Nuclear dilemma: The deal and beyond

K. R. Rao

The Indian Nuclear Power Programme, at present, is based on a mix of (a) imported enriched uranium-based light water reactors, (b) indigenized natural uranium-based pressurized heavy water reactors (PHWRs), and (c) fast breeder reactors (FBRs).

Before going technically heavy, certain basic and fundamental terms and aspects may help to understand and appreciate the underlying issues and technology. Certain heavy elements like uranium and heavier actinides contain a few isotopes that can undergo fission (break-up) when they absorb either thermal (low energy) neutrons or fast neutrons. Fission results in fragmentation of the isotopic nuclei, releasing neutrons and considerable energy. The neutrons that are released, in turn, can be utilized to sustain a chain of fissions in a 'critical' mass of fissile (fissionable) uranium isotopes, ^{233}U, ^{235}U or ^{238}U and isotopes of heavier elements including plutonium, in a proper environment (associated with say, 'moderators' like light water, heavy water, etc. and coolants). This critical mass may be in the form of rods, clusters or other geometrical shapes suitably configured in 'reactors' or in weapon assemblies. Thermal neutrons can be utilized to sustain a chain reaction in ^{233}U, ^{235}U or in ^{239}Pu, whereas ^{238}U needs fast neutrons. ^{235}U and ^{238}U are the only two fissile isotopes presented by nature. They have survived billions of years ever since the earth got formed; other isotopes have decayed during this period into non-fissile or stable isotopes of other elements. Fortunately nature has also provided us with isotopes of certain elements, notably of thorium, referred to as 'fertile' isotopes that can be converted into fissile isotopes of other elements. Specifically, ^{232}Th can be converted into ^{233}U; so also ^{238}U can get converted into ^{239}Pu. Monazite sands, that occur along our Indian coast contain copious amounts of thorium, whereas our supply of uranium is rather limited.

Hence, we have a situation that if we can separate ^{235}U from rest of uranium or produce ^{239}Pu from ^{238}U or produce ^{233}U from ^{232}Th by neutron absorption, we would have 'stockpiled' fissile materials. Availability of ^{233}U, ^{235}U or ^{239}Pu ensures a 'dual' purpose: for production of energy in power reactors or for weapons' production, to meet our 'strategic' needs. (A dictionary defines strategy as: 'a detailed plan for achieving success in situations such as war, politics, business, industry or sport, or the skill of planning for such situations'.) Production and separation of isotopes of fissile isotopes from the rest of non-fissile materials is based on highly technical and complex processes, both physical, as in centrifugal or laser-based separation of fissile isotopes of uranium generally referred to as 'enrichment' process and chemical, as in radiochemical laboratories or in reprocessing plants for separation of plutonium and uranium (^{233}U) isotopes. It is but natural that details of processes and facilities associated with this activity are a closely guarded secret all over the world.

Over the past 50 years, India has had a well thought-out sustained programme developing nuclear engineering in all its aspects. Starting from geological and radiological exploration and mining for uranium, chemical separation of uranium fraction from the ores, the activity has spanned enrichment, fuel fabrication for research and power reactors, reprocessing 'burnt' fuel for plutonium, reuse of such plutonium as fuel in fast reactors and as feed for weapons' research. Finally this 'nuclear fuel cycle' terminates in safe storage of highly radioactive 'waste'. Scaling up from laboratory research experiments to plants that handle tons of highly radioactive nuclear materials is no mean achievement. A large number of heavy water plants, nuclear fuel complexes, reprocessing plants, atomic minerals laboratories, research and power reactors and various research laboratories, all under the Department of Atomic Energy (DAE), dotting the length and breadth of the country is a standing testimony of the efforts and achievement of the scientists and engineers who have mastered the technology *in toto*.

