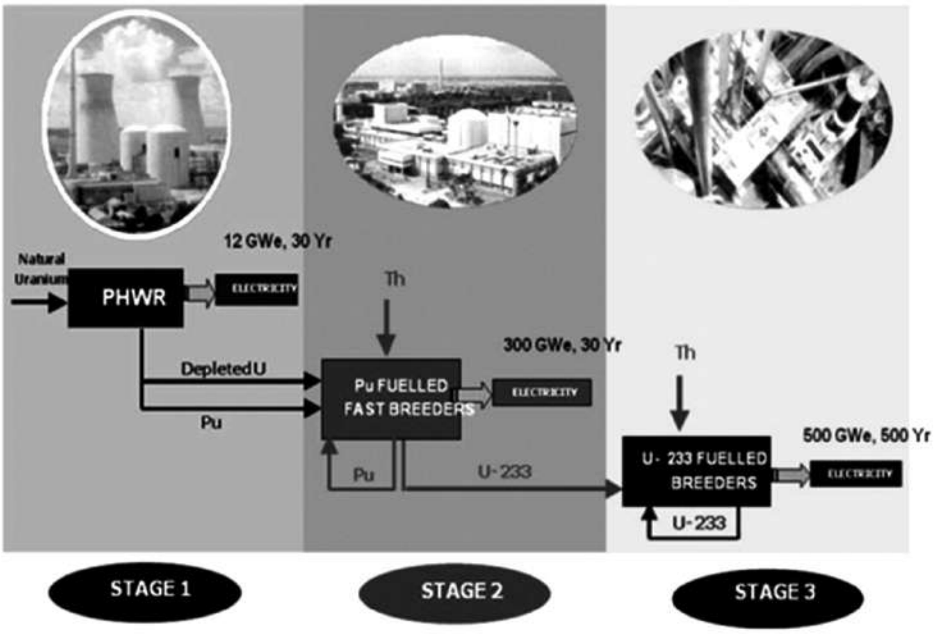


Fig. 3. India's three-stage nuclear power programme

The spent fuel from first stage thermal reactors (PHWR) contains a small quantity of $_{239}$Pu, along with residual uranium (predominantly $_{238}$U). The spent fuel can be reprocessed chemically to separate Plutonium239 which is a fissile material. The second stage, comprising of Fast Breeder Reactors (FBRs) are fuelled by fuels based on Plutonium mixed with reprocessed Uranium recovered by reprocessing of the first stage spent fuel. In FBRs, Plutonium239 undergoes fission producing energy, and at the same time, producing Plutonium239 by transmutation of Uranium238. Over a period of time, growing Plutonium inventory can multiply the number of FBRs. The process of increasing the nuclear power capacity can thus be achieved to a desired level in the country through Plutonium based FBRs. Thorium232 is not fissile and has to be converted to Uranium233 by transmutation in a reactor for use as a fissile material. In the second stage, once sufficient nuclear power capacity is built through Plutonium-based FBRs, Thorium232 will be introduced as a blanket material to be converted to $_{233}$U. The third stage of the programme will be using a $_{232}$Th—$_{233}$U fuel cycle in the reactors. Direct use of Thorium232 as a fuel will thus be in the third stage reactors[11]. A closed fuel cycle approach as mentioned above, involving reprocessing of spent fuel to separate the useful fissile and fertile isotopes from spent fuel and reusing them in nuclear reactors has been adopted as a guiding principle for our nuclear energy programme to ensure long term energy security for the country. As of now, India's first Prototype Fast Breeder Reactor had been delayed by few months - with first criticality expected in 2015[12].

Closed fuel cycle option followed in India is beneficial from radioactive waste management angle in terms of reducing considerably the volume of high level waste to be handled. The quantity of high level wastes, generated during reprocessing of fuel, to be managed is relatively small. For example, the high level waste generated by a 1000 MWe station is of the order of one ton per year. India has developed the technologies in this regard which is immobilization in inert glass matrix by a process of vitrification and such waste immobilization plants are in operation. After intermediate storage in specially designed facility for the required period, ultimate disposal of immobilized waste will be in a repository. R&D work is in progress on the ultimate repository.

At present, Thorium is not economically viable because global uranium prices are much lower. India is importing good quantity of Uranium from Russia, Kazakhstan and France. The recent Indo- US Nuclear Deal and the NSG waiver, which ended more than three decades of international isolation of the Indian civil nuclear programme, have created many hitherto unexplored alternatives for the success of the three-stage nuclear power programme. India is installing Light Water Reactors (LWRs) from Imported sources to meet the present deficit. Around 40GWe of power production is planned by year 2030 from imported LWR source. Reprocessed spent fuel from all the sources will be utilized in FBRs. Expected deficit of 5|00GWe by the year 2050 will practically be wiped out if we can project FBR program high. Further with thorium, nuclear installed capacity (600 Gwe) can be sustained for very long period.

Another aim of India's Nuclear power programme is to extend the use of nuclear power to non-power applications in a big way, in particular for desalination and high temperature processing applications, including those for generation of hydrogen or nonfossil fluid fuels. To meet these objectives in medium as well as long term time frames, keeping the current international trends in nuclear technology in view, India is developing Advanced Heavy Water Reactor (AHWR); High temperature reactor-based power packs for high temperature process heat and hydrogen fuel production; Accelerator driven fertile converters, with fast subcritical reactor, minor actinide burner; and Molten Salt Reactors including breeders for generating electrical power, high temperature process heat and transmutation of minor actinides.

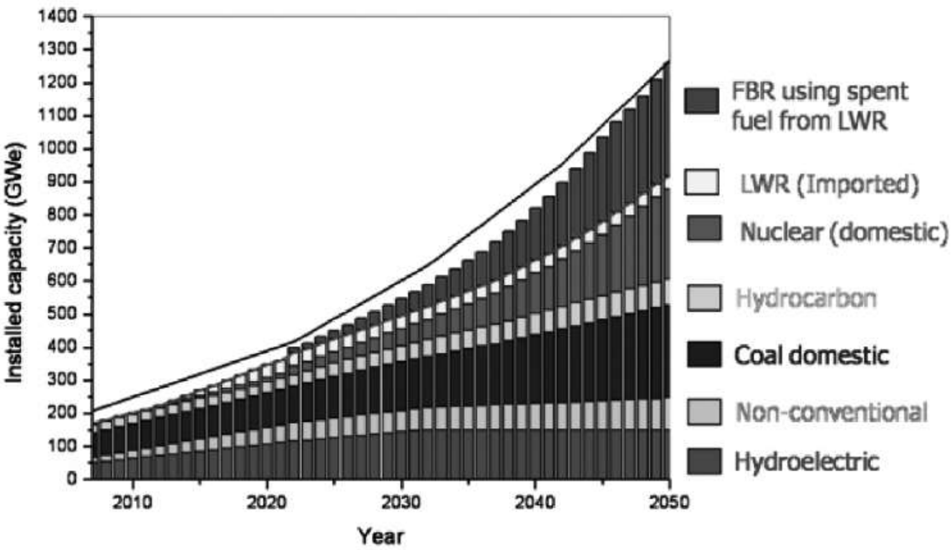


Fig. 4. Strategies for long-term energy security [13]

Facts and Myths

People are generally afraid of things they can't see and touch, such as radiation. In addition, media highlight a lot about the rare nuclear accident compared to the more frequent car accident or shooting because of which many more people die. In addition many people are not very familiar with the advantages of nuclear power and thus are suspicious of it. Also, some people think of nuclear bombs when they think of nuclear reactors although the two are completely different; a nuclear reactor can never explode like a bomb.

All radiation is not bad, only high levels can sometimes cause harm. The important thing is that radiation is not something only associated with nuclear power; we are surrounded by radiation at all times. These low levels of radiation are all safe; so are those that you get from living around a nuclear power plant. The risk of using nuclear energy comes from the possibility that radioactive elements might be released into the environment. However nuclear power plants are very carefully built to prevent such releases. Nuclear energy has a very good safety record and hundreds of nuclear power plants all over the world have operated for more than fifty years without any serious accidents. Even the two worst nuclear accidents in history (Chernobyl and Fukushima) have harmed very few people compared to the pollution from fossil fuels. In fact there are people and animals living around Chernobyl who are in excellent health.

The problem of nuclear waste disposal is challenging but it is not unsolved. For starters, the total amount of nuclear waste from all reactors is extremely small and can be placed in a 3m pile on a single football field. In addition only a small part of that waste is long-lived. Thus the small part can be separated from the shortlived waste which will disappear soon. Some of the waste can be used in generating more electricity from nuclear reactors.

Table 4. Comparing deaths/TWh for all energy sources [14]

Energy Source	Death Rate (deaths per TWh)
Coal (elect, heat,cook –world avg)	100 (26% of world energy, 50% of electricity)
Coal electricity – world avg	60 (26% of world energy, 50% of electricity)
Coal (elect,heat,cook) – China	170
Coal electricity- China	90
Coal – USA	15
Oil	36 (36% of world energy)
Natural Gas	4 (21% of world energy)
Biofuel/Biomass	12
Solar (rooftop)	0.44 (0.2% of world energy for all solar)
Wind	0.15 (1.6% of world energy)
Hydro	0.10 (europe death rate, 2.2% of world energy)
Hydro - world including Banqiao	1.4 (about 2500 TWh/yr and 171,000 Banqiao dead)
Nuclear	0.04 (5.9% of world energy)

Table 5. Estimated life expectancy lost due to various health risks & industry type [15]

Smoking 20 cigarettes a day	6 years
Overweight (15%)	2 years
Alcohol (US Ave)	1 year
All Accidents	207 days
All Natural Hazards	7 days
Occupational dose (300 mrem/yr)	**15 days**
Occupational dose (1 rem/yr)	**51 days**
All Industries	60 days
Agriculture	320 days
Construction	227 days
Mining and quarrying	167 days
Manufacturing	40 days

Conclusions

About 40% of the country and 500 million people still have no access to Electricity. Cleaner/greener, adequate and secure supplies of energy at affordable costs are essentially required for prosperous India. Impacts of unchecked anthropogenic climate change due to greenhouse gas (GHG) emissions from burning of fossil fuels are catastrophic for both densely populated human societies and natural ecosystems. The alternative of rampant climate change is more risky. Thus, low carbon energy sources are desperately needed.

Nuclear power plants do not pollute the environment and leave no carbon footprint in their operational wake and they provide a lot of energy from a very small amount of fuel. They also generate a very small amount of waste. Geothermal energy, solar and wind energy are promising sources but they are not as reliable and powerful as nuclear energy.

