IEI Centenary Publication

# Dr Amitabha Bhattacharyya Memorial Lecture

A Compilation of Memorial Lectures
presented in

Indian Engineering Congress

35th Indian Engineering Congress

December 18-20, 2020

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

## Background of
# Dr Amitabha Bhattacharyya Memorial Lecture

Prof (Dr) Amitabha Bhattacharyya, President of The Institution of Engineers (India) during 1976-78, occupied the centre stage in the affairs of the Institution over two decades. A many-splendoured personality, Prof (Dr) Bhattacharyya's untimely death in June 1992 created a void which would take years to fill in. In grateful appreciation of the monumental work done towards furtherance of the cause of the Institution, the National Council, at their 563th meeting held at Hyderabad in July 1992, resolved to institute this Lecture to perpetuate his hallowed memory.

Prof (Dr) Amitabha Bhattacharyya, born on November 12, 1931, was a distinguished mechanical engineer and an eminent educationist and an acknowledged authority in the fields of production engineering, metal cutting and machine tools and had been honoured nationally and internationally for his outstanding contributions to the cause of engineering and humanitarian services.

He was a staunch advocate for the development of indigenous technology for the welfare of the common people. A persuasive teacher and eloquent speaker, he had travelled widely on many professional and academic assignments. An active and constructive social worker, he identified himself with the aims and aspirations of numerous social and cultural organizations and served them with great distinction.

As an ardent advocate for advancement of engineering, Prof (Dr) Bhattacharyya served its cause through various organs and activities of The Institution of Engineers (India) for three decades. During his Presidentship, the Institution's activities received an impetus and diversified its field of interest in many areas including rural development.

The Dr Amitabha Bhattacharyya Memorial Lectures
*was delivered during Indian Engineering Congress*

# Globalization, Development and Educational Policies

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I feel greatly honoured to be invited to deliver the first Amitabha Bhattacharyya Memorial Lecture during the Indian Engineering Congress at Bangalore, as this gives me an opportunity to pay my personal homage to a very distinguished son of India whose multi-faced contributions to the development of engineering education and to the application of engineering knowhow to rural development would remain unparalleled for a long time to come and would bear ample testimony to his qualities of leadership, sincerity of purpose and devotion to duty. The loss that the Institution of Engineers (India) has suffered through his untimely demise is too recent to permit us to make any objective assessment of his role in the meteoric rise of the activities and the prestige of this Institution during the last three decades. Alii can say at this stage is that all of us have felt orphaned by his sudden disappearance from the scene and it would take decades to fill the void created by his absence from the helm of the Institution's affairs.

In choosing the subject of the talk for this afternoon, I have purposely selected only those areas of current concerns in the engineering professional scenario of our country that were very close to Prof Bhattacharyya's own perceptions and on which I had had the privilege of having many discussions with him.

One of the most important developments of the last decade is the increasing globalization of engineering activities and the internationalization of the world economy. Globalization is the process of global integration of traditionally national markets or national economic and technological activities, including products, services, industries and the production process. The diffusion of technology across national borders is occurring at a very rapid pace due to growth of international trade, use of modern information technologies giving global access to knowledge and the presence of transnational firms. The differential in wage rates has made different parts of a complex engineering system to be designed, manufactured and assembled at different parts of the globe, and the marketplace is no longer bound by national frontiers but has become truly international. Since no part of the globe has a monopoly on engineering innovation, there is increasing emphasis in utilizing global talent in engineering for producing devices and systems at the lowest possible cost to remain internationally competitive ·This increasing trend in globalization will be further accentuated by the continuing liberalization of import policies of several nations, the unification of Germany, the coming together of the twelve nations in Europe in an integrated single market, and similar efforts of building common markets in Asia, Latin Amedea. India, Pakistan and even the former Soviet Union are currently going through structural adjustments to make their economy part of the global system by shedding rigid control of export/import policies through fiscal measures.

Globalization has thus become a reality and we can no longer shut our eyes to the changes which are taking place all around the, Globe. Globalization has been caused in part by technology which has led the countries of the world to become interdependent and to grow closer. The first major sustained effort in which many marketing engineering devices and systems was not in a capitalist economy as could have been anticipated but in the integrated common planning system of the countries of Eastern Europe, the countries covered by the Warsaw Pact. A planned economy did not only anticipate the economics of scale, but also optimally utilized the work force in several countries and made them interdependent on one other. Both economic and political factors governed this obvious engineering optimization problem. The modern impetus to globalization has, however, come from multinational engineering firms which utilized the differential cost of material, labour, trained manpower, manufacturing facilities, marketing techniques and tax rates to optimize resources and make the maximum profit. International engineering was thus born where design teams worked in one country, fabrication was done in another, assembly in a third, maintenance services provided by a fourth and products marketed all over the world. This marshaling of resources is not an easy operation because of varying national engineering standards, system of weights and measure, cultural ethos and linguistic diversities of the work force, and the acceptability of the device in different socio-economic milieu. However, multinational or international engineering teams are becoming increasingly common. The team members, inspite of their different educational and cultural backgrounds, enrich the problem-solving capability of the team and are able to provide a wider perspective on the application and adaptation of agreed engineering solution to suit different socio-cultural environment. The success depends mainly to the fact that engineering design presupposes well-defined goals and evaluation of alternate possible solutions before accepting the best. The common 'language of engineering' provides a unifying thread to their endeavour since properties of materials, scientific theories, engineering analysis and synthesis recognize no national or cultural barriers.

While products of low quality and reliability can survive and even contribute to a profitable business venture in a protected market surrounded by impenetrable national trade barriers, such a possibility disappears completely when the market becomes easily accessible to similar products of higher quality and reliability, thus providing the customer a choice and option to buy the best value. Globalization thus leads not only to a larger marketplace with larger demand but also ensures survival of the product and systems of the highest quality and reliability. Thus both the producer and the consumer benefit from healthy competition. The newly acquired search and emphasis in quality and reliability by Indian manufacturers is the direct result of the recent opening up of our market to competition from multinationals. Another striking outcome has been the readiness of our big business houses to become multinational through their increased engineering operation in foreign countries and also participating in joint ventures abroad. This further opens up opportunities for our engineering talent and increases our export earnings and foreign currency reserves.

While globalization demands quality and reliability of products and improved design, manufacturing and marketing techniques, it also brings both psychological and commercial pressure on managements to improve labour relations, reduce non-productive expenditure and wastage and eliminate strikes and lock-outs. A climate of greater participation of labour in the management decisions of the enterprise becomes a by-product of the compulsion for remaining globally competitive.

Summing up, one can say that increasing liberalization of trade and improvement in communication have compelled our engineering establishments to think globally, improve their products and services to survive against increased global competition, utilize their engineering manpower resources and managerial skills to operate and compete successfully in the global market place, and increase employment opportunities to our trained manpower. Let us now consider the problems created by globalization of engineering activities. It is essential from our point of view and perhaps for that of all developing countries that the basic tenet that engineering situations depends upon societal constraints like availability of labour, capital, raw materials and consideration of environment is fully recognized. It has to be accepted, that engineering is by nature, nation and situation-specific and there are no universal solutions which would fit similar situations in all parts of the globe. Global products, supported by aggressive advertising and marketing with only concessions to national and cultural sensibilities in the form of packaging, colour and labelling, lead to unwanted consumption and imitation of ways of living often against traditional values and thinking. System solutions are similarly forced without adequate local market survey to evaluate their acceptability (example: cross-bar telephone). Local conditions are bent and manipulated to fit in the technology rather than the other way about; for example, the mobile dispensaries mounted on bus chassis which cannot negotiate crowded Indian roads and became non-functional right from the start. There are temptations for local entrepreneurs and businessmen to start production of internationally accepted products under foreign collaboration thus inhibiting the growth of local R&D and encouraging repetitive import of technology. Social requirements are ignored unless they are part of global needs and manufacturing efforts, planning and future production are all geared up to suit in some way the international market without consideration of specific cultural and societal needs. There looms a danger of drab uniformity prevailing in engineering design and production, curbing scope for local innovation and driving intelligent customers all over the world towards handicrafts, handlooms, non-machine made products and custom designed items.

It must, therefore, be admitted that globalization is not an unmixed blessing and the challenges posed by it have to be faced with advanced planning and determination so as the country's needs in engineering, manufacturing, innovation, product upgradation and quality control, indigenous research and development, societal problem-solving and export earnings are adequately met, and the industry emerges a major player in the international engineering market place. There are several implications of the globalization issue on both our development policies and our engineering education system and these I would like to discuss now. Development is a complex multi-variable optimization process in which the natural, financial and human resources of a nation are fully exploited to bring about an economic advancement of the people and an enhancement of their material and spiritual comforts. Goals of societal development always reflect the aspirations of its people. The Indian constitution envisages a society based on 'Justice, social, economic and political, equality of status and of opportunity'. It further enjoins the state to endeavour to promote among citizens 'Fraternity, assuming the dignity of the individual and the unity and integrity of the nation', and underscores the nation's commitment to socialism, secularism and democracy.

On Independence, the country was faced with illiteracy, unemployment, lack of adequate food, nutrition, housing and shelter, and an absence of basic infrastructure for industrialization. Nehru, the architect of modern India, had been greatly influenced by the role of science and technology in the transformation and modernization of traditional societies and has expressed his faith in science thus: 'It is science alone that can solve the problem of hunger and poverty, of insanitation and illiteracy, of superstitions and deadening customs and tradition, of resources running waste, of a rich country inhabited by starving people. Who indeed can afford to ignore science today. At every turn we have to seek its aid. The future belongs to science and those who make friends with science'. In tackling problems of development, the new State had before it three international models with minor variations: the capitalist model encouraging private initiative and profit motive for generation of wealth and prosperity, the socialist model with planned economy and State control for ensuing development and distributive justice, and the welfare state model with parliamentary democracy, mixed economy and state control of a few selected sectors to ensure welfare of the employees. All the three models had inherent limitations as well as strength but none was directly suited to Indian conditions. The success of the erstwhile Soviet Union in industrializing itself and emerging as a superpower through planned development appealed to the intelligentsia of the country which, however, abhorred the lack of personal freedom in the socialist/communist system of that country. It was in this context that Nehruvian model of development was accepted by the country, which accepted centralized planning, mixed economy and parliamentary democracy as the basic tenets of our national policy. Nehru while accepting the welfare state concept enlarged the role of the public sector to ensure rapid development of the basic infrastructure of the economy: railways, communications, Electricity and power, heavy industry, defence production, etc the areas of endeavour which needed large scale investment for which the private sector was not ready. He also identified support to private initiative in non-protected sectors and encouraged with fiscal incentives the growth of the small scale sector primarily to increase employment. The State took full responsibility for the welfare sectors, *eg*, education and health care and emphasized self-reliance in critical sectors through scientific and technological research.

During the last 45 years, this development strategy was used to build a modern state with self-sufficiency in food, clothing, a wide range of consumer durables, medicine, transport and engineering goods, petrochemicals, heavy industrial plants for power generation, steel, cement, sugar, fertilizers, engineering goods, nuclear engineering and space technology, etc. In this process India has emerged as one of the largest producers of scooters, bicycles, chemicals, engineering and electronic goods and cotton yarns.

Inspite of these achievements, India continues to face large scale poverty, unemployment, illiteracy and malnutrition. The pressure of population has nullified much of our development gains, and inequitable distribution of benefits has compounded the problems of the common man. When development indicators are put on per capita basis India quickly drops from amongst the top ten industrial nations to the bottom twenty or so nations of the world. This is a hard reality and we should carefully analyze where we have gone wrong.

Both India and the erstwhile Soviet Union who charted the path of planned and controlled economy for achieving social justice did achieve a remarkable degree of self-reliance but with low growth rate inconsistent with the level of investment, inefficiency and low productivity, corruption in public places, high cost of goods and, in the Indian case, a parallel black economy. Sheltering the domestic market from competition through import/ export control and non-convertible currency have led to low quality of goods, low productivity, high cost of production, large scale of smuggling of foreign goods and components and laundering of foreign currency through dubious means. Reduced competitiveness of our products in the international market explains the progressive decline in our share of total world export which presently stands around 0.5%. Low level of exports inhibits import of even goods and components necessary for upgrading our technology which further reduces our competitiveness. A chain reaction sets in of balance of payment crisis, increased borrowings from international agencies, increasing burden of debt servicing, and inflationary trends, labour unrest, etc. A major change in economic and industrial policies appeared essential if India had to tide over its difficulties and increase the rate of development. Recent history has confirmed that only those countries have prospered economically in the last four decades who have adopted an environment of open market economy with little or no state control. Under this background the liberalization started by the Rajiv Gandhi Government and supported by subsequent governments has now been extended fully by dismantling bureaucratic controls, encouraging direct foreign investment and domestic competition, curtailing subsidies, devaluing the currency to make exports internationally competitive and attempting to integrate the Indian economy with the global economy. These measures are bound to have far-reaching repercussions on our concepts of socialism, self-reliance and political independence concepts which have become part of bur life since independence. Opening up the economy to multinational investment will definitely improve the quality of our products and their international competitiveness, lower our dependence on commercial borrowings from international agencies, and reduce the balance of-payment deficit due to increased export earnings. The promised full convertibility of the rupee will encourage judlclous import of goods and components, and reduce smuggling and laundering of foreign exchange. It is argued that any country that follows excessively inward looking policies behind heavy protectionist walls deprive itself of the technological changes taking place around the world. They also weaken the incentive to engage in meaningful research and development work designed to reduce cost and upgrade technology. As a result productivity does not improve and economic progress and competitive strength suffer. Inspite of the obvious advantages of liberalization .there are many specific questions on development policy which need to be answered.

(a) How does liberalization affect the planning process? With removal of controls on the size of the plant and its location is there a danger of mismatch between supply and demand, neglect of sectors with low profitability, and fostering of regional disparities?
(b) What would be the future of the small scale sector? Will large scale units being permitted to enter areas currently reserved for the small scale sector force either the closure of small units, make them 'sick' or inhibit their expansion? In all cases, the casualty will be employ-Jlliill1.
(c) Will import of technology through foreign investment in Indian industry inhibit the growth of indigenous research and development capability and reduce our emphasis on self-reliance?
(d) What would be the effect of globalization on poyerty-alleviation programmes?
(e) Is there a danger of economical or technological colonialism by opening our economy to multinationals?
(1) Will reduction of sybsidy on fertilizers, power for agriculture, etc lead to inflation and reduce incentive for higher agricultural production?
(g) Will privatization of public sector undertakings lead to more labour unrest due to anticipated lay-offs for improving productivity?

These issues and several others which can be raised are sure to get the attention of our policy planners. It is of paramount importance to all of us to ensure that trade and Industrial policy liberalization are not at the cost of self-reliance in critical areas, R&D effort in areas where we have potential to excel at the international level, employment generation and poverty eradication programmes. We may have to ma Readjustments to the individual roles of the State, the Planning Commission, the public sector undertakings, and the private sector. Nehruvian model of development is flexible enough to accommodate the necessary changes but we must realize that achieving a high rate of growth cannot be an end in itself. Development must ensure social justice along with a better quality of life. In a recent paper released by the World Bank, 'Trends in Developing Economies 1992', the bank has predicted that India could become one of the world's most dynamic economies during the second half of the 1990's and beyond, if the current pace of reform is maintained over the next three or four years. Let us hope this prophecy comes true but let us also watch out for pitfalls in implementing major restructuring of the economy. Certain unpopular and hard decisions have to be made for the sake of playing a major role in the global market place on our own indigenous strength, skills, innovation and sense of fair play.

While addressing a seminar at Bombay (November 28, 1992) on 'What does next twenty-five years hold for India', the Union Finance Minister Dr Manmohan Singh projected a better future for India in the next two decades on the basis of socio-economic policy directions aimed at eliminating poverty by stepping up a gross national product of 7%-8% per year and the industrial growth rate between 12%-15% per year along with anti-poverty programmes without which India will get little recognition from the world. He visualized the prospect of India emerging a self- reliant and major tradingnation through the process of elimination of dependence on concessional aid flow and a regime of moderate tariffs in the next two years. He emphasized that this scenario depended a great deal on expansion of .educational facilities and upgrading the quality of the Indian labour force to give stiff competition globally. A decade ago, Easterlin in his interesting, paper 'Why is not the Whole World developed?' *(Journal of Economic History*, vol 41, March 1981) had established a direct correlation between economic growth and enrollment rate in primary schools on the basis of analysis of data from twenty five of the largest countries of the world. He assumed that primary school enrollment was an indicator of the population's exposure to formal schooling and supported the idea that spread of the technology of modern economic growth depended on learning pot entials and motivations that were linked to the development of formal schooling. The recent emphasis of successive governments at the Centre on diverting resources to the rural sector in far larger measures than hitherto would definitely increase the economic prosperity of the rural sector through expansion of educational facilities to the rural children and adults. This is welcome but educational planners have to rethink on the consequential demands for increasing opportunities at the secondary and tertiary levels for the rural youths in the near future initially at the vocational and diploma levels but ultimately at degree and post gr:aduate levels as well. Simultaneous with the pressure of expanding educational opportunities to the deprived sections of the community, globalization of engineering activities and economy calls for improvement of the quality of engineering education so that the work force be comparable in skills to the rest of the world and the innovative and creative urges are encouraged and fostered for increasing our share of the global trade.

It is distressing that our industrialists, educators, and the government have so far not woken up to the implications of globalization on our engineering education system. I feel that the Institution of Engineers as the major professional organization in this area should start a national debate to study the problem in all its complexity and make suitable recommendations to the government and industry. Preoccupation with ISO-9000 is not enough, the quality of engineering manpower is, in my opinion, even more important than the quality of the product because improvement and innovations can be accelerated only through better trained engineers and technicians.

Let us examine some of the implications of our wanting to become a part of the global economy so far as engineering education is concerned.

I would like first to identify the issues:

1. Opening up our economy to foreign investment, and our domestic market to foreign goods would compel upgradation of the technological level of Indian industry. This cannot be sustained over a long enough period except through systematic upgradation of skills and ensuring importance of quality, reliability, safety and productivity in all engineering curricula.

2. The need for competing successfully in the domestic market would require emphasis on innovation and creativity in engineering design. Design education may need complete overhauling.

3. Successful entry to the world market would need Indian engineers to have a global perspective, familiarity with other cultures and practices, ability to communicate with international customers in their own tongue, and competence in practising engineering against diverse sets of engineering standards.

4. The Indian engineering industry would be required to set up plants either on their own or through joint ventures in other countries. This would need not only management skills of a high order but ability to optimize resources both local and foreign and make Indian engineers work smoothly in international teams of engineering professionals. Management of such teams would need specialized knowledge and skills.

5. For global competitiveness industry would need fast access to global knowledge, technology development, product development even at the prototype stage, and R&D successes and failures which may lead to early action on future product development. Japan and South Korea have shown that quick access to knowledge of international research effort provides a lead in the competitive global market place if one specializes in fast translation of research results into commercial products. The need for training in gathering industrial information on world-wide basis, and for fostering the attitude for life-long learning could become an essential feature of engineering education at UG and PG levels.

In a recent International Forum on 'Engineering Education' held in Washington, DC, (November 24-December 1, 1988) under the auspices of the Accreditation Board for Engineering & Technology (ABET), the role of professional education in a global economy for a technology competitive world was discussed in great detail. A global perspective in education was perceived along with emphasis on engineering practice and technology management. For the American engineering education system, the recommendations were clear and concise: develop better selection criteria, introduce foreign language and global competitiveness courses, emphasize laboratory and design courses, integrate the use of computers in all under graduate programmes, optimize and make better use of humanities and social science courses, organize students to spend sometime in other countries through exchange programmes, attract larger number of American students to graduate programmes, encourage more members of the minority communities and women to choose engineering as their career goal, make graduate programmes more relevent to industry, encourage recruitment of faculty with industrial experience and involvement of existing faculty in industrial research and development, introduce Ph D programmes for people working in industry and prepare graduates for life-long learning. I feel we have a lot to learn from this American Conference. Since the U S is recognized as a front runner in the field of engineering education, the ideas and philosophy generated in the U S have profound influence on the educational system of all other countries. One of the suggestions made in this conference by George Bugliarello, President of Polytechnic University of New York, was: 'To prepare students for global engineering, global standardization of engineering curricula needs to be accomplished. But this standardization should not be rigid to deprive us of originality, innovation and needed diversity. It should be kind of a 'performance specification' of curricula.' This particular suggestion needs to be examined critically. If curricula could be standardized, there is a danger that students would feel that engineering solutions have the same universality as scientific laws of nature. The nation and situation-specificity of engineering may get lost in the curriculum. It is admitted that students working in a global scenario would learn through experience if not by education that solutions that are valid in one set of socio-economic conditions may be completely inapplicable in other set of conditions. Engineering by nature has to involve local resources, local constraints, and local values and belief in tackling societal problems. Education must not close students mind to diversity in application engineering, need for adaptation, improvization, and innovation to tackle specific problems created by local conditions. An international dimension in under graduate education must create in students an ability to perceive environmental factors, societal constraints, and local resources, develop appreciation for other cultural norms, tastes, work practices, and evaluate various alternative solutions to select the best to suit the given situation. International perspective does not mean uniformity of approach - it should instead lead to strategic and global thinking. In the light of the issues raised above, I would venture to make the following suggestions:

1. Introduce all engineering students to concepts of quality management, failure analysis, reliability, safety and productivity. They must be also trained to recognize the quality level of engineering products and system solutions.

2. Restructure design courses in all disciplines and bring back the importance of synthesis in engineering curriculum. Emphasize the rnulti-disciplinary nature of design activities and give experience of working on interdisciplinary teams. Encourage participation in Industrial experience during under graduate programme and in working on real-life problem-solving.

3. Introduce courses on technology assessment, technology adaptation and transfer in all engineering programmes. Train students to think of alternative solutions to engineering problems to suit differing societal constraints. Let them develop a global perspective on satisfaction of societal needs.

4. Allow all engineering students to learn at least one foreign language like French, Spanish, Arabic, Chinese, etc and acquire an intermediate level of proficiency. Link the learning of language with lectures on the culture as well as on engineering systems in the region, and spending a vacation or a term on exchange with an engineering institution in the region. This would require conscious development of exchange links with institutions abroad.

5. Run regular continuing education programmes with active cooperation of Indian industry on international engineering and management for senior students, working professionals and executives in industry. Differences in standards and manufacturing practices, international economics, marketing and advertising and cultural preferences and beliefs must be brought home to the participants. Proper management of international engineering teams working on national/international projects must be evolved.

6. Expose Indian industry to state-of-the art in manufacturing and anticipated futures in various-areas through expert lectures and demonstrations, and suggest innovations through which we can have an edge.

7. Identify those areas of engineering-both manufacturing and services - where our knowledge and expertise could compete with the developed countries on equal terms, *eg,* software engineering, systems engineering, alternative fuels, etc and encourage industry to capitalize in these areas for global intervention.

8. Help Indian industry to develop mechanisms for faster access to engineering information available through international data banks, manufacturer's leaflets and research bulletins.

9. Establish linkages with industry for upgrading education in engineering practice, innovation and creativity to all engineering students through guest lectures from working professionals.

10. Establish technology watch centres in major institutions which could evaluate technologies being developed in different parts of the world, and a concise report on current developments be sent to all engineering institutions and industry through electronic mail if possible or by normal mail otherwise.

11. Improve transfer of expertise from R&D centres of engineering institutions and national laboratories through support of 'engineering design and technology transfer' units attached to them. The intellectual resources of staff and students should be utilized for these. The success of these units would help upgrading the technology level of Indian industry through relevant consultancy and technology transfer services.

These suggestions and others which may emerge when we discuss the implications of globalization through a tripartite national debate between educationists, industrialists and government policy makers, are implementable without much difficulty at least at the major educational centres. But perhaps it is more important to improve the technological literacy of the .citizen at large. We need an educated citizenry that can make intelligent and rational decisions and appreciate the complexity of the role of technology in societal development. This would need a massive effort in which the electronic and print media, school education agencies must take an active part. Removal of poverty, better distribution of fruits of development, improvement of the capability for self-reliance through indigenous research and development does not necessarily work at cross purposes with the liberalization of our economy and removal of public control. However, one needs careful planning to ensure that decontrol does not lead to free-for-all in the technology market place. Unfettered flow of state-of-the art knowhow in high technology areas and large scale utilization of our inherent skill at innovation can both be managed through a clever manipulation of market forces with little or no bureaucratic control. The scientific and engineering community in the country has a major responsibility to ensure that we do not fail in our effort to become a dominant player in the international market place. We have the inherent capacity but do we have the will to succeed? The eyes of the third world are on us, they had for long used us as their role model, let us not fail them at this hour of trial when the world economy is undergoing such violent changes.

# The Environment Revisited Gaia in Action

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HOMAGE

Let me, at the outset, express my deep gratitude to the President and the National Council of the Institution of Engineers (India) for inviting me to deliver The Second Amitabh Bhattacharayya Memorial Lecture. I deem it a great honour and it gives me an opportunity to pay my homage to that great soul. I never imagined that such an occasion would arrive so soon. During the last few years of his life, Dr Amitabh Bhattacharayya acted like a man in hurry, lived as if in a trance, concerned about the future of I',is dreams and visions. He tried to live with a vision. Living with a vision is very difficult, particularly if the chosen arena is constrained and limited. He is an intense person with deep affections and thwarting biases. His contributions are many but his concerns were far more. I enjoyed immensely his affection. I shall miss him. Perhaps that is a characteristic of life. He was interested in many social issues. I shall try to deal with one of them which is a live issue to all of us. That is the environment. I would like to present a new perspective on this. If he were alive I am sure he would have enjoyed this discourse.

THE CONCERN

Erich Jantsch, in his excellent book on The Self Organizing Universe" makes a profound but intliguing statement about our concern for the environment. He says:

'Perhaps we are worrying too much about the distortion of equilibrium due to impact of technology. We should, on the other hand, worry about the distortion in the non-equilibrium. However we cannot estimate which factors in the Gaia system easily -adjust themselves and which [luctuatrons touch sensitive points and might lead to a new autopoietic structure - which imply a n8W biosphere'.'

This statement has many implications for the way we are handling or approaching the environmental pr.oblems. In ract, it is in total contrast to our view of environmental problems as will' be shown in a few minutes. Biosphere is the entire living creation that is on earth, in the ocean and in the attached atmosphere. The atmosphere is the combination of o)ygen, carbon dioxide, nitrogen and other gases which envelop the planet earth. The combination of the two is called th9 Gaia system. We are constantly warned that deforestation has caused severe damage to the CO2-02 cycle by increasing the CO2 concentration in the atmosphere causing the green-house effect. But, It is pointed out by bioloqical scientists that the biological contribution of human technology to the Gaia system is very insignificant. The throughflows of CO2 and O2 are changed marginally according to Lovelock and MargUlis.2 Also, it is pointed out that two things are happening:

(a) The corresponding warming trend due to the 'green-house effect' seems to be offset by the cooling trend perceived since 1945 in the northern hemisphere.

(b) More importantly, the CO2.o2 cycle is maintained by suitably Injecting the right quantities of gases like methane, hydrogen, N2, NH3, etc as would be permissible in an equilibrium system with the given oxygen content and the primary oxygen/carbon dioxide cycle of life. This through-flow IS maintained by some living autocatalytic units called prokaryotes. The prokaryotes are in the system for the last 1500 million years. So, while the Gaia system is disturbed by humans, the entire biosphere together with the atmosphere acts as an autopoietic (self-producing) system organizing and regulating itself. This is the Gaia hypothesis. It is sometimes alternatively stated that life is introduced to keep stability in nature. Evidentiy, this is a remarkable finding. This is very graphically stated by Stuart Kaufman as, 'The adaptive agents collectively make the worlds they live in congenial to themselves and are drawn to that characteristic structure, the edge of chaos, where their interests are mutually balanced. Now that is homeostasls'."

These findings apart, we are undertaking massive programmes of afforestation to maintain- the original $O_2$-$CO_2$ cycle balance as well as to reduce ecological disturbances like soil erosion and to preserve meteorological cycle. However, there is a concern that the economies of the world may not be able to sustain the massive piantation exercises designed to maintain the $O_2$-C~ cycles." Even if this is so, as long as the massive army ot the tiny prokaryotes and eukaryotes keep on working to maintain the life cycle of $O_2$ and $CO_2$ perhaps we are not in such a massive danger of extinction. We also must do therefore whatever we can to help these tiny saviours as a simple self service.

THE PROBLEM

What then is the problem? !' viewed in the above manner, most of the problems of the environment, including pollution, raised by the concerned scientists and activists seem to be manageable. Then what are the implications of the warning of Jantsch about the distortion in non-equilibrium?

Simply stated, this concerns the massive induction into the biosphere/Gaia system of several kinds of technological structures by societies and civilizations over long periods of history, particularly in the last two centuries. Human designed technology systems represent a world of equilibrium structures while all nature is a non-equilibrium system. We are, therefore, Introducing equilibrium structures into a non-equilibrium Gaia system. Several distortions arise as a result of this.

(a) Most of nature's processes are life processes while technological processes are not. At best the latter can play some auxiliary role in the unfolding of life.

(b) Natural systems starting from chemical dissipative structures to ecosystems are self-organizing systems and so are self-limiting. On the contrary, technology systems are not self-organizing and are therefore not self-limiting.

(c) We have introduced into the Natural World a very large artificial world in the shape of human settlements, river valley systems, drainage systems, massive agriculture systems, industrial systems and large armouries. These are irreversible introductions. Everyone of the introductions is an event which gets registered in the cosmic existence and forms a large collage embedded into the large natural biosphere. This has changed the natural system, its non-equilibrium state, and its structure. No amount of human effort can change this and bring the original balance. It is said about the chlorofluoro carbons, which punctured the ozone layer, that we have pumped six times the amount of chlorine into the stratosphere that is naturally there. Even if we stop now, it will take several centuries for the chlorine in the stratosphere to decay to natural levels," Thus the structure of complexity of the world has been permanently altered.

(d) We are introducing massive fluctuations into the organization of life systems on earth. There can be some more distortions which will come to light when we consider the properties of complex systems.

LIVING SYSTEMS

All living systems are complex. Complex systems are characterized by selforganization, disorder, irreversibility, non-equilibrium, emergence and evolution. Even in non-living systems, if a process is introduced as in the formation of sand dunes, a critical state can be conceived where self-organizing starts operating creating 'avalanches'. Peter Bak and Kan Chen say, 'Large interactive systems perpetually organized themselves to a critical state in which a minor event starts a chain reaction that can lead to a catastrophe.

To appreciate some important properties of Living Systems, we should understand two important principles: (i) autopoiesis, and (ii) self-organization.

Autopoiesis: Continuous renewal of a system such that the integrity of the system structure is maintained.

Self-organization is the dynamic principle underlying the emergence of a rich vanety of forms manifest in biological, ecological, social and cultural systems. The conditions for self-organization are: (a) Openness, (b) High non-equilibrium. and (c) Internal reinforcement of fluctuations. As this principle operates through autopoietic processes, new structures are created and new properties emerge at various hierarchical leve!s. Evolution which takes place in the process increases the complexity. This increase in complexity is maximized at any given moment on the earth. Communication seems to be a key element in this movement

Thus, the problem of the environment or ecology is not what is normally understood. It is the problem of introducing a non-evolving artificial world into a live evolving nature; of introducing equilibrium structures into non-equrlibriurn systems: of introducing a massive irreversibie fluctuations into an evolving structure: of introducing non-self-limiting structures into self-limiting systems; of introducing relatively non-self-organizing systems into self-organizing systems.

What then is the kind of perturbation that we have introduced into the evolving nature? What then is the meaning of the visible pollution. epidemics, AIDS in terms of the internal happenings In nature? Are they symptoms of any major happenings In nature? This obviously is the concern expressed by Erich Jantsch.

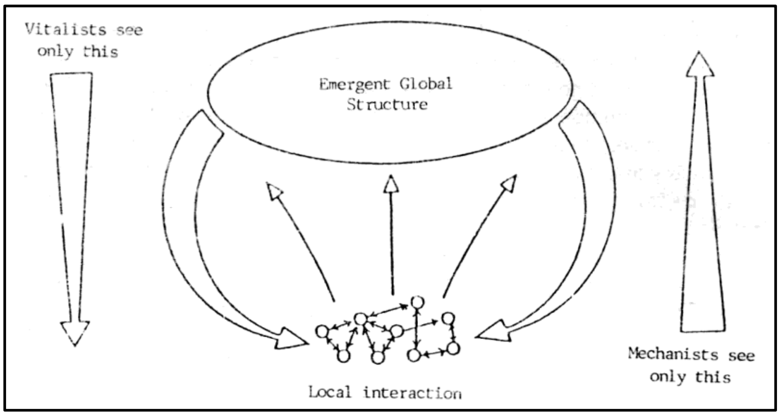
ENQUIRY FOR RESOLUTION

How do we then enquire into the situation? Evidently, our key concern, therefore, :s the process of evolution which is natural to any living system. Have we done anything to this evolutionary characteristic by our technologica! interventions and 'nductions? It seems to be so.

Since, according to Thomas Ballman and E V Weizsacker, complexity is continuously maximized by the number of elements and connections in the Gaia system which go on increasing during the evolutionary process. This means that the number of elements and connections in the system go on increasing. Further, it can mean that a new structure or elerrent, which has larger variety than the existing elements can emerge in time. Life and mind seem to be two illustrations of such an emergence during evolution. According to Jantsch, life is supposed to represent the autocatalytic processes and mind represents the self-organizing dynamics. One can then say that life and mind are present at various level of sophistication at every level of existence. This is also the position of many Indian philosophical systems.

Referring to this important feature of complexity and evolution, Roger Lewin? says, The notion of emergence and its role in illuminating patterns in nature is the principal message of complexity. Emergence of self-organizing dynamics, which, if true, wi:1 force a reformulation of Darwinian theory. Emergence of a creativity in the dynamics of complex systems in nature which, if true, will reassess the way complexity arises. Emergence of control within ecosystems which, if true, implies the existence of an 'invisible' hand that brings stability from the lowest to the highest level in the ecological hierarchy, culminating in Gaia herself. And the emergence of an inexorable drive toward even greater complexity and even greater information processing in nature which, if true, suggests the evolwtion of an intelligence sufficiently powerful to contemplate it all was inevitable.'

On the same property, Chris Langton says," 'Referring to the evolution of complex systems if you are a strict mechanist, then all you see are the arrows going upward, showing that the local interaction causes some qlobal property like life or a stable ecosystem (Fig 1). And if you are a stnct vitalist, all you see are the arrows pointing down, indicating some kind of mystical global property that determines th." behaviour of the entities in the system ......... What the science of complexity gives you is the insight that both dit ec~ tions are in a tight, never ending, feedback loop. The whole system represents a dynamical pattern with energy being dissipated through it. Indian seers have done a great deal in the vital direction. Now, coming to communication, the present way that nature (sans human) communicates is through matter and energy. Pollution, AIDS, epidemics, earthquakes, etc are the languages through which it tells humans that they are disturbing its evolutionary, non-equilibrium, self-organizing nature. But this kind of communication takes a long time. The distortion is Hffected before it is realized The neural kind of communication and the technological creativity are too fast for exchange with nature. Hence the hiatus in communication between the two systems." Inquiring into the problem becomes very difficult due to the feed forward nature of the problem between human system and its environment which is the biosphere together with atmosphere.




Vital is generally looked upon as external intervention which cannot be rationally argued.

Fig 1 Mechanists and vitalists view the world in opposite ways8

SURMISES ABOUT SOLUTIONS

So the present approaches to ecology and environment have only managerial intervention effect on limiting fluctuations/damage in our present parlance. When we look at the chaos (used in colloquial sense) in all areas of human activity around the globe, the world is at either self-organized criticality or 0'1 the edge of the chaos with a new dissipative structure emerging or at the start of the series of such structures leading to a stable structure.

One of the possible structures is to develop a communication by nature such that It can warn humans about the damages of inducting more equilibrium non-evolving structures into it. For this it may develop a neural mind. It can become more conscious. A second possibility is that humans revive their earlier ability of instinctive psychic communication and communicate with nature like poets and artists do. A third possibility is that humans evolve, what Jantsch calls as 'spiritual mind', and develop the ability to live in natural harmony with nature and take nature along in the evolution of Gaia. We may be forced to adopt a more sober, less consumerist, less desire oriented, pragmatical idealist style of life. There can be many other possibilities which cannot be easily seen. But one thing seems to be certain that we are at the self-organized critical state or will soon be at this stage through wars or very active peaceful interactions or both, with conflicts and social unrests spreading leading to a new state of complex existence. It is possible that the Gaia system may establish its harmonious existence by throwing up land masses and vegetations and regain the original level of non-equilibrium. This may mean massive earthquakes, changes in land mass-ocean ratios, changes in earth's rotation speeds and axis deviation.

Our fundamental research must be directed towards these long-term problems while we pursue the simplistic solutions of pollution control as short-term solutions.

Evidently the Gaia is in action. It is preparing a new evolutionary state. It is perhaps this that the Vedic seer echoes when he sings 10.11

Dhyativa Prithvi, Dhyativantariksam
Dhayativa Dyau, Dhyantivapo
Dhyanativa Parvata.

[The earth is meditating, the mid-region is meditating. The Akasa is meditating, Water is meditating. The mountains are meditating.)

Then adds:

Prithvi Santi, Vanaspatayah Santi
Aushadhaya Santi, Santi Reva Santi
May Earth be peace
May thetrees be peace
May the healing plants be peace
May peace be peace
Let us also meditate and sing
Mata Prithvi, Mother dear
Be kind, shake not and shiver
Lest the prodigal may sink and suffer
May you lead us to pragmatic light

Thank you,

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# The South-East Asia Power Grid

## Dato' Ir L Y Cheong

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INTRODUCTION

I feel very privileged to be invited to deliver the Third Amitabha Bhattacharyya Memorial Lecture.

Professor Dr Bhattacharyya was the most respected Asian professional engineer both in the worldwide context of the World Federation of Engineering Organizations (WFEO) and in the British Commonwealth context of the Commonwealth Engineers Council (CEC). His deep concern for the continuing professional development of the Professional Engineer in his personal advancement, in the uplifting of the engineering profession, but most importantly in raising the living standard and well-being of his community was renowned. Dr Bhattacharyya unceasingly championed the cause of engineers and engineering institutions in the developing world, often to the utter exasperation of his colleagues and friends from the developed world.

My most satisfying personal encounter with Professor Bhattacharyya was during the CEC Council Meeting, October 2-6, 1989, in Nicosia, Cyprus. As President of the Institution of Engineers Malaysia (IEM), I sought Dr Bhattacharyya's advice and assistance in the matter of the proposed establishment of the IEM training centre. Professor Dr Bhattacharyya inunediately offered the help of your Institution and your Engineering Staff College, leading to an exploratory visit by a three member IEM mission to India in 1990 and a feasibility study by Dr Shastry of the Engineering Staff College, Hyderabad, in 1991. The last occasion during which I had the pleasure of Professor Dr Bhattacharyya's company was the CEC Council Meeting, September 12-17, 1991, in Mauritius. His untimely demise continues to be a great loss to the world engineering fraternity.

On behalf of the Commonwealth Engineers Council, I would like to extend our heartiest congratulations to the Institution of Engineers (India) on your Platinum Jubilee. Your Institution is one of the six founder members of CEC in 1946. In the last half century, your Institution has assisted in the establishment of national engineering institutions in the newly independent nations of the Commonwealth. Your Institution can justifiably claim a large share of the credit that CEC today has 42 member institutions representing over one million Chartered or Professional Engineers. In thanking the Institution of Engineers (India) for your sterling contributions to CEC, I would like to urge your Institution to continue to work with CEC in realizing CEC's goal for the next half century, ie, to strengthen the pivotal role of the engineer in sustainable development of our Globe.

BACKGROUND

With the farsighted initiative of Mr V R Raghavan, the then Chief of the Power Division of the UN Economic Commission for Asia and the Far East (ECAFE), the seed of power system interconnection in South-East Asia was first sown in the Singapore meeting of the ECAFE Sub-Committee on Energy Resources and Electric Power in June 1968, leading to a preliminary feasibility study of regional power development by a Specialist Consultant, Mr K T Thomas of the Bhabba Atomic Research Centre, Bombay. .

The following extracts from the preface to the above-mentioned study report dated February 1969 amply demonstrates the visionary approach that is still relevant today:

This report was prepared with the belief that its greatest contribution will. be to foster and establish firmly the concept of regional cooperative effort to the largest extent possible. The key to opening out those areas which are less developed and expanding those areas which are already developed is electrical energy. The supply of power at the required place at the required time in required quantities is, therefore, very important.

This can be implemented only by far-sighted planning and timely construction of expanded generation using the latest technology, transmission and distribution facilities with capacities which will at all times keep pace with realistic forecasts of load.

The present is a time of rapid and accelerated change in all fields of engineering and the physical sciences. The time scale of technological change is growing shorter. Research and development are proceeding at a pace which will make obsolescent within a decade or so what we accept as the ultimate in engineering knowledge now.'

My own interest in power system interconnection was first aroused by being selected to represent Malaysia by my then employer, the National Electricity Board of the States of Malaya in the UN ECAFE seminarcum- study tour on 'Load Despatch Techniques and Application of Computer Technology to Power System Engineering Problems' from February 19-March 22,1970, in India. The ECAFE delegates from eight member countries were led by Mr V R Raghwan, Chief of the Power Division of ECAFE. -The Seminar in Bombay was organized by Tata Consulting Engineers and was declared open by Dr K L Rao, Union Minister for Irrigation and Power and Past President of the Institution of Engineers (India). Dr Rao made a fervent plea for the early realization of power system interconnections between States and between Nations, eg, India and Ceylon. The seminar dealt with the technical; commercial, financial and contractual aspects of electric power and energy interchange between power utilities and power systems. The three-week seminar was followed by a study tour of Bhopal, New Delhi, Bangalore, Hyderabad, Madras and Trichy.

Ever since then, the promotion of power grid interconnection amongst ASEAN countries and in South-East Asia has become my professional passion. It is thus most fitting that a quarter of a century later, I am delivering this status report on this most important topic to this august assembly in Calcutta, India.

RATIONAL FOR POWER GRID INTERCONNECTION

Electric power grid interconnections have been well established in Europe and North America for over seventy years. The three groups of multinational and multilateral power grid interconnections in Europe are. UCTPE in Western Europe, NORDEL in Scandinavia and CMEA in Eastern Europe. Major power utilities in the USA and Canada have long been interconnected, particularly in the Eastern States. In Australia, power grid interconnection was effected between the States of New South Wales and Victoria through the 330 kV Snowy Mountains Hydro- Electric Authority system. Many other power grid interconnections, often resulting from hydroelectric power development, are in existence throughout the world, eg, Kenya-Uganda, Zambia-Zimbabwe, Ghana- Ivory Coast, Mozambique-South Africa and Brazil-Paraguay. In the Asia Pacific region interconnections exist between the power networks of Hong Kong and China, and Laos, Thailand, Malaysia and Singapore.

Power grid interconnections have many technical and economic advantages for all the participating power utilities. They include:

(i) The pooling of power system reserve generating capacities;
(ii) Emergency assistance in day-to-day power system operations;
(iii) Economy interchange of energy to exploit time-dependent diversities in the peak demands of the individual power networks;
(iv) Economy of scale in the earlier installation of bigger and more efficient generating units;
(v) Exploitation of major renewable but non-transportable energy resource like hydroelectric power; and
(vi) Exploitation of major fossil-fuel energy resource like lignite and natural gas without incurring huge capital outlay in fuel transportation infrastructure.

The member nations of the Association of South-East Asian Nations (ASEAN), currently comprising Brunei, Indonesia, Malaysia, Philippines, Singapore and Thailand have collectively been experiencing one of the highest rates of economic growth in recent years and therefore one of the highest rates of electricity consumption growth in the world. It is therefore even more essential and pressing for them to seriously consider power grid interconnections for the common good.

Besides these six member nations of ASEAN, South-East Asia has aways been regarded to also encompass Burma, Vietnam, Cambodia and Laos. It is commonly expected that they will become members of ASEAN in the not too distant future. In the electric power context, these countries share the vast hydroelectric potential of the Mekong River with Thailand. The Thailand-Leos power interconnection is the oldest in South-East Asia. In this paper, the deliberations on the ASEAN power grid have therefore been widened to be those of the South-East Asia power grid.

HISTORY OF DEVELOPMENT OF THE SOUTH-EAST ASIA POWER GRID

As early as 1966, there was an agreement between Thailand and Laos on the exchange of electric power. In 1968, a Ll S kV transmission line was commissioned between Udonthai, Thailand and Vientiane in Laos. The ECAFE Committee for Coordination of Investigations of the Lower . Mekong Basins in Bangkok carried out investigations into mainstream and tributary hydro power projects, such as Pa Mong with 4800 MW capacity, Sambor with 3250 MW, Stung Treng with 7200 MW, Higher Luang Prabang with 2750 MW, Nam Thuen with 2500 MW and Ban Koum with 3300 MW.

At the Singapore meeting of the ECAFE Sub-Committee on Energy . Resources and Electric Power in June 1968, it was decided to carry out a study by Mr K T Thomas on the regional electric power development covering Peninsular Malaysia, Singapore, Sumatra (Indonesia) and South Thailand. The study recommended the interconnection of the power networks to enable the setting-up of regional energy centres which included a nuclear power and desalination plant in Singapore, the Asahan hydro project in North Sumatra and the Bukit Asam mine-mouth power plant in South Sumatra.

At the next meeting of the same ECAFE Sub-Committee in Bangkok in December 1972, PLN Indonesia (the National Electricity Corporation, Indonesia) again urged detailed study of the proposed interconnections between Sumatra, Singapore, Peninsular Malaysia and South Thailand to share the economic advantages of the Asahan hydro-electric power project.

Arising from an initiative by EGAT, Thailand (Electricity Generating Authority of Thailand) in 1973 on the possible interchange of electric power between South Thailand and Peninsular Malaysia, studies were carried out by EGAT and discussed between EGAT and LLN Malaysia, (National Electricity Board, Malaysia) in 1975-76, leading to an agreement to interconnect at 132/115 kV to exchange up to 50 MW.

In 1977, LLN proposed to purchase 20 MW from PUB Singapore (Public Utilities Board, Singapore). This supply to Johore Baru from Singapore via 22 kV cables was commissioned in 1978.

In 1978, discussions commenced regarding PUB supply to the neighbouring island of Batam, Indonesia, by 66 kV submarine cables.

A historic event occurred in Kuala Lumpur on July 27, 1978, when the General Managers of EGAT, LLN and PUB signed the two PUB/LLN and EGAT/LLN power supply exchange agreements. The three General Managers also agreed to strengthen cooperation by the formation of the EGAT/LLN/PUB Joint Computer Application Committee. The Committee was inaugurated in January 1979 in Kuala Lumpur. With the subsequent extension of membership to PLN Indonesia and NPC, Philippines (National Power Corporation, Philippines) in the July 1979 Singapore meeting, the committee was renamed the ASEAN Power .Utilities Computer Application Committee.

The first project adopted by the Committee was the joint study of EHV interconnections between EGAT, LLN and PlJB. The study was significant in the following aspects:

(i) It was the first study jointly undertaken by the three utilities,
(ii) It was carried out entirely by system planning engineers in the three utilities, and
(iii) It was completed using the computer hardware and software of the three utilities.

The results of the joint study demonstrated positive economic advantages for EHV interconnections between EGAT/LLN and LLN/PUB around 1985, based on the most conservative assumptions of system capacity-sharing with minimal energy interchange. Subsequently, PUB and LLN agreed to upgrade the interconnection to ~75/230 kV 250 MVA capacity.

In 1981, the Forum of Heads of ASEAN Power Utilities/Authorities was established under the auspices of the ASEAN Economic Ministers on Energy Cooperation. Of the ten cooperation projects adopted by the Forum, Project No 3 is the ASEAN Power System Interconnection Project to be coordinated by LLN, Malaysia. The Project No 3 task force was formally inaugurated in Kuala Lumpur in March 1982 taking over the work of the ASEAN Power Utilities Joint Computer Application Committee.

In 1977, another major power interconnection proposal was conceived by SESCO, Malaysia (the Sarawak Electricity Supply Corporation, Malaysia) to develop the 2400 MW' Bakun hydroelectric power project on the Pelagus River and transmit 1500 MW from Sarawak in East Malaysia to Peninsular Malaysia by 675 km of EHV Direct Current overhead lines and 650 km of EHVDC submarine cables. The feasibility study was completed in 1983. To date, engineering design and tender "specifications have been completed.

In February' 1981, the 132 kV/115 kV 80 MVA EGAT/LLN interconnection was commissioned. Due to uncontrolled power oscillations, this tie has not been able to be operated synchronously.

Since 1982, Singapore has been having ongoing discussions with Indonesia on piping natural gas from the Natuna gas fields to Singapore for power fuel.

In December 1985, the 275 kV/230 kV 250 MVA submarine cable interconnection between PUB Singapore and LLN Malaysia was cornmissioned.

A techno-economic study commissioned by ESCAP (UN Economic and Social Commission for Asia and the Pacific, the successor to ECAFE) was completed in 1987. It evaluated once more power interconnections between Thailand, Peninsular Malaysia, Singapore and Indonesia. The study again demonstrated the technical and economic benefits of upgrading the EGAT/LLN interconnection.

In 1991, Singapore received 150 MMSCFD of natural gas from Malaysia for Senoko power station.

TECHNICAL CHARACTERISTICS OF 'SOUTH-EAST ASIA POWER NETWORKS

The power networks of South-East Asia are still relatively small in capacity, largely isolated even within the individual national jurisdictions, and far from one another in distance on iand and over ocean. In South-East Asia, major power resources like hydro, natural gas and coal are far away from major load demand centres, necessitating the use of long-distance transmission for their exploitation.

In Thailand, major power flows are from coal and hydro sites in the Northwest via 500 kV j230 kV transmission lines to the Bangkok metropolis (EGAT Region No 1). Another major power injection is from power stations south of Bangkok fuelled by natural gas from offshore natural gas fields from the Gulf of Siam. South Thailand (EGAT Region No 3) immediately to the North of Peninsular Malaysia is weakly linked by 800 km 230 kV/115 kV tie lines to EGAT Region No L

In Peninsular Malaysia, major long-distance 275 kV overhead lines transmit power from the hydroelectric power plants in the North and the Northeast and from the Paka gas-fired power plant in the Northeast to the major load centre of Kuala Lumpur. In Sarawak, the transmission network is 275 kV whilst the Sabah transmission voltage is 132 kV.

In the Philippines, most of the power demand occurs in the island of Luzon. Here, most hydropower plants are located in the North butin the future more power will come from three large geothermal fields from the South. A planned 500 kV HVAC overland transmission link from these fields to Manila will serve to strengthen the southern portion of the Luzon power network. Elsewhere, a number of isolated island-wide power networks exist.

In Indonesia, power plants are somewhat dispersed through several major demand centres in Java, the island with most of the power demand (70 % of national total) as well as with the only interconnected power network. Its 600 km 500 kV AC transmission backbone was the first in South-East Asia. More than one-half of Indonesia's geothermal potential and considerable hydro potential are located in Western Central Java. Power networks in Sumatra, Kalimantan and other islands are isolated and not yet interconnected within the islands themselves.

In Brunei, transmission is at 66 kV with a major 150 MW cogeneration power plant in Lumut.

Burma has an identified hydroelectric potential of 10 000 MW in 25 major sites. However only 300 MW had been developed by 1987, constituting one-third of the total system installed capacity of 900 MW. The highest transmission voltage is 230 kV with a major 800 kill transmission line between the 170 MW Lawpita Hydro to Rangoon.

Vietnam has the largest hydropower plant in South-East Asia, the 1920 MW Hoa Binh power plant on the Da River, South-West of Hanoi. The North also possesses a 440 MW coal-fired power plant in Pha Lai. The installed capacity is far in excess of the demand in the North whereas around Ho Chi Minh City in the South, there is a great power shortage. A 1500'km 500 kV North-South transmission line with five 500/220 kV sub-stations is being built on an urgent basis to transmit the surplus power from the North to the South.

In Laos, the total installed capacity in 1987 was 165 MW, 150 MW of which is provided by the Nam Ngum hydro plant. About 120 MW is, exported to Thailand. Laos possesses a hydropower potential of 18 000 MW.

In Singapore, power plants are somewhat dispersed: at Senoko (2120 MW), Pasir Panjang (200 MW), Jurong (690 MW) and Pulau Seraya (1500 MW), all interconnected by 230 kV cables. A 400 kV cable system will be commissioned in 1996.

The main characteristics-of the power networks in ASEAN countries are summarized in Table 1 whilst the location of major energy resources is shown in Fig 1.

SOUTH·EAST ASIA POWER INTERCONNECTION CONCEPT PROJECTS

ASEAN

Due to the A,SEAN region comprising many scattered islands with power networks either interconnected with weak transmission lines to neighbouring islands or completely isolated, the ASEAN Power Grid was from its inception a concept perhaps not capable of full realization and integration even in the course of time.

Present interconnections in ASEAN are:

(i) The Malaysia-Thailand 132/115 kV 80 MVA interconnection, and
(ii) The Malaysia-Singapore 275/230 kV 250 MVA interconnection. '

The prospective i~terconnections under study since the inception of Project No 3 in 1982 are the following (Fig 2):

(i) Upgrading of voltage and capacity of the LLN-EGAT tie line;

(ii) Together with the commissioning of the 2400 MW Bakun hydroelectric power project in Sarawak, a 650-km EHVDC submarine cable link between SESCO and LLN;
(iii) SESCO-Sabah Electricity Board (SEB) overhead 500 kV or 275 kV transmission line with connection to the Directorate of Electricity Services (DES) power network in Brunei;
(iv) Sarawak to Pontianak, West Kalimantan 150 kV overhead transmission;
(v) Batam to Singapore submarine cable link for bulk power to be purchased by Singapore from proposed coal-fired power plant in Batam Island Indonesia;
(vi) Sumatra-Java EHV DC submarine cable link with development of coal mine-mouth power plant in South Sumatra;
(vii) Sumatra-Peninsular Malaysia submarine cable interconnection for transmission of bulk power from the Asahan Hydro; and
(viii) EHVDC connection from East Malaysia to Mindanao in the Philippines or to Luzon via Palawan island.

**TABLE 1 MAIN CHARACTERISTICS OF ASEAN POWER NETWORKS**

| Country | Total Installed Capacity, MW | | Highest Transmission Voltage, kV | System Frequency, Hz | Peak Demand, MW | | Total Hydro Potential, MW |
|---|---|---|---|---|---|---|---|
| | 1987 | 1993 | | | 1987 | 1993 | |
| Brunei | 250 | | 66 | 50 | 150 | 250 | 0 |
| Indonesia | 6200 | | 500 | 50 | 4750 | | 78 000 |
| Java | 4300 | | 500 | 50 | | | |
| Outside Java | 1900 | | 150 | 50 | | | |
| Malaysia | | | | | | | |
| Peninsular | 4600 | 6400 | 275 | 50 | 2350 | 5100 | 2200 |
| Sarawak | | | 275 | 50 | | 150 | 20 000 |
| Sabah | | | 132 | 50 | | 150 | 1900 |
| Philippines | 5800 | | 230 | 60 | 3620 | | 8000 |
| Luzon | 4100 | | | 60 | | | |
| Singapore | 3500 | 4500 | 230 | 50 | 2000 | 3000 | 0 |
| Thailand | 6800 | 12 000 | 500 | 50 | | 9700 | 8000 |
| | | | | | | | 14 000* |

* Rivers in common borders with Burma and Laos

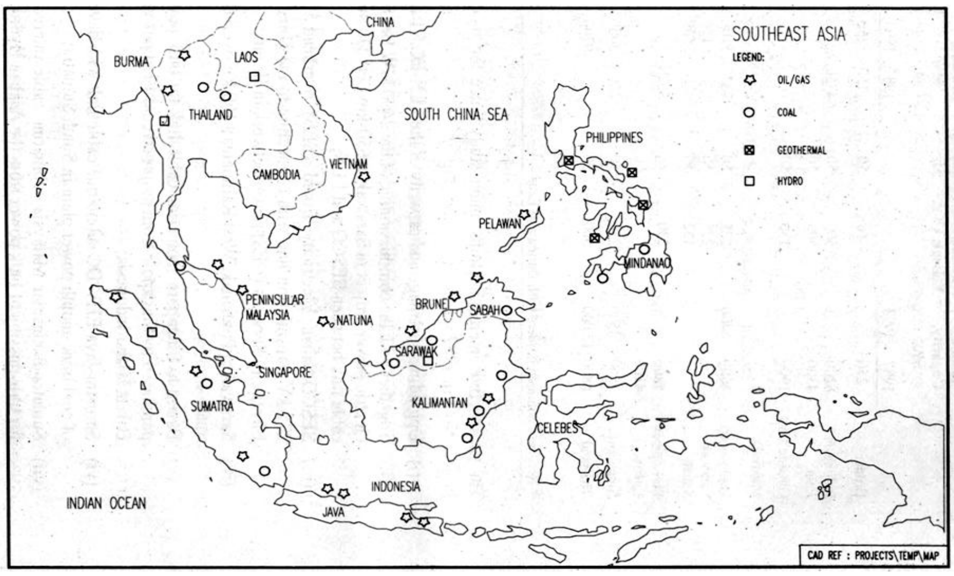


Fig 1 Location of energy resources

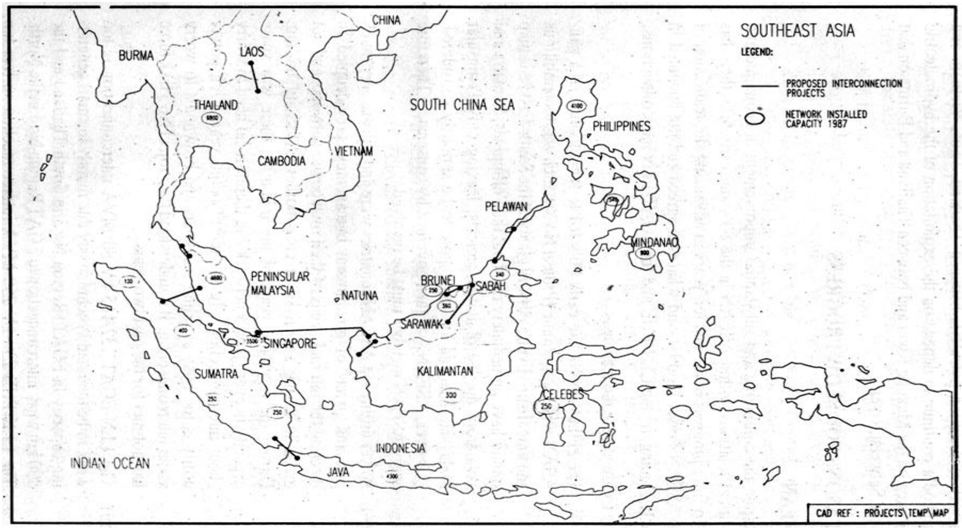


Fig 2 Proposed interconnection project

Indo-China

The only interconnection is still the Thailand-Laos interconnection. The interconnection potentials between Thailand, Laos, Vietnam and Cambodia continue to depend on the exploitation of the hydroelectric resource on the Mekong River and between Thailand and Burma on that of the Salween River.

REASONS FOR SLOW PROGRESS

ASEAN

Despite the continuing and substantial improvement in economic and political relations within ASEAN in the 80's and early 90's there has been little progress in the last ten years in advancing the realization of the ASEAN Power Grid beyond what was agreed and implemented in the beginning, ie, the LLN-PUB and the EGAT-LLN interconnections,

The following are the reasons>

(i) The enthusiasm of the early 80's led to the adoption of a pan- ASAN-wide programme (Project No 3) which was too ambitious and unrealistic. Even a cursory glance at the South-East Asia map should have immediately ruled out the Philippines, Sumatra and Java from the, list of initial projects, leaving only Peninsular Malaysia, Thailand and Singapore to be seriously considered. However, ASEAN was then governed by consensus. Therefore every ASEAN member must be involved.

(ii) Power utilities in ASEAN countries were and still are very much part and parcel of government bureaucracy, pre-occupied in meeting the internal needs of their own power networks and not given to taking any risks in cross-border electricity trading. During the recession years of the mid-80's, there was spare capacity in every power network and therefore no need to worry about interconnection. In the recent boom years each power utility is too busy avoiding blackouts and brownouts to worry about interconnection. It is understood the Project No 3 task force has not met for the past two years.

(iii) The LLN-EGAT 132/115 kV 80 MY A interconnection is too weak to be operated synchronously due mainly to small generating capacity in EGAT Region No 3 in South Thailand and the 800 km weak interconnection to EGAT Region No 1in the North. The LLN-PUB 230 kV 250 MV A interconnection suffers too from power oscillations due to the weak 275 kV Central-South transmission capacity in the LLN network. It is also the PUB perception that the benefits of emergency assistance always favour LLN. Any way the LLN-PUB interconnection has been operated normally at zero active power interchange. It has always seemed such a waste. Thus the operating experience of the two existing interconnections did not fuel any remaining enthusiasm for the ASEAN Power Grid.

(iv) The above operating experience has demonstrated quite conclusively that for the ASEAN Power Grid to be realised even in stages, the prerequisite must be strong transmission within the individual power networks. With the distances involved in the case of Singapore, Peninsular Malaysia and Thailand, this must mean a strong 500 kV transmission backbone especially in the LLN network. The ASEAN Power Grid was ahead of its time.

(v) The implementation of the 2400 MW Bakun hydroelectric project in Sarawak would have led to the concomitant implementation of the 650 km EHV DC submarine cable project from Sarawak to Peninsular Malaysia and the interconnection by 500 kV or 275 kV overhead transmission between Sarawak and Sabah, The

secondary interconnections to Brunei and Kalimantan would follow in due course. Unfortunately, the severe recession in Malaysia in the mid-80's together with the fall in oil/gas price deferred the Bakun project.
(vi) The export of Asahan hydropower from Sumatra by submarine cable to Peninsular Malaysia, Singapore and South Thailand was one of the earliest interconnection projects. It has since then been repeatedly discussed and studied. This project has foundered on the unrealistic expectation of Indonesia funding the project with scarce capital and recovering the investment over 20 years or more from export of electric power to Malaysia, Singapore and Thailand.
(vii) Little is being heard of Singapore purchasing narural gas from the Naruna gas fields of Indonesia or purchasing electric power from a coal-fired power plant in Batarn island. This shows that even in ASEAN, bilateral energy projects are difficult.

Indo-China

Continued armed political upheava I in Indo-China deterred any serious attempts to tap the hydroelectric potential of the Mekong River. Due to the closed economic policy of Burma, repeated attempts by Thailand to interest Burma in the joint development of the hydroelectric potential of the Salween River met with no response.

JUSTIFICATION FOR RENEWED INTEREST

The South- East Asia Power Grid concept has basically the following two regions where interconnections are feasible in the short to medium term:

1. Peninsular Malaysia, Singapore, South Thailand, Sumatra and Java.
2. Sarawak, Brunei, Kalimantan, Sabah, Peninsular Malaysia.

In Thailand, 500 kV transmission is well established from the North to the South of Bangkok. This 500 kV transmission network is continually being reinforced, leaving a 800 km weak 230 kV link to South Thailand. This weak EGAT Region l-Region 3 tie will be reinforced by the establishment of a 4000 MW Bang Saphan coal-fired power plant in 1999 some 400 km South of Bangkok on the Gulf of Thailand. With the extension of the 500 kV from Bangkok southwards to Bang Saphan, the 230 kV transmission to South Thailand will be shortened to only 400 km. Peninsular Malaysia is now committed to have the North-South 500 kV transmission network commissioned between 1998 and 2000. There is already the 500 kV East-West transmission backbone across Java. Singapore will have 400 kV network by 1996. EGAT and TNB (Tenaga Nasional Berhad Malaysia, the privatized successor to LLN) have committed to the upgrading to 300 MW EHV DC overhead transmission of their interconnection by·1997. The design of the line will enable the capacity to be increased to 600 MW. Thus the individual power utilities will have strong transmission networks to effect interconnections by the turn of the century.

In EGAT's Power Development Plan 1993-2006, emphasis is given to the import of energy fuel and/or electricity from neighbouring countries including import of natural gas and/or electricity from Malaysia, Burma and Vietnam and hydroelectric power from Laos, Burma and South- West China. A Memorandum of Understanding has been signed in June 1993 between Thailand and Laos to purchase up to 1500 MW from the proposed privatized BOT Nam Theun hydroelectric project in Laos. With the upgrading of the EGAT/TNB tie, EGA T expects to purchase up to 300 MW from Malaysia in 1997. Serious discussions between EGAT and one of the IPPs in Malaysia have already conunenced.

Malaysia has privatized the electric power sector much more extensively than any other South-East Asian countries. Besides TNB, there are already five IPPs (Independent Power Producers) constructing some 4000 MW of both base-load and peak-lopping power plants to be in service between now and 1997. The Government has agreed in principle to issue a licence to one of the IPPs to supply up to 500 MW of power to PUB Singapore. Steps are being taken on fast track basis to deliver 250 MW by 1997. This project will strengthen the interconnection between Peninsular Malaysia and Singapore and lead to a more meaningful role for the interconnection involving regular energy purchase and interchange.

The Malaysian Government has also recently given the go-ahead for the implementation of the US $ 6.0 billion Bakun 2400 MW hydroelectric project in Sarawak on a privatized basis. This will mean the parallel implementation of the 650 km EHV DC submarine cable interconnection between Sarawak and Peninsular Malaysia with the landing in Johor near Singapore. The 500 kV or 275 kV AC overhead transmission between Sarawak and Sabah will be implemented as well.

Java will continue to depend on Sumatra for its vast energy needs. Interest in coal mine-mouth power plant development in South Sumatra to supply Java via submarine cables across the Sunda Straits is being revived. With Java as its huge demand centre, it will become easier to justify economically the interconnection between Asahan Hydro in the North and the coal-fired power plants in the South of Sumatra , especially with the potential of exporting powel across the Straits of Malacca to Peninsular Malaysia as an added incentive. Already under the auspices I of the Northern Economic Development Triangle of North Malaysia, South Thailand and North Sumatra, a 400 MW coal-fired power plant in Sumatra is being proposed by a Malaysian IPP to supply power to Peninsular Malaysia and South Thailand by submarine cables.

