Three Dimensional approach to Energy Independence

Address at Energy Technology Conclave "Technology for Sustainability"

By Dr.APJ Abdulkalam [New Delhi, 13/Mar/2008]

Technology can lead to non-linear growth

I am indeed delighted to participate in Energy Technology Conclave with the theme "Technology for Sustainability" organized by India Energy Forum in partnership with other energy organizations. I greet the organizers, policy makers, teams in energy sector, technical institutions, researchers and energy experts from India and abroad participating in this conclave. Since I am in the midst of energy experts, I thought of sharing with you one scientific and technological area that is important for national development. That is energy independence. When many talk about energy security, I am emphasizing that we should work for Energy Independence. What does it mean? It means freedom from fossil fuel and lead India towards sustainable clean green energy and environment. The topic I have selected for discussion today is **"Three Dimensional approach to Energy Independence".**

Leading to Energy Independence

When we analyze the critical problems facing the planet earth today, three important issues come to our minds. First one is the continuous depletion of fossil-material-derived oil, gas and coal reserves as predicted by World Energy Forum. The second one is the continuous degradation of environment primarily due to extensive use of fossil materials for generating energy. Third is the continuous rise of cost of crude. I have been studying the price pattern of standard crude oil over the last five years. From under $25 per barrel in September 2003, the oil is now quoting at $110 per barrel. We are not only paying for the cost of fuel, but also paying for the continuous environmental degradation. The solution to these problems is achieving energy independence. Let us discuss.

Energy Independence - A Perspective: India has 17% of the world's population, but only about 0.8% of the world's known oil and natural gas resources. Based on the progress visualized for the nation during the next two decades, the power generating capacity has to increase to 400,000 MW by the year 2030 from the current 130,000 MW in India. This takes into consideration of energy economies planned and the design and production of energy efficient equipments and systems. Energy independence has got to be achieved through three different sources namely renewable energy (solar, wind apart from hydro power), electrical power from nuclear energy and bio-fuel for the transportation sector.

The hydel capacity generated through normal water sources and inter-linking of rivers is expected to contribute an additional 50,000 MW. Large scale solar energy farms of hundreds of megawatts capacity in certain number could contribute around 55,000 MW. The nuclear power plants should have a target of 50,000 MW of power. Atleast 64,000 MW of electrical power should come from wind energy. The balance 51,000 MW has to be generated through the conventional thermal plants through coal and gas and other

renewable sources of energy such as Biomass, Power through municipal waste and solar thermal power. The most significant aspect, however would be that the power generated through renewable energy technologies has to be increased to 28% against the present 5%. Let me discuss about the profile of renewable energy systems. Firstly I would like to talk to you on Solar Energy.

Solar Energy

Solar energy in particular has the potential for massive applications in the agricultural sector, where farmers need electricity exclusively in the daytime. This could be the primary demand driver for solar energy. Our farmers demand for electric power today is significantly high, which makes solar energy economical due to its large scale. Shortages of water, both for drinking and farming operations, can be met by large-scale seawater desalination and pumping inland using solar energy, supplemented by bio-fuels wherever necessary.

We need to embark on a programme in solar energy systems and technologies, for both large, centralized applications as well as small, decentralized requirements concurrently, for applications in both rural and urban areas. The key to success of this programme is the development of high efficiency photo voltaic cell using carbon nano tubes and solar thermal power plants.

Carbon Nano Tube (CNT) based solar cells for higher efficiency: The low efficiency of conventional Photo Voltaic (PV) cells has restricted the use of solar cells, for large power generation application. Research has shown that the Gallium Arsenide (GaAs) based PV cell with multi junction device could give maximum efficiency of less than 30%. Hence it is essential to accelerate the research tasks on Carbon Nano Tube (CNT) based PV cell which has the potential for higher level of efficiency.

