TOWARDS OUR SAFE AND SECURE ENERGY FUTURE

Dr. Anil Kakodkar

FORUM
OF FREE ENTERPRISE

"Free Enterprise was born with man and shall survive as long as man survives".

- A. D. **Shroff**
Founder-President
Forum of Free Enterprise

INTRODUCTION

Dr. Anil Kakodkar, Eminent Nuclear Scientist, presented a panoramic view of the country's energy scenario, both current and projected up to 2025 and beyond, while delivering the 44th A.D. Shroff Memorial Lecture in Mumbai on 27th October, 2010. He stressed that to sustain 9% plus GDP growth for the next few decades, combined with growing energy intensity, the country's total requirements will have to grow over 10- folds in the next 20 years at the current rate of consumption.

India's per capita power consumption currently is woefully low, 650 KWH, which is way below that of even most emerging countries. He pointed out that 5000 KWH per capita consumption was the desired norm for assuring a reasonably comfortable standard of living. Hence it would be best to pitch at a modest level of say 2000 KWH per capita in the next two decades. To achieve this target the generating capacity will have to be augmented over 20 times.

Currently about 65% of the country's power generation is met through thermal sources. India has the largest reserves of coal and which at the current level of consumption could last for over a century. However, assuming our attaining 2000 KWH per capita consumption in the next 20 years, the reserves would run out in 15 years. Dr. Kakodkar then dealt with various options before the country – nuclear, solar, wind and bio- mass – and their feasibility.

However due to serious constraints, especially land, combined with serious environmental issues, the best long term option before India, was nuclear energy, which contributes only 3% of our total requirements presently.

Energy security is critical. To sustain a high rate of growth, we have to do our best to step up nuclear generating capacity. This would require updating and including more modern

technology, exploring global resources for supply of uranium (of which the country has very limited reserves) and placing greater thrust of R & D work to exploit our huge thorium resources.

Fortunately, we have a band of exceptional scientists. They have relentlessly pursued alternate routes which are likely to be available through indigenous raw material sources. Fast breeder reactors and those using our vast thorium resources are well within the capabilities of our scientists to develop.

Thrust of R & D in the nuclear arena deserves government's top action, as also diplomacy at high levels with leading nuclear powers to procure advanced technology as also vital raw materials.

The lecture was delivered well before the Fukushima incident. The March 11 catastrophe has rightly created serious concerns globally. The Japanese Ambassador to India at a recent public meeting drew pointed attention that Japan has no other viable option save going in for nuclear plants in view of paucity of coal and oil resources. The Fukushima plant has equipment which is 40 years old and since then technology has improved significantly. Japan, which presently derives 29% of its electric power through nuclear sources has had no incidents in the last 50 years.

Further according to the announcement made by a Senior Japanese Government Official, Japan will maintain atomic power as a major part of its energy policy despite the Fukushima incident. It went on further to add that the Government has no plans to shut down any more nuclear reactors.

India's position is somewhat better regards alternate sources for generation of power, but not too good even in the medium term. Hence while safety considerations are of paramount importance, India has to take a hard look before rejecting or even delaying Jaitapur and other nuclear projects phased as we are with serious deficiency in power generation.

India has now come to be accepted as a dependable member of the global nuclear fraternity. The speaker exuded great enthusiasm in the possibility of India stepping up its nuclear power capacity at least ten-fold in the next two to three decades and thus putting energy security on a firmer footing.

This booklet is a fascinating analysis of India's energy scenario. The facts and figures revealed can be invaluable source of information on the subject. For students of India's energy it makes compelling reading.

Mumbai
10th May 2011

Minoo R. Shroff
President
Forum of Free Enterprise

TOWARDS OUR SAFE AND SECURE ENERGY FUTURE

by

Dr. Anil Kakodkar*

We have all heard about Mr. Ardeshir Shroff. He has left a mark in the world of Economics, in the world of Banking, in the world of business. He championed Free Enterprise and worked for it throughout his life. I read somewhere that he did believe in National Planning but not to the extent that it stifled individual initiative and enterprise. I think, this is a very important point, particularly in today's context, when we are at a point in our national development where we are exploring pathways to rapid growth in economy with greater inclusivity covering all strata of the society. So actually, we are in a way, trying to do two difficult things simultaneously. I would thus like to dedicate this lecture to this philosophy propagated by Mr. A.D.Shroff.

