THE NUCLEAR BLACKOUT

or

GATEWAY TO A DISASTEROUS FUTURE

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Our political leaders have little respect for the people. Even our democracy is hollow. The way our (?) government has handled the nuclear issue is a good example. There is a mounting campaign against the Koodamkulam Atomic Power Station in Tamil Nadu and the proposed Jaitapur mega station in Maharashtra. Look at the way our Prime Minister has responded to people fears. He just dismissed them as ill-advised. He got the services of Caucus Scientists, as anywhere else, to spread half truth and untruth amongst people. He declared: there is no question of reviewing either Koodamkulam or Jaitapur or even the New Indian Nuclear Programme. The way he got the sanction of the 'Parliament' for this programme is an example of how Indian democracy works. The drama played on 22nd July 2008 in the Indian Parliament – the drama of "confidence" motion will go down as a Dark Day in the history of Indian democracy. The subsequent scenes of the drama were even more sinister.

Nuclear Power Stations are inherently dangerous not only while operating but also while not operating. The costs of disasters are astronomical. The nuclear manufacturing companies won't pay it. The insurance industry refuses to insure against nuclear accidents. They all wanted the government to pay while the profits belong to them. People rose against this. Scientists rose against nuclear programme. Ultimately the government decided to stop the nuclear power generation programme, in 1978. That was even before the Three Mile Island accident, in 1979. Since then USA has not built a single nuclear power plant.

One of the conditions under 123 agreements with USA was that India will enact laws which will limit liabilities of vending companies like Areva, GEC or Westinghouse. This the government did. They enacted a law limiting the liabilities of foreign corporations to a paltry sum of Rs.500 crores, however large the cost of the accident to the nation may. And recently Manmohan Singh announced that the government has taken a decision to limit even this, to the guarantee period of five years which means freeing them from almost any liability. All the costs will have to be born by the people of India. Dr. Manmohan Singh's diction thus comes to "Polluter Takes the Profit, People Pay the Price."

The people of India will not agree to this. But today he is least concerned about it. He has the mandate of the "super people". Ordinary people don't count. This, however, is not an essay on democracy, but on nuclear energy. It is about the patent lies, not mistakes, propagated by the political leadership on the one hand and on the other hand by a section of the scientific community led by no less than the former President of India, Shri. APJ Abdul Kalam. Every argument put forward by them in favour of the new nuclear programme of the country is wrong and it is promoted knowingly. I assert this on the basis of my direct experience as a nuclear engineer in the Bhabha Atomic Research Centre from 1957 to 1975 and also as a close observer of the development of nuclear energy world over for the past 40 years. I challenge the scientists and engineers who supported the Indo-US nuclear deal and the new nuclear power program for an open debate based on facts and figures. I accuse that the present nuclear programme is intended,

(i) to help US Business through large scale commerce in nuclear reactors (Jaitapur and beyond) and nuclear fuels

(ii) to help Indian Big Business who will act as intermediaries

(iii) to tie India to all the misdeeds and interventionist actions of the USA

(iv) and perhaps, to accelerate an absurd nuclear weapons programme

I feel that the recent intervention of our former President Shri. APJ Abdul Kalam in the nuclear energy debate is an unfortunate one (the Hindu, Nov.6, 2011)

To understand why unfortunate we should have a little grounding on the principles of operation of nuclear reactors and India's nuclear trajectory as was traced by late Dr. H.J. Bhabha the pioneer of India's Nuclear Science.

NUCLEAR REACTORS

When neutrons enter the nucleus of certain elements like U^{235}, P_u^{239}[1] etc., the disturbance caused splits their nucleus into two or three fragments. It also generates two or three free neutrons. These neutrons, generally escape into the environment. However if we pack uranium suitably, at least one of the free neutrons generated out of the fission of the uranium nucleus enters into and splits a second uranium nucleus. One of the free neutrons generated out of this second fission causes a third uranium nucleus to be split. This can go on for ever. Such a situation is called a *chain reaction*. If, from the free neutron coming out of the fission of uranium nucleus, more than one, say two neutrons succeed in splitting two new nuclei and further four the chain will diverge and multiply very fast. In less than a few micro seconds all the nuclei will be split and terrible amounts of energy will be released. This is the atomic bomb. A nuclear (atomic) reactor is one in which the chain reaction is kept steady and not allowed to diverge. By increasing the number neutrons active at any instant the number of fission taking place per second and the power levels can be adjusted.

It is not easy to ensure that the free neutrons coming out of fission cause at least one more fission. They have high energy. They move fast and escape from the system before they get an opportunity to encounter another uranium nucleus. The uranium we mine from the earth is a mixture of two isotopes, uranium-238 and uranium-235. Neutrons are not capable of splitting U^{238}. They can split only U^{235} easily. But its percentage is generally very low – less than 0.7%. 99.3% is U^{238} which is not fissionable. Any neutron that enters its nucleus gets trapped there and in the

[1] The nucleus of atoms of any element consists of a definite number of protons and an indefinite number of neutrons. It is the number of protons that define an element. For example the element uranium has always 92 protons in its nucleus. The number of neutrons could be 141, (U^{233}), 143 (U^{235}), 146 (U^{238}). They are called isotopes. The numbers 233, 235, 238 etc. are the total numbers of protons and neutrons.

process it gets converted into a new element called Plutonium 239. Luckily this too is fissionable like U^{235}.

In order to ensure that at least a little more than one neutron succeeds in causing a second stage fission, one has to reduce their speed. Inserting between uranium pieces, light nuclei like Hydrogen (H_2O), Heavy hydrogen (D_2O) and graphite (C) we can slow down their speed. Such neutrons will be more successful in causing second and further generation of fissions. Materials used to slow down neutrons are called “moderators” and reactors which work on slowed down neutrons are called **thermal neutron reactors**. These moderators should not absorb neutrons heavy water is the best one. It absorbs least number of neutrons. In the power plants at Rajasthan, Kalpakkam etc. we use natural uranium as fuel and heavy water as moderator. For extracting the heat generated in the reactor, pressurized heavy water is used as coolant.

Through a rather costly process we can change the composition of isotopes in uranium. The percentage of U^{235} can be increased from 0.7% to 2-3% and even up to 99%. This process is called enrichment. The uranium is called enriched uranium. If we use this in place of natural uranium, we can use ordinary water as both coolant and moderator. The US reactors mostly use enriched uranium as fuel and pressurized water has coolant. This water can be allowed to boil within the reactor itself and produce stream directly. Thus we have both Pressurized Water Reactors (PWR) and Boiling Water Reactors (BWR). The Koodamkulam reactor belongs to the first type - PWR. The old Tarapaur reactors are of the second type - BWRs. All other Indian reactors are of the Natural Uranium Heavy Water type. They are of Canadian origin and are called CANDU – Canadian Deuterium Uranium – reactors (Deuterium is heavy hydrogen with one neutron and one proton in the nucleus).

In all these reactors we have still large quantities of non fissionable U^{238}. For every neutron absorbed in one nucleus of U^{235}, 0.5 to 0.6 neutrons get absorbed in U^{238} producing fissionable Pu^{239}. After some time when its concentration in the reactors grow sufficiently high it too participates in the chain reaction process and produce power. This extends the life of the fuel in the reactor.

On an average for every atom of U^{235} that gets split 0.5 - 0.6 (this is called the conversion factor) atoms of Plutonium is formed. In the fuel reprocessing plants this plutonium is separated. It was the plutonium thus obtained from nuclear reactors that was used in the Pokhran explosions. This plutonium can be used to enrich natural uranium. If we enrich it to a sufficient degree, 15-18%, it can be used for another type of reactors. Here we do not use any moderator to slow down the neutrons. The fast neutrons now have a higher probability to hit the nucleus of fissionable uranium or plutonium because their concentration has increased. If a proper configuration is designed and if proper materials are used, then there is a possibility that for every atom of U^{235} or Pu^{239} that gets split a little more than one atom Pu^{239} is formed. This could be 1.05 – 1.10. Then a strange situation arises: for every kilogram of U^{235} burned (split) we get 1.05 to 1.10 kilogram plutonium 239. Over a period of time which may be anywhere between 15 to 50 years we will get enough extra plutonium to build a second reactor. The reactor has 'bred' new fuel. Such reactors are called "breeder reactors". The time required to double the initial fuel charge is called the breeding time. Now in place of one reactor we can have two reactors of the same size. Since they work on fast neutrons, they are called **fast breeder reactors**.

INDIAN NUCLEAR TRAJECTORY

The theory of all these are known since long. Once we can build breeder reactors, we can convert not only uranium but also Thorium into reactor fuels. When thorium nucleons absorb a neutron, it becomes an isotope of uranium U^{233}. This too is fissionable like U^{235} and Pu^{239}. But this has to be 'cooked' in reactors as we cook plutonium. As early as 1955 Dr. Bhabha envisaged a three stage nuclear development programme for India.

The fifties and sixties of the 20th century were years of high hopes on nuclear energy. It was considered to be so abundant and so cheap that people talked about free, unmetered, supply of nuclear energy. Dr. Bhabha was audacious enough to predict that fusion energy too will become commercial before the end of the century. But he knew clearly that India has only limited reserves of natural uranium, at that time estimated as about 30000 Te, and that there are severe limitations to a programme based on natural uranium. However, India has got a much larger reserve of thorium, a fertile material - estimated to be about half a million Te, at that time. Thus he conceived a three stage programme for nuclear energy in India.

Stage one: Pressurised Heavy Water Reactors using natural uranium dioxide as fuel and heavy water as both coolant and moderator. Indian uranium will suffice to fuel about 10000-15000 MW for about 25 years. Energy released from the fission of 120 gram of U^{235} will suffice to generate 1 million units of electricity. Each kilogram of natural uranium has about 7 grams of U^{235} in it. We cannot burn all the U^{235} within a reactor. The maximum that can be burned, that is fissioned, is only about 50-60% or 3.5-4 grams. To generate one MU of electrical energy we would, therefore, require about 30-40 kg of natural uranium. One tonne of natural uranium can, thus, yield 25-30 MU of energy. For every 100 atom of U^{235} split, about 45 atoms of U^{238} would have been converted into plutonium 239. For each MU of electricity generated about 50 grams of plutonium would have been generated. India has, so far up to Dec. 31, 2010) generated about 30,000 MU of energy from nuclear reactors, as per official statistics. This must have generated, in all, about 15 Te of Pu^{239}. How much of spent fuel has been reprocessed and how much plutonium has been recovered is not an information in public domain.

Current estimates of domestic natural uranium availability, including low grade ores, is about 50000-70000 Te, sufficient to maintain 10000 MWe for about 40 years. It is obvious that this is woefully inadequate to meet India's energy requirements. Herein comes the second stage.

Stage Two: This envisages the use of Pu^{239} obtained from the first stage reactors, as fuel in what are known as Fast Breeder Reactors. Here Pu^{239} serves as the main fissile element mixed with depleted uranium from the first stage with about 0.3-0.4 percent of unburnt U^{235} in it. Plutonium enrichment in these reactors will be of the order of 15-20 percent, as compared to 2-3% in light water PWRs and BWRs. There will be a blanket of U^{238} surrounding the fuel core which will absorb neutrons and produce Pu^{239}. In PFBR (Prototype Fast Breeder Reactor) and earlier FBTR (Fast Breeder Test Reactor), the fuel was in the form of carbide. According to the original scheme of Bhabha, the blanket will have, besides uranium238, thorium 232 too, which on capturing neutrons will turn into U^{233}. This too is fissile and is the fuel for the future, third stage of the programme. However the 500 MW Prototype Fast Breeder Reactor being built at Kalpakkam does not have any thorium in its blanket. So, to produce U^{233} for the third stage the present proposal is to use uranium based fuel, enriched with a blanket of thorium, plutonium, in an Advanced Heavy Water Reactor (AHWR). The technical difficulties associated with thorium are supposed to be several times larger.