Way back in the 1950s, Homi Jehangir Bhabha outlined the 'three-stage nuclear programme'. He envisaged a power programme using nuclear energy to be self-sustaining, without being overly dependent on foreign sources. The route, he outlined, was to build and operate: (a) natural uranium and heavy water-based reactors in the I stage, incidentally stocking plutonium derived from reprocessed 'burnt' fuel, (b) fast reactors using plutonium-based fuel to breed ^{233}U from thorium in the II stage, and (c) fast reactors using ^{233}U-based fuel and thorium in the III phase, regenerating ^{233}U cyclically for almost endless supply of nuclear power. Each phase demanded high technology inputs as in production of heavy water or mastering liquid sodium coolant technology or handling highly radioactive ^{233}U for fuel production, etc. We are in the II stage in this scenario, although one has to scale up resources; having operated the fast breeder test reactor (FBTR) successfully over the past two decades ('in splendid isolation', as someone stated) the fuel having seen more than 100000 MW-days without any incident, the technology is in our grip. The prototype fast breeder reactor (PFBR), under construction, is to pursue the path towards phase III. In outlining this 3-stage nuclear power programme, it was clear from the beginning that we have rather limited availability of uranium ores in India unlike in some other countries wherein nature has endowed with abundant high-grade ore of uranium. Hence our strategy has been quite different from those of other countries like USA or France, taking into account our geo-political interests also. It was also clear that the technology gestation period involved in going from I stage to III stage was several decades. The only way that this intervening period could be reduced was by importing either uranium or enriched uranium (enriched in ^{235}U)-fuelled reactors; enriched uranium by itself would not have been available unless the country compromised on several basic issues ingrained in our foreign policy. The Tarapur power reactors were the first and last power reactors to have been imported till recently; they were based on enriched uranium fuel, under bilateral agreement between USA and India. After 1974, when India tested its first nuclear 'device', international embargoes came into place limiting not only assured supply of fuel for these reactors but also restricting

access to various nuclear and other materials; affecting many other technological developments, one faced 'technology denial regimes'.

The II stage of power programme has had progress under the constraints outlined above and is bounded by a technical reason; as Lord Walter Marshall of Goring in a tongue-in-cheek statement noted, 'fast breeders do not breed fast'.

To meet the insatiable hunger for power of our burgeoning population, one has to accelerate our nuclear power programme, as other fuels like coal, natural gas or oil are non-renewable, their inventory depleting fast and economically turning out to be far too expensive. Of course, there are advocates of non-nuclear energy sources who compare and comment on cost-issues of nuclear and non-nuclear fuels (see for example, an article in *Economic and Political Weekly*, 23 April 2005). Compared to coal, gas or oil, nuclear fuel wins hands down as energy output per unit mass of the latter is a couple of million times that of any other fuel. This, in turn, therefore is advantageous in that we do not need vast storage depots and road/rail transportation networks, etc. needed for handling the 'fossil fuels'. The share of nuclear energy, at present, in the total energy scenario in India is barely 4%; the planners and the government are keen to increase this share to around 10% by the year 2020. How is this achievable? Either one has to import enriched uranium-based nuclear reactors lock stock and barrel or one has to import enriched uranium and other nuclear materials for fabrication of fuel for some to-be-planned future reactors.

As already stated, fissile materials supplied to any country, can be diverted to 'dual' use. It is because of this, various treaties like Treaty on Non-Proliferation of Nuclear Weapons (NPT), Fissile Material Cut-off Treaty, Proliferation Security Initiative; Comprehensive Test Ban Treaty (CTBT), etc. have been in vogue. Import of uranium or enriched uranium would have been perhaps possible if we had signed NPT and other treaties which would have compromised our sovereign rights to indigenous R&D and growth of nuclear science and engineering to take care of strategic interests. Submitting to 'safeguards' is another issue. The International Atomic Energy Agency (IAEA) has been advocating peaceful uses of atomic energy on one hand and also 'safeguards' on the other.

What is this 'safeguard'? And what are the implications from a layman's point of view? A dictionary definition of 'safeguard' is 'a precautionary measure warding off impending danger or damage or injury, etc.'. According to the IAEA, 'by definition, the safeguards system comprises an extensive set of technical measures by which the IAEA Secretariat independently verifies the correctness and the completeness of the declarations made by States about their nuclear material and activities.' One set of measures referred to as 'traditional safeguards' relates to 'the nuclear material verification activities performed at facilities or other locations where States have declared the presence of nuclear material subject to safeguards'. 'Another set relates to the measures endorsed or encouraged by the IAEA Board since 1992 for strengthening the safeguards system ... A comprehensive safeguards agreement together with an Additional Protocol will allow the Agency to draw safeguards conclusions both about the non-diversion of declared nuclear material and the absence of undeclared nuclear material and activities in that State'. IAEA in 1998, embarked upon development and implementation of 'integrated safeguards', 'in order to achieve maximum effectiveness and efficiency within the available resources'. The IAEA has safeguards agreements in force with nearly 150 States. Nearly 1000 facilities around the world are under IAEA safeguards.