Indian Nuclear power program, visualized by Dr. Bhabha in early fifties is on course and is being developed and successfully deployed with indigenous efforts, placing the country in elite club of countries possessing advanced nuclear technology. As per Indian Nuclear vision document, nearly 20 GWe power is planned to be generated through PHWRs by 2030. In addition, the generation capacity from the imported Light Water Reactors (LWRs) is likely to be about 40 GWe. By 2050, it is planned to install FBRs in large scale. Nuclear power program is also extended to desalination and high temperature processing applications, including those for generation of hydrogen or nonfossil fluid fuels.

All energy sources have both advantages and disadvantages. Nuclear energy has a number of advantages that warrant its use as one of the main methods of supplying an energy-demanding world. Nuclear power in the 21st century promises to be more modular, reliable, sustainable and much safer than existing power sources. To conclude, nuclear power is an inevitable option for energy requirements of India and the world.

[1] Jerald L. Schnoor (Editor-in-Chief), Nuclear Power: The Last Best Option, Environ. Sci. Technol., 2013, 47(7), pp 3019-3019 DOI: 10.1021/es400852n Publication Date (Web): March 14, 2013 Copyrig©h 2t0 13 American Chemical Society.

[2] Load Generation Balancing Report 2014-15, Central Electricity Authority, Ministry of Power, Govt. of India

[3] Physical Progress (Achievements)". Ministry of New and Renewable Energy, Govt. Of India. 31 January 2014. Retrieved 21 February 2014.

[4] Power Generation from Various Renewable Energy Sources". Ministry of New and Renewable Energy. 9 December 2013. Retrieved 10 January 2014.

[5] Pushker A. Kharecha and James E. Hansen, Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power, Environ. Sci. Technol., 2013, 47, pp 4889-4895 DOI: 10.1021/es400852n Publication Date (Web): March 14, 2013 Copyright© 2013 American Chemical Society.

[6] Information from U.S. Energy Information Administration.

[7] Nuclear Power in India, http:/Awww.worldnuclear.org/info/CountryProfiles/ CountriesGN/India/, World Nuclear Association, updated December 2014.

[8] Data from U.S. Energy Information Administration (EIA) and U.S. National Renewable Energy Laboratory (NREL).

[9] Data from European Nuclear Society, http:/Avww.euronuclear.org/info/encyclopedia/ coalequivalent.htm

[10] Availability of Thorium, Press Information Bureau, Government of India, 10 August 2011, retrieved21 March 2012.

[11] S A BHARDWAQ, Indian nuclear power programme — Past, present and future, Sadhana Vol. 38, Part 5, October 2013, pp. 775-794. © Indian Academy of Sciences.

[12] "Start-up of India's PFBR delayed". Nuclear Engineering International. 11 August 2014. Retrieved 1 September 2014.

[13] "AStrategy for Growth of Electrical Energy in India', document 10, August 2004, DAE.

[14] Data taken from World Health Organization (WHO) and compiled by blogger at http://nextbigfuture.com/2011/03/deaths-per-twh-by-energy-source.html

[15] Data taken from World Health Organization (WHO) and compiled by blogger at http://nextbigfuture.com/2011/03/lifetime-deaths-per-twh-from-energy.html

The Discipline of Computer Science and Engineering

Dr Gautam Barua

Mentor Director
Indian Institute of Information Technology Guwahati

India is an Information Technology (IT) powerhouse. IT exports constitute more than 20% of the country's total exports and it directly employs more than 25 lakh people. Computer Science and Engineering (CSE) is the academic discipline that underpins IT. There are hundreds of Engineering Colleges in India offering B.Tech / B.E degrees in CSE. So CSE education forms an important part of our higher education system. Because of the success of the IT industry, CSE is also the most sought after branch in Engineering education. So what is CSE? This questions needs to be asked because it is a young field which is still growing rapidly and which therefore overlaps with a number of other, more well-established disciplines. In this lecture, I will try to answer the question - what is CSE - from a CSE academic's point of view.

First of all, we must look at the difference between IT and CSE. One way to differentiate the two is to say that IT refers to the industry and CSE to the academic discipline. But then there are a number of degrees being offered in IT, in India. The IT discipline is different from CSE mainly in two respects: less emphasis on formal and theoretical aspects, and more emphasis on commercial computer systems and their study. As a CSE academic, I see IT as but a subdiscipline of CSE. Then again, due to the increasing importance of communication in the use and spread of IT, the term Information and Communication Technology (ICT) is sometimes used instead of IT. So when I speak of CSE, I am including IT and ICT as sub-disciplines.

CSE is accepted as an engineering discipline but the word “science” is included in the name of the discipline. This is due to historical reasons. Computer Science emerged as a discipline out of Mathematics in the West, and so it had “science” in its name. Later, when the discipline matured, it was realised that there are many engineering aspects involved since one of the main goals behind studying the discipline is to build systems. So “engineering” was added and the discipline became “Computer Science and Engineering”. In many institutions of India, the discipline emerged out of Electrical Engineering and became Computer Engineering. Since the West continued to use Computer Science, the name Computer Science and Engineering was coined in India. The term CSE is not used universally in other parts of the world. In most parts of the developed world, the discipline is still called “Computer Science”. In the USA, there is no separate undergraduate degree in engineering: BS is the common degree for disciplines in Science and Engineering. So they had no need to identify Computer Science as an engineering discipline. However, this has led to many interpretations there of whatconstitutes Computer Science and so the curriculum in a BS in Computer Science programme can vary quite a bit.

What we need to note that it is agreed that a core part of CSE is science oriented. Of course, the difference of Science from Engineering is itself something that is not easy to make. In fact, what CSE has is a core of Mathematics, rather than Science per se. But then, one may argue that every engineering discipline relies heavily on Mathematics and every discipline can claim to have a core of Mathematics. My argument is that the Mathematics in CSE is more intrinsic than in other disciplines. Please observe how the argument unfolds. So what is this core? First of all there is the theory of computation developed in the middle of the twentieth century with Turing, Church, Kleene and Post as the main players. Church's thesis states “afunction can be computed by some computer if and only if it can be computed by a Turing machine.” Or to put it in another way, all that we will ever be able to compute is what a Turing machine can compute. Turing had earlier described a simple machine which is now called the Turing machine (it is a hypothetical machine, in that it assumes infinite amount of memory is available). Even though this thesis seems so bold, it holds even today. Any program that solves a problem using the fastest supercomputer available today can be solved by a program on a simple Turing machine. The difference will be in the speed of computation. This is an amazing thesis which has withstood 75 years of relentless advances in computing hardware. So there is a model of computation which can be used to find out if a function is or is not computable.

The theory of computation further distinguishes between problems that a computer is guaranteed to find an answer and those problems where we cannot be so sure. That is, in the first set of problems, an answer will be given in a finite amount of time. In the second class of computable functions though, we do not know if there will be a solution in finite time in every case (each case corresponds to a different input to the problem). One such problem is the famous “halting problem”. Can we write a programme P1 which, when run on a Turing machine (and so any machine for that matter), has as its input any computer programme P2, and the input to that computer programme P2. Can this programme P1, which we have written, always finish (and so halt) and answer yes or no according to whether P2 will complete its solution with the given input in finite time? The answer is no. The halting problem (P1) cannot be guaranteed to give an answer in finite time.

The next set of theoretical results has to do with how much time and how much space a particular algorithm takes. We have moved from functions to programmes to algorithms. I will come back to algorithms again, but let me elaborate on these theoretical results. They are part of what is called "Complexity Theory". Sticking to time complexity, an algorithm is said to have complexity O(n) if the time taken to run the algorithm on any computer is no more than K*n, for some constant K, where n is the length of the input. Thus, for example, if we want to find the largest of n numbers, our algorithm will take the first number as the largest, and compare it with each of the other numbers. Whenever a larger number is found, it replaces the current largest number. So after n comparisons, we find the largest number. We can prove that we can do no better: any algorithm to find the largest of n number has to use n comparisons. We say that the complexity is O(n). It is a worst case time complexity. It has been proven that the time complexity of the best algorithm to sort n numbers is O(nlog2 n). We can do no better than this. This becomes a basis to decide if we have the "best" algorithm.

Unfortunately, this refers to the worst case, and the average time taken to sort n numbers may vary from algorithm to algorithm.

CSE is about the design and analysis of algorithms. Whether the subject is Databases, Operating Systems, Graphics, Compilers, in each subject we discuss algorithms to perform different tasks. An algorithm is a step-by-step set of operations to solve a given problem. These steps can be made to be executed by a computer. This is done by converting an algorithm into a computer programme. Given a problem, we must first find out if it is computable. If it is, we must find the best algorithm we can to solve the problem. An algorithm is "best" if it has the least possible time complexity. Theoretical results may tell us what is best for a class of problems. If we do not know the best time complexity of the class of problems in which we are working, we need to find out if the problem is "intrinsically hard". The theory behind this assumes that if the time complexity is exponential in the input length, the problem is hard. So, suppose the best algorithm we can find to decide if a given number is a prime number is O(2n), where n is the number of digits of the number we are checking for primality. Then we may conjecture that this problem is intrinsically hard (a complexity of the form O(nx) where x is a constant, is said to have polynomial time complexity and is considered "easy"). We conjecture, because, we are not sure if we have tried hard enough to find a better algorithm. In order to put more substance into our conjectures, a set of problems have been identified and they are called NP-complete problems. For none of these problems have polynomial time algorithms been found. Further, methods have been found to reduce one member of the set to another member of the set in polynomial time, so that a chain of reductions are present such that if any one problem has a polynomial time complexity, all the problems have polynomial time complexity. Since this set has grown quite large in the last 45 years of the theory, it is likely that these problems are "intrinsically" hard. Coming back to our primality testing problem, if we can reduce any of the existing NP-complete problems to an instance of the primality testing problem in steps that are a polynomial of the length of the input of the existing problem, we will have shown that the primality testing problem is NP complete. Nobody was able to show such a reduction for a long time and so it was not known to be NP complete and yet the best algorithm known was of exponential complexity. In 2003, Manindra Agrawal, Neeraj Kayal and Nitin Saxena of IIT Kanpur ([1]) found a polynomial time algorithm for the primality testing problem and became famous overnight as they had solved a long-standing open problem.