Stage Three: Start up U^{233} is obtained from Th^{232} blankets in FBRs and also from AHWRs, fuelled by Pu^{239}. This U^{233} is used in Fast Breeder Reactors together with thorium 232 and from then onwards, it is almost super abundance. Scientists have calculated that we can produce up to 358,000 GWe of power against the present production of 140 GWe and will suffice to meet the growing needs of India for even the next century and beyond.

Such was the nature of Bhabha's vision. He had envisaged the completion of the first stage by the eighties of the last century and stabilization of the second stage by the turn of the century. We are, at least, three decades behind schedule. Many today question the feasibility and wisdom of even the second stage. Regarding thorium-uranium fast breeders, there seem to be certain problems which are as hard to solve as problems associated with fusion reactors and practically nobody believes that it will ever become practical. But, there is no necessity to reject it now.

Tarapur units 1 and 2 and Rajasthan units 1 and 2 are the oldest reactors. Instead of closing them down, they have been de-rated to 160 MW and 100 MW respectively.

Table - 1

Unit	**Type**	**Capacity (MWe)**	**Since**
TAPS-1 (Tarapur, Maharashtra)	BWR	160	October 28, 1969
TAPS-2 (Tarapur, Maharashtra)	BWR	160	October 28, 1969
TAPS-3 (Tarapur, Maharashtra)	PHWR	540	August 18, 2006
TAPS-4 (Tarapur, Maharashtra)	PHWR	540	September 15, 2005
RAPS-1 (Rawatbhata, Rajasthan)	PHWR	100	December 16, 1973
RAPS-2 (Rawatbhata, Rajasthan)	PHWR	200	April 1, 1981
RAPS-3 (Rawatbhata, Rajasthan)	PHWR	220	June 1, 2000
RAPS-4 (Rawatbhata, Rajasthan)	PHWR	220	December 23, 2000

RAPS-5 (Rawatbhata, Rajasthan)	PHWR	220	February 4, 2010
RAPS-6 (Rawatbhata, Rajasthan)	PHWR	220	March 31, 2010
MAPS-1 (Kalpakkam, Tamil Nadu)	PHWR	220	January 27, 1984
MAPS-2 (Kalpakkam, Tamil Nadu)	PHWR	220	March 21, 1986
NAPS-1 (Narora, Uttar Pradesh	PHWR	220	January 1, 1991
NAPS-2 (Narora, Uttar Pradesh	PHWR	220	July 1, 1992
KAPS-1 (Kakrapar, Gujarat)	PHWR	220	May 6, 1993
KAPS-2 (Kakrapar, Gujarat)	PHWR	220	September 1, 1995
KGS-1 (Kaiga, Karnataka)	PHWR	220	November 6, 2000
KGS-2 (Kaiga, Karnataka)	PHWR	220	May 6, 2000
KGS-3 (Kaiga, Karnataka)	PHWR	220	May 6, 2007
KGS-4 (Kaiga, Karnataka)	PHWR	220	November 27, 2010
Total Capacity		**4780**	

Under Construction

Unit Under Construction	**Type**	**Capacity (MWe)**	**Expected Date**
KNPP-1 (Koodankulam, Tamil Nadu)	LWR	1000	June-2011[7]
KNPP-2 (Koodankulam, Tamil Nadu)	LWR	1000	Mar-2012[7]
KAPS-3 (Kakrapar, Gujarat)	PHWR	700	Jun-2015[8]
KAPS-4 (Kakrapar Gujarat)	PHWR	700	Dec-2015[8]
RAPS-7 (Rawatbhata, Rajasthan	PHWR	700	Jun-2016[9]
RAPS-8 (Rawatbhata, Rajasthan)	PHWR	700	Dec-2016[9]
Total Capacity		**4800**	

Table 2 – Growth of Nuclear Power in past decades

Period	**Nuclear Power Addition (MW)**
1969-1979	660
1980-1989	660
1990-1999	880
2000-2008	2180

Table 3 - Share of Nuclear Energy in total energy generation – World

Year	Percent
1970	<1
1975	6
1980	8
1985	16.0
1990	16.1
1995	16.4
2000	16.3
2005	16.1

Table-4 – Electricity Generation and Share of Nuclear Energy

Region	**2006**			**2030**		
	Total Billion Unit	**Nuclear Billion Units**	**%**	**Total Billion Units**	**Nuclear Billion Units**	**%**
N. America	4137	880.7	19.0	6038	1042	17.2
L.America	1172	30.5	2.6	2305	65	2.8
W.Europe	2008	875.3	29.1	3750	544	14.5
E.Europe	1810	322.1	17.8	2548	564	23.0
Africa	546	10.1	1.8	988	26	2.6
Middle East, S.Asia	1152	18.1	1.6	2116	136	6.4
South East Asia	662	--	--	1169	5.8	0.5
Far East	4537	522.8	11.5	6961	942.0	13.5
WORLD	**17525**	**2659.7**	**15.2**	**25785**	**3325**	**12.9**

For three decades the growth rate stagnated at 660-880 MW per decade. In the next decade, already 2180 MW has been commissioned. Another 2000 MW is going to be commissioned at Koodamkulam. This is a turnkey project executed by Russia. Against this a massive people's campaign is going on.

It is not only in India that nuclear power growth rate got stagnated. The world over the share of nuclear energy in total energy generation has been rising up to eighties and then got stagnated at around 15-16%. See Table 3.3

Table 4 gives the expected share of nuclear energy generation world over in the year 2030 as compared to 2006. Instead of increasing, the share of nuclear energy is expected to fall from 15.2% in 2006 to 12.9% in 2030. (Source: IEA Estimates, 2007 Edition). After Fukushima there is further reduction in targets.

From these figures it is clear that even old time nuclear (energy) states like North America and Western Europe are slowing down. Western Europe which currently produces 30% of all its energy from nuclear (France, more than 75%) sources is, in fact, planning to reduce its nuclear production from 875 billion units to 544 billion units. Nowhere in the world there is any excitement about nuclear energy except in China and perhaps in India. No country has any major programme of Fast Breeder Reactors either. Nuclear reactors continue to be accident prone. Chernobyl was not the last of this. Fukushima too is not the last. Of course, there were major accidents earlier. But later too, major accidents have taken place. For example on April 10, 2003, in the nuclear power station of Paks, about 115 kilometer from Budapest, 30 highly radioactive fuel assemblies got overheated inside the storage tank and got destroyed, releasing huge quantities of inert radioactive gases into the reactor hall from which the operators fled in panic. The entire radioactive air was blown out into the open atmosphere to make the place accessible to personnel in radiation protection gear. Investigations into the chain of events revealed that only luck prevented a runaway situation, a partial explosion. Nuclear reactors are inherently unsafe. Contrary assertions of 'experts' and of politicians (as safe as a match box!) will not make them safer.

Of course, India needs to produce more energy. The oil and gas reserves are extremely limited, even globally. Burning of more fossil fuels and release of more

CO_2 into the atmosphere, of course, chiefly by US, Europe, China and Japan will lead to unallowable increase in the global temperature and to unacceptable climatic changes. India's contribution is much smaller, yet significant. So, alternative and abundant sources of energy are to be looked for. All these are genuine concerns. But a 'concern' does not justify any 'solution' that comes up. The solution may create more problems than the original concern. The issue of loading of the earth with human made radioactive materials (fission products, several times more than what exists naturally) is one such problem. Scientists, for the past five decades have been pondering about the issue of the ***final*** disposal of radioactive fission products. Even today they have not come to a consensus, though the US has decided to go ahead with a disposal plan of vitrification and sealing permanently within deep holes drilled inside stable rocks. Even then it requires constant surveillance because the intensely radioactive material will heat itself to dangerously high temperatures unless it is constantly cooled. Thus we are leaving to posterity a responsibility which they may not like. **The arguments put forward against massive utilization of atomic energy in the sixties and seventies hold true even today**. We will now turn our attention to these early debates.

During the first stage we will have a series of natural uranium – heavy water reactors. We have already built 18 such reactors, 16 of them of 220 MW each and 2 of 540 MW capacity. We have gained fairly good experience in building such reactors. The total capacity is about 4000 MW. We have built fuel reprocessing plants to separate plutonium; we have built uranium metal plants, fuel fabrication plants, we can manufacture pressure vessels, turbine control systems…. We were almost self reliant and self-sufficient in the field of nuclear energy.

However our own reserve of uranium was limited. It would suffice to sustain only about 10,000 MW, and that too for one life time of about 40 years. We cannot build an expanding and sustainable nuclear program on it. This limitation was proposed to be overcome by a three stage strategy. As mentioned earlier the plutonium separated from the spent fuel will be used to build fast breeder reactors, using thorium oxide, and plutonium oxide as fuel. In these reactors, thorium will be converted into uranium-233, producing more uranium than the amount of plutonium used. A good number of such reactors will be build and substantial quantities of uranium-233 will be bred or cooked. Thus we have a stock of U^{233} sufficient to build fast breeder reactors using a mixture of thorium oxide and uranium oxide as fuel. This will breed more uranium-233 than what is used up in the reactor. In a number of years – more or less depending upon the breeding efficiency of the designs - enough U^{233} will be formed to build two such reactors instead of one. This is stage three. Our thorium reserves are fairly large. It was estimated that once we reach this stage, we can forget about energy problem. We an produce enough energy to meet the entire requirements of the country for centuries and even millennia to come. In late fifties and early sixties our nuclear scientists were so ecstatic about nuclear energy that they used to brag about "free" energy – nuclear energy will be so cheap – less than a paise per unit – that it won't be worthwhile to even meter the supply! This euphoria was soon to be shattered, in the middle of sixties when it was finally established that the effects of radiation on life are much, much more serious than what it was thought to be. About this, more later.

India's long term program was, thus firmly set on a three stage strategy.

Stage one: Thermal neutron rectors using natural uranium as fuel and heavy water as both moderator and coolant – about 10000 MU.

State two: Fast breeder reactors using thorium and plutonium as fuel, liquid metals - sodium or sodium potassium alloy - as coolant

Stage three: Fast breeder reactors using thorium and Uranium 233 as fuel. There were a few variants for each case:

- there could be a thorium blanket with a uranium-plutonium core;
- the fuel could be in oxide form or carbide form and so on.

It was this three stage strategy that was rejected by Dr. Manmohan Singh. (The rejection came not from the Department of Atomic Energy or scientists, but from the Prime Ministers Office). The natural uranium reactors are given a holiday. Our own scientists and technologists would have built another 6000 MW of such reactors provided sufficient funds were given. Instead the new strategy rests on a massive foundation of thermal reactors using enriched uranium as fuel and pressurized water both as coolant and moderator – the US's PWR and the USSR's VVER. The entire fuel and most of the components have to be imported. The Bhabha Atomic Research Centre and other research establishments will become redundant. We are no longer self sufficient or self reliant. We are forced to sing to the tunes set by USA. The Manmohan Singh government is bent upon purchasing 4000 MW of Soviet VVER (PWR) reactors and 9600 MW of AREVA (AUS-French Company) reactors, to begin with. They want to reach 63,000 MW from the existing 5000 MW, by 2031. Can they? And should they?

If government of India can put in one million crores of rupees to purchase 50,000 MW from manufactures all over the world, it may be able or even then it may not be able to reach the target. However the US, French and Russian companies will be only too glad to receive such big orders. But even globally there are limits to growth for uranium reactors. Its supply is limited. A truly large programme is possible only when fast breeders become commercially viable.

FAST BREEDERS

Experiments on FBR's have a history of more than five decades. And not a pleasant one. Dozens and dozens of breeders have been built and abandoned. Fast breeder is a nasty piece of equipment. It has large qualities of fissionable material confined in a small space. It has, also, a very nasty liquid, molten sodium circulating within it. Sodium reacts violently with water. Sodium fires are common in such reactors. Accidents can become much more damaging. There are over half a dozen operating breeder reactors world over, but none of them yet commercial. None of them has yet bred enough fuel for a second reactor. The cumulative PLF (Plant Load Factor) of all of them taken together is less than 20% - meaning thereby that generally they operate only 2-3 months per year.