* *The text is based on the 44th A. D. Shroff Memorial Lecture delivered in Mumbai on 27th October 2010. The author, eminent scientist and formerly Chairman, Atomic Energy Commission and Secretary, Department of Atomic Energy, Govt. of India, is presently the DAE Homi Bhabha Chair Professor at the Bhabha Atomic Research Centre, Mumbai.*

I come from the field of energy, more particularly, Nuclear Energy. Energy is crucial to development. However as is the case with many other things, we are now beginning to face serious questions related to sustainability of energy resources as well as the climate change. I therefore thought I should talk about the energy situation not just as we see it today or tomorrow but rather talk in the context of a much longer time horizon. I want to do so because most of the times we get trapped in the problems of present, which are by themselves very difficult and we have to deal with them, however, in the process, we cannot compromise on the needs and interests of generations to come. We have to prepare for our future following a new path. That preparation has to start now before it is too late.

As India rises up on its rapid economic growth path, we need to secure energy resources that are necessary to support the growth in economy and help us bridge our development deficit. Further we need to secure energy resources to sustain us and our future generations for a long time into the future and most importantly be able to do so without harming the environment and disturbing the climate. This is a question of our very survival in the present day very competitive, selfish and unkind world. As we go on, you will see that more of the same is not going to be of any help as far as India's energy future is concerned. And so we need to prepare ourselves for such a future and that's the core theme of whatever I have to say.

To develop a perspective for this purpose, let's look at some numbers – the numbers in terms of population, the annual electricity generation, emission of carbon dioxide and per capita electricity availability (see Table).

When you look at these numbers in the context of the world as a whole, in the context of the advanced countries in the world such as the OECD group of countries which have a per capita GDP beyond a particular threshold and the rest - the developing countries, the disparities are quite apparent. The non-OECD countries which roughly constitute 516th of the world population, have to live with just around 40% of the total electricity production. For supporting a reasonable standard of living, many experts have concluded that something like 5000 kWh per capita is a reasonable number. So what will be the scenario if the non-OECD countries raise their average consumption to 5000 kWh per capita from existing 1500 kWh per capita? (In OECD it is already a way above that, at 9000kWh per capita). It would mean that the

	World	OECD	Non-OECD
Population (Pillions)	6.7	1.18	5.52
Annual Electricity Generation (trillion kWh)	18.8	10.6	8.2
Carbon-di-oxide Emission (billion tons/yr)	30	13	17
Annual av. per capita Electricity (kWh)	~2800	'9000	~1500

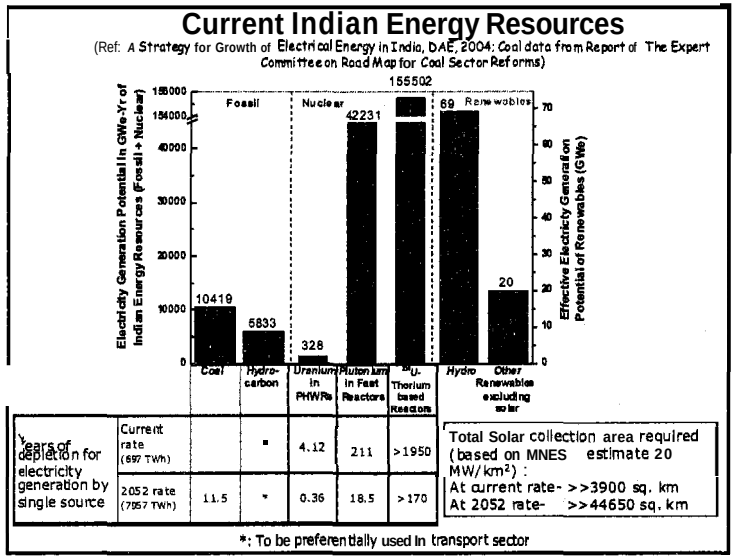
Additional annual electricity generation needed just to reach 5000 kWh average per-capita electricity (necessary for a reasonable standard of living) in non-OECD countries would amount to ~20 trillion kWh that is roughly equal to present total generation. India alone would need around 40% of present global electricity generation to be added to reach 5000 kWh per capita.

world electricity production would have to double. Today it is at around 18.8 trillion kWh. You have to add another 20 trillion kWh to the global electricity production. While finding the required energy resources for electricity production at this level is in itself a big challenge, what about its effect on global warming? While per capita carbon-di-oxide emission from the developing world would still remain lower than the corresponding figure for the OECD countries, the total CO_2 emission would in fact double. Development aspirations of developing countries are thus under a serious dual challenge of access to energy resources as well as the carbon space. How do we get over this problem?