The formation of the six-nation Mekong Development Conunittee at Ministerial level consisting of Thailand, Burma, Laos, Cambodia, Vietnam and China should accelerate the joint development of hydroelectric projects leading inevitably to more interconnections amongst the power networks. The existence of the North-South 500 kV Thailand power transmission and the North-South 500 kV Vietnam power transmission will make future power interconnections much easier. However judging from the experience of the ASEAN Power Grid, actual implementations of cross-border power interconnection, with the exception of Laos-Thai interconnection, are many decades away.

The ASEAN economies continue to grow apace whilst the Indo-China economies are opening up to market forces. Even Burma shows signs o. opening up. This will mean a great and continuing hunger for electric power. The ASEAN Free-Trade Area (AFTA) has been set up in 1993. Hopefully this will lead to a common market. Cross-border trade in energy and electric power will inevitably become very much part of the agenda. Perhaps the most encouraging aspect is the involvement of the private sector in the following vital links of the ASEAN Power Grid, ie, the development of Laos Hydro for export to Thailand; the implementation of the 500 kV supergrid in Peninsular Malaysia; the development of the Bakun hydro in Sarawak and the EHVDC overhead and submarine transmission to Peninsular Malaysia and the increased export of power from Peninsular Malaysia to Singapore and South Thailand. Hence, it will not be too far-fetched to visualise the South-East Asia Power Grid stretching from at least Laos, Thailand, Peninsular Malaysia, Singapore, East Malaysia, Brunei and Kalimantan and even possibly Sumatra and Java in the first decade of the 21st Century.

## CONCLUSIONS

The concept of the South-East Asia Power Grid in the 70's was well ahead of its time. As it result, it was in limbo throughout the 80's. However, developments in the political and economic scene in South- East Asia in the last few years have dramatically altered the electric power landscape. There is now a genuine possibility of the first phase of the South-East Asia Power Grid being realized in the first decade of the 21st Century.

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# Infrastructure Planning

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## INTRODUCTION

In the next stage of policy formulation for infrastructure provision, the emphasis has to change from achievement of targets to effectiveness. This is an important issue. since there is every indication that macro demand is rising and with it industrial production. Capacity constraints will be hit soon and the liquidity overhang of 'financial investments' will then move to direct asset creation reacting to rising demand and profitability. The foreign exchange and food markets will then need management but the 'more important constraints will be in power, water supply and urban services. I

## THE CONVENTIONAL METHOD RECENT REFORMS

Planning for infrastructure, particularly irrigation and power, was done in India through the use of large-scale econometric models and material balances. Thus, electricity was one of the sectors in the Indian plan model and the projections were also cross checked with a detailed material balance described below. Irrigation was the major control instrument in the agricultural sub-model of the Five-Year Plan, which was formulated for the first time in the revised Fifth Five-Year Plan and work on which had begun when Dhar Saheb was the Deputy Chairman of the Planning Commission.

Power projections in the Five-Year and long-term plans emerge from the Plan model. These derived 'growth rates' were cross checked with a detailed material balance, an illustration of which is presented in Table 1. In fact, the power material balance was strongly interconnected with the growth of the leading sectors of the economy.

The reforms in encouraging private investment in infrastructure are interesting although the regional variations in the effective The present power supply system problems of a sub-station were examined so that alternative solutions could also be considered. Interestingly the politicization of transmission system has meant that at the lowest level of 11 kV feeders power requirements are specified at the hourly level. Thus the 8-hour period in which power is supplied at a particular 11 kV feeder is fixed. The working of the transmission and distribution system shows sharp variations and low capacity utilization level as estimated in the feeder study. The problem should be considered in a different light. In any distribution problem at the lowest level, if requirements are over specified and rigid system efficiencies will always be low. In a programming sense, such a result would always emerge, as compared to a system with less rigid specifications of demands. If it is true that both price and hours demand are fixed, quality of supply will be poor since at the peak, the system supply is short. Also there are no incentives to improve capacity use.

The system will also be characterized by excess demand since in the above example, it gets power in 8 hours and that too erratically. Demand, for example, may be for 10 to 12 hours of more reliable supply. However, in the existing situation, the consumer settles for an 'equity' based system - 8 hours of low quality supply, ie, contracted cheap power-class A power.

In this example the consumer will be having an unsatisfied demand of 2 t~4 hours of quality power supply for which he will be willing to pay market rates. In this area there were a number of diesel gensets. The solution to this system is to start a supply of B class power outside the contracted period at the market rate of Rs 1.70 paise/kWh and to give an assurance of supply. Such power could be sold through a contractor.

## EFFICIENCY AND COSTS: HOW SMALL IMPROVEMENTS GO A LONG WAY

The study observed lower operational efficiency in terms of (a) outages higher than normative level, and (b) actual heat rate higher than the specified design heat rate in 15 thermal power plants under study. Details of the technical parameters and other facts for the year 1991-92 are given in Table 2.

The unit-wise performance analysis in terms of outages and heat rate indicate possibility of improving operational efficiency. In summary, the following targets are achievable by the Board.

**TABLE 2: DETAILS OF OUTAGES AND HEAT RATES OF 15 THERMAL PLANTS**

| Outages | 1991-92 |
|---|---|
| 1. Forced Outages, h | 8889 |
| (a) Forced outages due to tube failure | 3129 (35.20) |
| (b) Forced outages due to boiler related other faults | 4058 (45.68) |
| (c) Forced outages due to turbine related faults | 1702 (19.05) |
| 2. Planned outages, h | 25 560 |
| 3. Total outages, h | 34 449 |
| 4. Plant availability at full capacity utilization, h | 131 400 |
| 5. Actual plant availability, h | 96, 951 |
| 6. Plant availability factor, % | 73.78 |
| 7. Actual power generation, million units* | 13 179.22 |
| 8. Plant load factor, % | 57.7 |

*Note*: Figures in the brackets are percentage of outages to total outages.

* Power generation in 15 thermal power plants under study

| Heat Rate, kcal/kWh | 1991-92 |
|---|---|
| Average actual heat rate of 15 power plants | 2824 |
| Specified design heat rate | 2386 |
| Actual heat rate higher than design heat rate | 438 |

| Design Heat Rate and Actual Heat Rate in Four Power Stations 1991-92, kcal/kWh | Actual Heat Rate, AHR | Designed Heat Rate, DHR | Difference between AHR and DHR |
|---|---|---|---|
| TPS No 1 | 2900 | 2395 | 505 |
| TPS No 2 | 2512 | 2381 | 131 |
| TPS No 3 | 2995 | 2386 | 609 |
| TPS No 4 | 2888 | 2382 | 506 |
| Average for all power stations | 2924 | 2386 | 438 |

**Summary: Facts at Present**

| | | |
|---|---|---|
| 1. | Cost to serve, p/kWh | 137.88 |
| 2. | Cost of power generation, p/kWh | 80.30 |
| 3. | Fuel costs, p/kWh | 76.77 |
| 4. | Coal consumption, $10^5$ t | 84.74 |
| 5. | Coal consumption, kg/kWh | 0.64 |
| 6. | Calorific value of coal, kcal/kg | 4238 |
| 7. | Total thermal power genration, M/kWh | 17 286 |
| 8. | Installed thermal capacity, MW | 3609 |
| 9. | T and D losses, % | 22.89 |
| 10. | Average rate of realization (with tax and electricity duty), p/kWh | 107.00 |

**Targets for**

| | 1993-94 | 1995-96 | In long run |
|---|---|---|---|
| Outages reduction, % | 3.5 | 5 | Normative level |
| Heat rate reduction, kcal/kWh | 100 | 250 | design heat rate efficiency |

These targets should be achieved compared to actual outages and heat rate in 1991-92.

SCOPE FOR ACHIEVING TARGETS

Outages

Thirty-five per cent of forced outages of the units studied were on account of tube failure. 45.65% of outages were on account of boiler related other faults. Reduction in forced outages by 3.5% in 1993-94 and by 5% in 1995-96 is possible if tube failure outages are reduced. NTPC has a system approach to tube failure control with norms of efficiency enforced. Recently the Badarpur power station has brought such factors under control. There is no reason for the Boards not to be able to achieve such efficiencies. Setting more moderate tragets upto 1995-96, also leads to large savings.

**TABLE 3: NORMATIVE SAVINGS ESTIMATES OF OUTAGES REDUCTION**

| | 1992-93 | 1993-94 | 1995-96 | In long run |
|---|---|---|---|---|
| Total Outages, h | 34449.00 | 34139.00 | 32727.00 | 26280.00 |
| Targets to reduce total outages, % | — | 3.5 | 5 | 23.71 |
| Plant availability, h | 96951 | 97262 | 98673 | 105120 |
| Power generation, million units | 13179.22 | 13221.50 | 13413.30 | 14289.69 |
| Additional power generation with reduced outages, million units | — | 42.28 | 234.08 | 1110.47 |
| Cost of power generation* after reduction in outages, p/kWh | 80.30 | 80.10 | 79.23 | 75.45 |
| Savings in costs of generation, p/kWh | — | 0.20 | 1.07 | 4.85 |
| Financial savings, Rs crores | — | 3.46 | 18.49 | 83.83 |
| Total costs of power generation, Rs crores | 1388.06 | 1384.60 | 1369.57 | 1304.23 |

*Cost of power generation is for 17286 million units of power in 1991-92.

Table 3 presents the estimates for increase in plant availability, increase in power generation and saving in unit costs of generation if targets for outages reduction are achieved.

42.28 million units of power in 1993-94, 234.08 million units in 1995-96 and 110.47 million units of power in the long run (if outages are reduced to 20% level of the full capacity plant availability recommended by the Rajadhyakshya Committee on Power, 1980) can be generated in addition to the power generation in 1991-92. Higher utilization of power generation capacity itself will bring down the unit cost of generation from 80.30 paise/kWh in 1991-92 to 80.10 paise/kWh in 1993-94, to 79.23 paise/kWh in 1995-96 and to 75.45 paise/kWh in the long run. Thus saving in unit cost of generation will be 0.20 paise/kWh in 1993-94, 1.07 paise/kWh in 1995-96 and 4.85 paise/kWh in the long run. Outage reduction effect on financial saving could be Rs 3.46 crores in 1993-94, Rs 18.49 crores in 1995-96 and Rs 75.45 crores at the normative efficiency in the long run. However, the savings will be higher since operational efficiencies can increase power generation. It is a continuous process activity and start-up costs are high. Lower outages will mean' that heat rates and efficiency costs will go down.

Heat Rate

In the light of the detailed analysis conducted in this study variations in the difference between actual heat rate and design heat rate at unit level in four power stations are from 102 kcal/kWh to 662 kcal/kWh. The actual heat rate varies from about 2500 kcal/kWh to 3000 kcal/kWh compared to specified design heat rate in different units under study. Reduction in actual heat rate by 100 kcal/kWh in 1993-94 and by 250 kcal/kWh in 1995-96 appears to be easily achievable. In the long run the thermal plants under study should achieve the design heat rate efficiency. Considering this, estimates for possible savings in real fuel costs and financial costs,

**TABLE 4 : NORMATIVE SAVINGS ESTIMATES OF HEAT REDUCTION**

| | 1992-93 | 1993-94 | 1995-96 | In long run |
|---|---|---|---|---|
| Average design heat rate of 1.5 thermal plants, kcal/kWh | 2386 | 2386 | 2386 | 2386 |
| Average actual heat rate, kcal/kWh | 2824 | 2724 | 2574 | 2386 |
| Targets for reduction in actual heat, kcal/kWh | — | 100 | 250 | 438 |
| Difference between design heat rate and target level actual heat rates, kcal/kWh | 438 | 388 | 188 | 0 |
| Loss of heat rate to 13179.22 mission units of power, billion kcal | 5772.50 | 4454.58 | 2477.69 | 5772.50 |
| Energy saving with reduced heat rate, billion kcal | — | 1317.99 | 3294.80 | 5772.50 |
| Savings in consumption of coal with reduced rate, $10^5$ t* | — | 3.06 | 7.66 | 13.42 |
| Fuel costs saving, paise/kWh** | — | 2.80 | 7.02 | 12.30 |
| Financial savings, Rs crores | — | 37.02 | 92.56 | 162.17 |

* These estimates are calculated considering on an average 4300 kcal/kg calorific value of coal consumed

** Saving costs estimates are worked out considering Rs 1208/t coal price of 1993.

which could be achieved through reduction in actual heat rates are presented in Table 4.

The reduction in per unit costs of power generation on account of improved fuel use efficiency in power generation which must be aimed is as follows:

| Year | Financial savings, p/kWh |
|---|---|
| 1993-94 | 37.02 |
| 1995-96 | 92.56 |
| In long run | 162.17 |

The impact of these efficiencies being achieved in financial terms will be as follows:

| Year | Fuel costs saving, p/kWh |
|---|---|
| 1993-94 | 2.80 |
| 1995-96 | 7.02 |
| In long run | 12.30 |

An alternative estimates for saving in consumption of coal is worked out considering the increased power generation through higher plant operation (a) target level 'outages reduction, and (b) by considering cost escalation of coal by about 50% in 1995-96 of the present cost of Rs 1208/t. Increase in coal price from 1986-87 to 1990-91 was from Rs 469/t to Rs 703/t (about 50% increase). Taking into account the savings achieved by the improvement in plant utilization the fuel savings targets will be as follows:

| | Savings in Fuel Cost |
|---|---|
| Year | p/kWh |
| 1993-94 | 20.77 |
| 1995-96 | 6.95 |

**Financial Savings**

| Year | p/kWh |
|---|---|
| 1993-94 | 36.62 |
| 1995-96 | 92.14 |

The system must target for a saving of Rs 40 crores in 1993-94 and Rs 100 crores in 1995-96 on this account only.

Overhead Costs

Higher output will mean that overhead costs of power generation and supply will be distributed over larger volume and per unit overhead costs will go down. The reduction on account of this factor arises from the fact that the Board has surplus manpower and hence wages and salaries will be distributed over larger volume. The impact of target will be as follows:

**Savings in Overhead Costs**

| Overhead costs | Unit costs, p/kWh | Savings in unit costs, p/kWh | Financial saving, Rs crores |
|---|---|---|---|
| 1991-92 | 40.22 | — | — |
| 1993-94 | 40.12 | 0.10 | 1.73 |
| 1995-96 | 40.08 | 0.14 | 2.43 |
| In long run | 37.68 | 2.54 | 46.85 |

PRICING AND NORMATIVE COSTS

Under the existing pricing systems under the Electricity Act actual costs are loaded on to the tariff. This is obviously incorrect in the conditions being described. Normative costs should be used to determine the tariff and for capital costs the efficiency costs at the margin. If for some reason. The Government does not allow this price, it must bear the subsidy.

The Government compensate the Board for its normative costs of power generation as worked out above and not for its actual cost of power generation.

This normative cost of generation at 1991-92 prices, is thus example works out as follows:

**Normative Costs to Serve**

(p/kWh)

| Year | Generation | T & D losses | Overhead costs | Total saving | Normative costs to serve |
|---|---|---|---|---|---|
| 1993-94 | 3.00 | 6.25 | 0.10 | 9.35 | 128.53 |
| 1995-96 | 8.09 | 18.75 | 0.14 | 26.98 | 110.90 |
| In long run | 17.15 | 37.50 | 2.60 | 57.25 | 80.63 |

A cost escalation factor should also be provided in the year 1991-92 to work out normative costs for any particular year. Costs escalation is worked out for coal costs and for wage costs for 1993-94 and 1995-96 as an illustrative exercise.

Coal Cost Escalation: In 1990-91 prices a 10% increase in coal cost leads to a 1 paise increase in cost/kWh.

Wage Cost Escalation: Similarly, a 10% increase in wage costs at 1990-91 level leads to a 2.6 p/kWh increase in cost of production. Illustratively, the normative costs after making provision for coal cost and wage costs escalation will be as follows:

**Normative Costs with Costs Escalation Factor**

| | | (p/kWh) |
|---|---|---|
| | 1993-94 | 1995-96 |
| Normative costs before provision for cost escalation | 128.53 | 110.90 |
| Provision for wage costs rise | 3.92 | 9.10 |
| Provision for coal costs rise | — | 2.60 |
| Normative cost to serve after provision for cost escalation | 132.45 | 122.60 |

Following are the estimates for financial saving at normative efficiency.

**Financial Savings at Normative Operational Effciency**
**(with provision for costs escalation)**

| | | | (Rs crores) |
|---|---|---|---|
| | 1993-94 | 1995-96 | Long run |
| Outages reduction | 3.46 | 18.49 | 83.83 |
| Heat rate reduction | 37.02 | 92.56 | 162.17 |
| Overhead cost reduction | 1.73 | 2.43 | 46.85 |
| Reduction in T & D losses | 108.00 | 324.00 | 648.00 |
| Total | 150.21 | 437.48 | 940.85 |
| Provision for coal cost escalation | — | 45.15 | — |
| Provision for wage cost escalation | 67.73 | 157.30 | — |

On an average the Board can save Rs 82 crores in 1993-94 and Rs 235 corores in 1995-96 if the normative costs to serve of 132.45 p/kWh and 122.60 p/kWh, respectively, are achieved even after the provision for cost escalation factor is made, The average rate of return per unit of power served in 1991-92 was 107 p/kWh. The Board at present bears loss per unit 30.88 p/kWh considering 137.88 p/kWh present cost to serve. With normative costs to serve the Board has to bear 25.45 p/kWh loss in 1993-94. The Board can recuce its loss by 5.43 p/kWh in 1993-94. With normative costs for 1995-96 the Board has to bear 15.60 p/kWh instead of 30.88 p/kWh at actual costs to serve. The Board can reduce loss by 15.28 p/kWh (about 50%) in 1995-96 for working at normative efficiency level. The State Government should, therefore, give subsidy on the normative cost to serve of 132.45 p/kWh in 1993-94 and of 122.60 p/kWh in 1995-96 and not on the actual costs to serve. If the money costs rise as in the past these estimates will be 132.45 p/kWh in 1993-94 and 122.60 p/kWh in 1995-96. In actual practice the Government will have to compensate only for the actual cost increase and not that estimated in this study as illustration. If the average rate for supplying power of any category of consumers is less than the normative costs the Government should give full subsidy to the Board.

The Government in turn should realize on an average the normative cost from the consumer. In 1993-94 the average realization should be around 135 p/kWh. This figure was 107 p/kWh in 1991-92. If the agricultural average rate is 60 p/kWh the average non- agricultural rate will be 184 p/kWh.

THE ESSENCE OF THE ECONOMICS OF POWER

This numerical illustration shows how a technical improvement in this case, management of tube failures at the level of boilers - leads to two kinds of tremendous savings. Real costs go down in the case of coal. More power is available and hence again since fixed costs get distributed as larger volumes, unit costs go down further. The efficiency costs of producing power it is shown are much lower than real costs. I believe that if efficiency costs are targetted - the consumer will be able to bear the traffic - at the most with some cross-subsidization. It is unfortunate that the Finance Commission and the Planning Commission when dictating policies in a 'resource raising' frame do not make this simple but important point. Consumer resistance to paying for inefficiency is not only high it is justified and so the game is lost at the outset. The distribution of power is also a neglected area. The main point is that apart from many implementation factors, optimization studies from the distribution angle are not done. This is true not only for location of generation systems, but also for planning of transmission and distribution for power already generated. Apart from maintenance problems there are no system approaches to back up the distribution of power generated in an optimal manner. This leads to increasing losses. Given the present power supply system problems of sub-stations, alternative solutions may also be considered. Interestingly, the politicization of transmission systems has meant that at the lowest level of 11 kV feeder demand is fixed. The working of the transmission and distribution system shows sharp variations and low capacity utilization level. If requirements are over specified and rigid, system efficiencies will always be low. In a programming sense, such a result would always emerge, as compared to a system with less rigid specifications of demands. If both price and hours demand are fixed, quality of supply will be poor since at the peak the system supply is short. Also there are no incentives to improve capacity use.

The world over the emphasis is now changing to computerization and systems improvements in transmission. Thus, the Canadian public utility Transalta has introduced retail wheeling of power in countries like Chile and Argentina. Alternative suppliers like mini hydel, other non-conventional and co-generation, can compete through real time with conventional sources in a grid and modern systems permit prices to vary depending on demand-supply configurations. Such systems have great possibilities in India.

CONCLUSION

Economic theory and policy has therefore to playa major role in policy reform for infrastructure planning. Improvements in operational efficiency help as we have demonstrated empirically in different ways. Input costs go down. Overhead costs go down. These together with additional output produced improves finances in the three additional ways defined above.

Decentralization helps operational efficiency. It also permits alternative organizational strategy with mixes of public and private initiatives. These are again efficiency augmenting and resource creating. Our only contribution is to empirically demonstrate the possibilities in India today. Many exciting possibilities lie ahead.

# Cooperative CAD-CIM over the InfoHighway - the Shape of Innovations to come

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## INTRODUCTION

As we are nearing the Twentyfirst Century,' Engineering Design is getting a shot in the arm by the fusion of three apparently different technologies:

• Computer Aided Design and Computer Integrated Manufacturing (CAD-CIM) with its sophistications in the Art and Science of Surface Modeling, Design Productivity Tools, Parametric Editing Automation and the evolution of direct paths from CAD to analysis.

• Computer-Communication Network bringing about Information Highways and Information Super Highways based on high speed Satcom and very high speed fibre optic communication enabling cooperative Video Conferencing.

• Multimedia Systems and Virtual Reality.

Within the country, the National Informatics Centre (NIC) is pioneering the synergetic combinations of these technologies to achieve a cooperative CAD-CIM over the Information Highway through correlated innovations. This evolution is traced from the past achievements to the present problems to the future prospects.

## THE FIRST PART: PARADIGM SHIFT IN CADCIM

While the country has seen a rapid spread of the CAD culture in all areas of engineering design through such software packages as Auto CAD, ICEM, CADDS, SESAM, I-DEAS, EMS - the accelerated deployment of CIM packages is only a recent phenomenon. The pioneering work of SDRC, CDS, AutoDesk, among others, has made available the tools for Surface Modeling/for Solid Modeling, Design Productivity toolsets, Parametric Editing, Design Drafting Numerical Control (DDN), to mention a few. The paradigm shift is the result of the use of these tools and methods for a modular approach for simultaneous engineering solutions, creating point solutions, seamless coexistence of 2-D and 3-D design data, sharing design data with multiple CAD systems, creating customized engineering environments, direct data link between engineering drawings and MRP systems, simple and effective management of engineering drawings, creating standard pattern libraries, sophisticated tools and methods for numerical control programming and, above all, an increasingly versatile integration of all such features.

Almost every progressive engineer is interested in making his engineering more and more efficient. There is a clamour for shortening the product cycle. To improve the response time while doing things in 3-D, the engineers learn to move away from terminal oriented systems to distributed workstations. Faster engineering, ability to customize on the job and do it quickly and shorten the product cycle is what one would look for when a lot of what we do in manufacturing depends on processes that start with an engineering design. Improving overall productivity calls for substantial improvement in drafting and productivity in the design areas as well as tool path creation. This would require engineers to get off their drawing boards and plunge on to a workstation.

For such requirements, what should we look for in the CADCIM system for the product development? To accomplish very sophisticated tasks, the system must have a comprehensive set of functions and features which can be dovetailed to your specific requirements. Yet, the system must be flexible and modular, so that it can be integrated into the existing engineering environment to provide the most efficient and cost effective use of the system. Comprehensive set of components, openness and inter-operability, simple yet powerful user interface, become the watchwords. The modular system architecture can provide a high degree of flexibility. Along with user-friendliness resulting from a parametric graphical programming language, modularity helps to set up one's own specific applications or special functions in a short time thereby giving a competitive advantage.

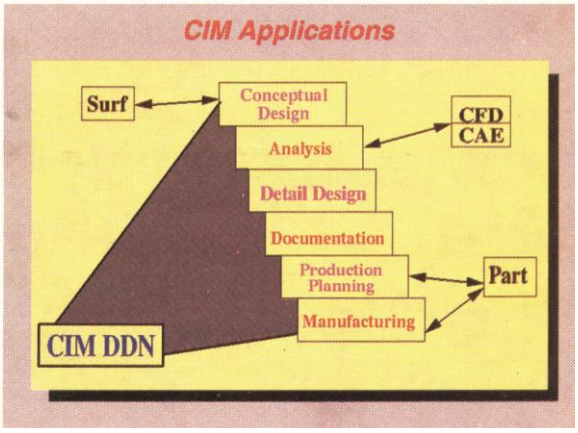
The DDN has to be flexible enough to optimally adjust the design process to the requirements of the current task. It has to adapt to your needs, whether you prefer to model a complex 3-D geometry first and then derive the engineering drawing from the 3-D model, or alternatively, prefer to create first of all 2-D detailed drawings and then go on to generate the 3-D model. This would call for a common database for 3- D and 2-D models along with a uniform user interface to allow you to design in 3-D space or in 2-Dimensions as convenient and economical. To make modifications easy, parametric functions can be utilised. The numerical control modules of DDN should provide all the necessary NC Programming methods from, say, two-and-a-half axis milling upto five axis machining operations in the framework of a seamless manufacturing.

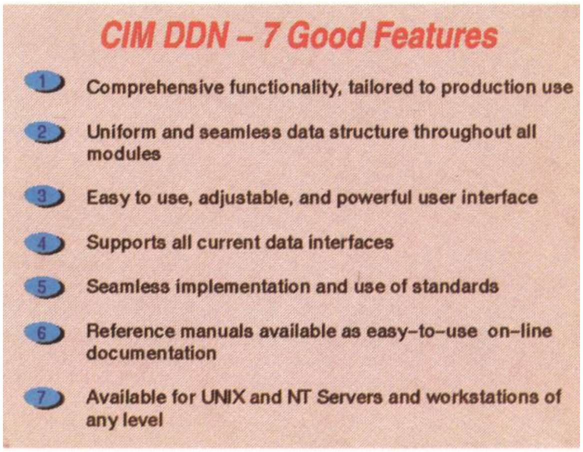
The paradigm shift in CAD-CIM mainly originates from the speciation into specialised 'point' solutions pinpointing a narrow specialisation area of manufacture for application of integrated CAD-CIM. Each 'point' solution is a module sitting on top of the base level DDN Software package, be it 2-D or 3-D or draughting or surface modeling or NC modeling. The basic DDN along with appropriate point solution software suite can model the geometry of an entire system along with all its parts juxtaposed in a perfect fit and create a grid out of the geometry of the entire system. This system can be as complex as an entire aircraft with all its parts. The DDN Software can create 3-D mesh sub-domains for the entire aircraft or car or a complex machine tool and even give matching schema of grid machining points. The software tools give a 'perfect' output for corning out with a 'perfect' dye which will result in a 'perfect' fit thereby directly translating CAD to CIM.

The surface modeling DDN software operates on a Potmaker's strategy of massaging, chipping, shaping and morphing of the clay or plaster of Paris - Here it is entirely done as an interactive software with massaging, chipping, shaping and morphing instructions. Even surface aesthetics can be designed using the software. The designer can program colour combinations which are aesthetically pleasing and bring out high quality surface finish by manipulating the changing reflection lines, until a good look results.

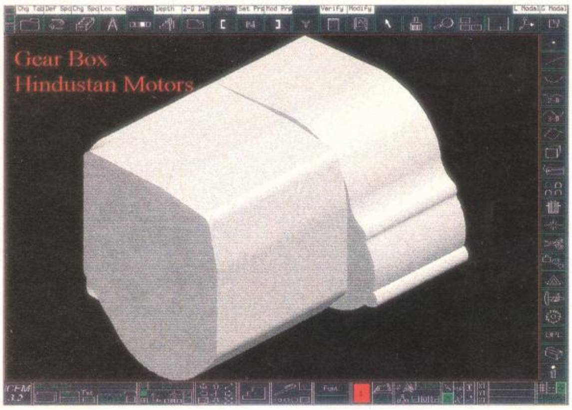
By using the software concept of intelligent associativity, a new drawing can be automatically generated as soon as a dimension has been changed, even if the drawing has not been completely dimensioned. All such flexible features enable 'Just-in- Time' manufacture for meeting the increasing demands of custornization.

In this' general background we may examine the CIM applications and decide what constitutes a set of good features for DDN and how a DDN Program suite should look like. After deciding these we have to understand what key technologies are behind CIM solutions and work towards a suite of point solutions.



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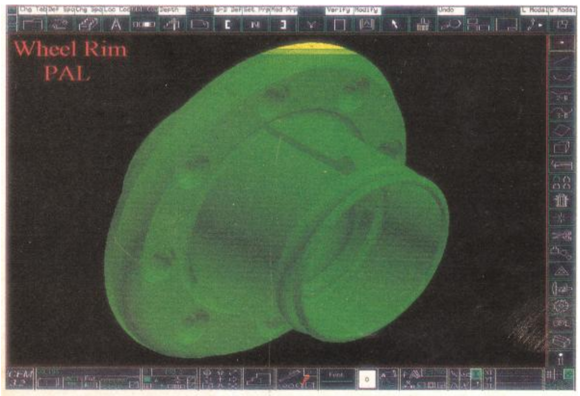
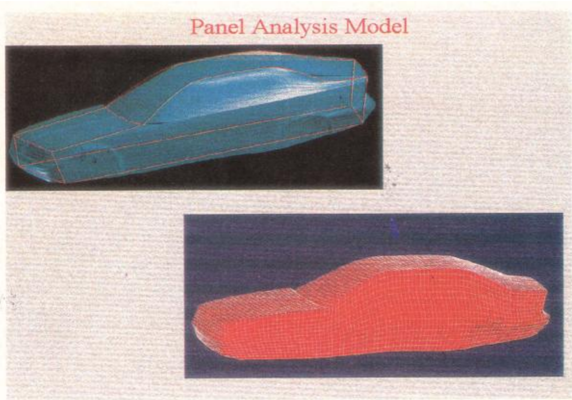

Wheel Rim
PAL


Steering Knuckle
Maruti Udyog Ltd.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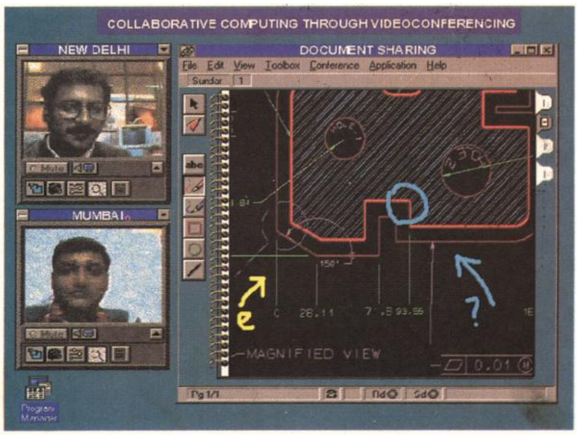
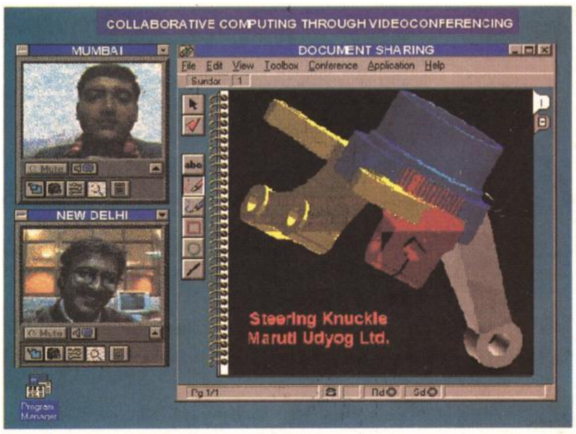

COLLABORATIVE COMPUTING THROUGH VIDEOCONFERENCING
NEW DELHI
DOCUMENT SHARING
MUMBAI
MAGNIFIED VIEW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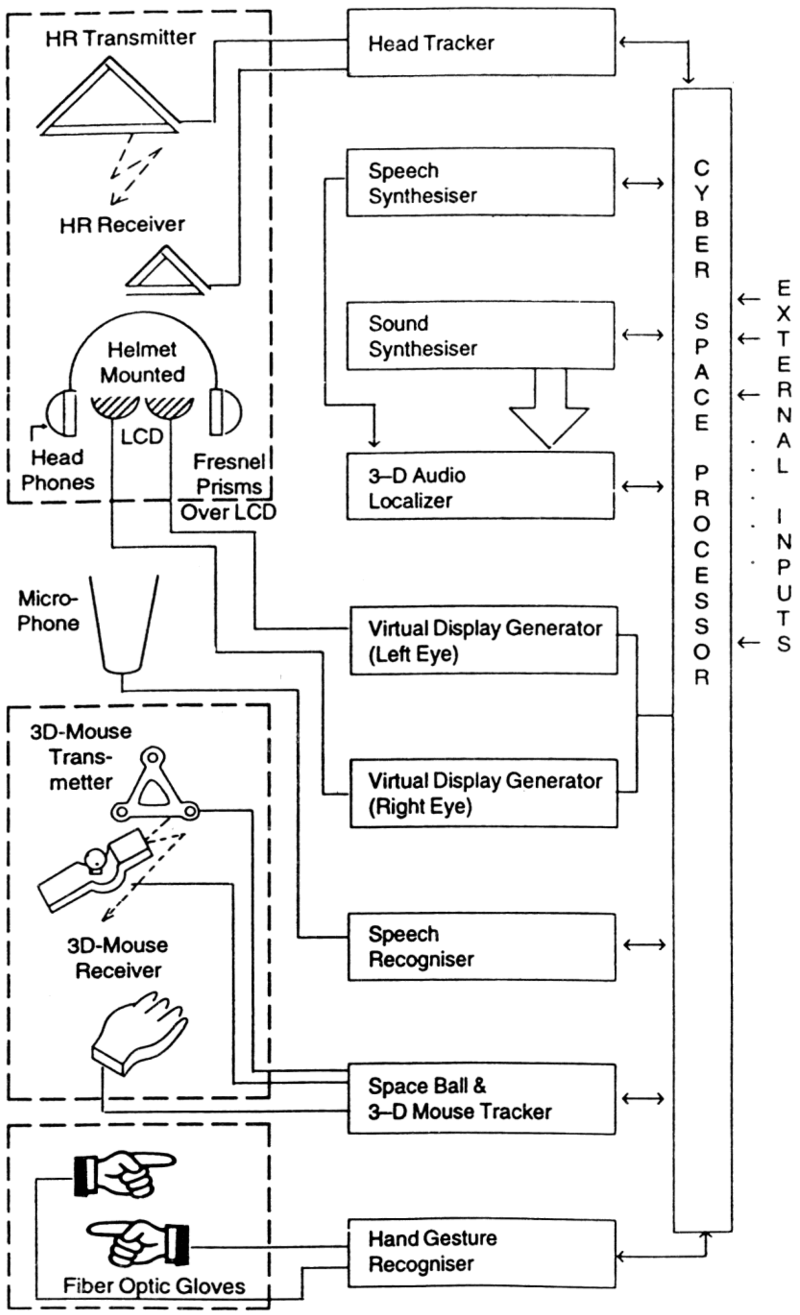


*Components of the Virtual Environment Laboratory of the National Informatics Centre (VELNIC)*

THE SECOND PART: INFO HIGHWAY FOR COOPERATIVE CAD-CIM

With the promotional role played by the National Informatics Centre, Central Machine Tools Institute, Structural Engineering Research Centre, Hindustan Machine Tools Limited, Central Mechanical Engineering Research Institute and other such organizations, the country already has the CAD-CIM tools and methods outlined in the foregoing, except an adequate level of cumulation of experience and the spreading of the CAD-CIM culture. Fortunately, we now have the major tool necessary for realising this 'spread effect' - the Information Highway and Super Highway.

With the setting up of Single Channel Per Carrier (SCPC) VSATs over NICNET, the Computer-Communication Network of the National Informatics Centre, we have demostrated the capability of data transmission upto 2.2 Mbps per node. This speed is almost a 100,000 text pages per hour of transmission. Sophisticated multimedia communication becomes possible over this NICNET Info Highway. With the demonstration of/the ability to transmit complicated drawings from one city node to another, NIC has shown that the country now has the means for interactive CAD bringing the day when several designers working on the same design problem interact over the Info Highway and arrive at solutions to common problems.

The 20 Video Conferencing Studio facilities created by NIC in as many cities can now be connected to user locations through intracity Integrated Services Digital Network (ISDN) links. These ISDN links create a network of low-cost Desk-Top Video-Conferencing workstations based on the software packages developed by NIC using Intel ProS hare chips. In the ProS hare Video Conferencing System, the hand-set and two video windows are displayed as one integrated unit. The shared notebook lets you copy a file from your computer into the notebook and review it with the person you are interacting with. You can run the same application and work on a file together. This file may be a design drawing. When sharing the notebook, both the designers in two different cities can see the same drawing on the respective computers and both can update it together.

Over the NICNET Info Highway, at present, five designers can work on the same drawing from five different cities. While good commercial software for this is available, NIC has developed a number of specialised software packages for enabling cooperative CAD-CIM over the Info Highway. It is planned to start a regular service over the Info-Highway by the first half of 1997.

THE THIRD PART: COOPERATIVE 3-D VISUALIZATION THROUGH VIRTUAL CONFERENCING

Virtual Reality System in which a participant interacts with computer-generated objects, in an artificial fully-irnmersive environment, is a visionary technology which was forecast more than a quarter century ago by Sutherland. Virtual Reality System, a name coined by Jerone Lanier, emerged from the earlier concept of a visually-coupled system as a computer-simulated environment that is continuously updated with respect to the head position. Since 1989, persistent demands have been made for developing realistic space and time-based multimedia solutions for certain environments into which participants can 'enter' and virtually participate in the events of the animated environment. The interactive virtual environment can be a computer simulation of a real world situation or an abstract form of a real world event or a design drawing. . In the limiting case, the animated world can display synthetic cues which would be indistinguishable from those displayed in the real world. Attempts are being made to render virtual objects look, sound and feel like the real objects that they represent and display dynamical and behaviroual patterns obeying the raws of the real world like Newtonian mechanics. Though this ultimate goal is beyond contemporary technology, the increasingly emerging gadgetry prodded by new developments in computer hardware, software, control systems and transducer technologies, among others, are giving an increasing level of realism to the virtual environment. The emerging commercialisation of virtual reality systems is indicative of the strides made in the past four years since it became an organised technology.

Hendersen introduced virtual reality through the concept of cyberspace. Our experience in interactive multimedia simulation is applicable for designing virtual reality. Similarly, work in multimedia database is applicable for designing the cyberspace environment. In this sense, virtual reality is a step in the technological evolution of interactive multimedia.

The approach adopted by the author in creating the Virtual Environment Laboratory of National Informatics Centre (VELNIC) is to conceptualise, explore, adopt, modify and develop the approaches to virtual reality technology which tend to minimise the system cost while developing applications which are relevant to the problems faced by countries like India in areas such as training in specialised subjects and cooperative CAD-CIM. A complete schematic diagram of VELNIC is given in Figure, which is being realised with an investment less than Rs. Forty lakhs through the introduction of concepts and techniques which tend to minimise the system cost. An Iarray of input and output devices, each device serving a sensory channel, is considered. A conscious effort is made to minimise the tactile components through the introduction of such concepts as 'virtual participant' and 'virtual camera'. Fibre Optic gloves can be used for the recognition of hand gestures and orientation of fingers on each hand. Though costing considerably less, the VELNIC virtual environment system is highly integrated through maximally substituting hardware by software and by the creation of virtual hardware like the virtual camera in place of the real one. VELNIC has the following components at present:

Visual components: (1) A head-mounted LCD display with Fresnel prisms; Crystal Eye System, (2) Head tracking system based on ultrasonic triangulation, (3) Flying Mouse along with 3-D tracking system, (4) SpaceBall device

Auditory Components: (1) Digital sound synthesis system, (2) 3-D audio localisation system, (3) Speech sensory system, (4) Speech recognition system

Tactile Components: (1) Low cost fibre optic gloves for hand gesture recognition

Interface Unit and Development Tools: (1) MultiGen Genlock Adaptor, (2) Audio-Video (n x m) distributor, (3) Software like MediaDB-2, Vistapro 3.0, Vistamorph, Chips Winvideo, CDK-Cyberspace Kit, Knowledge-Pro, Knowledge-Maker, Autodesk 3D Studio, SMILE, Animator, Mathematica, etc.

A Pentium Computer with 32 MB main memory and 2 GB modules of disk are used under WINDOW platform.

Systems like the above located in various cities can be endowed with conferencing capability. This will be useful when the same 3-D visualization is required to be shared by several designers in different cities and cooperatively arrive at a desired design. This is especially advantageous for surface Modeling art work when different people have to concur on the aesthetics of a surface design. While at present, emphasis is given to the Window view spacial 3-D perception from different locations, work is already in progress regarding the immersive virtual reality conferencing. Though the feasibility has been established for the Window View VR Conferencing, Real Life applications in cooperative 3-D Modeling is constrained at present by the limited bandwidth over the Info Highway.

THE FINAL PART: INTEGRATING AND SYNERGIZING THE THREE TECHNOLOGIES

At the National Informatics Centre, varying degree of capability has been established in the above three technologies - adequate enough to begin the process of their integration and synergization. This has been carried out with two technologies at a time - Shared Notebook Video Conference of 2-D/3-D design problems and Window-View Virtual Reality of 3-D Modeling. Immersive Tele- VR is still in its conceptual stage. A complete integration of all the three is expected by early 1998.

# The Energy, Environment and Ecology Dimensions of Sustainable Development

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## INTRODUCTION

There can be no doubt that the standard of living currently enjoyed by Man (particularly in the developed countries) is significantly higher than what prevailed before the Industrial Revolution. The principal instrument for this transformation has been Technology, in its many forms. While Technology has bestowed several benefits in opening up new avenues of living and working, it has also created a series of problems in its wake. It is but natural to seek out Technology again to offer solutions to these problems. As in Man's quest for knowledge. wherein new discoveries throw up more problems than answers. Technology too creates new problems as it generates new artifacts. Not all of these are technological in nature, and hence tractable through Technology itself. Many of them have social, political, economic and ecological ramifications, as, for example, weapons, hazardous chemicals, automobiles, etc.

Rachelle Carson was perhaps the first to point out the fragile 'web of life' in which Man participates and, hence, is responsible for protecting it. Since then, several people have been active in debates of Development vs. Environment. The transnational nature of pollution (air/water/nuclear) exemplified by acid rain in Canada, pollution of the Rhine river which traverses more than one country, the Chernobyl radiation fall-out, ozonehole, global warming, etc. served to highlight the spatial propagation of pollution and its lack of recognition of national borders. The irreversible nature of many effects of pollution and of depletion of non-renewable energy resources drew attention to the temporal or intergenerational features of Energy and Environment. It is this concern for future generations, essentially impinging upon the survival of the human species on this planet, which triggered the concept of Sustainable Development.

## THE CONCEPTS OF SUST AINABIUTY AND SUSTAINABLE DEVELOPMENT

The origins of the concept of 'sustainability', with special reference to 'sustainable development', may be traced to the 'World Conservation Strategy' developed by the International Union for the Conservation of Nature and Natural Resources, Worldwide fund for Nature, and the United Nations Environment Fund. Some of its interpretations and implications are given below:

• Sustainable development meets the needs of the present generation without compromising the ability of future generations to meet their own needs [The Brundtland Report, 1987].

• An increase in (real) domestic product, duly allowing for the consumption of produced capital and the depletion and degradation of natural capital, taking into account the past trends of depletion and degradation that can be offset or mitigated by technological progress, substitution and new discoveries of natural resources, or new additions to them, and changes in consumption patterns [Environmental Accounting with an Operational Perspective, UNSO Handbook].

• Keeping something going for an 'indefinite' period of time. Thus, sustainable extraction of fossil fuels or sustainable farming employing chemical fertilizers are oxymorons.

• Conservation of living resources, or management of the biosphere for human needs and use. This represents an anthropocentric attitude, implying that animals and plants are all for human use.

• Wise use of nature and its resources; to provide the greatest sustainable benefit to present generations while maintaining the potential to meet the needs and aspirations of future generations.

• Living in harmony with nature.

• Living off the income of nature, without eroding the capital.

• Must give back to the earth what we take from it [Aga Khan].

• Living within the 'carrying capacity' of the environment.

• Realization that the biosphere is both for us and for our descendants. 'We have not inherited the earth from our parents; we have only borrowed it from our children.'

Notwithstanding the several graphic descriptions cited above, the concept of sustainability is ambiguous, and its interpretation is a function of the user. It is often found fashionable to tag it on to several human activities:

• growth • development • agriculture • yields • power

It has an aura of respectability and comprehensiveness, and is often employed loosely and without basis.

There are three groups of sustainable development protagonists:

• die-hard preservationists of the natural environment without any change induced by human intrusion.

• middle-of-the-road conservationists, who hope that sustainable development willsafeguard the earth's resources to ensure their survival for the use of succeeding generations.

• hypocrites. who pay lip service to the concept and exploit this concept for short-term gains.

Sustainable development is an inter-generational concept, seeking equity over time, and minimization of disparities between generations. Some important issues in this context are:

• The sustainable development paradigm presumes that the present standard of living is high-almost a maximum, and can only decrease for future generations.

• Even now only a very small fraction of humanity is enjoying the good life even within the DCs, and there are wider disparities in the LDCs.

• Development projects involve exploiters and the exploited-those who derive benefit and those who pay a price. Often the two groups are not the same.

• Since the present standard of living is low in most LDCs, people aspire for a higher standard. Sustainable development cautions that there are limits to such growth, due to:

• finite stock of resources (both energy and materials)

• pollution of the environment

• exploding populations

• escalating aspirations

• conflicting interests

We cannot discuss sustainable development without discussing the population problem. It has been characterized as the 'population bomb' by Paul Ehrlich and as the 'cancer of the planet' by Sir Julian Huxley. Human survival and development depend on two crucial factors:

• population control

• successful management of the world's natural resources.

No development plans will be expected to bear fruit unless efforts are simultaneously made to contain population. However, politicians, who have the principal responsibility to design measures to limit the population, operate with reference to a time frame of about five years. It is quite unreasonable to expect them to be different from us, considering public good more important than personal gain. We have invented euphemisms to refer to population control: population stabilization, family welfare, etc. but the real problems have evaded our attention.

Two closely related problems are those concerned with education and employment. While education, or at least literacy, is a prerequisite for effective democratic government, indiscriminate expansion and diversification of professional programmes will only result in large-scale frustration due to unemployment and underemployment. The Human Development Report (1993) has termed the recent economic growth of the industrialized countries as 'jobless growth', with adverse consequences. One of the major problems plaguing these countries is unemployment. While several developing countries, in particular India, pride themselves on possessing a large stock of educated manpower, the critical index of development is the number of jobs created in relation to the population. Both extensive job creation and urgent population control are prerequisites for economic development and social harmony.

THE CORREIA TION BETWEEN QUAUTY OF UFE AND STANDARD OF UVING

Both the quality of life and standard of living depend strongly on energy and environment factors. It is often pointed out that we should distinguish between the level of consumption and the level of life; the former defined by access to white goods and other artifacts which represent luxuries and status symbols, and the latter by some measure of the enjoyment of life through indicators of health, education and leisure, which are combined into a Physical Quality of Life Index by the UNDP in their World Development Report.

Two issues are often raised in connection with the historical correlation between energy use and standard of living.

• Is a high GNP per capita really necessary for people's welfare and happiness?
• Is the use of energy in achieving a high GNP per capita as efficient as it should be?

In studies investigating the interpretation of the meaning and significance of GDP/energy use ratios and their relationship to lifestyles for different countries, a composite index has been developed to include the number of telephones, cars, radios, TVs, etc. in use; the share of expenditure for food, drink, clothing, rent, recreation, etc. This index was expected to quantify lifestyles in industrialized countries. The study revealed wide differences in lifestyles among, for example, the EC countries. While it is conceded that energy consumption will be reflected in any given society's lifestyles, they mean different things to different people, and at present no consensus exists as to what it is or what it means.

Cook (1976) considers energy use, environmental sanity, and the quality of life as independent variables. Each variable is considered to have at least one real limit. The limit on energy use is a maximum, measured as the. rate of availability of useful energy that can be sustained during any chosen period. The limit on environmental sanity can also be considered to be a maximum, either of pathogenic pollution or of uncontrolled disease organisms, in either case determined by the ability of the human species to survive. The quality of life also has a maximum, namely, the number of persons that can be supported by the available food supply or that the social mechanism can tolerate before it destroys itself. The two most threatening social costs of present energy systems are environmental poisoning and social collapse due to the exhaustion of non-renewable resources.

## THE NATURE OF THE ENERGY AND ENVIRONMENT PROBLEMS

Both energy and environment problems are multidimensional, multidisciplinary, and dynamic, and require positive and timely responses. Often, there are no unique solutions, but a matrix/mix/multiple solution. Both require an integrated approach, integrating technology and management, education and training, and social and economical aspects and S & T and management aspects. In particular, energy problems require an integrated approach to energy and materials, conventional and non-conventional energy sources, and non-renewable and renewable energy sources. In a similar fashion, environment problems require an integrated approach to chemical solutions and biological solutions, abatement and prevention, waste reduction and recycling, environment and development, environment and safety, and environment and health.

## THE ENERGY DIMENSION

### Comparison of Different Energy Sources

The technological, commercial, social and environmental factors characterizing the three major energy sources, viz. fossil fuels, nuclear fuels, and renewable energy sources are compared in Table 1. This brings out the merits and demerits of these three energy sources.

**Table 1 Comparison of different energy sources**

| Factor | Energy Sources | | |
|---|---|---|---|
| | Fossil Fuels | Nuclear Fuels | Renewable Sources |
| ● Technological: | | | |
| ■ Technology availability | + | + | ? |
| ● Commercial: | | | |
| ■ Sustained supply | – | – | + |
| ■ Cost (present) | + | ? | – |
| ■ Storage | + | + | except biomass |
| ● Social : | | | |
| ■ Convenience in use (energy density) | + | + | – |
| ● Environmental: | | | |
| ■ Acid rain | – | + | + |
| ■ Global warming | – | + | + |
| ■ Health (chemical pollution and nuclear radiation) | – | – | + |

The Role of Energy Conservation Strategies

The two oil crises have clearly demonstrated the Energy Resource Conservation is one of the most effective strategies for energy management. Energy conservation is considered to be an important 'energy resource', which has the additional merit of posing no pollution problems. The motivation for energy conservation stems from at least four concerns:

• realization of the severely finite nature of the terrestrial fossil fuel resources

• need to preserve the environment

• concerns of long-term radiation hazards of nuclear power

• uncertain future relating to alternative renewable energy technologies.

There are several (surmountable) barriers to energy conservation, to overcome which we need policy initiatives and structural changes.

A Parameter for Assessing Energy Resource Conservation Measures

A fundamental prerequisite for the identification and evaluation of energy resource conservation measures is a parameter for assessing the efficiency of the energy system or process with reference to energy utilization. Although 'efficiency' is a commonly-used concept in engineering, and has an aura of respectability and comprehensiveness about it, it is often an ambiguous and nebulous measure, particularly if not defined and qualified suitably.

For example, what does it mean in the statement that' early guns took so long to load and fire that bows and arrows-in trained hands-were twelve times more efficient'?! [Asimov : Book of Facts] In a given situation, it is usually possible to define several different forms of efficiency, depending upon what is considered to be the output and what is considered as the input, all of which will not have the same significance or relevance.

Some Deficiencies in the Common Perception of Efficiency

The efficiencies of different energy systems involving different types of energy inputs and outputs cannot be compared directly. For example, the typical 'efficiencies' of fossil-fuel-fired electricity generating plants and electric hot water heaters are in the range of 40% and 80%, respectively. Does this mean that electric hot water heaters are more nearly perfect than electricity-generating plants? The fact of the matter is that while the former involve work to heat conversion, the latter involve the sequential conversion of chemical energy of fuel to sensible ehthalpy of steam to mechanical work, and ultimately to electrical work. The second law permits 100% conversion of work to heat, but limits the efficiency of conversion of heat to work to a value which is less than 100%; the actual value is dependent primarily on the heat source and sink temperatures. Furthermore. if the efficiency of thermal power generation is included in assessing the performance of the electric hot water heaters, then the overall application efficiency may drop to about 30%, which shows it to be not so perfect after all.

'Efficiency' implies a maximum value of 100%, causing us to invent new names if it appears to exceed 100%. Such a viewpoint is based on its interpretation as the ratio of 'what we want' to 'what we have to pay for'. For example the parameters for assessing the performance of electric refrigerators and heat pumps are designated as 'coefficients of performance' , since they can and usually have values greater than 1. It is only when both the outputs and inputs are energies of the same 'quality', as in the case of electric motors and generators, that the concept of efficiency may be expected to be unequivocally valid.

It is particularly important to be careful in defining efficiencies, since they not only serve to compare different energy systems but also provide guidelines for allocation of fiscal resources for achieving energy resource conservation. Even today, it is just the first law which is employed for this purpose, whereas not only does it not provide rational guidelines for energy resource conservation, but also leads to wrong conclusions and decisions.

The simultaneous consideration of the second law is essential for obtaining the proper perspective.

Why Seek High Efficiency?

Although it is intuitively clear, there are two explicit reasons for seeking high efficiency in power plant practice

• The higher the efficiency, the smaller is the quantity of fuel required to accomplish a given task, thus resulting in lower cost for fuel, slower fuel resource depletion, and less environmental damage in the extraction and combustion of the fuel.

• Because the efficiency is always less than 100%, from the first law, whatever energy is not tapped for work must be rejected to the environment and disposed of in some way. Typically, about two-thirds of energy in the fuel will be rejected, partly to the atmosphere through the stack, and partly to the cooling water. Thus, higher the efficiency smaller is the waste energy to be disposed of [Q2 = Q1 (1 - h)]

The thermal pollution from ~uclear power plants is greater than that from fossil-fuel-fired power plants for this reason. The efficiency of the nuclear power plant is less than that of its fossil fuel counterpart because the practical upper temperature limit of the former is less, being limited by the materials which must be used to contain the fissionable substances. For example, for an identical power output of 500 MWe, assuming an efficiency of 40% for a fossil fuel plant and 30% for the nuclear plant (a reduction of 25%), it can be shown that the heat rejection in the latter case is increased by 56%.

Efficiency Considerations for Heat Engines and Cyclic Processes

In Thermodynamics a heat engine is defined as a continuously operating thermodynamic system at the boundary of which there are heat and work interactions. Thus, the steam power plant and the 'closed-circuit' gas turbine power plant are classed as heat engines, while the reciprocating internal combustion engines and 'open-circuit' gas turbine are not heat engines. While 'direct' heat engines deliver network output, 'reversed' heat engines, viz. refrigerators and heat pumps, involve work and heat transfers in the opposite direction.

Several practical energy systems involve thermodynamic cycles. The concept of efficiency for cycles is commonly based solely on the first law, representing the fractional part of the heat supplied to a cycle which is converted into work, and may be verbally stated in the following alternative ways:

(i) what we get / what we have to pay for
(ii) useful output / (costly) input
(iii) useful effect / energy that must be purchased
(iv) quantitative value of desired result / quantitative value of inputs used to produce that result

Identification of particular energy quantities as output and input gives rise to different definitions for efficiency, leading sometimes, as in the case of electrically-driven heat pumps and refrigerators, to values greater than 1, and appearing anomalous. As pointed out earlier, the situation is redeemed by calling them coefficients of performance (CoP).

The Distinction between Performance Parameters and Criteria

It is important to note that while performance, parameters merely provide a measure of plant performance, it is performance criteria which provide a yardstick against which the actual performance can be judged. After a plant is designed, built and operated, it is necessary to ask how much better the performance could have been. Performance criteria, not performance parameters, are capable of providing the answers. These criteria cannot result from practical experiment, since all real-life processes are in some degree imperfect. They are derived from the application of the laws of thermodynamics to reversible processes.

A Miscellany of Other Concepts of Efficiency

Depending upon the nature of activity and the desired outcome, different expressions are employed to relate the outcome to the input. Some of these are listed below :

• Task Efficiency: It is the ratio of the theoretical minimum input required by the first and second laws to accomplish some task to the actual input for a particular means. In another form, it is the ratio of the actual output to the maximum theoretical output.

• Technical Efficiency: It is the product of the conversion efficiency at an intermediate step (if there is one) and application efficiency at the device that performs the useful work; it is a measure of the useful work done as a percentage of the gross energy input.

• Economic Efficiency: It takes into account factors such as the work expended in extraction, refining and transportation of fuels, in the construction and operation of energy conversion facilities, power equipment and electricity distribution networks, and in the handling of waste products and employment of environmental protection measures.

• Concentration: In addition to the concept of energy quality, there is an additional intrinsic characteristic of energy sources, which provides a measure of 'goodness'. It is 'concentration', which may be defined as energy per unit volume or per unit mass for fossil fuels, and as energy crossing unit area (energy flux) for solar energy. Other factors being equal, the higher the concentration, the better the energy source, and the extraction, transportation, storage and handling are easier and cheaper.

• Work Ratio: A theoretical power cycle may have a high thermal efficiency; yet the real prototype may have an extremely low thermal efficiency. A warning of this possibility is given by the work ration, rw:

$$rw = \frac{\text{net work from cycle}}{\text{positive work of cycle}}$$

Typically, it is large for Rankine power cycle and small for gas turbine cycle.

Two Significant Statements of World Energy Conference, Montreal, 1989

At least two significant statements were made during the World Energy Conference in Montreal in 1989, which have important consequences:

• Case for Energy Conservation :

'Fossil fuels will continue to meet most of the world's growing energy demand.' This proclaims that (i)the world's energy demand is bound to monotonically increase both due to increases in population and more energy-intensive lifestyles; and (ii) most of this energy demand will be met by fossil fuels, hence the inevitability of our dependence on fossil fuels, and the need for us to use them more rationally .

• Nexus between Energy and Environment:

The economical rational use of our energy resources is essential for protecting the environment.' Modern living depends on the use of energy resources, and all energy use is accompanied by environmental degradation. Higher efficiency of energy use has the twin benefits of slower resource depletion and reduced pollution.

A SWOT Analysis of Renewable Energy Sources

Table 2 provides a SWOT analysis of renewable energy sources, and delineates the role they can play in supplementing the conventional energy sources, and highlights the barriers to commercialization and use which need to be overcome before they can become viable solutions.

**Table 2 Renewable energy—SWOT analysis**

| **Strengths** | **Weaknesses** |
|---|---|
| ● Unlimited/Perennial potential | ● Energy availability is seasonal and intermittent |
| ● Environmentally benign | ● RE sources are usually of low density, requiring large areas of space |
| ● Favoured option for sustainable development ensuring equitable distribution of benefits | ● Imposes a greater demand on labour |
| ● Naturally recycled resource base | ● Financial viability unfavorable |
| ● RE plants and devices are modular in size | ● Costlier and more capital-intensive than conventional energy systems |
| ● Decentralized energy option. | ● Capacity utilization lower, because of low density and inconsistency of supply. |
| **Opportunities** | **Threats** |
| ● Environment-driven awareness | ● Closely linked with environmental concerns |
| ● Policy initiatives at global and national levels | ● If social and environmental costs are ignored, RET cannot compete with conventional energy |
| ● Short gestation schemes; quicker project implementation | ● R & D efforts inadequate |
| ● Easy to install standalone systems | ● Incentive / subsidy-driven momentum is temporary. |
| ● Opportunity for rural electrification | |
| ● Generates rural employment | |
| ● In most cases, fuel transportation costs eliminated | |
| ● Cost of other inputs is also considerably less | |
| ● Social benefits | |
| ● Can be matched with the scale of the need. | |

THE ENVIRONMENTDIMENSION

The Significance of 'Emission Index' and Related Parameters for Characterization of Pollutant Emissions

The primary measurement of pollutant emissions from practical combustion devices is in terms of the volumetric (or molar) concentrations; for pollutants occurring in trace quantities such as NO and UHC, it is expressed as parts per million, ppm (1 per cent = 10000 ppm). It has been found necessary to convert these concentrations into mass emission performance parameters in order to make realistic and meaningful comparisons of the emission characteristics of the different combustion devices. Several alternative parameters have been found useful for this purpose.

Emission Index

In engines employing continuous combustion systems, typified by the gas turbine engine, the parameter found most useful in comparing the emission characteristics of different combustors is the 'emission index'. The SAE Aerospace Recommended Practice 1256 has recommended the use of an emission index parameter based on the mass rate of emission of a particular pollutant normalized with respect to the fuel flow rate. The emission index of a burner describes how efficiently the burner consumes the fuel supplied to it in terms of the pollutant emitted, and is defined as the grams of pollutant emitted per kilogram of fuel burned.

The advantage of using the emission index for characterization of pollutant emissions is the fact that it eliminates the need to specify the local mixture ratio (or degree of dilution) at the point of sampling. The emission index is a cumulative parameter obtained by mass-averaging the pollutant concentrations at the burner exit plane, and, hence, involves a knowledge also of the velocity (and density) profiles at this plane.

The utilization of emission index rather than concentration for comparing engines operating at different mixture strengths removes the fuel-air ratio effect by relating the emission levels to the fuel consumption. A plot of pollutant concentration as a function of overall fuel-air ratio for constant emission indices will show that in order to maintain a constant emission index the permissible concentrations decrease significantly for fuel-lean conditions. In other words, for identical pollutant concentrations, relatively high emission indices occur at low fuel flow rates, and vice versa. Combined with the observation that errors of measurement of the exhaust gas components have a stronger effect in the lean-mixture region than in the rich region, this means that even small errors in composition measurement under fuel-lean conditions of operation will be amplified into large errors in computed emission indices. At low emission levels, of course, instrumentation errors and sampling procedures may also playa larger role.

Specific Emission

It is shown that while the emission index provides an excellent means for rating the emission performance of a burner, when the burner is installed in an engine. a different standard of comparison would be required to specify the emission performance of the engine. This should take into account the· efficiencies of not only the combustion system, but also the efficiencies of all of the other power plant components. For this purpose, the emission levels are presented in terms of the 'specific emission' which is a function of the engine output, for example thrust, horsepower, or MW; the specific emission parameter reflects overall power plant performance.

Vehicle Emission

A third parameter is needed to compare the emissions of vehicles, which must reflect the performance of the entire power train (engine, transmission, drive line) and the vehicle aerodynamic drag and rolling resistances, when the vehicle is operated over a prescribed driving schedule of steady-state and transient conditions. The emission data are reduced to a single vehicle mass emission value for each pollutant expressed as grams per test mile. It must be pointed out that these are the units of the US Federal Standards.

Kinetic Ratio

The 'kinetic ratio' is defined for different pollutant species, relating their concentrations as determined by chemical kinetic and equilibrium considerations, and is, therefore, determined by the rate-controlling parameters for their formation and oxidation. For NO, the kinetic ratio is defined as the ratio of the kinetically-limited primary zone NO concentration to the equilibrium NO concentration. For CO, it is defined as the ratio of frozen CO concentration minus the equilibrium CO concentration to the difference of primary zone and exhaust equilibrium CO concentrations. In the limit, when the kinetic ratio is zero, the final CO concentration would be equal to the theoretical equilibrium concentration at the final conditions of pressure, temperature and equivalence ratio.

Some Anomalous Trends in Variation of Emission Parameters

The different emission parameters defined above are all interrelated in a complex fashion, and extreme caution should be exercised in correlating data and establishing trends.

For instance, as already pointed out, since the emission index defines the weight of pollutant per unit weight of fuel, for equal values of pollutant concentration and equal exhaust flow rates, less fuel consumption will result in a greater EI. However, reduced fuel consumption and its consequent effect on EI, as noted above, need not necessarily result in a greater value of VE in grams per mile. This is because, even though EI increases as fuel consumption decreases, the fuel consumption per mile will also now be less, and hence the emission in grams per mile need not worsen .

At lower inlet air temperatures the fuel economy is usually reduced, resulting in increased fuel consumption, so that for the same value of VE, EI should be less at low inlet air temperatures. Conversely, at higher inlet air temperatures fuel economy improves, and for the same value of VE, EI could be more.

Principal Variables Governing the Variation of Emission

Parameter

The previous discussion has demonstrated the importance of consideration of the principal variables governing the variation of the individual emission parameters. The important factors for the different emission parameters are as follows:

Burner emission concentration :f {fuel-air ratio, burner inlet pressure, burner inlet temperature, burner outlet temperature, ambient air humidity, burner design, combustion intensity}

Vehicle emission grams per mile: f{burner emission concentration, engine air flow}

It is pointed out that while the common practice is to correlate emission levels in terms of engine output parameters such as thrust, horsepower or MW, the more rational procedure would be to correlate them in terms of the engine combustor input parameters such as temperature pressure, fuel/air ratio, humidity content, etc. the link with engine output being established by means of conventional engine cycle and performance analyses.

THE ECOLOGY DIMENSION

The Ecological Perspective

The principal causes for ecological degradation in the industrialized counties, particularly in the post-World War II era, are drastic changes in the technology of agricultural and industrial production, and transportation. In most cases, the new, more polluting technologies have also been more energy-inefficient than those they replaced, but were more profitable because they used cheap energy.

The Origins of the Ecological Crisis

The ecological crisis has been blamed on different things by different groups in the West (Barry Commoner, 1974):

• Exploding Populations, particularly in the LDCs d. Garrett Hardin, Biologist: 'Freedom to breed will bring ruin to all.'

• Affluence and Wastefulness, particularly in the DCs d. WS Howard, Biologist: 'The affluent society has become an effluent society. '

• Man's Innate Aggressiveness

d. W Roth, Director, Paicific Life Assurance Co: 'The first problem is people. The second problem, a most fundamental one, lies within us - our basic aggressions.'

• Profits

d. C E Phillips, Congregationalist Minister: 'Environmental rape is a fact of our national life only because it is more profitable than responsible stewardship of earth's limited resources.'

• Religion, particularly Anthropocentric Stance

d. L White, Historian: 'Christianity bears a huge burden of guilt ..... We shall continue to have a worsening ecological crisis until we reject the Christian axiom that nature has no reason for existence save to serve man.'