There is only one breeder reactor which can be said to running commercially, meaning thereby producing about 70% of energy that it is capable of. That is BN-600 in Beloyarsk Nuclear Power Station in Russia. That is in operation for more than two decades. Its operating history is chequred. It has seen several incidents and accidents, fortunately not yet a major one. However the neighbouring area of the power station has high levels of nuclear contamination

The first Indian Prototype Fast Breeder Reactor (PFBR) using uranium-plutonium oxide as fuel is nearing completion at Indira Gandhi Atomic Research Centre at Kalpakkam, Tamil Nadu. It is likely to be commissioned in 2012. It ought to have been on commercial operation years ago. Though it is designed on the basis of the operating experience of a Fast Breeder Test Reactor (FBTR) the technological and operational troubles can persist for long - one doesn't know how long. How many years it will take to breed enough plutonium to fuel itself and another reactor of the same size? It is yet anybody's guess. Theoretical calculations can go wide off the mark. According to Homi Bhabha's vision we ought to have commissioned of the first commercial Breeder Power Reactor three or four decades ago.

Bhabha was an over optimistic person. Even during the first Geneva Conference on Peaceful Uses of Atomic energy (1955) he dared to prophesize that Fusion Reactors will become a reality in the 20th Century itself. Abdul Kalam is a true disciple of Bhabha in this aspect of over optimism?

We are, yet to enter the second stage of Bhabha's three stage trajectory. Already Dr. Manmohan Singh, (not the nuclear scientists) has changed the trajectory. From what one can understand from the actions taken so far, the "Prime Minister of India" has said goodbye to Dr. Bhabha's program. He has rejected the, natural uranium – heavy water reactors in which we have became fully self reliant, and adopted the path of buying reactors from global vendors, who cannot find a market for their products in their own countries. The talk about second and third stages, of fast breeder reactors is not the least convincing. The rhetoric about unlimited abundance of energy from thorium-uranium fast breeders is sheer blabber. The second stage of uranium-plutonium fast breeder reactors is itself still in a developmental stage. It is under such circumstances that Abdul Kalam, together with one Srijan Pal Singh, a management expert wrote the infamous article in Hindu, Nov. 6, 2011.

In this essay they passionately argued that "nuclear power is our only gateway to a prosperous India" and accuse anti-nuclear propaganda as being supported and promoted by imperialistic developed countries. They reject solar energy for the future and they reject coal for the present. They hope that India will be the "first nation to realize the dream of a fossil-fuel free nation". They argue that compared to coal burning stations nuclear reactors are cleaner and safer. They dispose of the problem of nuclear waste management very easily – "waste from a 1000 MWe plant can be safely stored after vitrification, in an area less than quarter the size of a food ball field, for hundreds of years without causing any risk to the environment or to the people."

The half truths and untruths about nuclear energy propagated by the political leadership a section of the scientific community like Abdul Kalam is nauseating. Every argument put forward by Abdul Kalam is wrong, and it is put forward knowingly so.

This was an article that one did not expect from an engineer. They have confused between units of energy and units of power, between million and billion, between fertile material (U-238, Th-232) and fissile material (U-233, U-235, P_u-239), between radiation and explosion, they went on even to suggest that one unit of energy from nuclear reactors is more productive than one unit of energy from coal burning stations. Leaving aside such mistake, which might have crept in inadvertently the main arguments of the article are all wrong. The clearly expressed objective of the essay was to convince the people.

(i) that nuclear energy is not particularly harmful,

(ii) that coal burning stations are relatively more harmful

(iii) that it is possible to replace entire coal and other fossil fuels by nuclear fuels

(iv) that nuclear energy is cheaper,

(v) any opposition to nuclear energy is tantamount to objection to science and progress.

However, before proceeding further, it would be interesting to trace the history of nuclear energy in the USA itself

POISONED POWER

Richard Goffman and Arthur Tamplin were two scientists engaged by the Lawrence Radiation Laboratory of USA to study the harmful effects of nuclear radiation on human bodies. They were assured that whatever their findings be, they will be made available to the public. They had an excellent field sample to study: the survivors of Nagasaki and Hiroshima bomb explosions - the *Hibakushas*. Their studies led them to certain frightening facts: that the nuclear radiations are far more harmful than what was thought earlier; that the concept of threshold levels of radiation, below which there will be no harm because the body will repair itself, is invalid; that effects of radiation are cumulative. This, immediately, questioned many of the design criteria of nuclear reactors. Radiation levels have to be brought down to one hundredth of what was allowed originally, protective arrangements for those working in various types of nuclear establishments have to be enhanced several times and so on. This made the entire nuclear programme far more costly than what it was hoped to be earlier. In the mean time, several nuclear /radioactive material related accidents/events began to get reported. A feeling that 'all is not well with nuclear business' began to permeate and spread among the masses. Goffman and Tamplin being prevented from reporting what they found, came out of the establishment and published two explosive books: *'Poisoned Power'* and *'Population Control Through Nuclear Pollution*.' Insurance companies began to include nuclear exclusion clauses in their policies. Real estate values around all forms of nuclear establishments began to fall. People's struggles against building nuclear establishments in their vicinity and later, anywhere began to gather momentum. The government went on withholding vital information from the people or providing them with distorted information. Conscientious scientists began to question the wisdom about the massive nuclear energy policy. About 2300 scientists, including several Nobel Laureates in chemistry, biology and medicine, under the initiation of Harold C. Urey gave a mass petition to the President of U.S.A. to stop the nuclear programme. He pointed out that our nuclear power program involves unacceptable risks.

> The late President Kennedy's well-remembered remark about nuclear weaponry, to the effect that we cannot put the genie back in the bottle, applies no less clearly to the technology for generating electricity by nuclear fission. More than 50 nuclear reactors scattered throughout the United States, and others in many other parts of the world, are already producing significant quantities of power by this means. Given the projected growth of the energy needs of the nation and the world, it may be unrealistic to propose abandonment of this source.

But just as there are enormous dangers evident in the destructive power of nuclear weapons, so are there great dangers implicit in the use of nuclear fission even for peaceful purposes. Our urgent necessity is to recognize these dangers forthrightly and bring them under the greatest degree of control possible. That is the intent of the petition, of which I am one of the sponsors, recently presented to the White House and the Congress and signed by 2,300 members of the American scientific and technical community. It asserts that "it now appears imprudent to move forward with a rapidly expanding nuclear power plant construction program; the risks of doing so are altogether too great."

Among those risks are:

1. Nuclear reactors regularly and unavoidably release some radioactive materials into the environment - small quantities, to be sure, but at some risk of causing cancers and genetic damage to the individuals exposed and their progeny.

2. The danger of serious accidents cannot be precluded, and their consequences could be catastrophic. Although it is happily true that there have been no such accidents to date, experience in the operation of nuclear reactors is too brief to provide adequate guarantees of safety for the future. The risks of malfunction, human error, natural disasters and civil disorders would all be compounded in a society heavily dependent on power from nuclear fission.

   In 1973, in fact, the Atomic Energy Commission (AEC) recorded 861 "abnormal events" at nuclear power plants, 371 of which it considered to have had a potential of being hazardous. It is this sort of record that gives point to the statement of Sir Alan Cottrell, formerly chief scientific adviser to the British Government in rejecting an American-built reactor. "The security of a light-water reactor vessel depends on the maintenance of an immaculate standard of manufacture and quality control, and on a regular in-service inspection of the most rigorous and detailed kind. I hope the safety of this country will never be made dependent upon almost superhuman engineering and operational qualities."

The safety problem also has an international dimension, in light of the fact that the United States and some other advanced nations are promoting the industrial sale of nuclear reactors to a number of countries that do not have the most minimal technical infrastructure and administrative controls to meet these exacting standards. This is a danger that has been given even less attention than the political problem of how to prevent such countries from diverting the by-product plutonium to nuclear weaponry.

Finally, it should be mentioned that all aspects of the safety question will be vastly increased if reactor technology advances to construction of the so-called "fast-breeder reactors" as planned.

3. No adequate long-range techniques have yet been perfected for the transportation, storage and disposal of nuclear wastes. The fact that some of this material will remain lethally radioactive virtually forever in human terms makes this problem unique. It has been well stated by Alvin Weinberg, former director of the AEC's Oak Ridge National Laboratory: "We nuclear people have made a Faustian bargain with society. On the one hand, we offer - in the catalytic nuclear burner - an inexhaustible source of energy. But the price that we demand of society for this magical energy source is both vigilance and longevity of our social institutions that we are quite unaccustomed to... The society must then make the choice, and this is a choice that we nuclear people cannot dictate."

4. In order to protect a great complex of nuclear power plants from criminal and/or political terrorism, a vast apparatus of physical security would be necessary. The possibilities of theft and sabotage at the sites, and during the thousands of trips a year that would carry radioactive materials to and from them by truck, rail and barge, would call for policing almost on the scale of a garrison state.

For all those reasons and more, I think it would be an incalculable error for the United States to commit itself now, irretrievably, to increasing the number of nuclear reactors in this country from the present 50 to the anticipated, 1,000 by the year 2000. Given time and intensified research, which the proposed

> slowdown in the construction program would provide, perhaps many of the problems that can be foreseen will be resolved. But our present planning is just too great a gamble.
>
> If the objection is raised that the nation cannot afford such a delay in meeting its growing energy needs, especially in light of the uncertainties surrounding oil supplies from overseas, the answer surely is that America now blatantly wastes more energy than the entire nuclear reactor program is expected to generate. A real conservation effort could be linked to a stepped-up research program both in improving conventional coal-burning power plants and in deriving energy from the sun, the winds, the tides and the heat in the earth's crust. The effort to harness nuclear fusion - as distinct from fission - also deserves continued effort.
>
> These are the sources that offer the ultimate hope of assuring the supply of truly healthy lifeblood for our civilization. Let us not neglect them in order to plunge ahead in a reckless over-commitment to nuclear fission.

The Atomic Energy Commission had their own team of scientists who questioned the apprehensions of Urey and others. The American Nuclear Community headed by Eugene P.Wigner, a Nobel Lauareate in physics, together with 11 other Nobel Laureates, issued a counter statement: "Nuclear Reactors Offer Surest, Safest Way of Meeting Our Energy Needs." He wrote:

> The recently issued Scientists' Statement on Energy Policy, of which I was one of the sponsors, was signed by 32 eminent members of the American scientific and technological community - including seven Nobel Laureates in physics, three in chemistry and one in physiology and medicine. Since the harnessing of uranium power is the culmination of basic discoveries in physics, and these are the people who have worked for the longest time on problems of nuclear energy, it seems reasonable to say that they can speak responsibly about the subject. Their conclusion is summed up in these words:
>
> "On any scale, the benefits of a clean, inexpensive and inexhaustible domestic fuel far outweigh the possible risks. We can see no reasonable alternatives to an increased use of nuclear power to satisfy our energy needs."

The risks that are involved are not unlike those inherent in all mankind's progress in technology and industrialization resulting from his increased knowledge of nature. For purposes of the present discussion, I do not wish to address the question of whether this has indeed been "progress" - whether there is virtue in our affluences, and thus whether we perhaps should consume less power - except to suggest that it is difficult now even to visualize modern life without these profound changes.

Simply to enumerate some which have occurred in the present century- the railroads, the automobile, electric lighting, central heating, airplanes, telephones, radio and television - is to recall their tremendous effect. Science and technology have contributed enormously to our ability to earn our daily bread, to our greatly increased leisure time, and even to the possibility of our living longer lives. Perhaps the most striking single measure of change touching all of us is the fact that life expectancy at birth in the United States has increased during the 20th century from 47 to 71 years.