Seeing purely in our context, if India reaches 5000 kWh per capita, which it should, because after all, that is our right – right to development; if that happens, India alone would require additional electricity that would constitute 40% of the present total world electricity production. This would amount to a tenfold increase in our electricity production. We thus have to cope up with a much bigger challenge even as compared to other developing countries, even China. This is because per capita electricity consumption in China is much higher than ours. Our population is large and the development gap that we have to bridge is much larger in comparative terms. What then is the resolution? Certainly if we have to reach fruits of development to all our countrymen, we need to produce such large quantum of electricity. We need to do so without adding too much to carbon-di-oxide emission into the atmosphere. We have to realize this recognizing the ground reality today, that is, most of our electricity generation is based on coal, which is almost 65% of the total electricity production.

Now let's take a look at the energy resources that we have in India (see Figure). We should look at our resources in the context of 5000 kWh per capita consumption. If we organize ourselves well this may happen in three or four decades from now. Hopefully our population would have stabilized by then, may be at around 1.6 billion people Our annual electricity consumption at that time would work out to around 7000 terrawatts, ten times larger than the present 700 terrawatts. In order to be able to assess the energy resources that we have in India, in the figure, I have plotted all available energy resources with a common unit of Gigawatt-electric-year. This allows us a quick comparison between them and also enables us to assess how long a particular source would last. Seen in these terms, you will find that our resources are rather small. For meeting the entire requirements at the level of 5000 kWh per capita annual consumption, coal would last around 11 years, hydro carbon would appear insignificant and would not be able to meet the needs of even transportation sector, uranium in once through mode of usage can last only few months and even with re-cycle, uranium can be stretched to around 18 years, not much. So you find that of all the non-renewable sources, thorium is the only one which can last you for a reasonable time, around 170 years. Tomorrow when fusion energy becomes a reality we could realise energy security for long time into the future. On the renewable energy front, again you will find that on this scale of energy use, except solar energy, all other renewable energy sources including hydro appear small. One would need to earmark around 45,000 sq. km area to collect the required quantum of solar energy to meet these

needs. We also need to take into account the fact that the sun does not shine all the time and so you would have to supplement solar energy with other large enough energy source and that is why I say that solar and thorium are the only two main energy sources that we can bank on for the present.



It so turns out that both these sources are nearly free from carbon-di-oxide emission and would allow us to also realize the transition to carbon free energy scene. That should be our goal. Till we reach there we have to depend on full utilization of all available renewable and non-renewable energy resources simply because our energy needs are growing very fast and we must find ways and means to cope with them to sustain our development process.

Realization of full potential of solar and thorium energy both represent major technological challenges. In case of solar technology, we have to bring the cost down so that it is commercially competitive without the need to subsidize it. Can we produce thorium energy on a large scale today? The answer is "no". There also we need to develop relevant technologies. Luckily Dr. Bhaba visualized the importance of thorium right since the beginning of our atomic energy program and he launched the famous three stage nuclear power development program, so that we develop capability to reach a stage where we can make use of thorium on a scale that the country would require. Many of you must have heard of the three stage program. Stated simply, you begin with thermal reactors using uranium from the nature, go to fast reactors using recycle of uranium and plutonium recovered from the used fuel in the first stage. This system enables us to enhance the power generation capacity through self breeding of plutonium without the need for any further fresh uranium. The difference between a thermal reactor and fast reactor is that the uranium that we have in the country today while it would support 10,000 megawatts of generation in PHWRs, fast reactors would enable growth of generation capacity to a level some 20 to 50 times higher utilizing the same uranium after it has been used once in PHWRs. This multiplier that can be brought about without having to depend on any additional uranium is the key to India's energy independence.

Thus the crucial point that we need to recognize is that unless we attain the domestic capability of bringing in a multiplier through fast reactors and of course later with thorium, we would be in a trap – trap of permanent

dependence on import of energy from outside. Also, it is not as if import to meet our needs would always be possible. Energy at the level large enough to meet our needs may not even be available. Even if it does, the price could become prohibitively large. We must therefore develop the technological capability to set up large capacity in fast reactors and in thorium reactors in a commercially successful manner and bring to bear this capability on our domestic resources as well as on whatever nuclear energy we may import. This is the only assured way of realizing true energy independence in a reasonable timeframe. Even in case of solar energy we need to get our act together to develop the requisite technologies. But that I will reserve that for some other day.

We have done rather well in terms of development of necessary nuclear technologies within the country. We are now recognized to be a country with advanced nuclear technology. This recognition has not come simply. It has come because our thermal reactors have demonstrated world class performance and they have been so recognized internationally. Our reactors have received global awards and the people who manned these reactors have been awarded on a global platform. With respect to fast reactors we are among few countries, one of the two countries as a matter of fact, which are globally advanced in this technology. Other people would now like to benefit in respect of this technology from India. You can see the tables slowly turning. As far as thorium is concerned, we are globally unique and even there you will find that this will become an attractive proposition for the world at large at some stage. I will explain that later.