• Technology

d. V Hartke, Senator: 'A runaway technology, whose only law is profit, has for years poisoned our air, ravaged our soil, stripped our forests bare, and corrupted our water resources. '

Four Laws of Ecology

In order to survive on the earth, human beings require the stable, continuing existence of an appropriate environment, which encompasses a thin skin of air, water, and soil. Barry Commoner has enunciated four Laws of Ecology that highlight the scope of this science of planetary housekeeping :

I Law: Everything is connected to everything else

The ecosystem consists of multiple interconnected parts, which interact with each other. The feedback characteristics of ecosystems result in amplification and intensification of several processes.

II Law: Everything must go somewhere

In nature, there is no such thing as 'waste'. In every natural system. What is excreted by one organism as waste is taken up as food by another. Nothing can be expected to 'go away'.

III Law: Nature knows best

Modem technology aims to 'improve on nature'. This law holds, however, that any major man-made change in a natural system is likely to be detrimental to that system.

IV Law: There is no such thing as a free lunch

In Ecology, as in Economics, this law is intended to warn that every gain is won at some cost. In a way, this law embodies the previous three laws. Because the global system is a connected whole, anything extracted from it by human effort must be paid for; payment of the price cannot be avoided, it can only be delayed.

A Recent Taxonomy of Ecology

Fritj of Capra, in his recent book 'Web of Life', provides a Taxonomy of Ecology, which takes into consideration some recent concerns:

• Deep Ecology: This concept, proposed by Arne Naess during the early 70s, does not separate humans from the natural environment. The world is perceived not as a collection of isolated objects, but as a network of phenomena that are fundamentally interconnected and interdependent. It recognizes the intrinsic value of all living beings, and views humans as just one particular strand in the web of life.

• Shallow Ecology: This concept is anthropocentric or human-centred. It views humans as above or outside of Nature, as the source of all value, and ascribes only instrumental or 'use'. value to Nature.

• Social Ecology: This concept is based on the premise that the fundamentally anti-ecological nature of many of our social and economic structures and their technologies are rooted in the' dominator system' of social organization. Particularly, imperialism and racism are examples of social domination that are exploitative and anti-ecological.

• Feminist Ecology and Eco-Feminism : This is a special school of social ecology, which addresses the basic dynamics of social domination within the context of patriarchy. It links the exploitation of Nature with that of women's; and women's history with the history of the environment.

• Industrial Ecology: In the industry sector, a new paradigm, termed 'industrial ecology' has been proposed for adapting Technology for a sustainable world. The essential idea is that industrial processes resemble those of a natural ecosystem wherein materials and energy circulate continuously in a complex web of interactions : Micro-organisms turn animal wastes into food for plants, which are either eaten by animals or enter the cycle through death and decay. By and large, natural ecosystems are self-contained and self-sustaining. Some wastes are not recycled; for example, fossil fuels! Industrial ecology focuses less on the inputs of each industrial activity in isolation, and more on the overall impact of all such activities. It is hoped that industrial ecology will promote environmentally responsible behaviour.

Some Recent Initiatives for Defining Ecological Standards

ISO-14000:

This represents a series of international standards for environmental . management systems, life-cycle assessment, environmental auditing of processes, environmental labelling, environmental performance evaluation, and terms and definitions.

150-14000 includes four phases :

• Planning the environmental management system (to identify significant environmental aspects and to set environmental objectives);

• Implementation and operation of the system (to educate and train employees to improve the company's environmental performance and document the system);

• Monitoring and corrective action (to oversee and audit the environmental performance); and

• Management review and continual improvement (to review the use of the system and to set new environmental objectives for improving the environmental performance).

BS 7750:

This was the first national standard for environmental management systems, published by the British Standard Institute in 1992 and revised in 1994. Once published as an international standard, ISO 14001 will supersede BS 7750.

There are four elements under 'Policy and Management Systems' :

- Environmental policy statement
- Environmental management system(s)
- Management responsibilities and reporting links
- Legal compliance

Under 'Input/Output Inventory', there are nine core requirements:

- Materials use and trends
- Energy consumption and trends
- Water consumption and trends
- Health and safety
- Environmental accidents
- Major waste streams
- Air emissions
- Water effluents
- Product impacts during use

EMAS

The Eco Management and Audit Scheme is a regulation within the EC to promote continuous improvement in the environmental performance of industrial activities by :

- establishing and implementing environmental policies, programmes and management systems;
- systematic, objective and periodic environmental performance and evaluation; and
- providing information about environmental performance to the public.

The EMAS requires implementation of an environmental management system. A standardized system can be sued if the standard has been recognized by the EMAS. Recognition is being sought for both ISO 14001 and BS 7750.

Life-Cycle Assessment (LCA)

The LCA is a recent management tool to appraise and quantify the total environmental impact of products or activities over their entire lifetime, by analyzing the entire life-cycle of a particular material, process, product, technology, service or activity. Life-cycle assessment consists of three complementary components: 0) inventory analysis, (ii)impact analysis, and (iii) improvement analysis.

The LCA is aimed at producing products that reduce 'cradle-to-grave' environmental impact, measured from the design phase right through lifetime operation and disposal or recycling, not just the impact within the factory. It requires major investments in data collection and information systems, and also a change in the mind-set among the development staff and suppliers.

In the concern for 'cradle-to-grave' environmental impact, it is pointed out that, while it is important to continue reducing the environmental impact of manufacturing, the real environmental battle embraces all products that employ electricity in operation. Improvements in operational ecoefficiency is expected to have a much greater impact than improvements in manufacturing the product.

For example, making a 50-kW electric pump requires about half-a-ton of metals, and electricity generated by burning about half-a-ton of coal, with a resulting emission of 2 tons of CO2. During 20 years of operation, the pump consumes about 9000 MWh of electricity, which corresponds to 1000 tons of coal and emissions of 4000 tons of CO2. It is thus seen that in terms of CO2 emission alone, the environmental impact of the pump operation is 2000 times greater than its manufacture.

CHANGING PARADIGMS AND PERCEPTIONS

Table 3 provides a summary of changing paradigms and perceptions relating to Energy and Environmental practices.

CONSTRAINTS ON HUMAN AMBITION

There are essentially two classes of constraints which place limits on human ambition:

• The laws of Nature not only provide a description of Nature and its many processes, but also set limits on the possibility of achieving some targets. Some examples are:

1. Perpetual motion machine (First Law of Thermodynamics)
2. Complete conversion of heat to work (Second Law of Thermodynamics)
3. Achievement of the absolute zero of temperature (Third Law of Thermodynamics)
4. Certainty in extraction of information at the sub-microscopic level (Heisenberg Uncertainty Principle)
5. Possibility of faster than light motion (Einstein's Principle)

**Table 3 Changing paradigms and perceptions**

| Past / Present | Future |
|---|---|
| • Transportation for providing 'mobility' | • Transportation for providing 'access' |
| • More of individual transport than mass transit | • More of public transport |
| • Considerable distance and time to get to work; much business travel | • Considerable work done from home; teleconferencing and IT decrease need for business travel |
| • Utilities meant to provide energy and power | • Focus on providing services (heat, power, light) |
| • Per capita energy use is an indicator of standard of living | • Physical quality of life index uses other indicators not related to energy use |
| • 'End of pipe' clean-up technologies to reduce pollution | • Clean technologies to prevent pollution |

It is interesting that the most well-established laws of Nature deal with the impossibility of achieving certain goals, and have been consequently dubbed as 'Principles of Impotence'.

• The second class of constraints includes devices and processes which are not precluded by any laws of Nature, but cannot be practically realized, primarily because of non-availability of suitable materials.

Some examples are discussed below :

• It is well known that the cycle efficiency in steam and gas turbine plants improves with increase in turbine inlet temperature. While remarkable advances in blade cooling technologies permit metals to withstand gas temperatures that exceed their melting temperatures, and advances in materials technologies have resulted in high-temperature-resistant materials such as composites, single crystal materials, thermal barrier coatings, etc. there are still practical limits to turbine inlet temperatures.

• One of the constraints in nuclear fusion is the non-availability of containment materials.

• The efficiency of fuel cells and of solar photovoltaic systems is limited by the availability of electrode materials and of photovoltaic cell materials.

SOME CONTENTIOUS ISSUES

There are several contentious issues in discussions of Environment and Sustainable Development, particularly those between DCs and LDCs :

• Pollution is transnational and borderless : Polluters in a specific location may not suffer, but may affect victims in another location. For example, the ozone-hole over Australia, acid rain across the US-Canada border, the effects of the Chernobyl accident in Europe, the effects of global warming on coastal countries, etc.

• LDCs are lagging behind DCs in quality of life, and are hoping to catch up. The following issues are contentious:

• Do the same norms apply for all?

• Should we reckon gross or per capita 'pollution?

• Clean technologies being recommended for LDCs are expensive.

• Most LDCs lack clean energy sources (oil, gas, good quality coal, .... ).

• A holistic approach to problems is lacking. Mass transportation is still not popular in DCs, and the LDCs are experiencing car and two wheeler explosion in the wake of globalization policies. Since rural infrastructure and conveniences are limited, there is considerable migration to cities in LDCs. There is also considerable resistance to change in work-styles by labour, for example, in re-scheduling shifts.

• Some suggested solutions are limited in scope:

• The so-called 'zero-pollution' electric cars transfer pollution from distributed sources in cities to concentrated sources in remote locations.

• The NIMBY(Not In My Back Yard) syndrome governs the location of nuclear power plants (and polluting chemical industries).

• Even hydropower has drawbacks; in fact, it must be recognized that no power is 'clean'.

• There are serious trade-offs between Environment on the one hand, and Development and Employment on the other. For example, the closure of tanneries in Tamil Nadu, of the South India Viscose Factory at Coimbatore, and of foundries at Coimbatore brought up these issues to the fore.

• It is not only Industry which is responsible for pollution, but also the municipalities and corporations. This raises the issue of government vs. private sector and the role of the Pollution Control Boards.

• While there are enough laws covering Environmental Protection, it is the lack of enforcement of these laws which is the stumbling block.

• There is no gainsaying the fact that economic growth is crucially dependent on energy sources and their utilization, with attendant natural resource depletion and environmental degradation.

• While 'green' activists point out shortcomings, they do not propose viable alternatives.

A RANGE OF ISSUES FOR DISCUSSION

There is a wide range of issues which concern sustainable development, for which solutions need to be found:

• Is the current level of economic growth of the developed countries 'sustainable'? Are the aspirations of the developing countries to attain such growth realistic?

• What strategies are required to make the developed countries curtail their affluent lifestyles and the developing ones control their exploding populations?

• How can economic growth and employment generation be made compatible?

• What should be the desirable linkages between energy use, development, national income, standard of living and quality of life?

• What path should developing countries follow for achieving better living conditions for their people? .

• How should energy analysis and economic analysis complement each other in order to guide decision-making?

• What are the ecological limits to economic growth?

• What should be the criteria for matching energy demand and energy supply for different sectors and applications?

• How can the role of renewable energy sources in the energy plans of nations be enhanced?

• How should the 'external costs' be taken into account in the pricing of conventional energy and power?

• What measures should be taken to promote decentralized energy systems as a strategy for fulfilling the needs of regions uneconomical to be serviced by conventional sources?

• How can energy conservation be promoted to serve as a demand-side management strategy for containing the burgeoning energy and power demand and also environmental damage?

• How can Technology be designed to be ecologically benign and economically efficient? What are the roles of technologists, industry, government and society?

• How can Technology Policy be employed as an instrument for maximizing the benefits of Technology?

• How can it provide guidelines for technology transfer and for priorities in indigenous technology development?

• What is the role of Technology Assessment for national economic development?

• What are the special characteristics of developing countries which require strategies different from those adopted by developed countries for achieving economic growth and national development?

• How can the seriousness and urgency of the necessity for sustainable development by impressed upon the policy-makers and government, and upon the public at large?

## CONCLUDING REMARKS

The advanced or developed countries have crossed the stage of development characterized by industrialization, and are into the stage characterized by information technology and service industries. On the other hand, the majority of our country is still involved in agriculture, and only a small proportion is involved in the processes of development and utilization of industrial technology, and much less in the case of information technology and service industries. For the foreseeable future, the situation is not expected to change, what with the population exploding, particularly of the poorer and illiterate sections of society. For technology to have an impact on the living standards of the majority of people through rapid economic development, an uncompromising strategy toward containment of population and the inculcation of a preparedness for change among our vast population is required.

The former UN Secretary-General, Javier Perez de Cuellar, has recently stated that 'the transition to sustainable development implies a radical change in the styles of development in North and South alike. It cannot succeed till we have policies that follow plural trajectories, do not endanger bio-diversity and are based on the achievements of science and modem technology'. 'Our pattern of development based on the continued expansion of material consumption are neither viable nor infinitely extensible'. He calls for a kind of Marshall Plan on a worldwide scale to be devised for culture and development. The means for taking such decisions were listed by the IMF Director-General, Michel Carndessus, at the Rio Summit :

‘,... reduction in unproductive expenditure, particularly in the defense sector, in all countries; a search for optimization in public expenditure; the implementation of new policies taking account of non-economic, environmental and cultural costs; introduction of new fiscal policies, and negotiation of new commercial policies; and greater resource allocation to human and cultural development-thus to education'.

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# Professional Education through Distance Mode

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## INTRODUCTION

Relevance of any educational system should be adjudged in terms of the criteria that give the system a significant social function. Following four criteria characterise the functioning of any educational system.

• To give instructions in skills : The primary function of an educational system is to give instructions in skills that are related to and-promote a general division of labour and at the same time respond to changes in such division of labour.

• To build a cultivated society: Education also aims to develop the power of the mind besides imparting skill that are purely practical. It thus attempts to produce a cultivated society. I

• To advance learning : Educational system must contribute to the growth of knowledge which in turn leads to advancement of truth and removing ignorance.

• To transmit the secular view: Educational system must seek to transmit a common human culture, spread of rationality etc.

The conventional university imparts face to face education to the students but now it functions almost like ivory tower showing little care for the needs of the students or the society. Some of the commonly levelled charges against the conventional education system are :

• Educational courses offered are not relevant to the existing social needs.

• The highest paid teachers are reached by fewer selected students,

• Age old teaching method has become ineffective, and hence, large absentism,

• Inflexible system regarding duration, system of admission, age criteria etc, and

• Only a few privileged ones enjoy benefits of higher and better education.

Thus, it is found that there is mismatch between present socioeconomic need and the conventional educational system.

Distance Education - Distance education is a type of education in which education is given to learner from a distance. In other words, there is physical separation of a teacher and a learner. Let us examine system of distance education in the light of all the four criteria for functioning of any educational system as mentioned earlier and see whether this system meets these or not.

• Imparting skill - Distance education depends on print media as well as audio-video, ie, multimedia approach. Basic learning of skill is inherent in distance education and meets all the three categories of skill, ie :

a) Communication skill (Reading, Listening, Writing, Oral skill),

b) Intellectual skill (Reasoning ability), and

c) Specialized skill (Scientific and technological ability including management skill).

• Building a cultivated society - Distance education leads to a general improvement of learners and through them society as a whole. Since this system of education can act without restraining conditions of numbers, it can reach very large groups. Thus, it can bring changes in the society at a faster rate.

• Advancing knowledge - Research in distance education concern the designing, selection and innovation of courses, strength and weakness of different media, study habit of learners, process of learning, teaching and effective academic communication.

• Instilling Secular View - Distance education is an alternative system which accepts the challenges of existing constraints on resources, infrastructure, funds, availability of teachers etc. It seeks to mobilize resources to provide much needed instructional package. The education system provides sufficient skillto get jobs, general education giving reasonable understanding of the nature of human being and education in morality. Thus, it tries to develop good human culture.

PHILOSOPHY OF DISTANCE EDUCATION

Distance education is a form of education which has following characteristics -

• Separation of learner and teacher which distinguishes it from conventional face-to-face education,
• Use of technology like multi-media system such as video, audio, computer etc,
• Provision of two-way communication like interactive teleconferencing so that learner can interact,
• Influence of an educational organization in planning and preparation of learning material,
• Provision of student support system which differentiates it from private study and teach yourself programme,
• Teaching of learners as individuals and rarely in groups, with the possibility of occasional meetings such as contact programmes, and
• Participation in a more industrialized form of education. Distance education is based on mass production of materials, mechanization, automation, use of technology, centralized distribution of materials etc.

ADVANTAGES OF DISTANCE EDUCATION

Advantages of distance education are many but these can be mainly classified in three parts :

• Leamer's perspective,
• Employer's perspective, and
• Government's perspective.

Learner's Perspective

• Leamer can get education without disturbing his own work schedule, ie, if he is engaged in some profession, I
• One can get education at his own pace, place and just in time,
• Effective continuing education programme can be followed,
• Opportunity to acquire knowledge in some skill or profession,
• Specialized training or re-training,
• Integration of education and training,
• Conversion of work place into learning environment, and
• Relaxed entry requirement.

Employer's Perspective

• No disturbance in the work schedule of employer as learning is done beyond working hours,
• Very cost effective method of training and learning as it is cheap compared to conventional method of education,
• Employer saves time and money in sending worker for training at some other place. Avoidance of travel and its associated cost,
• A few trainers take care of large number of trainees,
• Training can be imparted at much faster pace compared to traditional training system, and
• Learners dispersed at large number of work places can be trained simultaneously without any extra cost.

Government's Perspective

• Meeting the growing demand of higher and specialized education in a very cost effective way. Government cannot open large number of institutions to fulfil the demand as cost of opening new institution have become prohibitive,
• Fulfilling accumulated unmet demand from adult learners for education opportunities,
• Shortage of teachers in technical and professional institutions is very large. This can be overcome as only one teacher can cater to thousand of students through video lecture,
• Fulfilling the aspirations for education of people living in distant and remote areas hilly areas and backward pockets,
• Fulfilling the aspiration of disadvantaged groups like women and handicapped people,
• Re-training of government employee, skill development programme, spread of new technology, computer, management and other education, and
• Distance education provides good opportunity to bridge the gap of education by extending the outreach of programmes to cover more locations and more people with same level of investment. Investment made once get spread over large number of people for large number of years, and hence, per capita cost is very low.

## INTERNATIONAL SCENARIO IN DISTANCE EDUCATION

Distance education started with correspondence courses in various parts of the world and it was widely accepted in the early part of this century. The wide spread acceptance of correspondence courses promoted some imaginative correspondence educators to organise an international forum for this innovative system of education.

International Council for Distance Education (ICDE) was established in 1938 and its first meeting was held in the USA. The second meeting was held in 1948 only due to world war, since then ICDE has been actively engaged in spread of distance education. This organization is affiliated to UNESCO and more than 100 countries are members. The organization acts as a coordinating body and strives to promote knowledge and improvement in distance education throughout the world. The period between 1960 and 1985 has been the most progressive period for the development and credibility of distance education. The period after 1985 marks a stage of stability.

A brief description about the establishment of distance education university/organization in different parts of the world is given in Table l.

**Table 1**

| Sl No | Name of Country | Description about distance education University/ Organization |
|---|---|---|
| 1. | England | First Open University UK Open University was established in 1969 at Milton Kenyes. University has created world-wide impact on distance education. |
| 2. | France | Central National Institute of Distance Education (CNED) was established in 1939 in Paris. It is a mega open university and has more than 4 lac students. |
| 3. | Germany | The then German Democratic Republic established an Open University in 1976. Federal Republic of Germany established Fern Universitat at Hagen in 1974. This university is known for research in distance education. |
| 4. | Italy | CUD (Italian Open University) was established in 1984 at Rende in Southern Italy with office in Rome. |
| 5. | Netherlands | Netherlands Open University was established in 1984. |
| 6. | Norway | Norwegian Associate for Distance Education was established in 1985. University of OSLO offers number of courses through distance education. |
| 7. | Russia | Russia Open University was established in 1990. Correspondence education was part of normal university. |
| 8. | Spain | Distance Education University (UNED) in Spain was established in 1972. |
| 9. | Sweden | The Swedish Association for Distance Education was established in 1984. Distance education is an integrated, departmental activity mainly carried out in a small scale in dual mode structure. |
| 10. | Bangladesh | Bangladesh Open University was established in 1991 to overcome the shortage of well qualified and adequately trained workforce. |
| 11. | China | The National Network of Radio and Television University was set up in 1979. The system of RTVU is organized at Central and Regional levels and has five-tier structure. There is provincial radio to take care of local needs whose number is 43. There are more than one million students. |
| 12. | Indonesia | Universitas Terbuka (UT) was established in Indonesia in 1984. It has more than 6 lacs students and is considered one of the mega universities of the world. |
| 13. | Japan | University of the Air of Japan (UAT) was established as an Open University in 1985. It provides very innovative and flexible system of education. |
| 14. | Republic of Korea | Korea National Open University (KNOU) was established in 1982 and has more than 2 lac students. |
| 15. | Malaysia | Universiti Sains Malaysia was established in 1971 at Penang and is using technology and electronic media for counselling. |
| 16. | Pakistan | Allama Iqbal Open University was established in 1974 at Islamabad. There are more than one lac students. |
| 17. | Philippines | Distance Study System was launched in Philippines in 1976 and is famous for teacher education. |
| 18. | Sri Lanka | The Open University of Sri Lanka was established in 1980 at Nawala near Colombo. |
| 19. | Thailand | Sukhothai Thammathirat Open University (STOU) was established as single mode distance education university in 1978. It has a beautiful campus of 54 acre and has played very significant role in education in Thailand. |
| 20. | Hongkong | Open Learning Institute was established in 1989 in Hongkong. It is a completely self supporting institution providing distance education of very high quality. |
| 21. | Singapore | Singapore Institute of Management Open University was started in 1994 in Singapore to provide education to those who missed the opportunity. |
| 22. | Australia | Distance education is controlled by Open and Distance Learning Association of Australia. Distance education is part and parcel of universities and other institutions of higher learning. Some universities have become very famous in this area such as Deakin University, Royal Melbourne Institute of Technology etc. |
| 23. | New Zealand | The New Zealand Technical Correspondence Institute is the largest institution and offers a wide range of technical and vocational education. Some famous universities are : Massey University, Open Polytechnic and University of Otago. |
| 24. | Papua New Guinea | University at Papua New Guinea established an open education department in 1974 to serve diverse communities isolated from one another and outside world on account of geographical factors. |
| 25. | The Pacific Islands | University of South Pacific established in 1968 in Suva is a big distance education university in that area. |
| 26. | Middle East | Jordan set up an Open University in Amman named Al-Quds Open University. Payame Noor University was founded in Iran in 1987. It is quite a big university and has more than one lac students. Israel set up an Open University of Israel in 1974 and is using satellite technology for counselling. |
| 27. | Canada | There are a large number of distance education institutions and Universities in Canada using high end technology. Athabasca University was opened in 1978 as open university. University of British Columbia in Vancouver has become very famous in the area of open education. |
| 28. | United States of America (USA) | There are about 71 American Universities which impart education through distance mode for various types of courses. Some of the famous universities in this area are — Texas Technical University, University of California, University of Wisconsin, Pennsylvania University, Louisiana State University etc. |
| 29. | South and Central America | Costa Rica, Venezuela, Argentina and Brazil are the countries which have made progress in imparting education through distance mode. Distance Education University (UNED) was established in 1977 in Costa Rica mainly to impart professional courses like management, nursing, health services etc. First Open University (UNA) was established in Venezuela in 1977 and also teaches professional courses like engineering education besides general programmes. |

Thus, it is seen that distance education programme has spread in almost all countries of the world and is engaged in giving academically viable and cost effective alternate channel of education.

## DISTANCE EDUCATION SCENARIO IN INDIA

Demand for higher education in India has increased by leaps and bounds after it gained independence in 1947. There were only 19 universities and 635 colleges in India before independence. A number of colleges and universities were opened in all the states of India after independence but the demand continued to soar. Ministry of Education set up an Expert Committee in 1961 under the chairmanship of Dr D S Kothari, the then Chairman of UGC. The Committee recommended the institution of correspondence courses in view of its greater flexibility, economic viability and innovative method of imparting education through well prepared printed material. The Committee also suggested that Delhi University may launch the scheme of correspondence course at the undergraduate level as a pilot project. As a follow up, Delhi University established the School of Correspondence Courses at Delhi university, the UGC encouraged other universities to set up Directorate of Correspondence Courses. However, again the Education Commission under the Chairmanship of Dr D S Kothari recommended in 1964 that opportunities for education through correspondence courses be extended as widely as possible and that these programmes should also include courses in Science and Technology.

## GROWTH OF CORRESPONDENCE COURSES

Success of correspondence courses in Delhi University encouraged many other universities to launch correspondence courses from 1968 onwards. Punjabi University, Patiala was the second university in the country to set up a Directorate of Correspondence Courses not only in English but also in regional language. During the first decade (1962-72) the number of such directorates rose to eleven whereas in second decade (1973-83) the number rose to 28. In the third decade (1984-94) the total number rose to 49. Presently there are 56 directorates of Correspondence Courses in India. Southern region has the highest enrolment of learners whereas Northern region is next. Least number of students enrolled is in Eastern region. Thus, there has been haphazard development of CCI in whole country. However, correspondence courses did give opportunities to lacs of in service people, women and disadvantaged groups of people for higher education. Most of the correspondence courses depend heavily on printed materials which are of indifferent standard in a large number of cases. However, correspondence courses institutions (CCI)have certain inherent limitations. These are more or less extension departments of conventional universities. Hence, these have not exploited the full potentiality of distance education system. However, some correspondence institutions have done good job even in starting professional courses like engineering, computer, management etc.

## GROWTH OF OPEN UNIVERSITY SYSTEM IN INDIA

United Kingdom established world's first open university in 1969. Deficiencies of CCI motivated India to apply its mind to the concept of open university. UGC organized a seminar in 1970 and Prof V K R V Rao first mooted the idea of establishing open university in India. Government of India approved a working group with Shri C Parthasarthy as Chairman to study the concept of open university. The group strongly recommended the establishment of a National Open University by an Act of Parliament in 1975. Unfortunately, no action was taken on this recommendation for about a decade. Dr Madhuri R Shah, Chairperson, UGC again re-opened the issue and recommended the creation of National Open University without further delay in 1984.

## FIRST STATE OPEN UNIVERSITY IN ANDHRA PRADESH

While the effort of UGC and Ministry of Education was continuing. For creation of National Open University, Government of Andhra Pradesh decided to establish an Open University in 1982 and thus Dr B R Ambedkar Open University (BRAOU) came into existence. The main purpose of the creation of BRAOU was to provide access to higher education to adult population and equalization of educational opportunities. BRAOU offers academic programmes leading to Ph 0, MPhil, Master Degree, Bachelor's Degree in Arts, Science, Commerce. The university also offers professional courses leading to MBA and other management programmes.

## MAIN OBJECTIVES OF OPEN UNIVERSITIES

The Central Advisory Board of Education (CABE) Committee report listed the major objectives of open universities as :

- To provide an alternative cost-effective non-formal channel for tertiary education,
- To supplement the conventional university system and to reduce the pressure on it,
- To provide 'second chance' education to those who have had to discontinue their formal education or could not join regular colleges or universities owing to social, economic and other constraints,
- To democratize higher education by providing access to large segments of the population, in particular the disadvantaged groups such as those living in remote and rural areas, working people, women and other adults who wish to acquire and upgrade their knowledge and or skills,
- To strengthen and diversify the degree, diploma and certificate courses related to employment and necessary for building the economy of the country on the basis of its natural and human resources,
- To provide continuing and life-long education to enrich the lives of the people, and
- To provide an innovative system of university level education, which is flexible and open in terms of methods and pace of learning, combination of courses, eligibility for enrolment, age of entry, conduct of examination and operation of the programmes with a view to promoting learning and encouraging excellence in new fields of knowledge.

## INDIRA GANDHI NATIONAL OPEN UNIVERSITY

Shri Rajiv Gandhi, the then Prime Minister of India, took great initiative in creating National Open University for the fulfilment of major objectives. Indira Gandhi National Open University came into being by an Act of Parliament on September 20, 1985 and was officially inaugurated in November 1985. The university launched its first programme in January 1987. 50 far the university has offered 39 programmes and 486 courses enveloping various disciplines such as arts, commerce, education, management, science, engineering, health, computer etc. The number of students enrolled is 4.3 lacs. The university was designated as 'Centre of Excellence in Distance Education' in 1993 by Commonwealth of Learning, Canada due to its excellent performance. The university has established a huge Electronic Media Production Centre (EMPC) with Japanese help which is a unique centre in this part of the world for production of video-audio cassettes.

STATE OPEN UNIVERSITIES

Ministry of Human Resources Development in its National Policy on Education (1986) gave prominence to open university system as a means to strengthen opportunities for higher education. This was a turning point for distance education in India.

| Sl No | Name | Established |
|---|---|---|
| 1. | Dr B R Ambedkar Open University, Hyderabad | 1982 |
| 2. | Kota Open University, Kota | 1987 |
| 3. | Y C Maharashtra Open University, Nashik | 1989 |
| 4. | Nalanda Open University | 1988 |
| 5. | M P Bhoj University, Bhopal | 1992 |
| 6. | Dr Baba Saheb Ambedkar Open University, Ahmedabad | 1994 |
| 7. | Karnataka State Open University, Mysore | 1996 |
| 8. | Netaji Subhas Bose University, Calcutta | 1997 |

The first three universities are fully functional while remaining universities are still in various phases of establishment.

INSTRUCTIONAL SYSTEM IN DISTANCE EDUCATION

Main feature of instructional system in distance education is multi-media approach and mainly consists of following:

• Self instructional printed material : Students are supplied with the printed material in blocks. Each unit in a block is written in self instructional style and consists of structure of the unit, introduction, objectives, main contents, sub contents, self check exercises, summing up, unit end activities, points for discussion, key words and suggested readings.

• Video - audio : Video - audio is a supplementary material to printed books. They are in the form of lectures, debates, discussion and also shows different manufacturing process, design system etc so that a student can have a full comprehension of the subject.

• Assignments : Assignments are an integral component of distance education and are compulsory. The assignments may be computer marked or tutor marked. These assignments serve the purpose of continuous evaluation of student's performance. Students get feedback on their performance through tutor marked assignment. These assignments are evaluated by local counsellors and they provide feedback alongwith a number of suggestions for student's performance.

• Academic Counselling : Counselling is an important' activity in this system of education. Counselling is different from the usual classroom teaching. Counsellors answer learner's question in counselling sessions besides clarifying their doubts and overcome the difficulties which they face while going through the text. During counselling sessions, learners also interact with their peers. Audio-video cassettes are also played during such session and their contents are analyzed.

• Interactive teleconferencing : IGNOU has also started interactive teleconferencing from 1994 using satellite. IGNOU headquarters in Delhi has an uplink station. This is a one way video and two way audio conferencing system and the talk back is provided through long distance telephone. Broadcasting is done from studio in Delhi and the same is received at the other receiving end. Programmes are transmitted on line or through specially recorded video. The studio has telephone / fax facilityand learner can ask questions, seek clarifications through terrestrial telephone system from the teacher. Broadcast is done on extended C-band transponder of INSAT 2-B. This system of interactive teleconferencing has proved to be very successful for professional education like management, computer etc.

• Practical training and intensive counselling : Depending upon the subject, minimum amount of practical training is also imparted in colleges / institutions or work centres. In certain specialized subjects, intensive counselling is also resorted to.

• Project report : learner is also required to prepare project at the end of the term and is evaluated.

UNIQUENESS OF ENGINEERING AND OTHER PROFESSIONAL EDUCATION

Engineering and other professional courses like management, computer science etc have certain specific uniqueness and therefore, the approach to distance education in this area is a little different. A basic general assumption is that learning is primarily an individual activity and is achieved through an internationalizing process. The basic purpose of distance education will then be as to how this individual learning can be supported and facilitated using latest technology.

• Target group : In the case of engineering the target group presently is diploma holder whereas in case of management these are graduates / post graduates. In case of computer the target groups are 10 + 2 as well as graduates. In the case of nursing the target group is GNM.
• Course preparation becomes different as these include theory, practical and design courses,
• Programme study centre for practical,
• Work centre,
• Support from industry for leamer,
• Laboratory courses,
• Field work related functional assignment,
• Participation by employer group and industry for project work.

COURSE DEVELOPMENT PROCESS

Course development process consists of four major tasks :

Course Formulation,
Course Designing,
Development of Printed Material, and
Audio-video Production.

• Course formulation: Formulation of course is the first step and consists of need assessment, identification of target group, course identification and formulation of course outline.
• Course designing : Course designing consists of defining the content of block, finalizing unit wise course outline, deciding themes for audio-video programmes and integrating the media components.
• Development of print material : Following are the operations in development of print material.

Unit writing,
Content editing,
Format editing,
Language editing,
Finalization of manuscript,
Developing graphics, and
Printing.

• Audio-video production : Audio-video production consists of following stages:

Preparation of academic note,
Development of academic script,
Development of production script,
Programme production,
Post production activities like editing etc, and
Preview.

KEY STEPS IN DEVELOPMENT OF PRINTED MATERIAL

Task analyses is one of the first procedures to be developed in instructional design in case of technical subjects. It should be done in such a way that it reduces the skill requirements to a set of operator procedures. Task analysis may be distinguished in terms of the basis on which they are carried out :

Objectives,

Behavioural analysis,
Information processing,
Decision paradigm,
Subject matter structure, and
Skill schemata.

In case of developing material for any practical work or laboratory work; the task analysis can be carried out in following way.

• To break it down into series of steps sufficiently explicit so that a learner unfamiliar with the procedure could follow what was involved.

• To document the break down in a proper form.

Use of 'Mental Practice'

Mental practice is the name which has been given to the introspective rehearsal or visualization of psychomotor skills.It has been used very widely as a means of boosting athletic performance in sports. Filts and Posner have suggested that mental practice is most effective in the initial cognitive stages of skill learning. The idea of using mental practice is to prepare learners for what they would be doing in practical classes. The function of the package would be to enable learners to 'Climb as far up the learning curve' as possible before arriving for practical. They should be able to imagine what it would like to perform the work themselves. It should be described in such a way that the practical should look real for them and the learner should be able to visualise as to what was involved. Learner can mentally practice the skills before their arrival at the work place. This would not only give them an understanding of the total procedure but also a 'feel' as to how the work or test will be done and sense of its overall 'structure. '

Diagrams in Test

It is believed that realism makes a significant contribution to the effectiveness with which learners can make use of diagrams in text. Yet the research evidence suggests that the opposite is the case. It was found that students learned from abstract linear presentation, very effectively and realistic photograph was no more effective. It seems the photograph is ineffective, not because it contains extraneous information but because it presents more information than the perceptual and memory systems can handle. Therefore, it is desirable to Simplify the diagrams to their essential elements. In terms of instructional effectiveness an abstract diagram or detailed shaded diagram, had not much difference but there will be big difference in cost because detailed shaded diagrams costs much more.

Instructional Video for Distance Education

Following are the strength of video while using video in distance education.

• Video personalises distance learning materials by introducing the tutor to the learner.

• Video is able to direct the attention of the learner to the relevant materials, for example using techniques such as close ups, image freeing, masking non-essential visuals, pans and tilts.

• Video is able to show motion which is very crucial in demonstrating operation of machines. It can also clearly demonstrate different stages of manufacturing process.

• Video is able to combine various sounds with a range of visuals such as animation, stills, graphics, outdoor scenes, studios shorts, interview of leading authorities in various fields etc to stimulate and motivate the learner.

• Open ended video segments may be used in problem solving situations, either to trigger group discussion or for individual assignments.

• Video permits safe observation of phenomena that might be hazardous to view directly, for example dangerous scientific I experiments and demonstrations.

• Video is very helpful in combining concrete images with words to illustrate difficult abstract concepts.

Designing Instructional Video

Points to be considered while discussing instructional video.

• Apply Schrammian communication model.

• Discuss strength and weaknesses of different presentation styles and decide when to use them.

• Apply the concepts of integration, activation and segmentation in video design.

• Identify key design issues and apply accordingly.

• Try to make programme interesting to the learner.

PRODUCTION OF INSTRUCTIONAL VIDEO

• Working relationship between course writer, script writer and media producer must be established.

• Course development must fit into three stages of production ie pre-production (design and development), production (shooting graphics) and post production (rechecking of script and editing).

• Conveying ideas to the media producer - There is fundamental culture gap between producers who are generalists and academics who are specialists and who see the content as very important. Hence, there must be proper interaction between them and should talk to one another in the same language.

• At the end, there should be formative evaluation to correct mistakes that may have been made in design of instructional materials so as to revise the product.

Integration and Use of Video in Distance Education

Integrative multimedia learning packages are very useful in increasing learning potential of students. Video must be integrated with printed text to make it educationally useful. There are two important concepts in practical teaching.

• Integration - It increases the efficiency of communication and relates to the clarity and competency of message transfer.

• Activation - It increases the effectiveness of communication and relates to the retrival and understanding of the message.

Integration occurs when a presentation in one medium, is supported, complemented, elaborated and/or reinforced by a presentation in another medium. The efficiency aspect of integration arises as a consequence of whether the message are presented to the student in such a way that they are learnable. It is a fact that no single medium is capable of transmitting all messages. Multi-media learning packages, where the different media commonly act in tandem is an advancement or the communication of the message is improved. However, with integration there is synergistic effect. Though the different media acting to reinforce each other messages by offering alternative perspectives, presentational styles and by catering for students learning behaviour, the transmission of those messages is greater than what would be achieved if each medium has been used in tandem. In these integrated situations, the learning potential of students is increased.

Activation - The concept of activation centres on student doing something of being physically active in their learning. There is strong evidence to suggest that learning by doing gives the most effective long term results. A video programme should always be integrated into the curriculum and with print medium through its text, photographs tables and self help exercise. The questions should reinforce concept and should provide an assessment based on the understanding of the topic. Thus exercise themselves can become a teaching tool.

Activation can occur through exercises which can occur during and or after viewing exercise can take any form such as ;

• Simple fill in the blank exercise to help memory recall;

• Projections, suppositions and analytical exercises to list and agenda deeps thought;

• Project work where students to do some research to help apply the principles to their own situation; and

• Feedback mechanism. It can be in the form of assignments, letters or evaluation.

ENGINEERING EDUCATION THROUGH DISTANCE MODE

Allama Iqbal Open University started functioning in Pakistan in 1975. There was serious shortage of middle level technical personnel and hence a Department of Technical and Vocational Education was also opened in this university. The university has started offering a number of technical and vocational courses including skill development programme. However, these courses are limited only upto diploma level. Some of their skill development programmes are quite popular in Pakistan among working people as these programmes give an opportunity to them to improve their qualification. ,

Sri Lanka Open University also offers a number technical and vocational courses to fulfil the need of middle level technical personnel. They have also started making an effort to develop programmes for graduate engineering courses for diploma holders.

India has developed a massive technical educational system comprising about 500 engineering colleges and 1070 polytechnics, accommodating, over 70 000 students at degree level and 122 000 students at diploma level after it gained independence in 1997. While the existing infrastructure is ably serving the nation, the rate of technology modernisation at work places has created new demands for further education of fresh entrants to work and for providing second chance for learning for those who have already gone through technical education and are desirous of continuing education for professional development at work.

Need of distance learning in India in engineering

Even at the beginning of 1985 itself, India had an estimated accumulated manpower of over 3 70 000 engineering graduates (including post graduates), of which over 320000 were economically active and of over 5

60 000 estimated accumulated manpower of engineering diploma holders of which over 4 50 000 were economically active constituting a large potential learner group' for updating and upgrading hitherto not served by the formal system of technical education.

While engineering institutions have been conducting post-graduate level programmes and short-term continuing education courses for professional development of working graduates, the main responsibility for upgradation to degree level of sub- professional with engineering diploma education, who are mostly employed has mainly rested with professional societies such as Institution of Engineers and other offering associates membership certificates.

The programmes by professional societies, serve a very important national human resources development need. However, the very task in terms of numbers to be catered is so gigantic, that there has been a need to explore every other possible channel to meet the learner's demand.

The first effort in imparting engineering education in India through distance learning was made by Jawaharlal Nehru Technological University, Hyderabad.

CORRESPONDENCE EDUCATION AT JNTU

Jawaharlal Nehru Technological University (JNTU) was established in 1972 by an act of AP State Legislature. Four colleges were transferred to the University as constituent colleges. These were the JNTU College of Fine Art and Architecture at Hyderabad, (established in 1940). and the JNTU Colleges of Engineering at Hyderabad, Anantapur and Kakinada (established in 1965 and 1946, respectively).

The School of Continuing and Distance Education was established in 1983 and offers at state level the following correspondence courses : B Tech in Civil Engineering, Electronics, Electronics and Communication and Mechanical Engineering. Proposed courses include: Computer Science and Architecture.

B Tech courses are open to in-service diploma holders in the state with one year experience subject to an entrance examination. Correspondence courses are delivered mainly in the form of printed correspondence text. Personal contact programme takes place at all four .colleges on Sundays. The university is in the mode of changing to distance mode using multimedia technology etc.

DISTANCE EDUCATION IN ENGINEERING AT DIPLOMA LEVEL BY YCMOU, NASHIK

Yashwant Rao Chavan Maharashtra Open University, Nashik was first open university which started offering technical courses at diploma and vocational level. The main feature of the programme structure is the open access at all levels with the possibility of multiple entry, multiple exit and vertical mobility. This gives modularity and flexibility to the programmes with wide choice to learners. Learners may be of any group such as less educated, educated and higher educated (tertiary level).

Following programmes are offered in YCMOU :

- Diploma in Applied Electronics;
- Diploma in General Electronics; and
- Certificate programme in engineering vocations like Mason, Plumber, Fitter, Wireman, Lathe Operator, Radio Mechanic etc. Practical

Students are required to carry out 12 to 16 home experiments with the help of a kit provided by YCMOU and six experiments at a laboratory in electronics. They perform the experiments at home using a working platform and some small cheap instruments such as a multimeter. The laboratory experiments are to be carried out on a regular workshop basis under the supervision of staff at the study centre.

Industrial Training Project Work

On completion of the theory and practical courses, a student will contact on his own an industrial unit for in-house training and project work. The study centres will however, assist the student in finding a place in the industry. In-service students can complete the project at their place of employment.

Assessment

Each course has two components : theory as well as practical. For the theory component of each course, there will be continuous assessment, conducted periodically at the study centre through class test, home-assignments and a university examination at the end of the programme.

PROGRAMMES IN ENGINEERING IN INDIRA GANDHI NATIONAL OPEN UNIVERSITY

Indira Gandhi National Open University (IGNOU) has designed its employment related engineering programmes seeing the emerging needs of technical education system in the country to cater to professional development.

Target Leamer Group

In the first instance, learners are to come from those who are diploma holders of a polytechnic or above and are' employed. The learners will represent:

• Existing work-force,

• Entrants to work place,

• Those desirous of second chance of learning ie elderly (aged) working population.

• Those in need of training for technology upgrading, and

• Those with potential for emerging employment areas.

Methodology of Programme Area Identification

The 'University has identified the areas of 'Water Resources' and 'Construction Management' as its priority areas in the first instance. This identification is in accordance with the urgency felt in the needs for training and for continuing education and retraining in these areas as confirmed by Ministry of Water Resources and Public and Private Sector Construction Industries.

IGNOU proposes to follow similar approach in identifying its other programme areas. Specifically in choosing a programme area, IGNOU builds upon the experts recommendations by establishing direct dialogue with respective employer groups and national industries, R & D and teaching and training. institutions and professional bodies; particularly those which are already committed to continuing education and retraining at post-diploma level.

This enables the University to have a check on the utility of the programme area identified and on expected learners numbers. The various parameters that the University thus keeps in mind in making the choice of the programme area are :

• Criticality of the area in National Economy,

• Possibilities of large scale expansion in the area,

• Explicitly felt continuing education and retraining needs by the employer groups/industries!R&D institutions etc at post-diploma level,

• Availability of large student number,

• Non-availability of education and training facilities in the area under the conventional system, .

• Preparedness of professional bodies/employer groups/industries R& D organizations to participate in preparation and implementat ion of programmes, and

• Availability of resource base in the country for programme development. Methodology for Programme Development with Aexible Structure With the identification of such user commitment to programme needs, the University, in participation with industry, defined employment oriented functional course packages for training of engineering diploma level (and beyond) work-force in the programme area identified. These functional courses are then further complemented with necessary theory, skill, laboratory and where necessary, additional field-training inputs so as to form employment - related advanced diplomas and degrees at UG and PG levels. Thus, the approach to designing a degree curricular structure is such thartt consists of an advanced diploma at the first stage, leading to a degree in the second stage; thereby offering the student the flexibility of an intermediate exit point, if desired.

A learner is expected to complete 32 credits each year. He can earn an advanced diploma having a programme duration of 2-years after diploma from a polytechnic.

To offer a degree. in a given engineering discipline with specialization in the functional area the programme structure have two more modules of one year duration each beyond an advanced diploma.

The University proposes that the employment related degrees be so designed that it would be equivalent to corresponding engineering degrees in the country.

In-service Training Packages

As explained above, employment-related course packages at the level of two modules of advanced diploma or at the level of two modules between advanced diploma and degree are meant to ensure a specific employment orientation to engineering programmes of IGNOU. Further, the approach to programme design is such that advanced diploma can include a post advanced diploma certificate comprising one module and post-advanced diploma modules leading to B Tech Degree could include a post-advanced diploma certificate once again of one module; thereby giving the learner greater flexibility of exit points while serving different industry-related training needs.

However, it is appreciated that there could be certain industries who may have a need for training of their employees only in functional courses, with no urgency on the part of its employees to pursue an advanced diploma or a degree. This throws up a new learner group.

In such a case, the programme structure design as above provides for introducing further flexibilitywhereby proposals from an interested industry or a group of learners could be developed for conducting in-house functional course packages, which will not have any diploma or degree equivalence considerations but which will offer the interested industry or the learner group an important in-service training facility. The University has made such in-service training opportunities a built-in component in its flexible programme designs.

Course Preparation

For Engineering and Technology courses, the University prepares self instructional print material with the help of course preparation project teams drawn from the reputed Indian Institutes of Technology, engineering colleges, universities, R& D institutions, industries and professional bodies from all over the country. ,

Similarly, audio and video cassettes are produced in consultation with the course writers, other technical experts, in-house faculty and producers and, where feasible, with the help of other universities, R & D institutions and industries.

Support Services

The University provides support services for engineering courses by augmenting existing study centres with work centres established at collaborating engineering institutions and industries situated at the locations of the study centres.

Work Centres for Engineering Programmes

While study centers take care of support services in general, work centre takes care of specialized courses because of special needs such as :

- access to academia and practicing professionals as tutors/counsellors,
- participation by practicing professionals in conducting work-related functional assignments and syndicate exercises,
- laboratory/workshop use,
- access to subject library, technical documents and training software of institutions/industries for educational use,
- access to computer facility,
- access to site equipments, site testing facility and actual work situations for work-related learning components, and
- access, in case of need to additional counselling space and seminar room, etc.

The University seeks collaborative help and support of engineering institutions/ industries/organizations (situated at the locations of study centers), which act as work centers augmenting student support services at the study centers.

The University welcomes participation in its programmes as above by universities, technological institutions, engineering colleges, R & 0 institutions, industries and their training establishments, agencies of employer groups and centres of professional bodies by offering specialized inputs in their capacity as work centers; and, where adequate support services are available for a complete programme, by offering even Programme Specific Study Centers.

Individualized Employer Support for a Learner Employee

Finally, every learner admitted to a programme in Engineering & Technology is attached to a study centre of the University. As the engineering programmes are addressed to learners who are employed, the University recognizes that, more often than not, the employing organization of a learner will not be a study centre of the University. However, the said employing organization may be in a position to offer to its learner employees some of the support services as at a study centre and/or at work centre, like ; individualized access to professional(s) of the organization as tutor/counsellor, access to technical library, computer, access to site, etc.

Further, in respect of functional, field-oriented courses under the programme, the employing organization of the learner employee may also be in a position to assign to the learner 'functional assignments' mentioned above which, along with knowledge about work practices and extracted examples from work, may enable learner to practice the knowledge acquired in real work situations.

The University welcomes such individualized educational support by employer organization to their respective learner employees, as this in turn would enable the University to greatly widen its resource support base at the locations of the study centres.

Laboratory Courses

Laboratory courses under the advanced diploma and degree programmes, will be organized at selected work centres with the help of collaborating institutions/organizations, and may extend over a period of two weeks for a 2-credit laboratory course. The students will have to attend the laboratory course on full-time basis, the attendence being compulsory.

In addition to normal laboratory experiments, the laboratory course, thus implemented through residential term, may also comprise extensive syndicate exercise(s).

Computer Education

Role of computer in our society has become all pervasive. There is no area where computer has not crept in; be it a shop, a home or office. People cannot imagine good life without computer. Therefore,. computer education has a very large role to play. A large number of people have to be trained in a very short time. Changes in computer technology is very fast. In other words, obsolescence rate is very fast in the field of computer. Therefore, people have to be retrained occasionally and that also within a short time span. Distance education is the only mode of education which can train large number of learners at one time simultaneously at minimum cost.

Keeping in view the need of time, IGNOU started computer education by establishing school of Computer and Information Sciences. First course was launched in 1991 leading to Diploma in Computers in Office Management. Presently following programmes are on offer :

• Master in Computer Application (MCA),

• Bachelor in Computer Application (BCA),

• Diploma in Computers in Office Management (DCO),

• Certificate in Computing (CIC),

• Certificate in Networked Oriented Office Computing (CNOC),

• Certificate in Website Design and Management-{CWDM),

• Certificate in Software Application (CSA),

• Certificate in Internet Application (CIA), and

• Preparatory Programme in Computing (PPC).

Programmes have been designed on the principle of multiple entry, multiple exit and certification at each stage of completion. For example, if a learner has completed CIC, he can discontinue his study and go for employment. After some years, he can again join BCA and get the degree and if he continues, he can even get MCA. However, admission to MCA programme is not granted directly. They get admission only after completing some of the programmes like CIC, DCO or BCA etc.

Main purpose of Distance Education Programme in Computer is as follows:

• Certification,

• Improvement of skills,

• Acquisition of professional qualifications,

• Continuing education and professional development at work place,

• Self enrichment, and

• Diversification of knowledge.

Programme Delivery: Programme delivery is learner oriented as the student is an active participant in the teaching and learning process. Traditional distance education using multimedia approach is used in computer education also. It comprises:

• Self instructional printed material,

• Assignments for assessment and feedback,

• Supporting audio-video programmes,

• Academic counselling,

• Practical at designated institutions,

• Project work, and

• Functional assignment/work related field project.

The programme is based on credit system and evaluation is done by standard procedure for the University. Concept of partner institutions have also been introduced by the University in which total student delivery system is taken care by the partner institution.

Web based training by IGNOU - increasing efficiency, effectiveness and competitiveness is a big challenge for everybody in modem society. Overcoming this change is imparting education/training. Universities have to find out new way Jo educate and retrain people to keep them up to date. Delivering education and training by internet is a key tool to meet the challenging requirements of modem society.

Advantages of Internet based training are as follows:

• Time factor as one gets all information instantly,

• Quick receipt of course material,

• Future work place environment will consist of Interner Intranet and extranet; hence such training is more useful,

• Access to current information, and

• Study from your home at your time.

Indira Gandhi National Open University has designed the IGNOU's learning zone in response to real requirements and pressures facing to-day's learners/professionals (http://www.ignou.edu).

Students can join the courses on internet by logging the website and getting all information. One can select the programme and pay the required fee. After receipt of the fee the University will send password and then one can download the materials. Provisions have also been made to get internet facilities through an 'Empanelled Internet Access Point'. Website is a dynamic source of latest information and will be undergoing continuous updates. Access to course materials, assignments are restricted only to those who have paid fees.

Kota Open University, Kota, YCMOU, Nasik and MP Bhoj University, Bhopal also offer a few computer courses. A number of other dual mode universities in India also offers computer education through distance mode. Computer education through distance mode has became very popular and is imparted by various universities throughout the world such as Australia, USA, UK, Europe etc.

MANAGEMENT EDUCATION

Management education in India represents one of the fastest growing segments of technical education today. The growth is primarily a market led one, fuelled by the need for managerial personnel in an economy seeking to rapidly globalize and liberalize. In addition to the burgeoning industry demand, government, public and social sectors in India, the so called undermanned sectors show a need and supply gap of managerial personnel. Developments like management education through the distance mode are significant in that they reflect the response of the society to the need of creating equal opportunities for large target through the enabling mechanisms of technology so as to meet the challenge of equipping its human resource in managerial skills. Management Education through the Distance Mode Distance education programmes in management in the country in the accepted sense of open and distance learning, were initiated with the setting up of open universities in India. First distance education programme in management at the PG level in the country was launched by Indira Gandhi National Open University in 1986. It was a pilot programme of the University with an intake of about 3000 students. Today the University has an average registration of around 35 000 with management programme and has since been declared a Centre of Excellence by the Commonwealth of Learning for the quality of its programmes. The management programme has about forty courses on offer which in various combinations offers certification for MBA, four post graduate function specialization diplomas, a post graduate diploma in management and a diploma in management. In addition the School of Management Studies is in the final stages of putting on offer its Ph 0 programme in management and an undergraduate programme as BBA very soon.

Following Programmes are on offer in Management in IGNOU

• Master of Business Administration (MBA),

• Diploma in Management (OM),

• Post Graduate Diploma in Human Resource Management (PGDHRM),

• Post Graduate Diploma in Financial Management (PGDFM),

• Post Graduate Diploma in Operation Management (PGDOM), and

• Post Graduate Diploma in Marketing Management (PGDMM)

The distance education system in management today in India is represented by one national and three state open universities offering management programmes lat the post graduate level. The open universities were set up with the basic aim of providing opportunities for higher education to large segments of population, to extend the benefits of such education to disadvantaged groups or individuals and for providing opportunities for upgrading knowledge and skills.

Most of the State Open Universities, in order to avoid the duplication of resources and efforts have adopted the IGNOU Management programme.

In addition to the above, there are institutes like the All India Management Association, established by a local management association and privately founded institutions which offer duly approved programmes in management at the PG level. A large number of universities operating in the dual mode, offer correspondence courses in management, through their correspondence course institutes (CCls). The major difference in the teaching - learning through the open universities and the correspondence mode of CCI is in the mode of delivery of instructions and the provision of student support services. Print material which is usually the only mode of instruction used by the CCI is not in the self-instructional mode. The open universities, and other open learning institutes use a multi-media mix in addition to the print material sent to them. Some features of the open and distance learning programmes in management along with a description of the methodologies used in design development and delivery of programmes is given below.

Special Features of Management Education Through Distance In conformity with the levels of management education in general, the distance education programmes in management prescribe the eligibility conditions of graduation plus some years of experience. Intake quality is regulated through a National Entrance Test. The target segment for most distance education management programmes specially in the university sector, is not the same as that of conventional management institutes and comprises marketing executives or those in supervisory position, aspiring to be managers. Some of the important features of distance education management programme are :

• High quality self-instructional material in standardized house styles, designed with inputs from open learning instructional technologies to assist self learning;

• Networked approach to programme design and development, with best resources available in the country, both from academics and industry, participate in the design and preparation of print; audio and video material for the courses. This enables industry interaction and responsiveness besides providing a richer resource base to build the programme;

• Provision of equal opportunity of admission to people from all over the country / state;

• Provision of learning at the learners' own pace, place and time;

• Cost effective and cost efficient educational operations;

• Multi-media approach in the preparation of course packages with self instructional printed and audio visual course materials;

• Indian Regional case studies in print or AN formats;

• Network of student support services throughout the country/state with face to face or distance counselling wherever needed;

• Both continuous and term end evaluation, with term end examination being conducted twice a year;

• Use of information technology and communication technology in course design, delivery and programme administration;

• Interactive satellite aided teleconference to reach learners wherever they are; and

• Credit weightage of courses to facilitate comparative evaluation across institution and facilitate credit transfer.

Programme Design and Delivery System by IGNOU

After due approvals of a programme by the bodies of the University, expert committees are constituted from among the eminent academics and practitioners of management to deliberate upon the type and scope of courses to be in the programme. The expert committee meetings are followed by specific course committee meetings, drawn from a broad base of subject specialists and practitioners. At these meetings detailed course contents are decided upon and the course work is allocated to resource persons both internal and external, depending upon their respective specialization. Internal faculty also acts as the course coordinator and / or editor of the course. This networking with a large number of external resources has enabled the open university to create around 200 blocks (booklets) of print material in management, about 112 video programmes and 68 audio programmes, all of which have been found to be quality material by the users. All courses in distance education programmes have standardized hours of student work measured in credits, one credit being equal to 30 hours of work. Most courses could have a credit weightage of 6 to 8 credits. The programme is delivered through network of study centers (126 in number) throughout the country. Each learner who joins the programme is assigned a study centre of his choice. Complete academic services of counselling, assignment evaluation and monitoring are provided at the study centers. These study centers are administered through 19 Regional Centers which are decentralized administrative offices of the University in state capitals/major city of each state.

Counselling is now also provided through interactive video teleconferencing, which is a one-way video two-way audio configuration. The satellite uplink is stationed at IGNOU headquarters at Maidan Garhi. The teaching end studios offer facility for all kinds of personal and electronic presentations. All 126 study centers for management are activated as the service sites for video teleconference. The talk back facility is at present through terrestrial STD lines. This configuration is also available to other distance learning institutions to utilize it for their training / teaching activities. The configuration is interactive. Synchronous dialogue with large number of learners, otters excellent opportunities, 'Of faculty development efforts through teleconference, case study discussion, learner update workshops and counsellor on mutation programmes all of which have been utilized for the management programme of the University.

Academic counselling is an important instructional component of the distance teaching-learning at open universities. Both general (person specific) and subject specific counselling is provided at these study centers. The following facilities are extended to the students at the study centers:

• Subject specific academic counselling by part-time academic counsellors,
• Audio and Video facilities, and
• A Library corner.

Reception and information services relating to rules, procedures, schedules etc of the University.

Submission of assignment and then evaluation with tutor comments and grades.

Evaluation System

The evaluation system in open and distance learning institutions is also different from conventional universities, in that the evaluation has both a continuous and term-end component. Conventional management programmes also have a system of in-class assessment by the concerned faculty. In distance education management programmes, however, on account of the distance between the teacher and the taught, assignments are centrally prepared and dispatched according to a preannounced schedule, who are supposed to submit the same to their study centers or I headquarters as the case may be, where they are evaluated. The weightage of continuous assessment has been found to vary between 30-40.

Term End Examinations

The term-end examinations are .usually held at the end of each semester on preannounced schedules, with study centers also acting as examination centers. Most distance education programmes in management follow a grading system instead of a marking system.

HEALTH EDUCATION THROUGH DISTANCE MODE

In the evolution of educational process, all systems of teaching and training have undergone a sea change. This change is a culmination of technological advancement, quest of knowledge and the need of the society in its process of evolution. Medical education is no exception. Usually, it is seen as the most conservative discipline. Conservative because, it follows rigid and rigorous methods of training the student so as to make them fit to handle human lives. When the world is concerned about the quality of life and quality assurance in all systems, obviously medical education cannot afford to compromise in the quality dimension.

But the fact remains that the medical education has to cope with the increasing demand for creating health professionals to meet the need of the country created by population explosion. Though, it is true for all the countries, the developing nations have to search for a suitable alternative in manpower development while ensuring the qualitative aspect of the training system.

In developing countries like India, health manpower management is the most neglected field. In contrast to developed countries, the developing countries have more number of doctors than that of the nurses and paramedical personnel. For example, in India there are more than 365 000 doctors, 264 000 nurses and about 350 000 paramedical health workers. There is one doctor for about a population of 2000. Still, worse is that there is no scope for updating the knowledge of this vast army of health manpower that is existing at present. Moreover, a large majority of doctors and nurses are working in urban areas.

To keep pace with the fast growth of knowledge in health sector, updating of knowledge and skillsat least in every 5 to 10 years intervals is a necessity. Similarly, the strength of the nursing and paramedical personnel has to be increased about four fold of the present capacity. This vast manpower training is only possible through a flexible, cost effective system, ie the distance learning mode of training and education - which could not only meet the manpower gap but also fill up the time lag in developing such a manpower.

The crux of the problem lies in quality assurance vis-a-vis the feasibility of imparting hands on training (ie skill training in health) through distance learning mode. The school of health sciences, Indira Gandhi National Open University (IGNOU) has taken up this dual challenge and has launched two programmes, ie, Post Graduate Diploma in Maternal and Child Health (PGDMCH) and B Sc (Nursing) for MBBS doctors and diploma holders nurses, respectively. Few more programmes are in advanced stage of development, ie, Post Graduate Certificate in Rural Surgery (CRS), Auxiliary Nurse Midwife (ANM) Upgradation Programme, Certificate in Health and Environment and an one year Diploma in Geriatric Medicine.

All these programmes are unique in their approach to meet the national health challenges. Though the curriculum of the above programmes are different from that of the conventional educational system in India, they are designed to address the priority need of our population so as to take care of the important health indicators. A brief account of these programmes is given below :

• B Sc Nursing Programme

B Sc Nursing programme was launched in July 1994 for in service diploma holder (RNRM). It is a 3-year programme with a provision of 500 seats in each academic year. In December 1997, the first batch of students completed three-year programme. It has 80 credits (36 credits in theory and 44 credits in practical) and comprises 10 theory and 8 practical courses.

The programme is offered through 17 work centres/Programme Study Centres established in various colleges of nursing all over the country. Every year 25-30 students are enrolled in each work centre for counselling and practical contact sessions. At work centres learners perform the supervised practical activities under the supervision of clinical supervisors and perform self-activities at their work place .

• Post Graduate Diploma in Maternal and Child Health (PGDMCH)

This one-year diploma programme meant for MBBS doctors was launched in January 1998 with a provision of 720 seats in each academic year. This programme covers tre concepts, practices and application of knowledge in the field of maternal and child health (MCH) with a view to:

• Improve the knowledge the skills in MCH as conceptualized in the CSSM programme, and

• Upgrade clinical competence of medical personnel for providing quality MCH care for achieving goal of Health for All as envisaged in National Health Policy.

This is a comprehensive programme which comprises 6 courses from three disciplines of medical specialties, ie, Preventive and Social Medicine, Gynaecology and Obstetrics, and Paediatrics. Out of 32 credits it has 18 credits of theory and 14 credits of practical component.

This programme is being implemented through a diversified approach which is an innovative method with three-tier system involving Medical Colleges (Programme Study Centre, PSC), District Hospitals (Skill Development Centre) and the workplaces of the enrolled doctors to provide hands-on training.

This method is being supplemented with the monitoring mechanism at school level by school faculty, at state level by Regional Health Sciences Advisory Committee (RHSAC) and at peripheral level by the Regional Consultants.

Twenty-four medical colleges have been identified as Programme Study Centres (PSCs) throughout the country. At each medical college, 30 students are being enrolled where they are being demonstrated important practical skills by qualified academic counsellors. The students perform certain activities/skills at identified skill development centres (SDCs) under the supervision of qualified specialists (SDC counsellors). The rest of the activities are being performed by the students at their work place .

• Post Graduate Certificate in Rural Surgery (CRS)

The objectives of this programme is to provide Continuing Medical Education (CME) to practicing surgeons so as to enrich them with appropriate skills to meet the emergency surgical need and demand of people from peripheral health setups. The target group includes  Post-Graduate Degree/Diploma holders in speciality of General Surgery/ Orthopedics ENT /Obstetrics and Gynaecology. After undergoing this programme, an orthopaedician will be able to practice other emergency surgical operations eg general surgery, obstetrics and gynaecology, ENT. Similarly, a gynaecologist ENT specialist/general surgeon will be able to handle emergency surgery of other disciplines mentioned above .

• Diploma Programme in Geriatric Medicine

A 32 credit one-year Diploma Programme in Geriatric Medicine for family physicians is being developed by the School with a view to enhance the knowledge and skills of practicing doctors in the field of geriatric care.

Programme Implementation

The programme implementation component is the most challenging part in distance education system. The SOHS, IGNOU is implementing the PGDMCH programme through a diversified approach which has been designed on the principles of pedagogy of learning and integrated with a mechanism of quality monitoring. It includes a three-tier system of training and a three-tier system of monitoring.

The three levels of hands on training includes teaching and demonstration of practical skills at a tertiary setup (medical college), supervision of skills at a secondary setup (district hospital) and self practice at a primary setup (clinic/primary health centre). The breakup of duration of training at the above three setup are approximately 30%, 30% and 40%, respectively.

Similarly, the three levels of supervision includes peripheral level of monitoring by regional consultant (a retired medical person with state level experience), state level monitoring by regional health sciences  advisory committee (RHSAC) which has state level health officers and representatives academic and administrative functionaries from various levels, and central level monitoring by the School of Health Sciences. A provision is also being made to have independent appraisal of the quality of the training package. The periodic teleconferencing acts as a reinforcing mechanism.

ROLE OF TECHNOLOGY IN DISTANCE EDUCATION

Knowledge and information has become the strategic resources and transforming agents of post industrial society. Computer, electronics and satellite technology has brought revolutionary changes in the society. Obsolescence time of technology has become very small because new technologies are coming in the market at a very fast rate. Technology has played a large role in spreading distance education because information and communication technology has reduced the cost of electronic delivery system. Multimedia approach has become order of the day and integration of print, audio-video added with computer capabilities has created a lot of possible applications.

Distance education has been at the leading edge of many educational innovations, especially during last twenty years due to the application of a wide variety of new technologies. Distance education has tried to overcome the assumed, though unquestioned, limitations of the lack of ·face to face interaction between teachers and students by using various types of technologies. From technology point of view, the distance education can be categorized in four generations.

First generation

Correspondence education comes under first category in which the print medium has predominant role to play. Some sort of counselling was used as a supplementary to print media. Recent innovations in printing technology has made printing much easier and cheap.

Second generation

Multimedia model appeared as second generation. This model entailed the use to highly developed and refined teaching - learning resources including printed materials, selected readings, video tapes, audio tapes, computer based courseware, computer managed learners, computer assisted learning, interactive video etc. This model has already become very popular in the open universities. This model lacks interactivity although the model has good flexibility in terms of time, place and pace. Materials produced in this case is highly refined.