When thinking about the advantages and disadvantages of nuclear energy, it is useful to remember how many other technical innovations were vociferously resisted in the past. Thus it was feared that people living near railroad tracks would be driven insane by the noise of trains, and that the passengers' health would be impaired if the speed of trains exceeded 30 miles (48 kilometers) an hour.

Although such dire consequences obviously did not materialize, it is true that a good many people have been killed in railroad accidents; many more are killed by automobiles today. Even such a positive result of medical science as the increase in life expectancy has confronted the world with serious population problems.

The truth is that just about every development in human affairs has its disadvantages. In assessing the prospect of widespread use of nuclear power, the need is to look at the total effect, bad and good. I will begin with consideration of the specific questions raised by critics, commenting briefly on four of them:

1. The easiest to dispose of, although one of the most frequently raised is that nuclear power plants emit radioactivity into the atmosphere, causing cancer and other ailments. The plain fact is that a coal-fired plant producing an equal amount of energy emits on the whole more radioactivity than a nuclear plant- to say nothing of such other pollutants as sulphur dioxide, which causes much more harm than the radioactivity. Moreover, one physicist has calculated that, if the United States met all its needs for electricity from nuclear plants, the amount of radioactivity they would emit in normal operation would be about as dangerous to the average citizen as smoking two cigarettes in the course of an entire lifetime.

   Only at the so-called reprocessing plants for nuclear materials, which are planned but not yet operating, is emission likely to be a serious problem, and there is every reason to believe it can be dealt with in such plants as well by careful design.

   It is important to remember also that as far as the easily foreseeable future is concerned, we cannot count on any other energy source but uranium and coal. Our oil production, which now furnishes the largest portion of our energy needs, is decreasing; the more recent official estimates are almost as pessimistic as those of the oil companies. And, of course, oil burning also produces sulphur dioxide, although only half as much as coal.

2. As to safety, the first point to be stressed is that not a single member of the public has ever been hurt in a nuclear reactor accident during 2,000 reactor years of experience - that is to say, during the total cumulative operating time recorded to date by all the world’s uranium-powered installations. Even among workers inside nuclear power plants, only 900 man-days a year are lost through on-the-job accidents, as against 9,000 in coal-fired plants.

   Another fact that is not well understood is that it is simply impossible for the kind of nuclear reactor now in operation to “blow up like a bomb,” It uses a fuel which contains only a small fraction of the special kind of uranium employed in weapons and the resulting mixture cannot explode. The most serious accident that could occur in a light water reactor would be a loss of the coolant that could lead to a "core melt," which could release dangerous amounts of radioactive materials into the atmosphere or conceivably - if the reinforced pressure chamber containing the uranium fuel core were also to give way - into the ground and ground-water underneath the plant.

But it is precisely in order to guard against this hazard that an emergency core cooling system (ECCS) has been built into the design of U.S. reactors.

3. The problem of the disposal of radioactive wastes likewise needs to be put into perspective. If all America's power were to be furnished by nuclear reactors - and nobody expects or wishes this to happen - a year's total accumulation of such wastes would amount to about half a cubic inch-one cubic centimeter - per person, and one year after the removal from the reactor would have a heat production a bit less than one watt. It remains true that some of this material is a very severe poison-and will have to be kept from contact with people for a very long time, but safe methods of accomplishing this purpose can be found. The point is that the waste disposal problem is not actually so massive or insoluble as it is sometimes made to appear.

4. Finally, I would concede that the most serious criticism of nuclear reactors concerns the need to protect them against theft or sabotage, against armed attack, and against the diversion of nuclear materials to weapons purposes. Providing physical security against these dangers will require great vigilance and great skill, but it should not be beyond the capacity of governing authorities to do so. Meanwhile, it should be recognized that shutting down all the reactors in the United States would not help us significantly in this respect, as long as nuclear power plants continue to operate in other countries. It is also worth remembering that men bent on evil may acquire for their purposes other materials, such as botulin or typhoid bacteria, that are more poisonous per unit weight than plutonium.

These are some of the factors that have entered into the conclusion expressed in the Scientists' Statement on energy Policy that "Nuclear Power has its critics, but we believe they lack perspective as to the feasibility of non nuclear power sources and the gravity of the fuel crisis." Or to put it another way, in

> the words of the director of the U.S. Energy Research and Development Administration (ERDA), "The Potential of nuclear energy is too great and our future energy needs are too demanding to let our determination now flag because of the problems remaining to be overcome."
>
> Let us not forget, either, that nuclear power plants have not caused any fatalities or debilitating sicknesses so far - nothing comparable to the coal miners' black lungs.
>
> On any scale, the benefits of a clean, inexpensive, and inexhaustible domestic fuel far outweigh the possible risks. We can see no reasonable alternative to an increased use of nuclear power to satisfy our energy needs.

Wigner went on to argue that all the dangers pointed out by Urey and others are either phantom scares or insignificant ones. He went on to compare them to those who opposed rail roads, automobile, electric lighting, airplanes... etc. He argued that "even if the United States met all its energy needs from nuclear plants, the amount of radioactivity they would emit in normal operation would be about as dangerous to an average citizen as smoking two cigarettes in the course of an entire life time." He also rejected the possibility of nuclear accidents. "The waste disposal problem is not actually as massive or insoluble as it is sometimes made to appear" he argued further. The Director of US Energy Research, Development and Administration proclaimed: "The potential of nuclear energy is too great and our future energy needs too demanding to let our determination now flag because of the problems remaining to be overcome."

These arguments of Wigner and Co. had been profusely used by the protagonists of nuclear power in Kerala, during the period of Silent Valley polemics in their opposition to thermal power which, they argued, would release more radio activity than nuclear stations and that nuclear reactors are as safe as 'match boxes'. The people of Kerala were not so naive as to believe them. They rejected nuclear stations. A few years later 'Chernobyl' proved that their decision was wise. I have quoted from Wigner's and Urey's documents so extensively only to show that the current Indian debate is almost the same. Wigner, being a physicist can be excused of his ignorance about safety, but not Abdul Kalam who is an engineer. As Alvin

Weinberg observed: "We nuclear people have made a Faustian bargain with Society. On the one hand we offer - in the catalytic nuclear burner - an inexhaustible source of energy. But the price we demand of the society for this magical energy source is both vigilance and longevity of our social institutions that we are quite unaccustomed to.... The society must take a choice, and this is a choice that we nuclear people cannot dictate."

Unfortunately this is exactly what is taking place now. Not only the nuclear people, but also the ruling political people. They misguide, they dictate, they blackmail. The people have to assert their choice.

Civilian protest in USA, however, against nuclear power expansion succeeded. The struggle was initiated not by scientists, but by informed lawyers and other citizens, and was supported only by 'citizen-scientists'. As mentioned earlier, the first cry was uttered by Goffman and Tamplin through their disclosures of much larger harmful effects of nuclear radiation through the publication of their two books, *'Poisoned Power'* and *'Population Control By Nuclear Pollution*.' The citizen's concerns were aroused by the reports of earlier undisclosed nuclear accidents resulting in releases of unacceptable quantities of radioactive material. A decade and half long debate and protestations including litigations ensued. Many scientists like Harold C. Urey joined the people. In the end, the US government decided to stop the nuclear power programme. Since 1978 the US has not built any new nuclear power station. Even the sanctioned and partly constructed ones were converted into thermal stations. Afterwards, only now they have again come up with nuclear proposals. US is the only major country which refused to sign the Kyoto Protocol, to reduce the emission of green house gas. For long the US government had been trying to 'manufacture' an alternative view that there is really no global warming taking place and that it is all a fiction. Having failed to obtain any credible support to such an argument, it used the universal concern about global warming, to blackmail the people of US, to bring back the nuclear power programme. There are other economic reasons too. It has a large reserve of nuclear manufacturing capacity with firms like General Electric, Westinghouse etc. which has to be made use of. It has, also a substantial quantity of highly enriched uranium and plutonium. With the collapse of the socialist block and melt-down of the cold-war situation, there is no longer any need to increase the stock of bomb grade material. It can make excellent additive to enrich natural uranium for BWRs and PWRs. So an expanding market for BWR/PWR is doubly welcome. This, arch commercial interest, could be the reason for the awakening of new interest in nuclear power.

Initially the major accident in the US's ' Three Mile Island' reactor in which only by luck a core melt down situation did not arise and later the much larger blow up of the Chernobyl reactor in USSR opened the eyes of people the world over. It became clear that nuclear reactors are not as safe as match boxes, as many protagonists of nuclear power argued. Several studies have been done on nuclear reactor accidents and uncontrolled release of radioactive materials. Not being directly felt like heat, pain or smell, citizens don't even know that they have been subjected to radiation. The nuclear establishments too are not very much anxious to inform the public. There has always been an element of opaqueness in everything related to nuclear programmes and establishments. Popular protests were gathering momentum the world over. However, they were not successful in Japan and in many European Countries. France and Japan went nuclear in a large way. So did many former socialist East European countries. Today more than 75% of France's, and Lithuania's too, energy production is from nuclear power stations. In Japan it is more than 30%. However, Japan had to review the entire nuclear programme after the Fukushima disaster. It has initiated a "go slow" programme in nuclear power. The world average share of nuclear energy in the total energy production has been about 16% and that of installed power 8% for the past twenty years and the prognosis for the coming two decades is a global decline in the share of nuclear energy, particularly so, for Europe and North America as seen from table 4. After Fukushima there is a further revision downward.

Currently there are about 440 commercial power reactors operating in the world. Some of them are more than four decades old. Some are recent. They vary very much in design concepts. New Reactor concepts have been developed and are getting ready for implementation. Even more exotic designs are on the table.

The question however is: are these 'new generation' reactors any safer? Experience so far does not encourage us to believe them. Three Mile Island and Chernobyl were not the only accidents that have taken place in nuclear industry. The

Sellafield reprocessing plant in UK, the Monju breeder reactor in Japan, the Japanese reprocessing plant at Tokaimura... One can name any number of them. Wherever people work they make mistakes. And they can be fortunate that the chain of errors, invariably called inexplicable, does not always produce consequences as grave as Chernobyl.

Safety continues to be a critical issue for nuclear reactors. There are no "inherently safe nuclear power plant", no "walk away" reactor as the Americans called them quarter of a century ago. The Vice President of a US vendor at that time is quoted "Even if the worst of all conceivable accidents take place, you could go home, eat lunch, take a nap and then return to take care of it without the slightest concern or panic." This was before Chernobyl and Paks.

True, reactor operators have learned from mistakes and have benefited from advances in technology. But, unfortunately reactors won't become safer as they grow old. The global reactor fleet is "ageing". Corrosion, radiation damage, and fissuring, of both surfaces and welded seams of central components have taken place. Serious accidents are often avoided because damage is discovered in time due to routine checks during down time and repairs and often, by chance.

The average age of the currently operating reactors is about 25 years. At the time of their construction it was often assumed that reactors would not operate for more than forty years. However in order to retain the nuclear share of the electric supply and to maximise profits, life extension offers an attractive proposition for the nuclear operators. There are nearly 70 reactors which are more than 35 years old. They are already showing signs of ageing. Plant life extension will allow them to continue for another 25 years, leading to dramatic increase in the overall plant risk.

Reactor pressure vessels, pipelines, main coolant pumps, steam generators, turbines, concrete structures, cables, electronic devices - all are subjected to ageing, increasing the probability of failures and in fact increasing number of failures are getting reported.