Hans Blix, formerly of IAEA, has noted 'With the development of the safeguard system operated by the IAEA, the world moved from an era when perceptions of national sovereignty resulted in everybody rejecting any international control to a stage when all accept some degree of common control. ... We cannot devise inspection systems that give 100 per cent guarantee about the absence of limited research efforts or absence of equipment or facilities of limited size ... Unfortunately, a system built to be extremely sensitive is also likely to be extremely intrusive and expensive. It may also give many false alarms, which may cause unjustified international reactions. We must settle for something practical. If on the one hand we cannot construct a system that is foolproof, there would be no point, on the other hand, to pay money for an inspections system that is cosmetic; indeed, that would be more dangerous than having no inspection at all because it might lead people to false and dangerous sense of security ...'.

Over several years now, discussions have been taking place between India and the United States on civil nuclear energy co-operation. A major milestone was signing an agreement on 18 July 2005 in Washington DC for giving a concrete shape for implementation of some of the issues. As Prime Minister Manmohan Singh has noted in his *suo motu* statement of 27 February 2006, 'our effort to reach an understanding with the United States to enable civil nuclear energy cooperation was based on our need to overcome the growing energy deficit that confronts us. As India strives to raise its annual GDP growth rate from the present 7–8% to over 10%, the energy deficit will only worsen. This may not only retard growth, it could also impose an additional burden in terms of the increased cost of importing oil and natural gas, in a scenario of sharply rising hydrocarbon prices. While we have substantial reserves of coal, excessive dependence on coal-based energy has its own implications for our environment. Nuclear technology provides a plentiful and non-polluting source of power to meet our energy needs. However, to increase the share of nuclear power in our energy mix, we need to break out of the confines imposed by inadequate reserves of natural uranium, and by international embargos that have constrained our nuclear programme for over three decades'. Continuing he has noted that 'international trade in nuclear material, equipment and technologies is largely determined by the Nuclear Suppliers' Group (NSG) – an informal group of 45 countries. Members include the United States, Russia, France and the United Kingdom. India has been kept out of this informal arrangement and therefore denied access to trade in nuclear materials, equipment and various kinds of technologies'. Over several decades, our record and credibility in non-proliferation is increasingly appreciated internationally, although we are one of the only four countries that have not been signatories of the NPT. To quote our Prime Minister, 'India's impeccable non-proliferation credentials. ... We are among very few countries to adhere to the doctrine of "No first use"'. The Prime Minister, relating to improved perceptions and ties with several nuclear countries, has said the proposed agreement with USA includes 'a positive mention

of possible fuel supply to the first two nuclear power reactors at Tarapur. US support was also indicated for India's inclusion as a full partner in the International Thermonuclear Experimental Research Project and the Generation IV International Forum'. Therefore clearly the agreement entails many advantages to India; however it has to be a win–win situation to both parties. There are certain subtle issues involved in coming to the agreement; one of the crucial issues is related to 'separating the civilian and strategic programme. However this was to be conditional upon, and reciprocal to, the United States fulfilling its side of the understanding'... Extensive negotiations have centered around four 'critical elements'. They are: 'the broad contours of a "Separation Plan"; the list of facilities being classified civilian; the nature of safeguards applied to facilities listed in the civilian domain; and the nature and scope of changes expected in US domestic laws and NSG guidelines to enable full civilian nuclear energy cooperation with India'.