Third generation

Telelearning model is third generation in which interactivity has been ensured. This model consists of audio teleconferencing, video conference, audiographic communication, broadcast TV/radio and audio teleconferencing. This model has good interactivity but lacks flexibility in time, place and pace. Distance educators have felt in need to provide opportunities for social interaction to support effective learning. This model has tried to simulate face to face communication through these technologies. These technologies can support continuous two-way communication between learners and teachers. Sometimes local counsellors are also provided for social interaction. It is worth mentioning that the necessary balance between social and individual interactivity will vary from course to course and willbe a function of such variables as the subject matter, the specific objectives of the course, the structure and quality of the learning materials and student target group.

Fourth generation

In many cases the target group for distance education consists mainly of part time learners in full time employment. Hence they need flexibility in terms of time, place and pace. Therefore, they have to be provided printed materials, video-audio tapes, computer based course ware of high quality which can be used at a time and in a place which is convenient to the learner. Hence, 'flexible access' technologies will only fulfil this condition. Fourth generation mode is 'flexible learning model' and consists of interactive multimedia (IMM), internet based access to www resources and computer mediated communication. This model fulfills almost all the criteria of flexibility refinement of materials and interactivity. Internet facilitated interactivity, without sacrificing the benefits of flexible access as it can be used to support asynchronous communication. This flexibility allows the learners to learn at their pace.

Networking and Internet

Networking of open universities is very essential from the point of view of optimum utilization of resources. In a world in which it is not just the distance which is shrinking but the resources are also dwindling optimal use of available resources is of paramount importance. Networking may include:

• Sharing programmes and courses among open universities;

• Establishment of a common pool of programmes contributed by all open universities for sharing through adoption, adaptation and/or translation;

• Standardization of the processes associated with the design and development of programmes, credit transfer, grading pattern and methods of delivery of services; and

• Sharing of hardware, software and study centre facilities.

As the demands get varied and numbers multiply, perhaps the learners in the future will discover that no single institution can meet 'all their needs and hence they have to look to multiple institutions to satisfy their needs. Technology has also given us means to pool intellectual and physical resources scattered across distances and shared among large number of people, A significant feature of such network is, their participatory and collaborative style of functioning. A single institution may contribute only a small component but together with the rest, each one makes a major impact. Such partnership arrangements help develop policies for sharing new technologies and use them in the delivery of programmes more effectively and at lesser costs.

Internet

Internet provides a new medium for distance educators because this reduces the distance and increases the opportunities for communication content delivery through internet is very cost effective and provides a variety of opportunities to enhance the quality of text material. Some of the special merits are as follows:

• In the absence of library access to allow students to read around the subject links to additional readings on the web can be included to take advantage of mass of information available;

• Lot of excellent reference and teaching material already in existence on the web can be included as part of course;

• Links can be used to provide students with alternative paths through the material to match their needs such as locating information relating to assignments etc,

• Self assessment, multiple choice question can be inserted to provide immediate diagnostic feedback;

• Easy access to the course glossary can be arranged for cross reference;

• Links to internet based support services can be built into the material;

• E-mail service allows students to interact with teachers and peers;

• Electronic assignments can be done through Internet; and

• Electronic tutorials can also be conducted.

FUTURECHALLENGE

Interactive Television Class-Room

Interactive Distance Learning System enables teachers to simultaneously reach large numbers of students in multiple locations. The teacher is seen on a television screen delivering a lecture to the students who are using an interaction device. Information about the students appears on the teachers touch screen. In case of question the hand is raised and the student is connected. His question is heard by the teacher as well as all the students in remote classes. The teacher answers the question which can be simultaneously heard by all students. Computer presentation and video clips can be used. The student can request the teacher to repeat the explanation as we do in a normal class-room. The multiple choice question is asked by the teacher and answers are submitted by the student by pressing a key' The results are also immediately available. The printer in each class receives and prints homework assignment. All activities can be recorded and stored for further analysis. If the student is not present in the class this can be stored in his computer.

System Architecture

The system consists of three layers ;

• The communication infrastructure - Hardware,

• The contents - Programmes, and

• The Interaction system - Software.

Main Components

The main components consist of Class Control Unit, Lesson Control Unit (LCU), Communication Server, The Help Desk Server and Network Monitoring System.

Salient Features of LCU

• The LCU screen is designed as a touch screen;

• "(he teacher can know which students are attending and at which site;

• Students' attendance and performance data is available to the teacher in real time;

• Voice communication is totally controlled by the teacher; and

• Command include asking multiple choice questions, viewing detailet! information and pictures of students, connecting students for voice or video conversations, initiating a file transfer or remote printing etc.

Server-based Class-room

Another model of implementing the virtual classroom is to use the World Wide Web to bring students and teachers together in the learning process. A server providing the course contents on a CD- ROM could be used. A judicious combination of software, which can be browsed, or down loaded and used on web meetings for peer to peer as well as learner to teacher interaction can result in enhanced and effective learning.

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# Engineering Education and National Development

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It is indeed a privilege and an honour to deliver this 8th Dr Amitabha Bhattacharyya Memorial Lecture at this 14th Indian Engineering Congress dedicated to the theme of 'Human Capital Development in Engineering for Global Competitiveness'. Dr Bhattacharyya has made many outstanding contributions to the cause of engineering education which, I believe, has become a matter of crucial importance in the context of rapid transformation our country is going through. In the current economic and Information Technology era, we must continuously enhance our competitive edge in areas of our strength, explore new areas of strength, and maximise value addition activities in our country. This has to be achieved in an atmosphere of stiff market competition, not only abroad, but even more importantly in our own domestic markets. Human capital development has, in my view, become the single most important factor that we must focus on in order to achieve success.

The national development process we are going through involves providing essential items such as food, water, shelter, clothing and energy; basic minimum necessities such as education and health services; infrastructure in the form of communication, transportation, information access etc, and finally the vast range of wealth generating activities involving a very wide spectrum of production of goods and services. The resources needed for carrying through this development process are indeed large. We are no longer a resource rich country as we were in our ancient past. Our resources have dwindled, partly due to their exploitation over the years by us, as well as by others; and also, as a result of the large population increase, the per capita resource availability has become much smaller.

As engineers, our task is to find and implement effective solutions which accelerate the pace of development and wealth generation. We must do this in a manner most relevant and applicable to our society and be consistent with areas of our strength, which should get further strengthened. We must certainly learn from past experience, both our own, as well as that of others. However, we should be cautious about the copy-cat culture of following models evolved under alien situations,

## HUMAN RESOURCE DEVELOPMENT

I strongly believe that our Human Resource is the key to solution of all our problems. Of all the resources that go into the development process, this perhaps is our strongest asset. In our country, with such an enriched heritage and time tested value system, it is sad that we cannot at times raise our heads high, in a number of human behaviour actions that we see around us, rather frequently these days. Our bonds to our primary roots seem to have been infected. At least as far as the engineering human resource development is concerned, there is an urgent need to groom our young, upcoming engineering students to be oriented to problems of our country, using engineering knowledge drawn from anywhere, but communicated in the backdrop of Indian scenario. With an army of talented as well as committed engineers, who can take upon themselves the task of implementing right solutions in a right manner, I feel there could be no unsurmountable challenge. At worst, we may have to sequence their tackling appropriately so that the other complimentary resources that are also required can be raised as we go along. I am conscious that this in fact is happening in a number of areas. But then, as leaders in engineering profession, it is our task to channelise maximum possible fraction of our engineering manpower to this cause.

Engineering education in our country needs to be refocussed to real life activity based learning. This in turn would mean a much greater interaction between our academic institutions, industry and society. In fact, all the three segments must participate in the activities related to engineering education, in a manner that our students understand the problems that we have before us, and develop an ambition to solve them. Our education system must light the spark of innovativeness in them to work out original ideas and empower them to implement such ideas with confidence and courage. This can happen through their deep involvement in whatever is happening around them. While they learn and grasp the engineering knowledge, they must also develop an affinity towards the society around. They must develop a feeling to do their bit in the national development process.

Our engineering education system is in fact very large. However, there is a serious problem in terms of quality and competence. Most of our students are perhaps trained in ill-equipped institution, both in terms of faculty as well as laboratory and workshop facilities. There is also a problem of mismatch between demand and supply in specific areas. We face anomalous situation of not being able to find good quality engineers in certain specialised areas, while there is a large number of engineering students waiting to find employment. The problem is further aggravated by migration of our talented students, some abroad, and others to professions/disciplines different from the discipline in which they were trained.

We must change this. In this context, I would like to quote some portion of direct relevance to us from a report of the Council of Academies of Engineering and Technological Sciences,(CAETS) and I quote:

*'A basic understanding of the complex world we live in is hard to imagine without mastering the technological tools around us at a minimum level. Educational systems should prepare the children for the complexity of modern society. Many of the most important societal issues that we are facing have strong technological and scientific elements; the environment is only one of them. Still, it should be realised that much would be gained already, if technology is also seen as part of the solution, and not just as all or part of the problem. When developments such as information and communication technologies are rapidly changing not only the traditional industrial sectors, but also the service and finance sectors, technological insight will be essential to foster economic prosperity and create job opportunities. Universities should adjust to the rapid change and try to prepare for a range of future scenarios. If they do not act, they will become obsolete and be bypassed. Communication and simulating programmes should not only lead to a consolidation of the past, but assist in preparing for the future. In this respect, young people may have a keener sense of what is important for the world, than professors who claim that their under-attended courses are essential for society's prosperity. Although lifelong learning will become the norm for many, choices made at a young age are often irreversible. Changes in the educational system should, therefore, take place on a broad front from primary through secondary and tertiary education. Increased re-entry of adults into an educational system should be taken into account. Re-entering not only to learn, but also to teach and communicate. Engineers should both enhance their abilities to listen and to communicate. For the many action plans to be successful, it is essential to match remedy with cause. Problems caused by economic cycles need different medicine from those caused by uninspired teaching at secondary school level, or unbalanced and outmoded university curricula. More attention is needed to couple fun and interest in life situations to science and engineering at all levels of education'.*

The industry and national laboratories must thus get themselves involved in the process of enriching and reorienting engineering education to suit national needs in general, and their specific needs in particular. This must be a highly interactive and inter-dependent process, rather than the process of support from outside. After all, they have all stakes in each other. In this process, if the 'train and hire' model existing currently, gets transformed, at least in part, to 'hire and train' model, it would make a sea change in enriching our human resource capital. It will also enable a decentralised curriculum linked with the local or regional development and economic growth necessities.

HANDS ON EXPEWENCE WITH TECHNOLOGICAL TOOLS

The impact of learning opportunities through participatory activities is already visible in a large measure in software area. The strong market pull, along with the relative ease with which hands on training opportunities can be created in this area, does promise a huge potential in terms of opportunities for Indian human resource to make a big contribution to our economic progress. We should, however, make additional efforts to capture a larger share of market in applications involving higher technological level involvement.

There is, however, a serious concern which all of us should address with regard to making similar things happen in the hardware area (not only computers but others as well). While the flight of a large fraction of our engineering talent to software area is understandable, we can ill afford our hardware technology, and its growth, to be crippled for want of quality manpower inputs. Our hardware capability in many areas is yet to fully evolve and mature in comparison to other indistrialised countries. This is very important in the current liberalised business regime, in view of the strong competition the Indian industry has to face even within our own country. I think we should work to create an environment which encourages our engineering students and young trained engineers to pursue hardware related programmes, consistent with their aptitude, rather than follow the software bandwagon, unmindful of their own likes and dislikes. For this to happen, the industry and academic institutions must make special efforts to come together and create opportunities for our students to work on projects of direct use and interest to our industry or society.

Experimental work should have a special place in such projects. This will not only add value to the project, but more importantly, will expose our students to available technological tools. With a properly designed programme, such an effort could become beneficial to all. Industry could realise immediate and useful return for the inputs it may provide for such an effort. Academic institutions would be able to focus the research at the institute to the needs of surrounding industry/society, with meaningful faculty participation. However, the most important benefit of this effort would be to students to finding creative expression to their aptitudes, and the confidence ·to make a good career in the field of their choice.

## R&D TO ROBUST TECHNOLOGY TRANSFORMATION

Talking about research, we have yet to establish indigenous interface between our basic research and its functionalisation into societal benefits. After all, all new applications and technologies arise out of available knowledge pool generated through research and technology evolution. Apart from the aspect of satisfying human curiosities, which in itself is very important, basic research froms the source for new technologies. In our country, we have had an excellent tradition in research. While our science has contributed to the international knowledge pool significantly, our technology is largely based on patterns evolved elsewhere. For a large country like ours, we must have ambition to evolve new technologies out of our own domestic knowledge resource, both modern as well as traditional. This is the only way we can become leaders and not remain followers. Collective working of universities with all its science and engineering disciplines, in close partnership with industry and national laboratory infrastructure must have this agenda.

The other day, I came across a very perspective expression RD3 meaning Research, Development, Demonstration and Deployment. Undoubtedly, this expression in contrast to the more familiar R&D, provides an orientation to take research activity right upto its logical end. At least from the stand point of engineering, the vocation in which all of us are involved, as also in the larger context of realising socio-economic development catalysed through science' and technology, this orientation should be unquestionable. Of course, this is easier said than done. Apart from the challenge of transforming new or existing knowledge into something that is considered useful by the end user, there are many other obstacles. Conflicts between the so called time tested proven products and the new innovations with attendant teething troubles; or the manoeuvres by established business, which may feel threatened by the arrival of new innovations on the market scene, are a few examples. Thus, a successful RD3 programme in contrast to an R&D programme would involve Research, Technology development, Engineering and Management strategies, all together. Surely, all of us would like to see more and more innovations through the entire RD3 chain with success. This is undoubtedly of paramount importance for maximisation of indigenous value addition activities, a key, in my view, to rapid strengthening of our economy.

This, however, requires an integrated approach. An aspect we thoroughly lack. Uncoordinated working between researchers, technology developers and industry cannot complete the RD3 chain. Even if it does, it would leave several weak links that can be easily severed by forces that I mentioned earlier. In the current competitive and liberalised environment, this has become even more important. As engineers, I think we have a special responsibility and also a special role. As a collective group, we are in a position to diagnose the situation around us better and propose comprehensive solutions spanning the entire RD3 chain. We should perhaps also organise model projects to test out the solutions we wish to propose. This would afford a degree of credibility to out recommendations.

## CLOSING REMARKS

Nurturing excellence is crucial to success in our human resource development effort. While cherishing democratic values, societal consciousness, pride in our traditions and our rich cultural heritage, we must not forget that we can survive the global competition, in which we are inevitably involved, only on the basis of excellence. While market forces will determine our success in economic sphere, as far as our human resource is concerned, we must test our excellence in applied research and technology on the basis of deployment of our technologies in industry and society. On the other hand, our basic research, which as I said earlier, must feed into our application development and technology, must be judged on the yardstick of international excellence. Basic research which does not stand peer scrutiny, and is not close to best in the world; and applied research/technology which does not enter the market place/societal applications,in my view, needs a careful review to bring in appropriate corrections.

Our country has been an important contributor of knowledge and wisdom to the rest of the world. Intelligence of Indian mind has been acknowledged time and again, both here and abroad. As we move in the new world order characterised by knowledge revolution, we must awaken the Indian mind which perhaps would constitute one of the largest knowledge resource globally, for the material and spiritual elevation of Indian society, and through it, the rest of the world.

# Engineering Capability for a Globalworld: The Institution's New Agenda

Shri Chandra Mohan

Chairman, Twenty-first Century Battery Limited, Chandigarh

Looking back into our profession over the last half a century, Amitabha would tower as one name who could not only sense the pulse of futuristic technologies, but also launch us into them. I had the privilege of meeting Amitabha when he had just returned from UK. A new department of CNC and Robotics had been opened for him in the Jadavpur University by its visionary ,vice Chancellor. Dr Gopal Sen. I met him again in the seventies when he was the Director of liT Kanpur and Chairman of this august Institution. Though meetings were brief and casual, charisma born out of knowledge was unmistakable.

It is a privilege to be asked to deliver a lecture dedicated to such an illustrious path-finder, when top-tigers of the profession have gathered to awaken the profession to its responsibilities as the builder of world-class technological society. Beginning of a new millennium gives it added flavour. Sir, I am indeed honoured.

Modern prosperity with its instant access to knowledge and people across the universe, is the cumulated result of the effort of millions of engineers since the first humanoid. These were the engineers who could look into the future and vision new needs of their societies. They then also created new physical products from their knowledge to serve these needs. Finally, they also staked their lives to produce and deliver their newgizmos. Such were the stalwart creators of modern society: the Harrisons, the Stephensons, the Edisons, the Fords and the Stockleys.o

It is the vision of such eta Iwarts that gave birth to Institutions such as oure, The founder of Institution of Mechanical Engineers of UK was George Stephenson himself. Our own Institution is a product of the foresight of the post-war Commission on Industry of 1918. Its Royal Charter of August 13, 1935 proclaims its objectives loud and clear: 'To promote the general advancement of engineering and engineering science and their application in India:

Mark the emphasis on 'application'. Without application for the benefit of society, scientific knowledge has no meaning. Application not only finds equal emphasis in the charter of every professional society of engineers but, drives all activity.

Over the last two and a half centuries of its existence, IMechE has continuously renewed itself to lead the profession in tune with changing needs of society. Its velocity of change today is light-years ahead of the Stephenson era. What has driven its break-neck change is the need of engineers equipped to face the challenges of the nano-second internet age.

A super-attractive Young Engineer of Britain Award was instituted as early as 1980 to initiate innovation and creativity in young school-going minds. Its importance can be gauged by the fact that presentation is made by the Queen herself. Imagine the excitement of such an Award to young schoolgoers; I would have cart-wheeled in joy for a mile.

The Wills Faber National Competition for excellence in Manufacturing Technology in which the best of British Companies participate was launched in 1982. Projects are quantum jumps and involve fancy combination of diverse technologies.

Its GRANT studies of 1985 revealed urgency of radical changes in every facet of technical education. The new society needed professionals who not only designed, produced, sold, operated and maintained high quality artefacts and systems of the future, but also understood the structure of industry, commerce and society and played an effective role in their management. The need was for engineers who would be competitive globally. Institution initiatives led to change in every facet:

• Revamp of curriculum. Its linkage to the world of application and practice.

• Linkage between academia and industry .

• Life-long professional development. Monitoring. Enforcing compulsion. Japan was a war-devastated rubble in 1945. Its shoddy products were a laughing stock of the world. Foresight, initiative and sustained dedication of JUSE, the Japanese Union of Scientists and Engineers alone turned those ashes into the ultra-modern and rich global leader which Japan stands today. JUSE foresaw the hidden value in the teachings of Deming and Juran and began the Quality Movement. Let us also not forget that this pioneering step was taken their American country-men classed them as looney theoreticians. But JUSE marched ahead, undeterred and no holds barred. New strategies were evolved whenever obstacles surfaced and in the evolution came education on Quality for Foremen on Japanese Radio in 1950, the world's most honoured Deming Prize for Quality in 1952 and Quality circles in 1965. It was because of JUSE's perseverance that the Movement gathered momentum and snow-balled. Some of the most renowned tools of modern management are a product of this evolution: Kaizen; JIT; SMED; Lean Manufacturing; QFD and Taguchi methods; Business re-engineering.

The entire country was transformed in two decades. In one more, it had become the Global Quality Leader and the entire world was struggling to copy Japanese management. Sony's transistor radio, Shinkanzen and Walkman were some well-known milestones in that march. More recent examples are Do.Co.Mo's wireless cellular service and world's meet advanced robot, Sony's pet dog Aibo. This unbelievable societal revolution was masterminded and driven by a Society of our own profession.

I have been a member of SAE of USA for the last three decades. It has led Automotive Engineering in its advancement by the nose: Technology; Standards; Design. And, across the world. Professionals eagerly pore through its Journals to know the latest and then go ahead with its application. Publication of a paper in one of SAE Publications is the highest of honours for an engineer. Yet, despite its eminence for the automotive profession, it felt it necessary to widen its horizon and change into a Society for Advancing Mobility in Land, Sea, Air and Space. The border-line between these sectors had become wafer-thin and cross-application of technologies was becoming routine.

Has our own Institution of Engineers responded to the challenges of our society in similar fashion? Has it provided the professional lead which our society desperately seeks in its search for better life? Has it reshaped the profession to find new ways to raise resource-productivity without which no improvement can begin'? If members were to search their hearts. the answer would be an unambiguous NO.

Had we performed as responsible professionals. our roofs would not have continued to leak. Our roads would not have developed potholes within months. Our buses and trains would not be filthy and would also run to time. Our trade deficits continue to balloon. The unfortunate part is that all this has happened notwithstanding our claims to the second largest pool of trained scientific manpower in the world. Something is positively wrong in our professional equation. The bogey can be broken only by Professional Institutions of our eminence and reach. It is to outline approach to these new dimensions that I now move on to.

I begin with some projects in the concrete dimension. where initiatives result in deliver physical products for use by society for benefit. To my experience. success with unquestionably visible deliverables is imperative for giving a healthy start to the Change of the dimensions that we are looking for. They alone can transform the pervasive environment of diffidence and convert die-hard doubting Thomases.

Mass housing would stand-out as tops. It is the biggest societal need. Volumes at 2 million a year talked of. are phenomenal. Forecast investments are in the order of 4 billion dollars a year for decades on end. Tangibly apparent results can be achieved in 24 months. R&D expenditure would barely run into a crore. Can the Institution not mount a National Initiative'? Very achievable first stage goals for a 4-storey 48-unit Block are:

| | | |
|---|---|---|
| • Cost reduction | : | 20% |
| • Time reduction (Ready to occupy) | : | To 8-months |
| • Quality | : | Top-class; No leaky roofs. |

Technology must be physically demonstrated in two Blocks and could involve any discipline. It should not be capital intensive and be easily reproducible across the country. In the decade of the fifties. Lewitt in US looked at construction of mass-housing as an automobile Assembly Line.

The result was houses at the rate of 400 a week within one year and costs lopped off by 207 e, 1am sure HFDC and HUDCO would welcome such an initiative and also participate financially. Similarly, can we do something for roads and their inescapable twin of flyovers 5prouting in cities'? Our flyovers. Even after recent improvements take ages to build. They in any case cost a bomb.

I was visiting Caracas in Venezuela as long ago as 1975. We actually drove over a recently built 6-lane fly-over completed in 31 days. Mind you, this was accomplished a quarter of a century ago. Similarly, the Belgian Bridge to get relief from Bangkok's traffic snarls was laid over the week-end. Do we stand anywhere in this race'?

An investment of the order of 50 billion dollars in roads during the next two decades is talked of. Room for improvement is also colossal: Quality, Cost, Time. National team competitions, where live physical application is compulsory, could trigger a super-sonic boom.

Besides excitement, such Competitions would generate hundreds of innovations and patents in design and technology spanning the array of engineering disciplines: materials; foundations, structures, mechanicals; electronics; logistics. It will produce a new breed of young engineers: Less invested in the past than the elders; Minds, which instinctively question what exists; Unshackled intellects free to attempt the impossible.

It would also spawn new clans of fast-growth industry across the country. It would generate attractive employment for millions. It would give birth to a new mould of aggressive world-beater engineers and enterprises baptised through fire. Brains would start flowing inwards, not only to join the excitement but, take a dip in the gold-rush. This Silicon Valley will be rooted in construction. Didn't the Koreans do it three decades ago'? They called shots at every major contract in the world. You would also be surprised that some very interesting patents in elevated express-way construction are held by Indonesians.

I have pulled out only two examples to illustrate. Sectors such as these can be multiplie Cl by dozen. Unfortunately, the ball would get'rolling only when:

•• Professional eyes start observing and questioning things;

•• Apply their scientific knowledge to deliver new products which our society of today needs and not the western world.

The community is sick of high-sounding sermons. It has started looking at degrees gilded on fancy paper with cynicism. What is desperately seeks is promises delivered.

I now move on to the most important role of an Institution such as ours: creation of long-term value in a profession which forms the bed-rock of modern technological society. Tops in my list is Technical Education .

We all express anguish at our shoddy quality, our woeful competitive capability and absence of innovation and creativity. We have been crying hoarse on brain drain for decades. Let us once for ever understand that its roots lie in education, particularly technical education. In the constant fiddling of education through 50 years of independence, its fundamental objective of creating minds which strive to learn, apply and evolve knowledge throughout life has been forgotten. Effort has all focussed on driving-in of knowledge as a pill. It is time for the Institution at least to stop sermonising and get on with action. It is very much its own domain. With the clout that the Institution commands as a Professional Body, no University or AICTE can also dare to refuse a considered review under its aegis. It can also garner resources to create new instruments and new dimensions. Let it also not forget its direct role ae an educationist; change therein is its own domain in entirety.

Education across the world in the last decade and a half, has reshaped itself radically. Each society has retailored its education to its own needs and to the realities of its own pocket. Blind aping of the West would not do and, this includes our head-long romance with IT of recent years. Millions of PC's and instant access to the best of global knowledge on the internet is certainly fashionable. But it carries no meaning, unless it improves the production or delivery of some product. Someone has also to earn enough and to spare for its ownership. And, there lies the catch. Production and Delivery can alone provide that juice.

In the words of Bill Gates himself, lT does not produce any goods or service; it only helps refine and opttmlee what you do. Digitisation and quick calculation only enable you to manipulate information and quickly view it from different angles. It thus hopefully helps you take more informed and better decisions. Final decisions however is only yours, that of your brain.

Our national priority today lies in producing more, in producing more efficiently, in producing better. That alone generates wealth. But then, more can be produced only if there buyers to purchase what is produced. Mounting stockpiles of food-grains and sugar amply prove that production alone is not enough. Spread of purchasing power and afforilability must accompany.

Focus of all education must therefore lie in that dimension: application of knowledge not, hollow theories. Today's education is all directed towards creation of job-seekers, prepared to wait infinitely for being lassoed and led by the noose. What we desperately need are entrepreneurs who conceive innovation and then create new jobs for production and delivery of innovation. Just think of the employment and prosperity created by Ray Kroc: over 20,000 franchises across the world selling a simple bun and a meat-patty. I was jokingly telling some friends the other day: a samosa is a much contraption than the hamburger; it is only one piece while the other calls for an assembly of five. What has taken it to that summit is entrepreneuring alone and in full style. They only needed an Indian Kroc. And then, Rooh-afzah and Coke also belong to the same slfgary-water species.

I have been raising questions in the same vein with the custodians of Indian R&D and Science, Dr Mashelkar and Prof. Ramamurthy whenever we meet: If the experiment of Swaraj tractor and PTL has proved an eminent success beyond the wildest dream of every stake-holder, why is it that we have not been able to replicate it for 30 years'? Some thing, somewhere in the system is certainly wrong. Isn't it time to find out and correct'? To me, its root all lies in Education: it kills curiosity; it smothers questioning; it knocks out experimentation spirit; perseverance and team-work figure nowhere. What it in stills instead is slavish obedience and fear of failure.

Let us also remember that only a handful of engineers ary required to manage a production plant. On the contrary, top-engineering talent in hundreds is required to design, tool-up and mass-produce a marketable chair for today's discerning customer and reaching it to him. Expertise is also of multi-coloured hue. The largest employers, and of knowledge, today are R&D and Innovation; immaterial whether it is product or service. A recent issue of Time was full of enticing designs of mundane products like waste-paper baskets and toilet brushes. Willy nilly, competition and quality will thrust down-sizing of production managers. A shift in our emphasis to this dimension will alone create employment for educated and reverse the brain-drain.

In the reform of Technical education, let us also not try and ape the methods of the rich western world. We do not and, will not, have that class of resources for the next 50 years. Methodology thus has to be ours: tailored to our needs; within our means. A well-proven route is toys and models. Toys can be a very effective medium for practical application of the most advanced technologies and at fractional costs. Properly used and promoted as a tool for Team Competition, they will engender Team spirit and excitement no less than KBC's Crorepati. Do not forget that the most advanced robot of the o world today, is Sony's pet dog Aibo. Leading the National Quality Movement in the style of JUSE can provide an excellent start to the reform of technical education. A large number of initiatives have been mout1ted in the public, institutional and private domain in recent years. Every organisation also talks of Quality Policy and Quality Manuals and ISO:9000 and Q~:4000 certificates are legion. The Rajiv Gandhi National Award tops an endless string of national, institutional and regional awards for quality. Yet our Quality remains in percentiles, when the world is already in 6-sigma and talks of billion-bands.

But for absolute customer trust in infallible quality, e-commerce would have been a dead-duck from the word go. The global customer of today takes quality for granted. His demand has already shifted up-scale into esoteric and intellectual realms: sensual excitement, instant gratification and pride of ownership and display. National transformation on the quality front is thus urgent. A professional institution with a reach as wide and deep as ours will, to my mind, be the best to deliver.

Friends, people have heard our poetic, rhetoric and empty promises ad nauseaum. We have flogged our great heritage till it appears phony. We have also begged long enough but, to nowhere. A stage has been reached when everyone has turned a defeatist and become a cynic. It is high time we woke up and, changed radically.

Since engineers are the ones who build and create the new, there could be no better instrument for change than this Institution. Let it be the one which triggers a new spirit, which challenges what exists and, dares the new. It has the reach. It has the numbers. It requires the will. It will also demand hard work. But believe me, satisfaction will be phenomenal. Two billion folded hands will rise in prayer to bless you for making their life better. A new millennium is an ideal moment to begin. In creating such a vision and propelling it through, lies the essence of leadership.

# Sustainable Development

Prof G P Lal, *FIE*

Past President IE(I)
Vice President WFEO

I consider it a great privilege to be invited to deliver Dr Amitabha Bhattacharyya Memorial Lecture. I thank the President, IE(I)and the National Council for the same.

It was during my Presidentship of the IE(I) that its Council resolved to establish Dr Amitabha Bhattacharyya Memorial Lecture in view of the great contribution made by him for about two decades to the growth of the Institution of Engineers , (India).

It was my great pleasure to work in close association with Dr Bhattacharyya in The Institution of Engineers (India) for a long period. I recollect his passion of bringing the Institution to the forefront in the National and International arena. His visions, particularly in regard to development of engineering educational standards and improving the standards of publication, are extremely noteworthy. He also brought the Institution to the forefront of international relationship by establishing international tie-ups and organising many World Congresses and International Meets. He held the Chairmanship of the Committee on Engineering and Education of WFEO for a long time and his contribution in that capacity is still remembered with great appreciation.

I take this opportunity to pay my most respectful homage to the memory of Dr Amitabha Bhattacharyya.

Dr Bhattacharyya was the Founder Chairman of the Rural Development Forum of The Institution of Engineers (India) and he was highly involved in addressing the various programmes for rural development and poverty alleviation. Touching this subject which was close to the heart of Dr Bhattacharyya, I am reminded of what Mahatma Gandhi had dreamt about rural (village) uplittrnent :

'If my dream is fulfilled and every one of the seven lakhs of villages becomes a living republic in which no one is idle for want of work, in which every one is usefully occupied and has nourishing food, well ventilated dwellings and sufficient khadi for covering the body and in which all villagers know and observe the laws of hygiene and sanitation, such a state must have varied and increasing needs which it must supply unless it would stagnate'. The Gandhian concept of rural development was based on a Chieving self sufficiency of villages in which every one would have adequate food, shelter, clothing, proper hygienic and sanitation facilities and every person willing to work, is provided gainful employment. India is predominantly rural country. ~bout 75%of its total population live in rural areas as per 1991census. The objectives of rural development are very broad and

to mention a few are as under:

(i) Development of human resources including

(a) Literacy, more specially female literacy, education, and skill development,

(b) Sanitation and public health measures, and

(c) Family limitation;

(ii) Land reforms;

(iii) Development of the productive resources of the area;

(iv) Infrastructure development; and

(v) Special measures for alleviation of poverty and bringing about significant improvement in the living conditions of the weaker sections of the population.

POVERTY

Poverty has been defined and identified in various terms by various experts and agencies. One simple definition is that "Poverty Line" is a line which divides the poor from non-poor by putting a price on the minimum required consumption levels of food, clothing, shelter, fuel and health care etc.

The poverty scenario today is explained by conditions where millions of women, children and men are suffering from poverty, chronic hunger and deprivation. Poverty reduction can be achieved if we propose and demonstrate sustainable pathways for achieving the national goals of food, drinking water, health and education for all. At the same time, poverty alleviation has to be linked with environment protection and achieving a policy for a better common present for all members of the human family in order to achieve a better common future.

It is with this background that the United Nations Environment Programme(UNEP) has pointed out that unless we take immediate steps to halt habital destruction and genetic erosion, we will been tering the second age of mass species extinction. In such a prevailing mood of despair, there is a need to launch an initiative for poverty alleviation.

The approach for reduction of poverty comprises of judicious exploitation of natural and human resources while absorbing the State-of-the-Art technologies in every sphere of engineering activities. For this, the policy-makers need to understand the problems with clear mind and utilise scientific temperament along with strong commitment and zeal to fight the problems being faced by the mankind. The target set by the World Social Summit is that by 2015poverty should be reduced by half at the global level. To achieve this it is advised to have the following approaches:

• switch over to the market based economic development where the poor are not excluded from the market but are brought into the market;

• adopt the sustainable development concept in a" developmental activities;

• fight poverty at a" levels, through national and international support; and

• the developed countries to provide technology and financial assistance within the framework of International Treaties and Conventions.

I would wish to quote extracts from the WHO Report" Policies to Reduce Poverty and Accelerate Sustainable Development, 2000.

'India reduced poverty substantially since the mid-1970sas growth rose and human development indicators improved. In the mid-1990s growth increased sharply and human indicators continued to improve. Yet, poverty race declined only marginally. The inconsistencies between the national accounts and the national sample surveys that are used to measure poverty suggests that this may be statistical RT fact. Partly the slow down may also be explained by the higher average inflation in the 1990s compared to the 1960sJ specially the more rapid increase in food prices.

More fundamentally, while some states were able to take advantage of the stabilisation and reforms to speed up growth and poverty reduction, others increasingly lagged due to poor governance, infrastructure, lack of human development, lack of physical adjustment and compression of development spending.

Should the recent developments be taken as evidence that stabilization and reforms have worked against the poor? We would argue not. First, there continues to be some reduction in poverty, particularly in the urban areas and in some states. Second, and more importantly, the issue is not reforms and stabilization which were clearly needed to correct an unsustainable situation, but incomplete, and partial reforms. In particular, it is generally agreed that agriculture, which may have lost its impetus in reducing poverty, remains the least reformed, most distorted sector. Lack of reforms of labour and product markets limit both the rate of growth and its labour intensity. Reform of India's anti poverty programmes are now underway, but has taken place too recently for the benefits to show up ... moreover further institutional and governance improvements will be needed to make the programmes fully effective. Institutional and governance issues also arise in social sector services. Finally, at the state level, differences in governance and fiscal adjustment have led to differences in human development, infrastructure and private investment that contribute to the differences in growth and poverty reduction across the states ...'

Against this backdrop, there is a concern that poverty reduction will continue to stagnate unless a second phase of reforms occurs.

POPULATION

Global population is still increasing at over 2% per year and this increase is occurring mostly in developing countries. Malthus had warned more than two centuries ago about the socio-economic chaos that may occur due to this population increase. Today many experts believe that the fears of Malthus may still come true, unless the growth of both population and environmental degradation can be arrested.

One of the problems in the developing countries in matter of poverty reduction has been the higher rate of population growth. United Nations projection of world population in 2050 is anywhere between 7.7 billion to 11.1 billion as against the population of 6 billion in October 1~99. The population growth in developing countries is faster as compared to growth in the developed countries as would be seen in the Table below which shows the projected population in 2010 and 2025 on base population of 1992 population. A rough calculation also indicates the population doubling time in years of some of the countries.

| | Population (millions) | | | Population Doubling Time (years) |
|---|---|---|---|---|
| | 1992 | 2010 | 2025 | |
| Bangladesh | 111.4 | 165.1 | 211.6 | 29 |
| India | 882.6 | 1172.1 | 1383.1 | 34 |
| Nepal | 19.9 | 30.2 | 40.8 | 28 |
| Pakistan | 121.7 | 195.1 | 281.4 | 23 |
| Sri Lanka | 17.6 | 21.4 | 24.0 | 46 |
| South Africa | 41.7 | 66.0 | 92.0 | 26 |
| Developing Countries | 4197.0 | 5782.0 | 7115.0 | 34 |
| Australia | 17.8 | 21.5 | 23.9 | 83 |
| Japan | 124.4 | 129.4 | 124.1 | 217 |
| The UK | 57.8 | 59.0 | 61.0 | 257 |
| The USA | 255.6 | 295.5 | 327.5 | 89 |
| Developed Countries | 1223.0 | 1333.0 | 1392.0 | 148 |
| World | 5420.0 | 7115.0 | 8507.0 | 41 |

From the table it would be seen that the average doubling time of population in developing countries is 34 years whereas the same is 148years for the developed countries. This population growth is setting off many of the efforts for poverty alleviation and so one of the important issues is to contain the population growth. It has also been identified that while all people are affected by environmental degradation, the poor tend to be the most vulnerable to environmental degradation.

SUSTAINABLE DEVELOPMENTAPPROACH FOR POVERTYREDUCTION

Linkage of sustainable development with poverty has been in the forefront since 1972. Even recently, in a Report issued at the end of 1998, the United Nations Environment Programme (UNEP), the World Bank and the National Aeronautics and Space Administration summarized why the environment is important and should not be considered in isolation. The Earth's physical and biological system provides humans with essential goods and services. A set of physical, chemical and biological process link global environmental problems so that changes in one have repercussions for others. Actions taken to meet human needs have local, regional and global consequences. The same driving forces – population size, consumption levels and choice of technologies - underlie all global environmental problems. All people affect the environment, and vice versa, but the rich have a disproportionately higher impact and the poor tend to be the most vulnerable to the effects of environmental degradation.

GLOBAL CONCERNFOR ENVIRONMENT

The challenges of eca-development have emerged as a matter of global concern since the last four decades, which have been discussed and deliberated upon at a series of UN Conferences. The first such deliberation took place at the UN Conference on the Human Environment in Stockholm in 1972, which spurred a series of activities and events in the form of the following :

• UN World Conference on Environmental and Development (the Brundtland Commission) in 1987;

• Emergence of the concept of Sustainable Development in the Brundtland Commission Report of 1987;

• UN Conference on Environment and Development (popularly known as the Earth Summit) held in Rio de Janeiro in 1992;

• Follow-up of the Rio Conference recommendations, particularly its Agenda21 during 1997(Rio+ 5);

• Further proposed follow-up during 2002 known as (Rio + 10 Summit);

• The 55th General Assembly of UN in 2000, has decided that during September2·11,2002a 'World Summit on Sustainable Development' would be held in Johannesburgh South Africa; and

• This 2002Summit is expected to review and identify what new challenges and opportunities have emerged since the Rio Conference 1992and come out with policies to assure a balance between economic development, social development and environmental protection.

CONCEPTOF SUSTAINABLE DEVELOPMENT

This concept was enunciated in the United Nations World Commission on Environment and Development (the Brundtland Commission) Report Our Common Future in 1987.The Report has defined sustainable development as development that meets the needs of the present generation without compromising the ability of the future generations to meet their own needs.

It further proclaimed this concept as a workable objective for everyone around the world, at all levels, namely, international, national or regional and that with the adoption of this concept the conclusions that would be fundamental would be the following :

• sustainable development is a global issue;

• poverty and environmental concerns must be addressed together;

• significant improvements in the material standard of living of developing countries are a precondition to sustainable development; and

• significant opportunities exist to improve environmental quality and human development through scientific, engineering, and technological (SET) developments and institutional reforms.

This concept was given a formal shape in the form of Agenda 21 of the United Nations Conference on Environment and Development (UNCED) and popularly known as the Earth Summit held in 1992 at Rio de Janeiro. Agenda 21 contained as international action plan for sustainable development.

EARTHSUMMIT1992 (RIO CONFERENCE;1992)

The Earth Summit in 1992madehistory by bringing global attention to the following major challengers :

• that the planet's environment and development were intimately linked with economic conditions and problems of social justice;

• that the social, environmental and economic outcome could be met in a balance with each other for sustainable outcomes in the long term;

• that if the environment is abused and resources are over-consumed, the people suffer and economies deteriorate; and

• that if the people are poor and the national governments are weak, the environment suffers.

Sustainable Development Concept has made efforts in the direction of meeting these challenges, but still the gravity and consequences of the challenges continue to exist. Today it has become clear that internationally, Agenda 21 has largely remained an action plan on paper, as is evident from the situation that both the global environment and the human condition have deteriorated.

PROPOSEDWORLD SUMMITON SUSTAINABLEDEVELOPMENT- 2002 (RIO + 10 SUMMIT)

The target of sustainable development is difficult and no clear indicators are available that can be universally applied. Every region has its own priorities and accordingly the indicators used for measuring success of the implementation of sustainable development initiatives. By 1997,ie, at the stage of Rio + 5, the United Nations General Assembly decided that by 2002,the formulation and elaboration of national strategies for sustainable development which reflect the contributions and responsibilities of all interested parties should be completed in all countries, with assistance provided, as appropriate, through international cooperation. The regional priorities for sustainable growth varies from region to region and for this purpose round tables/discussions were organised at different regions recently for preparation for the Johannesburg Summit.

(i) Europe and North America Round Table during June 6-8, 2001,

(Ii) Latin America and the Caribbean Round Table during June 18-20,2001,

(ill) African Round Table during June 25-27,2001,

(iv) East Asian and Pacific Round Table during July 9-11, 2001, and

(v) Central and South Africa Round Table during July 30 - August 02,2001.

In these round tables/discussions, for sustainable development ideas that emerged varied from consumption, waste, climate Changes, stronger administrative infrastructure, food, agriculture, energy technology base, transport, infrastructure, peace and stability, poverty reduction, inadequate finances for sustainable development, drug trafficking, cultural values etc.

During 2001,a ten-year review of progress achieved in the implementation of the outcome of the UN Conference on Environment and Development has recommended that at a Summit Level Meeting the following areas should be reviewed :

• initiatives for encouraging global commitment to sustainable development, and

• steps for ensuring a balance between economic development, social development and environmental protection, as these are interdependent and reinforcing components of sustainable development.

The World Summit on Sustainable Development - 2002 is expected to review and identify what new challenges and opportunities have emerged since the Rio Conference 1992.These are as follows : •

• identified major accomplishments;

• identify major constraints hindering the implementation of Agenda 21 and propose specific time bound measures to be taken and institutional and financial requirements and identify the sources of such support;

• address new chalienges and opportunities that have emerged since the UNCED within the framework of Agenda 21; and

• address ways of strengthening the institutional framework for sustainable development and evaluate and define the role and programme of the work of the commission for Sustainable Development.

WORLD CONGRESS ON SUSTAINABLE DEVELOPMENT- TECHNOLOGICAL CHALLENGES FORTHE 21ST CENTURY

While many seminars and conferences have been held on the subject, I would like to mention about the World Congress organised by The Institution of Engineers (India) in collaboration with World Federation of Engineering Organisations (WFEO) as a measure of IE(I)'s effort on the subject. The Congress was addressed by the Prime Minister of India, Shri Atal Behari Vajpayee and ended in publication as Kolkata Declaration. The Prime Minister had said -

' we are also committed to rapid economic development and creation of infrastructure for sustained growth. The present infrastructure is expected to expand at a much more accelerated rate. This expansion is especially necessary in the energy, telecommunications and transport sectors.

But all these development activities must not be allowed to result in severe depletion of natural resources and degradation of our environment. We must synergise our needs with the availability of natural resources'.

The Prime Minister further advised that attention be focussed on the following key areas:

• access to information on State-of·the-Art technologies;

• a framework for dissemination of information on the sources of availability of environmentally sound technologies;

• development of guidelines for transfer of technologies; and

• training of personnel to undertake technology assessment for the management of such technologies.

The Panel Discussion on 'New Directions for Sustainable Development' resulted in formulation of the 'Kolkata Declaration' which gave thrust on the following areas:

• Enhance Institutional and Participatory Capacities for Improved Convergence of Economic Growth and Environmental Protection,

• Resolve Contradiction between the Overpopulation of the Developing World and Unsustainable Consumerism of the Developed World,

• Improve Environmental Education, Information and Communication,

• Support Infrastructural Development to Improve Health and Education of the Poor with International Cooperation,

• Stress Scientific, Engineering, Technological and Social Issues of Environmental Management and Minimize Political Role,

• Support Environmental Planning and Management (EPM) to Eliminate Strategic Threats to Water Resources and Aquatic Life,

• Support Sustainable Strategies for Energy, and

• Provide Expertise, Information and Communication for EPM.

Mention of engineering/engineers may be highly missing in the RioSummit document but when it comes to blame it is said that the engineers are the cause of world environmental problems. The discharge of sewage into open water with minimal treatment, the thermal power plants discharging pollutants in the atmosphere, the big dams diminishing fish migration, disturbing the ecology and creating rehabilitation problems, highways with traffic congestion are all the product of the engineers. The engineers have to explain this to the civil societies and participate with them in the global environment, principles, ethics and policies to make them respectable partners in the future built environment. To increase the visibility of Engineers the WFEO has taken keen interest in the Earth charter dealt below.

EARTH CHARTER AND ROLE OF ENGINEERS

Beginning as early as 1945, during the formation of the United Nations, discussions began about the need for an earth ethic. In 1972 at the UN Stockholm Conference, where the current environment declarations were initiated, discussions continued about an earth ethic, and in 1982 The World Charter for Nature was adopted by the UN General Assembly. The 1987 Brundtland Commission Report, 'Our Common Future', also described the need for an Earth Charter. During the 1992 Earth Summit, the Earth Charter was to have formed the ethical foundation upon which Agenda 21 and other Rio documents were to have been based.

A new Earth Charter initiative began in 1994 by Maurice Strong, Chairman of the Earth Council and Mikhail Gorbachev, Chairman of Green Cross International. An Earth Charter Commission was appointed and numerous drafts have been developed and circulated among the nations of the world. A Benchmark Draft II was distributed in October 1998 and was revised as a result of the work of many National Earth Charter Committees and Regional Conferences. Another Benchmark Draft" was published in April 1999. As a result of a broad global review and a virtual conference for further discussion, a new draft was released on November 15, 1999.

The final Earth Charter was launched on June 29, 2000 at The Hague. The resulting Earth Charter is more a document of values, rights, social responsibilities and spiritual living than one of methods of improving the quality of life. Though there are fewer principles having engineering implication but engineers may like to address many of these with the interest in the issue and values the WFEO.

EARTH CHARTER DRAFT PRINCIPLES

The November 15, 1999·Draft contains sixteen principles as did the previous draft. There are additional sub-principles which now number sixty-eight. Although most principles have indirect engineering implications, eleven of the sixteen principles have direct engineering implications. Thirty-two of the sixty-eight sub-principles relate to the works of engineers. It is clear that the objectives of the Earth Charter principles can not be accomplished without engineering knowledge and support. Therefore, it is clear that practicing engineers must become knowledgeable of the

Earth Charter principles.

The 16 Principles are stated below, eleven marked (with asterisk) are having engineering implications.

1. Respect Earth and life in all its diversity;

2. ·Care for the community of life with understanding, love and compassion;

3. Build societies that are free, just, participatory, sustainable and peaceful;

4. 'Secure Earth's bounty and beauty for present and future generations;

5. 'Protect and restore the integrity of Earth's ecological system, with special concern for biological diversity and the natural processes that sustain life;

6. 'Prevent harm as the best method of environmental protection, and when knowledge is limited, apply a precautionary approach;

7. Treat all living beings with respect and consideration, and protect them from cruelty and wanton destruction;

8. 'Advance worldwide the study of ecological system and the dissemination and application of knowledge that enables communities to care for Earth;

9. 'Adopt patterns of production, consumption and reproduction that safeguard Earth's regenerative capacities, human rights and community well-being;

10. 'Ensure that economic activities, including world trade, support and promote human development in an equitable and sustainable manner;

11. 'Eradicate poverty, as an ethical, social and environmental imperative;

12. Affinn and promote gender equality as a prerequisite to sustainable development;

13. 'Establish transparency and accountability in governance, and provide access to infonnation, inclusive participation in decision-making, and access to justice;

14. Honour and defend the right of all persons, without discrimination, to a natural and social environment supportive of their dignity, bodily health, and spiritual well-being;

15. 'Integrate the knowledge, values and skills needed for promoting sustainable development into universal education and life-long learning; and

16. 'Create a culture of peace and cooperation.

ROLE OF ENGINEERS IN SUSTAINABLE DEVELOPMENT

Many of the critical environmental problems we face today, as outlined in the Rio Declaration 1992 and subsequent discussions arising out of various round tables! discussions relates to unfair use of World's resources, undue pressure on region's biodiversity, technology transfer, public participation in governance etc. And to add to the list of problems and challenges is the challenge of poverty, particularly existing in the developing countries. Various aspects and issues relating to these challenges, particularly environment and poverty, have been deliberated upon earlier.

Let us identify and spell out what role the engineers have to play in addressing these challenges. While scientists have been playing a significant role in understanding and developing policy to support decision makers, the applied knowledge of the engineering community has been largely absent from the policy debate, in spite of the fact that engineers use science to plan, build and operate the infrastructure which may directly contribute to solutions for these challenges.

Sustainable development approach to arriving at solutions for these challenges has been globally accepted. For this, the nature of development in future will demand a new role for engineers - not just their traditional problem solving role - but as leaders of the interdisciplinary teams involved in the decision-making process itself and as agents of change. In this new role, engineers will have to play the role of facilitators of sustainable development which will be achieved through:

(a) broadening the education of engineers and finding new ways to doing more with less resources, less energy consumption and less waste generation,

(b) focus on new manufacturing processes and equipment, expanded use of recyclable materials and the development of regenerative/recyclable products and packaging,

(c) broader understanding of political, economic, technical and social issues and processes related to sustainable development,

(d) information exchange through global communications network to share ideas, conduct business, develop sustainable engineering solutions and technological innovation, and

(e) working on a global scale to promote public recognition and understanding of the need for sustainable development.

One of the significant objective of the new role of engineers will be to achieve an ecologically sustainable world for future generations.

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*The Eleventh Dr Amitabha Bhattacharyya Memorial Lecture was delivered during The Seventeenth Indian Engineering Congress, Patna, December 19-22, 2002*

# End Product Manufacture and Food Extrusion Technology

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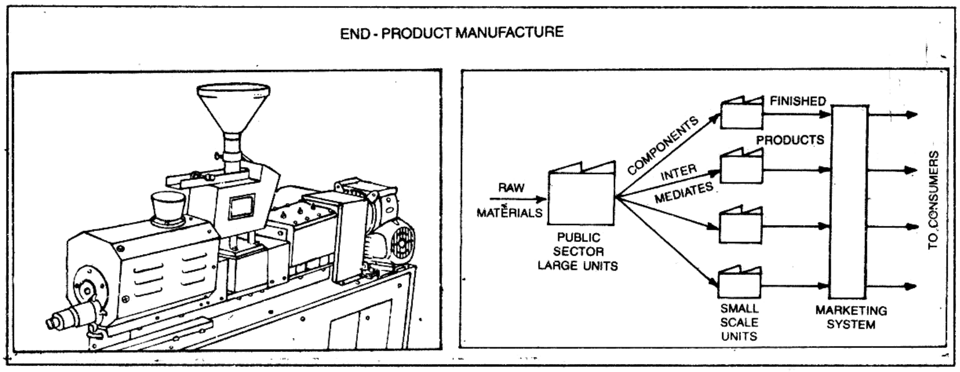
I am deeply indebted to the Council of the Institution of Engineers (India) for giving me the opportunity to deliver Dr Amitabha Bhattacharyya Memorial Lecture this year. Dr Bhattacharyya although roamed in the golden nimbus of higher science and technology but his feet was firmly entrenched in ground reality - specially to extend succour to the deprived and toiling masses. I am referring to his effort to establish the rural technology centre to introduce technology to the most important sector in rural area - food processing to impart nutrition ~nd to prevent disease prevention for the masses based on resources locally available. This attitude greatly influenced my activity and what little contribution towards food-processing I made is solely based on his inspiration and provocation. I take this opportunity in offering my deep seated regards and admiration to the memory of Dr Bhattacharyya. I am really honoured to be associated with this memorial lecture.

Eighteen years back in this great city of Patna I was installed as the President of this august Institution and I recall what I expressed as an engineer and what our society would expect from us. The time was just before seventh plan and now we are just commencing the tenth plan. The ground situation Changed, the public sector then was in a commanding position in economy while now these are commodities to be quickly disposed to inject strength to our economy some critics say for fire fighting purpose for our economy and not for permanent solution of our economic problems. One fact is apparent that whatever inefficiency (read misuse) of economy we incurred we have to repay it by borrowing from future bequething our family silver or lodging our future economy. We elders may not feel the heat so much but surely our progeny would have to face the music.

I would recall two points I mentioned in my presidential address in 1984, ego

o End Product Manufacture (EPM) - a strategy where large companies supply components to small industries who will make a complete product for home consumption and exports.

o Food processing based on extrusion technology to supply 'ready to eat' food for nutritional project, mid-day meal programme, 'food for work' scheme and community feeding programme.




I would again dwell on these two subjects as these are more relevant now to our economy even further.

End Product Manufacture (EPM) as explained before, is to divide the manufacturing process into two parts - the first part managed by large units which are energy - intensive and pollution-prone - to make components and the second part, which is labour intensive one, for assembling or processing to complete products. An example may be cited - manufacture of pumps/engine will regain its original efficiency meeting the energy-economy and pollution standard.

There will be two further gains for EPM - marketing will be easy because of assured quality, small scale units will have stock in complete marketable condition which will be valued higher than the components and bank will allow higher loan against this stock. The small scale units will get proper acceptance of his labour and skill in the assembled complete product as colateral by banks. '

You will appreciate that EPM is a sure way to utilise the natural skill and productive capacity of our artisans to create wealth for our economy. This natural skill is well exhibited in once flourished mechanical industry in Howrah, diesel-pump industry in Rajkot or gold-smith and diamond-setting units in MumbailSurat to give some examples. How unfortunate is that these naturally grown skilled persons are being displaced from their profession by the WTO regime induced globalisation. In order to mitigate the situation EPM can playa significant part with the help of research institutions to offer economic and efficient design and planning experts including banks to formulate financial package and marketing experts to develop production planning. In fact, this system will give the research institutions an opportunity to help the economy directly by providing energy-efficient and pollution free designs of pumps, diesel engines, agricultural implements.

This example of pump-diesel engine can be extended to other area of consumer goods like shoes, clothes even drugs and pharmaceuticals including herbal drugs and most importantly in food processing. I think I am able to impress upon the fact that to strengthen the economy the natural skill and entrepreneurship should be properly utilised which would include the technically trained people and skilled persons of village craftsman to create wealth for the nation. In this context I may mention the call address of Chinese President Jian Jeminis in recent communist party congress to include the private entrepreneurs, employees of foreign funded firms, self-employed and free-lance professionals to join in the economic development of nation and a political will is essential for this development in India also.

All these proposals are directed to enhance the productive-power . of a nation to create wealth for subsequent distribution to the nation and unless wealth is created at the desired rate we should be prepared to accept distribution of poverty. This brings the question of manufacturing vis-a-vis service sector. There is some rejoicing in India that our service sector now occupies 50% of GDP but manufacturing occupies only 15%. Predominance of China in manufacturing is far ahead of us attracting 47 billion dollars of Foreign Direct Investment (FDI) far surpassing of ours of only 2.3 billion dollars. Thus, China enjoys a stable economy assuring steady growth. However, rejoiced we are for our claiming information technology dominance our situation is always vulnerable as we are solely depending upon the economic situation of the customer-countries specially USA and if it sneezes we will catch cold.

My assertion to manufacturing by the proposed EPM scheme would ensure the steady growth by inducing complementarity of large industry with small-scale industry. The inefficient running of public sector units are not due to deficiency in productive technology only but also for their marketing strategy. A marketing strategy for the components/constituents manufactured by them for the small-scale industry to make a complete marketing product by them should be based not on charity but by sound economic and marketing principle. Some fiscal assistance however, may be allowed to large scale industry in view of the benefits accrued nationally due to energy-saving and environmental gain as explained in diesel-pump project.

Now I come to the area of food processing. In a recent seminar at Kolkata on economic progress of India it was indicated by the number of television sets sold but in fact, it should be indexed on how many Indians go to bed hungry. In a newspaper report it is indicated that a third of India goes hungry every night (The Statesman, October 27,2002). It may be appreciated how serious it is for a nation. Our great visionary and reformer Swami Vivekananda once propounded that god comes to a hungry man in the form of a plate of rice. These facts establish food with many faceted features in economy, religion, health, political freedom and well being of a nation. I would like to discuss contribution of technology in this situation. Let me delve a little in fundamental of food processing - daily course of cooking in household by burning fossil fuels in urban area' and wood-oven in rural area. The objective of cooking is to gelatinise the starch of cereals and de-nature the proteins (animal proteins, seed and pulse proteins) so that, human system can assimillate it. About 50 years back a new system of cooking was evolved in developed countries which use mechanical energy to cook cereals and proteneous materials by subjecting these to pass through high shear system under pressure in an equipment called extruder which, in simple term, is an Archemedean Screw rotating in a barrel. Nowadays, two screws are used and the feed materials pass through these screws cooking it instantaneously by the heat shearing effect. The energy consumption of extrusion-cooking is almost 10% of what a wood-oven would require - 1 kg of cereals would require 1.3 kg of wood to be burned. Take the case of rural people who may be given free grain as in 'food for work' scheme but he has to collect wood locally, destroying the environment. Forest cover in India is a bare 10% - far below the targeted 34% and dwindling continuously for simple reason of daily cooking and to some extent for lumbering.

A glaring example is Sub-Himalyan region causing the area barren as a result of deforestation resulting in loosing top soil and flood in plain land. The people has to travel longer year after year to collect fuel-wood for cooking. In early time of human history when fire was discovered, Homo sapiens learnt to cook food. Extrusion technology, by using mechanical energy (shear cooking) can be regarded as second generation of cooking technology.

The other advantages of extrusion cooking are

o The products are bacteria-free
o It kills anti-growth factors in cereals and proteneous materials making food more healthy
o Extrusion-cooking kills anti-nutritional factors in legumes, cereals, pulse-proteins and tubers
o It has a long self-life of 3 months and above
o It is amenable to good packaging
o This mechanical cooking process is instantaneous and there is no loss of products as off-grade products can be recycled
o There is no effluents
o No indoor pollution
o As explained, technology is highly energy-efficient

You may consider that I am introducing an alien food-culture in this country like the exotic extruded break-fast cereals of western countries. But in urban India this food culture is already dominating our household thanks to multinational companies intense propaganda through electronic media on noodle products. Out next generations already accepted it. This convenience food originated from China, invaded South-East Asia and entered Indian sub-continent, exported to Europe and America. According to international food experts Asian noodle will be world-dish very soon. Here is a challenge to our food research institutes and home science colleges where considerable funding has been made by Government. Now is the time for these institutes to pay back their debt to the nation by managing projects like school-feeding programme, mother-child projects, community nutritional projects by involving themselves throughout the project period and not producing only a small sample of extruded projects (and plethora of research papers) stating this is not their mandate to do the extension service. A political will should prevail on this project to include these programme by research institutions at least for quality control and development of extruded products with acceptable ethnic taste based on local raw materials as supplemental food and staple food. India has an enormous source of cereals and reasonable amount of oil seed and pulse-proteins to be utilised in these projects.

Another important area of extrusion technology is using natural herbs and spices in the extruded food which is marketed as nutraceuticals in advanced countries (enjoying a 64 billion dollar market in USA alone). A poor country like India will be immensely benefitted by nutraceuticals by using natural products co-extruded with cereals to produce a calorie-dense product both for nutrition and desease prevention. A micro-nutrient intervention project can be benefited by using extrusion technology as the rnicro-nutrients are evenly distributed if coextruded with cereals and irreversibly mixed - locked in gelatinized starch.

Nutrition is a neglected sector in India. We allocate a large sum for health sector involving drugs and medicines but very little attention is given for prevention of disease through food intake by nutraceutical route. Hippocrates expounded long ago that 'let food be our medicine and not medicine our food', the latter path we are following towards a pill popping nation (which our urban elders almost become). Extrusion technology offers excellent opportunity furnishing calorie as well as disease prevention effect as extruded food.

Food is not only restricted to its use as daily intake but it is a great economic factor involving health and productive power of nation. Unfortunately, classical economic study involves price of food upto the retailer's shop. But the ultimate destination of food is on the platter involving the cooking energy and its detrimental effect on environment as explained before. When considering extrusion technology this cooking energy factor should be considered on 'plough to platter' basis with the concomitant benefits of energy-saving and pollution abatement. Another bane of developing country is pilferage and distribution logistics of perishable products. This technology amply solves these problems as it is a single-step process, easily measurable system of input-output producing a shelf-stable product.

Everything said and done on the process of extrusion, now I will dwell upon its delivery system. The technology requires the machine, eg, twin screw extruder to process the cereals, oil seeds, pulses, tubers like potato and cassava, to make the extruded product which can be crunchy products and subsequently pulverised to form instant soup.

Now poor man's food is only carbohydrates and extrusion technology can make it a balanced 'ready to eat' product by co-extruding with proteneous oil-seeds. Twin screw extruders in foreign countries are highly capital intensive and of higher rated capacity. Developing countries can not afford to purchase, operate and maintain these equipment. There is need for less expensive, low rated capacity of twin screw extruder with sturdier design and control systems suited to the skill of local people. Here is the area where engineering design comes into play and it is now possible to develop such equipment suitable for developing countries - tried and tested by leading research institutions.

*The Twelfth Dr Amitabha Bhattacharyya Memorial Lecture was delivered during*
*The Eighteenth Indian Engineering Congress, Lucknow, December 21,2003*

# Energy Options for India

## Subir Raha

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The Homage

Watching Dr Amitabha Bhattacharyya walk tall in the campus of my alma mater, Jadavpur University, in the late Sixties, I could never even dream of the honour to stand in his name at the Indian Engineering Congress. Our batch mates in Mechanical Engineering would worship him for his brilliance. If I remember correctly, for the first time in India, specialization in Production Engineering was introduced in Jadavpur University, thanks to Dr Bhattacharyya's foresight. He was committed to the cause of India. We would watch him personally conduct Bratachari dance practice on the sports field, single-mindedly promoting a great tradition. As a professor, he would not only teach the theory and practice of engineering but also in still ethics and values among all of us. Intensely committed, deeply patriotic, professionally outstanding, Dr Amitabha Bhattacharyya remains a role model for all of us. I am sincerely grateful to the Council of the Institution of Engineers (India) for the privilege granted to me.

My chosen discipline was Electronics & Tele-communication Engineering; my chosen profession is management in the Oil & Gas Industry. In the hallowed tradition of the National council of Education, Bengal, Dr Bhattacharya was one of the great teachers who guided us to think "India First", always and every time, before our individual, sectoral interests and concerns. Today, in this august assembly of distinguished engineers, let us discuss the Energy Options for India.

The Challenge

We, one billion Indian citizens, constitute some 15% of the human population. The energy consumption in India is 3% of the global total. This mismatch represents the negative differential in the Quality of Life of the Indian People.

The aspiration for a better Quality of Life can not be denied or controlled. This is a historical inevitability, as proven by the collapse of the doctrine of centralized, state-controlled planning, and the on-going demolitions of walls and boundaries between nations. Half a century after Independence, we Indians stand at the threshold of an unprecedented opportunity to evolve into one of the Top Three Nations of the World in the next half-century. The World recognizes this potential. We must build on this opportunity, and we must do it the First Time Right, because there may not be a second chance, ever.

Conventional wisdom is that the Quality of Life of the American People sets the global bench-mark. The per capita annual energy consumption in the USA is 8.55 (Tonnes Oil Equivalent) TOE. The global average is 1.68 TOE. The figure for India is 0.32 TOE. This is the distance that we have to travel, providing clean, reliable, economic energy at 25 times the current availability to every one of the billion Indians. We need to do many other things as well, but everything we do requires energy.

Option 1: Oil & Gas

We have 15% of the World's population but 0.5% of the World's Oil & Gas reserves. In contrast, the countries in the Middle East hold 65% of the Oil & 36% of Gas reserves.

Because of the obvious advantages, we are increasingly using Oil & Gas in all sectors. The most serious issue, to my mind, is that the historical experience of assured availability at controlled prices has diluted the motivation for investments in conversion efficiency and conservation. There is no significant initiative for conservation, because of the subsidies and the controls which isolate the Indian consumer from the pressures of the global market. In three decades after the Oil Shock of 1973, the industrially developed nations have achieved conservation of the order of 15%, whereas our performance remains around 3%. At current level of consumption in India, every percentage point represents one million tonne of Oil & Gas. We will always be a net importer @ 70% or even more if we consider the potential growth in demand, and therefore, we must adopt global prices, as well as global practices in conversion and conservation.

The taken-for-granted availability of artificially-priced Oil & Gas has also removed the incentive for investments in substitution. It is only in the transport sector, other than Railways, that there is no substitutability for petrol or diesel or CNG or Auto-LPG for road transport, jet fuel for air transport and diesels or fuel oils for sea transport; similarly, substitutes are not available for all lubrication and feed-stock requirements. For all other fuel uses, electric power from the grid is a substitute. Because of artificial pricing and unreliable availability of electric power, we have built a huge capacity in captive generation for industrial, commercial and household requirements, using Oil & Gas with scant regard for efficiency of conversion as well as conservation. This is an absolutely lose-lose proposition.

The prognosticated availability of 0.5% of global Oil & Gas reserves in India is located in 26 sedimentary basins covering more than 3 million square kilometers. Our current production comes from less than 20% of this area. More than 50% of the area is either unexplored or poorly explored. Sincere the 'easy oil' has already been discovered, incremental explorations require increasing investments.

The next big discoveries are expected in deep waters on both coasts, and perhaps in the logistically difficult on land areas. Talking about deep waters, we plan to survey and drill' in water depths upto 3 kilometres. This calls for cutting-edge technology, big money and big risks. To give you the perspective, we in ONGC have launched Project Sagar Sammriddhi in August this year, with the objective of discovering 4 Billion Tonnes of Oil plus Oil-equivalent Gas in the two decades of 2001-20. The investment is of the order of 1 million US Dollar every day. These investments and inevitable risks can be sustained only by global market pricing of Oil & Gas. The temptation for below-market pricing, by compulsion, to obtain short-term advantages will take India back to the Dark Ages.