Let's now look at the Indian electricity scenario as it is likely to evolve between now and 2050. Based on the detailed analysis of the electricity requirement in the country and optimistic contribution that can be brought about from all available energy sources, – hydro, non conventional, coal, hydro-carbons, and the three stage indigenous nuclear development program; it appears that there would be a sustained 25%-30% gap between the requirement and availability throughout this period. The only way you can bridge that gap today, is by import of energy. By middle of the century, by the year 2050, one would need to import something equivalent to about 1.6 billion tons of coal annually to bridge the deficit of around 400 Gigawatts or 400,000 Megawatts. Now I think you are all from the world of business, you will understand what it means in terms of money, what it means in terms of infrastructure and what it means in terms of impact on other segments of economy if the infrastructure gets choked on handling of coal imports on this scale. This clearly is a serious problem and we need to take proactive actions with a long term focus to be able to deal with such situations.

We are now in a situation where we can get nuclear energy from outside, both uranium as well as reactors. This was not possible earlier. Imagine a scenario in which we import 40,000 Megawatts over a ten-fifteen year period, say up to the year 2020 or 2025. Using our domestic capability to set up fast reactors, just as we are planning to do in case of domestic program, we should be able to multiply nuclear power generation capacity set up through international cooperation, through recycle of used fuel from imported light water reactors. This can be done without the need for any

additional uranium. Detailed analysis has shown that following such a strategy one can bridge the gap between requirement and production of electricity without the need for import of any further energy resources for electricity production. Import of only 40,000 Megawatts can be multiplied by ten times by the year 2050 and bridge electricity supply deficit without having to import energy. Domestic technology thus still remains the key to India's energy independence even though restrictions on imports have now got lifted. That is the key point that I think we need to recognize and ensure that we remain in the forefront in technological terms.

In this long term context, where are we today? We have a nuclear generation capacity of around four and a half thousand Megawatts in operation. Several reactors are under construction. Two and a half thousand Megawatts capacity out of this will get added to the grid, may be in a year and a half or so. Construction of four 700 MWe capacity PHWRs have been started recently. They may take around six years to complete. By then the capacity would reach 10,000 megawatts. And then we have a number of additional projects in the pipeline consisting of a mix of domestic PHWRs and FBRs as well as light water reactors set up through international cooperation. All these proposed projects would come to something like 37,000 megawatts and so one can expect that in around ten years time from now, by 2020, it should be reasonable to expect that we would reach a capacity between 25,000 and 30,000 Megawatts. We need to continue this strategy of pursuing a combination of import of nuclear energy and multiply the capacity so set up on the basis of domestic technology of fast reactors and thorium

reactors and if you do that you can in principle bridge the energy gap. You can make India energy independent through this route. You can meet all your energy requirements without having to import energy from outside.

There are of course challenges. The domestic three stage program must continue in an aggressive manner because, as I mentioned earlier, that is the key to our energy independence. We must protect domestic technologies both within the department of Atomic Energy and also more importantly in the industry. We have a lot of technology that has been developed in the Indian industry. Many times when you set up new collaborations'with foreign partners, get into technology transfer agreements, you end up doing that at the cost of domestic technology. We have seen that happening time and again. Thanks to liberalization, many good things have happened, but several Indian brands have vanished from the market. You look at our own households, may be ten or fifteen years ago many products in our homes were Indian brands. Even though most were based on technology acquired from outside through collaboration, they were Indian brands. You look at the scene now I think most of the Indian brands seem to have vanished somewhere. Now this I think is not acceptable. Even in a conventional or consumer goods segment, it is not acceptable. In major segments of our economy and most certainly those that are somewhat strategic and are sensitive in nature it has tremendous ramifications not only in terms of economy but also in terms of security and other issues. So we must make sure that such things do not happen. Especially in nuclear energy, as we have discussed

earlier we need our own domestic technology to multiply energy generation capacity through recycle of used fuel both domestic as well as imported. We must always remember that we are unlikely to get this technology from outside. So we must protect and grow our domestic technological capability while aggressively acquiring energy resources from outside. This should cover uranium mines and fuel cycle assets (uranium conversion, enrichment etc.) and at the same time we should expand domestic fuel cycle activity linked with imported nuclear fuel. You will notice that China is doing this very aggressively and is cornering energy resources all over the world. Our energy requirements are as large or may be in terms of additional energy that we need to acquire, even larger and so we have to be much more aggressive in creating access to energy resources. In the context of oil we have started doing that but we need to do that also in terms of all energy resources and proceed aggressively.