Coming back to algorithms and programmes, we know that one of the main tasks in the IT industry is to write programmes. Programmes are based on algorithms, and algorithms are a sequence of unambiguous operations. It has been argued that describing the algorithms to obtain properties of a set is a mathematical model of that set. It is an alternate formulation to the traditional axiomatic mathematical models. So the whole business of creating software can be seen as one big mathematical exercise. Programmers are mathematicians without realising that they are! Time does not permit me to go deeper into this thought process. Listeners are encouraged to read a fascinating article by Roddam Narsimha in Economic and Political Weekly (2003). Different algorithm design paradigms have been identified and these are aids to the designer to design a particular algorithm. The major paradigms are Greedy Method, Divide and Conquer, Dynamic Programming and Searching with Backtracking.

What about the engineering aspects of CSE? Is CSE only Mathematics? This audience in the Engineering Congress will be able to appreciate the engineering aspects. To build a complex structure, we need to build it in parts. The parts must fit each other in some known manner so that the parts can be built independently. This results in building of standard interfaces, standard notations, standard values, etc. As an engineering discipline matures, standards become more pervasive. The same has been the case in CSE. At the hardware level, many of the standards were the same as what were already established in electrical engineering. In communications, protocols such as TCP/IP, HTTP have become standards. Communication end points can be easily built independent of the other side. An Android App to run on your smart phone relies on these communication standards to contact and communicate with services on the Internet whose functionality is only known, not their implementation. Language standardisation allows moving programmes from one environment to another. More importantly, it allows humans to learn a few languages and become programmers for almost any application. Operating system standardisation allows multiple hardware vendors to compete in the marketplace. The large number of Android smartphones is a consequence of standardisation of the Android operating platform (although done by one vendor: Google). Building blocks in the form of data structures and objects have been identified and studied and these are used by programmers as building blocks. Some common data structures are arrays, linked lists, queues, trees, hash tables.

There is a sub-discipline called software engineering which deals with writing large programmes. Such programmes cannot be written by one person and so various methods have been proposed to organise the activity of many persons working together to write one large programme. The various stages are specifying the requirements, designing the software, writing the functions that make up the programme, testing the programme. Over time, many methods have been suggested, and with changes in technology, many different methods have been tried. Standardisation has not taken place, probably because of the variety of requirements, and the variety of problems to be tackled. It is also a management problem and a number of software engineers have to be managed to work together to solve one problem.

CSE is a growing discipline as the technology which drives it is growing rapidly. The theoretical underpinnings have matured and are stable. Tools, building blocks, languages are evolving and are leading to better and better practices as time goes by. It is the engineering aspects of CSE that are seeing changes. To teach CSE, we therefore need to teach the theoretical foundations and the more stable building blocks. Students will have to learn new techniques, new systems in their workplace as these are changing all the time. Our job is to equip them with the fundamentals so that they can learn new things easily.

[1] Manindra Agrawal, Neeraj Kayal, Nitin Saxena, Primes is in P, Annals of Mathematics, Vol. 160, 2, Princeton University, 2004.

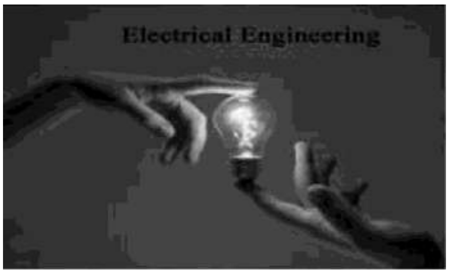
[2] Roddam Narsimha, Axiomatism and Computational Positivism, Economic and Political Weekly, August 30, 2003.

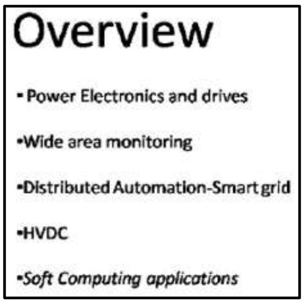
Recent Developments in Electrical Engineering

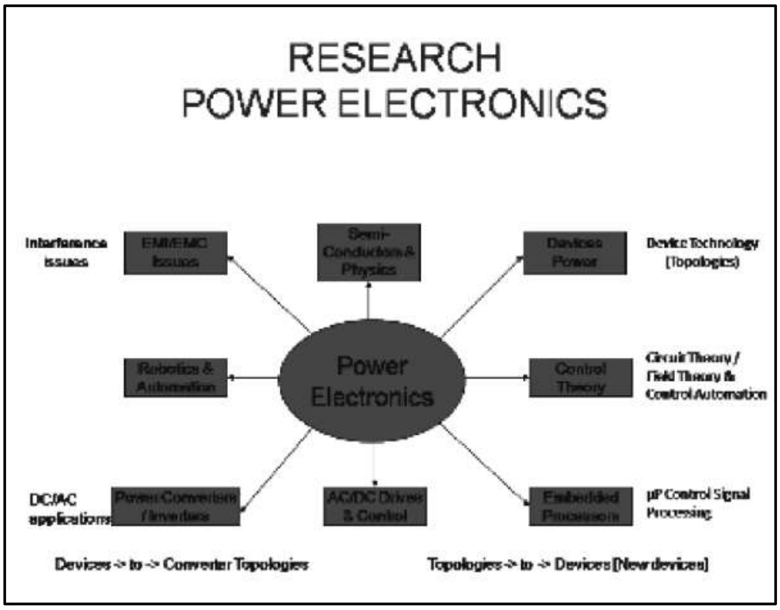
Prof A P Mittal

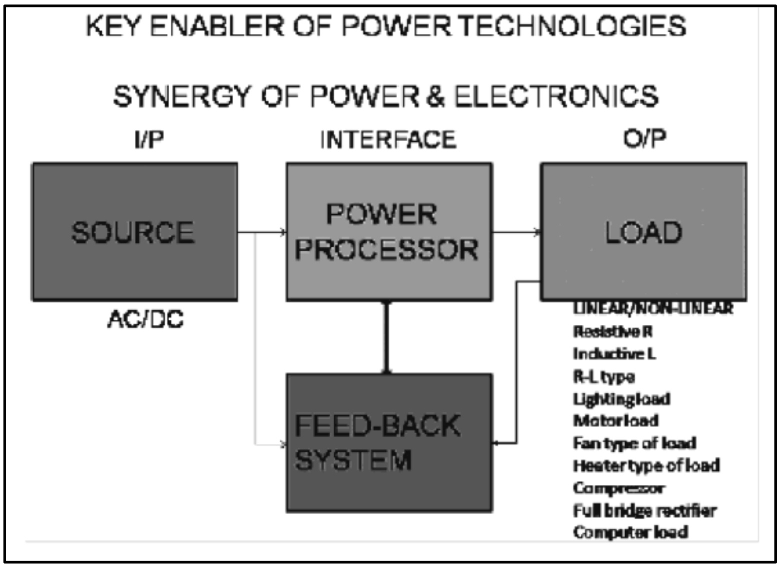
Member Secretary, AICTE

Professor, Netaji Subhas Institute of Technology

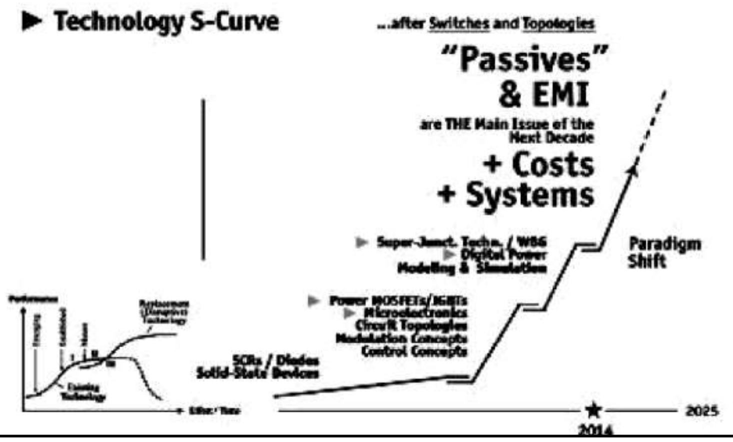








POWER ELECTRONICS - TECHNOLOGY TREND GRAPH



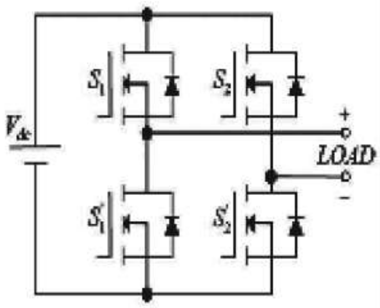
Some Applications: Electrical traction systems

Multistage Converters

1. Multistage converters has chain of 4 converters per phase (4 stage converter), with a main converter that manages more than 80% of the total power
2. Three Slave converters that takes rest of the power (less than 20%).
3. It can generate almost perfect current and voltage waveforms, because it is modulated by amplitude instead of pulse width modulation.
4. It can generate near sinusoidal voltages with only fundamental frequency switching.
5. It have almost no electromagnetic interference of common mode voltages.
6. They are suitable for large volt-ampere rated motor drives & high voltages and it is lower frequency devices.

Multistage Converter

- S2 and S1' are switched on the output is –V dc.
- Either pair S1 and S2 or S1' and S2' are on the output is zero.
- S1 and S2' are on the output is +V dc.