The CNTs provide better electron ballistic transport property along its axis with high current density capacity on the surface of the solar cell without much loss. Higher electrical conductivity and mechanical strength of CNT could improve the quantum efficiency to the order of 35%. But, this is not sufficient. Recent research has shown that the alignment of the CNT with the polymer composites substrate is the key issue and this aligned CNT based PV cells would give very high efficiency in photovoltaic conversion. The polymer composites increase contact area for better charge transfer and energy conversion. In this process, the researchers could achieve the efficiency of about 50% at the laboratory scale. Our scientists have to take up this challenge and come up with the development of a CNT based PV cell with an efficiency of at least 50% within the next three years so that it can go into the commercial production within five years. In addition, they can also take up the development of organic solar cells, dye-sensitized solar cells and third generation solar cells. There are lots of opportunities for research in fundamental science in this area and I would like to see these opportunities used by a wider spectrum of our Universities and Research Laboratories in a coherent, consorted way with a mission mode programme. During my visit to US in October 2007, I have seen quality CNT being produced in large scale at Rice University and high efficiency photo voltaic cell with CNT-polymer combination and also using tioxide (Titanium di-oxide) being produced in the Arkansas University laboratory. In India, CNT is now being produced at DMSRDE (Defence Materials and Stores Research & Development establishment) Kanpur. Now let me discuss about the wind energy.

Wind Energy

The experts have estimated that the potential of wind energy in India is around 45,000 MW. Studies must be launched to explore other potential sources such as off-shore wind farms, especially, since India has over 7000 km long coastlines. It may also be necessary to apply advanced techniques in wind velocity measurement and relating it to available electrical out put. We need to standardize the wind turbine power plants to realise the cost reduction due to economies in the scale. Also research and development is required for reducing the

investment per MW through improved designs and application of newer technologies. The generation cost at presently is between Rs.2.5 to Rs.3.5 per unit depending upon the site. Research is required to bring down this cost to Rs.1.00 per unit based on improved designs and maintenance free systems. In islands and remote areas autonomous wind generating units should be established if the site has the wind potential. Feasibility studies have to be conducted to determine economic sizes of wind energy plants which can be used for lifting water from 30 meter level and serve the needs of farmers having small holdings in a region with an average wind speed of 8 to 10 km per hour. Integrated actions on all these areas should enable realization of 64,000 MW of electric power from wind energy sources from the present generating capacity of 7000 MW. Let me now discuss with you on the power generation through nuclear energy.

Nuclear Energy

The present nuclear power capacity which is around 3900 MW is expected to go to 7160 MW by 2012 with the completion of nine reactors which are now in progress. Eventually as per present plan of BARC and Nuclear Power Corporation the capacity by 2020 is expected to be increased to 24,000 MW (By the end of 12th Plan – overall nuclear power – 18160MW) There is a need to plan right from now to increase this capacity to 50,000 MW by 2030 through uranium and thorium route.

Nuclear power generation has been given a thrust by the use of uranium-based fuel. However to meet the increased needs of nuclear power generation, it is essential to pursue the development of nuclear power using Thorium, reserves of which are higher in the country. Technology development has to be accelerated for Thorium based reactors. Thorium is a non-fissile material. For conversion of Thorium and maximizing its utilization development of Fast Breeder Reactor has been rightly taken up. Building the thorium based reactors require participation of multiple research institutions. Researchers assembled here can work with department of Atomic Energy and draw a detailed road map for research which can accelerate the process of establishing thorium based power plants.

As the transportation sector in India consumes about 90% of the total available oil (Imported and indigenous), I would like to discuss the possible energy option and actions in the sector.

Energy in Transportation Sector

The Transportation sector in India is the fastest growing energy consumer. We import nearly $ 54 billion (Rs.2,20,000 crore) of oil annually and this bill is continuously increasing. Our indigenous oil production meets only 25% of our total requirement. Hence, there is an urgent need to find alternative fuels and energy sources since the cost of crude oil has already touched $110 per barrel and the trend shows that there will be further increase. One of the promising areas for the country is production of bio-fuels in the case of transportation.

Use of Biofuel: We had a Bio-diesel Conference towards Energy Independence in Rashtrapati Nilayam, Hyderabad on 9th and 10th June 2006, where all the stakeholders (farmers, entrepreneurs, marketing agencies, researchers, policy makers and NGOs) actively participated. The conference suggested the following mission mode actions.