Option 2 : Coal

We have 7% of the World's coal reserves, but import increasing quantities because of quality constraints. Coal-based generation, in any case, involves the challenge of pollution control.

The artificial pricing of Oil & Gas in the domestic market, besides all the other undesirable and unsustainable consequences, has damaged the case for investment in Clean Coal technologies. Even to reach the global average of 1.68 TOE per capita energy consumption per year, we have to achieve a five-fold increase from the current level of 0.32 TOE. There is no choice but to exploit our coal and lignite reserves with accelerated investments in Clean Coal technologies. The Kyoto protocol provides a window of opportunity for India; we must not waste this through inaction.

A large part of our domestic coal reserves, lying in depths of the order of kilometre, is considered unmineable. Therefore, like deep waters exploration for Oil & Gas, Underground Coal Gasification (UCG) is a priority for us. There are major advantages when we take the potential to 'covert coal into synthetic fuels, fit for use as fuel and feed-stock without any change in the existing engines and conversion processes. UCG inherently addresses the issues of environmental pollution and site restoration. In ONGC, we have initiated actions to develop and exploit UCG and down-stream technologies, in association with the Department of Coal, Council of Scientific & Industrial Research (CSIR), and Gujarat State Petroleum Corporation (GSPC).

Option 3: Renewable Energy

In today's discussion, we have focused on 90% of the energy basket, as may be seen from the following tabulation of global and Indian patterns of usage. The area of concern, although in the long term, is that this 90% consists of fossil fuels i.e. Oil & Gas, and Coal.

| | Energy Basket (%) | |
|---|---|---|
| | **Global** | **India** |
| **Oil** | 37.5 | 30.2 |
| **Gas** | 24.3 | 7.8 |
| **Coal** | 25.5 | 55.6 |
| **Nuclear** | 6.5 | 1.4 |
| **Hydro** | 6.3 | 5.2 |

So far, our national effort in development and application of renewable energy has not yielded any result of significance. With imported technology, some wind-power firms are coming up, but the total capacity, in the national context, is negligible. Solar street-lights, water heaters and cookers are still curiosities. One does not even hear of the Biogas campaign any more. Hydrogen fuel cells end geo-thermal technology are still demonstration events, Bio-fuels, as of today, are only on paper.

One reason, to my experience at the Indian Institute of Petroleum, is that we do not focus on commercialization as the corollary of experimentation. Excellent developments are either not marketed at all, or the marketing effort is either incompetent or inadequate. I am referring to the practice of marketing in the holistic sense of converting an idea into a saleable product, and then actually delivering it to meet the needs and wants of customers, in a profitable manner. The other reason is that the efforts are individualized or localized, scattered, and often duplicated among academic institutions and independent- or company- research laboratories. It is also true that notwithstanding the tax-breaks provided by the Government, Indian companies do not make any meaningful investment in R&D, preferring to buy commercialized R&D from overseas, perhaps developed by Non-Resident Indians.

Setting up one more Task Force does provide a convenient escape from the reality of the problem; in any case, there are reports from all kinds of committees on all conceivable issues on some shelf or the other, consolidating the wisdom of five decades!

What we propose to do in ONGC is to set up a world- class facility for academic- and applied R&D on all forms of energy, and manage it on corporate terms, graduating from a cost centre to a profit centre in each technology over definite time-frames. We will provide best-in-class facilities including professional support for commercialization. We have already acquired the site in New Delhi, and hope to commission the "ONGC Energy Centre" as a national node for profitable R&D within the current Plan period.

The Best Options

To all of us engaged in the pursuit of technology, the challenge of going from 0.32 TOE to 1.68 TOE to 8.55 TOE per capita annual energy consumption by our fellow citizens provides the best option for putting our collective knowledge, skills and experience to the test.

The Institution of Engineers (India) could perhaps take the lead among all the Institutions in different professional disciplines to organize the national effort for promoting the Quality of Life for all Indians.

Such an initiative will surely be a precious contribution to the memory of Dr Amitabha Bhattacharyya, a great teacher and a great leader.

# Destination 2020: The Role of it in India's Development

Shri N M Nilekani

CEO, President and Managing Director
Infosys Technologies Limited, Bangalore

Size of Indian IT market is approximately $20 billion.

Indian IT's contribution to GDP has gone up from 1.3% in 1998- 1999 to 4% currently. By 2008, it is predicted to account for 7% of our GDP. Exports are predicted to grow by approximately 21% this year. Software and services export's contribution to India's total invisible receipts is also continuously increasing, indicating the strength of the software sector as the driver of overall foreign exchange reserves.

In 1997-1998, IT's contribution to overall invisible earnings was less than 18%. Now it is close to 74%. Additionally, the share of software and services exports in India's exports has increased to almost 22%. This share is predicted to increase to 35% by 2008. Software sector exports grew at a Compounded Annual Growth Rate (CAGR) of around 32% between 1998 and 2003 and are estimated to grow at 38% between 2003 and 2008.

Indian IT companies have pioneered the GDM. This is the basis of all offshore outsourcing. GDM has gone mainstream and is globally accepted now.

Most importantly this industry has raised India's rank in the comity of nations.

The label 'Made in India' is now considered a seal of quality. To date, this industry has employed an estimated 813500 professionals.

Countries and companies across the world are looking for partners who can bring them value.

Initially the India-advantage was based on cost-arbitrage. Now, however, it is quality, productivity and rapidly scaleable skills. Better customer service and reduced time-to-market have become as important as cost.

Further, India has an enviable reputation with regard to offshore outsourcing.

According to Gartner, India was ranked as the primary country for supplying offshore IT services by more than 70% of large U S corporations surveyed. Additionally, the UNCTAD's World Investment Report 2004 ranks India as the second largest base for IT and IT enabled services.

Clearly the IT industry has a vital role to play in driving India's economic development and its position in the world. At the same time, in a country like India, IT is important from a development point of view.

UNDP : Technology is creating the potential to realize in a decade, progress that required generations in the past.

In a country such as India, where :

• 26.1 % of population live below the poverty line

• 51% of population do not have access to essential drugs

• 35% of population is illiterate

• 70% of population resides in rural areas

The power of IT should be leveraged to leapfrog poverty barriers, and promote economic and' social development.

leT projects could be the most effective way of driving change: socially, by ensuring equal access for all groups; economically, by creating new types of transactions and financial instruments; and politically, by improving the quality, speed and responsiveness of the state interaction with individual citizens.

In order for development to take place, it is imperative that our governance structures are reformed.

A World Bank report, 'Doing Business In 2004' argues that redtapism and bureaucracy are closely allied with slow development and poverty. The reports asserts that very often, the governments of developing countries tie their own people down in a thicket of regulations.

What is required is answerability, participatory democracy, a platform for professional volunteerism and, most importantly, disclosure and transparency.

Through e-governance, governments can provide the required infrastructure to effectively service citizen's needs.

An e-governance software platform can include important municipal applications like property tax collection, ward works management, GIS. public grievance and redressal, trade licenses, etc.

Such a platform can enable urban governments to overcome the vicious cycle of poor infrastructure, citizen apathy and corruption and inefficiency. It can provide universal access of services, streamline institutional arrangements and institutionalize citizen participation.

Perhaps the most important aspect of computerization and egovernment is bringing a change to the mindset of the civil servents.

Clearly, e-governance is important for a number of reasons :

- It introduces transparency in data, decisions / actions, rules, procedures and performance of Government agencies.
- Automates processes to take away discretion,
- Provides an entry point for simplification of rules and reengineering processes,
- Builds accountability through greater access to information,
- Provides documentation to citizens for follow up,
- Centralizes data for better audit and analysis, and
- Enables unbiased sampling for audit purposes.

At the same time, IT can also be used extensively at a rural level. Networked technologies in rural and underdeveloped regions can compensate for the absence of infrastructure in the form of roads and financial institutions.

These information centres can allow new knowledge, services and resources to flow in and out of regions over long distances, thus alleviating the disparities between urban and rural regions.

Once money begins to flow into these economies, the capital to finance basic infrastructure including roads, dispensaires, sanitation systems and so on will be more easily available.

The Bhoomi project launched in India, to digitize rural land revenue records, is a resounding success, making the process more accessible and transparent.

Today, the project serves about 7 mm farmers and connects 177 districts.

IT is also an important tool for development across other sectors. E-learning is a cost-effective way of providing education at a distance.

The student based in rural regions will be able to access the best Libraries and Laboratories in the world. The Carnegie Mellon University's Informedia project is already a step in the direction of Digital Libraries.

The use of IT in rural banking and micro finance can impact a J broad cross-section of the population.

Handheld computers and smart cards can reduce the costs of providing loans, as well as monitoring them. Reducing these transaction costs is critical for sustainability of micro-finance schemes in the rural areas.

Further, in rural India, farmers are now using the e-choupal to go on-line and check prices for their soya beans at the nearest government-run market, or even on the Chicago futures exchange. However, before this can happen, some issues that must be addressed.

The competitiveness of a country depends on the ability of its people to leverage technology.

Unfortunately, India is increasingly getting divided into people who do, and people who do not have access to - and the capability to use - modern information technology. India needs to increase penetration In terms of PCs and communication lines.

About 70% of India lives in the villages. Our villages, unfortunately, are characterized by poor Internet connectivity. Connectivity options to the rural areas can be improved by using wireless access. corDECT, an advanced, wireless access system developed by the TeNeT group of IIT Madras, Midas communications and Analog Devices, is an instance of this.

In addition, cyber cafes in the urban centres, and village information kiosks in the rural areas will enhance the reach of IT. India has a large population with great linguistic diversity. Local language content will make ICT more relevant and accessible to a broader cross-section of the population.

Nasscom predicts that the number of Internet subscribers will increase from 2.46 million subscribers currently, to 7.18 million in 2005. This calls for additional investments in bandwidth. Education is fundamental for a knowledge-based industry like software.

It is predicted that there will be a need for approximately 1.1 million people by 2008. Supply of professionals, however, based on current trends, will fall short by over 200000.

Unfortunately. in India, total enrolment in higher education is only 6% of the relevant population (17-23 year olds).

We need to ensure an adequate pipeline of 'English-speaking' graduates. At present, India's large English-speaking population is one of its advantages over countries like the Philippines and China.

However, achieving proficiency in English in now gaining high priority in China. In Beijing alone, there are over a thousand language training centres.

The software industry also requires good infrastructure and facilities. An open skies policy could make air travel more viable for a larger section of the population, and also allow more international flights out of IT hubs.

Guaranteed and steady electricity supply is vital for the growth of any indusry. At present, we rank 75th. in the quality of our electricity supply (The Global Competitiveness Report). With traffic expected to grow by around 10% per year, the requirement would be for 30000 km. It is obvious that money and effort need to be put into improving our road network.

IT has already helped establish that India can be globally competitive and a strong intellectual contender. Clearly, we are firmly positioned in the information age.

The next 20 years will be focused on using the information age to drive India to developed nation status.

In the words of Jeffrey Sachs and Nirupam Bajpai India has a chance for a tremendous breakthrough in economic development, in this decade.

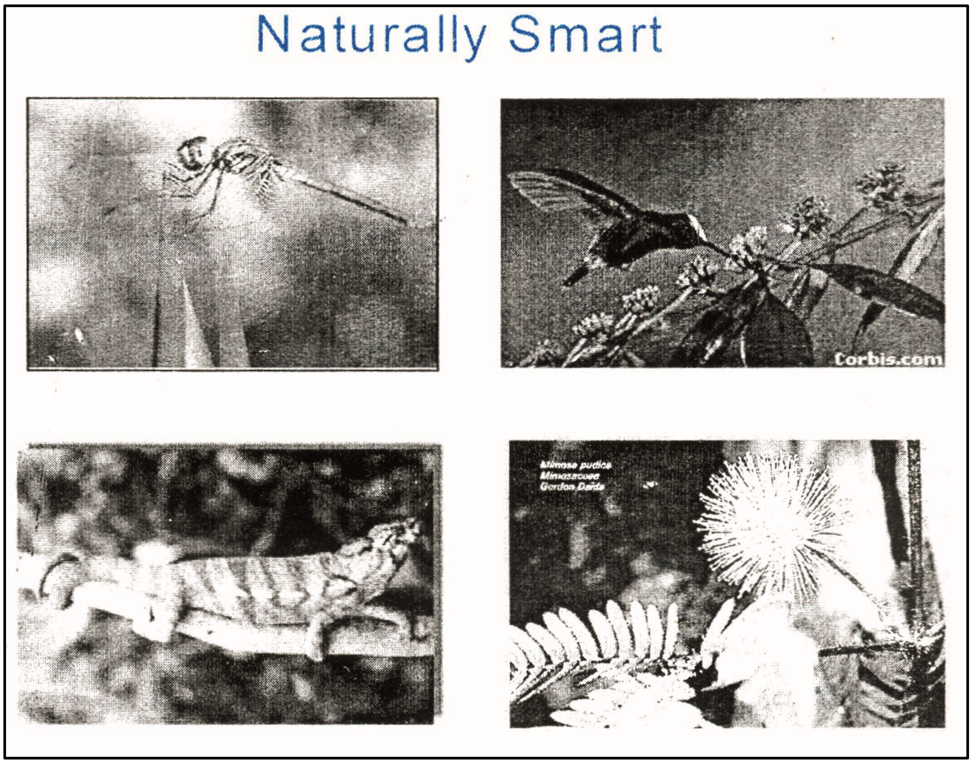
This is a great opportunity for us. If we can link our undeniable intellectual pool with the challenges faing our country, the multiplier effect will be formidable!

*The Fourteenth Dr Amitabha Bhanacharyya Memorial Lecture was delivered during*
*The Twentieth Indian Engineering Congress, Kolkata, December 15-18, 2005*

# Smart Structures and MEMS: An Emerging Technology

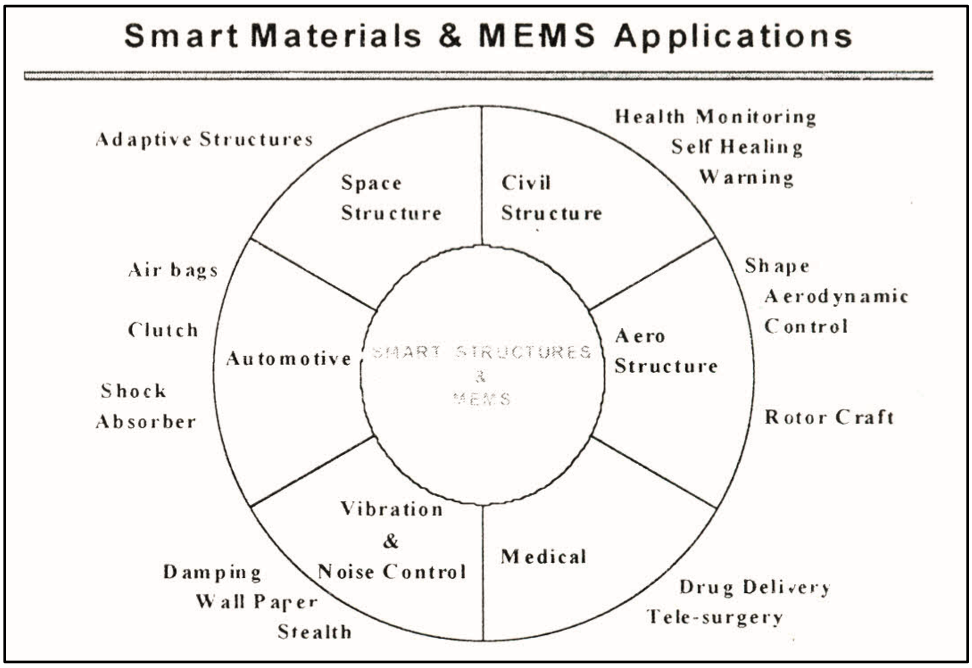
Dr Vasudev K Aatre

Former Scientific Adviser to Defence Minister and
Ex - Director General R&D

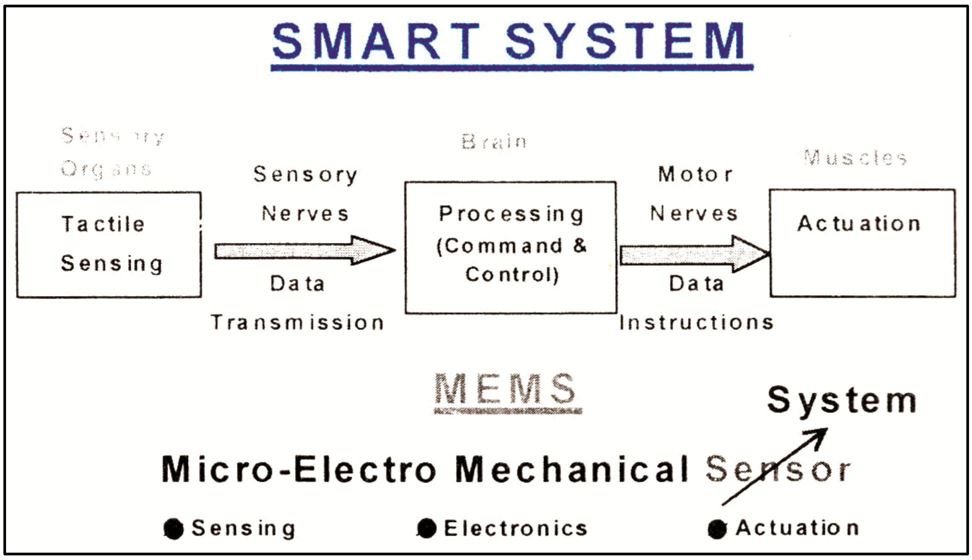



Material development has played a major role in the technological development. If we look back on the developments in the twentieth century, science and technology have made amazing developments in the design of electronics and machinery using standard materials, materials which do not have particularly special properties – properties other than the normal physical and chemical ones - like steel. gold, aluminum etc. We can well imagine the range of possibilities if we can have materials whose properties can be manipulated by scientists. Some materials have the ability to change their shape or size simply by adding a little bit of heat, or to change from liquid to solid almost instantly when brought near a magnet. Smart materials have one or more properties that can be dramatically altered. Most everyday materials have physical properties, which cannot be significantly altered, for example if oil is heated it will become a little thinner, whereas a smart material with variable viscosity may turn from a rluid which flows easily, to a solid. A variety of smart materials already exists, and ;s being researched extensively. These include piezoelectric materials, magneto-rheostatic materials, electrorheological materials, and share memory alloys. Some everyday items are already incorporating smart materials (coffeepots, cars, the International Space Station, eyeglasses) and the number of applications for them is growing steadily.

Smart materials and Micro-Electro-Mechanical Systems (MEMS) are the areas that have attracted considerable attention of the scientific world in the recent years and have vast potential for strategic and commercial exploitation. Major applications of smart technology including those of MEMS cover areas from aerospace to automobile engineering, from biomedical systems to environmental control, from defence systems to a vast array of civilian applications. Extensive research and development is going on in this field in many of the advanced countries aimed at materials and processes, device design and fabrication, application methodology, standardization etc.

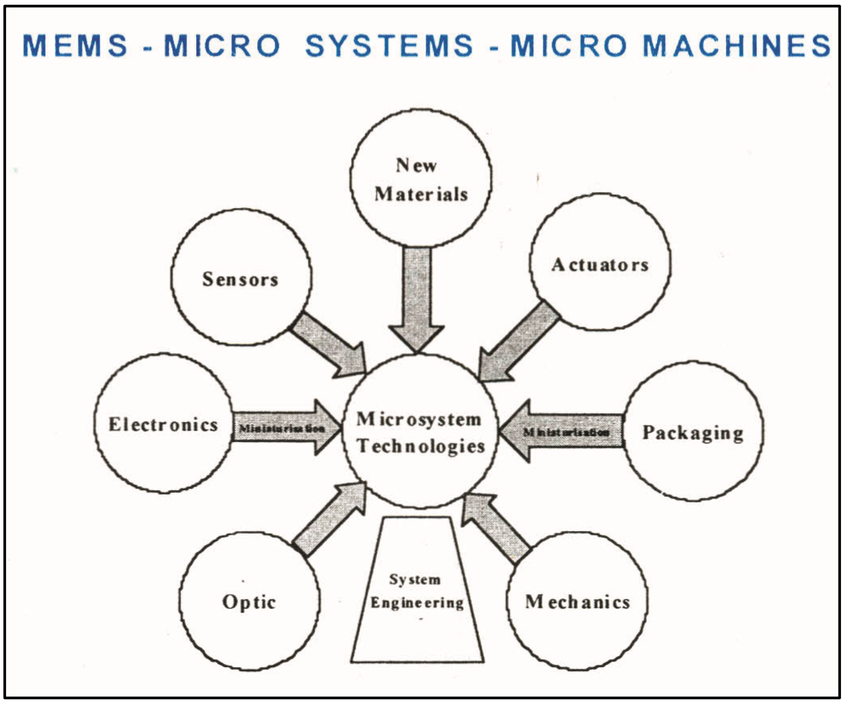



Smart material systems are non-living systems that integra> the functions of sensing, actuation, lcgic and control to respond adaptively k changes in their condition or t':e environment to which they are exposed, in a useful and usually repetitive mariner. The basic idea is to build systems which mimic nature.




With the development of micromachining techniques, the era of miniaturing mechanical systems like beams, cantilevers, gears, motors and pumps has led to the use of silicon and VLSI technology to fabricate electro-mechanical systems incorporating mechanical and electronic devices on the same chip - system on a chip - and mass production of such MEMS, reliably and at low cost has led to the popularity of this highly application oriented technology. In fact even opto-electronic systems have been integrated with mechanical systems to yield MOMS, MOEMS. As indicated, the application of this technology is wide spread - from aerospace to biomedical, from automobiles to cosmetics – the potential business is estimated to be in several hundreds of billion dollars.

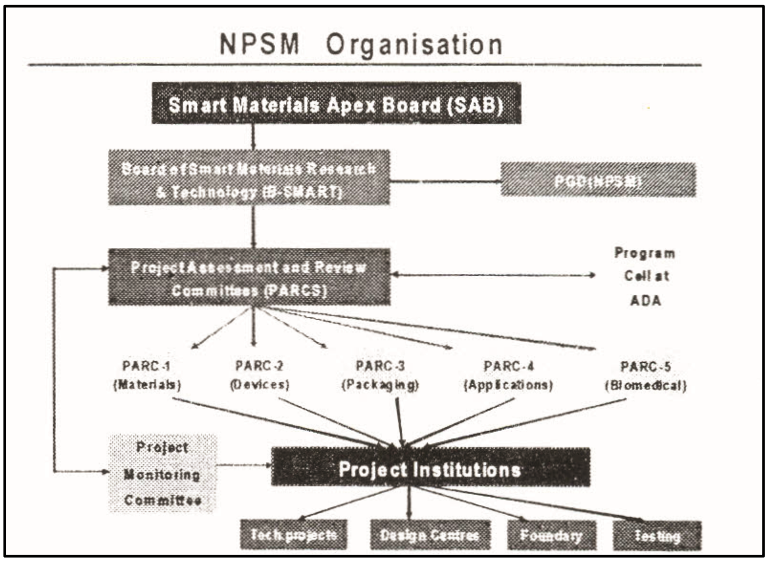
| Application | Technology |
|---|---|
| Semi active vibration controls | Piezo-ceramic stack actuators; PZT and MEMS accelerometers; controllable fluids; magneto-strictive mounts |
| Active noise cancellation | Piezo-ceramic pick-ups and error sensors; PZT audio resonators and analog voice coils; digital signal processor chips |
| Chromogenic mirrors and windows | Electro chromic (sol-gel, sputtered and vacuum-evaporated oxide; solution-phase reversible organic redox); suspended particle; dispersed liquid crystal; reversible electrode position |
| Smart navigation/guidance systems | Piezo-ceramic and MEMS accelerometers and rotation rate sensors; quartz, piezo-ceramic and fibre-optic gyros |
| Intelligent transportation | IR, vision and fibre-optic sensors and communi cations systems |
| Smart security systems | Accelerometers; driver recognition chips |
| Smart safety systems | Piezo yaw-axis rotation sensors (antiskid, antilock braking); ceramic ultrasonic "radar" (collision avoidance, parking assist); MEMS accelerometer (air bag controls); electronic stability control (four- wheel independent auto braking) |
| Smart performance systems | MEMS sensor systems (engine and dynamic chassis handling, acceleration, pressure, fuel, air, combustion, position); PZT combustion pressure sensors |
| Smart comfort control systems | Piezo polymer IR sensors; rain monitors; occupant identification; HVAC sensors; air pollution sensors (CO and $NO_x$) |



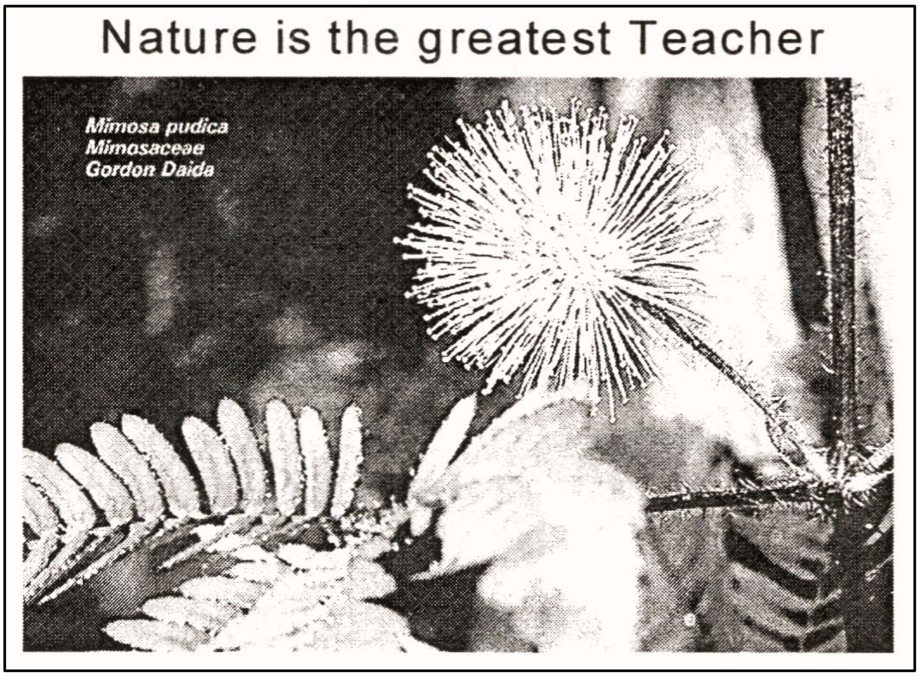
In India also the fields of MEMS and Micro Systems have received considerable attention, several programmes being launched in academic institutions and research establishments in the recent years. Following the first international conference in 1996, a professional society called Institute of Smart Structures and Systems (lSSS) was founded in India in 1998 to promote smart materials technology in the country. It was also felt at this time that a well-focused national effort was required to coordinate the work in the country in the area of smart materials research and development. This involved, on the one hand, identification and prioritization of national requirements, strengths and weaknesses, and on the other, channeling the limited resources for the right developmental tasks through a synergised effort. Two major programmes were thus formulated and submitted for the approval of the government; (i) the National Programme on Smart Materials (NPSM) and (ii) the Development Initiative for Smart Aircraft Structures (DISMAS). The programmes were sanctioned by the Government in July 2000 and January 200 I, respectively.

The National Programme on Smart Materials, sanctioned in July 2000, is a joint programme of five concerned scientific departments of the Government; namely Departments of Defence Research, Space, Science and Technology, Information Technology and Council of Scientific and Industrial Research. The main objective of NPSM is the development of smart sensors, actuators and MEMS devices and associated technologies of materials, processing, qualification and applications through a weil focused effort. It is a 'Directed Programme' in the sense that projects tailored to meet the programme objectives are to be sought and sanctioned to institutions having necessary expertise and facilities.


The Programme is being managed and monitored by a three-tier management structure as given herein. Five PARCs were constituted to look after specific areas, namely, Materials and 'Processes, Devices, Packaging and Qualification, Applications and Bio-medical devices. A Programme Cell at the Aeronautical Development Agency, Bangalore (responsible for managing the prestigious Indian Light Combat Aircraft Programme) is responsible for the overall execution of the programme as per the directives from B-SMART based on the recommendations from PARCs.



While the national programme has established design and fabrication centres and developed certain technologies and devices, conversion of the same to production and establishing production is still some time away. However, it is anticipated that the second phase of the programme would attack this problem. The establishments of design and fabrication centres, workshops run by NPSM and ISSS have been very effective in triggering R&D in this area, though industrial participation in this all important area is minimal. There is clearly a role for the professional institutions like the Institution of Engineers in developing and exploiting this technology lest India miss the Microsystems revolution (which incidentally may be the precursor to the Nano revolution) like it did the Silicon revolution.



# Water Supply in Sri Lanka

D Lakdasa Taldena

President, The Institution of Engineers, Sri Lanka

Chairman, Distinguished members I bring you all greetings from The Institution of Engineers, Sri Lanka. Before commencing on my presentation proper, I must first of all thank the organisers of the 21 st Indian Engineering Congress for having bestowed the honour on me to deliver the 15th Dr Amitabha Bhattacharya Memorial Lecture. The theme of the Congress is 'Challenges of Engineering for Sustainable 10% Growth and Beyond'. When the request was made to me by Cmdr. Poothia, I decided to select the topic Water Supply in Sri Lanka', where I hope to cover material most of which would be within the theme of the Congress Sessions.

Ancient Sri Lanka

In ancient Sri Lanka water supply and irrigation were of a standard; that current Sri Lankans are proud of. The communities of obtained their water requirements from rivers, lakes, tanks and dug wells. Historical records indicate the existence of water supply and sanitation systems in the towns of Anuradhapura and Polonnaruwa. Pots of water, made of stone known as 'pinthaliya' (merit water pot) were kept for the use of the people, while they traveled from place to place. A cloth 'perahankada' had been used to filter the water. This practice is used even today, when buddhists offer 'atepirikere' to the monks, a 'perahankada' is one of the eight items.Epidemics due to contaminated water have not been recorded, although deaths due to other calamities such as starvation have been common, indicating accessibility to safe drinking water.

Storage and water conservation practices of ancient Sri Lanka were very developed and comparable with any of the civilisations of that period. The numerous tanks, water conveyance systems of which many are functional to this day, bear ample testimony. Water was used for consumption, bathing, agriculture and aesthetic purposes. Meticulously designed ponds and fountains added beauty to the cities. Nuwara Wewa and Tissa Wewa are two examples of tanks constructed by the ancient kings for the use of the city folk. Many similar tanks were used to provide water for irrigation purposes.

For the transport of water, slabs of stone were placed to form a rectangular duct. To make it 'water tight' the duct was encased in clay. From the 3rd century Be, clay pipes had been used in the country. Drinking water wells were constructed with clay rings. It was also customary to plant a 'kumbuk' tree close to the well, the roots of which is claimed to have the property of absorbing salinity. Varieties of dried seeds such as 'ingini-ete' and 'murunga-ete' were used for the purification of water.

Ancient Sri Lankans have also been very sensitive to sanitation. Latrines had cast clay closets piped to a pit system. Evidence of these are seen in the ruins at Anuradhapura and Polonnaruwa. At the Jetawana monastery complex, there had been a system to purify urine by passing through pots of sand, lime and charcoal prior to its discharge to the soil. The pots were placed one on top of the other.

Rainwater collection had also been practiced in ancient times. The summit of the 5th century rock fortress of Sigiriya is an example of a well engineered water garden. It consisted of a central island surrounded by four L-shaped pools connected by underground conduits at varying depths, which suggests an attempt to maintain different water levels. Rainwater was collected and transmitted methodically through horizontal and vertical channels shaped in the rock. Fountains made of marble slabs were activated were activated by the deep water conduits.

A greater feat of harvesting rain water was the system of tanks constructed in the dry zone. The rain water in the catchment area of a tank fed the tank. The tank also collected the water flowing after use from the tank above. In this way, every drop of water was made use of a number of times before it flowed into the sea. The system of the village tanks is perhaps unique. Many of the tanks still remain, while others have been destroyed.

Current Situation

In more recent times water for irrigation purposes is controlled by the Department of Irrigation, which has been functioning since British rule. Treated water for drinking purposes, domestic and other use is now under the purview of the National Water Supply and Drainage Board (NWSDB). This is a statutory Board and has taken the functions of water distribution in urban areas from the local authorities which did this function under British rule. By the end of 2005, the Board was maintaining 291 water supply schemes and around 18,500 hand pump/tube well installations and 12,900 rain water harvesting tanks have been constructed. Thus 29.5% of the population is served with pipe borne water supply, another 8% using hand pump/tube wells and a further 34% use dug wells and around 2% use other means such as rain water harvesting. Although the NWSDB is a commercially oriented organisation, it operates as a service organisation. Water is supplied through public stand posts to tenement gardens, public toilets and public bathing areas free of charge. Maintenance of hand pumps installed in the dry zone is also a free service by the Board.

A Public Utilities Commission (PUC) has been established and arrangements are under way to have appropriate amendments in the NWSDB Act in order to bring the latter organisation under its purview. This is being done in the interest of the public so that the quality, pricing and efficiency of service will be under the scrutiny of the regulator. The water tariff taken as a whole at present is just sufficient to meet the' operational cost and debt service. In terms of sustainability, the tariffs should generate revenue for the Board to be able to meet all O&M expenditure, debt service payments and make available funds for new development works. At present major projects are funded by donor assistance.

The following table indicates some of the features related to drinking water production and use related to the NWSDB

| Item/Year | 2004 | 2005 |
|---|---|---|
| Water production (million $m^3$) | 367 | 383 |
| Deep wells drilled and successful | 417 | 419 |
| O and M expenditure (SLR in millions) | 4583 | 5273 |
| Total revenue (SLR in millions) | 4963 | 5839 |
| Development expenditure (SLR in millions) | 12748 | 12648 |
| Total Staff (permanent, casual and contract) | 7737 | 7914 |

A detail of the water production cost is given below.

| Item/ Year | 2004 | 2005 |
|---|---|---|
| Personnel cost (SLR in millions) | 1919 | 2541 |
| Pumping cost (SLR in millions) | 1126 | 1245 |
| Chemical cost (SLR in millions) | 171 | 214 |
| Repairs and maintenance cost (SLR in millions) | 224 | 308 |
| Other costs (SLR in millions) | 316 | 355 |
| Establishment expenses (SLR in millions) | 451 | 610 |
| Total cost (SLR in millions) | 4207 | 5273 |

Donor Funded Projects for Water Supply

Donor agencies continue to provide the NWSDB with assistance by providing SLR 10,187 million as foreign funds for capital works during 2005. The Government of Sri Lanka made a contribution of SLR 5,945 million as counterpart funds and funds towards projects in the Small scale Infrastructure Rehabilitation and Upgrading project (SIRUP).

The donors contributing foreign aid were - France, JICA, ADB, JBIC, Korea, Australia/New Zealand, KfW, Austria, DANIDA and NORAD.

Some of the major water supply projects completed or under construction are as follows.

• Third Water Supply and Sanitation Sector Project - ADB funded

Total project cost US $ 140.2 million

Rural Water Supply Program consists of 734 village sub-projects and 26 water supply project projects in small towns have been completed.

Project commenced in 2000 and to be completed in 2006.

• Secondary Towns and Rural Community Based Water Supply and Sanitation Project - ADB funded.

Total project cost US $ 86.3 million of which the foreign ADB component is US$ 60.3 million.

Expand the existing water supply schemes at Polonnaruwa and Hambantota. Provide new piped water supply schemes in Batticaloa and Mittur.

The urban component aims to provide safe water to 969,000 people and the riral component to provide 322,000 people with community based rural water supply schemes in Polonnaruwa and Anuradhapura districts of the North Central Province covering 14 Pradeshiya Sabhas.

Project commenced in 2004 and is expected to be completed over a period of five years.

• Anuradhapura Group Town Water Supply Scheme - France and ADB French funding was used for the construction of the 4 MGD intake and treatment plant. ADB assistance was used for overall improvements to the distribution network.

The scheme benefits an additional 120,000 people in and around the town of Anuradhapura.

The project was completed in 2004.

• Improvements to the Matara Water Supply Scheme. - JICA funding

The objective was to improve the water treatment facilities at Malimboda, transmission improvements and expansion of the distribution network.

The cost of the project was SLR 1,568 million and implementation was completed in 2006.

• Kalu Ganga Water Supply Project - JBIC funding

The project was designed to use water from the Kalu Ganga as a:new water source to meet the increasing demand for water in the southern part of greater Colombo. Stage I of the project which is almost complete will produce 60,000 $m^3$/d from the treatment plant and convey to selected areas through transmission mains and reservoirs.

The total cost of the project is SLR 12,000 million.

The treatment plant is to be expanded and a further 60,000 $m^3$/d to be extracted to feed smaller towns in the Kalutara district is under consideration.

• Towns North of Colombo Water Supply Project - JBIC funded

The project is to establish a distribution network covering the areas of Ragama, Mahara, Ja-ela, Kandana, Welisara and Ekala. A population of 350,000 is expected to be benefited, with 20,000 new connections.

The total cost of the project is SLR 5 000 million, and construction activities commenced in 2002 and is almost complete now. Many of the new connections have not been given due to a shortage of water.

• Greater Kandy Water Supply Project - JBIC funded

The project includes the augmentation of the water supply within the Kandy Municipal Council and several surrounding Pradeshiya Sabha areas. The treatment plant will have a capacity 36,670 $m^3$/d.

The total cost of the project is SLR 4,820 million with the construction contract awarded in December 2003. Work on the project is almost complete.

• Integrated Water Supply scheme for the Eastern Coastal Towns of

A~parai District -Project funded by Australian new Zealand Banking Group (ANZ), export Finance Insurance Corporation (EFIC) and City bank, Colombo

The project is to provide water to the towns along the eastern coastal belt. The first part of the project was completed in 2002 and the second part is expected to cost SLR 9,635 million.

• Nawalapitiya, Amparai and Koggala Water Supply Project – German (KfW bank) funded.

The contracts have been awarded for the constructions in 2004, and construction work is in progress. The Nawalapitiya treatment worksis 4500 $m^3$/d, and expected to benefit around 17,500 people. The Amparai treatment plant of capacity 6,500 $m^3$/d is expected to cater to the urban council area of Amparai. The Koggala treatment plant is expected to cater to the Koggala export promotion zone and surrounding townships with a population of 37,000.

The total cost of the project is SLR 2,700 million.

• Greater Galle Water Supply Project - Korean assistance

The project is to construct water treatment facilities to provide water to a population of 160 000 in the surrounding areas of the Galle Municipal Council. A salinity barrier has been constructed across the Gin Ganga to prevent the intrusion of salt water to the intake during dry seasons. An additional population of 40 000 within the Galle Municipal Council area would also benefit from the project.

The total cost of the project is SLR 6 672 million and work on Stage I was completed in 2005. Work commenced on Stage II, which comprises of the balance part of the distribution system in December 2005.

• Hambantota, Ambalantota, Weligama and Kataragama Water Supply Projects - Austrian assistance

The activities in this project are the construction of water treatment plants at Weligama, Hambantota and Kataragama. 40,000 new connections would be provided for a total population of 140,000.

The total cost of the project is SLR 1,820 million and work is in progress.

• Kandy South Water Supply Project - DANIDA funded

This project covers townships in the South of Kandy. The total population to be benefited is about 330 000 with a total treated water supply of 53000 m3/d. Water is to be distributed using 18 reservoirs and about 300 km of distribution pipes.

The total cost of the project is SLR 6 668 million, and work has commenced in 2006.

• Nuwara Eliya District Group Water Supply Project - DANIDA funded

The project covers Hatton, Ginigathhena, Maskeliya, Walapane and Nildandahena towns and the surrounding areas. The population to be benefited is around 100 000. The contract has been awarded in 2006.

• Greater Kurunegala Water Supply Project - DANIDA funded

The project is to improve the water supply in Kurunegala town and its environs. The beneficiaries is a population of around 65,000. The new treatment plant is expected to give an additional output of 11,000 m3/d. Tenders are being evaluated at present.

• Greater Negambo Water Supply Project - Dutch Government funding

The project is to improve the water supply in and around Negambo town. An offer by a nominated sub-contractor is being studied and evaluated.

• Kelani Right Bank Water Treatment Plant DANIDA funded

The proposal is to build a 40 MGD treatment plant on the right bank of the Kelani Ganga, almost opposite to the existing treatment plant at Ambatale. The water would be used to feed the ever increasing demand in Colombo and its suburbs.

Tenders are being evaluated at present.

In order to be able to extract more water from the Kelani Ganga a salinity barrier has to be constructed downstream of both intakes.

• Integrated Trincomalee Water Supply Project - funded by France

The project is to rehabilitate the treatment plant located at Kantale which supplies Tincomalee and its environs. As there is inadequate water available from Kantalai tank, water is also to be extracted from the Mahaweli Ganga. This water will be piped to Kantalai for treatment. Design work by a French Consulting firm is in progress which is hampered by the hostilities in the area.

• Jaffna Water Supply Project

The project proposes to take 50 000 m3/d of water from the Iranamadu tank to feed Jaffna and its environs. Water has to be conveyed over a distance of about 85 kms.

Locally Funded Projects for Water Supply

I have listed the major foreign funded projects just completed, or where work is in progress or where firm proposals are available. The government of Sri Lanka also has a capital works program to fund water supply projects and 42 new such schemes are being constructed during 2005- 2006. The following table gives an indication of such projects in the districts.

| District | Allocations in 2005 (in million SLR) | Number of projects with fund allocations | Beneficiaries |
|---|---|---|---|
| Ampara | 51.76 | 2 | 39 000 |
| Anuradhapura | 20.00 | 1 | 8 200 |
| Badulla | 40.14 | 3 | 59 600 |
| Colombo | 440.03 | 5 | 1 05 900 |
| Galle | 66.38 | 5 | 83 000 |
| Gampaha | 89.03 | 6 | 33 750 |
| Hambantota | 67.19 | 3 | 38 500 |
| Kalutara | 81.59 | 3 | 1 52 000 |
| Kandy | 170.13 | 4 | 77 800 |
| Kegalle | 66.00 | 3 | 24 450 |
| Kurunegala | 273.92 | 4 | 26 800 |
| Matale | 91.00 | 4 | 73 100 |
| Matara | 99.73 | 7 | 22 000 |
| Monaragala | 26.00 | 2 | 28 700 |
| Nuwara Eliya | 20.00 | 1 | 26 000 |
| Polonnaruwa | 68.70 | 4 | 20 200 |
| Puttalam | 11.87 | 1 | 2 500 |
| Ratnapura | 173.00 | 5 | 71 100 |
| Trincomalee | 76.20 | 7 | 2 03 500 |
| Inter-provincial | 67.33 | 2 | 25 000 |
| TOTAL | 2000.00 | 72 | 11 20 600 |

Many of the water supply facilities in the tsunami affected area had to be repaired. Various donors came to the assistance of the NWSDB to offer their services to carry out the repairs and even to renovate and rehabilitate run down water supply schemes.

One of the targeted Millenium Development Goals (MDGs) that Sri Lanka hopes to achieve is to halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation. By 2006, Sri Lanka has reached a high level (86%) of access to improved water sources. However, sub-national differences exist between sectors with urban (96%), rural (82%) and estate (61 %). These differences are reflected in the provinces and districts where urban areas have better access. The lowest access (below 60%) is among populations in the districts of Sabaragamuwa, Nuwara Eliya and Badulla.

The goals in water supply have been set as -

Access to sufficient and safe drinking water to 85% of the population by 2010 and 100% by 2025,

Piped water supply to be provided to 100% of the urban population and 75% of the rural population by 2010, and

Service levels and the quality of water to achieve national standards in urban and rural areas.

The table gives the proportion of households with sustainable access to safe drinking water.

| Province | Percentage |
|---|---|
| Western | 91.5 |
| North-Western | 87.9 |
| North-Central | 80.5 |
| Southern | 80.5 |
| Central | 78.3 |
| Uva | 67.9 |
| Sabaragamuwa | 63.8 |
| **Note :** Data is not available for the Northern and Eastern Provinces | |

A draft Water Supply and Sanitation Sector Policy was formulated to provide guidance for the NWSDB, Provincial Councils, Local Authorities, Lending Institutions External Supporting Agencies, NGOs and other Community Based Organisations. It covers the design and implementation of programs, investment strategies to achieve the coverage targets, service quality and cost recovery objectives of the government of Sri Lanka.

Strategies have also been developed to address the rural poor and marginalized groups in seven districts. These strategies ensure that the poor in rural areas receive adequate water supply. The poor people are given opportunities to provide their labour in lieu of cash and other contributions. Marginalised consumers have been given the facility of getting individual service connections at concessionary rate of SLR 13 500/=, whereas the average service connection charge is about SLR 13 500/=.

The NWSDB has implemented a program funded by the ADB to construct rain water harvesting tanks in six districts, namely Anuradhapura, Hambantota, Kalutara, Kegalle, Monaragala and Puttalam. Details are as follows.

| | Cumulative number of tanks up to end of 2005 | Number of tanks completed during 2005 |
|---|---|---|
| Anuradhapura | 2 967 | 429 |
| Hambantota | 2 086 | 57 |
| Kalutara | 1 341 | 383 |
| Kegalle | 1 826 | 107 |
| Monaragala | 2 921 | 17 |
| Puttalam | 1 096 | 1 |
| Total | 12 237 | 994 |

The NWSDB has also carried out awareness programs on Rain Water Harvesting for the urban and industrial sector in collaboration with Lanka Rain Water Harvesting Forum and the Ministry of Urban Development and Water Supply. A National Rain Water Policy and Strategies were formulated by the Ministry of Urban Development and Water Supply with the NWSDB and Cabinet approval was granted for the policies and strategies to be implemented in the future.

Water Tariffs

The current pricing of water for domestic consumers is as follows.

| Consumption units per month unit = 1 $m^3$ | Number of units | Rate per unit SLR |
|---|---|---|
| 01 - 15 | 01 - 10 | 1.25 |
| | 11 - 15 | 2.50 |
| 16 - 20 | 01 - 10 | 1.25 |
| | 11 - 15 | 2.50 |
| | 16 - 20 | 8.50 |
| 21 - 25 | 01 - 10 | 1.25 |
| | 11 - 15 | 2.50 |
| | 16 - 25 | 30.00 |
| 26 - 30 | 01 - 10 | 1.25 |
| | 11 - 15 | 2.50 |
| | 16 - 30 | 50.00 |
| 31 - 40 | 01 - 10 | 1.25 |
| | 11 - 15 | 2.50 |
| | 16 - 40 | 60.00 |
| 41 - 50 | 01 - 10 | 1.25 |
| | 11 - 15 | 2.50 |
| | 16 - 50 | 70.00 |
| More than 51 | 01 - 10 | 1.25 |
| | 11 - 15 | 2.50 |
| | >16 | 75.00 |

The rates for non-domestic consumers are,

| | | |
|---|---|---|
| Religious and charitable institutions | units 1 - 50 | 4.00 |
| | > 51 | 12.00 |
| Schools | | 4.00 |
| Stand Posts | | 7.00 |
| Commercial institutions | | 50.00 |
| Industrial institutions | | 42.00 |
| Tourist hotels | | 50.00 |
| Government institutions | | 42.00 |
| Rural water supply schemes (maintained by CBOs) | | 7.50 |
| Local government institutions | | 9.50 |
| Shipping | | 250.00 |

Final Remarks

I have briefly given the situation in Sri Lanka about water supply. It is seen that considering the tariffs, the domestic sector is heavily subsidised, especially those households where the water consumption is low. Even taken as a whole, the policy of the government which is being implemented by the NWSDB provides only for a return on the O&M cost and loan repayment. The difference in tariff rates between the lowest block and the highest bock is around 40 times. The policy does not identify the needy, where a subsidy is required. Up to now, there has been generous foreign funding for most of the capital works. Whether this trend would continue in the future remains to be seen. Anyway, in the case of loans, the government needs to pay back to the funding agencies. The water treatment plants and networks need to be replaced and augmented at the end of their lifetimes. The government will have to continue to be heavily involved in the public sector in order to continue to provide safe drinking water to the people of Sri Lanka.

The country needs to develop in-house design and construction capability in water treatment plants. At present, even simple works, such as laying of pipe lines, construction of water reservoirs are included in foreign contracts. The foreign contractors in turn sub-contract to local contractors at a fraction of the money they receive.

There is a conflict of interest in the demands for water by both irrigation requirements and drinking requirements. A further complication arises, when the water is used for electricity power generation. When water is to be extracted from reservoirs for town water supply schemes, the farmers complain. Such complaints are now becoming vociferous. This has affected water supply to Anuradhapura and Trincomalee in recent times. In the case of Anuradhapura, the source had to be moved to Thuruwila which is a tank 14 kms away. Also, authorities had to agree that the waters at Thuruwila tank would be replenished from diverted water from the Mahaweli Ganga, before the farmers agreed grudgingly. A similar situation exists at the Kantale tank, where increased draw off is not agreed to by the farmers. The Kantale tank feeds Trincomalee. As a result, the additional water is now proposed to be extracted from the Mahaweli Ganga.

At present water for irrigation purposes is provided free to the farmers. The Irrigation Department controls the distribution of water for such purposes in co-ordination with farmer organisations. Farmers were up in arms when a comprehensive Water Policy Bill was to be introduced to Parliament recently.

Thank you very much once again for enduring me for the past 20 minutes, and I hope you have gathered some information about 'Water supply in Sri Lanka' and I wish you all a pleasant day.

# New Paradigms in Managing Design and Production — the Experiences of the Defence Industry

Rear Admiral Ganesh Mahadevan, *AVSM, VSM*

Indian Navy

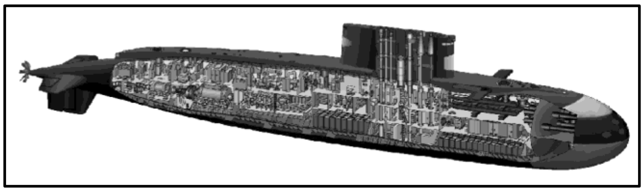
I feel honoured being invited by the Institution of Engineers (India) to deliver the Dr Amitabha Bhattacharya Memorial Lecture at the Indian Engineering Congress today.

Prof (Dr) Amitabha Bhattacharyya was a distinguished mechanical engineer and an eminent educationist in India. He was an acknowledged authority in the fields of production engineering, metal cutting and machine tools and has been honoured nationally and internationally for his outstanding contributions to the cause of engineering. I have chosen my subject today to carry forward the work done by Professor Bhattacharyya and his vision for the future. Let me add a few words to my introduction so as to bring my background as an engineer into perspective. The Indian Navy took a momentous decision in the 1960s that we shall make warships, rather than buy warships. This decision has led us through a fascinating trajectory, the accumulated experience of which forms the basis of my address.

The Indian Navy began its warship building endeavour with the Leander Class Frigates in the 60s at Mazgaon Docks Limited, Mumbai, and has, to date, gone through the experience of constructing over 80 warships in India, including submarines, destroyers, frigates, corvettes, tankers, landing ships, missile boats, patrol vessels and fast attack craft. We have a further 21 vessels under current production in four shipyards, including an aircraft carrier at the Cochin Shipyard.

The design and production of the associated machinery, weapons and fittings have kept pace through the DRDO and our industry, both in the public as well as the private sector, and we have an antisubmarine patrol vessel currently on order at Kolkata with 100% indigenous equipment.

A warship, or a submarine, is an exceedingly complex piece of machinery, involving the integration of myriad components, ranging from the hull itself, propulsion machinery to sustain the platform on the world ocean, the means to make it habitable for its considerably sized crew, the weapon systems that enable it to fight, and the devices required by it to navigate, ie, to float to move and to fight.



Weapon systems themselves are an intricate integration of sensors that help the platform to detect the enemy, to compute the best solution to engage him, and to deliver the munitions required to neutralise him. Over the years, the distance over which the enemy has to be detected, or the stand-off range, has gone far beyond the horizon, and now extends over the entire surface of the sphere that our planet is. The increase in the complexity of threats makes it imperative that huge quantities of information are processed to arrive at a decision, requiring complex computation and information management.

The hull itself is an area of well evolved and stabilised engineering practice developed the world over in the last century and a half. However, as will be elaborated in my talk, cost and time considerations have driven the industry to evolve more and more efficient methods of its erection, and the requirement for stealth has introduced innovation.

The submarine has always been a special case, having to withstand the pressure. The propulsion and power generation systems with their numerous auxiliary support systems have to be packed into a compact metal casing, with kilometers of piping and cabling. I have brought out these facts to define the framework of the engineering processes that have been my area of specialisation, in order to draw lessons for the engineering fraternity at large, seated before me. I hope to bring out that these experiences apply broadly to all areas of engineering, be it aerospace, process engineering, railways and the like.

My talk today sums up the cumulative experiences, not only of the Indian Navy, but the Defence Industries around the world, in sustaining design and production of these platforms, and to derive conclusions that indicate the need for the complete redefinition of the engineering process as understood so far. This need for a redefinition emerges not only from well known processes ushered in by the global engineering industry and the information technology revolution, but by the compulsion of the defence services to contain costs and enable life-cycle management of products.

It is my understanding that the compulsions of the Defence Industry, and the new methods that have been derived to cope with them are applicable to all areas of engineering, and these new methods merit a rethinking by us, the Engineering Fraternity of India, of almost all areas that drive us, including the education of our young engineers, vocational training of draughtsmen and supervisors, development of standards and specifications, reorganisation of engineering enterprises, recasting the role and the process of engineering design, the reorientation of life-cycle maintenance and logistics practices, focussing on rapid product upgradation through its life, and managing knowledge and information throughout a product's life.

I have, therefore, titled my talk as 'Managing Design and Production — New Paradigms based on The Experiences of the Defence Industry', and do hope it will benefit the engineering profession in the country.

The new paradigm I propose to speak about started in 1985 as an initiative of the United States Department of Defence in order to reduce the costs of maintenance, logistics and life-cycle support of defence equipment by leveraging information technology and networking. It was assessed that over 70% of the through-life cost of ownership of a warship, aircraft or tank lay in its post-acquisition support.

The fundamental aim of the project was to automate, and thus speed up the diagnosis of technical problems, identification of remedial action and to enable the rapid delivery and replacement of faulty parts. To this end, the initiative was to undertake the digital acquisition of logistics information on products as well as to including technical manuals and training materials, technical data packages, and product definition data.

It was soon realised that the problem was not as simple at it appeared — it was not just a matter of creating a database of parts and assemblies and linking users over a network. Information had to be generated and communicated to a manufacturer rapidly, and actions had to be executed and routed back. The first problem was that modern technologies and the need to cut down production costs required the widening the network of designers and vendors. Even the simplest of products would be developed by a large number of vendors, very often located in different countries. Also, it was in the nature of the technologies of the times that rapid component obsolescence would entail almost continuous upgradations in design. For a product like a military tank or a fighter aircraft, therefore, there would be hundreds of them in use around the world, each with a different version from the original design.

Information available with the user would be in the form of old fashioned paper manuals, which would be out of date soon, since the product would have undergone several changes from the original project, due to different versions of spare parts being delivered. Field-level methods of repair by swapping parts from similar products would be hazardous, since there could be no assurance of their being identical.

Keeping track of the variables involved had been tried using different methods and had all got bogged down. The problem was compounded by the difficulty in ensuring standardisation of data formats and software originating from numerous designers, vendors, users, computers and networks. The problem got even more intractable due to the need to collaborate in the battlefield with other NATO allies who followed different procedures.

It was realised that the only way to sort out this chaotic situation was to attack the problem at source. Life-cycle maintenance and logistics supports would have to be built in at the design stage itself. The project was named Continuous Acquisition and Logistics Support (CALS). The trajectory that this initiative has followed is a fascinating one involving strange twists and turns, and triggering off a potential engineering revolution in the process.

The first task was to bring about a seamless network between user, designer and manufacturer, together with the numerous subdesigners, sub-manufacturers and vendors. Defence acquisition projects would have to be based on continuous collaboration by all participants.

Everything from product conceptualisation, vendor selection preliminary design, working level design, prototyping etc would have to be done on-line.

Computer aided design (CAD) and computer aided manufacturing (CAM) had already become wide spread, and settling on one or the other product was not a problem. The problem was, however, in formulating standards by which a complex engineering product can be represented on the computer. It was realised that the exact solution to this problem would lie with the industry, and with the efforts then underway to arrive at an open standard. The industry itself was working since 1970 to define a better way of manufacturing using computer and information technologies and to arrive at an open, globally acceptable standard.

Serious problems were being caused by the use of different information technology systems by companies or organisations cooperating on a specific project, and even by different engineering disciplines within a company, eg, in engineering design and finite element analysis, or by companies operating within a single supply chain, ie, between parts suppliers and system developers. There was wide spread awareness of the need to manage data independently of specific information technology systems, eg, to maintain configuration control of data created or modified using a number of heterogeneous systems; and so also to manage data throughout the life of the products that the data relates to.

Various standards were in vogue like Initial Graphics Exchange Specification (IGES), developed in the USA in the late 1970s, the Standard D'Echange et de Transfert (SET), developed in France in 1985, driven by manufacturing companies in the automotive and aerospace industries; Verband der Automobilindustrie-Flächen-Schnittstelle (VDA-FS), developed by the car industry in Germany in the 1980s to support the effective exchange of surface models, such as those used in the styling and design of car bodies; the Electronic Design Interchange Format (EDIF), developed by the Electronic Industries Association (EIA); and DXF (Data Exchange File or Format) developed by Autodesk Inc to support links with their AutoCAD software.

Table 1 indicates the tower of babel which existed preventing the evolution of the world away from the paper based engineering drawings and the postal services for the exchange of the drawings.

**Table 1 Tower of Babel**

| | IGES | SET | VDA-FS | EDIF | DXF |
|---|---|---|---|---|---|
| Aerospace | √√ | √√ | — | — | — |
| Automotive | √√ | √ | √ | — | √ |
| Building and Construction | — | — | — | — | √√ |
| Process Plant | √ | √ | — | — | √√ |
| Oil and Gas | — | — | — | — | √ |
| Shipbuilding | √ | — | — | — | √ |
| Electrical and Electronic | √ | √ | — | √ | — |
| Consumer Goods | √ | — | — | √ | — |

Note : The double tick mark indicates the dominant standard then.

By the mid 1980s, however, it had become apparent that the industries needs would only be properly addressed by a more comprehensive international effort that would not only improve on the existing specifications, but also fulfil the requirements for life cycle product data support. A project was, therefore, initiated in 1984, with objective of

- The creation of single international standard, covering all aspects of CAD/CAM data exchange.
- The implementation and acceptance of this standard by industry, superseding various national and de facto standards with specifications.
- The standardisation of a mechanism for describing the product data, throughout the life of a product, and independent of any particular system.
- The separation of the description of product data from its implementation, such that the standard would not only be suitable for neutral file exchange, but also provide the basis for shared product databases, and for long-term archiving.

Work towards these objectives started in mid-1984.It was postulated that the new standard should be aimed at creating a Product Data Model (PDM)based on a three layer architecture, significantly influenced by the ANSI/SPARC three layer architecture for database systems covering,

- An applications layer : data models concerned with individual applications or disciplines such as mechanical products, electrical products, and building and construction.
- A logical layer : generic data models describing the common concepts used by all product data applications, such as product structure, shape (geometry and topology), and presentation.
- A physical layer : where a file format for data exchange.

It was decided that the standard shall be referred to as industrial automation systems and integration, product data representation and exchange, also known as the Standard for the Exchange of Product (STEP) model data. STEP should develop a computer interpretable data specification language that could be used to describe all the data models within the standard. This language, based on the initial work undertaken within McDonnell Douglas The Information Systems in USA, became known as 'EXPRESS' allowing a clear separation between the method for the description of data models, the data models themselves (applications and logical layer), and a mechanism for the exchange of data (file format).

It was realised that specific areas of the industry would need specific interpretations of versions of the data model. A number of data models were developed describing the requirements for the product shape (geometry and topology), engineering drawings, and industry-specific needs such as those of electrical applications and shipbuilding.

In 1988, these data models were collected together as an Integrated Product Information Model (IPIM). The IPIM, together with the EXPRESS language and the exchange file specification, was initiated in the mid-1980s within the International Organization for Standardization (ISO). The development, which is supported by most of the leading nations of the industrialised world, has led to the definition and publication of ISO 10303 published by the International Standards in 1995. The standard is divided into a large number of parts addressing different elements of the total requirements on STEP. An 'initial release' of the standard, fulfilling industry needs for exchange of engineering drawings, and of configuration controlled 3D design data, was completed in 1994 and published in 1995. Additional parts of the standard are being developed to meet the product data standards needs of many industry sectors. The initial release was aimed entirely at the exchange of explicit models defined in terms of geometry, possibly with additional topological information providing connectivity relationships between geometric elements. The database scheme of STEP has been further developed in order to include the complete life-cycle history of a component as well as design intent.

STEP can be used to exchange data between CAD, CAM, CAE, Product Data Management/EDM and other CAx systems. STEP addresses product data from mechanical and electrical design, geometric dimensioning and tolerancing, analysis and manufacturing, with additional information specific to various industries such as automotive, aerospace, building construction ship, oil and gas, process plants and others. Different industry specific features have been issued in the form of application protocols. The STEP application protocols can be roughly grouped into the three main areas, such as, design, manufacturing and lifecycle support. A small sampling of the application protocols (AP) issued is given in Table 2 in order to support my contention that all traditional notions of engineering drawing and design stand obsolete.

**Table 2 STEP Application Protocols**

| | |
|---|---|
| | Mechanical |
| Part 201 | Explicit draughting. Simple 2D drawing geometry related to a product. No association, no assembly hierarchy. |
| Part 203 | Configuration controlled 3D designs of mechanical parts and assemblies |
| Part 204 | Mechanical design using boundary representation |
| Part 207 | Sheet metal die planning and design |
| Part 209 | Composite and metallic structural analysis and related design |
| Part 214 | Core data for automotive mechanical design processes |
| Part 519 | Geometric tolerances |
| | Building |
| Part 202 | Associative draughting. 2D/3D drawing with association, but no product structure. |
| Part 225 | Building elements using explicit shape representation |
| Part 212 | Electrotechnical design and installation |
| Part 227 | Plant spatial configuration |
| | Connectivity Oriented Electric, Electronic and Piping/Ventilation |
| Part 210 | Electronic assembly, interconnect and packaging design. The most complex and sophisticated STEP AP |
| | Ship |
| Part 215 | Ship arrangement |
| Part 216 | Ship moulded forms |
| Part 218 | Ship structures |

Today, the daily handling of product data in many companies is unthinkable without STEP because STEP has become widely accepted. Implementation of the STEP was immediately recognised by government and industry in the US and Europe as the mechanism to achieve the CALS integrated weapon systems database.

As the system grew, new problems emerged along with the new solutions. It was realised that for the user's manual to keep track of continual changes in design, it had to be reformatted in electronic form, leveraging all the advantages of computer-based user interfaces and the power of the hyperlink inherent in web-based technology. This idea went a step forward when it was realized that this manual is best generated simultaneously with and as part of the design.

The US Department of Defence laid down specifications of five classes of interactive technical manuals ranging from simple cut and paste texts and graphics, to complex hyperlinked documents with 3D graphics. The specifications have evolved with the growth of the graphics processing capabilities of the computer and developments in mark-up languages, and the current standard in the industry is the S 1000D standard laid down by the Aerospace Industries of Europe (earlier known as AECMA), and endorsed by the United States Department of Defence. This specification is in the form of an impressive document titled, 'International Specification for Technical Publications Utilising a Common Source Database' which has in turn spawned a host of application software packages and training courses in developing such documentation, as well as a blogspot dedicated to discussing the issue.

The specification, or standard, stems from traditional engineering design activities that created product drawings and schematics on paper and using CAD tools to create parts lists (Bills of Material structures - BOM). The PDM and BOM data are used in ERP systems to plan and coordinate all transactional operations of a company (sales order management, purchasing, cost accounting, logistics, etc), and includes data such as the following, within the database, against each and every component like,

- Part number
- Part description
- Supplier/Vendor
- Vendor part number and description
- Unit of measure
- Cost/Price
- Schematic or CAD drawing
- Material data sheets

By 1988, the project was renamed 'Computer-aided Acquisition and Logistics Support'. This change in scope attempted to move CALS from a logistics focused program to a weapon system life cycle focused program. Also during the late 1980s, other digital information initiatives, such as Electronic Commerce/ Electronic Data Interchange (EC/EDI) emerged to enable computer-to computer exchange of business information. The cost of computer based transactions was dramatically reduced, increasing efficiency and reducing errors largely by eliminating rekeying of data. EC/EDI also provided a standardised means to integrate the business functions, enable process improvements, and establish a basis for virtual enterprises. The development of the internet, which had been spawned by the Department of Defence as the Defence Advanced Research Project Agency (DARPA net) enabled platform-independent and OS-independent networking, thus ending the problems associated with hardware and software standardisation.

The scope of CALS had grown well beyond what it started as, namely, a logistics program. In 1993, the term, Computer aided was replaced with Continuous, to de-emphasize the IT aspect, as well as to highlight the continuous use of CALS strategies throughout the full life cycle of a weapon system or product. The term Logistics was dropped in favour of life-cycle support to downplay the military aspect of CALS in hopes of encouraging greater acceptance of CALS principles and strategies in non-military industry sectors, and to promote CALS to small/medium-sized enterprises (SMEs) in particular. This title explicitly expanded the role of CALS to a total life cycle focus. Dramatic improvements were shown in the system development process. Research costs fell by 30% to 40%, weapon acquisition costs by 30%, spares procurement cycles by 22% and the time taken for system upgradations by nine times. The US Department of Commerce proposed another definition for the CALS acronym, that being 'Commerce at Light Speed'.

Very soon, CALS started being considered as simply a collection of best practices and business strategies that got assembled under an international banner called CALS.