Multistage Converter

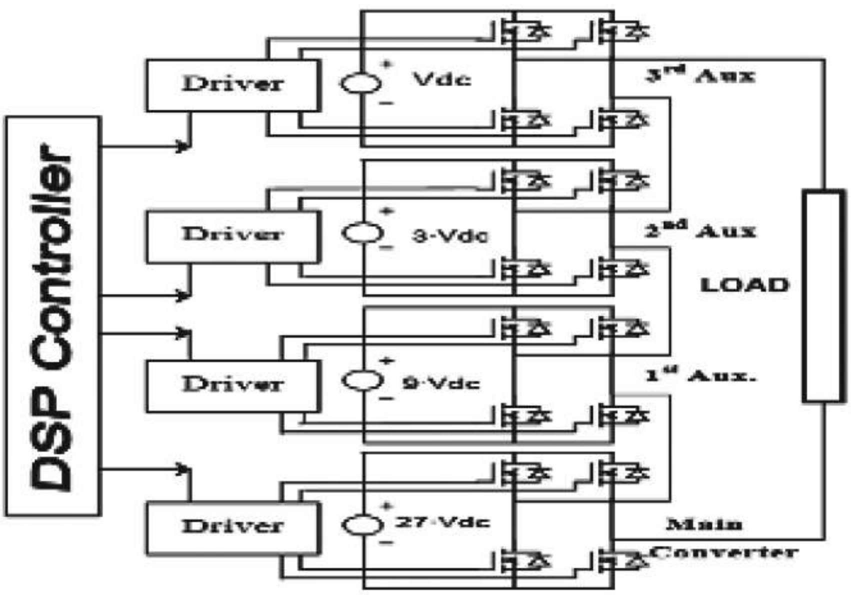
Modular Multi-Level Converter

- The MMC differs from other types of converters.
- In that the current flows continuously in all six valves of the converter throughout the mains-frequency cycle.
- As a result, concepts such as "on-state" and "off-state" have no meaning in the MMC.
- The direct current splits equally into the three phases.
- The alternating current splits equally into the upper and lower valve of each phase.
- The current in each valve is therefore related to the direct current I_d and alternating current I_{ac} as follows:

$$\text{Upper valve: } I_v = \frac{I_d}{3} + \frac{I_{ac}}{2}$$

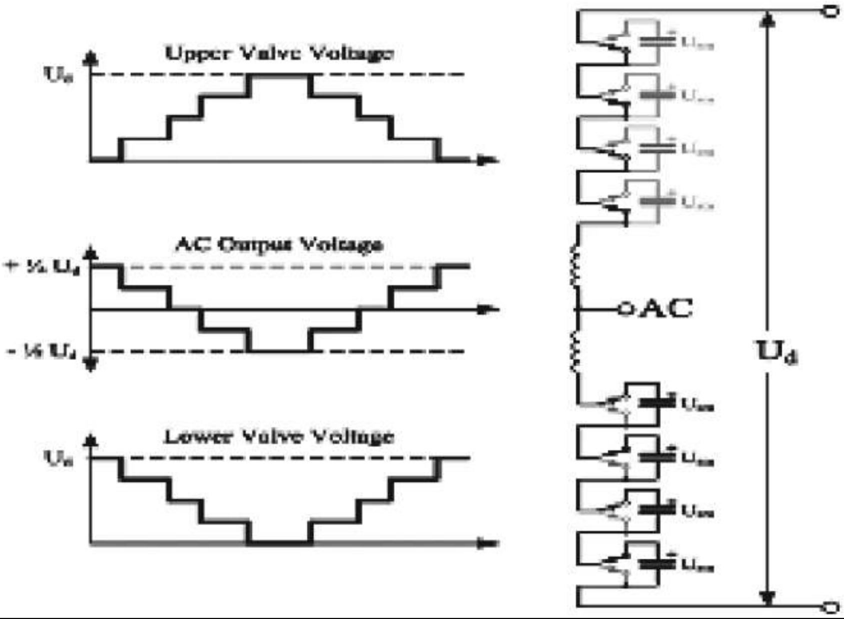
$$\text{Lower valve: } I_v = \frac{I_d}{3} - \frac{I_{ac}}{2}$$

4 Level Multi Stage Converter

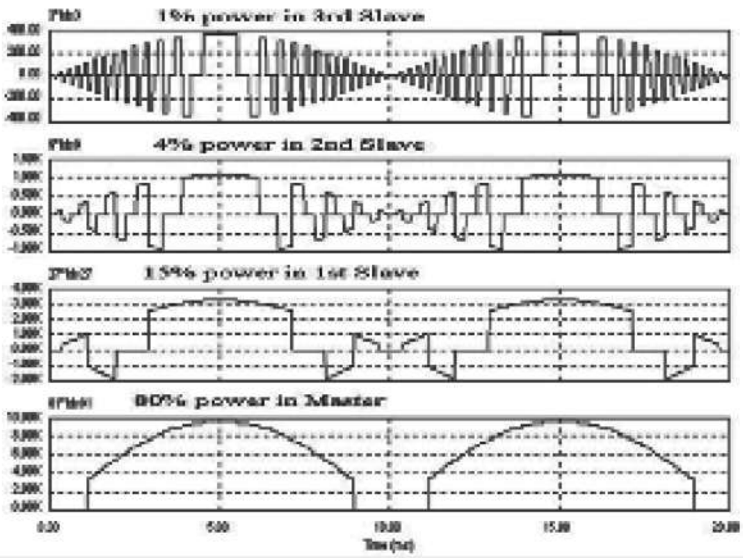


4 level Multistage Converter

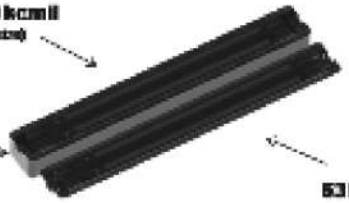
Modular Multi-Level Converter



Power Distribution in Multistage Converter



DISTRIBUTED SERIES REACTOR (DSR)



- Life: 20+ year life; zero maintenance
- Install de-energized or live line
- Fault current sense within 5 µs, then automatic transition from injection to monitoring mode in 5 ms.
- No corona at operating voltage
- Environmental: Resistant to – salt fog, Aeolian vibration, ice buildup, thermal cycling
- Conductor impact: No mechanical or thermal conductor degradation
- Lightning Strike: tested to line BIL
- Wind loading: up to 150 mph
- Communications: Module to ground or SCADA link as specified by owner.

50 µH per module per mile changes typical 138 kV conductor impedance by roughly 2%

SMART WIRES TECHNOLOGY – SMART GRID

Smart Wire DSR - Overview

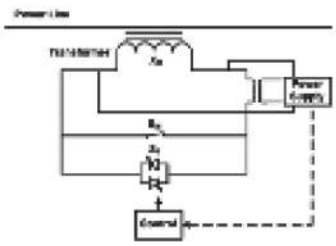
– Functions as a current limiter to divert current from the overloaded lines to underutilized ones.

– Increases line impedance by injecting a pre-tuned value of magnetizing inductance of the Single-Turn Transformer.

– Each module can be triggered at a predefined set point to reflect a gradual increase, or controlled remotely for an immediate change, in line impedance.

– DSRs automatically sense faults and remove themselves from the circuit, returning the native circuit, eliminating the need for modifications to the existing protection schemes. Fault sensing and switching occurs in 5ms or less.

– Two modes of operation:
  - Devices can operate autonomously without communication
  - Two way communications enabled for greater control and line monitoring

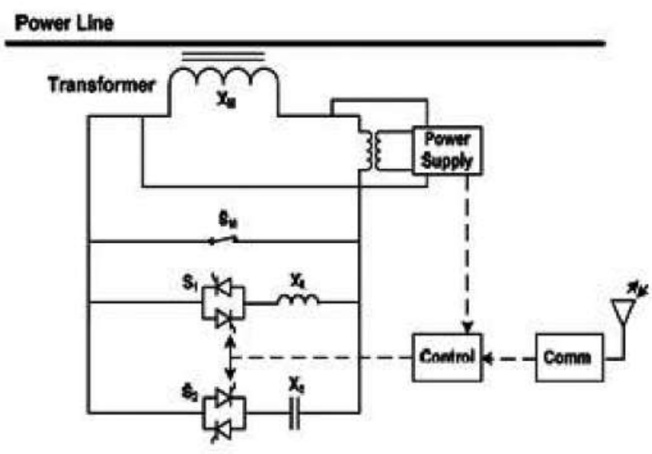


One DSR module per phase per mile changes line impedance (138 kV) by roughly 2%

DSRs FUNCTIONALITY

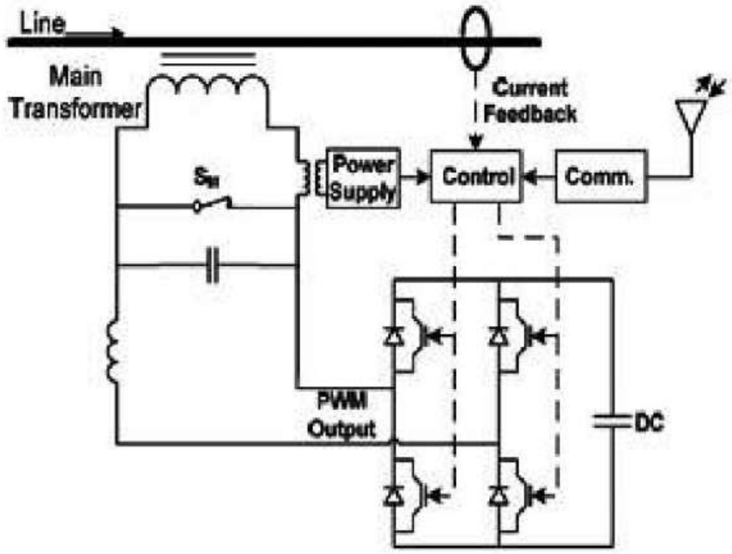
- Distributing Power Flow Control – Enabling the Dynamic Grid of the Future
- Overloads drive up generation costs and force you to shed load. But Smart Wires' PowerLine GuardianTM is a fast and simple solution. It pushes power away from heavily loaded lines to lines with available capacity, preventing overloads, reducing generation costs and eliminating power outages.
- PowerLine Guardians™ function as distributed series reactors installed along the transmission line and are attached directly to the conductor. The modules have been tested under a variety of conditions, including high fault levels, field contingencies, and are expected to operate continuously for more than twenty years with no maintenance.
- PowerLine Guardians™ are currently operational on three high voltage transmission lines.
- **Power Flow Control**— Provides incremental line impedance control, which when aggregated across the line, can significantly change power flows.
- **Monitoring**—Senses critical parameters such as conductor temperature, vibration, sag, fault location, and the presence of geomagnetic induct current all of which greatly adds to the situational awareness of the grid.
- **Quick Installation**— Typical PowerLine Guardian™ installations can be completed in less than one month
- Grid Resiliency

DSR EXTENDED THEORY



Generic DSI Design

DSSC WITH PWM INVERTER



Ckt system of DSSC

UPCOMING TECHNOLOGY: WIDE AREA MONITORING (WAM)

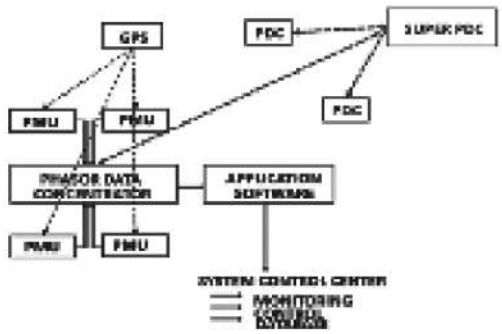


Figure: A Typical PMU based WAMS Architecture

A Phasor Measurement Unit (PMU or SYNCHROPHASOR) is a device which measures the electrical waves on an electricity grid, using a common time source for synchronization. It can be a dedicated device or incorporated in Relays.