A Chernobyl type of explosion with Fast Breeder Reactors could be devastating. Of late, a new form of threat has become real: terrorist attack. Nuclear establishments - reactors and reprocessing plants - form ideal targets for suicide squads. Confessions by two imprisoned Al Quida leaders indicate that nuclear power plants were definitely among the targets considered by the terrorists. According to the statements, of Mohammed Alfa, who later piloted a Boeing 767 into the North Tower of the World Trade Centre, they had already selected two reactor blocks at the Indian Point Power Plant on the Hudson river, located only 40 km from Manhattan. The plan was discarded only because the terrorists feared that a plane headed for the power plant might be blown up beforehand by anti-aircraft missiles. There were even more monstrous plans as admitted by Al-Quida leader Khaleel Sheik Mohammed. It consisted of hijacking simultaneously ten passenger jets with several nuclear plants on the target list. Such attacks have become much more probable after September 11, 2001. None of the four hundred and odd reactors currently operating can withstand a deliberate crash by large jet with a full tank of fuel. Neither is the fuel reprocessing plants or storage establishments, safe. Of course, terrorists need not always take recourse to such extreme steps as September 11. They can use conventional explosives. The attack on World Trade Centre was symbolic - to humiliate the US super power. An attack on a nuclear power station is in fact an act of war. Apart from hitting the generation of power, radioactive contamination of a whole region would possibly entail long term evacuation of hundreds of thousands, if not millions, of people. No other attack would have a comparable psychological effect on any society. Increase in the number of reactors and, correspondingly, reprocessing facilities, will increase the probability of such events, especially when the super powers continue such policies of global aggression. Weak and vanquished countries would be driven to walls, leaving them with no option other than terrorism.

There are other problems too. Even if we assume that the international tensions have eased, there is the problem of ultimate disposal of radioactive waste. In the sixties and early seventies, people were not much bothered about this. The famous physicist-philosopher Carl von Friedric Weizsaker is reported to have observed in 1969. “It wouldn’t be a problem at all. I have been told that all the atomic waste that would accumulate in Germany until the year 2000 will fit in a cubic container measuring 20 meter in size. If it is well closed and sealed and placed in a mine we can hope to have solved the problem” But others were not so optimistic and naive as Weizsaker. The question of whether radioactive wastes can be safely isolated from the biosphere for hundreds of thousands or millions of years is ultimately philosophical.

Gradually and belatedly, the major nuclear - power producing countries are reaching the conclusion that selecting a final disposal site is more than a scientific or technical problem. Final disposal plans in Finland and the USA are relatively far advanced at present. The gigantic facility at Yucca Mountain in Nevada, however, has been the object of controversy for decades and has been abandoned, for the present.

Uranium mining poses yet another problem. Mining brings to the surface radioactive material which has been lying far below, well shielded by tens and hundreds of meters of soil. Thousands of miners met painful deaths from lung cancer after years of heavy labour in poorly ventilated, dusty tunnels contaminated with radioactive argon. Some of the hardest hits were those at the East German “Wismut” facility which at times employed more than 100,000 people. If the proponents of nuclear power succeed in “selling the fear of climate change” and get popular approval of the people to increase the share of nuclear power across the globe to about 20% it will have the following consequences:

- Adding a very large number of new sites for potential reactors throughout the world;
- Creating new targets for military and terrorist attacks in developing and transitioning countries, including crisis areas;
- Greatly intensifying the final disposal problem as well as the danger of unmonitored nuclear weapons in every region of the world;
- Due to scarcity of uranium resources, replacing today’s standard light water reactors, soon and everywhere, by a plutonium-based system, featuring fast breeder reactors and extensive reprocessing, which is vulnerable to catastrophic accidents as well as terrorist and military attacks.

Given the obvious and serious side effects, this type of strategy would make sense only if the energy demands and the climate trajectory could not be countered by other, less problematic means. Based on everything we know, we can say that this is not the case. Realistic estimates show that even ambitious targets of large energy requirements and of greatly reduced green house gas emissions can be achieved without the help of nuclear energy. In fact, the net addition of CO_2 into the atmosphere can be brought to almost by the middle of 21st century if the following conditions are met.

- Expand the use of renewable of sources like solar, wind, hydro and geothermal.
- Gradually reduce the use of oil or gas for transportation through transition to fuel cells as well as reduce the economic necessity of transportation of goods and passenger travel, by restructuring the society and socio-economic system.
- Society learns to distinguish needs from greed; goods with positive welfare values from those with zero (vanity value) or negative (destructive) welfare values and reduce greatly the material throughput in the economy
- To realize this, transit from the competitive market economy (capitalism) to a cooperative solar economy (real socialism)
- Initiate a large programme for carbon sequestration through the route timber immobilized as structural-elements in place of steel; and
- Transition from petroleum to non-timber biomass as the raw material for chemical industry to produce all the goods which have positive welfare values.

HOW MUCH ENERGY WE NEED?

This is a billion dollar question. We, our government, have gladly embraced neo liberalism, not because *there Is No Alternative*, but because they found it. A Desirable *Alternative,* compared to welfare capitalism and communism. Neo liberalism is the new stage of capitalism – speculative or casino capitalism. This is characterized by

(i) Divorce of capital from production process, itself becomes a commodity of trade.

(ii) Transition from a commodity-commodity relationship (barter) to Money-Money relationship (share market) through the C-M-C stage of mercantile capitalism and M-C-M stage of industrial capitalism.

(iii) Uncontrolled growth of corporate power.

It, also maintains the basic characteristic of capitalism – incessant accumulation of capital. This demands continuous increase in the production and exchange of goods. Increased production demands increased availability of energy. Developed countries grow at about 1-2% per annum. Countries like India and China

and, all developing countries are far ‘behind’ developed countries. In order to catch up quickly they require a higher growth rate. India has been growing at a rate of 8% since last decade or more. China was growing even faster. Energy demand too has been growing at a fast rate. Based on the historical experience on the one hand and the declared objectives of maintaining a high growth rate, several estimates have been made on Indians future energy demands. Many of these studies, initiated in 2005, had a 25 year perspective and thus have estimated the expected energy demand in its various forms up to 2031.

An expert committee appointed by the Planning Commission submitted a report called Integrated Energy Policy in August 2006. As the title suggests it integrated a variety of sources of energy and also ways of energy savings, both electrical and heat, both commercial and non commercial under different rates of growth and differing relationship between energy and GDP. For our present purpose the very many details given in the report and the variety of choices discussed are not relevant. Gross tendencies will suffice our purpose. We are, also, not unduly worried about carbon emissions. We know that, unless the industrially advanced countries change the trajectory of their development and bring down their carbon emission rates, which they have not succeed even two decades after Rio Earth Summit what ever reductions we make, with substantial economic and social sacrifices, are of no avail as far as climate change is concerned.

Table 2.5 of IEP gives projection for Electricity Requirement based falling elasticity – meaning there by that as time goes on one unit of electricity will generate more and more value. Currently it is in the range of Rs.200-250 per unit of electricity ($ 5/KWh)

Table 6

Projections for electricity Requirement

Year	Billion kWh				Projected Peak Demand (GW)		Installed Capacity Required (GW)	
	Total Energy Requirement @ GDP Growth Rate		Energy Required At Bus Bar @GDP Growth Rate		@ GDP Growth Rate		@ GDP Growth Rate	
	8%	9%	8%	9%	8%	9%	8%	9%
2003-04	633	633	592	592	89	89	131	131
2006-07	761	774	712	724	107	109	153	155
2011-12	1097	1167	1026	1091	158	168	220	233
2016-17	1524	1687	1425	1577	226	250	306	337
2021-22	2118	2438	1980	2280	323	372	425	488
2026-27	2866	3423	2680	3201	437	522	575	685
2031-32	3880	4806	3628	4493	592	733	778	960

The Ministry of Power has a different estimate

Table - 7

Projection for Electricity Requirement by MOP

Year	Billion kWh		Installed Capacity (GW)	
	8%	**9%**	**8%**	**9%**
2006-07	700	700	140	140
2011-12	1029	1077	206	215
2016-17	1511	1657	303	331
2021-22	2221	2550	445	510
2026-27	3263	3923	655	785

2031-32	4793	6036	962	1207

Table below gives one possible scenario of obtaining the energy required as per table. 8.

A more detailed analysis consisting of 11 scenarios is given in table 3.27 of the said report. Of these two scenarios coal dominant one and a forced nuclear one are given below.

Table-8

Source	Coal dominant %	Forced nuclear %
Oil	25.7	25.8
Gas	5.5	5.5
Coal	54.1	52.9
Hydro	0.7	0.7
Nuclear	4.0	5.2
Renewable	0.1	0.1
Noncommercial	9.8	9.8

With Koodamkulam, Jaitapur and the rest. With all the lakhs and lakhs of crores of rupees spend on nuclear energy, the difference it makes is only an increase of 1.2% in total energy and reduction of coal by the same percentage. Is it worth the responsibility of having to keep hundreds of tonnes of dangerously radioactive nuclear waste under safe custody and live under the threat of Chernobyl's and Fukushima's. People have to decide – not the Ministers and bureaucrats.

Table 9 of IEP report gives details of generation capacities and load factors of different components under the following conditions: Nuclear, hydro, gas and renewable with increased coal efficiency, transport efficiency and increased share of railways.

Table – 9

Generation Capacities and Load Factors in scenario 11

Source	**Capacity (MW)**	**Plant Load Factor (%)**
Coal	269997	67
Natural Gas	69815	27
Coal Bed Methane	27778	36
In-situ coal Gas	22222	36
Nuclear	63060	68
Hydro	150153	30
IGCC Pet coke	3137	68
Wind-Onshore	32141	20
Wind-Off-shore	1200	25
Biomass Gasification	1200	75
Biomass combustion	50000	70
Solar	10000	17.5
Total	**700703**	**50**

This demands an installed capacity of 700,000 MW by 2031, a four fold increase from the present 150,000 MW. The estimates of Ministry of Power is even more – 960,000 MW.

Though nuclear energy can make only a modest contribution over the next 25 years, longer term consideration of even a modest degree of energy self-sufficiency suggests the need to pursue the development of nuclear power using Thorium. Despite the many delays and disappointments in achieving set targets of nuclear energy development in the past, this is an option we cannot afford not to pursue. Today the PHWR is economically competitive with coal-based plants at certain locations.

If the import of 6,000 MW of LWR reactors does not materialize, the installed nuclear capacity by 2031-32 will be 48,000 MW instead of 63,000 MW. The impact on the various scenarios will, however, be marginal and none of the policy conclusion would be affected. We have not depended on large scale import of LWRs due to the uncertainties involved. Imported LWRs could be an important option if the FBR and Thorium reactor routes not materialize or are found to be uneconomical. Energy security concerns may leave us no option other than full pursuit of the FBR and thorium routes.

> The optimistic nuclear development scenario as envisaged is contingent on 6,000 MW of additional import of LWRs whose plutonium could be used in FBRs along with the plutonium from the 10,000 MWe reactors using our own Uranium. Import of the additional 6,000 MW of LWRs (and associated fuel) depends upon the handful of countries constituting the Nuclear Suppliers' group (NSG). If the sanctions by the NSG are removed and India is able to import Uranium and nuclear power plants, nuclear power can play a much bigger role in the power sector. The capacity growth then would not be constrained by Table 3.4. However, if energy security concerns are our primary driver towards nuclear, then import of LWRs, even though more economical, may have to be limited to restrict our dependence on energy imports.

This is the scenario drawn up to 2031. Dr. Manmohan Singh made some alterations in this scenario. Instead of 6000 MW of light water reactor (PWR) he is contemplating an import of 14,000 MW in the coming five years and more in subsequent years. This is presumably, to build a larger Plutonium base for breeder reactors. However the delay – more than three decades – in the development of first stage commercial fast breeder reactors did not arise from shortage of plutonium, but from technological difficulties, the same difficulties which forced even the advanced countries, to shelve fast breeder reactor programme. We could have easily built up a much larger plutonium base, if we had accelerated the construction of natural uranium heavy water reactors, in which we are fully self reliant and self sufficient.