There have been a variety of comments and concerns articulated by many nuclear experts, other professionals, journalists and media commentators and analysts on the entire nuclear issue, especially about the separation plan. Some would say that what is involved is to pull India out of 'nuclear apartheid' state-of affairs. In an edit of *Indian Express* (23 January 2006) titled 'Atomic lethargy', there was reference to the so-called nuclear mess: 'it (DAE) neither has a successful civilian nuclear programme nor a purposeful weapons programme'. The edit advocated the so-called 'historic nuclear accord with the US'. Then there are points of view of 'non-proliferation faithfuls', whom some would refer to as 'non-proliferation fanatics'. If these reflected one extreme opinion, then there were others some made sarcastically, some with suspicion and some with caution keeping better interests of the country. A few samples follow: It is said that some analysts were 'vehemently arguing that we should accede to the demand for inclusion of FBRs in the civil lists (Does it mean subjecting them to safeguards?) and get on with the deal'. A. N. Prasad, former Director, BARC (in *Opinion* on 27 February 2006) stated 'India was never averse to international cooperation, its subsequent experience showed that these are highly undependable and subject to humiliating restrictions, embargoes and denials of supplies and technology on flimsiest pretexts ... Safeguards are like cancer. Once they get into the system, they spread throughout under the 'pursuit and contamination provisions' of safeguards agreements, which cannot be avoided and are also not amenable for negotiations, only those who know the intricacies involved can appreciate the complex issues, not armchair analysts!..... Grander vision does not mean signing on the dotted line and surrendering'. M. R. Srinivasan, former Chairman, AEC (in *The Hindu* on 25 February 2006) noted '... The signing of the agreement (in July 2005) came as a surprise, because until then ... there appeared to be no common ground to extend any civilian nuclear cooperation to India'. He went on to say '... It has been the understanding of India from the beginning that the FBTR and the PFBR, which is a *developmental reactor* (emphasis added by this author) built with indigenous technology and components, would not be under safeguards. Also, it has not been the situation with other advanced nuclear weapon states that they have to put their R&D facilities under safeguards ... It appears that some sections in the US seem to feel that India has to accept perpetuity safeguards and that voluntary safeguards would be applicable to only nuclear weapon states...'. Vasant Gowariker, former Director, VSSC (in *Indian Express*, 22 February 2006) asked, 'After America sorts out nuclear deal with India, what next? Launch vehicles?' An Edit (in *Indian Express*, 10 February 2006) noted that 'after claiming that its nuclear programme was entirely for peaceful purposes, DAE now insists everything in the programme is strategic'! Placid Rodriguez, former Director IGCAR, draws attention (in *The Hindu*, 28 February 2006) to the fact that 'India's decision to classify a facility as "military" does not necessarily mean that the facility is used for military purposes but India considers the facility crucial to its national security and interests... (in this sense) fast breeder reactors and advanced heavy water reactors and other systems for thorium utilization are crucial'. According to G. Parthasarathy, former ambassador (in *The Pioneer*, 17 February 2006), 'Washington wants all nuclear power reactors and at least one of our two plutonium reprocessing facilities to come under safeguards ... All that the US is prepared to agree to is that only two research reactors and plutonium produced in these reactors can be used for military purposes ... (In such a situation) we would be left with a deterrent ... that may be 'minimal' but not 'credible'. These (press interviews, statements and articles) help us comprehend a variety of insights.

I wish to end this catalogue of opinions and comments by quoting some of the views expressed by Anil Kakodkar, presently Chairman, AEC, the person in the hot seat, so to say. Early in August 2005 (in *The Hindu*, 12 August 2005), he said 'The determination of what is going to be identified as a civilian nuclear facility is going to be an Indian decision... . That determination will certainly take into account all our national needs in terms of security, development and R&D'. He went on to add that whatever is determined as civilian will be put under IAEA safeguards voluntarily. Both the DAE and the Government have reiterated time and again that 'the defense and security interests of our country are our highest priority and will continue to remain so'. In reply to a comment '.... the plutonium reprocessed from our PHWRs will come under safeguards and that IAEA may not allow that plutonium to be used in the breeders', Kakodkar said 'We are not going to put any developmental programme under safeguards'. In answer to a query if PFBR would come under safeguards, he had stated that 'The PFBR will not come. Of course, he had an escape clause by stating that all decisions will be taken at an appropriate time and that it will be done in a phased manner. Many of the views expressed in August 2005 have been reiterated once again by Kakodkar recently (in *Indian Express*, 8 February 2006). He has reflected and articulated well the nature of continuing R&D in many aspects of reactor technology. For example, he has noted that 'we have made a beginning with oxide fuel (in the fast reactor) but we have to change this fuel cycle to metallic fuel. Metallic fuel gives you short-doubling time, of the order of 12–14 years, even 10. Then only ... the third stage comes in. You cannot say, I will pump in more money and get more megawatts'. So it seems we can make a paradigm shift from notions that Lord Marshall expressed some three decades earlier. Kakodkar has given the right lead when he emphasized 'the integrity and autonomy of our being able to develop the three-stage nuclear power

programme, that we have to maintain, we cannot compromise on that'. He has also drawn attention to the reality that the three stages are intimately linked through fuel cycles and the 'fuel cycle is intimately linked with the strategic programme and our programmes. ... The fuel cycle is for the same infrastructure which also feeds the strategic programme and I don't have such a big infrastructure that I divide this saying, *ek beta ye aap ke liye, ek beta ye aap ke liye*'.