CALS has rapidly gained prominence in the non-defence sector as well, in about 25 countries including the USA, Canada, Japan, Britain, Germany, Sweden, Norway, Australia, Russia, China, Turkey and Korea. For the industry, CALS has proved useful in an environment of increasing competitiveness, when accurate information on the performance of a product is available on continuous basis, something indispensable in a market with rapidly changing demand, and the ability to react rapidly to a need and respond adequately by the creation, upgradation and support of a product, and to accurately predict demand.

The essence of CALS is in the continuous, integrated provision of information about a product to all involved parties, and requires the creation of an integrated computer based model of the product, which carries technical details as well as the history of its usage throughout its life-cycle, from the moment of its conceptualisation to its disposal. The electronic model is to contain the detailed, cumulative information on a product including its design, structure, manufacturing data, functioning rules, technical manuals, operating parameters, operating history and all its parameters throughout the life-cycle.

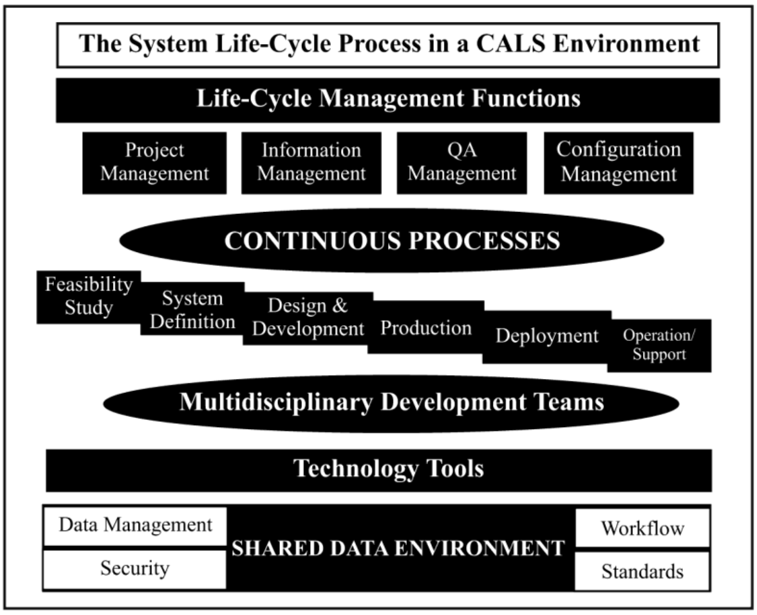
CALS also requires the integration of all agencies involved in design, manufacture and support in a single networked environment . All information on the product, related products and resources are stored on a network and is accessible to involve the agencies in electronic form, using electronic signatures.

The model actually exists in three parts :

- An electronic model of the product,
- A model of its life-cycle history, and
- A model of the manufacturing and operating environment.

The purpose of CALS is to reduce the defence system time to market, reduce total ownership cost and improve quality across the life-cycle. IT is an enabler used to support the adoption and use of a shared data environment based on international standards to manage the technical information on a product. The CALS strategy integrates IT, product data management, concurrent engineering (CE), multi-disciplinary work groups (MDG) and EC/EDI to achieve government-industry business objectives.

The Indian Navy has steadily built the infrastructure required to meet CALS objectives. The Naval Design Organisation, as well as the three defence shipyards, currently use the two most widely used STEP and CALS compliant ship design and construction software packages, Tribon and Catia. Pilot projects for electronic documentation for machinery and weapons systems have been undertaken through CDAC. The experience gained will be further consolidated with the Scorpene Submarine Building Programme. The Navy has a wide area network (WAN) in place with integrated logistics support and integrated maintenance management software in place, to create the data environment required where ecommerce solutions are under implementation. Similar projects have been put in place by the Indian Air Force and Hindustan Aeronautics Limited.




It is my contention, at this august gathering of the leading engineers of the country, that as India matures as a manufacturing nation, we need to review the foundations of the engineering infrastructure of the country. CAD, CAM, Product Data Management, ERP and ecommerce solution are not new to the Indian Industry.

It is my contention that there is a paradigm shift going on in the world in the way design and manufacturing processes are to be managed. The traditional drawing office as we know it, has been the pillar of engineering design since the mid-1800s, as laid down by Sir Joseph Whitworth. The very nature of the design office is changing in a profound manner. A new generation of engineering design and manufacturing standards are sweeping out the old. The user, designer and manufacturer have to be integrated so that lifecycle management of a product can be efficiently managed in an era of rapid obsolescence.

This calls for a review of basic engineering training at all levels, in engineering colleges and institutes as well as vocational training institutions. There is a need to ground our technicians and draughtsmen in fundamentally new methods. There is a need to keep in pace with the rapid changes in international standards. The IT revolution has to be leveraged across enterprises.

I would like to submit that the Institution of Engineers and this august gathering of minds is well placed to trigger initiatives in these directions.

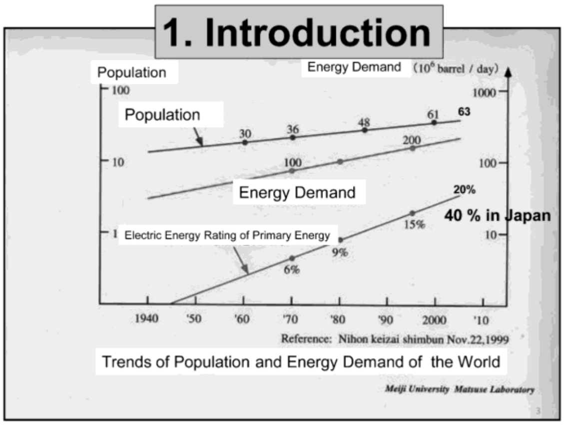
# Energy Efficiency Research and Development Work in Japan

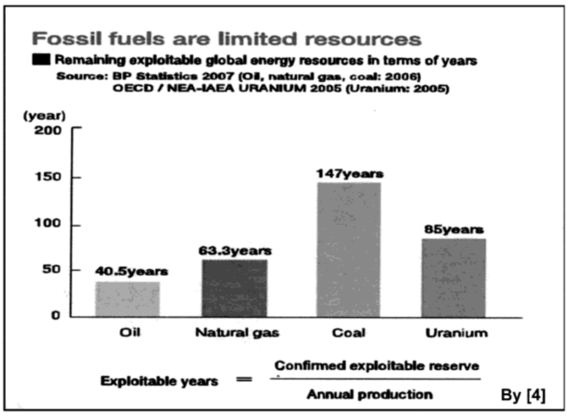

## Prof (Dr) Kouki Matsuse

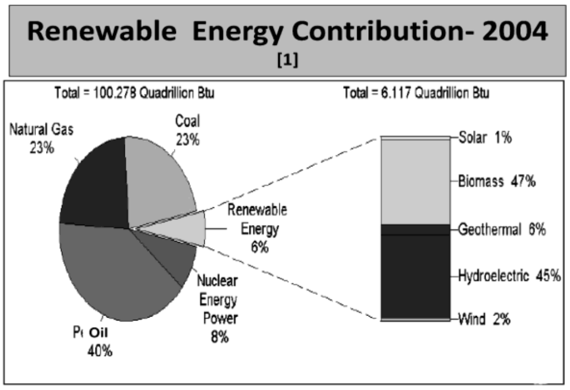
Meiji University, Japan
President-elect, IEE of Japan

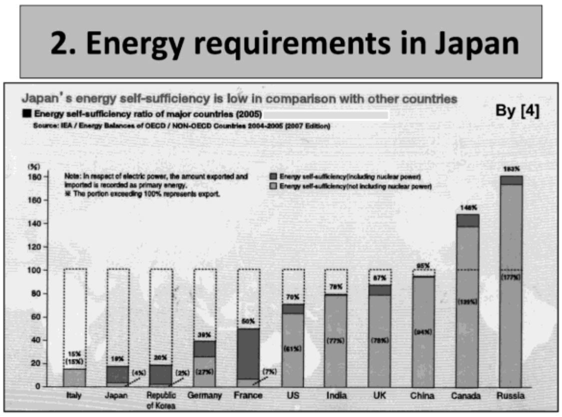

## Outline

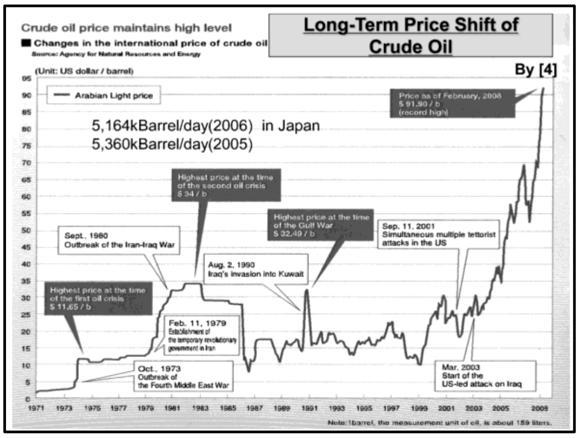
1. Introduction
2. Energy requirements in Japan
3. Renewable Energy Technology Work
   - 3.1 Hydroelectric Power
   - 3.2 Wind Energy
   - 3.3 Photovoltaic Energy
   - 3.4 Fuel Cell Power
   - 3.5 Geothermal Electric Power
4. Enabling Technologies
   - 4.1 Power Electronics
   - 4.2 Electric Double Layer Capacitor and Battery for Energy Storages
   - 4.3 Advances and Trends of Power Converters in Power Electronics
   - 4.4 Electric Machines and Drives
   - 4.5 EV, HEV, and FCEV
5. Government Incentives
6. Conclusions

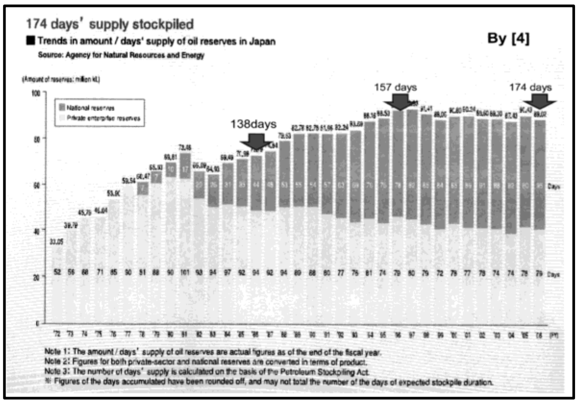


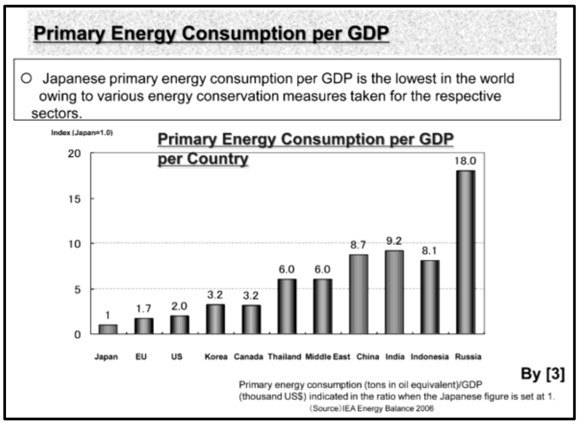



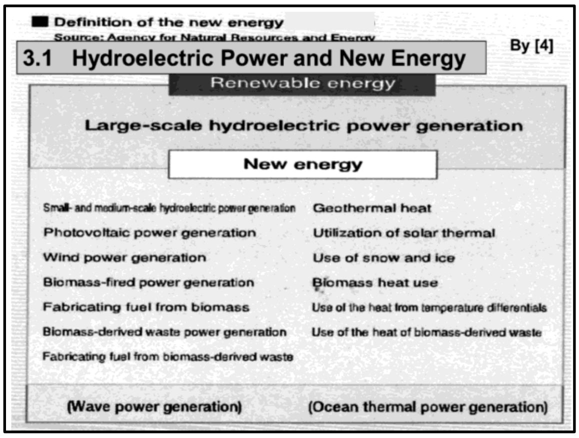


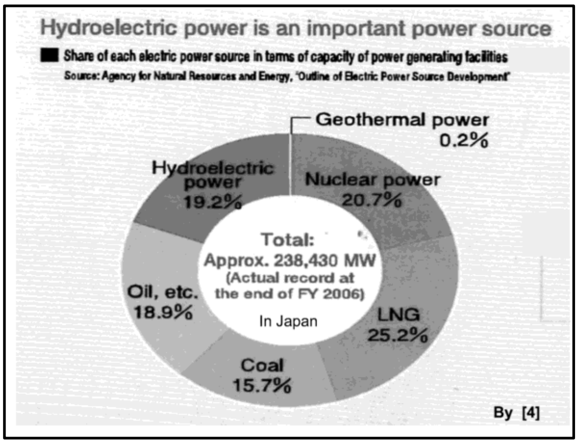



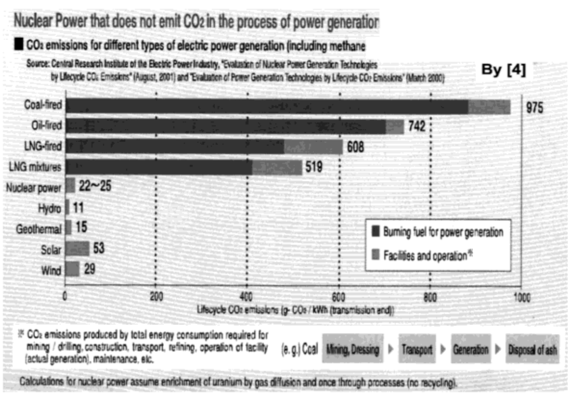




## 3. Renewable Energy Technology Work in Japan

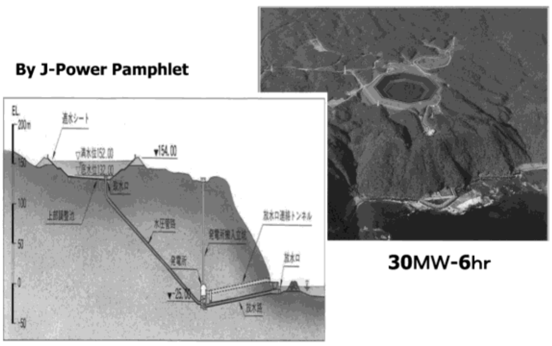
3.1 Hydroelectric Power
3.2 Wind Energy
3.3 Photovoltaic Energy
3.4 Fuel Cell Power
3.5 Geothermal Electric Power




## Seawater Pumped Storage Power Plant



## 3.2 Wind Energy [2]

1. Most Economical, Renewable, Environmentally Clean and Safe "Green" Power

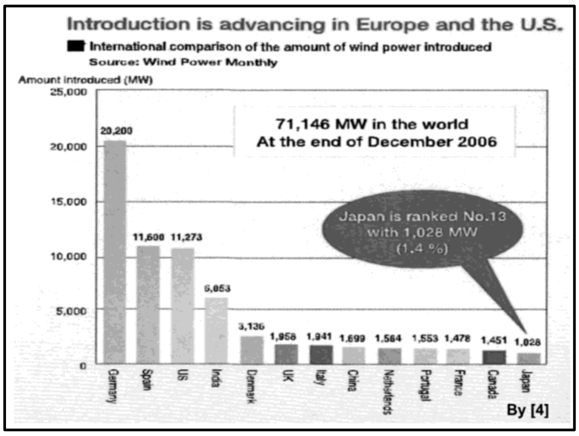
2. Enormous World Resources – Tapping Only 10% can Supply Electricity Need of the Whole World

3. Competitive Cost With Fossil Fuel Power

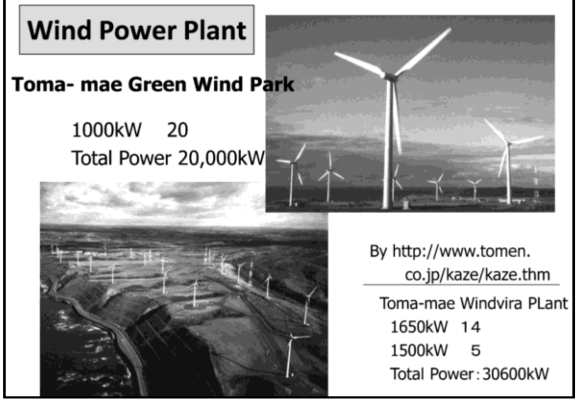
4. Technology Advancement in Power Electronics, Variable Speed Drives and Variable Speed Wind turbines

5. Germany is The World Leader – Distant Next is USA

6. Problem of Statistical Availability – Needs Backup Power



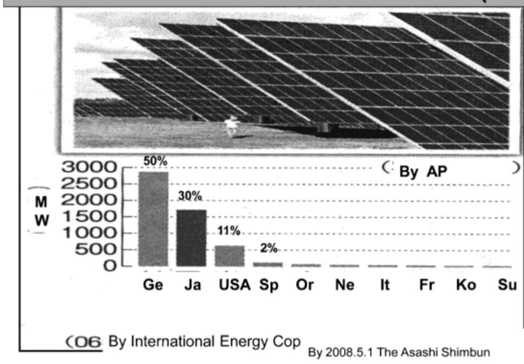

**Wind Power Plant**




## 3.3 Photovoltaic Energy [2]

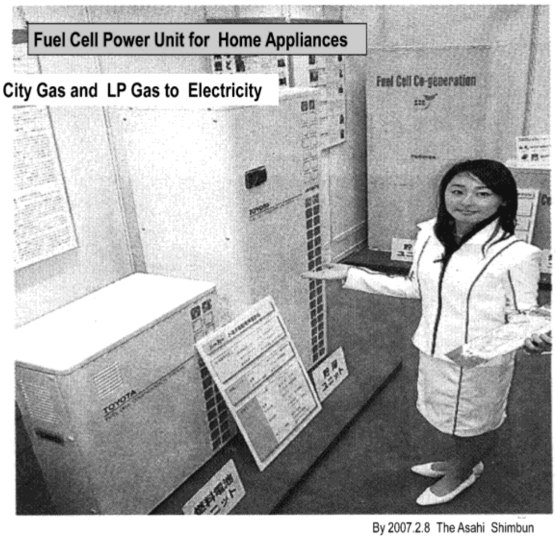
1. Safe, Reliable, Static and Environmentally Clean Renewable Power
2. Does Not Require Repair and Maintenance
3. PV Panels are Expensive
4. Applications: Space Power Roof Top Installations Off-grid Remote Applications
5. Problem of Sporadic Availability – Requires Back-up Power
6. Tremendous Emphasis on Technology Advancement for Cost Reduction

**Photovoltaic Power Plants of the world (2006)**

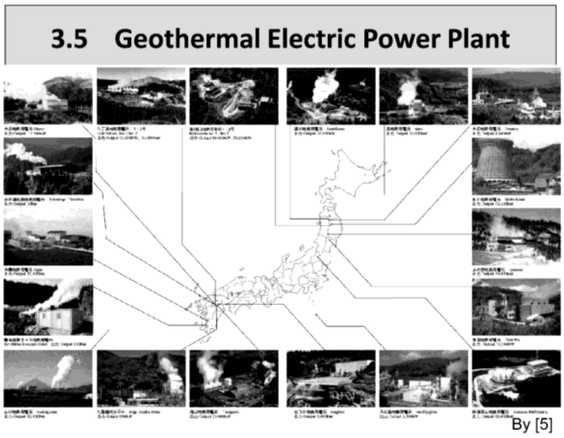


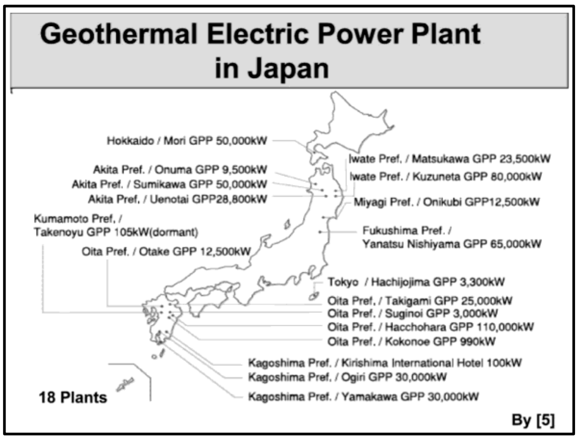

## 3.4 Fuel Cell Power [2]

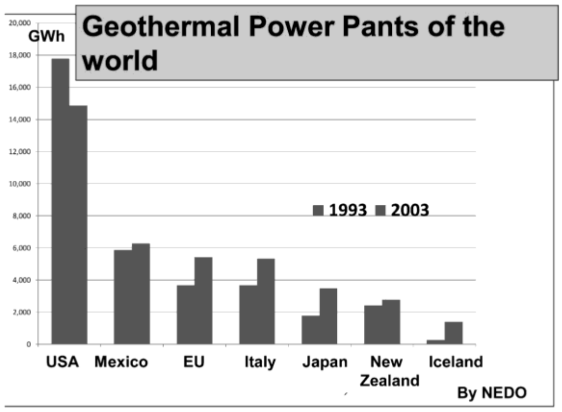
1. Hydrogen and Oxygen Combine to Produce Electricity and Water
2. Safe, Static, High Efficiency (50%) and Environmentally Clean
3. Fuel Cell Types:
   PEMFC, PAFC, DMFC, SOFC, and MCF
4. Generate $H_2$ by Electrolysis of Water, or By Reformer (From Gasoline, Methanol)
5. Generate $H_2$ by Wind Energy at Zero Emission (Possible by PV, Nuclear, or Coal Gasification (By $CO_2$ Sequestration and UG Storage)
6. Bulky and Expensive at Present State of Technology
7. Non regenerative and Slow Response – Problems in FC Car
8. Possible Applications: Fuel Cell Car, Portable Power, Building Cogeneration, Distributed Power For Utility, UPS System
9. Significant Future Promise

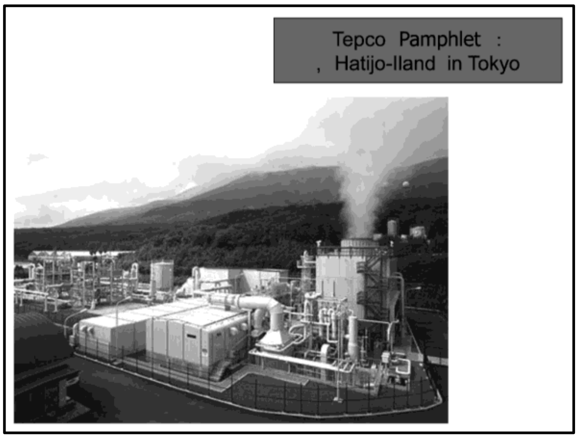

Fuel Cell Power Unit for Home Appliances
City Gas and LP Gas to Electricity
By 2007.2.8 The Asahi Shimbun


F C E V
By 2007.2.8 The Asahi Shimbun


3.5 Geothermal Electric Power Plant
By [5]


Geothermal Electric Power Plant in Japan
Hokkaido / Mori GPP 50,000kW
Akita Pref. / Onuma GPP 9,500kW
Akita Pref. / Sumikawa GPP 50,000kW
Akita Pref. / Uenotai GPP28,800kW
Kumamoto Pref. / Takenoyu GPP 105kW(dormant)
Oita Pref. / Otake GPP 12,500kW
Iwate Pref. / Matsukawa GPP 23,500kW
Iwate Pref. / Kuzuneta GPP 80,000kW
Miyagi Pref. / Onikubi GPP12,500kW
Fukushima Pref. / Yanatsu Nishiyama GPP 65,000kW
Tokyo / Hachijojima GPP 3,300kW
Oita Pref. / Takigami GPP 25,000kW
Oita Pref. / Suginoi GPP 3,000kW
Oita Pref. / Hacchohara GPP 110,000kW
Oita Pref. / Kokonoe GPP 990kW
Kagoshima Pref. / Kirishima International Hotel 100kW
Kagoshima Pref. / Ogiri GPP 30,000kW
Kagoshima Pref. / Yamakawa GPP 30,000kW
18 Plants
By [5]


Geothermal Power Pants of the world
GWh
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1993 2003
USA
Mexico
EU
Italy
Japan
New Zealand
Iceland
By NEDO


Tepco Pamphlet : , Hatijo-Iland in Tokyo

## 4. Enabling Technologies

4.1 Power Electronics
4.2 Electric Double Layer Capacitor and Battery for Energy Storages
4.3 Advances and Trends of Power Converters in Power Electronics
4.4 Electric Machines and Drives
4.5 EV, HEV, and FCEV

## 4.1 Power Electronics

### a) What is Power Electronics?

1. It is composed of
   Power Devices,
   Power Converter, and
   Control Technologies
   for Electricity Applications
2. Key Technology for Energy Conversion
3. Solutions for Energy and Environment Problem of the Earth

### b) Why Power Electronics is So Important Today? [2]

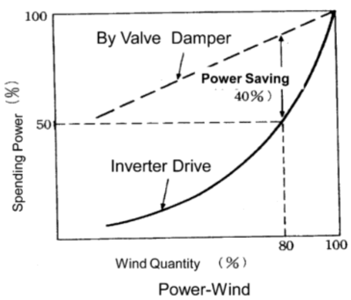
1. Electrical Power Conversion and Control at High Efficiency
2. Apparatus at Low Cost, Small Size, High Reliability and Long Life
3. Very Important Element in Modern Electrical Power Processing and Industrial Process Control
4. Fast Growth in Global Energy Consumption
5. Environmental Problems by Fossil Fuels, and Safety and Waste Disposal Problems of Nuclear Power Plants
6. Increasing Emphasis of Energy Saving and Pollution Control by Power Electronics
7. Growth of Environmentally Clean Sources of Power that are Power Electronics Dependent (Wind, Photovoltaic and Fuel Cells)

### c) Power Electronics in Energy Saving [2]

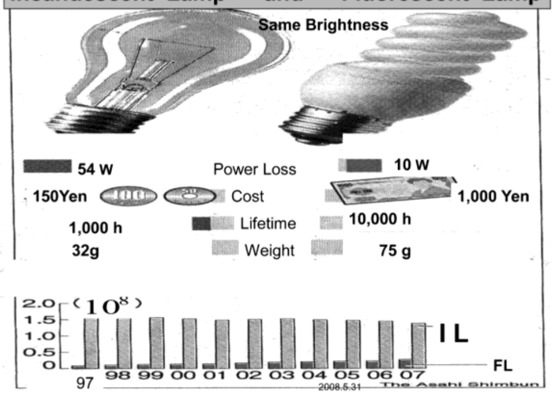
1. Control of Power by Electronic Switching is More Efficient Than Rheostat Control
2. Roughly 65% of Generated Energy in Japan is Consumed in Electrical Drives
   - Mainly Pumps and Fans -
3. Variable Speed Drives, Particularly Full Throttle Fluid Flow Control, can improve Efficiency more than 40% at Light Load
4. Improve Motor Efficiency up to 30%
5. Variable Speed Air-conditioner/Heat Pump can Save Energy up to 30%
6. 20% of Utility Energy in Japan is used for Lighting
7. High Frequency Fluorescent Lamps are 4 Times More Efficient Than Incandescent Lamps (In Japan , Incandescent Lamps will be not produced near future, and will go to LED in next stage) LED : light-emitting diode

### Energy Saving by Adjustable Speed Drives of Pumps and Fans-an Example

E. E. Handbook, IEEJ 1988 p.1616




### Incandescent Lamp and Fluorescent Lamp



## 4.2 Electric Double Layer Capacitor and Battery for Energy Storages

**EDLC : Features**

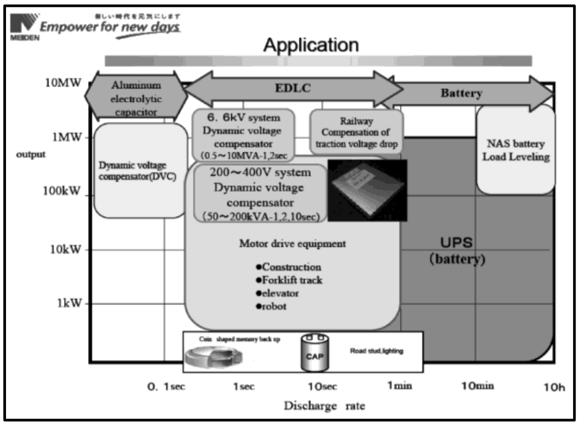
1. Rapid Response , High Charge-Ability, Easy Maintenance, and Long Cycle Life Because of No Chemical Reaction by using Ion Adaption Reactor
2. Huge Capacitance as compared with Conventional Capacitor
3. Earth-Friendly Storage Device having No Legal Control without Heavy Metal

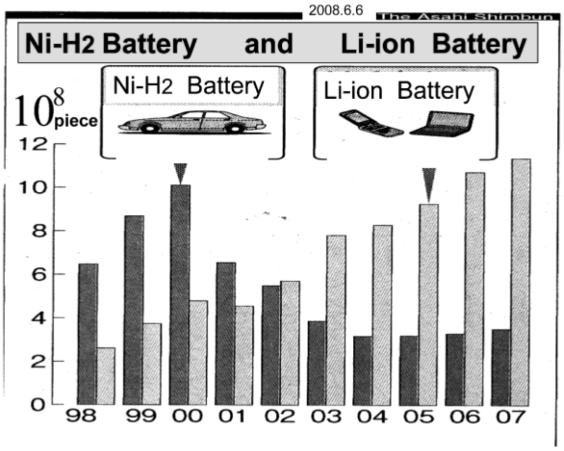
Empower for new days

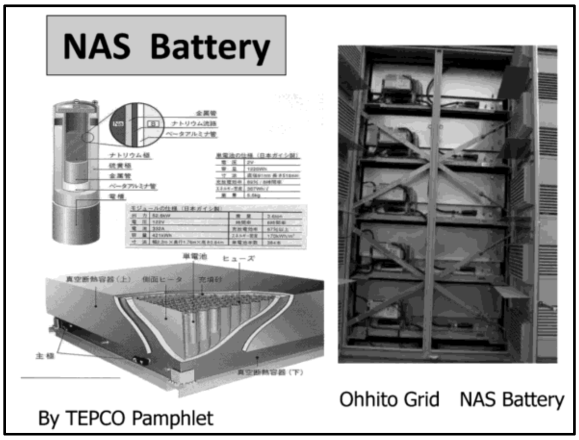
Comparison with other storage devices(1)

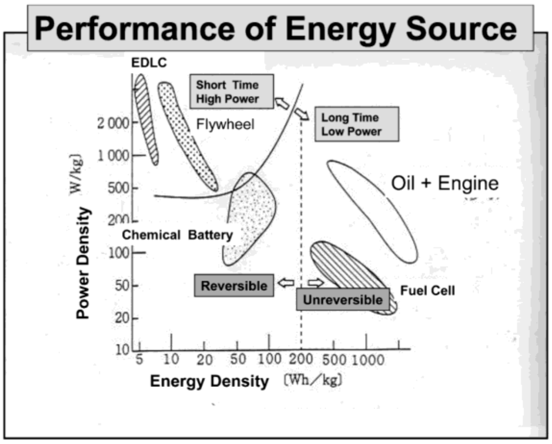
| item | Conventional Capacitor | EDLC | Battery (Lead-Acid) | Battery (Li-ion) |
|---|---|---|---|---|
| Energy density (Wh/kg) | <0.1 | 0.2～10 | 10～40 | 40～80 |
| Power density (W/kg) | 10,000 ～100,000 | 100～5,000 | 50～130 | 100～300 |
| Discharge rate | ～0.1sec | 0.1sec～1min | 10min～10h | 10min～10h |
| Cycle Life | >500,000 | >500,000 | 200～2,000 | ～10,000 |
| Shelf Life | 5～10year | 10～15year | 3～5year | 5～10year |
| Over discharge | O | O | × | × |
| Environment | O | O | × | △ |

Example : 160V 4.5F 70cells
72V 4.0F 32cells




## 4.3 Advances and Trends of Power Converters in Power Electronics [2]

1. Power quality and Lagging Pf Problems Will tend to Make Phase-controlled Converters Gradually Obsolete – Promoting PWM Type Converters on Line side
2. Voltage-fed Converters are Superior to Current-fed Converters in Overall Figure-of-merit Considerations
3. Two-sided Voltage-fed GTO/IGBT/IGCT 3-level PWM Converters are Replacing High Power Phase-controlled Cyclo-converters
4. Multi-level Converters of High Power Rating – For Utility System and Large Motor Drives
5. Space Vector PWM Is Superior To Sinusoidal PWM– Highly Computation Intensive
6. Soft-switched Converters for Motor Drives Do Not Show Any Promise – but Promise For HF Link System
7. Converter Technology is Approaching Saturation

## 4.4 Electric Machines and Drives [2]

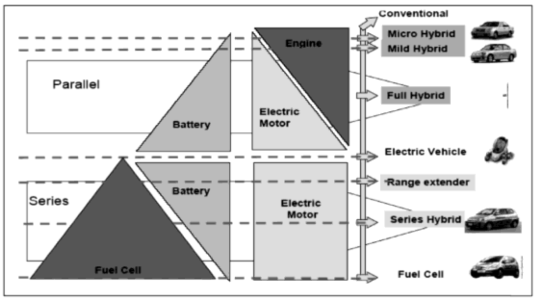
1. AC Machines have firmly established as Variable Speed Drives of Today and Tomorrow
2. Cage-High Efficiency -Type Induction Motor With Voltage-fed Converter is Universally Popular for General Purpose Drives
3. Future Emphasis of Machine-Converter-Controller Integration in the Lower End of Power – Intelligent Machine
4. Increasing Acceptance of Encoder-less Vector Drive – Although Zero Frequency Operation yet Remains a Challenge
5. Increasing Emphasis of Variable Frequency Soft Starter as the Converter Cost Decreases
6. PMSM has Higher Efficiency and Lower Life-Cycle Cost
7. AI-based Intelligent Control and Estimation With ASIC Chips Will Find More Acceptance in Future
8. On-line Drive Fault Diagnostics and Fault Tolerant Control Will improve Drive System Reliability

## 4.5 EV , HEV, and FCEV [1,2]

1. Power Electronics and Drives Intensive – Somewhat Mature Technology
2. Limitation of Battery Technology
3. Limited Range and High Life-cycle Cost of EV
4. Hybrid Vehicle can Replace ICE Vehicle–more Expensive (ICE : Internal Combustion Engine)
5. Potential Storage Devices: Flywheel – Ultra-Capacitor(EDLC)

## EV, HEV, and FCEV

Hybrid Power train Topology




## Energy Efficiency of Prius and FCHV

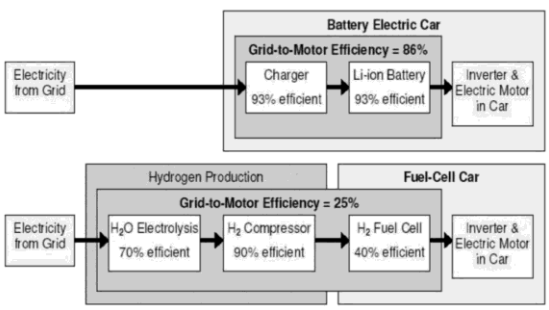
| | Prius | FCHV |
|---|---|---|
| Well-to-Tank | 88% | 58% |
| Tank-to-Wheel | 37% | 50% |
| Overall | 32% | 29% |

Today's Prius has a Better energy efficiency
FCV has potential for higher energy performance

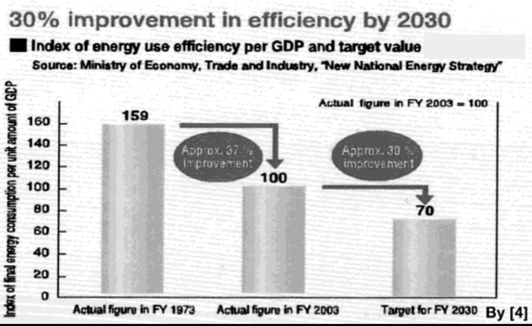
| | Well-to-Tank | Tank-to-Wheel | Well-to-Wheel |
|---|---|---|---|
| Gasoline ICE | 88% | 16% | 14% |
| Gasoline HV | 88% | 37% | 32% (hybridization) |
| $CH_2$ FCV | 58% | 38% | 22% |
| $CH_2$ FCHV | 58% | 50% | 29% (hybridization) |
| Future FCHV | 70% | 60% | 42% |

Source: Toyota

## Comparing the efficiency of Electric and Fuel Cell vehicle




## 5. Government Incentives




By [4]

**New National Energy Strategy** By [4]

**Targets aimed at realization**

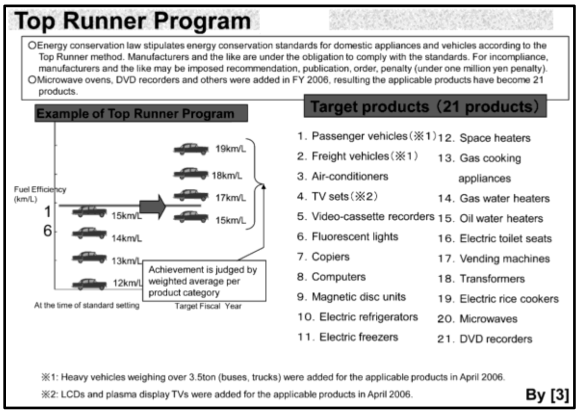
In the "New National Energy Strategy," the following three are targets to achieve.

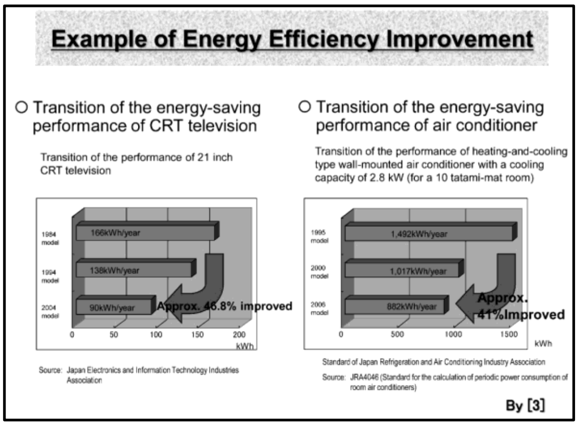
① Establishment of energy security measures that our people can trust and rely on
② Establishment of the foundation for sustainable development through a comprehensive approach for energy issues and environmental issues all together
③ Commitment to assist Asian and other nations around the world in addressing energy problems

**Numerical targets**

Five numerical targets were established to determine the long-term direction that the public and private sectors are to share when, in their united efforts, they firmly aim at the establishment of energy security.

① Target of energy conservation
This target will hereafter aim at further efficiency improvement in the future by at least 30% to be achieved by 2030.
② Target of nuclear power generation
This aims to increase the share of nuclear power generation in the total amount of the overall electric power generation to the level over 30-40% even after 2030.
③ Target of reducing oil dependence in the transport sector
This will hereafter aim to reduce the degree of dependence to about 80% by 2030.
④ Target of overseas natural resource development
This will hereafter aim to expand such overseas development further and raise its share to about 40% by 2030.
⑤ Target of reducing oil dependence
This will aim at reaching the level below 40% by 2030.




## 6. Conclusion

1. Power Electronics has now established as a Major Discipline in Electrical Engineering – Importance Not Less Than Computers.
2. Wide Growth of EV/HV and Environmentally Clean Wind, PV and Fuel Cell Resources in Future will need Extensive Applications of Power Electronics
3. Shortage of Fossil Fuels and Environmental Regulations will increase Cost of Energy – Promoting Widespread Energy Conservation by Power Electronics
4. Power Electronics will be an Effective Tool for Industrial and Energy Policies of Nations
5. The target set is to 30% Improvement in efficiency by 2030
6. The target for New Energy is to increase from 2% to 3% of the primary energy sources in 2010 and to reduce in dependence on Oil from 98% to around 80% in the transport sector by 2030.

Thank You for Your Attentions


References

1. Rajashekara,Fellow ,IEEE "Current trends in EVs, HEVs, and Fuel Cell vehicles with associated Power Electronics and Drives, at Meiji University on June 6,2007
2. Bimal K. Bose, Life Fellow, IEEE "POWER ELECTRONICS – PROGRESS AND PERSPECTIVE" The Invited Paper of Static Induction Device Symposium held in Sun Plaza Hotel, Tokyo, Japan on June 29,2007
3. Energy Conservation Policy & Measures in Japan, by Agency for Natural Resources and Energy (ANRE) and Ministry of Economy, Trade and Industry (METI)
4. Energy in Japan: by Agency for Natural Resources and Energy and Ministry of Economy, Trade and Industry
5. Present Status of Geothermal Energy Development : by New Energy and Industrial Technology Development Organization (NEDO)

# Science and Technology as Instruments of Faster, Sustainable and Inclusive Development

Dr Krishnaswamy Kasturirangan

Member, Planning Commission, Government of India

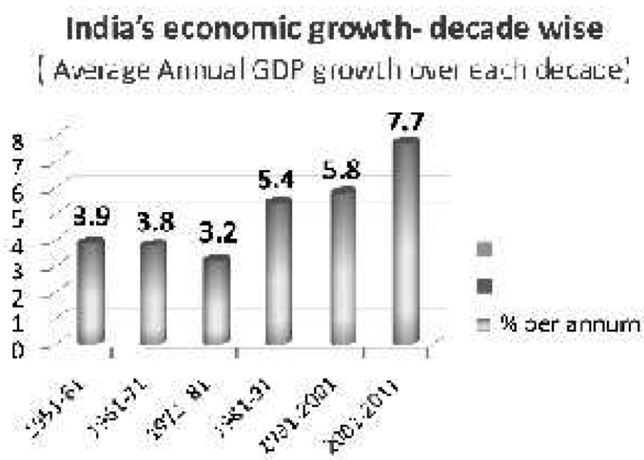
## India in Transformation

I deem it a privilege to deliver the 20th Dr Amitaba Bhattacharyya Memorial Lecture in front of this august gathering. Dr Amitaba Bhattacharyya's accomplishments in several disciplines such as production engineering, metal cutting and machine tools are not only invaluable but also serve as models to emulate. His multi sided capabilities as an outstanding engineer as well as an educationist are exemplary. But what are even more significant are the spirit and the commitment he displayed for developments in indigenous technology for welfare of society, which is the key issue that is now triggering new waves in academics, social actions, business enterprises and even polity. In the contemporary world, the spirit to innovate on technologies had been the central force that transforms emerging economies as their expanding market potentials provide enormously challenging environment which breeds innovations.

India is a rapidly transforming country. Over the past two decades, during the process of the liberalisation of Indian economy, steady growth was witnessed in India's GDP. For the decade of 2001-2011, India's GDP had grown at an average of 7.7 percent. Having witnessed a steady growth trend of GDP over the last two decades, India now stands at the door of an unprecedented opportunity to realize not just an incremental but a transformational growth. But the greatest challenge of course is how to make this growth inclusive and to ensure that its benefits are available to all sections of society. This is a challenge that captivates the best minds of India over the years.

If we look at just the past five years, the world had confronted a major economic crisis, which threw many advanced economies out of gear. Yet Indian economy showed its resilience and India's average GDP growth during the 11th Plan period is expected to be around 8.2 percent. There are reasons to be positive on many accomplishments during the 11th plan. First of all, the growth experienced in this Plan has been more broadly shared than ever before across the States. There was a special impetus to several programmes aimed at building rural and urban infrastructure and providing basic services with the objective of increasing inclusiveness and reducing poverty. We had marked improvement in the farm sector growth which is likely to be a little over 3 percent as against that of about 2 percent during the 10th Plan. A major achievement is also that school enrolment showed marked improvement and the gap in gender parity in this respect is also narrowed.

This is a positive momentum which should not be left to be diminished. Therefore, the 12th plan aims to target an ambitious average growth of 9 percent in GDP, to usher in a higher growth rate than past in agriculture, to create adequate livelihood opportunities and add to decent employment. Such a growth with inclusive objective also demands enhancing the quality of education and healthcare outcomes, further strengthening infrastructure, boosting energy supplies by about 7 percent annually during the plan, and paying greater attention to the management of water, forests and land.



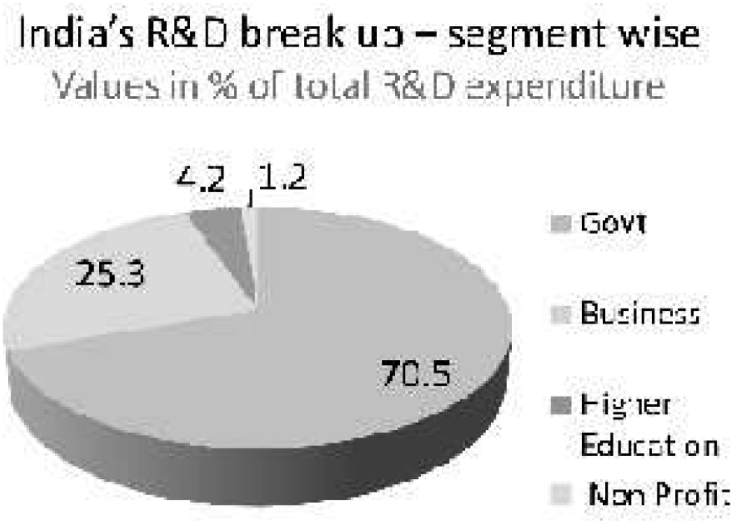
Science & Technology - The Key to Realise Aspirations

A crucial factor for realising the rising expectations and aspirations for future growth of India is the effective use of modern science and technology. Over the decades, in the post independence era, strong emphasis has been laid on developing capabilities in science and technology and a solid base has been built in terms of institutional infrastructure as well as human resources. India has done significantly well in the field of scientific research and indeed, in recent years, globally prominent organisations have set up R&D centres to take advantage of the high celibre human resources in the country.

The Science Advisory Council to the Prime Minister had laid out a vision for science which in essence envisages strong contribution of scientific knowledge for economic prosperity and for building a far more inclusive society, with the bulk of India's population gaining access to facilities for education and health care and living a life with hope and security. It also envisages India to emerge simultaneously as a global leader in science.

Burgeoning development needs characterise Indian society. Science has to play a seminal role in solving many problems that severely affect the quality of life. Energy, water management, farm production, medical research, waste disposal, healthcare, communications and transport, environment, climate change and security and a host of such areas need priority attention. However, major issue of concern is the weak linkage between research and development establishments including institutes of higher education and the organisations at the delivery end of the services. Equally important concern is inadequate resources deployed into R&D and innovations. In the 12th plan it is proposed to increase R&D spending to a level of two percent of GDP (from the current level of about 0.9 percent), with 1 percent contributed by public sources and the rest of one percent by the corporate sector.

One of the well recognised indicators of input into R&D intensity of a country is the research in institutions for higher education. The share of research in our universities/institutions of higher education is only about 4% of all that government spends on research and it needs considerable boost. This is too low as compared to share of research spending in universities in advanced economies like the USA, which is about 14%. There is need for institutes of higher education in India to increase their thrust towards research and nurture talented scholars for research and faculty. Several initiatives are necessary to improve the ecosystem for research in Indian Universities ranging from upgradation of laboratory infrastructure to recognition of talents, to institution of award/ reward system for meritorious faculty, and to improving linkages between national laboratories and industries.




Unleashing Innovation

Mere achievements in research and technology generation do not result into economic or social development unless an eco system for innovations is manifested. The eco system should encourage, enable and nurture innovations. India as the second fastest growing economy of the world cannot sustain its pace unless innovation becomes the driving force for growth, efficiency, quality, performance, cost effectiveness, delivery and environment friendliness. In the process of realising equitable growth, there are wide gaps in the delivery of services such as healthcare, education, urban facilities, water, sanitation, transport, and energy availability. A broad range of innovations are called for in products, processes, organisations, policies and services delivery. Recognising this all-round importance, the Government of India declared this decade as the Decade of Innovations.

The Government has established the National Innovation Council to catalyse the growth of an eco system for innovations in the country. It is endeavouring to generate Indian model of Innovations that are uniquely applicable to the Indian setting characterised by enormous opportunities at the bottom of the pyramid of the population, stupendous developmental challenges and diversities and high calibre human and natural resource endowments. The government endeavours to nurture innovative ecosystem by policy interventions, building infrastructures, catalysing markets and instituting incentives and funding mechanisms. The National Innovation Council is also enabling the development of a sound road map for innovations for this decade through multifarious initiatives. An institutional innovation such as development of industrial and university innovation clusters is one of the important initiatives. An India inclusive innovation fund for promoting innovations that serve the lower echelons of society is another major step. The sectoral and the state councils for innovation provide organisational muscles for integrating innovation culture into the governing systems. In achieving inclusive growth, improving public services delivery is the critical need. A transformation can only occur through robust connectivity to grass roots level of villages for information and knowledge transfer, capacity building and revitalising the governance.

Rural broadband will connect India's grassroots for innovations and a National GIS system which is conceived will enable organising the content for decision support and participative information system where the feedback from the field can enrich the monitoring and corrective processes and improve efficiencies. An India Innovation Portal has been brought into operation by the National Innovation Council to serve as platform for knowledge sharing on innovation. The council has also been championing and encouraging various other initiatives such as platform for best practices, strengthening of IPR generation and management, and domestic sources for risk capital. The National Knowledge network set up by the government is a high speed and high capacity network that connects educational and research institutions in India that will enhance collaborative innovations. Its connections to some reputed global research networks such as CERN, GLORIAD and TEIN 3 will facilitate real time collaboration and research.

It is to be emphasised that time is the essence in the globalised world. Whenever technology is acquired through buying, technology adaptation should be integral part of the transaction. There is need to tie up procurement strategy with the potential production agency. Mechanism to upgrade the technology and ensure sustainability of use of technology has to be identified, even if one time buy of high technology product or technology procurement is involved. Such a strategy would aim at innovations which will reduce costs further from the cost of acquisition.

Innovation is a major agenda for the country for the present century. The ability of the society to integrate the opportunities in the changing environment will be the major determinant of our progress. Even as our society grapples with adjustments and improvements in the governance systems, expansion of proper ecosystem for innovations should remain as our priority.

S&T for Faster, Sustainable and More Inclusive Growth

12th Plan's objectives of faster, sustainable and more inclusive growth need breakthrough innovations and significant S&T inputs in a wide range of areas. It is pertinent to see how S&T inputs and innovations, along with institutional reforms could transform various sectors that are vital from development perspectives.

Healthcare

Healthcare is a critical factor in nation's development. In today's world, it is also an area which provides the largest scope for job creation. The total expenditure in India on health is about 5% of GDP (in the 11th plan). It is largely contributed by private households. The public expenditure is about 1.4 percent of our GDP. Healthcare expenditures in advanced economies have even reached 8 to 16 percent of their GDPs. Improving the access to healthcare is a policy imperative driving the need to step up the investments, both through public and private sources.

India faces some of the toughest challenges in healthcare. Our healthcare indicators need still considerable improvement as seen with Infantile Mortality Rate (IMR) of 50 per 1000 live births and Maternal Mortality Rate (MMR) of 2.12 per 1000 births. Healthcare is still unaffordable for a significant proportion of population. 47% of the rural population and 37% of the urban population borrow money or sell assets to pay medical bills. The availability of doctors is a major issue. We have one doctor per 1700 people against the global average of 667. Less than 3% of specialists are available in rural areas. For managing a network of 1.5 Lakhs rural health centers, there is severe paucity of doctors and the shortage in India as a whole runs into seven to ten lakh doctors.

India is also facing major challenges of rising level of infectious and chronic degenerative diseases, increasing drug resistant varieties of diseases such as dengue, hepatitis and tuberculosis, or the epidemic dimension of diabetic cases and many such serious concerns, which need innovative solutions. Access to safe water and sanitation are also major challenges.

How can we Ensure Affordability?

Affordability of healthcare is a critical issue since a vast majority of population in India belong to middle income, low income and BPL groups. While this is to be addressed at policy level for increased public spending to improve access to preventive, primary and secondary and tertiary health care, equally important are low cost technological solutions to overcome disease burden.

As a nation with tremendous human resource capabilities, we have immense potential to innovate and improve healthcare in a cost effective way. We have a robust healthcare industry today including many state of the art hospitals, research laboratories and more than 10,000 enterprises producing pharmaceuticals. Many institutions have strong research capabilities. We have good talent pool of medical professionals. Our potentials to grow clinical research and research aimed at producing safe and cost effective drugs can be exploited further. Innovative approaches like CSIR's Open Source Drug Discovery platform, which addresses special needs of poor population, are important. Biotechnology Industry partnership program implemented by Department of Biotechnology (DBT) had resulted in development of many important vaccines like H1N1, pneumococcal and HPV vaccines. The partnership models of DBT have enabled availability of world's cheapest vaccines against pneumococcal pneumonia, rotavirus, HPV, chickengunia and Japanese encephalitis. Internationally and nationally collaborated research initiatives had contributed to innovative implants, medical devices and drug delivery systems. Further, we have tremendous scope for development and production of medical instruments, if we combine capabilities of different institutions. All these initiatives can give us a position and role in global arena besides meeting our priority needs.

A national mission on affordable healthcare is focusing on research and technology based solutions in the fields of diabetic control, non conventional health delivery, affordable diagnostic kits, and biomaterials for healthcare. If less expensive diagnostic kits which can easily be adapted to rural areas are innovated, and can be produced and marketed, it will go a long way in achieving affordable healthcare. Many existing PSUs can take up this challenge to produce and market them.

Improving Outreach Telemedicine

As availability of specialists is a major issue in rural settings, where 800 million Indians reside. Telemedicine system can be of immense value to bridge urban rural divide in the access to specialists and also to contribute to the continuing education of rural doctors. While nearly four hundred centres across the length and breadth of the country take advantage of this technology, there is tremendous scope for expansion with improved viability. Telemedicine's scope can also transform the future when miniaturised bioinstrumentation could make it possible to monitor patient's biological parameters to a finer level and transmit relevant information to specialists.

Institutional Renewal in Healthcare

Among the major institutional renewals needed in healthcare sector is to bring affordable insurance model as already being attempted in some states. Since a majority of health expenditure in our country is supported by uninsured private spending, there is immense potential for innovative insurance based models to improve access of health care by the population. There have been suggestions for guaranteeing access to preventive, primary and secondary health care freely for all through public funding and to be financed by general taxation. Tertiary care is suggested to be financed through single payer system wherein government and private collaborate. This would imply public spending which is now about 1 to 1.5 percent of GDP will have to be enhanced to about 3 percent.

In the scheme of accelerating the development of healthcare infrastructure, public private partnership models are increasingly relevant. A targeted approach to increase the infrastructure will be the key to ensure impact. This is essential to create facilities for post graduate education for all eligible doctors.

In order to enable rural communities to have better access to tertiary treatments, suggestions are made to convert district headquarter hospitals as a tertiary healthcare provider by starting advanced services like cardiology, neurosurgery, dialysis and organ transplant procedures. These may also be implemented under PPP model.

Energy

Energy is the lifeline for economic growth, with consequences for quality of life of people and environment. India's current primary commercial energy requirements, which include diverse sources such as coal, oil, natural gas, hydro and nuclear totals to about 520 million tons of oil equivalent (mtoe) and this is expected to grow to 740 mtoe by the last year of 12th plan (2016- 2017).

Currently we import energy to the tune ot 190 million tons of oil equivalent and this has to increase to 280 million tons to meet above demands. Import dependence is very high for petroleum and this will go up from 77 percent in the current plan to 80 percent in the 12th Plan. As we target the GDP to grow at 9 percent, when this growth is translated into requirements of various sectors, the commercial energy supplies will have to grow at a rate between 6.5 and 7 percent per year. Energy prices are rising globally making imports very expensive. This underscores the need for moderating the growth of energy demand by achieving higher levels of energy efficiency. At the same time, it is also necessary to increase domestic supplies of energy as much as possible. Both these objectives assume great importance for policy direction in view of volatility of petroleum prices as experienced over the last six years.

Technological Solutions

Technology advances also play a crucial role in harnessing the domestic energy resources for solar, wind, bio-mass, coal, coal gasification, shale gas, oil & gas and nuclear energy resources. Efforts in this area are crucial, given the scenario of rising energy prices and their possible adverse impacts on economic development.

Maintaining and developing diverse sources of energy is an important strategy that we can ill afford to ignore. For the renewable sources, which we have been harnessing over the last decade including wind, biomass and hydel, we have been using available technology resources. Since we hold a large wind, solar and biomass energy potential in the country, it augurs well to develop the means for quick exploitation to meet the power demands. Therefore we have to scale up the technology for high capacity wind turbines of 6-10 MW, to exploit both onshore and offshore wind potential. As the wind quality is good at 80-100 meters height, we need to develop technologies to tap the potential of wind power at higher hub heights.

Government has launched a solar mission to create 22000 MW solar energy capacities by 2022. This would create a large manufacturing opportunity for building solar power equipments in the country. Enabling technology oriented entrepreneurship will go a long way in building both solar and wind energy capacities.

Deep water Oil technologies would play an important role for exploration and exploitation of yet to be discovered oil in deep ocean basins. With the current technology, we are working at a water depth of about 2500-2800 meters in Pampos basin in Brazil. In KG basin we have struck natural gas at a depth of 2800 meters water depth. Further developments in technology to exploit the deep water reserves are essential.

Energy efficiencies are going to be critical for not only saving energy per unit of product, but also to reduce the emissions. Recently, project was launched for supercritical boiler technology for the coal based power generation. Such approach in fertilizer, refineries, power plants, cement, aluminum and iron ore industries have yielded good results and have resulted in reduction of energy consumption by 10 percent to 20 percent. Higher gains could be aimed through further technology innovations.

Institutional Issues in Energy

There are needs and scope for non-price initiatives to promote energy efficiency, as addressed by the National Mission on Enhanced Energy Efficiency which was launched in 2008. Pricing of tradable fuels in line with global prices as per the integrated energy policy, which was approved by cabinet in 2009 should be pursued to promote energy efficiency and a transition to more rational energy pricing is to be achieved. In the field of oil exploration, in light of experience, need is felt for a stable long-term regime of fiscal incentives as existing elsewhere. As the share of private sector participation in capacity of expansion of power generation is targeted during 12th plan at 50 percent, it is necessary to ensure timely availability of inputs such as coal. Policies to attract greater private participation in transmission segment are to be put in place. Modern systems of management and use of IT would ensure viability of publicly owned distribution system along with enforcement of accountability.

Agriculture

Agriculture is an important area, which affects livelihoods of a significant portion of our population apart from ensuring nation's food security. Agricultural sector sounded warning bells when it witnessed deceleration in growth during 9th and 10th plans. Subsequent interventions during the 11th plan led to food grain production touching a new peak of 241 million tonnes in 2010-11 and now overall growth in agriculture in the 11th Plan is likely to average 3.3 percent per year as compared to 2.2 percent in the 10th Plan. Food grain producing land area has almost been constant over past 15 years around 121 million ha and it may reduce further due to pressure of urbanisation and other demands. We need a different growth paradigm in context of needs of increasing population and also trends of climate change.

The major problems that continue to be of great concern in agriculture are: rapidly declining growth in productivity of food grains(the growth of two major food securing crops of wheat and rice had been 0.58 percent and 1.92 percent, respectively over the period 2001-02 to 2008-09); shrinking water resources; declining soil health and soil productivity; over two-thirds of the area remaining rain-fed with very low and inconsistent productivity; declining farm net-return; shortage of farm labour due to mass migration of rural folk to urban areas or other forms of work; increasingly limiting but badly required genetic variability; continued reservation against genetically modified crops; and unfolding adverse effects of climate change. Climate change has emerged as a major challenge to our agriculture and, indeed, to the management of our economy as a whole. The immediate problems that our farmers face relate to intra seasonal variability of rainfall, extreme events and unseasonal rains. These aberrations cause heavy losses to our crops every year. There is therefore an urgent necessity for us to speed up our efforts to evolve climate-resilient crop varieties, cropping patterns and management practices.

Technological Interventions in Agriculture

Technology can be prime mover of productivity in agriculture where natural resources are fixed. Studies have shown that at least one third of the future growth in productivity should come through innovations in crop technologies and applications of bio-technology. Apart from various GM crops developed, technologies for food fortification are at advanced stage of development in India.

Agriculture accounts for use of about 80% the annually available fresh water. It is, therefore, important to save every drop of water, and enhance water use efficiency. The saved water, if judiciously used adopting micro-irrigation devices, yield of rainfed pulses and oilseed crops can be increased by 30-40 percent. Precision Farming is emerging as one of the important areas that can improve agricultural benefits. India has a great potential to implement such technology interventions. Balanced use of major and micro nutrients and maintenance of organic carbon status through soil test based nutrient management are the remedial interventions now being advocated for sustaining soil productivity.

About 60 percent of the cropped area is rainfed and contributing to 45 percent of the total agricultural produce. Rainfed areas contribute more than 80 percent of the pulses and oilseeds grown as well as a substantial part of horticulture and animal husbandry produce. But rainfed agriculture has been risky, complex and grossly under invested. Its unexploited potentials may provide 10-11 million tons of additional food grains by improving the practices and water conservation methods in 20- 27 million ha. The second Green Revolution must therefore explicitly embrace dryland farming. Our irrigation efficiency is estimated to be around 30 percent which needs to be raised to at least 50 percent or higher.

Technology interventions had also become highly relevant in the context of post harvest losses to the food crops and preserving and processing solutions needed. In achieving food and livelihood security of India, agriculture needs continued interventions that can ensure synergy among diverse stake holders

Risk Management to be Widely Adopted

Several institutional measures are necessary to compliment technological solutions. Innovative safety nets against risks for farmers have become absolute necessity and these are to be institutionalised. Deficiencies in different links that lead to ultimate impacts such as current inadequacy of safe storage capacity and its quality to meet the level of food security buffer requirements of 52 to 74 million tons (in the context of Food Security Act). Adequate attention to marketing and logistics is also essential.

Water Resources

Due to increasing demands of agriculture, industry and population's needs, rising levels of pollution and increased urbanization and also changing climate patterns; water resource management is the greatest challenge or India. Out of the annual rainfall of 3840 Billion Cubic Meters (BCM), water availability estimates vary between 1123BCM to 654 BCM, providing for evapo-transpiration losses(uncertain), surface run off (1869 BCM) and ground water recharge(432 BCM). Current consumption is estimated at 634 BCM. Future requirements by 2025 as estimated by Ministry of Water Resources are 1093 BCM. As against this aggregate picture, availability of appropriate quality and quantity of water to the diversely spread populations and activities represents the huge problem. Also, 80% of the water use is for agriculture and used inefficiently.

A major issue is also the unsustainable exploitation of ground water. 60 percent of ground water drawn is used for irrigation and mostly through deep tube wells. This over exploitation pattern and lowering of ground water tables are increasing ground water pollution, and drinking water supply to villages. Biological pollution of surface water bodies and fluoride, nitrate and arsenic pollution of ground water are causing endemic nature of health risks.

Effective deployment of technologies and policy and institutional measures are of paramount importance in water management. These could include, for example, use of new micro irrigation technologies to optimize water use for crop consumption at crop root zone and for soil leaching. Another example is the improved command area management with participatory methods involving stakeholders, deployment of multi disciplinary professionals and through regulations. Modern tools like IT and space technology are highly relevant in monitoring large irrigation commands. Affordable technology for treating and purification of water for different uses is another area that needs a large scale deployment. As the rural drinking water supply schemes heavily rely on ground water, which poses safety concerns in as much as 71% of the areas, scientific aquifer mapping and delineation should be integrated into the management of that program. Adding to these dimensions are the scientific approaches that need to be deployed in areas like flood forecasting, zoning and flood proofing and urban water supply management.

Environment

In recent times, environment has emerged as a major area of governance bringing the scientific, social and political dimensions in a single crucible. Protection of environment is intricately linked to issues of development, growth and livelihood. The dynamics of environmental management revolves around diverse forms of natural resources, their phenomena and human activities such as use of land, conserving forests, mining, wildlife management, waste management, pollution reduction and protecting bio-diversity, which are all interconnected.

Environmental Governance is emerging as a holistic-concept in a nation's environmental policy which deals with defining/monitoring/managing the natural environment, in relation to social and economic development and achieving sustainability. A major challenge has been to develop adequate understanding of the processes involved in order to assess the impacts and to develop policies and programmes that ensure sustainable development in a dynamic scenario. There is a stronger realization that a scientific approach to understand the state of environment, its trends and the use of appropriate technologies in its management would be an effective tool to objective-policy making. This will also enable transparent and participatory methods to conserve and preserve natural resources, the best of cultural values and precautionary principles.

One of the major actions of importance for future years is to evolve mechanisms through which a suitable balance can be struck between the energy requirements for development and the need for environmental protection. Subsequent to the release of National Action Plan for Climate Change by the Honourable Prime Minister of India in June 2008, eight important national missions had been initiated. These cover the fields of solar energy, enhancing energy efficiency, water, sustainable habitats, Himalayan ecology, sustainable agriculture, green India and strategic knowledge on climate change.

These missions and many other policies associated with environment need a sound basis of observations, measurements, scientific modelling and analysis and interventions based on the knowledge. Application of science and technology to the field of environment is going to assume huge significance in view of potential impacts of environmental issues on the vast majority of population.

Globalizing R&D

Needs for sustainability of economic development in an interconnected world have brought in multiple paths for sharing and exchange of investments, technologies and human expertise in the quest of expanding markets across different geographical regions. As the markets for business enterprises are increasingly liberalised, the globalisation of R&D has become a natural consequence. This is also facilitated by increasing harmonisation of legal regimes for intellectual property rights. Under this scenario, several multinational corporations have already created centres in India for carrying out world class R&D through the skills of Indian researchers. Parallelly, many Indian companies are making forays into global markets through operations and acquisitions of overseas companies, in the fields of metals, engineering, energy, medicine etc. Therefore, Indian companies should be facilitated to establish world class R&D centres in India to generate intellectual property, which is vital for their growth strategy in the long run. Why not they even establish R&D centres abroad to use the special talent pools nurtured in different eco systems? Open source drug discovery program of CSIR, which was referred earlier, has been drawing good response and is an innovative model for low cost discoveries that can serve large sections of global population.

University Eco system

12th plan is going to provide a big boost to infrastructure in universities for research activities. A big thrust will also be given for human resource development in scientific and technological areas. Our experiments earlier with Inter- University centres in chosen areas of Science and Engineering have been effective in providing access to the state of the art facilities for researchers in universities and academic institutions. Three such centres, which are currently operating are focusing only on physics and astronomy. Such interuniversity centres functioning autonomously within an existing university/institution could very well promote cross disciplinary research. An inter- university consortium for advanced materials, for example, can focus research on many emerging requirements for energy storage, sensors, biomimetics, special polymers and nano materials and nano devices.