For the past decade and half the US and EU have been pressurizing India and China to go nuclear, in the name of carbon emission. They are using blatantly absurd and arrogant arguments that as a 'country' both India and China are releasing as much carbon as US and they should be compelled to bring down their emission! Since they have a military power with which we cannot compete and since the ruling class in India has destroyed India's moral-ethical power to resist them, we are in a difficult situation. To close their eyes on the fact that India has a population of 1310 million compared to their less than 300 million and that India's per capita emission is less than one fifth of US emission, is a sheer act of arrogance. They want India to cut down It's fossil fuel consumption because,

(i) An energy insecure India is more pliable to their manipulations

(ii) They have an excess of bomb grade uranium which they want to sell after mixing with natural uranium, to 2-3% enrichment level.

(iii) They can make India totally dependent on them by withholding fuel supply – they don't care for agreements.

(iv) They don't want India to compete with them in the oil and gas market.

The only rule which US follows is "Might is Right". They have interfered in the internal affairs of almost all countries in the world with the arrogant argument that "US has given to itself the right to intervene in any part of the world if it feels that its interests are under threat." The wordings of their act may be different, but the spirit is not.

One cannot expect anything better from a country whose history starts from barbarian occupation of the land by the vagabond and criminals of Europe, and the most savageous extermination of million and millions of the indigenous population. The USA is a country born out of violence, brought up through violence and living in violence. With the disappearance of former USSR, they have no more anyone to fear. Still, they do not dare to occupy rest of the world as they did America. They have learned their lessons in a hard way from Vietnam. But, now they don't have to. The elite ruling class of India has become their colleagues and the hippocratic middle class, their allies. The poor and very poor in India, who form the majority, more than 70%, has to oppose this sell out of the country. **They have nothing to lose except their poverty**. Even if not a single megawatt more of nuclear power is built in India, the majority does not have anything to lose. It is not shortage of power or energy that has denied them access to energy, but because they have been kept away from it by the arrogance of the rich and middle class. The energy (electrical) content of the food the poor eat, the cloths they wear, the house in which they live, the travel they make, the industrial products the consume is but a tiny fraction of what the rich consume. Just as the income inequality increases with "progress", so is the case with energy inequality, the energy Gini Coefficient increases continuously.

Just as we demand that the process of economic development should be so chosen so as to selectively favour the poorer half, ensuring them a faster growth rate, we also demand a process of energy development which provides selective advantage to the poor and deny the same to the rich. The current energy development programme of the Government of India with super nuclear stations and super thermal stations does exactly the opposite. It hands over the total control over energy to a limited few. The energy from these power stations will not light the homes of the poor, turn their fans, or run their pumps. It will convert the nights of cities and super cities into days, will run the vehicles of the rich at lightning speeds, it will provide them with palatial houses, it will provide them with myriads of goods which the poor can never afford it helps them to exploit the limited resources on the earth faster and faster and commit the future generation to barbarism and even extinction.

This is not fantasy, this is not scare mongering. This is a highly probable scenario drawn by scientists. The question is not limited to the dangers of the nuclear energy. In fact they became less dangerous if we follow the current path of development, less dangerous because we won't be there to face the danger. The species may become extinct or survive in very small numbers as barbarians. This is what Rosa Luxemburg had pointed out more than a century ago: the 'natural' outcome from capitalism need not essentially be socialism, it could be barbarism.

So, the discussion on whether nuclear energy is a "gateway to a prosperous India" or to a "disastrous future" should be conducted under two possible trajectories for the future: one a BAU (Business as Usual) trajectory of growth, faster growth and trickling down effect and a second one which redefines development and progress in a totally different way.

BAU Model of Development

1. In this model development means 'growth' a continuous increase in production and exchange of goods and services. It will consciously try to increase your consumption of electricity, fossil fuels, metals etc; it will make it necessary for you to travel and transport over longer distances, at far higher speeds; it will make you to produce and desire more and more; it will make you feel that amassing wealth

is a virtue; it will made you feel that sharing and caring is a weakness inherited from the past and has to be shed of.

2. It will increase the rate of extraction and conversion of non-renewable natural resources till they are exhausted and will take you to the point of the eco-catastrophe of the type indicated in the studies of the Club of Rome (*Limits to Growth 1972*, *1992 and 2002*). There are many who sincerely believe that the scenario pointed by the Club of Rome reports, though scientific is unnecessarily pessimistic. Humans are intelligent beings. They will, with the help of science and technology eventually discovers ways and means to avert such a catastrophe. We have always done it and we can do it again. For example, they argue that petroleum can be replaced by renewable bio-diesel and ethanol. They don't care to make any quantitative assessment. Nor are they bothered about the food for the poor majority. Perhaps they believe in the dictum of 'survival of fittest' and argue that the poor are not fit and shall not survive. But the poor majority may decide otherwise.

They are victims of a most sophisticated science superstition. For example, Bjorn Lomborg[2] wrote in a frighteningly referenced (more than 3200 references) book called *The Skeptical Environmentalist*: (Cambridge Universal Press, 2001).

> "Thus, this is the very message of the book: Children will live longer and healthier, they will get more food, a better education, a higher standard of living, more leisure time and far more possibilities – without the global environment being destroyed. And that is a beautiful world"

This is a beautiful dream which all of us wish to become true. But the condition is that the global environment should not be destroyed. The catch comes in from his assertion that the global environment under the neo-liberal dispensation, is in fact improving. Concluding part II of the book he writes.

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[2] Bjorn Lomborg is an Associate Professor in Statistics in the Department of Political Science in University of Aarhus, Denmark. He was formerly a member of Greenpeace. He became critical of the way in which many environmental organizations make selective and misleading use of the scientific evidence.

"We have many energy resources that can last far into the future. At the same time we have access to renewable energy resources which are getting ever cheaper, and these renewables can potentially supply us with much larger amounts of energy than are used today. We could produce the entire energy consumption of the world with present-day solar cell technology placed on just 2.6 percent of the Sahara Desert, and we have good reason to expect that these energy sources will be near-profitable or even underbid conventional energy production within the next 50 years.

Our consumption of the essential resources such as food, forests, water, raw materials and energy seem to have such characteristics that it will leave the coming generations not with fewer options, but rather with ever more options. Our future society will probably be able to produce much more food per capita, while not threatening the forests – or perhaps even allowing us to allocate more space and money to reforest the Earth to achieve higher living standards. Our energy consumption is not limited, in either the short run or the long run, when the almost unlimited source of solar energy can be harnessed. The evidence does not seem to point to tight limits on resources such as water and raw materials, and with sufficient energy in the long run both can be available in the necessary amounts. Consequently, there does not seem to be any foundation for the worried pessimism which claims that our society only survives by writing out ever larger checks without coverage.

The World Bank defines sustainable development as "development that lasts." In this respect our society certainly seems to be sustainable.

But although we not only uphold but also are likely to improve our immediate welfare, this is not enough to make society better for our children. It is possible that we pollute so much that we are in fact undercutting our life, our long-term welfare and the opportunities for our future generations. To this problem we shall turn next.

In part IV of the same book he continues:

"As emphasized by the World Bank, growth and environment are not opposites – they complement each other. Without adequate protection of the environment, growth is undermined; but without growth it is not possible to support environmental protection. The World Bank points out: "The key is not to produce less, but to produce differently. This is precisely what new technology has allowed the developed world to do. And it is precisely what it is increasingly allowing the developing world to do also.

"Unfortunately the myth lives on in many places. In a long litany of worries, published in the American Journal of Public Health in 1999, it is stated quite casually how personal health problems are turning into public environmental issues. "As communities discover toxic waste dumps, polychlorinated biphenyls (PCBs) in their rivers, and acid rain destroying their forests. Likewise, the Danish daily *Politiken* recently wrote, briefly and to the point: "Sulfur in the atmosphere produces acid rain. And acid rain kills forests.

Simple. But not borne out by the evidence."

"Summing up, rivers probably experience better water quality as income increases. Certainly, we have seen dramatic increases in the oxygen levels of the Rhine, the Thames and New York Harbor. This tendency towards improved oxygen levels has also been confirmed when analyzing more than 200 European rivers. Moreover, general silt measures for both the UK and the US show better river water quality. Persistent pollutants in fresh waters have been decreasing dramatically. When measured nationally through fish in the US or through herring gull eggs in the Great Lakes, pollutant concentrations have declined 80-90 percent.

"We have seen how human progress has been phenomenal. We have seen that whether we are talking about food, raw materials or energy, no shortages of resources seem to be forthcoming; no serious problems for the continued growth of production and welfare are in the offing. In Part IV we have seen that problem with pollution do not give us reason to believe that economic growth is in the process of destroying the Earth – rather the contrary. As far as the vast majority of significant areas are concerned, we have reduced pollution and increased environmental quality. On this front too, the world has become a better place in which to live."

Regarding our chemical fears Lomborg writes in Chapter 22:

“The consequences in terms of cancer frequency could be significant. The World Cancer Research Fund study estimates that increasing the intake of fruit and vegetables from an average of about 250 g/day to 400 g/day would reduce the overall frequency of cancer by around 23 percent. The American average intake of fruit and vegetables is about 297 g/day. Thus, a decrease of just 10 percent in fruit and vegetable consumption in the US because of higher prices would cause an increase in cancer of about 4.6 percent of the total number of cancers or some 26,000 surplus cancer deaths in the US. Moreover, other studies seem to indicate that death rates from non-cancer diseases such as ischemic heart disease and cerebrovascular disease would also be substantially increased.”

Thus decrease in use of pesticides will in fact increase cancer death. A clever argument!

He concludes Ch. 23 on biodiversity thus:

> “Of course, losing 25 percent of all species would be a catastrophe by any standards. However, losing 0.7 percent per 50 years over a limited time span is not a catastrophe but a problem – one of many that mankind still needs to solve. Facing these facts is important when we have to make tough choices, what to do the most good with our limited resources.”- Yes to limit them to the limited rich.

Chapter 24, is the longest one in the book – understandable. In this concluding pages he writes

> “The important lesson of the global warming debate is threefold. First, we have to realize what we are arguing about – do we want to handle global warming in the most efficient way or do we want to use global warming as a stepping stone to other political projects. Second, we should not spend vast amounts of money to cut a tiny slice of the global temperature increase when this constitutes a poor use of resources and when we could probably use these funds far more effectively in the developing world. To give a feel for the size of the problem – the Kyoto Protocol will likely cost at least $150 billion a year, and possibly much more. UNICEF estimates that just $70-80 billion a

year could give all Third World inhabitants access to the basics like health, education, water and sanitation.

"Since cutting back CO_2 emissions quickly becomes very costly, and easily counterproductive, we should focus more of our effort at finding ways of easing the emission of greenhouse gases over the long run.

Yet, one could be tempted to suggest that we are actually so rich that we can afford both to pay a partial insurance premium against global warming (at 2-4 percent of GDP), and to help the developing world (a further 2 percent), because doing so would only offset growth by about 2-3 years. And that is true. I am still not convinced that there is any point in spending 2-4 percent on a pretty insignificant insurance policy, when we and our descendants could benefit far more from the same investment placed elsewhere. But it is correct that we are actually wealthy enough to do so.

And this is one of the main points of this book."

We have quoted so extensively from this single book because it gives "scientific" support to the modern superstition that humans can solve *all* the problems they have created, that the present neoliberal growth model is the best and the only model for the future. He refutes bulk of the scientific community involved in the study of global warming and climate changes. He derides the Kyoto Protocol. Of course the industrialized nations have rejected it already. The Copenhagen and now the Durban negotiation have ended as total failures. The US and EU continue to shout that India and China are bigger culprits.

Under such circumstances the people of India will have to make choices – not only in electing their representatives to the parliament, but also what they should do in the Parliament. In a democracy the citizens have a responsibility – to participate in the decision making processes. Thus we have to decide whether one should follow a BAU trajectory or a different one? What will the new trajectory will look like? What should be the strategy for transition?

There is no reason to suspect that the BAU trajectory will lead to

(i) Exhaustion of fossil fuels in a few decades,

(ii) Exhaustion of many minerals like copper, lead, zinc, tin etc. too in a matter of few decades.