We should also recognize that global energy resources including uranium are depleting fast as a result of their accelerated use. This is particularly true with uranium. Although the recent global financial crisis has caused a little dampening in terms of nuclear renaissance but nuclear renaissance is here to stay. Studies done by World Nuclear Association as well as Nuclear Energy Agency of OECD both indicate a large increase of nuclear power generation capacity. In US, earlier in President Bush's regime they made a provision of 8 billion dollars for loan guarantees for new nuclear power plants, this was in fact further augmented by another 15 billion' dollars by the present administration. So it may be faster or not so fast but nuclear renaissance is

here to stay. And I think we need to take that into account in the context of securing availability of uranium from global market. Just as we are faced with the issue of availability of crude oil and gas today, the day is not very far off, may be 30 years from now or 50 years from now, but there will be a situation when we may not have reasonably priced uranium to commit to a new nuclear power station. There are of course people who say that if there is a demand, exploration investment will go up and more uranium would be found; all that I understand but I think in the least it will pass through a serious uranium availability crisis period. It is clear to me that around that time the world will make a significant shift from the once through use of uranium as is the case at present in many countries, to closed fuel cycle that enables recycle of uranium and plutonium from the used fuel back into fast reactors. France has been pursuing re-cycle of plutonium in a massive way for quite some time, we in India have pursued re-cycle as our basic policy right from the beginning, but I think the whole world will shift towards re-cycle of uranium and plutonium because as we saw earlier, if we re-cycle, the energy potential of mined material goes up 50 / 60 times larger.

Since we have been on that path right from the beginning, we would have lot of advantage but more importantly once you have re-cycle option in place, the world will compare re-cycle of uranium and re-cycle of thorium for their relative advantages and disadvantages. There are several parameters which would point out that thorium also has lots of advantages. Today nobody talks about thorium because you cannot start a nuclear reactor on thorium by itself. Thorium

has no fissile material content. So you have to irradiate thorium in nuclear reactors, produce more fissile material and then set up additional reactor capacity out of that. Once recycle becomes a significant activity worldwide, you will find that interest in thorium would also grow. And that would be another area of advantage for India, because we are pursuing thorium just as we are pursuing recycle. For us the two are mutually consistent.

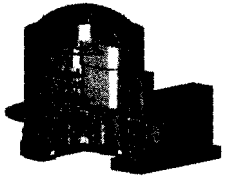
Seen in the context of future, we should also look at another scenario. That concerns safety. Now if the whole world were to get 5000 KW per hour capita and more as we saw in the beginning, and then if a significant part of that energy has to come from nuclear and solar, it goes without saying that the number of nuclear reactors that would be required worldwide will go up very significantly. Today there are around 400 nuclear reactors. May be in future one will require 3000 / 4000 nuclear reactors. Now can those reactors be of the same kind as the reactors of today? The answer is clearly "no". We need to make a quantum jump in terms of safety. Also terrorism has become a serious issue. We therefore need to evolve reactors that have in-built resistance in terms of freedom from vulnerability to terrorist actions. These are already big issues. If we have to build reactors in large numbers, then we have to develop more advanced reactors so that the risk remains at an acceptable low level in spite of large numbers, reactors that can be set up anywhere, right here, in the city of Mumbai for example, without unacceptable risks in terms of safety or security. Normally for setting up of a nuclear reactor, we would look for a place where there is not too much of

population, many sites away from population are not going to be available. We thus need to develop reactors that can be safely put up anywhere.

So this whole scenario is likely to change and as a part of preparation towards that, there is a move world-wide to develop the so called next generation reactors. The Advanced Heavy Water Reactor (AHWR) is an Indian proposal for the next generation reactor. It is an innovative configuration based on technology that we know and have mastered already. Important thing to note is that it can be implemented today while meeting all requirements of next generation systems. For example, if there is something wrong, operator will have three days grace period even if he decides to think what is wrong, telephone somebody, get some expert from somewhere and then implement a corrective

The Indian Advanced Heavy Water Reactor (AHWR), a quicker proliferation resistant solution for the energy hungry world

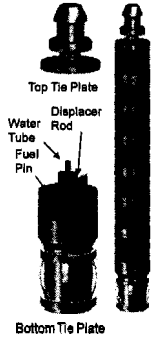
AHWR is a 300 MWe vertical pressure tube type, boiling light water cooled and heavy water moderated reactor (An innovative configuration that can provide low risk nuclear energy using available technologies)