WHAT WAM CAN DO?

1. Capturing the power system data in real-time

- Clearer anticipation of incipient problems
- Development of faster control action to improve power grid security

2. Measuring the power system data with precise time stamping

- Electric grid behavior over a wide area can be tracked in a synchronized manner
- Development of wide-area controls.

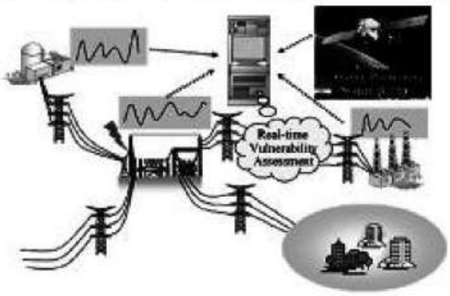
Has SCADA at the heart of the system!

The technology has the potential to change the economics of power delivery by allowing increased power flow over existing lines.

COMPARISON BETWEEN SCADA & WAMS

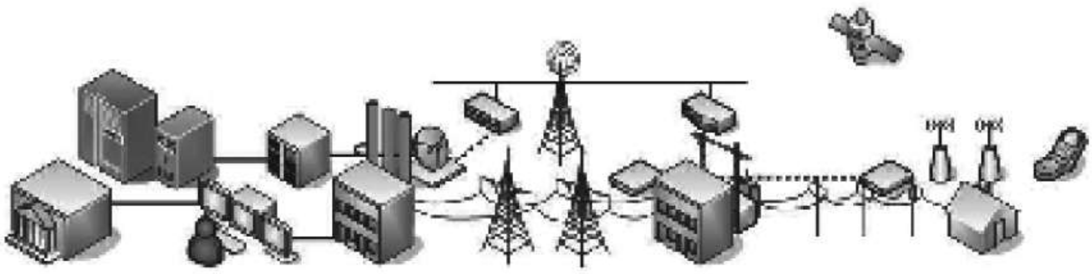
ATTRIBUTE	SCADA	WAMS
Measurement	Analogue	Digital
Resolution	2-4 samples per sec	Up to 60 samples per sec
Observability	Steady State	Dynamic/Transient
Monitoring	Local	Wide-Area
Phase Angle Measurement	No	Yes

Demerit of WAMS: Synchro-Phasor Technology is currently very expensive!



SMART GRID

- Uses information technologies to improve how electricity travels from power plants to consumers.
- Allows consumers to interact with the grid.
- Integrates new and improved technologies into the operation of the grid.