(iii) Continuous accumulation of green house gases in the atmosphere causing global warming and season changes in the climate.

(iv) Reduction in the availability of potable water, and food grains

All these can be presented in the form of a simplified diagram as given below:

In this, the firm line can represent any of the following parameters

(i) Population

(ii) Per capita food production

(iii) Per capita industrial production

(iv) Life expectation

(v) Quality of Life

All these will go an increasing for some time reach a maximum and then collapse rapidly. The time elements would be different for different parameters, but the shape will be more or less the same. The broken line represents pollution load on the earth. This increases continuously. Lomborg has not questioned this curve. He suggests that this shape can be changed, that the ‘fall’ can be avoided and that everything can increase continuously. However no scientist worth his salt, expect perhaps people like Mr. Abdul Kalam will accept this argument. Under neoliberal capitalist dispensation we cannot escape from the logic of this curve.

Taking one single parameter, under the 'growth' model, with 8% growth rate, the power requirement for India will be (with a doubling time of only 10 years).

2031	-	700 GW
2041	-	1400 GW
2051	-	2800 GW

This, simply, is non attainable. Even the projection for 2031-2032, of 700 GW is not attainable; the goal of making electricity available for all will not be achieved, not because there is not enough of it but because the rich and powerful will appropriate it for themselves. Let us make a demand projection based on a set of different parameters like

(i) Universal domestic access to electricity

(ii) Agricultural production

(iii) Producing industrial goods which have welfare value

(iv) Providing various services including travel and transportation

For this we have to disaggregate energy elasticity for different sectors.

1. Domestic Requirement

Under stabilized population situation India will have a population of 1500 million and about 400 million households. With LED lighting system, high efficiency fans, refrigerators, microwaves, induction heaters etc. an all electric home, the average annual domestic demand will be about 2000-2500 units. The maximum necessary electricity per year for 400 million households will be 1000 GU. Assuming an average production of 5000 KWh/Kw (capacity factor 58%) we require a maximum of 200,000 MW to satisfy the ultimate requirement of domestic energy.

2. Agriculture and animal husbandry

India is producing enough cereals and vegetables for everybody. That a great number of people are malnutritioned is not due to shortage of production. In fact there is a lot of over consumption by the minority and they suffer from obesity. The poor suffer from malnutrition because they are poor. In an altered trajectory of development the present inequalities in income will be reduced step by step and poverty will be totally eradicated from the country. That this is possible is proved by the experience of the Hivre Bazar in the Ahmednagar district of Maharashtra under the leadership of Popat Rao Pawar. With some increase in agricultural production all the food needs and fiber needs of the country can be met. Today in agriculture we use energy in a very inefficient way – over fertilization, over watering etc. By adopting scientific precision agriculture, but returning into soil every bit of biomass, including human and animal excreta, necessity of chemical fertilizers and pesticides can be brought to fraction of what is used today. Thus improving end use – crop production – efficiency the energy requirement for the primary sector can be kept at the same level as today or at most up to 20% increase. The current use of electricity in primary sector is 120 GU (giga units). The maximum we may *ever* require will be only 200 GU or an installed capacity of 40,000 Mw (40 GW).

3. Industries

As far as industries are concerned it is a different ballgame altogether. We have basic industries which produce metals, chemicals and other materials; we have industries which produce consumable goods. These goods may be

(i) essential for improving the basic qualities of life

(ii) Essential to produce the so called durable consumption goods like fridge, TV, computer, vehicles etc. the durability of one and the same type of product can vary very widely, often they are made obsolete through model changes.

(iii) We have got hundreds of consumer goods used by almost all of us daily or frequently in our households. We also have myriads of commodities, whose absence hither to have never reduced the qualities of our life, but now made so through incessant aggressive advertisement. These are vanity goods. To make each one of them we spend energy and materials, we produce wastes. We have to become wise enough to say ‘no’ to them.

We can and have to limit our industrial production to what is necessary to improve real quality of life. The maximum we may require for industrial sector, including transport and travel, will be only about 600-700 GU per year or an installed capacity of 120,000-140,000 MW.

4. Service Sector

The demand for electricity from service sector including trading, commerce, banking, entertainment can be limited to about 300 GU or about 60,000 MW installed.

Thus the very long term maximum electrical energy requirement, along a revised trajectory, will be about 2000 GU, at most 2500 GU. This would require the installation of 400,000 to 500,000 MW not by 2031-32, but even beyond.

The trajectory of progress/development we aim is one which.

(i) ensures ever improving quality of life to the entire people, increasing the life expectation to 80 years, reducing morbidity of all kinds, especially water borne and vector borne diseases dramatically through a total sanitation and “waste to wealth” program.

(ii) Enhances leisure time available for all so that they can engage themselves in creative, pleasurable avocations,

(iii) converts the productive labour too into an enjoyable act and

(iv) finally ensures that we pass on this earth, of which we are only beneficiaries, to the oncoming generations in condition better than what we got it, thus ensuing long term sustainability

In order to achieve these goals the society should strive towards

(i) Increasing end use efficiency of energy utilization

(ii) Complete change over to renewable energy sources, mainly the sun and also wind and hydro.

(iii) Develop technologies to recycle completely most of the materials we use as well as change over to renewable resources – mainly biomass for all purposes.

(iv) Expansion of biomass stock to the maximum extent possible and extract the same only at a fully sustainable rate, thus, on the one hand providing raw materials for chemical industry and on the other hand fixing carbon extracted from the atmosphere in the form of structural elements and other artifacts.

(v) Change over from a cereal dominated diet to the original human diet of fruit, root and meat

(vi) Develop local economies continuously to such an extent that compulsory travel of people and transport of materials is reduced to the least possible and so obtain more time and resources for pleasure travel.

(vii) Global exchange of knowledge and cultures in the cyber space so that every human being becomes a global citizen.

Understandably such things will not happen automatically. The momentum acquired by the human species will try to keep it on the existing trajectory. The capitalists will consciously oppose any such change. The humanists have to gather strength and apply force to effect a change in the trajectory. This will take quite some time. So, one can be sure that there will be an interregnum where the present path of development will be continued. One doesn't know for how many years. The humanists have to fight to ensure that,

(i) this will do least harm to the humanity and

(ii) inequality and wasteful consumption is brought down step by step

We have to have an energy programme which matches these requirements. In this nuclear energy is the least desirable one because first and foremost it burdens the posterity with a radioactive load of such a magnitude that is frightening. Two problems have been plaguing the nuclear program since its birth – the problems of long term management of radioactive waste and the problems of decommissioning the old reactors. Eugine P. Wigner wrote in his letter to the US President in 1974: “the waste disposal problem is not actually so massive or insoluble as it is sometimes made to appear”. Mr. Abdul Kalam echoed the same sentiments in his Hindu article. Unfortunately, the problems are serious. It has been defying solution for the past four decades in spite of best brains working at it. All the waste so far generated, from the four hundred and odd reactors including the very first reactors still await a scientific burial. They are still under “safe custody”. To keep them under safe custody is expensive. Practically none of the power reactors or even research reactors have been decommissioned, demolished and the site cleared of radio activity. When they had done, like in Chernobyl, it was entombment. That is not scientific decommissioning. In order to postpone the D-Day, the nuclear establishment is prolonging the operational life of many reactors far beyond what it was designed for. This is increasing the probability of technical failures due to operational fatigue. The major accidents of Three Mile Island, Chernobyl and Fukushima did not take place because of design flaws. They occurred because of human errors and natural disasters. Now we are entering an era of ageing reactors and routine incidents can become more serious accidents – increasingly so.

The Tarapur reactor 1 and 2 are 42 years old. They are designed initially for 30 years life time. After some years, because of technical problems, they had to reduce its production capacity – de-rate it – to 160 MW from 220 MW. Sooner or later we will have to close it down. We can remove the fuel assemblies to the reprocessing plant. But the entire site will remain a source of radiation. It has to be kept under constant surveillance. This costs money, without any returns.

Real nuclear accidents – they are yet to take place – can be much more disastrous than those we have seen, especially if fast breeder reactors become common.

FALLACIOUS ARGUMENTS

Even if all the other claims about the superiority of nuclear energy are true, this sword of Damocles hanging over our head is sufficient to keep us away from the nuclear option, as was argued by Harold C. Urey four decades ago. Not only that. All the claims advanced by the protagonists of nuclear energy like the Chairman of DAE, the Chairman of NPCL, the Prime Minister of India and the former President of India, all of them are wrong too. They argue that

(i) nuclear energy is cleaner

(ii) nuclear energy is cheaper

(iii) nuclear energy is abundant and it paves a way to fossil fuel free India

(iv) That thorium offers us the possibility of becoming the world's energy capital.

None of this is true.

Nuclear Energy is not cleaner than coal fired power stations. The sooty, black smoke emitting power stations are old time things. Modern thermal stations are as clean as nuclear stations. The CO_2 they emit is bad. But what we in India emit is a pittance compared to what is being emitted by developed countries like USA, EU, Japan and Australia. Finally CO_2 can be sequestered back from the atmosphere and fixed in timber structural elements, with a concerted effort. Radioactivity is long acting. Its deleterious effects cannot be reduced by any chemical or physical means. Large scale expansion of nuclear power, especially fast breeder reactors will increase the frequency of large scale uncontrolled release of radioactive material to the environment. The accumulated wastes of nuclear stations are extremely dirty. They are to be kept under total surveillance. Accidental releases can be really dangerous. Unfortunately much of the damage is not direct, but through genetic mutations affecting future generations. No. Nuclear power stations are not cleaner than coal fired power stations.

Radioactive Wastes from Nuclear energy get generated at

(i) Uranium ore mining - Low active waste

(ii) Uranium processing and fabricating Plants	- Both low and high active wastes
(iii) Operating Reactors	- Routine and accidentally releases - both low and high
(iv) Spent fuel processing plants	- Very highly active waste
(v) Waste Storage Sites	- Highly active, cooling down as time goes on

Of all these sources more than 85% is the contribution of spent fuel. It contains the highly radioactive fission products, un-burnt fuel, and the activated materials.

There is a common belief that once the plutonium, or for that matter U^{233} is separated from the spent fuel, the remaining waste is safe. Absolutely not. Bulk of the radioactivity resides in the spent fuel and not in un-burnt fuel – U^{235}, Pu^{-239} or U^{233}. The quantity of fission products and the amount of radioactivity depends, directly, on the quantity of energy produced. It does not depend on the reactor design, whether thermal or fast breeder.

The cultivated impression that since the tonnage of fuel in fast breeder reactors is lesser, the quantity of radioactive waste too will less. This is not the case. The quantity of uranium burned (fissioned) for a given amount of energy is same both in thermal and fast reactors.

As on today there is no scientifically agreed upon method for immobilizing spent fuel waste, without constant surveillance: India will be generating more and more spent fuel waste –even after fissile material recovery – as we produce more and more units of energy from reactors.

This is not a wise option, especially when there is no TINA situation. There are enough and feasible alternatives.

Nuclear power is neither cheaper. The capital cost today is about Rs.20 crore per megawatt. In a fully nuclear system one cannot accept a PLF (Plant Load Factor) higher than 55-58%. At 10 percent interest and depreciation rate the capital cost alone comes to Rs. 4 per unit. Add to this the fuel cost, the O and M cost, the spent fuel storage and surveillance cost and the decommissioning cost, which could be as high as the construction cost – then you get the real cost of nuclear energy. Private Insurance Companies refuse to insure against nuclear accidents. It is this fact that actually tipped the decision against nuclear power programme in the USA. Knowing this the US government had insisted when the 123 agreement was signed that the Government of India will enact a bill limiting the liabilities of supplier companies to a paltry sum of 100 million dollars, where as the actual damage may go up to the tune of several billion dollars. Later Dr. Manmohan Singh limited these liabilities to the first five years of operation. Defects come up only when the reactors have operated for a certain length of time. By that time, however, the suppliers are released from their liability. The entire cost will have to be born by the Government of India, that is by the people of India. What the US government was not ready to do in 1978, it is forcing the Government of India to do and it is doing that willingly. This is plain cheating. There is no other word for it. We saw the horse trading drama enacted in the Parliament on 22nd July 2008. The people, not knowing the treachery, and not having any other viable option, gave him a further mandate. He is using this mandate diabolically against the interests of the people and in the interests of Areva Company. The people are forced to pay the price for their folly of re-electing him.