AHWR can be configured to accept a range of fuel types including LEU, U-PU, Th-Pu, LEU-Th and ^{233}U-Th in full core

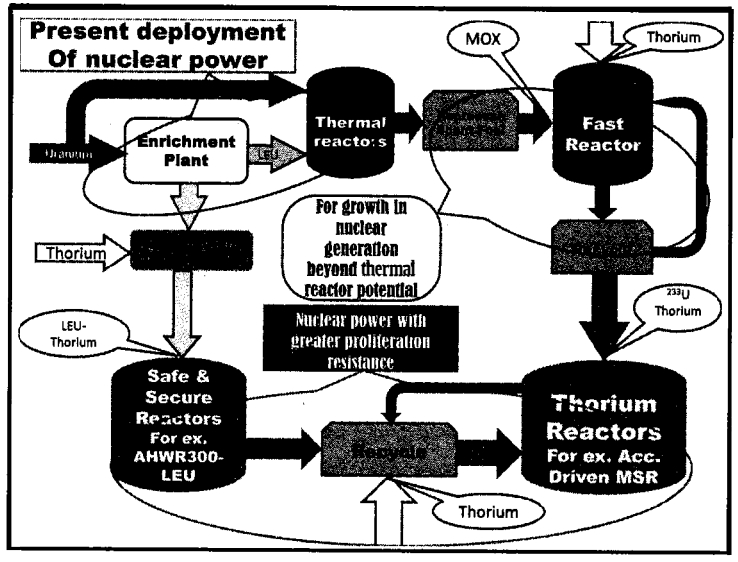
Maior desian objectives

- Significant fraction of Energy from Thorium
- Several passive features
  - 3 days grace period
  - No radiological impact
- Passive shutdown system to address insider threat scenarios.
- Design life of 100 years.
- Easily replaceable coolant channels.



AHWR Fuel assembly

measure. He will have enough time to do that. No action need be taken in panic. Similarly there are issues like can we say there will be no radiological impact in public domain? As far as AHWR Is concerned, the answer is "yes". Can the fuel or sensitive nuclear material derived from it pose a proliferation risk through diversion to weapons activity? Is there a risk due to malevolent actions including that of an insider? The answer is that the AHWR offers a very robust design to actually minimize such risks. So in AHWR we have an Indian proposal to meet next generation requirements that can be implemented today. There are similar proposals being worked upon in other countries. But they will take much longer to be available for implementation. Besides AHWR is a reactor that would derive most of its energy from thorium thus



meeting a key objective of Indian Nuclear power programme.

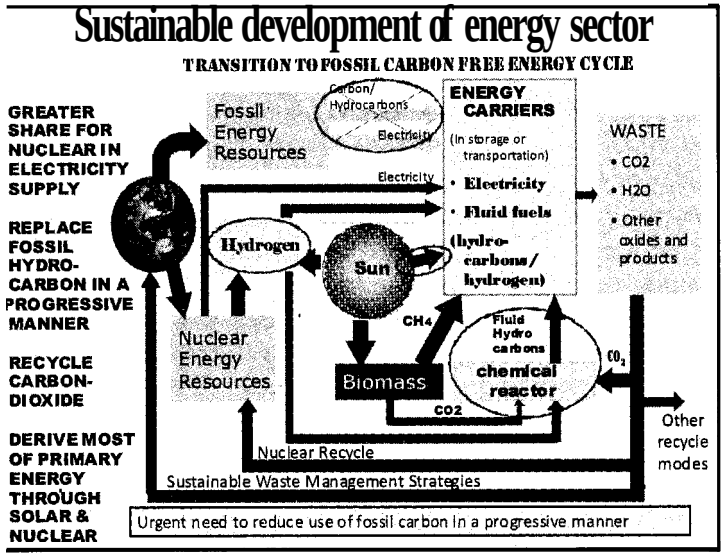
So how do you look at the development of nuclear energy worldwide in a manner that addresses the issue of sustainability and addresses the threats arising out of climate change. Further we need nuclear energy on a large scale without adding to the risks arising out of safety issues, proliferation and even terrorist actions. There is also a timeliness angle to it. We need to realize this before it is too late in terms of global warming or missing the chance of development in the under developed world as a result of depletion of fuel resources. We are talking about a global programme that would achieve this objective. Can we help this process even as we implement the Indian programme as per our well conceived plans.