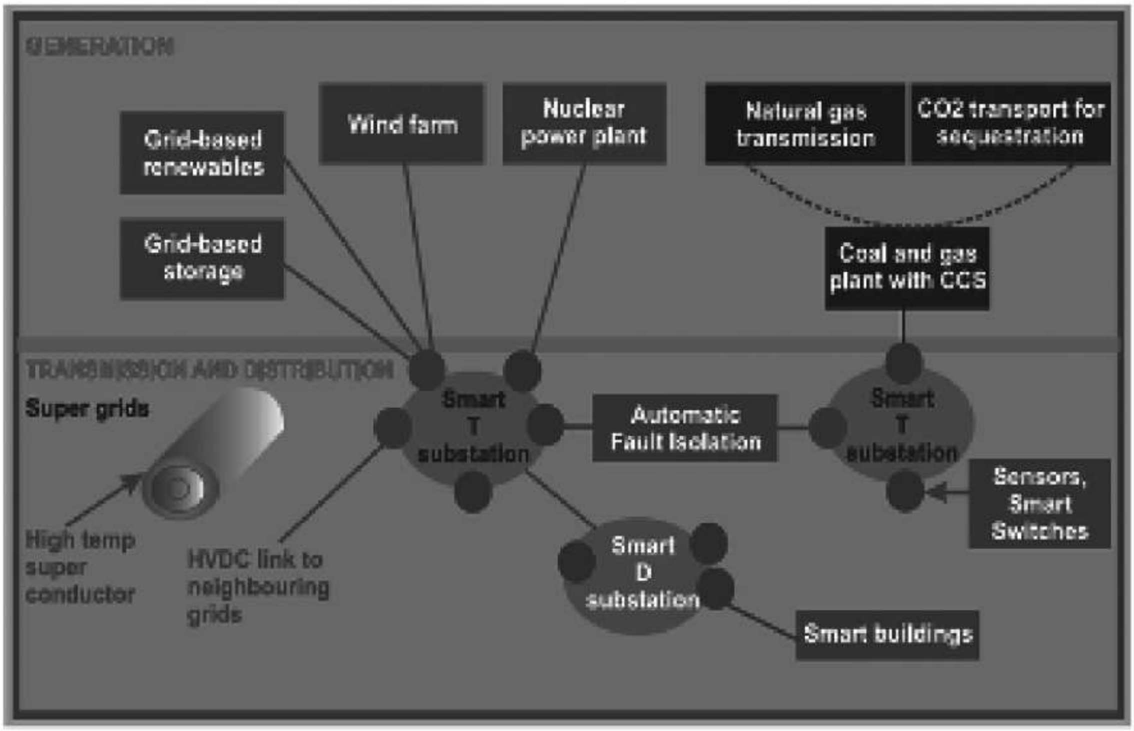


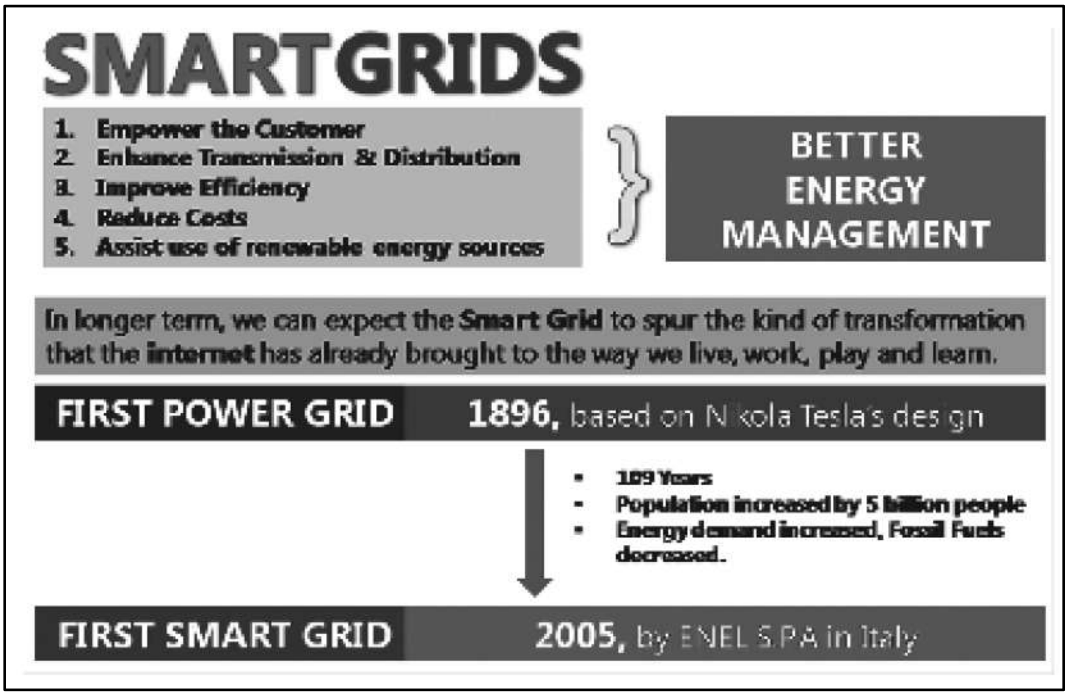
Smart Grid

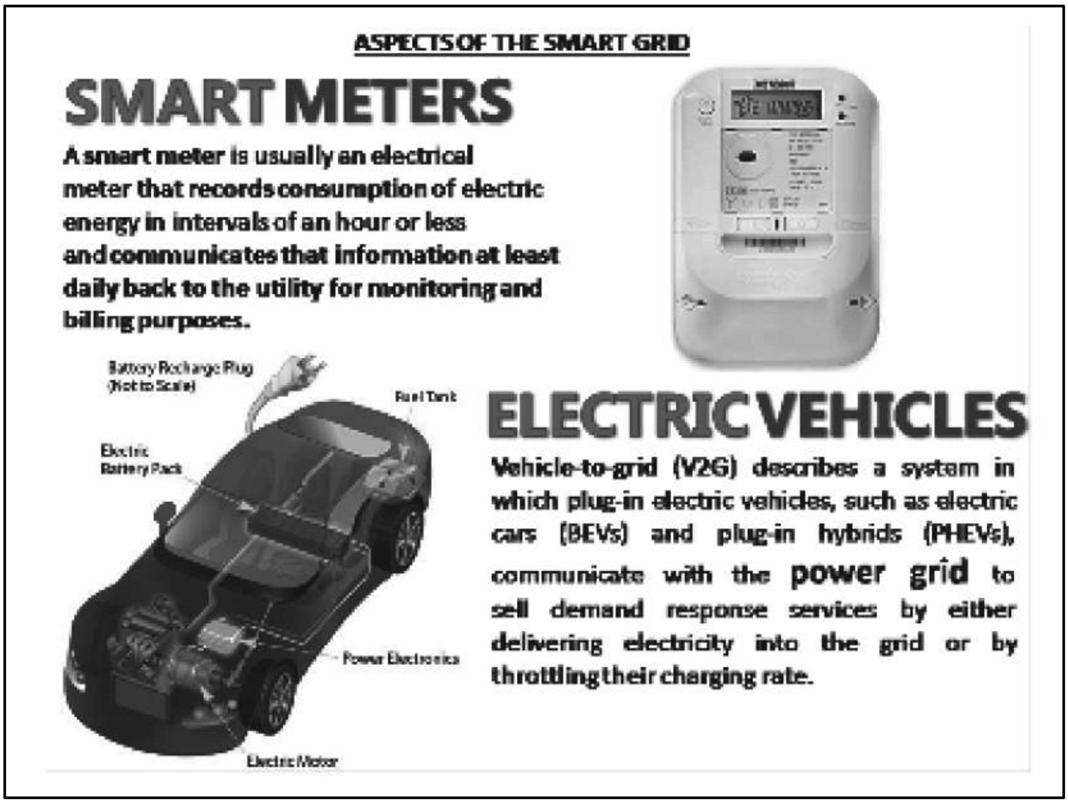
COMPARISON

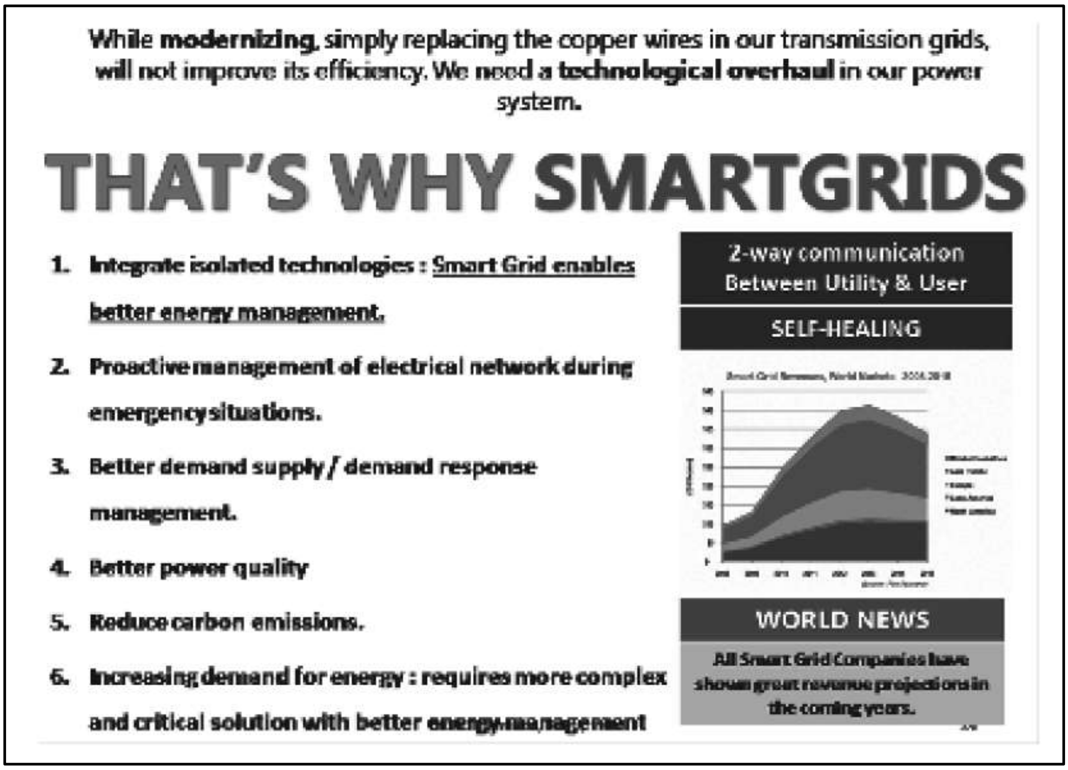
Existing Grid	Smart Grid
Electromechanical	Digital
One-way communication	Two-way communication
Centralized generation	Distributed generation
Few sensors	Sensors throughout
Manual monitoring	Self-monitoring
Manual restoration	Self-healing
Failures and blackouts	Adaptive and islanding
Limited control	Pervasive control
Few customer choices	Many customer choices

AN OVERVIEW OF SMART GRID

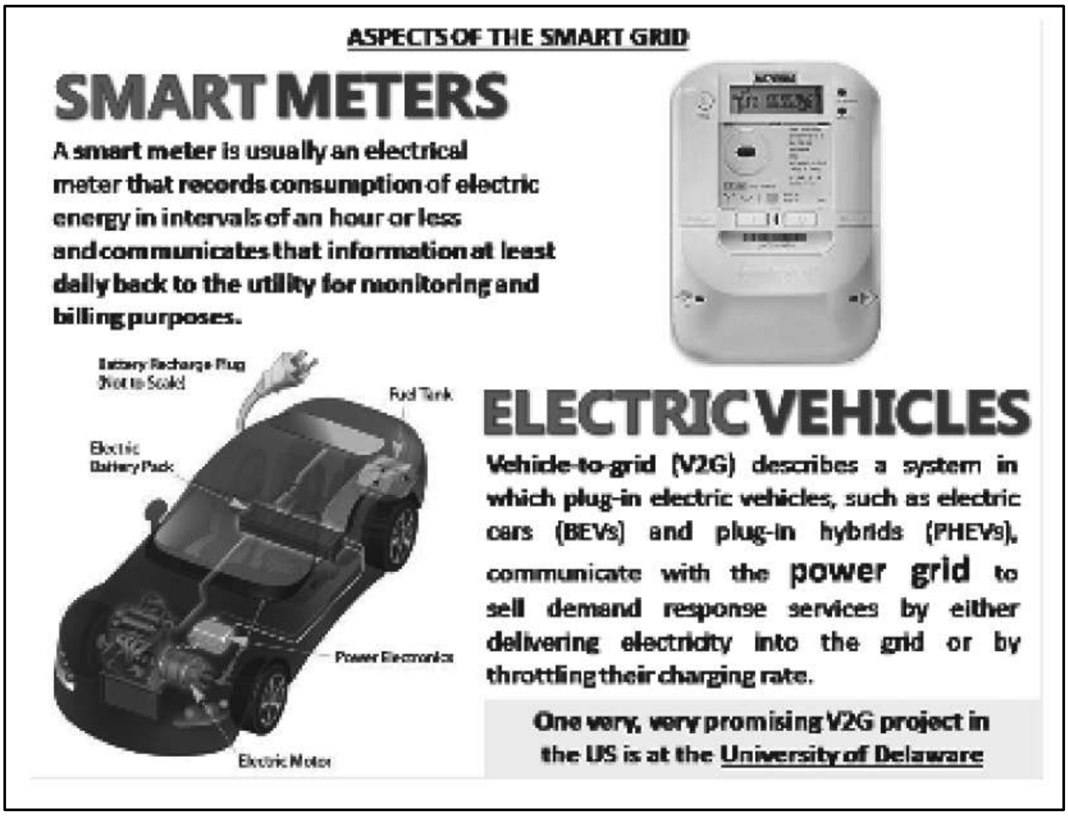


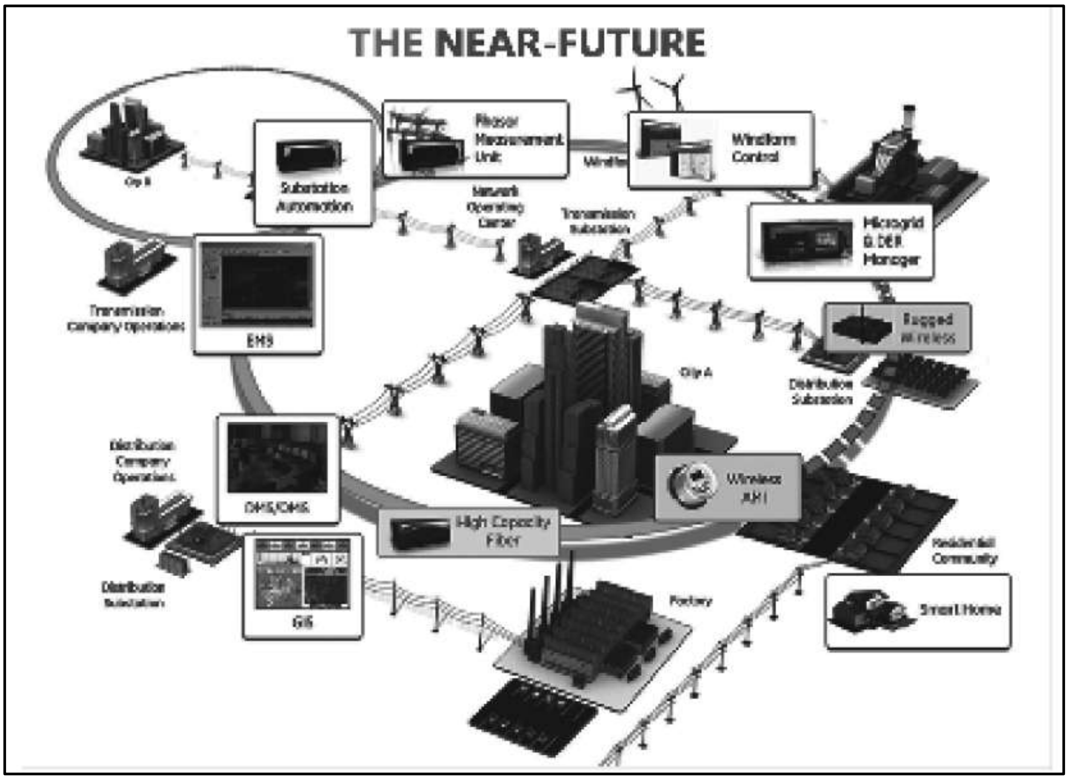

SMARTGRIDS
1. Empower the Customer
2. Enhance Transmission & Distribution
3. Improve Efficiency
4. Reduce Costs
5. Assist use of renewable energy sources
BETTER ENERGY MANAGEMENT
In longer term, we can expect the Smart Grid to spur the kind of transformation that the internet has already brought to the way we live, work, play and learn.
FIRST POWER GRID
1896, based on Nikola Tesla's design
109 Years
Population increased by 5 billion people
Energy demand increased, Fossil Fuels decreased.
FIRST SMART GRID
2005, by ENEL S.P.A in Italy