Nuclear energy is not abundant either. The prospect of a *fossil fuel free India* as dreamt by Mr. Abdul Kalam is stretching the imagination too much. Theoretically we can enlarge the installed capacity of thermal neutron reactors even beyond 10,000 MW, through import of enriched Uranium as India has now decided. But there are competitions - especially from China. The prospects of uranium fuelled thermal reactors is limited, may be to 20,000 MW or at most 30,000 MW. This is less than 5% of the demand projected for 2031-32. It is peanuts. Nuclear power can be said to be really abundant only when Thorium-Uranim-233 fast breeders become a commercial success. But there are too many hurdles to cross. The global scientific community does not yet believe in it. Wild dreaming is the nature of our nuclear experts. Dr. Bhabha, announced in Geneva in 1955 itself that commercial fusion reactors will be a reality in 20th century itself. Even today nobody is still confident of the possibility of fusion reactors. There is a powerful fusion reactor operating far, far way, about 150 million kilometers away – our sun. We can make use of the energy it emanates. To build miniature Suns on our own terrafirma is still only a dream. Before its realization we have to pass through an intermediate stage of thorium-plutonium fast breeders and even an earlier stage of Uranium-Plutonium fast breeders. We are yet to commission the Prototype Fast Breeder Reactor. We may be able to do it in 2012. Let us wait for the PFBR to be operationalized. Before that we should not proceed on the assumption that it will succeed and all the subsequent stages too will succeed. The abundance argument cannot be taken seriously for another two or three decades, before we get enough operating experience on PFBR. The Thorium-U-233 system is beset with a number of physics and technology problems. Even today there is no conceptual clarity about how to overcome them. Perhaps they could not be solved at all. It is too early to build dream castles based on abundant availability of thorium.

Because of all these factors it is wiser, and in the interests of the nation, to review the entire nuclear programme, and stop proceeding further before things become clearer.

(i) We shall stop the construction of all new nuclear reactors, forth with, till there is an accepted solution to waste disposal.

(ii) Even Koodankulam station could be modified to use steam turbines and normal coal fired boilers. Later it can be switched over to reactor-boiler system when reactors are proved to be safe and cheap and wastes so far generated are permanently disposed of.

(iii) Stop construction of Jaitapur as well as all other new units in old sites which too can be converted into coal fired thermal stations.

(iv) Commission the PFBR and obtain its operational experience.

We can restart the nuclear programme once we have disposed off bulk of the accumulated nuclear wastes world over, permanently and the PFBR becomes a full success.

IMPACT OF A NUCLEAR HOLIDAY

In spite of massive protests by common people not only in Jaitapur and Koodankulam, but also from all over India, as well as a large section of the scientists, the Government of India has signed an agreement with Areva to purchase 6 reactors of 1650 MWe each at an exorbitant cost of more than Rs. 2 lakh crores. The people are told that this reactor has such design features which will make it absolutely safe. It is called as a Generation III plus – design developed over past 15 years, based on the experience of Pressurized Water Reactors (PWR, VVER), Boiling Water Reactors (BWR) and even CANDU (Natural Uranium, Heavy Water). The specific features claimed by them are:

1. Standardized designs for each type to expedite licensing, reducing capital cost, and reducing construction time.
2. A simple and more rugged (?) design making them easier to operate and less vulnerable to operational upsets (like Chernobyl?)
3. Higher availability and longer operating life – typically sixty years.
4. Reduced possibility of core melt down accidents.
5. Minimal effect on environment.
6. Higher burn up to reduce fuel use and the amount of waste.
7. Burnable absorbers to extend fuel life.

All these are very general statements. They are more concerned about quickly licensing and extended of life – both commercially attractive. Basically these are Pressurized Water Reactors of the US and Russian type. The effectiveness of design improvements is yet to be confirmed. There is, still, not a single operating reactor of this design. The first one ever to be ordered by the Finnish government for their 01kiluoto plant is running behind schedule. The technical advantages claimed by them are all yet to be proved. The first set of reactors, with major design changes always have an element of risk built into them.

These reactors are called EPR which in Europe stands for European Pressurized water reactor and in USA, for Evolutionary Power Reactor.

What will happen if we halt the construction of new nuclear power stations including the commissioning of Koodankulam plant? Nothing disastrous. We will be loosing about 4000 MW in all for the coming ten years. This can be easily compensated by enlarging the target of coal burning stations. However, concentrating production in pithead stations can cause unacceptable environmental impacts. So even at the cost of transporting coal we may have to decentralize production. People can decide through a referendum whether they want nuclear power stations/coal burning thermal station/or no stations to supply their increasing demand.

The IEP has given several scenarios of meeting India's growing electricity demand. We assume that no more nuclear reactors will come on grid for ten years to come. Even the PFBR will not be considered as a commercial station. It is a Prototype. We have to learn from it.

There are three broad strategies to be adopted

(I) Supply enhancement

(II) Loss reduction

(III) Demand management

We have to pursue all of them. The extraordinary loss rates reported from the north east could be either bad planning and resulting technical losses or theft leading to commercial losses. One has to differentiate between the two. The technical losses across the nation can be brought down to 15% or less from the present 25% plus. This requires

(i) Sufficient transmission and distribution equipments – transformers, conductors, control systems etc.

(ii) Better planning of distribution systems, limit 440 V lines from any transformer to not more than 500 M, increasing intermediate voltage to 33 KV from 11 KV, enough number of lower capacity transformers etc.

(iii) Good quality workmanship – joints, jumpers, earthlings etc.

Loss reduction increases availability by 15000 MW without adding any carbon foot print. An all out effort to bring down technical losses to 12-15% has to be made. Without that, any talk about increasing production capacity will sound hollow.

On the supply side the following sources can be developed simultaneously. The only limiting factor is resource

(i) hydro
(ii) coal
(iii) wind
(iv) biomass
(v) solar energy

Bulk of the resources set apart of for nuclear stations can be diverted to solar energy harvesting. We can arrive at a better mutual understanding on foreign collaboration, than in the case of nuclear. There is no question of fuel. We can expand our solar panel production capacity several fold and even can become self sufficient.

Hydro

The major issues are environmental impacts, displacement, inter-state and inter country disputes and techno-economic feasibility.

The Government of India together with state governments can plan a massive programme to complete all the investigations of feasible projects, prepare a short DPR on each of them together with environmental impacts, displacement and rehabilitation programme. Let these be debated widely. Based on referenda, in the project affected as well as benefited areas, the decision to go ahead or not can be taken. Objection from PAP can be overcome by ensuring prior rehabilitation to their satisfaction. Environmental impacts are to be taken seriously and decisions are to be taken based on the opinion both of the people and of the scientists, in the background of future energy scenario. Of the 150,000 MW ultimate potential and of the 84,000 MW realistic potential we may be able to take up 60,000 MW in the coming 20 years. This has to be given first choice and resources should be set apart for this.

Coal Burning Thermal Stations

There is no immediate shortage of coal underneath. But their quality is poor and their mining has limitations. Our mining capacity has to be increased. This leads to both environmental problem and displacement problems. The later is more important. The experience of rehabilitation has been extremely bad. The first thing, to be done is to arrive at a rehabilitation package acceptable to the displaced. The second thing is to implement the entire package to the satisfaction of the displaced proper – PAP. Simultaneously environmental impacts too are to be studied. Environmental fundamentalism can become counter productive. One will have to arrive at reasonable compromises. Without a large scale coal based programme India's energy needs cannot be met. Nuclear energy will help little.

Each site has got a definite carrying capacity. It shall not be loaded more. Those who want electricity should also share some of its pollution. It cannot be put on the shoulders of those who live in the vicinity of coal mines alone. Each state will have to find suitable locations, to build thermal stations, to receive and handle and to dispose the waste. Without that the state cannot claim any share of power generated elsewhere. It is better not to load any particular site with more than 2000-3000 MW.

Our BHEL can make all the equipments necessary for both thermal and hydro stations. No foreign power can screw us down. It is a self reliant path.

The long term alternative is solar energy. It may take another two to three decades before it can substantially replace conventional sources – namely coal and gas. Even if we continue a "present rate of growth" scenario, we have enough minable coal for yet other four or five decades to come. Even with the suicidal nuclear option taken by the government of India, the reduction in coal demand will be only 10-15%.We can safely opt for a non nuclear program without any shortage of electricity due to that.

Wind

Wind power farms can be built up at multiple locations, in parallel. Equipment production/purchase is no problem. The entire wind power potential of 60,000 MW can be realized by 2031-'32.

Biomass

Biomass can be used for electricity generation in a number of ways.

(i) Steam generating boilers

(ii) Producing combustible gas in gassifier

(iii) Biomethination

An all out campaign to convert all biodegradable waste into either compost or methane plus slurry is important, also, to recover all the nutrients we have removed from the soil and to put them back. Twigs and other non biomethinatable waste can be burned either in gasifiers or in furnaces.

Solar Energy

THE SOURCE of energy in the long run is the Sun. Capital costs and energy costs used to be exorbitant. They have come down dramatically. If taken up as a massive programme we can bring down the capital cost to Rs. 15 crores per MW with invertors and storage batteries. If we have hybrid systems with biomass gassifiers/methinators as well as pumped storage hydro system the total cost can be brought down to even Rs. 10-13 crores per mega watt. The National Solar Mission has planned about 20,000 MW by 2031. If one divert the entire money set apart for 30,000 MW of nuclear plants to solar we can build, easily 50,000 MW.

There are millions and millions roof tops – many of them belonging to the rich and upper middle class. The National Solar Mission can initiate a programme similar to One Million Roof Top Solar Installations in California. Here it could be 10 million easily – less than 2% of the total roofs. If the NSM aggressively promote a *"going solar"* programe – aggressively with a subsidy of about Rs. 80 to 100 per watt, a large number of them will install one, two or three kilowatt units on their roof tops. Easily one can conceive 10,000 to 15,000 MW of private stand alone roof top installation over a period of 8 to 10 years. Our very many reservoirs can accommodate tens of thousands of MW of solar installations on floating platforms. And there are the Rajasthan deserts and waste lands of Central India. A 50 KM X 50 KM area in Rajasthan desert can produce 75,000 MW of solar power which can be fed into the national grid.

A whole industry, a multibillion dollar industry will get evolved – silicon production, panels, invertors, storage, services…..

Demand Management

As mentioned earlier, if we don't change our paradigm of development to one based on increasing welfare or increasing Gross National Happiness (GNH) as Bhutan puts it, if we continue on the path of exponential consumerist growth, long term plans become insignificant. One can plan not to give electricity to the poor and make more of it available to rich. This planning can be done very cleverly – insufficient distribution systems, permanent low voltage, frequent breakdowns and power cuts – with all these we can reduce the consumption of both rural and urban poor and ensure the supply to "high priority" areas where the rich and the elite live. There are a thousand and one ways to favour the rich. The poor majority has to fight against this. It shall be their slogan that by 2017 at least 70% of all households in India should yet electricity with high supply quality. By 2022 the coverage should reach 95%. We should be able to provide an average of 1000 units of electricity per year for a family of four. This is essential for a good quality of life. However unless we reduce production of vanity goods and destructive goods, which fetch good profit, we may not be able to extend supply to the most poor. The progressive political parties and movements like PSM should carry out, as quickly as possible, an extensive as well as intensive citizen education campaign about the necessity of boycotting vanity goods and services, and about the probable consequences if we don't.

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