An inter-university consortium for advanced manufacturing and fabrication focusing on the research on large scale, rapid and cost effective manufacturing technologies, and involving interdisciplinary approach is proposed to be set up to generate several new applications including large area functional coatings, food and pharmaceuticals and even fast moving consumer goods where scaling up can lower the costs very significantly. Likewise another inter-university consortium on Analytical Geochemistry is conceived to help generating high quality data on diverse earth materials including those containing energy elements. As there have been dramatic advances in recent years in the area of chemical/materials analysis which require well maintained, professionally run facilities, and which cannot be easily established at individual institutions. Elements in trace or ultra-trace levels and isotopicratios of radioactive, radiogenic, cosmogenic and stable elements in a large variety of earth materials are essential to understand subsurface and surface earth processes, mineral concentrations, pollution transport and fixation processes. There are many areas such as functional materials, bio diversity and genetic epidemiology, mathematical modelling, cyber security, cognitive sciences and plant molecular biology and other areas where inter institutional centre feasibilities could be examined.

Quality of human life, particularly that of poor and vulnerable sections depends upon natural environment and its endowments, which support their livelihoods and basic needs. Deeper understanding of phenomena such as climate change, impacts of diverse pollutants, biological processes at minute levels which have consequences for human health and basic livelihood capacities need scientific efforts at cutting edge level. In tune with this need, centres with state of the art facilities are planned to be created in institutions with proven track record in fields such as plant phenomics, chemical biology and bio engineering, animal modelling, high throughput platforms for genome analysis and synthetic biology, material behaviour at atomic scale, low temperature physics and super conductivity, physics of astroparticles, extreme matter, combustion and heat transfer, water research, imaging and spectroscopy. Advanced research enabled by such state of the art facilities has important consequences in the fields of sustainable agriculture, understanding of origin of biological disorders and diseases, environmental control and energy systems.

Concluding Remarks

India's growth comes at a crucial juncture of international developments and domestic readjustments with structures and governance systems. Sustainability of such robust growth crucially depends on the leverage provided by the science and technology endeavours through their multi dimensional role for creation of wealth, inclusive social development, strengthening national security, enrichment of knowledge and in shaping India's relations in the comity of world's nations. Indian science and technology endeavours are poised to see a quantum jump in basic science endeavours with mega facilities like national synchrotron facility and gravitational wave astronomy. India has the unique challenge and also a historic opportunity, to achieve inclusive development through its demographic dividends and effectively using the tools of science and technology. An important task is to shape an eco system, with the diverse strategy, policy and organizational contours which will accelerate our march towards the goal. It is in this context that the role of independent professional bodies likes The Institution of Engineers (India) is extremely important and relevant.

I would like to acknowledge the help I received from Dr K R Sridhara Murthi in the preparation of this paper.

# Sustainable Development and Inclusive Growth

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## Introduction

Businesses operate in an increasingly heterogeneous environment, including globalization and trade, increasing transparency, unprecedented innovation and change, changing legislation, and a market shift towards 'Sustainable Development' (SD). Creating a sustainable future, economically, socially and environmentally requires all organizations and individuals to rethink on how we use our resources, how we interact, and what we want to achieve, so that our future generations are able to meet their own needs.

## Sutainability Defined

Sustainability agenda has become an archetype of "sustainable development", a concept developed by the Brundtland Commission in their report in 1987. It is therefore important to understand the historical context of sustainability and sustainable development. The Commission defined sustainable development as "development that meets the needs of the present, without compromising the ability of future generations to meet their own needs". The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; the idea of limitations imposed by the state of technology and social organizations, and on the environment's ability to meet present and future needs.

Sustainability is traditionally defined, as the capacity of an eco-system to endure. Exploiting the carrying capacity of the planet want only, impoverishes future generations. The word "wantonly" is critical, because you could add to future capital by innovating new models of production and consumption. The capacity depends on the degree of human ingenuity and innovation. This is what has enabled Homo-sapiens to thrive on this planet, and take gigantic leaps despite monumental natural handicaps.

The Oxford English dictionary dates the first usage of 'sustainable' to 1965, meaning capable of being maintained at a certain level. The term and concept of sustainability grew out of biology – specifically ecology – as a perspective from which to judge the 'evolutionary success', 'adaptability', and thus 'survivability' of species.

Ever since the publication 'Limits to growth' appeared in 1972, as a result of the discussions in 'The Club of Rome', there have been proposals that mankind has to limit its growth ambition based on the Earth's resources. Hence, the term sustainability has become a major global issue. It seems to be almost a Hegelianism – from growth over limits to growth, or 'sustainable growth' to now 'limits to sustainability'.

## Concept of Sustainable Development

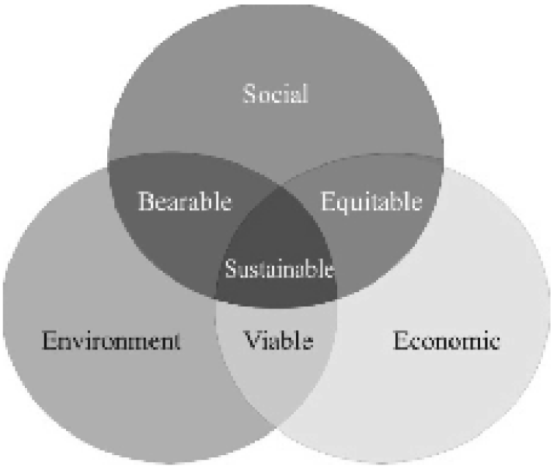
In microeconomic sense, organizational sustainability interfaces with economics through the social and ecological consequences of economic activities, undertaken by a firm in pursuit of fulfilling its avowed goal, mainly concentrating on maximization of shareholders' wealth. Sustainable means endurable. The idea of sustainable development has evolved over the last four decades with a proliferation of its interpretation in terms of vision, values and principles. The focus of sustainability ranges from the total carrying capacity (sustainability) of plane ecosystems, countries municipalities, individual lives, individual goods and services, and so on. However, a universally accepted definition of sustainable development remains elusive, because it is expected to achieve multifarious phenomena.

## Sustainability Framework

Sustainable development, as defined by the Brundtland Commission, is a commendable definition, but is too general to be operationalized, and the following need to be adopted:

- A triple bottom line perspective, that considers environmental, economic and social aspects;
- A time dimension, which incorporates short term to long term, and considers impacts along the lifecycle, from supply, production, use, and fate, including impacts on future generations;
- A multi-scalar place-based approach, which recognizes that values are a function of people, culture and Maslovian circumstances.
- A resource context, resource integrity, with respect to scarcity, over-abundance, or potential to disrupt resource availability in the future.

The figure below indicates the relationship among the three pillars of sustainability i.e. economic sustainability, environmental sustainability and social sustainability.




Three Pillars of Sustainability

Most sustainability frameworks incorporate considerations of environmental, economic and social impact. Some sustainability frameworks ever assess those impacts, along lifecycle stages. Part of the problem is that the sustainability framework is dynamic, and evolutionary. In order to be effective, it must be multi-dimensional and multi-scalar. Companies struggling to move from the "why" to the "how" of sustainability, must recognize that the goal of achieving sustainability should be global, at the system-level; however implementation, in most cases, must occur at a more local level.

Principles of Sustainability

The sustainability principles could be briefly summed up, as under:

- Conserve, protect, and where needed, restore the productivity and diversity of nature (ecological processes and structure), to levels necessary to maintain ecological health (within special focus on key areas such as riparian areas, floodplains, wetlands, native plant habitats etc).

*Why? Because ecosystem science shows that human health and prosperity depends on the ability of nature to produce a continued supply of physical goods (wood, water, fish) and ecological services (e.g. clean air and water) and on natures ability to break down and reassimilate human waste and turn them into new resources. Today, many resources and ecosystems are below the levels needed to provide these goods and services in perpetuity.*

- Phase-out the use and emission into nature of toxic minerals, metals and fossil fuels and synthetic persistent bio-accumulating toxic materials and substances while phasing-in the use of renewable energy and naturally occurring, non-toxic materials and substances in production processes, goods and services.

*Why? Because to maintain ecological health toxic materials must not be discharged into nature faster than nature can break them down and reintegrate them into natural cycles. Today, we are emitting toxic materials and substances faster than nature can assimilate them (which cause pollution).*

- Eliminate waste through reduction at the source and enhanced reuse, remanufacturing and recycling internally within and externally between agencies, institutions and business.

*Why? Because materials and substances must be used as efficiently as possible to prevent the overharvest of natural resources and to reduce the discharge of waste and pollution into nature faster than nature can assimilate them.*

- Increase the efficiency by which natural resources and energy are extracted, processed and used.

*Why? Because materials and substances must be efficiently as possible, to prevent the overharvest of natural resources, and to reduce extracted as the discharge of waste and pollution into nature faster than nature can assimilate it.*

- Enhance business development, economic competitiveness, job creation, fairness in the distribution of resources to meet basic human needs, public safety, health care and education consistent with the principles above.

*Why? Because to meet all the above principles, we must have health, economies and communities, which benefit all members of the society. Everyone must be included in our prosperity to ensure social equity and cooperation which will lead to better support for and involvement in sustainability programs.*

Corporate Sustainability

Corporate sustainability is the business approach that creates long-term shareholder value, by embracing opportunities and managing risks deriving from economic, environmental, and social developments. The Journal of Environmental Strategy defines corporate sustainability as 'the capacity of an enterprise to maintain economic prosperity in the context of environmental responsibility, entails the creation of sustainable competitive advantage by means of building the capacity of a firm to add value through the product it produces or services it renders, and ensuring its operation ad infinitum in a socially and environmentally just and equitable modus operandi". From this perspective, a sustainable enterprise maybe defined as 'one that contributes to sustainable development by delivering simultaneously economic, social and environmental benefits, the so-called triple bottom-line'.

Businesses should support inclusive growth and equitable development and recognize the challenges and social economic development faced by India, and build upon the development agenda that has been articulated in the government policies and priorities.

Stakeholder Engagement

(a) Companies need to form a strategy to periodically engage stakeholders on sustainability issues. These engagements need to be on three levels:

Corporate level: Engaging with the largest and most influential stakeholders for the company.

Project/site level: Engaging with relevant supply chain partners, local communities, government officials and non-profit organizations.

Issue specific: Engaging with relevant stakeholders on issues of concern like water rights issues for a particular region, and social justice among others.

(b) For each level of engagement, companies need to identify specific sustainability risks in consultation with the stakeholders that will be tracked over time. Participation of senior management should be encouraged so that the relevant decisions could be taken fast.

Public Participation

In many cases, all the relevant key stakeholders cannot be identified at the start of a project. As elective participatory approach is inadequate and the participation of large audience is needed. For major complex infrastructure projects, a dialogue with the general public is often necessary. This process involves general communication and information activities, contacts with the media and the management as large proactive, transparent and fair, thus providing opportunities for genuinely interested parties to influence the outcome.

A robust natural resources management strategy, will have the following key aspects:

- Identifying all critical natural resources in the entire supply chain, and not limiting to water and fossil fuels.
- Elevating natural resources management, as governance priority for Board members and executives.
- Conducting scenario analysis for natural resource stressed future to define technologies, products, markets and locations.
- Boosting engagement with key stakeholders such as local communities, shareholders, suppliers, government regulators and employees.
- Going beyond normal routine compliance business mind-set to a natural resource compliance business mind-set-to natural resource leadership by adopting international best practices for natural resources management.

Innovation

Innovation is discovering new ways of creating value. Innovation serves as the lifeblood of many organizations, whose survival and growth depend on developing new technology, products and services. A successful organization is a creative organization. In a successful organization, innovation is sustainable and on-going, rather than a process characterized by succession of "boom and bust" events. A creative organization is "led," rather than "managed." A sustainable innovative organization must be fluid and "organic", almost biological in nature to foster the constant creativity vital for the success of a modern organization. A degree of security and stability is essential to "incubate" creativity. In the fiercely competitive 21st century marketplace, innovative ability is essential for survival. The following are major ingredients for sustaining innovation:

Financial and operational performances are no longer the exclusive drivers of business. Business community is no longer expected to merely make profits. How that profit is made is also important to investors and stakeholders. Increasing public consciousness and stricter government regulation have resulted in growing demand for disclosure. And hence Economic, Social, and Environmental factor are now being recognized to play an important role in business success. This recognition along with encouragement from internal and external stakeholders has led the companies to perform in these areas, which has resulted in surfacing of sustainability reporting. There is paradigm shift in measuring and reporting sustainability performance. With burgeoning globalization, India is bracing itself to keep up with the international competition.

12th Plan's objectives of faster, sustainable and more inclusive growth need breakthrough innovations. It is pertinent to see how S & Tinputs and innovations, along with institutional reforms could transform various sectors that are vital from development perspectives.

Leadership for Sustainable Future

For a company to embark on a process of sustainable growth, its leaders and employees have to understand two critical things: what they value and how they create value.

Seven Principles of Sustainability Leadership:

- Sustainability leadership creates and preserves sustainability learning.
- Sustainability leadership secures success over time.
- Sustainability leadership sustain the leadership of others.
- Sustainability leadership addresses issues of social justice.
- Sustainability leadership develops rather than depletes human and materialresources.
- Sustainability leadership develops environmental diversity and capacity.
- Sustainability leadership undertakes activist engagement with the environment.

Having incorporated sustainability as a part of their mission, increasing number of companies are creating departments, within the management structure, that take care of sustainability practices that are lucrative both for sustainability officers, and energy managers. Look up the organizational structure of all reputed business groups today, and you'd see that the role of a sustainability chief is assuming equal emphasis, vis a vis marketing, sales and even finance.

Managing Sustainability Performance through the Value Chains:

Global Drivers of Sustainability

There are four sets of drivers related to global sustainability. Afirst set of drivers relate to increasing Industrialization and its associated material consumption, pollution, and waste generation. Industrial activity has grown to the point where it may now be having irreversible effects on the global environment, including impacts on climate, biodiversity, and ecosystem function. Resource efficiency and pollution prevention are therefore crucial to sustainable development.

A second set of drivers relates to the proliferation, an interconnection of civil society stakeholders. As the power of national governments has eroded in the wake of global trade regimes, nongovernmental organizations (NGOs) and other civil society groups have stepped into the breach, assuming the role of monitor.

A third set of drivers relates to emerging technologies that may provide potent, disruptive solutions that could render the basis of many of today's energy-and material-intensive industries obsolete. Genomics, biomimicry, nanotechnology, information technology, and renewable energy all hold the potential to drastically reduce the human footprint on the planet, making the problems of rapid industrialization all but obsolete.

Finally, a fourth set of drivers relates to the increases in population, poverty, and inequity associated with globalization.

In short, global sustainability is a complex, multidimensional concept that cannot be addressed by any single corporate action. Creating sustainable value thus requires that firms address each of the four broad sets of drivers. First, firms can create value by reducing the level of material consumption and pollution associated with rapid industrialization. Second, firms can create value by operating at greater levels of transparency and responsiveness, as driven by civil society. Third, firms can create value through the development of new, disruptive technologies that hold the potential to greatly shrink the size of the human footprint on the planet. Finally, firms can create value by meeting the needs of those at the bottom of the world income pyramid in a way that facilitates inclusive wealth creation and distribution.

Sustainability Performance:

Sustainable growth refers to creating share holder and societal value, while reducing the environmental footprint, along the value chain. Sustainability is the path to business growth the new lingua Franca in the marketplace, as Indian corporate start thinking beyond. For managing sustainability performance business focuses on supplychain management to achieve its sustainability goals. Governments give emphasis to communication rather than legislation. Community and NGO pressure on the commodity resource sector has led to important multi-stakeholder life-cycle-management. These approaches are most effective in a cooperative framework.

The creation of shareholder value thus depends upon the firm's ability to creatively destroy its current capabilities in favour of the innovations of tomorrow. Firms must perform well simultaneously in all four quadrants of the model on a continuously basis, if they are to maximize shareholder value over time.

Firms like Kodak and Xerox, which failed to adequately invest in digital technology, illustrate how overemphasis on today's business (to the exclusion of tomorrow's technology and markets) may generate wealth for a time but will eventually erode shareholder value as competitors enter with superior products and services. Similarly, the recent experience of many internet companies stands as testimony to how preoccupation with tomorrow's business (to the exclusion of performing today) may be exciting and challenging, but short-lived.

Green Supply Chain

On a longer-term basis, it is worth all participants in the supply chain, working together to improve general efficiency and thus securing the security of the supply chain as well as working to maximize cost effectiveness. Historically, supply chain decisions were based on cost and service levels. For example, lean production systems created small batches, to reduce inventory with fast lead times. This necessitated more frequent transportation of shipments, often from low manufacturing cost countries, which may now conflict, with the new requirement for energy efficiency. Similarly, Wal-Mart worked with the Carbon Disclosure Project (CDP) to assess the company's greenhouse gas emissions and discovered that the refrigerants used in grocery stores made up a larger percentage of the company's greenhouse gas footprint than its truck fleet, Although a significant effort is focused on trucks to improve their fuel efficiency, this new insight is focusing Wal-Mart on the potential of reducing its refrigerant footprint as well.

Rapidly rising energy costs and environmental concerns have driven 'green' issues ever higher on the business agenda. However, if companies are to prove their green worth to shareholders, they need to take greening the supply chain. But the term 'green' is actually potentially misleading. Normally, 'green' implies good environmental performance, as perceived by the stakeholder group. However, a green supply chain (GSC) needs to cover all relevant green areas as well as incorporating more holistic social and ethical challenges. Furthermore, a GSC is not an alternative to a lean supply chain. Indeed most businesses find that GSC initiatives deliver bottom line benefits, in addition to meeting green credentials.

Generally, GSC initiatives reduce risk, improve brand perception, comply with consumer demand, reduce costs and contribute to the implementation of corporate responsibility strategies. But to be effective, a GSC initiative should address every stage in the supply chain, and not simply the key suppliers. This means incorporating transportation issues and ethical sourcing, while considering the complete life cycle of the delivered product or service.

In addition, consumer demand for 'green' products is growing. A study by Accenture of more than 7,500 consumers in 17 countries in America, Europe and Asia found that 64 per cent of respondents said they would be willing to pay a higher price (a premium of 11 per cent on average) for products and services that produce lower green house gas emissions. For many, the over-riding reason for GSC initiatives is corporate responsibility; companies need to be able to demonstrate that they act responsibly on social and environmental issues. This is highlighted by the rapid growth in management system standards, such as ISO 14001 (environmental management system) and SA 8000 (social accountability).

Sustainable sourcing is vital to business in the long-term. Companies must take responsibility for their extended value chains, which go beyond their own direct impact of factories, offices and transport. They must look both upstream and downstream to maximize the opportunities available. Leading responsible growth also means broadening access, and participation in the supply chain. It means looking at all suppliers, big and small. But the challenge is not just to source, manufacture and distribute our products sustainably; it is as important, if not more, to motivate consumers around the world to be part of this agenda.

Sustainability Plan

Having defined the system boundaries, detailed objectives and action plans for developing professional services can be drawn up for each of the following sustainability dimensions.

- Environmental Dimension
  - Increase material efficiency by reducing the material demand of non-renewable good
  - Reduce the material intensity via substitution technologies
  - Enhance material recyclability
  - Reduce the energy required for transforming goods and supplying services
  - Support the instruments of international conventions and agreements
  - Maximize the sustainable use of biological and renewable resources
  - Consider the impact of planned projects on air, soil, water, flora and fauna
- Economic Dimension
  - Consider life- cycle costs
  - Internalize external costs
  - Consider alternative financing mechanisms
  - Develop appropriate economic instruments to promote sustainable consumption
  - Consider the economic impact on local structures
- Social Dimension
  - Enhance a participatory approach by involving stakeholders
  - Promote public participation
  - Promote the development of appropriate institutional frameworks
  - Consider the influence of the existing social framework
  - Assess the impact on health and the quality of life

Economic Performance

Growth is not a matter of increasing GDP. It must be sustainable growth, which is inclusive (majority of citizens must benefit). There is a special impetus to several programmes, aimed at building rural and urban infrastructure and providing basic services with the objective of increasing inclusiveness and reducing poverty. Responsibility profits will have to be the only standard in tomorrow's world. Sustainability is not justabout doing good things, but is good business. The synergistic effects of market demand, societal expectations and product innovation create collaborations up and down the value chain.

An important subset of sustainability metrics consists of Eco-efficiency metric, which relate to two of the three dimensions of sustainability – environmental and economic performance. Metric provide a useful decision support tool for evaluating alternate processes for the manufacture of a given product. Testing the effect of a new process in each metric category, gives decision-makers an understanding of which impacts could be reduced and which impact areas might present increased risks. The eco-efficiency metrics also provide an excellent set of data, for integration with additional tools, such as life cycle inventories and total assessment.

Economic Instruments

A variety of economic policy instruments may integrate a sustainability dimension, into the economic decision making process. However, at the present time mostly refer to the environmental dimension:

- Environmental taxation (there is a trend towards comprehensive tax reform)
- Ecological tax reform (revenues from environmental taxes are being used to reduce taxes on labour)
- Sustainability asset management
- Subsidy reform (subsidies may have both damaging and beneficial impacts on sustainability)
- Extended cost-benefit analysis
- Tradeable permits/joint implementation
- Green procurement' and 'green' accounting
- Voluntary and negotiated agreements

In the long tier, there may be a more radical shift, away from taxing “goods” such as labour, towards taxing “bads” such as environmental damage.

Environmental Governance

While the economy of a country relies critically on environment, its national accounts do not reflect this. Decisions are made on the basis of gross domestic product (GDP). But in most countries, GDP does not take into account natural capital, apart from the usual minerals and timber kind of resources that are conventional inputs in industry. What about the rest of the capital that makes up global ecosystems? Natural Capital Accounting would include ecosystem services and other natural resources that are not traded or marketed, and are therefore harder to measure. This would take into account the “regulating” services of ecosystems, such as forests for pollination and wetlands for reducing the impact of floods. However, would such an accounting system be accurate, considering its subjective nature?

Environmental governance is emerging as a holistic concept in a nation's environmental policy which deals with defining/monitoring/managing the natural environment, in relation to social and economic development and achieving sustainability. A major challenge has been to develop adequate understanding of the processes involved in order to assess the impacts and to develop policies and programmes that ensure sustainable development in a dynamic scenario.

Environment governance has been a neglected topic. The media attention given to environment problems had tended to emphasize catastrophic events, controversial individuals, or interest –group conflict. Climate change is far too complex an issue to be solved simply through proclamations. While the media and vested interests are sensationalizing the climate change to advance their respective agenda, there is little action to prepare the world to combat the impending catastrophe in a holistic manner, that could turn this crisis into an opportunity.

Natural Resources

Natural Resources and raw materials like land, water, fossil fuels, ores, minerals, forest products, and agriculture goods are integral to the sustained economic growth of all companies. Corporates generally operate in an environment, where natural resources are loosely guarded by regulatory enforcement. This has created perverse incentive for the companies to exploit the resources, ignoring the sustainability concerns. Managing such a risk without a robust natural resources management strategy, would be a daunting task, which all business leaders would like to avoid.

A robust natural resources management strategy will have following key aspects

- Identifying all critical natural resources in the entire supply chain and not limiting to water and fossil fuels.
- Including natural resources management as a governance priority for board members and executives.
- Conducting scenario analysis for natural resource stressed future to define technologies, products, markets and locations.
- Boosting engagement with key stakeholders such as local communities, shareholders, suppliers, government regulators and employees.
- Going beyond normal routine compliance business mind-set to a natural resource compliance business mind-set to natural resource leadership by adopting international best practices for natural resources management.

Green Economy

Sustainable Development with social inclusion and a transition to a greener economy is indispensable. The earlier the transition to sustainable development and to a greener economy starts, the more the transition can be managed to avoid the economic and social cost of disruptive changes, and to seize the opportunities for economic and social development.

The green economy requires sustainable production, and consumption patterns. These will trigger modifications to practices in most enterprises and structured change across the economy: for example

- Introduce environmental tax reform, in particular an eco-tax, which shifts the burden to resource use and pollution and away from labour.
- Encourage investment in a greener economy.
- Provide targeted support to SMEs.

Green economy strategies and policies to reinforce developing countries' poverty eradication and social development goals is the only way forward. To ensure that the momentum towards a greener economy is sustained, and a new sustainability model realized, a comprehensive policy approach is needed. The approach must recognize the country-specific and sector-specific challenges, while ensuring that opportunities for decent work and social inclusion are achieved.

Sustainability Tools

If one is to implement sustainability, not only must there be a common understanding of the inherent dimensions to be considered, but also how to determine performance along those dimensions. The question is how to correctly measure the performance of the right attributes, along the right dimensions.

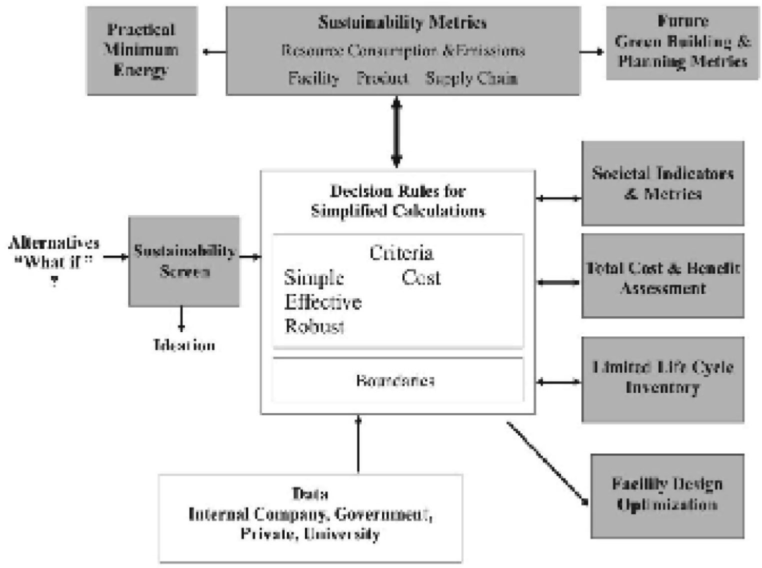
Some of the objectives, in utilizing sustainability tools are to;

(i) provide timely, strategic and tactical input to support substance and product technology development and life cycle management by identifying, evaluating, and controlling ESH issues and capitalizing on sustainability opportunities;
(ii) integrate the process and equipment design to ensure safe and timely changes and technology relocation to pilot plant and commercial scale.

(iii) evaluate process and equipment changes to ensure a sage process;
(iv) Continually evaluate alternatives to eliminate and/or reduce waste in all media (water, air, and land), throughout the life cycle.

Tool Box

These considerations have been addressed through the tools in the Sustainability Toolbox. Each of the tools, used alone, provides a mechanism by which it integrates sustainable development into business decisions, operations and practices. However, the significant power of the tools lie in their combination and integration.




Sustainability Toolbox

1. Sustainability Screen: The front plane of the sustainability framework represents the Sustainability Screen, the first tool in the Sustainability Toolbox. At every lifecycle stage, it can be populated with questions about alternatives under consideration:

- Environmental: How does a company perform in terms of its consumption of resources: material, energy, and water, and its emissions of pollutants and toxics? At what level environmental performance are we concerned: facility, product, supply chain? How can the manufacturing processes, which generate the environmental impacts be improved to reduce those impacts within cost constraints?
- Economic: what are the costs (and benefits) of those impacts currently, and in the future? Internal to the company, and externally in society? In tangible and intangible terms? What economic benefits flow to society, as a result of the business operation? How do future societal costs become-internal company costs?
- Social: what are the impacts on society, with respect to resource consumption and demission's? How do the stakeholders feel about the firm and its products/services, from employees to neighbors, community to suppliers and business partners and stockholders, etc? To what extent are people protected in terms of health, safety and security, relative to the business? What is the service value, the level of functional performance, which is intended to meet a societal demand?

2. Sustainability Metrics. The development of sustainability metrics is an excellent way for many companies to begin the implementation of sustainable business practices. Sustainability metrics consolidate key measures of environmental, economic and social performance. These measurements allow managers to evaluate products. Facilities or business units in terms of sustainability, develop strategies for improvement, and track progress in moving towards more sustainable practices.
3. Life Cycle Inventory. The purpose of performing a life cycle inventory (LCI) is to identify the environmental impacts, at each phase of a product's life. All input and output flows, from cradle-to-grave, for raw material extraction and production, product manufacture, use and end of- life are inventoried. A life cycle assessment (LCA) is an organization of the flows into impact categories, such as material intensity or greenhouse gas emissions. The LCA is essentially a compilation of environmental metrics across the life cycle of the product. The holistic view provided by the LCI and LCA tools, is really key to identifying the areas of greatest impact and preventing myopic strategies for improvement that cost too much and accomplish little significant reduction in impact.
4. Life–Cycle Costs (LCC): Cost as well as environmental issues must be considered from life-cycle perspective. The reasons are clear-cut: cost saving measures in design and construction may increase

significantly over the cost of operation and maintenance, or reduce significantly in the project lifetime. A realistic overall cost assessment for the client's benefit, can only be made from a project life-cycle perspective.
5. Alternative Financing: Identifying alternative financing mechanisms is always an option for engineering projects. Life-cycle cost assessments and the incorporation of external costs will make such considerations even more important in the future. This is because these life-cycle assessments, in addition to external costs, provide a broader picture of the overall project budget and its implications. Alternative financing models may then be viable, especially in a long-term perspective. For instance, assessments could result in a risk profile for a given project implying that public financing may be necessary because private investors could be reluctant to intervene.
6. Economic Instruments: a variety of economic policy instruments may integrate a sustainability dimension, into the economic decision making process. In the long tier, there may be a more radical shift away from taxing "Goods", such as labour, towards taxing "bads" such as environmental damage. However, at the [resent they mostly refer to the environment.

- Environmental taxation (there is a trend towards comprehensive tax reform)
- Ecological tax reform (revenues from environmental taxes are being used to reduce taxes on labour)
- Subsidy reform (subsidies may have both damaging and beneficial impacts on sustainability)
- Extended cost-benefit analysis.
- Tradable permits/joint implementation
- "green" procurement and "green" accounting
- Voluntary and negotiated agreement

The sustainability toolbox provides a mechanism by which to incorporate the concept of sustainable development into management decisionmaking. These tools allow companies to operationalize the concept of sustainable development through cost-effective, practical applications that build toward a systematic approach defined by business practices that lead to less waste and less pollution, safer practices, greater good will in the community and products that provide increased value to customers and shareholders.

Integrated Sustainability Reporting

Global Reporting Initiative (GRI) defines Sustainability Report as "the practice of measuring, disclosing, and being accountable for organizational performance, while working towards the goal of Sustainable development". A sustainability report provides a balanced and reasonable representation of the sustainability performance of the reporting organization, including both positive and negative contributions.

By integrating your sustainability report in to your strategy, both opportunities and risks are identified, such as:

- Identifying changing market trends and consumer concerns
- Providing a different perspective for management to view the business, that can identify new markets
- Measuring the resources and energy intensity of your business inputs, creating cost savings and process efficiencies
- Attracting and retaining talent and increasing brand value
- Encouraging deep and broad analysis of business partners and your supply chain, can identify potential reputation risks.
- Better understanding business impacts and stakeholder concerns, and in turn proactively managing these issues.
- Proactively disclosing management concerns, so that you can manage any adverse publicity.

To be effective, Corporate Responsibility (CR) reporting is not about an "add on" to "business as usual", or a focus on glossy year-end report, its about integrating business strategy, performance reporting and stakeholder communication into your business.

- Consistent dialogue with stakeholders
- Identifying the impacts you have, on the environment and the communities you operate in
- Developing responses to stakeholder concerns, that are consistent with your business strategy.
- Effectively communicating your impacts, mitigations and performance in key sustainability areas

In India, today there are more than 65 companies disclosing information on environment and social performances, based on the GRI Guidelines, although with varying application levels and assurance approaches. Over 80% of these reports correspond to application level 'A' (or A+), the remainder were either undeclared or lower level of adaptation. The breath of the reports and their coverage of most GRI indicators prove that Indian reporters are committed, but the number of such commitments need to grow at a much faster rate than what it is today, compared to other emerging economies like Brazil, South Africa and China. From the list of sustainability reports registered on the GRI website, it is observed that many companies like ITC, Reliance

Industries, Jubilant Organosys, Dr. Reddy's, are the leading companies with over 8 years of experience on sustainability reporting.

At last count 21 Indian companies had taken up triple bottom line reporting, which, besides financial disclosures cover impacts on society and the environment also.

Sustainable Development – Role and Paradigm for Engineers

Since the 1960s, many people have been regarding technological change as one of the main reasons for environmental degradation and depletion of natural resources. The same "Progress," that was so overwhelmingly present in the reasoning on technology in the fifties (Atoms for peace, post WW II reconstruction), was earmarked as a road to collapse in the seventies. The instrumental way in which technologists dealt with nature was held responsible for environmental exploitation and destruction.

This negative interpretation of the role of technology, in regard to environmental degradation, was based on various, partly contradictory starting points:

- that technological change is unidirectional, i.e. that the history of technology and its future is a linear sequence of artifacts, practices. and systems, moving away from the natural, "technology less" man.
- that the rate of change of specific technologies is (except for minor aberrations) fully determined by the growth rate of the pool of scientific knowledge and technological change of adjacent technologies.
- that technology is not influenced by society, or societal change: technology is not autonomously produced by the technologist; it is creative assembly of technological as well as social developments.
- that technological change is the driving force of societal change: It is an analytic mistake to blame technologist for the “rebound effect” of their work.

Addressing sustainable construction is vital if the region's plan for economic and population growth is to be achieved in a way acceptable to the modern day pressures of sustainability. lf a development is to be as successful as it can be, the sooner its environmental impact is measured, considered and limited, the better. The energy being used to heat, cool, light and service, commercial, buildings are now responsible for over 20 per cent of all carbon emissions. New guidelines can force developers to consider how they can update existing buildings, whilst ensuring that new buildings are designed to be of long life, energy efficient, and are able to adapt to a variety of uses to meet changing needs. Also, they are constructed of low energy and renewable materials. These standards can cover areas, such as energy usage, pollution, transport, land use, building materials and water consumption.

If there is to be a common approach to sustainable practice amongst professionals, then the framework and training for this needs to come through their professional bodies. The International Institute for Sustainable Development, states that in a sustainable society:

- Any materials mined from the earth should not exceed the environment's capacity to disperse, absorb, recycle or otherwise neutralize their harmful effects to humans and the environment.
- Synthetic substances in their manufacture and use should not exceed the environment's capacity to disperse, absorb, recycle or otherwise neutralize their harmful effects to humans or the environment.
- The biological diversity and productivity of ecosystems should not be endangered.
- A healthy economy should be maintained, which accurately represents the value of natural, human, social and manufactured capital.
- Individual human skills, knowledge and health should be developed and deployed to optimum effect.
- Social progress and justice should recognise the needs of everyone.
- There must be equity for future generations.
- Structures and institutions should promote stewardship of natural resources and the development of people.

All professional bodies and industry' lead bodies should have sustainable development criteria included within their training course accreditation requirements. The challenge of sustainable development has profound implications for professions, across a range of disciplines - engineering, planning, chemical, environmental, accounting, design, manufacturing or whatever profession; in both the practice and role of the professional. Sustainable Development is therefore the great new challenge for the engineers of the 21st century. What kind of engineers do we need to do a better job? How do we train such engineers?

Sustainability Training for Engineers

The profession of scientifically trained engineering came into existence in 19th century. It was, in fact, a product of the enlightenment. It implied rethinking traditional technologies in order to rationalize and optimize them. Training of engineers therefore had to change from merely apprenticeships (in order to learn the traditional methods) to the teaching of science and mathematics. In various debates, engineers generally took the view that they had the means to best solve a problem. What they sometimes failed to recognize, was that the real issue at stake was not a scientifically/mathematically solvable optimization problem, but a choice between irreconcilable norms and values.

In the debates on (nuclear) energy in the seventies and eighties, engineers often failed to recognise that there was far more at stake than (cost-) efficient electricity supplies. Even if they took the issue of safety seriously, they often failed to recognize that disasters in the order of magnitude of a nuclear meltdown were completely unacceptable No matter how small the chances might be enormous efforts to calculate risks, minimize them, control them or play them down appear to be futile.

Engineering education must be given new impetus in ways that will generate required skill in the emerging high-tech era. Traditionally defined boundaries between disciplines are vanishing and therefore, engineers must have the capacity to work in interdisciplinary areas.

Greater emphasis should be on creative problem solving and just not merely on analytical skill. Education in emerging high-tech era should not neglect appropriate training in life sciences, as engineers interact with medical, agricultural, climate scientists leading to the development of new technologies and products for human welfare.

Proper training should be arranged in the fields of multi-criteria decision making, basics of business and management, professional ethics and laws pertaining to intellectual property rights, environmental impact assessments and sustainability. Converging nano-technology, biotechnology, info-technology and cognitive science (NBIC) in conjunction with traditional engineering technologies are expected to change the ways research, product manufacturing and education are planned.

The global challenges associated with sustainable development are multifaceted, involving economic, social and environmental concerns. As a global society, we are living on the edge. Approach to challenge the conventional wisdom and changing the corporate psyche to demonstrate virtues of being ethical, transparent, equitable and responsible in their decision making, by lifting economy, Corporate Social Responsibility, Corporate Governance and environment to much higher levels.

The concept of sustainable development has been transposed from the macro to the corporate dimension; in as much as a corporate entity is a productive agent of our socio-economic system, a conduit of the eventual implementation of sustainable issues and a socially responsible citizen. Sustainability concept has been gradually gaining worldwide recognition and acceptance. Thousands for companies throughout the world are currently using sustainability reporting as a means of communicating with their stakeholders, as well as a tool of internal management and control.

Sustainability today, is not an option but an imperative, at the core of corporate strategy. If businesses are to achieve long term success and sustainable growth, they will have to be inclusive, making a real contribution to the socio-economic development of the communities, within which they operate. Equally, in an era of diminishing natural resources, by protecting the environment in which they do business, corporate can lay the foundation for their own long term sustainability.

I believe that applied sustainability will be a common denominator of successful global companies by the end of the twenty-first century – and most likely much sooner. Governance, corporate social responsibility (CSR) and sustainability are headline news today. No wonder!

# Human-Friendly River Restoration and Management in Korea

## Prof Myung Pil Shim

President, Korean Society of Civil Engineers
Professor of Inha University
Former Minister of The Office of National River Restoration, Korea

ABSTRACT

The Four Major Rivers Restoration Project of Korea were implemented over the Han, Nakdong, Geum and Yeongsan Rivers to restore the natural river functions and to provide a total solution for river restoration, covering flood control, water security, and ecosystem vitality for the regions along the major rivers and their tributaries. The project has five key objectives: 1) to implement comprehensive flood control; 2) to secure abundant water resources and safeguard against potential water scarcity; 3) to improve the water quality and restore the ecosystems in and around the rivers; 4) to create multi-use spaces for local residents; and 5) to prepare for further revitalization of these river systems under regional authorities in the future.

The project has renewed and revitalized a total of 929km of Korean rivers nationwide. In addition, subsequent projects subjected to be administered by regional governments will restore more than 10,000km of local streams and 39 riparian wetlands. Among the various purposes of the Four Rivers Project, flood control was highest priority. To take preemptive measures against floods caused by climate change, the plan was to dredge sediments from the riverbed so as to prepare for 200-year periodic flooding, reinforce dilapidated levees, and build flood control detentions. This resulted in a flood control storage capacity of 920 million m3.

Despite record high heavy summer storms in 2011, the maximum and average flood water level was lowered 4.45m and 1.31m, respectively, due to the Four Rivers Project. The outcomes of the Four Rivers Project will continue to be monitored against more frequent extraordinary floods and natural disasters due to climate change and variability.

Various measures for flood control were constructed including 16 weirs with movable gates, remodeling works for elevating existing agricultural reservoir banks, and small- to mid-sized dams for water supply securing a sufficient amount of water totaling 1.3 billion m3 in order to prepare for water shortages. The weirs are designed to discharge silt that is deposited at the river bed over time and to control the amount of water according to weather conditions.

The waterfronts have been revived into multipurpose spaces that bring together lifestyle, leisure, tourism, culture, and economy. In addition, bicycle lanes stretching 1,757 kilometers, a total of 454 sport facilities including 65 soccer fields and 45 baseball fields, and a total of 1,529 camping sites, with a capacity of 520 camping cars were prepared. These changes have brought cultural infrastructure to the local communities.

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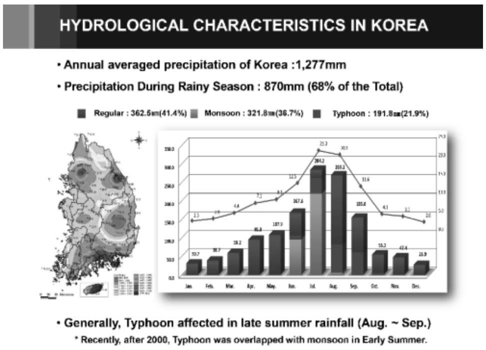
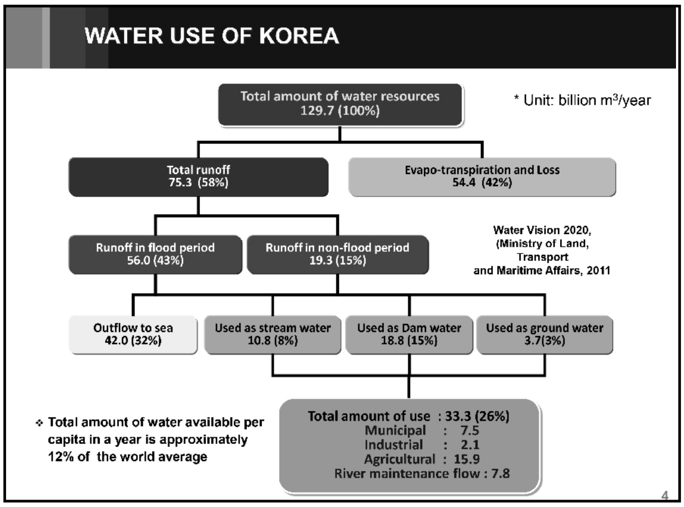
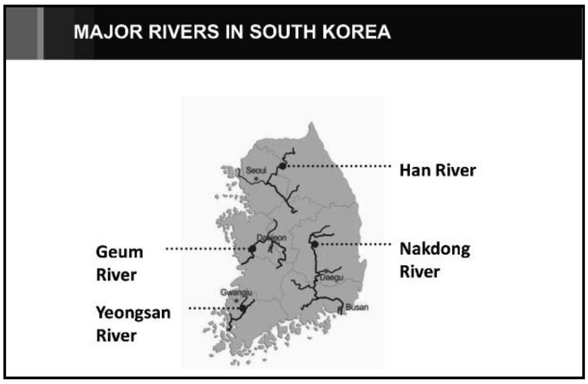
Human-Friendly River Restoration and
Management in Korea
THE FOUR RIVERS RESTORATION PROJECT
Overview of Water Resources in Korea



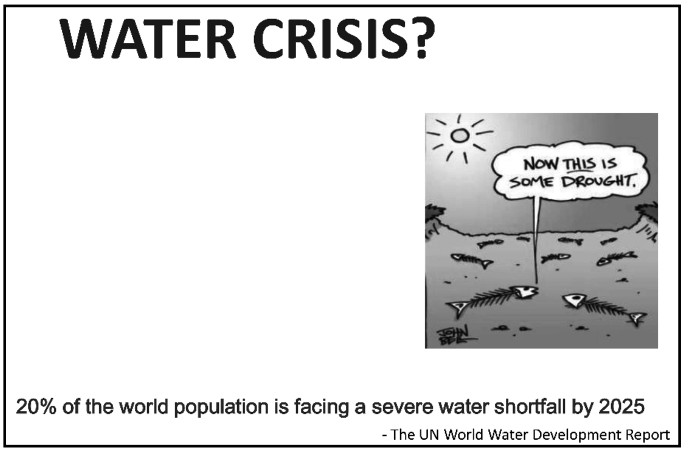
The annual average precipitation of Korea is 1,277mm, which is 40% more than world average of 880mm. However, the amount of water available per capita in a year is only about 12% of the world average. Because 68% (two-thirds) of the total rainfall occurs during the rainy season from June to September, and little rain happens in the dry season. As a consequence, we used to suffer from disasters caused by repeated floods and droughts.




This figure shows various water use of Korea. We could use up to 26% of total amount of water resources. Agricultural use is about half. Water use can be increased by about 1 percent with a Four River Project.



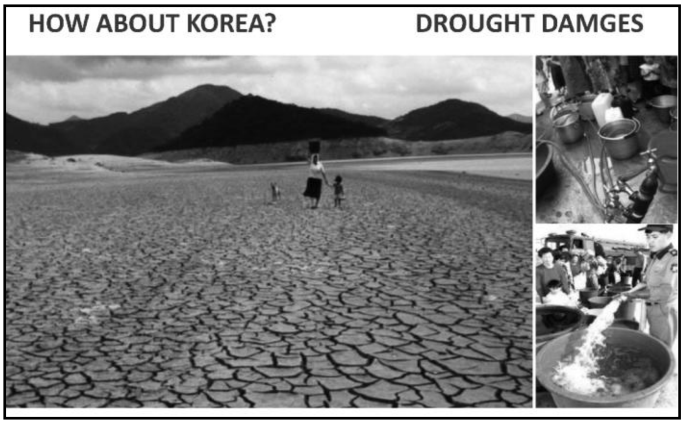

This map shows 4 major rivers in South Korea. Han River is one of the most important river in Korea which flows through the center of Seoul, the capital of Korea.




As you know, the world is facing an impending water crisis.

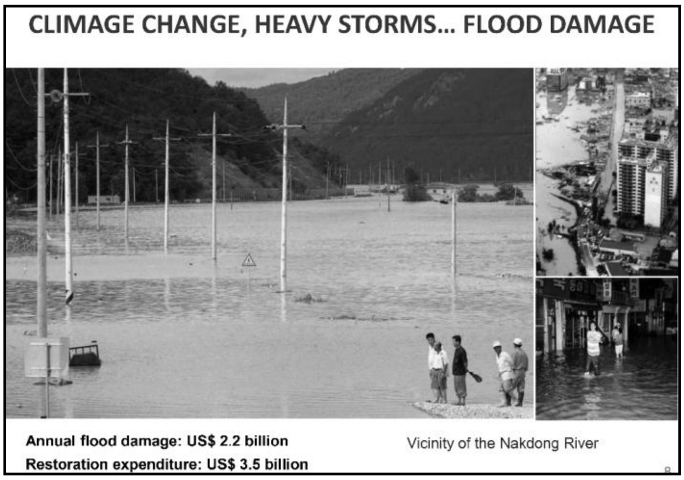
According to UN World Water Development Report, 20 percent of the world population will be facing a severe water shortfall by year of 2025. It's clearly evident that climate change and water shortage are becoming an inevitable global problem in the world. Therefore, water issues have an utmost importance in all international documents on sustainable development.

(Over the past 30 years, we have observed in many parts of the world rapid population growth, mismanagement of water resources leading to increasing water related problems. Water problems are strongly linked in a complex nexus that threatens a region's environment, health, and natural resources. And just as the problems are connected, their solutions need to be integrated and mutually reinforcing to reverse this downward spiral.)




(Just as much of the world is experiencing historically abnormal weather phenomena.)

Korea has also faced water shortages in the recent years

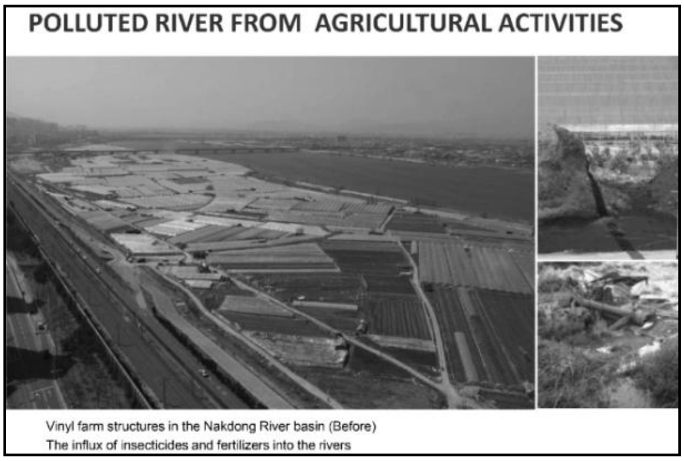



Heavy storms and flood damage are becoming more frequent during summer. This picture shows flooded area of Nakdong River which is the longest river in Korea. (before the Project)

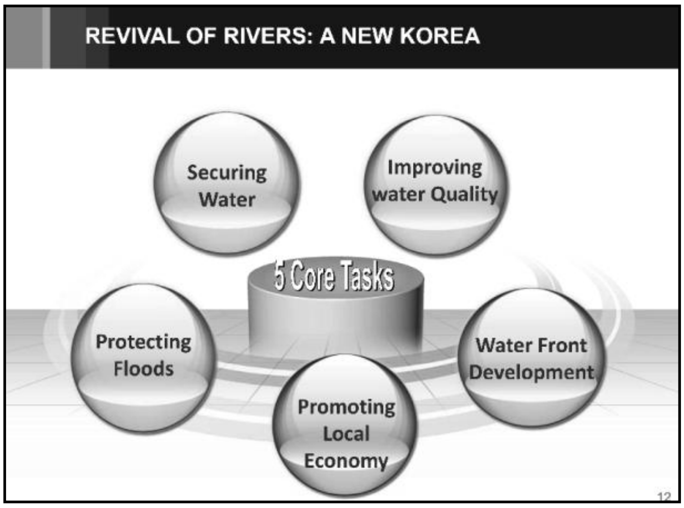
(For the last five years) the average annual flood damage in Korea was approximately 2.2 billion US dollars. And Cost of restoration expenditure is about 3.5 billion US dollars.

In addition to the water related natural disasters, our rivers have experienced (some degree of) water pollution as well.

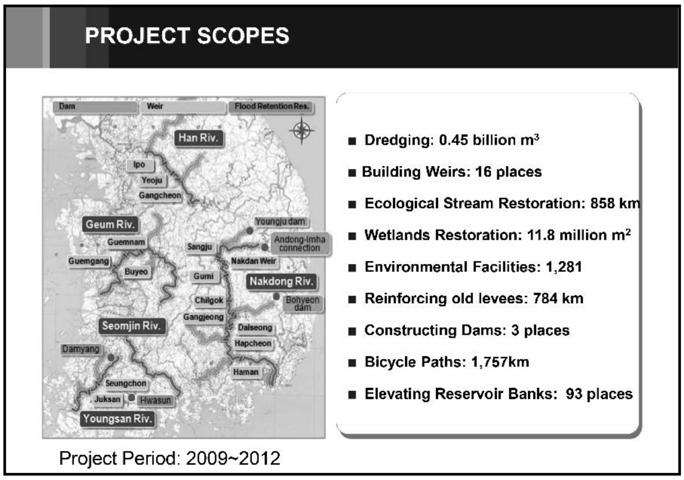
Due to the water pollution, our nature, especially aquatic eco-system has continuously degraded.



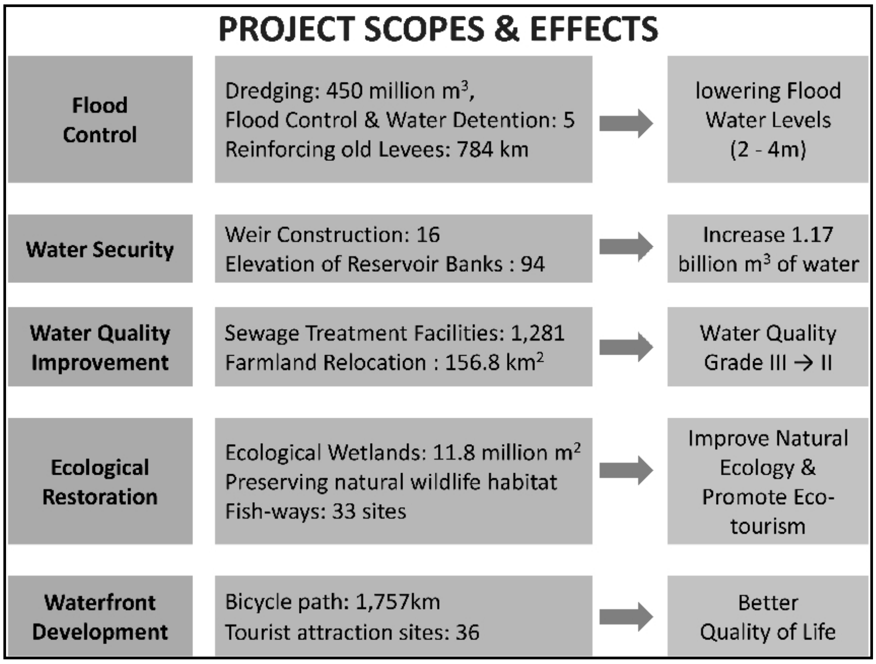

Furthermore, agricultural activities along the rivers pollute the rivers. Vinyl farms affect the rivers by the direct influx of insecticides and fertilizers into the rivers. All of these farms were removed during the Project



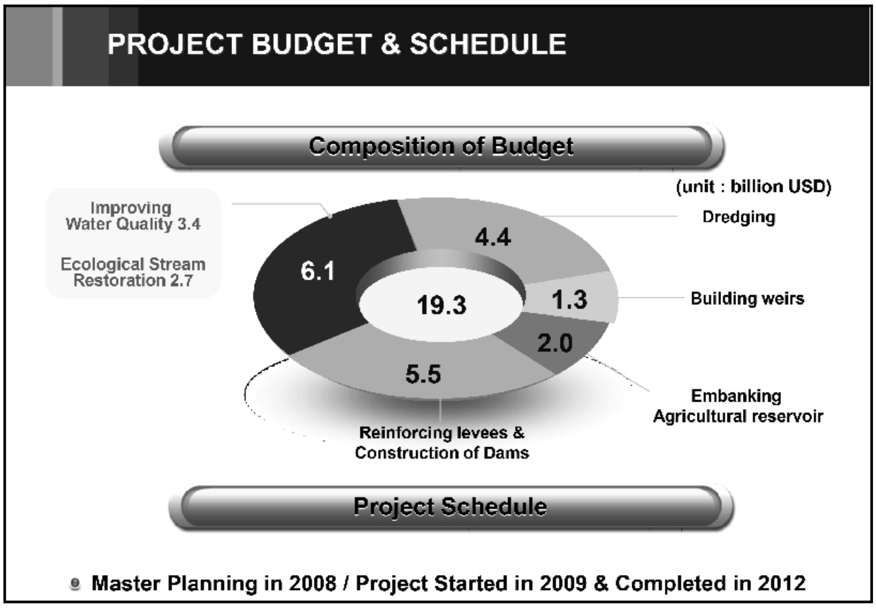

The vision of the Project was 'Reviving Rivers for a New Korea!'. Under this vision, the Four River Restoration Project has five key objectives. (which means five core tasks). First, protecting against flood (and implementing comprehensive flood control measures), Second, securing water resources, and (3) improving water quality and restoring river ecosystems, (4) Water front development, and (5) promoting local economy by balanced regional development centered on rivers.



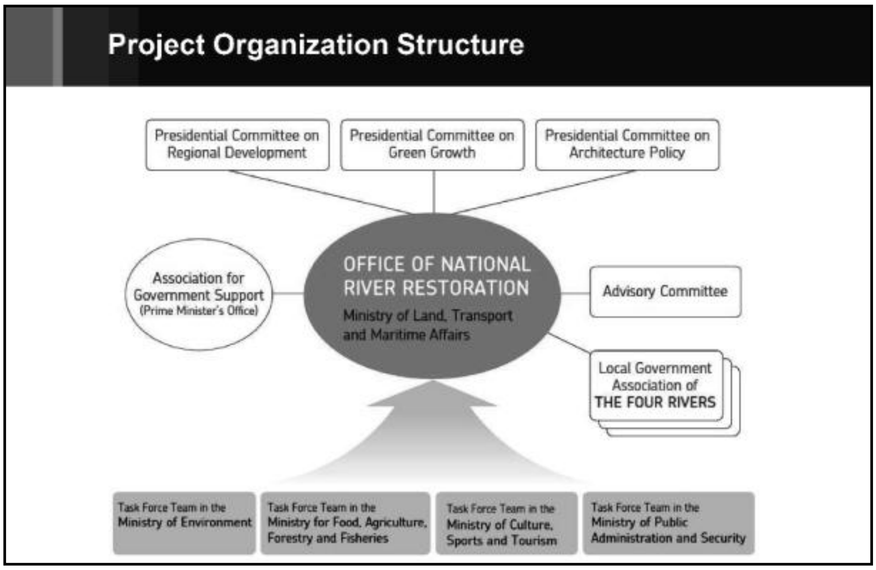
This figure shows the scopes of the project. This project includes 450 million cubic meters of dredging of riverbeds, and building of 16 weirs for securing abundant water. (On this graph, the green boxes represents new dams, yellow ones newly constructed weirs, purple ones flood retention reservoirs. The project period spans 4 years from 2009 to 2012 including setting up the master plan.)




This figure shows the scopes and effects of the Project. For flood control. we dredged sediments of the low-flow riverbed as a preemptive measure. Then, the water flow capacity in the rivers will be increased, and the flood level will be lowered in 2-4 meters (which is up to the levels of the 200-year flood.). With construction of 16 weirs and elevation of existing reservoir banks, We can store 1.17 billion $m^3$ of water. Restoration of ecological streams and wetlands for revitalization of natural ecology can Improve Natural Ecology & Promote Eco-tourism. After the completion of the Project, we expect for the minimized damage from potential water disasters like flood so to reduce the waste of budget. And, as the rivers centered, there are more opportunities of lifting up the life quality by creating the cultural spaces contributing people to inspire among nature.

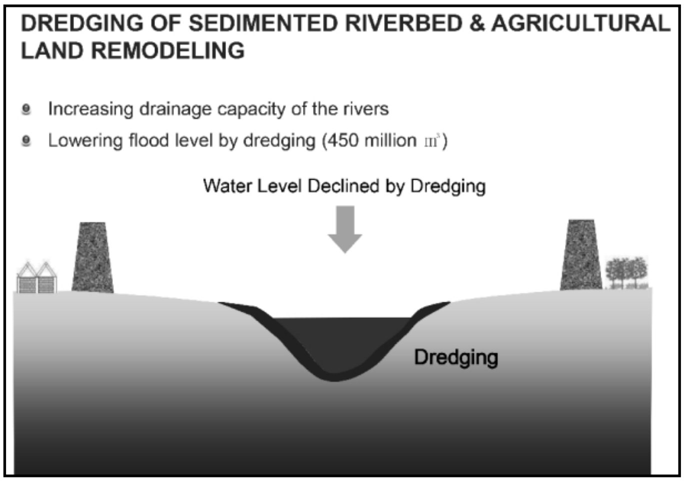



Now, let's me explain the budget and schedule of the project. The total budget of the project was 19.3 billion US dollars. We finished the overall project in 2012 except new dams.

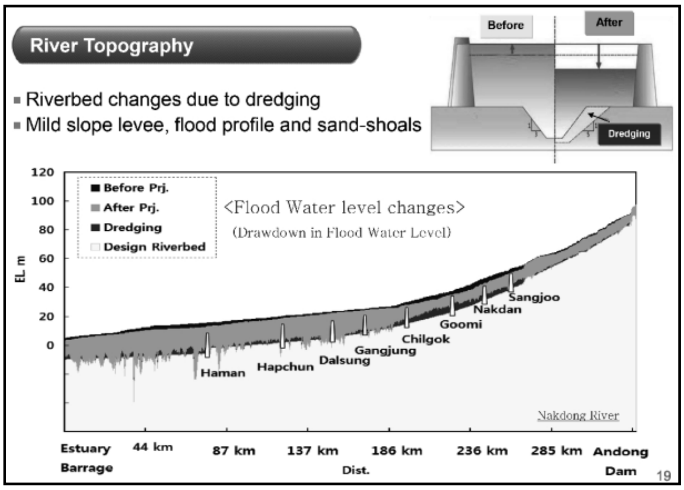



As a comprehensive public project, the project includes a variety of plans submitted by several ministries, but coordinated by the Office of National River Restoration. I was in charge of this project.

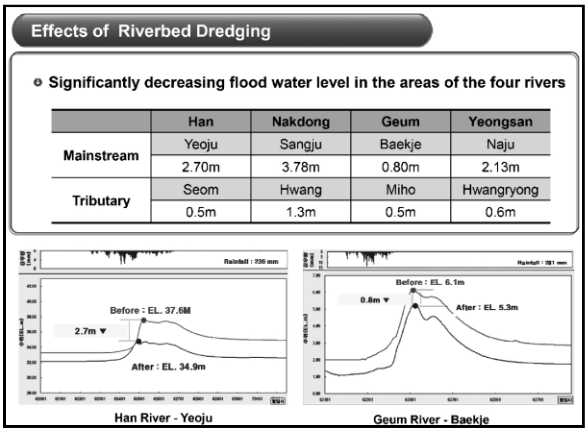
Flood Control



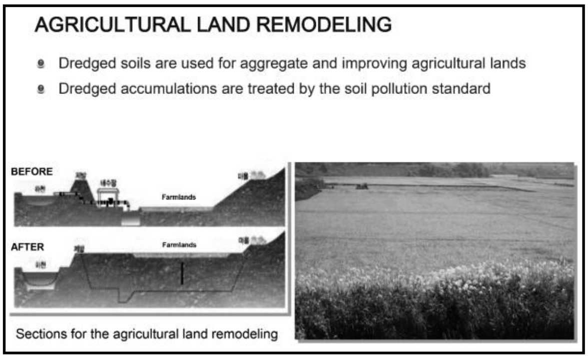

By dredging sediments of the low-flow riverbed, the water flow capacity was increased, and the flood level should be decreased up to the levels of the 200-year flood.



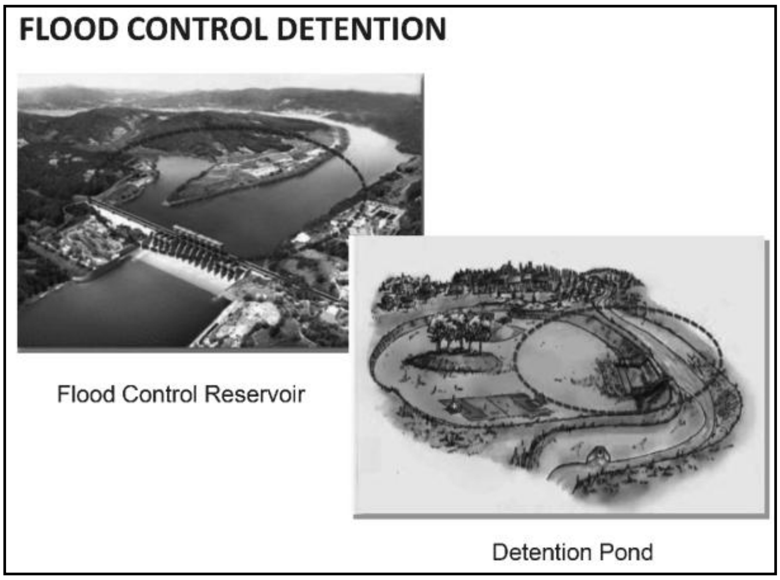
This figure shows river topography. Riverbed was changed due to dredging. Dark blue means flood water level before dredging of riverbed, and light blue shows lowered level after dredging.



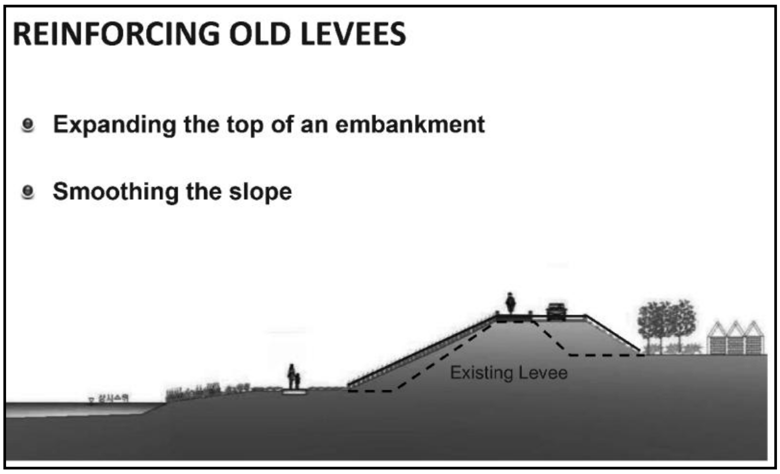

| | | Han | Nakdong | Geum | Yeongsan |
|---|---|---|---|---|---|
| Mainstream | | Yeoju | Sangju | Baekje | Naju |
| | | 2.70m | 3.78m | 0.80m | 2.13m |
| Tributary | | Seom | Hwang | Miho | Hwangryong |
| | | 0.5m | 1.3m | 0.5m | 0.6m |



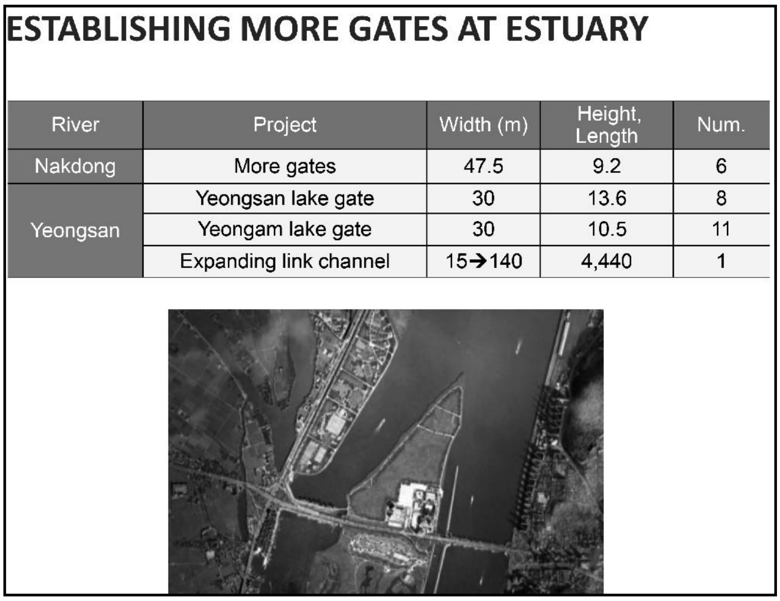

Dredged soils were used for aggregate and improving agricultural lands.