(i) Realizing the production of 60 million tonnes of bio-diesel per annum by 2030 (this would be 20% of anticipated oil consumption in 2030).
(ii) As a first step towards reaching this target, a coordinated plan for achieving 6 million tonnes production by 2010 which would be 5% of the present import of oil.
(iii) To improve through research, the productivity of seed and extraction techniques and expand the area under bio-diesel crops towards achieving 30 million tonnes oil by 2020 and

60 million tonnes by 2030.

For realizing the above, we need to concentrate on following research and development activities.

Research, Development and Production of Jatropha Plantation

India's waste land (63 million hectares) is spread in different regions with different climatic conditions and also falls in the category of rain fed or irrigated land. To cater to this variety of soil and climatic conditions research is required to determine the particular plant variety which will give the maximum yield of Jatropha seeds for a given soil condition and the maximum yield of oil from that particular seed. Also research is required to find varieties of species and hybrids which will start yielding Jatropha seeds early within a year and higher yield of oil content per plant. Based on this research seed farm or stem farm are required to be created for each state and the selected proven seedlings or seed must be provided to the farmers including the know-how on the number of plants and pattern to be used per hectare, preparation of soil prior to plantation and the right time of planting the seeds. Later, farmers should also be advised to use the right type of fertilizers and organic pesticides including trimming methodology and the periodicity. Also farmer should be given advice on friendly intercropping plants which can co-exist with Jatropha and provide enhanced revenue to the farmers. Finally it has to result in establishing number of high yield Jatropha seed banks in the country. Our oil PSUs have successfully carried out blending studies in ethanol and bio diesel and today, the entire petrol sold has 5% blending of ethanol. Nation has to implement the Ethanol policy based on Brazil model. Presently, over 354,000 hectares are under Jatropha cultivation which is likely to increase by 250,000 hectares every year. There is a need to increase the rate at which additional waste land is being brought under Jatropha cultivation.

Crushing and Esterification:
Tamilnadu agricultural university and Anand Agriculture University have developed small sized bio-fuel plants and technology is available for 600 liter per day production. There is need to scale up this plant further and produce standardized plant in the range one to five tonnes per day capacity for installation in different regions. Also there is a need to identify plant manufacturers who can produce quality standardized plants in different regions across the country and also undertake trouble free maintenance of the plant. Oil PSUs should undertake indigenous design and production of cost effective, high efficiency, seed processing, crushing and esterification plants for commercial availability including exports. Specialization of oil companies in building oil refineries can lead to the establishment of high efficiency esterification plants for bio-diesel.

Efforts in this direction will help the industry with fabrication of plants and increased industrial activity leading to employment potential for the skilled technicians and engineers. At the same time energy intensive industries like sugar, distilleries, cement plants, power plants and the like will also be benefited with alternate fuel availability for their full or part of operation requirements at economical costs thus reducing the import burden of oil.

Automobile Manufacturers:
While we are taking fast action to produce large quantity of bio-diesel and ethanol, the automobile companies in partnership with oil marketing companies have to work on developing automobile power plant and other systems using 100% bio-fuel. Simultaneously, action is required to work on increasing the cetane number and octane number of bio-diesel and ethanol using molecular engineering methods.

Conclusion

The energy scene in the 21st century is going to see a major shift. Very soon, oil and gas will see its finiteness. It is high time that we realize this factor and work towards the fuel of

the future. I suggest that the energy researchers should re-align their research and development contribution for generating commercially viable technologies for Solar energy, Wind energy and Nuclear energy power plants and production of Bio-fuels both ethanol and bio-diesel sufficient to substitute at least 20% of the fossil fuel. Work is also required for developing emulsified fuels which could enable further saving of 25% fuel. I would suggest this Energy Technology Conclave to submit comprehensive recommendations for leading India to become energy independent by the year 2030 for discussion and approval by both Houses of the Parliament as Energy Independence Bill.

My best wishes to all the participants of Energy Technology Conclave success in their mission of realizing sustainable technologies for energy system of the future which will lead us to energy independence by the year 2030.

May God bless you.

Dr. APJ Abdul Kalam,
13 March 2008.