The figure (page 19) presents a proposal in this regard. The top left hand corner shows what is being practiced today, deployment of thermal reactors which use either natural or low enriched uranium. In order to grow generation capacity beyond what is possible with available uranium, we have to move towards the top right hand corner that shows deployment of Fast Breeder Reactors. But eventually we will have to move to deployment of next generation reactors that address the sustainability, safety, security and waste management issues as shown at the bottom. Bottom left is an idea which can be implemented today. So if we get started with that while we are pursuing the top row, we can simultaneously enhance the power generation potential with the uranium that we have and at the same time enhance deployment of nuclear energy with minimum risk. Eventually we should develop further

technologies to move towards bottom right where both these objectives can be met by the same technology. And that in my view, when implemented on a scale that the world would need, would be the real answer for addressing the challenge of development in a sustainable and risk free manner.

As mentioned earlier there is considerable urgency to development mentioned above. However that does not mean that development of nuclear energy technologies would halt there. Technology development is a continuous process. Technology has to keep on improving, keep on evolving. So we are talking about development of accelerator driven systems where you can grow capacity with thorium which otherwise would not grow or grow very slowly. We need to eventually develop accelerator driven molten salt reactor systems. We need to move towards artificial fluid fuel alternatives, particularly for the transportation sector, that can be produced using nuclear and solar energy as primary energy sources and eliminate our dependence on primary energy that has significant carbon foot print. A possible scheme is shown in the following figure. Such a scheme would eventually lead to hydrogen energy economy. However till that happens, we would need to make full use of current investments in transportation infrastructure that primarily depends on hydrocarbons. In this phase one could make use of hydrogen produces from nuclear or solar energy and combine it with carbon-di-oxide to produce the required hydrocarbons. Thus whatever carbon-di-oxide that comes out of thermal power plants or chemical plants can be synthesized with hydrogen to produce the required hydrocarbon and recycled. Such possibilities do exist. We need to perfect

the requisite technologies and bring them into play. The result would be – you would get the fuels that substitute for petrol, substitute for diesel which are not derived from fossil energy but which are made out of hydrogen using nuclear energy and carbon dioxide which we in any way want to sequester. So it would become, to begin with, a carbon neutral energy solution. Eventually in fact leading to, reducing carbon-di-oxide because as we move more towards hydrogen we can bring the carbon-di-oxide down.



So, that in my view should be the strategy. For this purpose you need to develop high temperature reactors because you require high temperature to produce hydrogen and then you require technology for use of hydrogen for production of hydrocarbon fuel. Continuing further in this development chain, the next is the fusion

energy and of course the solar energy. We need to develop all aspects of solar energy technology. The photo voltaic, solar thermal where high temperatures can be produced for hydrogen production and so on.

Thus the electricity and hydrocarbons derived from fossil fuels extracted from the earth have to get replaced by electricity and hydrocarbon (eventually hydrogen) produced using nuclear and solar as primary energy sources. That would pave the way for our sustainable energy future with the possibility of progressively reducing the carbon-di-oxide in the environment. Through appropriate technology development this can in fact be done keeping the risks at an acceptably low level.

We must also remember that biomass also represents an important source of carbon neutral energy. We however need to recognize that for production of biomass if you are going to divert land resources, then it is going to be in conflict with our food security issues. While we cannot compromise on food security both for humans as well as animals, there are agricultural residues as well as biodegradable solid waste which can be converted into methane to be used as non-fossil hydrocarbon energy. This actually avoids emission of methane, a far more harmful green house gas, directly into the atmosphere; significantly reduces the public health management burden as result of avoidance of microbial pollution; and saves land that is required for landfill. Availability of organic manure to improve farm productivity and enhanced livelihood as a result of decentralized urban solid waste management is an added advantage.

To conclude, I have presented a dream before all of you. A dream, if converted to reality with a degree of urgency, can take us on a sustainable development path avoiding or minimizing the risks that are eminent. This, however, requires urgent actions to develop the requisite technologies. Since our needs are far more urgent as compared to other countries, we have to gear up ourselves to develop these technologies indigenously. We need to channelize our efforts for realizing such a goal. And that is the message I want to leave with you.

The views expressed in this booklet are not necessarily those of the Forum of Free Enterprise.

Ardeshir Darabshaw Shroff
(1899-1965)

A.D. Shroff was one of those rare gifted individuals who leave an indelible mark on their environment and an impress on the hearts and minds of those whom come across them. When the history of India's industrial development, particularly industrial finance, is written, his name will figure prominently. But that was not the only area wherein he excelled. His contributions to economic thinking and public education in economic affairs were equally significant.

Shroff was a champion of free enterprise and a great leader of business and industry and an economist whose predictions have proved right over the years.