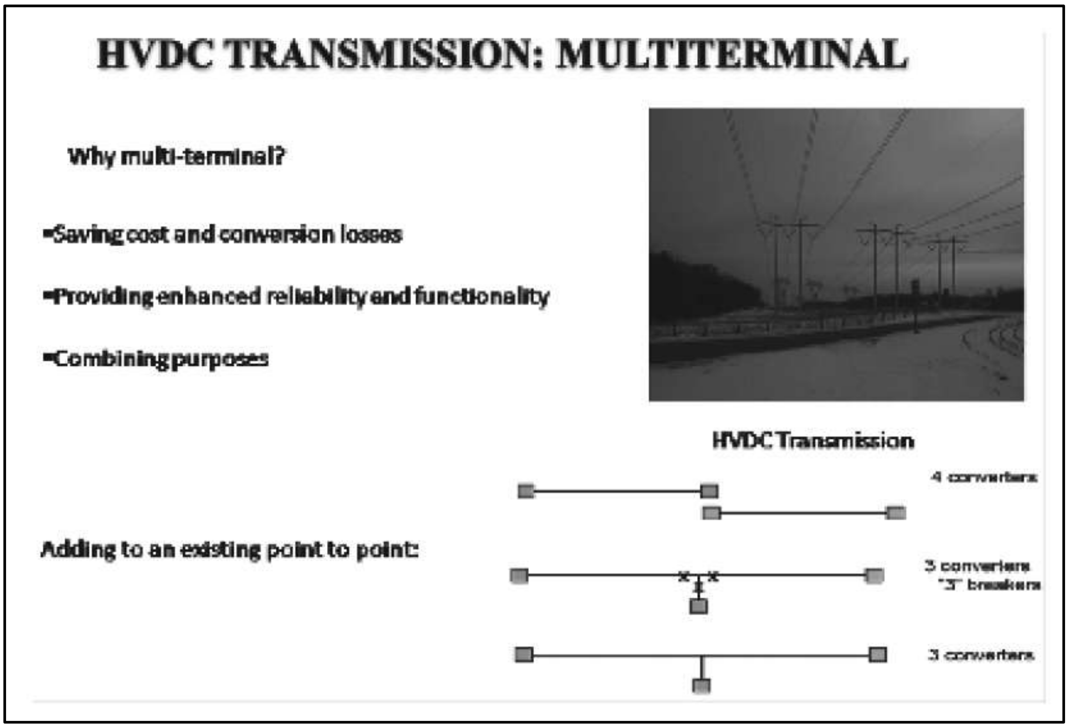

ASPECTS OF THE SMART GRID
SMART METERS
A smart meter is usually an electrical meter that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing purposes.
Battery Recharge Plug (Not to Scale)
Fuel Tank
Electric Battery Pack
Power Electronics
Electric Motor
ELECTRIC VEHICLES
Vehicle-to-grid (V2G) describes a system in which plug-in electric vehicles, such as electric cars (BEVs) and plug-in hybrids (PHEVs), communicate with the power grid to sell demand response services by either delivering electricity into the grid or by throttling their charging rate.

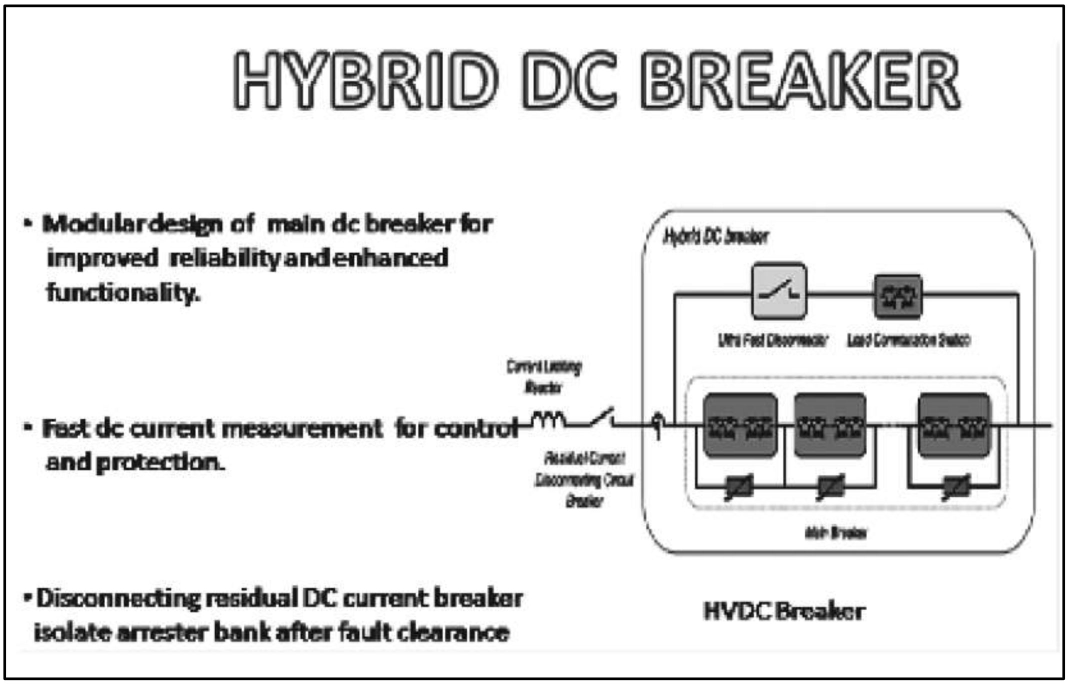

While modernizing, simply replacing the copper wires in our transmission grids, will not improve its efficiency. We need a technological overhaul in our power system.
THAT'S WHY SMARTGRIDS
1. Integrate isolated technologies : Smart Grid enables better energy management.
2. Proactive management of electrical network during emergency situations.
3. Better demand supply / demand response management.
4. Better power quality
5. Reduce carbon emissions.
6. Increasing demand for energy : requires more complex and critical solution with better energy management
2-way communication Between Utility & User
SELF-HEALING
WORLD NEWS
All Smart Grid Companies have shown great revenue projections in the coming years.

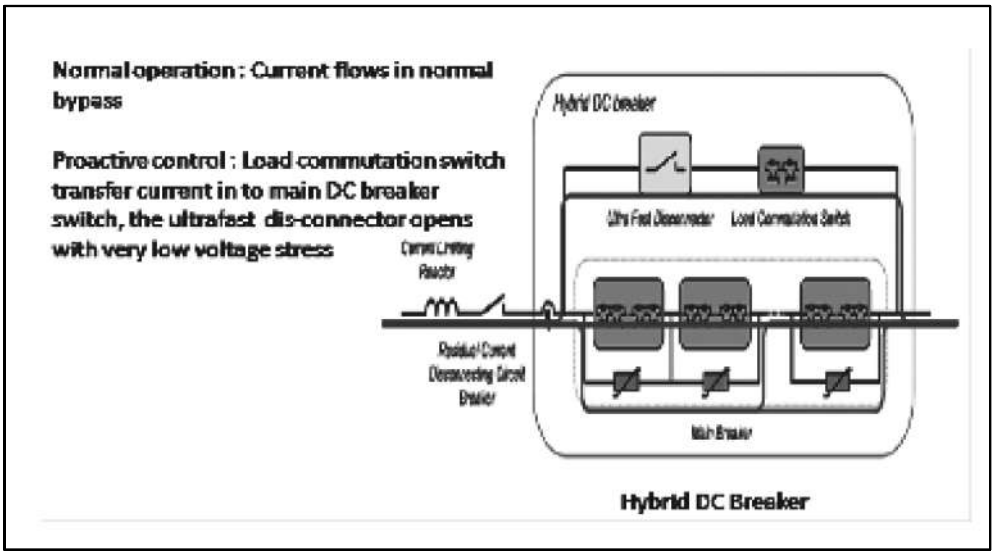

DISTRIBUTION IN SMART GRID
WHAT IT MEANS
• Automatic Distribution
• Demand Optimization - Selective Load Control
• Operation → Islanding of Micro-grids
• Managing Distribution Network Model
• Outage management and AMI Integration
• DMS & Advanced Switching Applications
• Integrated Voltage / VAR Control
WORLD NEWS
Smart Grid Distribution Automation Spending to Total $46 Billion Worldwide by 2015
A.M.I
Advanced metering infrastructure (AMI) is an architecture for automated, two-way communication between a smart meter with an IP address and a utility company.
The goal of an AMI is to provides utility companies with real-time data about power consumption and allow customers to make informed choices about energy usage based on the price at the time of use.

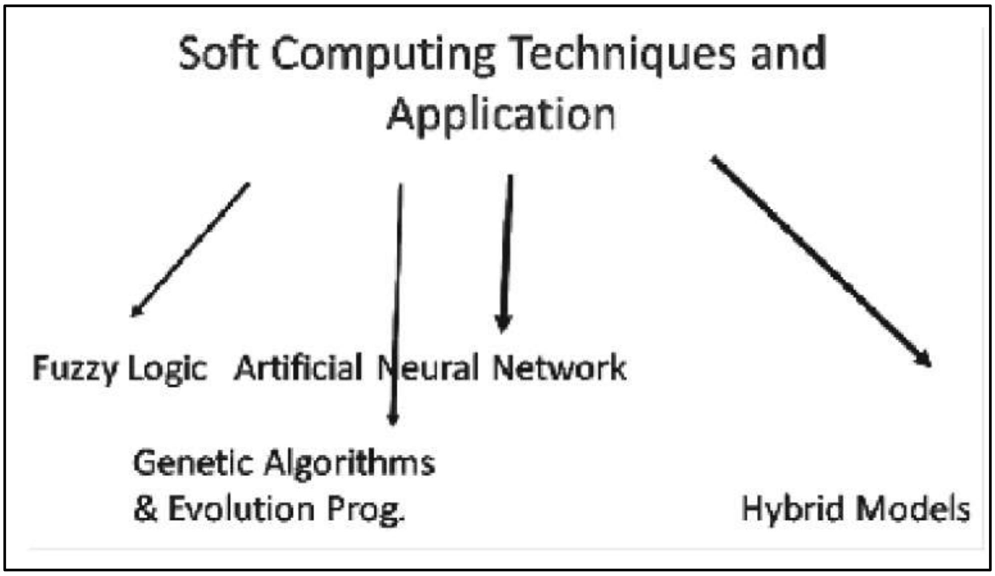

ASPECTS OF THE SMART GRID
SMART METERS
A smart meter is usually an electrical meter that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing purposes.
Battery Recharge Plug (Not to Scale)
Fuel Tank
Electric Battery Pack
Power Electronics
Electric Motor
ELECTRIC VEHICLES
Vehicle-to-grid (V2G) describes a system in which plug-in electric vehicles, such as electric cars (BEVs) and plug-in hybrids (PHEVs), communicate with the power grid to sell demand response services by either delivering electricity into the grid or by throttling their charging rate.
One very, very promising V2G project in the US is at the University of Delaware