Also, we built flood control reservoirs and retention ponds.

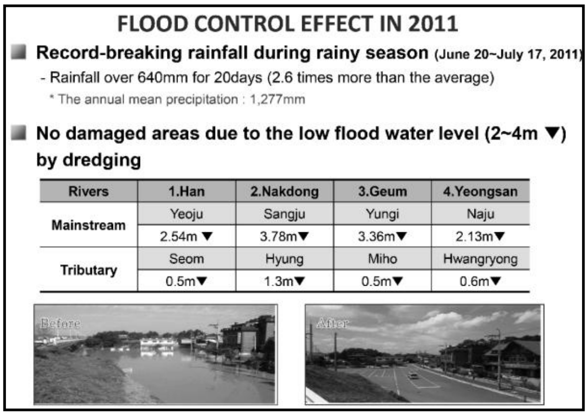



We reinforced old levees with expanding the top of embankment and smoothing the slope.




| River | Project | Width (m) | Height, Length | Num. |
|---|---|---|---|---|
| Nakdong | More gates | 47.5 | 9.2 | 6 |
| Yeongsan | Yeongsan lake gate | 30 | 13.6 | 8 |
| | Yeongam lake gate | 30 | 10.5 | 11 |
| | Expanding link channel | 15→140 | 4,440 | 1 |

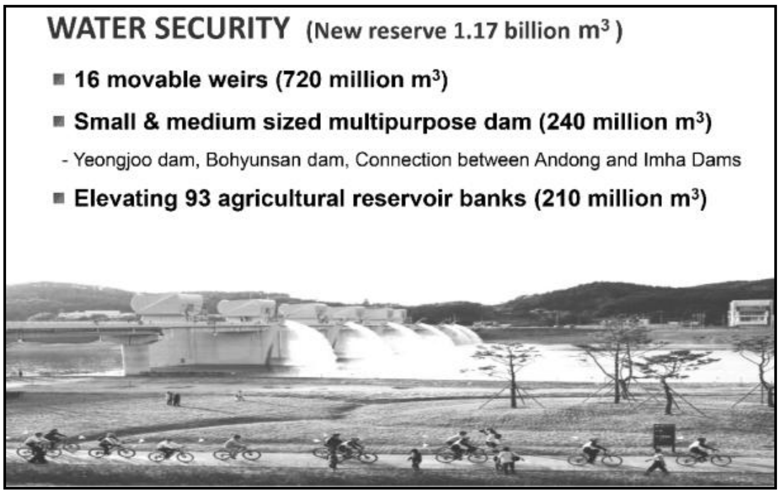
And, more gates were established at the estuary to expand flood control capacity.


| Rivers | | 1.Han | 2.Nakdong | 3.Geum | 4.Yeongsan |
|---|---|---|---|---|---|
| Mainstream | | Yeoju | Sangju | Yungi | Naju |
| | | 2.54m ▼ | 3.78m▼ | 3.36m▼ | 2.13m▼ |
| Tributary | | Seom | Hyung | Miho | Hwangryong |
| | | 0.5m▼ | 1.3m▼ | 0.5m▼ | 0.6m▼ |

These pictures make the comparison of before and after the project.

Safe Water Security

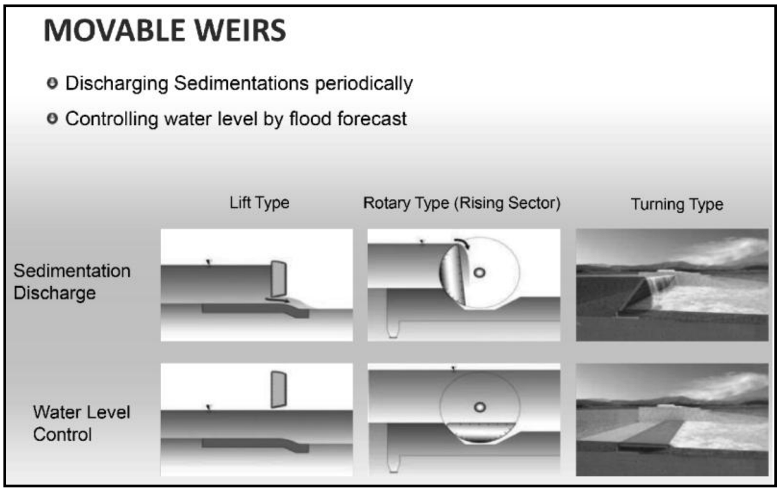



This project secured total 1.17 billion cubic meters of water by constructing 16 weirs, dredging sediment, elevating existing agricultural reservoir banks, and constructing two new dams.

Ipo weir in Han River

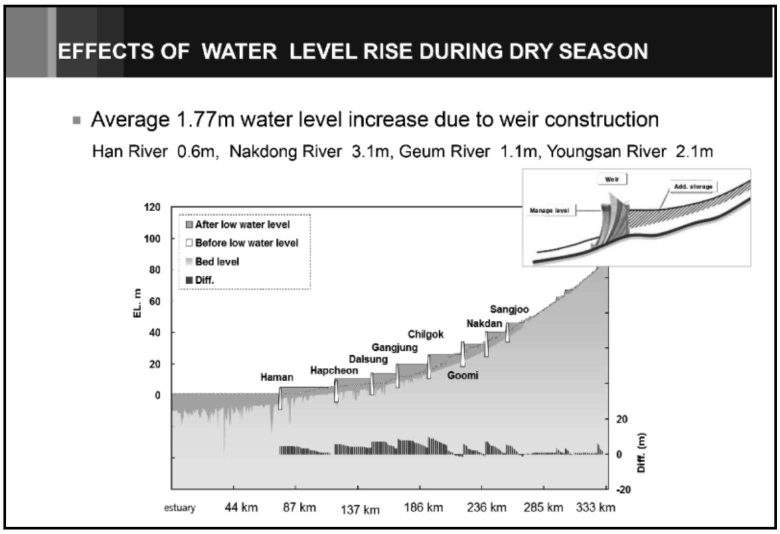
This is Ipo Weir in Han River which is one of 16 weirs. The weir is composed of two parts.

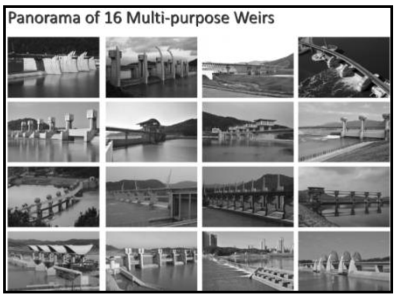
One is a fixed form to maintain water level, and the other is a movable form with gates to prevent floods. The gates will be operated to control water level

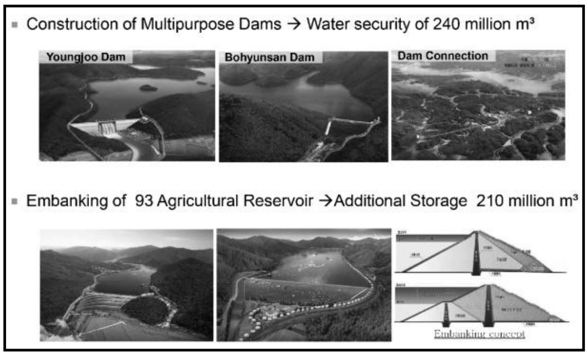


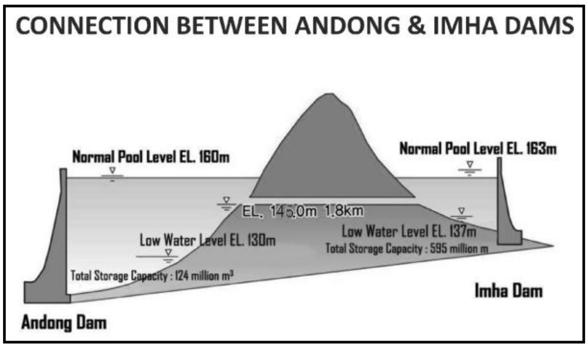

Moreover, the movable weirs are designed to prevent accumulations with cutting-edge water management technology, combined with information technology.

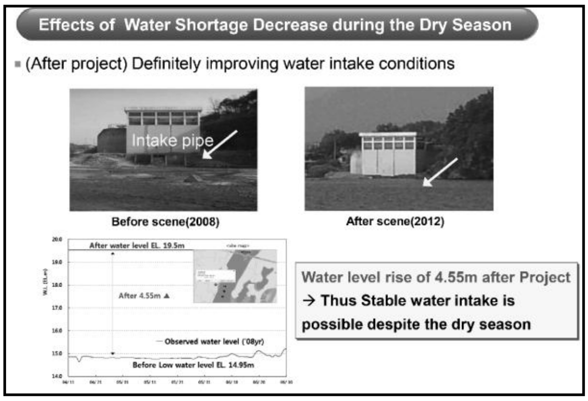
The gates will be opened to discharge water during the flood event, while the gates will be operated to maintain water level during the dry season.

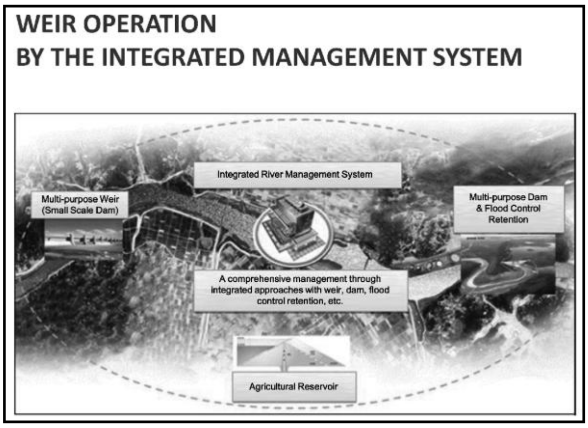




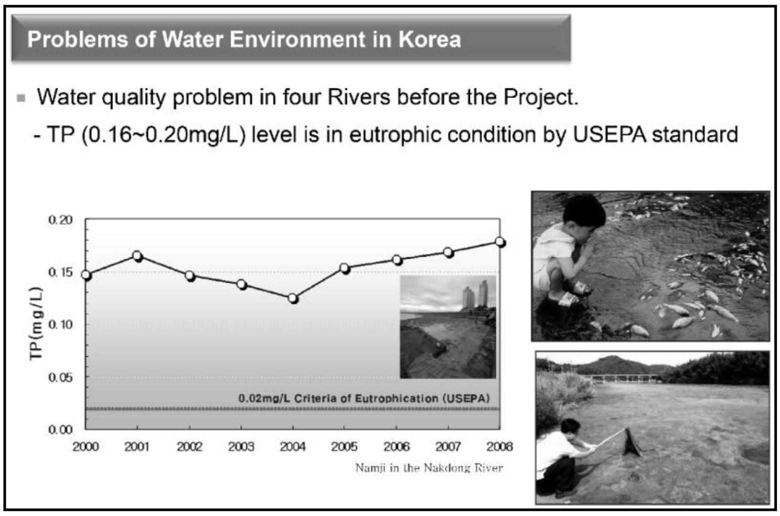



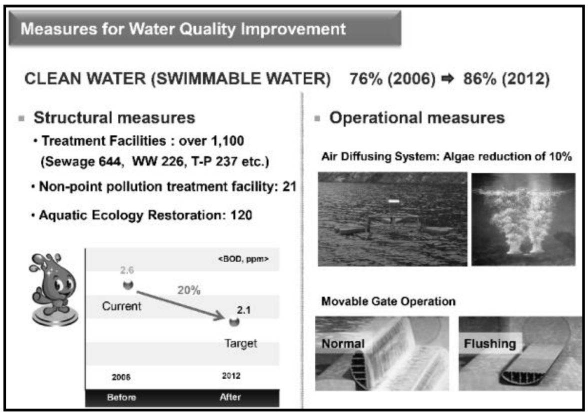




Based on our advanced IT, the Four Rivers will be managed comprehensively by the integrated management system. This system will control weir, dam, floodplain, and agricultural reservoir simultaneously.

Water Quality Improvement

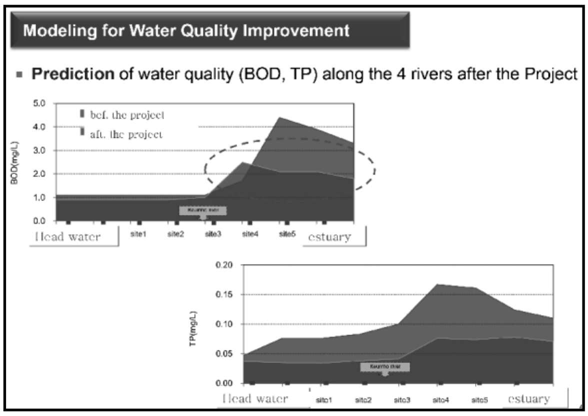


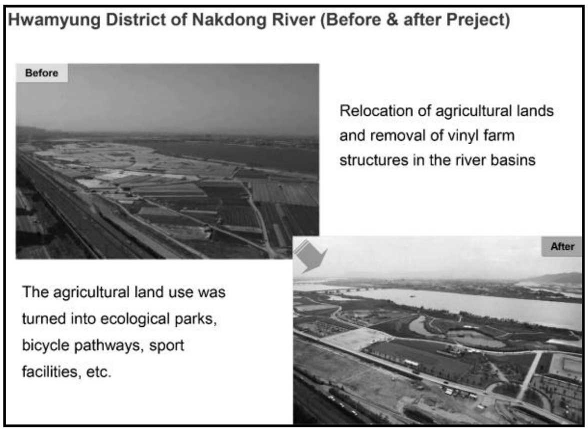

The third task of the project is to improve water quality and restore eco-system




The Project was planned to improve the water quality of mainstream to Level Two with a Biochemical Oxygen Demand (BOD) of less than 3ppm from 76% to 86% by 2012, through reducing non-point pollution source in the river basin and the expansion of 1,100 treatment facilities. There are two ways: one is structural measures, and the other is operational measures. In normal condition, we will close the gate. When the water qualities get worse, we will open it fully and flush the pollutants. (The current water quality in BOD is 2.6 ppm).

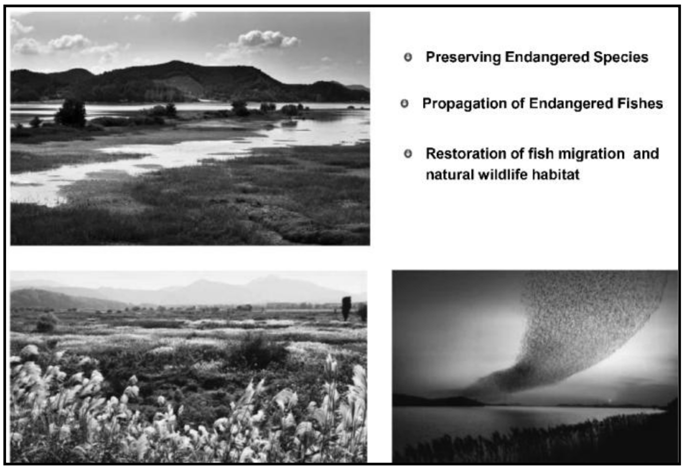
After the project, BOD will be projected to decrease to 2.1 ppm by constructing waste water and non-point pollution treatment plants. For operational measures, we are installing air diffusing system in order to circulate the stagnated water by force. We expect 10% of algae reduction. Also we are installing movable gate to discharge the bottom water and sediment by force, which is susceptible to deterioration of water quality.



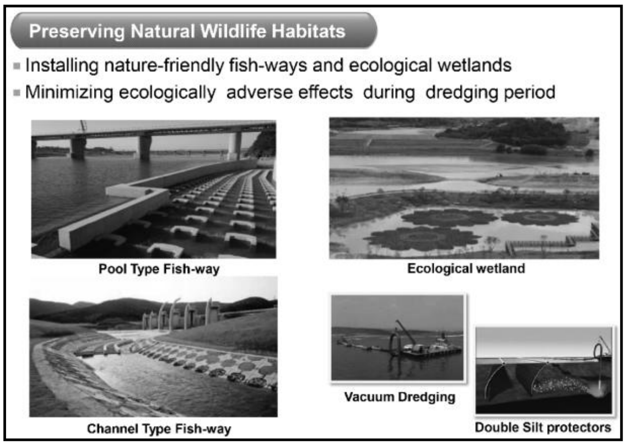



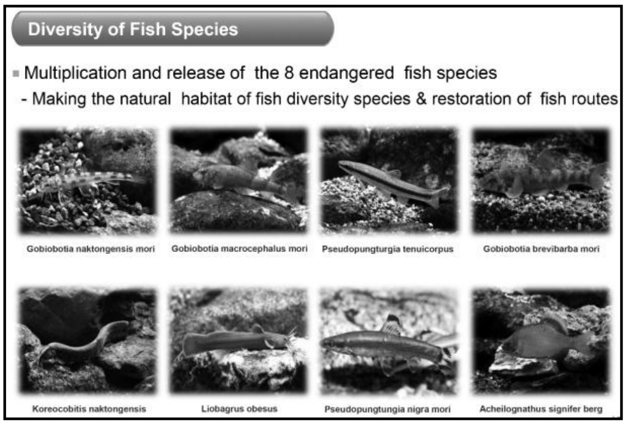

Relocation of agricultural lands and the removal of vinyl farm structures in river basins are preventing the influx of insecticides and fertilizers into the rivers. These areas were turned into an ecological park, bicycle pathways, sport facilities.

Ecological Restoration

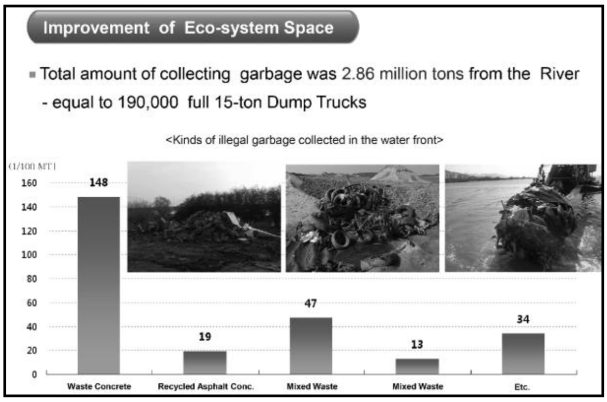



Through this project, total 929km of ecological rivers was restored, 39 ecological wetlands were preserved and restored in the riverside, and 140 local streams were restored.

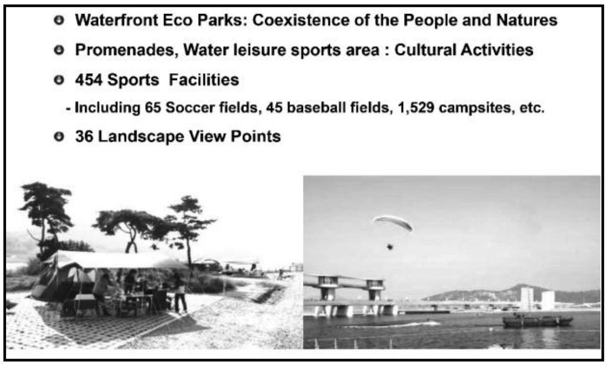


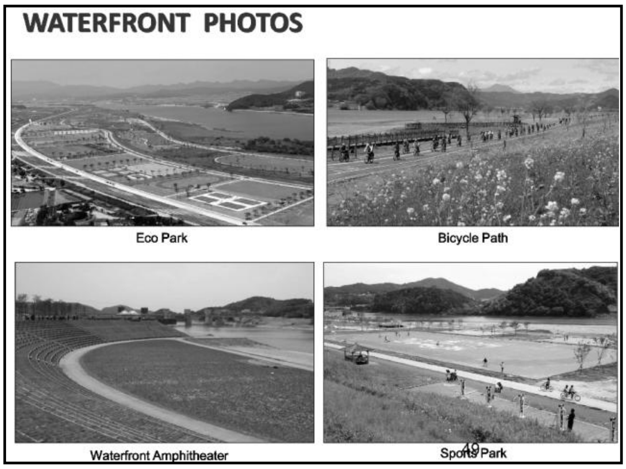

We also preserved endangered species. Currently, we propagated 11 endangered fishery species and restoring fish migration routes in 14 sites with establishing natural wildlife habitat.



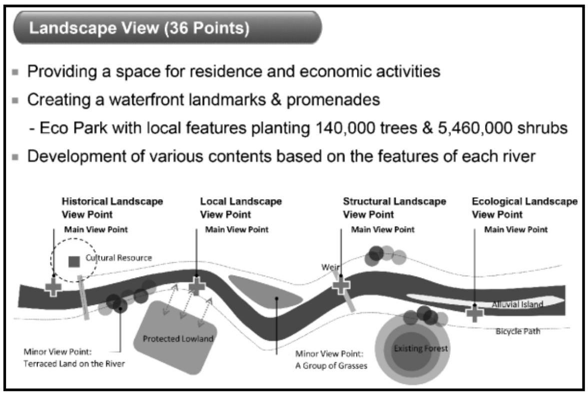

Waterfront Development

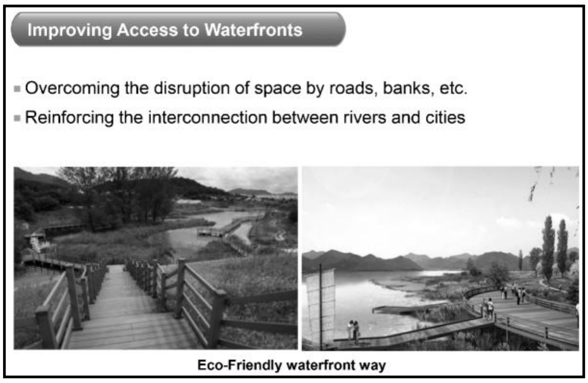


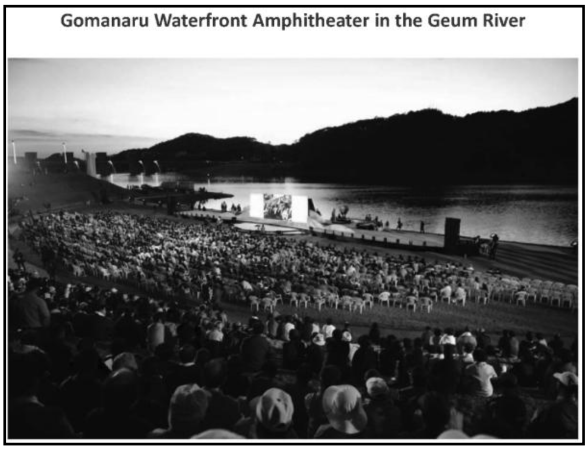
Neglected lands along the rivers was turned into a beautiful, revitalized waterfronts that provide increased access to the water and that enable people to engage in a diversity of cultural and recreational activities that enhance their daily lives.

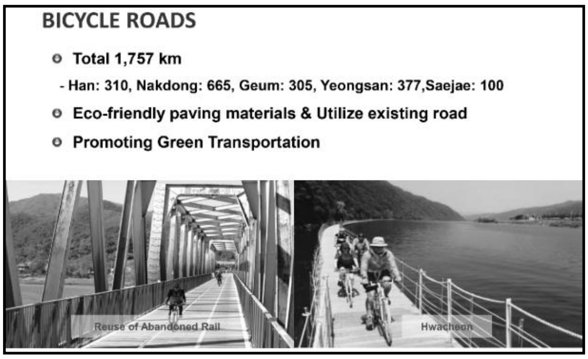



The waterfronts have been revived into multipurpose spaces that bring together lifestyle, leisure, tourism, culture, and economy.



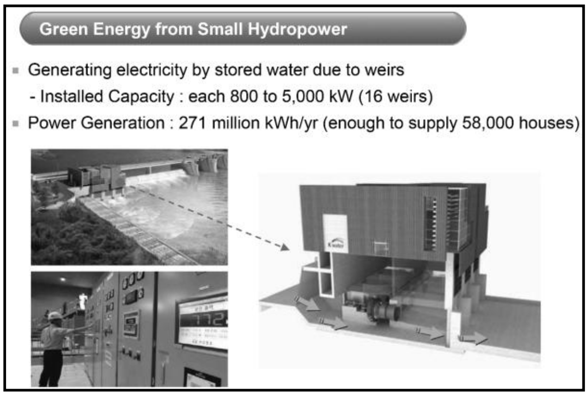



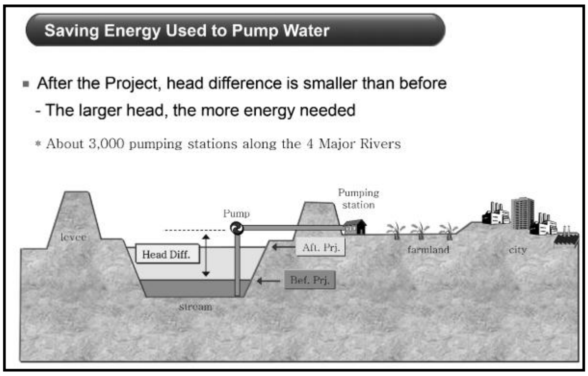




This project includes establishing a network of bicycle paths totalling 1,757km. The bicycle paths will encourage low-carbon, green transportation.




Green Energy




# Make in India in Defence

## Dr G Satheesh Reddy

Scientific Advisor to Raksha Mantri
Ministry of Defence, Government of India

Historically, lack of research and infrastructure facilities made us dependent on imports to a larger extent. But in recent times, India has been making strides towards indigenization in all fields. Stage is set to prove that there is no dearth of entrepreneurship and policy making initiatives in India. Already the pace of manufacturing goods and equipment in India has picked up. Many industries are bringing their own brands into the market and pitting them against the imported brands. The day is not far, India, once regarded as country of imports, will transform itself into a country of net exports. The much needed impetus is given by `Make in India'.

The new Government policies are enabling many foreign firms to start operations and produce their products from India. The response to 'Make in India' call is overwhelming. The manufacturing sector, so far neglected and left to themselves has energized and invigorated.

In this backdrop, manufacturing of defence equipment has acquired special significance. As we all know India is one of the biggest importer of defence products and equipment in the world. Indigenous products are limited to less than 40% of the country's defence needs.

Present Scenario of Defence Production in the Country

The defence production in the country today is mostly dominated by the Govt controlled public sector units. PSUs have significantly contributed towards enhancing self-reliance but still could not fulfill the needs of our Armed Forces. The problem areas plaguing the defence production sector in India needs a critical review for improving self-sufficiency and reducing imports. Some of the visible problems in the defence production units are :

(a) Defence sector is highly technological intensive. All the production units in the country have been producing defence equipment with borrowed technology. Though there have been some wining examples but the efforts on the national scale need to be revamped for enhancing self-reliance.

(b) Due to the control on the defence production by the Govt., the private sector has not matured enough.

(c) The defence orders and volume are not very convincing to private business houses to make a commercial sense.

(d) A scant investment in R&D.

The need of the hour is to evaluate the strengths and weaknesses and work out a plan to better the defence production of the country for self-sufficiency and if needed to earn the much needed foreign exchange through exports.

The large skilled manpower and the knowledge bank in the DPSUs can be harnessed to better efficiency of defence production. Certain defence production assets can be amalgamated with a national planning and self-reliance perspective. The modern management principles need to be adopted in defence PSU by reducing Govt. control and making them govt. owned and privately managed entities. The R&D base at these production entities must be augmented to perform latest in the technology frontier of their respective businesses, bringing in a competitive R&D culture.

Defence Research and Development

Since, 1958 Defence R&D has grown from infancy to be capable to deliver strategic missile systems, EW, Electronics, Naval and complicated platforms such as the Light Combat Aircraft. DRDO has been able to achieve success in some technological frontiers but lot more areas still need to be developed.

Research funding in the defence R&D domain must be increased for garnering more opportunities for basic research to develop niche technologies. As the defence R&D is a high risk high gain business the demand for a larger R&D budget is quite well justified. A typical of 4-7 % is invested in R&D activities by business houses globally with boeing topping the list with 9% of the turnover. If we estimate the need of defence R&D budget in India we can draw cue from the defence expenditure estimates. The estimates pegs the defence R&D estimated to be 30 bn/year hence with industry standards we must be investing two bn/year on R&D activities. The academia must be encouraged to take up defence R&D related research projects to aid fundamental research needs.

The mission mode projects must be treated separately from the technology developmental and science & technology projects, as the mission mode projects would typically have a larger system development expenditure marring the funds not being utilized for basic/fundamental research.

Futuristic R&D in Defence

As our Hon'ble Prime Minister envisaged, India needs to focus on the futuristic technologies to become future world leader. Till now we have been concentrating on many of the technologies which are denied to us. Now, it is the time to identify the futuristic technologies for the next 10-20years and take a lead in the R&D of these technologies. There is a driving need to establish focused research centres in the specific technologies at R&D centres and academic institutes. State of the art infrastructure need to be established at these centres and funded. Innovations at Small and Medium Scale industries should be encouraged and supported. The country needs to have innovative manufacturing institutes with public and private partnership. Also, these technologies must be devised for ultimate exports to earn valuable foreign exchange for the country. Bio-sensors, Photonics, NEMS, MEMS, high energy materials, futuristic power supplies, stealth technologies, advanced materials, high power computing are few such identified areas to be driven with greater pace.

Futuristic R&D is only possible by engaging the scientific manpower appropriately. The mere augmentation of research manpower will heed no results until a research conducive ecosystem is evolved and put in place.

HR and Skill Development

For any organisation, basic strength comes from its human resources for fulfillment of various goals and objectives and the HR has very important role to play in defence sector, where the domain knowledge base is specific to technologies. Country is today void of universities and institutes with curriculum related to the defence science and technologies. The students after completing their graduation with the basic engineering backgrounds like electronics, mechanical, metallurgy, electrical etc straightaway start working on the defence technologies without any formal knowledge and training in these areas. It is essential to design the curriculum with subjects related to the defence and incorporate them in the syllabus of leading institutes in the country to nurture the knowledge base and skill sets.

The second aspect is that the best talent needs to be attracted towards Defence whether it is DRDO or DPSUs or defence related Industries. With concentrated efforts in last few years, many graduates from IITs, NITs and other reputed academic institutes have joined DRDO. The youngsters also need to be encouraged to become entrepreneurs with innovative ideas.

Capacity and capability development

The research eco system must comprise of DRDO, Industry participative R&D labs, academia and DPSUs. More impetus must be on development of first of the kind systems and new technologies. The numbers of patents with the Indian subcontinent is at 1/3 ratio when compared to only Chinese patents, efforts must be made to increase the same to have a global benchmark for defence technologies produced in India.

Non-committal order and a foggy future of business prospects have banned Indian industry to invest in defence related R&D. With a thorough understanding that Make In India is only possible with active industry participation even at the R&D level, we must chalk out a plan for implementation.

Necessary production capabilities with professionalism and quality standards today are a lacuna in the Indian industry setup. A very few oasis of industries created by first generation engineers have supported to an extent to provide niche capabilities. The need of the hour to make the niche capabilities available in a much larger scale. The SME industries must be encouraged to invest in R&D activities after assured business for the investments taken up by them. There is a need to create a framework for industries to involve themselves in innovation whilst being competitive. Steps like ease of financing, preferred partner status will bolster the small industries to take a bold step to inculcate R&D habits in defence related production.

It is evident from the current scenario that R&D institutes are engaged more in Development than in Research and the public sector is fully into production and with the private industries being the suppliers of components and subsystems. Now, the roles are getting redefined; R&D institutes will concentrate largely on Research and the public sector units will be roped in for development and subsequent production, playing a vital role as lead integrators. The private sector will also carry out R&D in specified areas and produce the sub-systems and systems. This will also enable such industries to transform their capabilities to the level of lead integrators.

Today, the private sector already started playing a major role. In last 10 years, the private industries have graduated from mere component producers to a challenging role of developing the state-of-the-art sub systems and systems. For instance, more than 70% of the supplies for Akash missile system are coming from a conglomerate of private industries. Hence, it is evident that the private industry is going through transformation to handle greater challenges. In my view, redefining the roles of the three sectors will bring in more synergy between R&D organizations, DPSUs and private industries.

With the defence requirements in the next decade meeting the $200 bn mark there will be growth in defence expenditure. This will call for high investment in R&D by the Indian industry. The Govt. has made many policies conducive to pave a path for this much needed investment regime in defence production, one policy is allowing 49 % FDI. There are many steps taken by the Govt. in the recent years to improve the R&D horizon for defence manufacturing.

Not but not the least a word of caution must be emphasized that Make In India must not turn to Assemble in India with no IPR and design control and hence exposing ourselves to total dependence to foreign suppliers.

Make in India can be seen as a tool to transform the R&D horizon of the country to new levels of achievement and self-reliance in strategic areas.

# Smart Technologies for Natural Resource Conservation and Sustainable Development

## Mr P M Chacko

Past President
The Institution of Engineers (India)

As I stand before you, my thoughts go back to the early 80s when I attended my first Council Meeting. Dr. Shankar Lal, Director of IIT, Kharagpur was the President. It did not take much time for me to realize that Dr A Bhattacharyya, a former President strode like a colossus in the proceedings and allied activities. It did not take long for us to understand each other, eventually leading to a close and intimate friendship which continued till he suddenly passed away during one of his European visits. Occasions were many when he took me to Jagadal wherefrom the Rural Development Forum functioned. Such visits helped me understand him better and also to learn a lot about the IEI from one of its tallest stalwarts of those days. It is undoubtedly an honour to deliver the Dr A Bhattacharyya Memorial Lecture during the 31st India Engineering Congress and that too in Kolkata, his own place. I am thankful to President Mr H C S Berry for inviting me.

The theme of this Congress will never lose its sheen. Since natural resource conservation and sustainable development are there to stay with undiminishing relevance and answers have to be sought and found through smart technologies, the topic will remain evergreen. Global concern about environmental and developmental issues was perhaps voiced loudly first in the Stockholm Conference in 1972. However, it was some years later that a World Commission on Environment and Development known as the Brundtland Commission came into being. It was through its effort for years that the famous document “Our Common Future” was prepared and presented; and it was through this document that the concept of “Sustainable Development” became known and in due course, accepted internationally. The Rio Earth Summit in 1992 was a follow up activity by the international community and the term “Sustainable Development” got implanted and accepted.

The IEI had the proud privilege of organizing a large international conference on the theme “Energy for Tomorrow's World, Concerns and Issues of Developing Countries” at New Delhi in November 1994, coinciding with the IEI Platinum Jubilee Year activities. The subject was closely allied to the central theme of the Rio Summit. Maurice Strong who was Secretary General of UNCED (United Nations Conference on Environment and Development) as the Rio Summit was known, was an active participant in the New Delhi conference.

A definition of sustainability which I like to recall is that given in a UNEP report of 1991 under the caption “Caring the Earth”, which is as follows “Improving the quality of life within the carrying capacity of supporting ecosystems”. It can be taken as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable development consists essentially of three wide components: environment, society and economy. The fruits of these three are in many areas common and not separate. This being a Congress of Engineers, I am restricting my comments essentially to the first mentioned ie., environment, which itself is such a wide subject. Permit me friends to limit my talk, touching just three aspects viz. quality air to breathe, safe water for drinking as also other essential purposes and control of climate change within bearable limits.

Air

Clean air must be treated as a fundamental right of the citizen. Air Quality Index (AQI) measures the concentration of fine particulate matter (PM 2.5) in the air. For accepting the air quality as good, the value is to be within 50 according to US Environmental Protection Agency. Some areas in the National Capital Region (NCR) of Delhi had values as high as 1000 in the recent past, 20 times the limit of 50. The Hon’ble High Court of Delhi referred to the city as a gas chamber. Power generation units, industries, vehicles, construction activities and cooking are regular contributors. In NCR, there are other contributors from nearby areas of the neighbouring states too.

Average life expectancy in NCR drops by six years due to this one factor alone. Former environment minister is reported to have informed the Parliament that on an average, pollution kills eighty people every day in the national capital, making it a staggering 29,000 plus deaths gasping for breath in one year in NCR. Air pollution in India is not confined to Delhi. A recent WHO report stated that 10 of the 20 most polluted cities of the world are in India. It is reported by a global agency that over 6 lakh Indians lost their lives due to air pollution in 2010.

Bengaluru is our garden city. Cubbon Park spread over 197 acres is one of its main lungs. It used to have joggers aplenty. But people are advised now to use “fogmask” in Cubbon Park or prefer to have their exercises in-doors. Some comparisons may not be out of place. Paris is twice polluted as San Francisco. Beijing is 10 times more polluted than London, whilst New Delhi is twice worse off than Beijing. A study has reported that Kanpur, Ludhiana, Lucknow and Indore are also highly polluted cities in India. In all, 94 cities haven't met Air Quality Standards in 5 years. Analysts have reported the following as five reasons or five 'sins' linked to pollution.

(1) We are not monitoring air quality in real time.

(2) We don't know sources of air pollution.

(3) Governments fail to enforce.

(4) Health risks are ignored.

(5) People aren't pitching in

Let us see how China is tackling air pollution.

(6) Red Alerts

In Dec. 2015, Beijing issued its first pollution “red alert”, closing schools, factories and construction sites. Odd-even bans were ordered for cars etc.

2. Cutting Coal Use

By 2017, Beijing aims to reduce use of coal and by 2020, plans to be coal-free. Across the country, coal use will be brought down to 65% by 2017.

3. Laws

China's Environmental Protection Law came into force on 1st January, 2015.

There is no cap on fines for polluting companies, public interest law suits can be filed by non-shareholders, local authorities can levy fines. local governments are held accountable. An environmental scientist was appointed as Environmental Minister in 2015.

4. Real Time Monitoring

Real time monitoring is strictly followed. All details are made public.

5. Off the Road

High polluting heavy vehicles to be taken off the road by 2017. Large cities are limiting the number of vehicles.

Can India do this? We certainly have to, by making necessary strict laws, and enforcing them. This is a challenge, technological and political, in the immediate future. Improved steps have to be kept going on a continuing basis. Smart Technologies must be resorted to.

Water

A water scientist was explaining the futuristic water scenario. He said ‘I have some good news and some bad news. A few decades from now, the water you get from your tap may be treated effluent discharge’.

One voice from the gathering ‘And what is the good news?’ Reply: ‘That is the good news. The bad news is that even such water won't be available in the required quantity.’

Around the world, approximately 25,000 people die today because of bad water management; the same number will die tomorrow, the day after that and the day after that; says UNEP. We cannot ignore the basic fact that like air, water should also be accepted as a fundamental right of the citizen, and it goes well beyond humans. It is the fundamental right of every living being, from worms to elephants and for vegetation of every kind as also for mother earth for its sustenance. Water is comparable to bloodstream in a living organism.

At the end of the last ice age, 14 thousand years ago, we were ten million people on the earth. At the time of Thomas Malthus, we were roughly one billion. This number had doubled to two billion 130 years later and now we are 7.4 billion with 100 million more humans getting added annually. Demand for fresh water doubles every 21 years. The world population is expected to be around 8.5 billion by 2025. With water availability going down and down due to a variety of reasons globally, in most countries and in the majority of regions, the scene is terrifying. Of the 1.4 billion cubic km of water on earth, only 2.6%, ie, 36 million cubic km alone is fresh water. That is shrinking at a fast rate.

Coming as I do from Kerala, a small state reportedly having 44 rivers, also considered by many within the country and the state to be a water surplus state, permit me to share some details.

A good number of the 44 rivers are not larger than irrigation canals. Most of the rivers lack oxygen, with high levels of chemical pollutants and coliform bacteria present and water quality levels shockingly low. Fertilizers and pesticides used in plenty in the higher reaches naturally get carried down, affecting adversely the water quality available in the lower reaches, which is what the population in villages, towns and cities use for everything including drinking. Worse still is the shocking fact that presence of heavy metals like lead, chromium and nickel has been noticed and that such metals find their way to human bodies through the fish they consume.

Periyar, the longest river in Kerala (224 km) is referred to as the 'Lifeline of Kerala'. But in a few decades, the river which nurtured Kerala for generations is likely to be choked to death.

Some related facts are listed.

1. Water even when it looks clear is not clean. Even watertreatment does not remove colourless toxins.

2. Rules of the Pollution Control Board are not strict enough to take care of all aspects. Worse still is the fact that even such inadequate rules are violated with impunity by the industries, nor does the PCB carry out proper checks.

3. The pollution intensity has substantially increased due to the reduced water flow.

(The North East monsoon this year has been less than average by 61.9% according to the Meteorological Department).

Linked to the thoughts indicated, may I invite the attention of this august audience to the Rainsar Convention and related facts. The Convention's mission was the conservation and wise use of wetlands through local and national actions and international cooperation as a contribution towards achieving sustainable development throughout the world. At the core of the Ramsar philosophy is the “wise use concept” defined as “the maintenance of their ecological character achieved through the implementation of ecosystem approaches within the context of sustainable development”.

The Ramsar sites in India include three from Kerala viz. Vembanad, Ashtamudi and Sasthamcottah. I belong to the Vembanad Lake periphery and hence I may be pardoned to give some details thereof.

1. As against 36,000 hectares in the mid 19th century, the lake is only around 11000 hectares now. The depth which was about 7 m on the average has come down to less than 2.5 m now. The water storage has dwindled to almost one tenth as compared to mid 19th century.
2. If there were less than a dozen House-Boats in 1990, there may be around 900 or more now.
3. The main problems faced by the lake are (i) pollution (ii) unauthorized filling (iii) silting (iv) accumulation of wastes with a high percentage of plastics etc.
4. The paddy fields upstream use chemical fertilizers and pesticides in plenty which finally find their way into the lake waters.
5. The motor boats cause oil spills and droppage of untreated human waste.
6. The lake had over 150 species of fish which has now dwindled to just a few. There is substantial reduction in availability of fish and clam-shell.
7. Bio-diversity in general has been reduced drastically,
8. Despite being declared a Ramsar lake in 2002, proper follow up steps have not been taken to protect the same.
9. Failure to take effective steps expeditiously will lead to ecological disaster, including gradual extinction of the lake with a series of shockingly serious consequences.

The governmental authorities will do well to consider and implement as many of the following suggestions for a water security plan.

1. Discourage use of pesticides.
2. Stop disposal of solid waste into river and other water bodies.
3. Put an end to indiscriminate sand mining in rivers.
4. Ensure that the forest cover, particularly in the upper terrain does not get reduced.
5. Saline water intrusion into rivers / water-bodies should be prevented.
6. Disposal of industrial, hospital, hotel, slaughter-house wastes into rivers etc. must be stopped.
7. Adopt rain water-harvesting on a major scale wherever feasible.
8. Carry out all possible measures to ensure maximum quantity of surface water flows maintaining a minimum required quality level.

9. In view of the importance of water availability in relation to developmental needs and even sustenance, all necessary steps are to be initiated and carried on with full vigour and seriousness to avoid what otherwise could lead to a disaster.

The water scenario in the rest of India may not be identical, but problems of somewhat similar nature exist everywhere. Action is called for on a war footing now using all smart technologies available and new technologies developed to fulfil our basic duty to the coming generations.

Climate Change

Climate change is a change in the statistical distribution of weather patterns, when that change lasts for an extended period of time (i.e. decades to millions of years). Climate change may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions (i.e. more or fewer extreme weather events). Climate change is caused by factors such as biotic processes, variations in solar radiation received by earth, plate tectonics and volcanic eruptions. Certain human activities have also been identified as significant causes of recent climate change, often referred to as “global warming”.

Of the 7.4 billion people on this plant, around 1.5 billion live in varying conditions of poverty. A symptom of the disorder is deterioration of land quality world-wide. A quarter of the earth's agricultural land is already degraded, mainly through overuse or cutting down of the trees that protect it and help rainfall percolate into the ground. Scientific surveys have identified two billion hectares of degraded and deforested land worldwide.

Then, there are changes in the chemistry of the atmosphere. Acidification, which is mostly local in character can be partially remedied with political will and corrective action. Ozone depletion has global consequences. It increases inspite of international agreements leading to increased ultra-violet B radiation. But more important than the danger of increasing human melanomas is the potential effect on other organisms from vegetation and crops to phytoplankton in the ocean.

Global development will have to continue at a faster pace than hitherto, particularly in the less developed countries (LDCs). It is difficult, as of now, to achieve this without use of fossil fuels, leading naturally to higher Greenhouse Gas (GHG) emissions. The ecosystem simply cannot afford to continue receiving emissions at increased levels. This is the dilemma that the world is facing 25% of the global population used to consume over 75% of natural resources. The general position is that developed countries (DCs) have upto 8 times per capita consumption rates of natural resources compared to less developed countries (LDCs). The pattern is unsustainable and needs to be analysed in the proper perspective and corrective steps taken.

Similar to consumption of resources, 25% population are responsible for 75% emissions. Further, Chlorofluoro Carbons (CFCs) are substantially emitted by DCs. It is thus very clear that the global warming as is happening now as also the ozone depletion are essentially created by the DCs with 25% population or less.

Environmental scientists and others who studied the subject related to $CO_2$ and other anthropogenic emissions had been warning the international community of the need for reducing emissions. Whilst their voice received attention by and large, some powerful parties scoffed at the very suggestion of climate change possibility. United Nation Framework Convention on Climate Change (UNFCCC) was supposed to do the needful. Meetings of governmental representative were often held, referred to as Conference of Parties (COP). The Developed Countries were mostly evading the main issues. May I take you to COP 21 held in Paris in 2015, which must be fresh in our minds.

In Paris, small island states and many less developed countries o desired to set the temperature increase limit to 1.5 C. It requires a o lot more effort than the more widely supported 2 C. The DCs will need to pump in more supporting finance and take very quick and effective action in transfer of technology.

A British Scientist, Naomi Klein said that the positives of the Paris deal included putting some bold goals in writing, even though the language included “wriggle room and technofixes like ocean fertilization”. She said that the targets set in the INDC (Intended Nationally Determined Contributions), the very heart of the Paris agreement, add up to a 3-4 degree increase in global warming, a far cry from the 1.5 degree target cap and the countries have said they will meet every 5 years to discuss details. She commented the outcome in Paris as “politically ambitious but scientifically catastrophic”.

The then Indian Environment Minister Mr. Prakash Javadekar told the West during COP 21 that they must vacate carbon space to give room for developing countries. There was indication that the INDCs based on voluntary pledges would lead to 2.7°C global temperature rise. The Minister indicated that India proposed a seven fold rise in renewable power capacity after which coal consumption in India will come down substantially.

In this setting, it is topical to recall what the Cochin International Airports Ltd (CIAL), a PPP organization has achieved in the field of energy generation. A solar unit was commissioned with 12 MWp in 2015, which, with the already existing 1.1 MWp plant raised the total to 13.1 MWp. This was showcased at the round table meeting of Renewable energy at San Jose, USA which was chaired by our Hon'ble Prime Minister during September 2015. There has been a subsequent addition of 2.4 MWp unit taking the total as of now to 15.5 MWp. Steps have already been initiated to increase the capacity to 30 MWp from the present 15.5 MWp. Incidentally CIAL is the only airport in the world as of now to depend fully on self-generated solar power. With the completion of the expansion projects in hand, the daily generation of green energy at CIAL will be approximately 1.18 lakh units (KWh). This will avoid CO2 emissions by more than 7.20 lakh tonnes over the next 25 years which is equivalent to planting 70 lakh trees or not driving 1800 million miles.

I am delighted to inform my friends of yet another interesting green activity in Cochin. A trial run was taken by a solar powered boat in the backwaters of Cochin on November 25, 2016 with seventy passengers. The boat could run for six hours, with an average speed of 7.5 nautical miles per hour. When it starts its regular service run next month, it will be the first in India; yet another path-breaking step in the green energy scenario of the country.

Linked to this, may I refer to a news item which appeared in the Times of India dated September 7, 2016 attributed to Hon'ble. Union Minister Nithin Gadkari that "India will soon be zero petroleum import country". I hope you will all join me in sending our good wishes to the minister and hoping that his words will turn prophetic soon.

Whilst COP 21 at Paris (2015) received a lot of media attention, related reporting was minimal for COP 22 at Marrakech (2016). Paris decisions were reiterated; but many gaps remain to be filled. Though developed countries renewed their promises (no legal commitments!) to raising $100 billion a year in climate funding by 2020; no new money was pledged at Marrakech. Without adequate financing and transfer of clean energy technologies to developing nations, the Paris agreement will flounder. However, a few bright spots cannot be ignored. A group of 48 countries including some poor nations committed themselves to become zero carbon societies by 2050. The Framework Agreement of the International Solar Alliance launched by India to promote solar energy was opened for signing in COP 22.

Given that 2016 is slated to become the hottest year on record with o parts of the Arctic now 20 C above normal that is akin to 50 mid November day time temperature in Delhi – no one can afford to take climate change lightly, or get away with a casual comment that climate change is a hoax. The nations have to meet again for COP 23, finalise plans to raise more money than the $100 billion planned earlier to be raised annually, earlier than 2020 and also make serious plans for transfer of relevant technology to developing nations. There has to be a shift on the part of developed countries from Intended Nationally Determined Contribution of a nonbinding nature to legally binding larger contributions, to save the planet from major climate change.

Limiting the comments to environment, and further limiting the concerns to Air, Water and Climate Change, it is obvious that the engineers have a tremendous lot to do. When a lot is heard through politicians and almost nothing through engineers, I am reminded of the saying "working steam is not heard; it is the escaping steam which makes noise". When scientists and engineers are compared, I am reminded of yet another saying "Scientists study the world as it is, engineers create the world that never has been".

An encouraging comment I read recently regarding rapid changes in technology says: "To a world reeling under consequences of environmental degradation, there came a report regarding a welcome break-through, development of a bacteria that not only degrades water pollutants, but even effectively helps recovery, demonstrating that in response to rapid changes in world ecology, technology too is moving fast", yet another with headlines "Nuclear-waste batteries that will last for more than 5000 years" using a process that does not involve emissions and requiring no maintenance either. The life time of these batteries could revolutionise the powering of devices over long time scales. Engineers have to be ever innovative. New approaches, skills and greater speed are needed. In short SMART technologies have to be resorted to in every conceivable way for National Resource Conservation and Sustainable Development.

Jai Hind.

*P.S:*

*Given hereunder is copy of a report which appeared in The Institution of Civil Engineers, London, February 1995 issue, which is self-explanatory. $ 100 billion per year proposed to be raised by the developed countries for passing on to developing countries in addition to transfer of appropriate technology included in COP 21 Paris deal (2015) and repeated at Marrakech COP 22 (2016) is in effect a modified version of my suggestion placed before the international community as reflected in the report. Having done some studies on the subject, I feel that "tradeable permits of emission quotas" would have been much more beneficial to a less developed country like India with high population density. First, COP 21 pledge of the individual DCs regarding raising $100 billion annually is not binding. Second, it is scheduled to become effective, only 2020 onwards.*

# Environmental Challenges and Technological Development in Water and Industrial Wastewater Treatment – Indian & Asian Scenario

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Abstract

The ground and surface water resources in many locations in and around polluting industries such as textile, chemical, pharma leather tanneries, etc. contain high Total Dissolved Solids (TDS) and not fit for domestic and industrial use. Conventional treatment system reduces the Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids (SS), heavy metals etc. and not TDS and salinity which are mainly contributed by chlorides, hardness and sulphates.

There is not much scope in mixing the treated industrial effluent with domestic sewage to achieve the TDS level in many locations in the absence of organized sewage treatment plants of required capacity. Many industries are located in the land locked areas and there are constraints to discharge the treated effluent with high TDS.

The TDS limit is being enforced in India and other parts of the World depending upon the final mode of disposal. In addition to the removal of TDS in the treated effluent, it is necessary to recover water for reuse to meet the challenge of water shortage. Different types of units such as Micro Filter (MF), Ultra Filtration (UF), Membrane Bio-Reactor (MBR), Nano Filtration (NF), Reverse Osmosis (RO) etc. have been developed for recovery of water from saline ground water, Sea water and domestic/industrial wastewater with high TDS. Management of the concentrated saline stream RO system seems to be one of the major issues in land locked areas. This technical paper deals with environmental challenges and technological development in domestic and industrial wastewater treatment and management in Asian Countries.

Keywords : Industrial effluent, Membrane system, Environmental, Wastewater

## Introduction

The conventional physiochemical and biological treatment systems designed and implemented only reduces the Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids (SS), heavy metals etc. and not TDS and salinity which are mainly contributed by chlorides, hardness and sulphates. Due to inherent quality of wastewater from many polluting industries, the treatment plants are unable to meet the prescribed standards in terms of TDS, chlorides and salinity in the treated effluent.

There is not much scope in mixing the treated industrial effluent with domestic sewage to achieve the TDS level in many locations in Asia in the absence of organized sewage treatment plants of required capacity. Many industries are located in the land locked areas and there are constraints to discharge the treated effluent with high TDS in the Sea.

The TDS limit is being enforced in India and other parts of the World depending upon the final mode of disposal. In addition to the removal of TDS in the treated effluent, it is necessary to recover water for reuse to meet the challenge of water shortage. In many states in India, the pollution control authorities insist on water recovery integrated with Zero Liquid Discharge (ZLD) system. Different types of units such as Micro Filter (MF), Ultra Filtration (UF), Membrane Bio-Reactor (MBR), Nano Filtration (NF), Reverse Osmosis (RO) etc. have been developed for recovery of water from saline ground water, Sea water and domestic / industrial wastewater with high TDS. However, the achievement of Zero Liquid Discharge concept has got many technical challenges in addition to the application of various types of membrane systems. Management of the concentrated saline stream treatment by adopting energy intensive evaporation system seems to be one of the major issues in land locked areas. The marine disposal of saline reject from membrane system with high TDS over and above 40,000mg/l requires special development and provisions to safeguard the aquatic life.

## Treatment Technologies for Salinity and TDS Management

For recovery of quality water from industrial and domestic wastewater with high TDS, the required treatment steps are (i) Conventional physiochemical and biological effluent treatment systems to reduce BOD, COD, SS etc. and (ii) Tertiary treatment systems including, micro-filter, low pressure membrane units such as ultra-filtration etc., before the application of single or multiple stage Reverse Osmosis (RO) system.

Fig. 1 – Elevated receiving Chamber cum Pre-settler in CETP – First of its kind

The number of stages and types of RO system are based upon the TDS concentration in the feed water, estimated percentage of quality water recovery and reduction in volume of saline reject. High pressure Sea water membrane is adopted for handling treated effluent with TDS concentration more than 10,000 mg/l. The quality water recovery rate could be achieved to the level of 70 to 90% depending upon the feed water TDS level, type and stages of membrane system etc. In addition to recovery and reuse of quality water by the industry, the additional benefits are savings in chemical usage in the tanning process and reduction in pollution load in the effluent. The reject saline stream from RO system needs to be managed by adopting the options of forced / thermal evaporation system or disposal into Sea wherever feasible with suitable control.

Many full scale membrane systems have been installed for recovery of water from domestic and industrial wastewater with capacities ranging from 100 to 20000m3/day. RO System Linked With Membrane Bio-reactor (MBR) Membrane Bio-Reactor (MBR) is a low pressure membrane unit integrated with aeration unit. It requires continuous recirculation cum backwash facility. MBR replaces the secondary clarifier and sophisticated tertiary treatment units prior to RO system. MBR system is developed using ultra filtration type membranes with high recirculation provision in the aeration unit along with bio-mass to maintain required mixed liquor suspended solids (MLSS).

MBR system is commonly adopted in many countries to remove the residual BOD, suspended solids / coliform, etc. from the effluent. After treatment with MBR, the water is applied through RO system for removal of TDS and salinity to get drinkable quality water with TDS less than 500mg/l. A Common Effluent Treatment Plant (CETP) in Spain with MBR and RO system for water recovery was established in 2005. Recent times many CETPs in India have adopted MBR and other membrane system for water recovery and reuse from the industrial effluent. After MBR / UF treatment, the suspended solids and BOD values in the effluent are below detectable level and taken for treatment with RO system for recovery of water after the removal of TDS and salinity.

In China also water is becoming a scarce commodity in many locations. Expansion of high water consuming industries is allowed only if they are provided with water recovery system in the effluent treatment plants. To recover water from the tannery wastewater, submerged MBR linked with activated biological treatment is provided in the first stage. Following MBR system an RO plant in “Christmas Tree” configuration has been installed and operated at 12–16 bars. The RO plant produces about 70% permeate and 30% concentrate. The quality of the recovered water meets the drinking water standards. The saline water concentrate stream is further treated with Fenton process before disposal. A view of the submersible MBR in one of the industrial effluent treatment plants in China is shown in Figure 2.

Fig. 2 – Submerged Membrane Bioreactor

The Nano Filtration (NF) is adopted for removal of colour and salts such as sulphates from the treated effluent after ultra filtration or MBR stage. Nano-filtration membranes are operated under low pressure with high yield of about 90%. Adopting NF will improve the efficiency of RO in water recovery and to decrease the volume of saline reject.

Residual Saline Stream Management

The disposal of the concentrated saline stream from the membrane system is one of the important issues to be addressed in land locked areas. The conventional method for disposal of saline stream is to adopt open solar evaporation pans. The average evaporation rate in solar pans ranges from 4 mm to 6 mm depending on the locations. These evaporation pans occupy large land area. The sprinkling system linked with solar warming developed under UNIDO assisted programme improves the evaporation rate by 300%. However, the spreading of aero salt from the sprinklers is one of the limiting factors. To overcome the problems, a forced evaporation system in a closed unit is designed, developed and implemented as a demonstration unit. This system improves the evaporation rate of saline stream by about 800%. Condensed saline stream is discharged in the solar pan and the dried salt is collected periodically. Multiple stage evaporators using thermal and electrical power have been installed for evaporation of the reject saline stream from RO system. The process flow diagram of the forced evaporation system is shown in Figure 3.

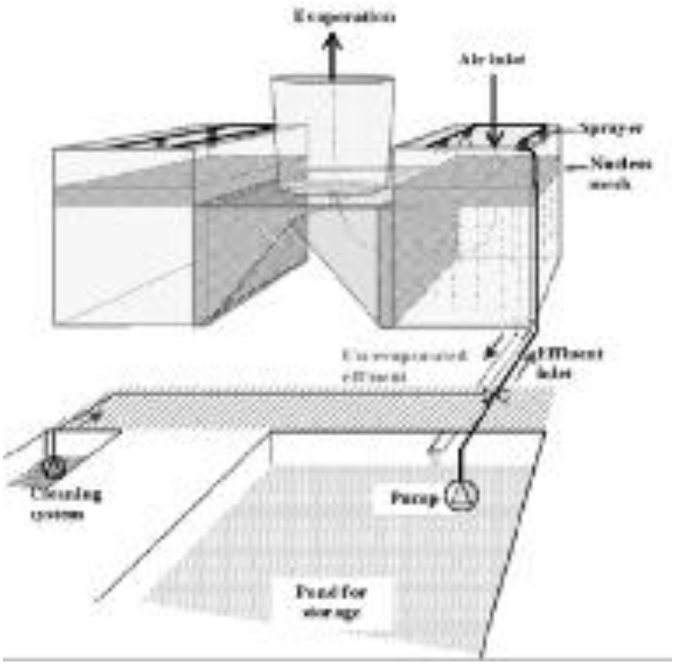


Fig. 3 - Forced Evaporation System

However, there are many technical issues such as constrains in continuous operation of the system, meeting the required quality of the condensate water from the evaporator for reuse, management / utilization of the recovered salt with impurities etc., The capital and operational costs are also high. Further techno economical review and modified options are required on the sustainability of the system particularly in land locked areas.

Marine Disposal of Treated Saline Streams

A novel technological development has been made for the drawl of Seawater of 30,000m3/day from nearby Sea for the desalination plant integrated with a major industrial complex in South India. Out of the total water quantity, freshwater of about 10,000m3/day will be generated and the remaining 20,000m3/day will be discharged into Bay of Bengal with special bio-control and dispersion system to safe guard the aquatic life. The industrial complex will be using the freshwater generated by desalination plant for its process requirements and 9,000m3/day wastewater will be treated, mixed with saline reject of the desalination plant, stored in a water tight pond for a capacity of about 10 days and discharged into the Sea by laying 5 km pipeline using high pressure HDPE pipe and special sprinkling system. The combined treated saline stream with a quantity of about 29,000m3/day will be discharged once in a week under the overall control of environmental protection authorities.

With the support of many National Institutes and other organizations, model studies were carried out in finalizing the novel marine outfall. The spreading of an effluent cloud released in a marine environment is governed by advection caused by large scale water movements and diffusion caused by comparatively small scale random and irregular movements without causing any net transport of water. Hence, the important physical properties governing the rate of dilution of an effluent cloud in coastal waters are bathymetry, tides, currents, circulation and stratification.

A five port diffuser systems with 0.18 m diameter is planned with a jet velocity of 2.5 m/sec, for the release of treated effluents and reject water from the proposed desalination plant. The Environmental Clearance (EC) has been accorded to this unique integrated project with water recovery using desalination process, industrial wastewater treatment, novel and safe saline reject disposal into Sea without affecting the marine life which is first of its kind in India.

Recent Technological Developments in Asian Countries The recent developments in cleaner production and waste management in Asian and other selected countries are given below.

BANGLADESH : The main industrial cluster in Bangladesh is located in Dhaka city. Tanneries introduced cleaner technologies and chrome recovery system etc. with the support of UNIDO. The other industrial units from the Dhaka city are being relocated in a newly developed industrial estate with Common Effluent Treatment Plant (CETP) of 30MLD capacity.

CHINA : There are many newly developed industrial clusters in China. Till now, about 13 CETPs are in operation, some more are under planning. Planned to reduce the volume of water usage and pollution load at source through cleaner production programme. The tanneries and other industries are permitted to expand the capacity without increase in the water usage. One of the major industrial unit has implemented the MBR and RO system for water recovery and reuse.

Fig. 4 - A Self Cleaning Screen and Biological treatment in a CETP

As such there is no specific restriction on the Total Dissolved Solids (TDS) or salinity norms for the disposal of treated effluent. However meeting the BOD, COD norms for the saline streams from RO is one of the issues being addressed by new technological development.

INDIA : Zero Liquid Discharge concepts by adopting membrane system for recovery of water from industrial effluent have been implemented mainly in the South India with huge industries. A biggest CETP in Asia with a capacity of 48,000m3/day (48 MLD) for 450 industrial unit is being planned with a budget of about 60 million USD in Kanpur city.

Disposal of the saline stream from membrane units in land locked areas is one of the unresolved technical challenges. Decentralized secured landfill system linked with CETPs for industrial sector had been implemented in many clusters

Fig. 5 - UASB system with Bio-Energy generation from a CETP in India

(First of its kind in the World). R&D activities on bio processing are under progress.

ITALY : Total aerobic biological oxidation system without the use of chemical is adopted in major CETPs for reduction of COD and sludge generation. Thermal treatment of sludge, energy generation from volatile organic matter and overall sludge management are followed. Central chrome and other chemical recovery and reuse system are being adopted in many industrial clusters.

Fig. 6 – Aerobic oxidation using diffused aeration in Italy

ROMANIA : Cleaner Production programmes are being carried out with the co-operation of INCDTP / ICPI, Institutions COTANCE etc. in Romania. Using Media and Conference to promote the importance and image of environment protection activities.


Fig. 7 : ICAMS 2016 – Romania

RUSSIAN FEDERATION : Many institutions such as Department of Leather and Fur Technology. Water Recourses and Commodity Research, East Siberia State University of Technology and Management, Ulan-Ude, Russia and other industrial organizations promote technological development and environmental protection in industrial sector.

Fig. 8 - LAKE BAIKAL – EAST SIBERIA 25% of World's Quality Water – Preserved without Pollution

TAIWAN : Many industrial units are having individual treatment plants with capacities ranging from 300 m3–2000 m3/day. They adopt conventional physiochemical and biological treatment systems.

Fig. 9 – Elevated aerobic biological treatment system

TURKEY : There are about large number of polluting industries including tanneries, textiles are existing in 14 zones. Eight Common Effluent Treatment Plants (CETPs) have been established and are in operation. The biggest CETP with a capacity of 36,000m3/day is in Tuzla near Istanbul. The other major industrial cluster is in Izmir with an integrated CETP. Many polluting industrial units had resettled in industrial zones.

Fig. 10 CETP in Istanbul (Tuzla), Turkey with Sea discharge

R&D activities on cleaner production and environmental protection are being continued in universities such as EGE University, Izmir etc. Sludge disposal is a major problem similar to other countries.

Observations and Suggestions

Recovery and reuse of quality water from domestic and industrial waste has become a reality. The membrane system has been widely adopted for different applications for water recovery from domestic and industrial wastewater. It has become mandatory to achieve the zero liquid discharge in many states in India and resulted in development of many innovative treatment technologies to suit the local conditions. The review of options and long term planning for the disposal of saline stream from land locked areas is necessary.

The sustainability of the small-scale units is becoming a serious issue to meet the environmental requirements. Major investments are being made for environmental protection and resettlement of industries from the urban areas to the industrial parks with common effluent treatment plants. New regulations and restrictions such as REACH on the use of certain chemicals, salinity and water recovery under zero discharge concepts, disposal/management of chrome containing sludge etc. envisage continued Research & Development activity. Innovative industries processes which will greatly reduce the water and chemical usage and minimize solid waste generation are needed together with overall environmental planning and management.

Acknowledgement

- The contributions of Asian International Union of Environment (AIUE) Commission with 30 representatives from 20 countries, UNIDO, European Union are acknowledged.
- Acknowledgment is made for technical support by UNIDO, Vienna and Regional programme for South Asia. The contributions of CSIR-CLRI Environmental Technology Dept. Scientists are greatly acknowledged.
- Acknowledgement is made for the various industrial associations of Asian countries, Govt. of India for the technological development and implementation of Common Effluent Treatment Plants (CETPs), Membrane system for water recovery, etc.

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