After graduating from the University of Bombay and the London School of Economics, Shroff started as an apprentice at the Chase Bank, London. On return to India he joined the firm of stock brokers in Bombay, Batliwalla & Karani. As a partner of this firm, he gained increasing recognition in corporate circles and came in close contact with several senior Tata Directors, particularly the Chairman, Sir Nowroji Saklatwala. This eventually led to his being invited to join the House of Tatas. In 1940 he joined the Board of Tatas and became their Financial Advisor.

In 1944 Shroff, along with seven other leading industrialists like J.R.D. Tata, G.D. Birla, Kasturbhai Lalbhai and Krishnaraj Thackersey authored what has come to be known as the 'Bombay Plan', setting out

the fifteen year perspective plan, and with "the greatest possible role for the private enterprise and reducing controls to the very minimum so that private enterprise may operate under conditions of market economy."

Shroff was one of the two non-official delegates to the Bretton Woods Conference in 1944, which led to the formation of the World Bank and IMF. He ardently put forth the case for the status of India's sterling balances. Lord Keynes, a leading protagonist of the Conference, who initially described Shroff as a "highly articulate maverick – a snake in the grass trying to catch us (Britain) out and filled with suppressed malice", later on expressed appreciation of his moderate, friendly and realistic statement of India's problem.

Shroff was Chairman and Director of numerous companies. He was Chairman of Bank of India and of the New India Assurance Company for several years. He was greatly exercised by the growing socialist ideology of the Indian Government in the early 1950s culminating in the nationalization of the Imperial Bank of India, airlines and life insurance. To educate public opinion of the serious implications of these measures, and to project the great contribution private enterprise could make to speedy development of the economy, he promoted the Forum of Free Enterprise in 1956.

Shroff passed away on 27th October 1965. At a meeting convened by the Sheriff of Bombay to condole Shroff's death, J.R.D. Tata suggested that a Trust be established to perpetuate Shroff's memory. Therefore the A.D. Shroff Memorial Trust was set up in 1967 with Nani A. Palkhivala

as the Founder-Chairman. The other Founder-Trustees were: B.M. Ghia, Jaykrishna Harivallabhdas, Sir Cowasji Jehangir Bart, Tulsidas Kilachand, J.H. Tarapore and K.M.D. Thackersey.

Shroff's contribution to India can be best summed up from the following excerpts of the eulogies paid to him: Mr. M. Narasimham, former Governor, Reserve Bank of India: "Shroff was a member of the Indian delegation to the Bretton Woods Conference in 1944, and the assiduous zeal and nationalistic dedication with which he argued India's case in the discussions there, even to the point, as the Keynes Papers indicate, of displeasing the British delegation." He foresaw with remarkable prescience even then, "what we with the wisdom of experience and hindsight have come to realize, that a centralized command economy and a pluralist democratic polity do not go well together....."

Mr. J.R.D. Tata, eminent industrialist: "".....two qualities stand out: an exceptionally powerful mind and moral courage. Born in humble circumstances and without, therefore, the influence of wealth and position, Mr. Shroff would nevertheless have made his mark anywhere in the world...."

Mr. George Woods, former President, World Bank: "Few patriots did more than he (Shroff) did to make friends for the Indian nation and to build confidence in that nation among those throughout the world whose business it is to provide capital for sound investment opportunities." "His courage, his strength of mind, his passion for his countrymen, particularly for those who, like him, had roots in humble places, stirred admiration

even among those who often could not share his opinions."

Having been connected with national planning earlier, Shroff believed in planning but not to the extent that it stifled individual initiative and enterprise. He was against Soviet style of comprehensive centralized planning as adopted in India which encompassed all aspects of life. Events have proved Shroff right. The liberalization of the economy in July 1991 was a vindication of Shroff's vision and economic philosophy.

During Shroff's birth centenary in 1999-2000 the Government released a commemorative stamp in honour of A.D. Shroff. His biography entitled 'A.D. Shroff – Titan of Finance and Free Enterprise' by Sucheta Dalal was also published.

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"People must come to accept private enterprise not as a necessary evil, but as an affirmative good".

- Eugene Black
Former President,
World Bank

FORUM
of Free Enterprise

The Forum of Free Enterprise is a non-political and non-partisan organisation started in 1956, to educate public opinion in India on free enterprise and its close relationship with the democratic way of life. The Forum seeks to stimulate public thinking on vital economic problems through booklets, meetings, and other means as befit a democratic society.

In recent years the Forum has also been focusing on the youth with a view to developing good and well-informed citizenship. A number of youth activities including essay and elocution contests and leadership training camps are organised every year towards this goal.

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