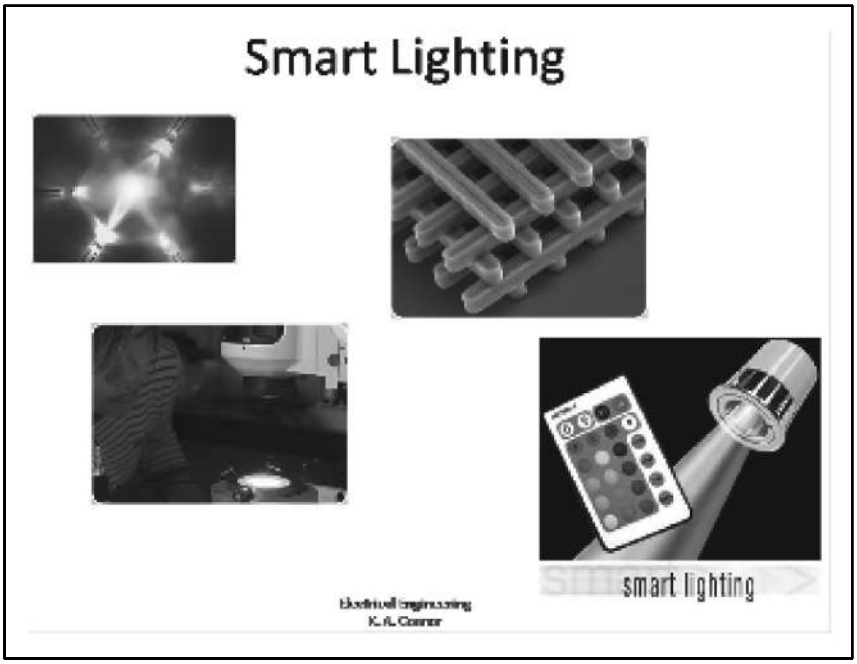

THE NEAR-FUTURE
Phasor Measurement Unit
Windfarm Control
Substation Automation
City B
Network Operating Center
Transmission Substation
Microgrid & DER Manager
Transmission Company Operations
EMS
Rugged Wireless
City A
Distribution Substation
Distribution Company Operations
DMS/OMS
Wireless AMI
High Capacity Fiber
Residential Community
Distribution Substation
GIS
Factory
Smart Home


HVDC TRANSMISSION: MULTITERMINAL
Why multi-terminal?
▪Saving cost and conversion losses
▪Providing enhanced reliability and functionality
▪Combining purposes
HVDC Transmission
4 converters
Adding to an existing point to point:
3 converters
"3" breakers
3 converters

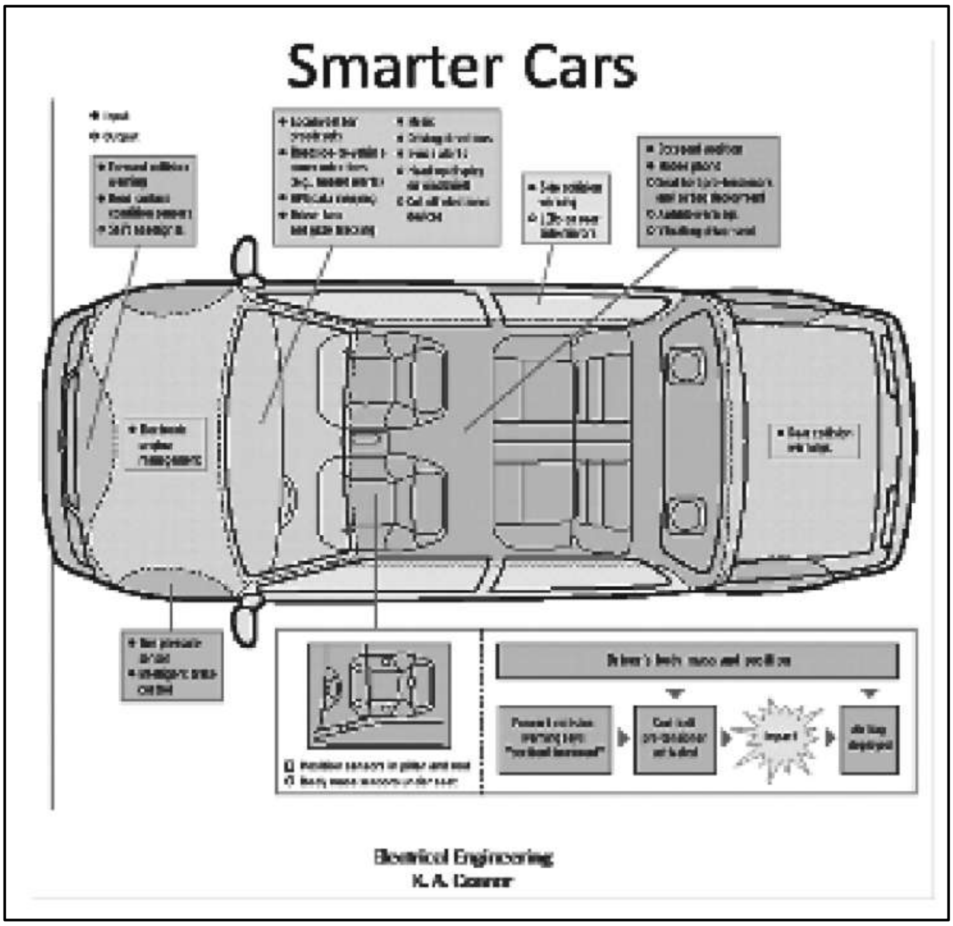

HYBRID DC BREAKER
• Modular design of main dc breaker for improved reliability and enhanced functionality.
• Fast dc current measurement for control and protection.
• Disconnecting residual DC current breaker isolate arrester bank after fault clearance
HVDC Breaker


Normal operation : Current flows in normal bypass
Proactive control : Load commutation switch transfer current in to main DC breaker switch, the ultrafast dis-connector opens with very low voltage stress
Hybrid DC breaker
Ultra Fast Disconnector
Load Commutation Switch
Current Limiting Reactor
Residual Current Disconnecting Circuit Breaker
Main Breaker
Hybrid DC Breaker


Soft Computing Techniques and Application
Fuzzy Logic
Artificial Neural Network
Genetic Algorithms & Evolution Prog.
Hybrid Models


Smart Lighting
smart lighting
Electrical Engineering
K. A. Connor


Wind Power
Electrical Engineering
K. A. Connor

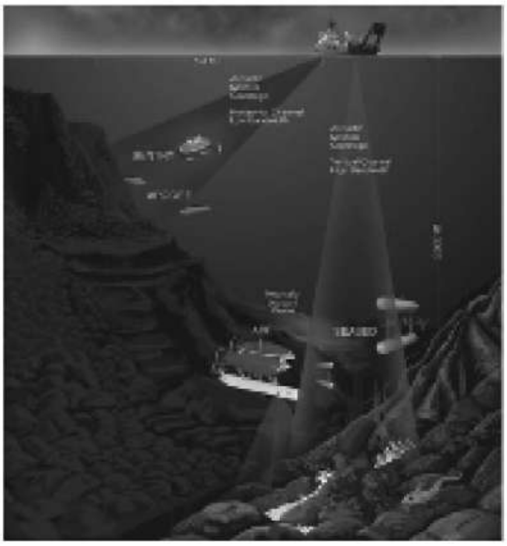

Smarter Cars
Electrical Engineering
K. A. Connor

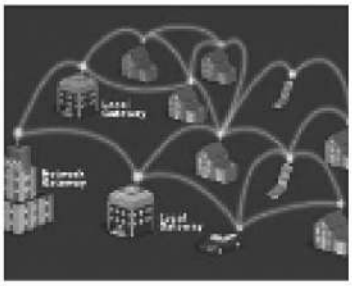
Robotic Surgery

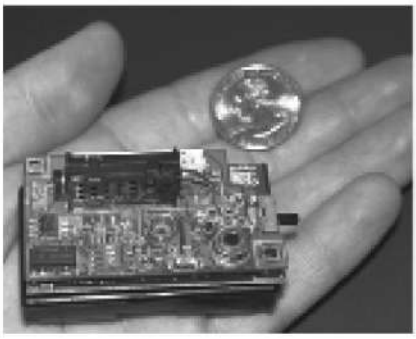
- A doctor in New York removing a woman's gallbladder in France.

Electrical Engineering
K. A. Connor

Sensor Networks







Electrical Engineering
K. A. Connor

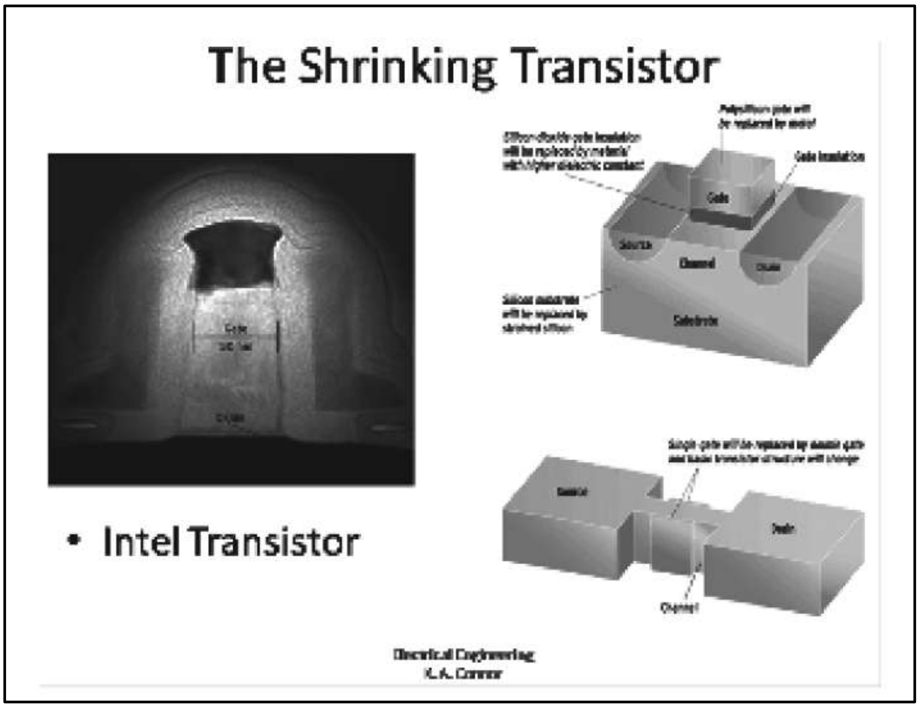
Fuel Cell Power

- Toyota Fuel Cell Hybrid Vehicle

Electrical Engineering
K. A. Connor

Linking With Light

Electrical Engineering
K. A. Connor


The Shrinking Transistor
• Intel Transistor
Electrical Engineering
K. A. Connor

The Institution of Engineers (India)
8 Gokhale Road, Kolkata 700020
Phone : +91 (033) 2223-8311/14/15/16, 2223-8333/34
Fax : +91 (033) 2223-8345
e-mail : technical@ieindia.org; iei.technical@gmail.com
Website : http://www.ieindia.org