Assuaging the varied perceptions outlined above, the Prime Minister has stated clearly, 'I reiterate today that no part of this process would affect or compromise our strategic programme ... our doctrine envisions a credible minimum nuclear deterrent to inflict unacceptable damage on an adversary indulging in a nuclear first strike. The facilities for this, and the required level of comfort in terms of our strategic resilience have thus been our criterion in drawing up a separation plan. Ours is a sacred trust to protect succeeding generations from a nuclear threat and we shall uphold this trust ... We will offer to place under safeguards only those facilities that can be identified as civilian without damaging our deterrence potential or restricting our R&D effort, or in any way compromising our autonomy of developing our three stage nuclear programme ... our proposed Separation Plan entails identifying in phases, a number of our thermal nuclear reactors as civilian facilities to be placed under IAEA safeguards, amounting to roughly 65% of the total installed thermal nuclear power capacity, by the end of the separation plan. A list of some other DAE facilities may be added to the list of facilities within the civilian domain. The Separation Plan will create a clearly defined civilian domain, where IAEA safeguards apply. On our part, we are committed not to divert any nuclear material intended for the civilian domain from designated civilian use or for export to third countries without safeguards ... We have made it clear that we cannot accept safeguards on our indigenous Fast Breeder Programme...'.

On 2 March 2006, Prime Minister Manmohan Singh and US President George Bush reached an understanding in New Delhi on implementation of the 18 July 2005 Agreement on civil nuclear cooperation; further details were not available. While the interests of the US may be based on business opportunities, India's interests to overcome trade barriers and to meet technological inputs not only for nuclear facilities but other programmes may be fulfilled. Some have opined that this also is an opportunity for Indian technical personnel to be outsourced, although this writer is not too gung-ho about this prospect. The late-news (*The Hindu Business Line*, 3 March 2006) is that 'India has agreed that 14 of its civilian nuclear reactors would be open to safeguards', while the FBR programme would be outside this purview. 'The separation of India's 22 nuclear reactors would be undertaken in a phased manner and completed by 2014 ... India has also made it clear that classification of nuclear reactors to be built in future would be its sole decision and there would be no debate on it'.

Much needs to be discussed and negotiated at the US Congress, IAEA, NSG, etc. for implementation of the 'Deal' in the months and years to come. Nevertheless, the steps taken by the Government and the Prime Minister are laudable and are in the right direction to mitigate energy deficit in the long run.

K. R. Rao lives at 29/2, 11th Cross, off 3rd Main, Malleswaram, Bangalore 560 003, India.
e-mail: krrias@yahoo.com

Geoethical audit of tsunami of 26 December 2004: Challenge before leaders, media and scientists

Arun D. Ahluwalia

After World War II, if there was another landmark moment in human history, it was indeed on the morning of 26 December 2004. The three hundred thousand dead included citizens of 52 countries. Millions lost their homes and/or dear ones. A tsunami was initiated soon after the Sumatra quake at 00.59 GMT and within 8 minutes a warning was possible. The geoethical question being avoided is: could the number of deaths have been much less with a little alert and conscionable utilization of scientific understanding, data and available communication skills within reaction time? As a safeguard in future, geoethical rectitude must be inculcated and audited regularly and systematically across the globe in a spirit of accountability to the taxpayer. The strong will behind various wars and space explorations was missing in this war on the biggest disaster of human history. This war was lost without a fight. Tsunami, the enemy, gave 15 min to several hours warning. Humanity could not ask for more from nature. There was no line of command and no system existed of a civil or military defence against such a disaster. Defence personnel were ignorant of the tsunami and political leaders/administrators learnt about the tsunami from media. The warning dissemination system needs to be decentralized. It should be every scientist's mandate to interact with communities. That fruits of science and technology did not reach victims of a second worst quake and worst ever associated tsunami, calls for redefining and prioritizing societal duties of scientists. Scientific establishments like USGS, BGS, NGRI, Meteorology Department and GSI cannot make excuses that awakening the masses in such rare emergencies is not their job. This should have been the natural reflex action of any establishment blessed with knowledge and resources. To do the right thing at the right place in future, it is worthwhile