

Nuclear energy needs and proliferation misconceptions*

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Nuclear energy is going to be an increasingly important option to satisfy the future energy needs of the world. And for the developing countries of Asia, if they want to aim for a quality of life comparable to that in the already-developed countries, their electricity production must go up substantially. For international nuclear co-operation to expand, the present proliferation misconceptions must be abandoned and coercive technology controls avoided. A new parameter – Stockpile Increase Significance Coefficient – is introduced in this context. We must seek a nuclear world order where, while moving towards global nuclear disarmament and addressing genuine proliferation concerns, the growth of safe nuclear power is accelerated and the world's nuclear heritage is preserved.

Per capita electricity consumption is an important measure of development in a developing country. It is obviously related to per capita Gross National Product, but it also correlates strongly with life expectancy in developing countries, as can be seen from the central portion of Figure 1. Per capita GNP and life expectancy are two of the three main parameters used by UN in defining the Human Development Index. While there are differences due to ethnic and national factors, there is a definite trend of increasing life expectancy from an increasing per capita electricity consumption. If any electricity-producing system is introduced in a developing country, a good part of the electricity produced will go for urban consumption but a part will also go to fulfil the needs of small towns and villages, which will get better health care and other amenities and this has an impact on all health parameters including life expectancy which is the ultimate health parameter. If the developing countries of Asia want to aim for a quality of life comparable to that in the already-developed countries, their electricity production must go up substantially.

Fuel resources

Among possible energy sources, fossil fuels are likely to run out sooner or later. India, for example, has a couple of hundred billion tons of coal located mostly in the eastern part of the country and, for

the next two or three decades, most of its power sector growth will indeed have to come from coal-based thermal plants. But, after that, like the rest of the world, India will also begin to think of conserving fossil fuel sources for carbon-based industries of the more distant future. Hydroelectric systems use a renewable resource and, in addition to electricity, provide water for irrigation but inevitably they displace people and have also been criticized for disturbance to ecology. Solar, wind, biomass and other renewable sources are very important, but, at the present time, are not competitive, except in remote areas, with hydroelectric, fossil fuel-based thermal or nuclear power. It is in this context that one must see the increasingly important role that nuclear energy is likely to play in satisfying the future energy needs of the world (including India). In some countries, which have no significant indigenous fossil fuel sources, nuclear power is seen as providing energy security.

The carbon dioxide emissions problem

The effect on climate change by greenhouse gas emissions has been a matter of scientific debate for many years. In the recent (October 2000) COP6 Climate Change Conference at the Hague, the Chairman of the UN's Inter-Governmental Panel on Climate Change, Robert Watson announced new estimates of likely increases in global surface temperatures over the next 100 years¹. He said that, according to revised scientific models, temperatures are now predicted to rise between 1.5 and 6 degrees Celsius, compared with an original projected range of 1 to 3.5 deg-

rees Celsius. Even at the lower limits, such changes in global climate could have alarming consequences. Though the issue of atmospheric CO₂ emissions as the principal driver of climate variability has been recently contested by Veizer *et al.*², by interpreting the ¹⁸O/¹⁶O oxygen isotope ratio variation in marine fossils (there is some doubt about the validity of their proxy CO₂ concentration estimations), the general consensus among scientists studying climate change makes out a strong case for reducing fossil-fuel emissions by developed countries. Unfortunately the developed countries have not shown uniform enthusiasm for the latter. The contribution of nuclear energy in reducing CO₂ emissions in the past, and possibly in the future, if a rational attitude to this clean energy source is adopted, has also to be recognized.

Proliferation misconceptions

John Ritch III, the former US Ambassador in Vienna and the present Secretary-General of the Uranium Institute in London has said³: 'The fear of nuclear proliferation is simply misplaced in the global warming debate. Most current carbon consumption is in countries which already have nuclear weapons or which can be relied upon as good faith parties to the Non-Proliferation Treaty (NPT). And the largest growth markets in energy consumption are China and India, both of which already have weapons capabilities. In short, almost everywhere the reduction in carbon emissions could yield important benefits for climate protection, proliferation is not even an issue.'

The 'full-scope safeguards' system is specific to the Non-Nuclear Weapon

*Based on the keynote speech at the International Symposium on 'How to harmonize peaceful uses of nuclear energy and non-proliferation: Considering the future of nuclear development in Asia', organized by Japan Atomic Industrial Forum, Tokyo, 7–8 March 2001.

States (NNWS) and is implemented by the International Atomic Energy Agency (IAEA) in Vienna. In its presently strengthened form, IAEA's verification activities seek credible assurance not only of non-diversion of declared nuclear material for weapons' purposes but also of the absence of undeclared nuclear activities. (Obviously, therefore, other treaties like CTBT and FMCT are basically irrelevant to non-nuclear weapon states.) The NWS, as designated by the NPT, accept 'voluntary safeguards' on a few of their civilian facilities. For other countries, the safeguards are specific to nuclear materials in the facilities established through international co-operation and to imported nuclear materials. In the case of India, we have such 'facility safeguards' agreements with IAEA for the reactors at Tarapur (TAPS 1 and 2), Rajasthan (RAPS 1 & 2) and we will have them for the two VVER-1000 reactors being set up in Kudankulam. Any reasonable world nuclear order can only expect countries to fulfil their international safeguards commitments and no more than that.

The Nuclear Suppliers Group (NSG) guidelines, however, make demands beyond genuine proliferation concerns and are obviously coercive in intent and are slowing down the expansion of nuclear power capacity in the world. In the case of

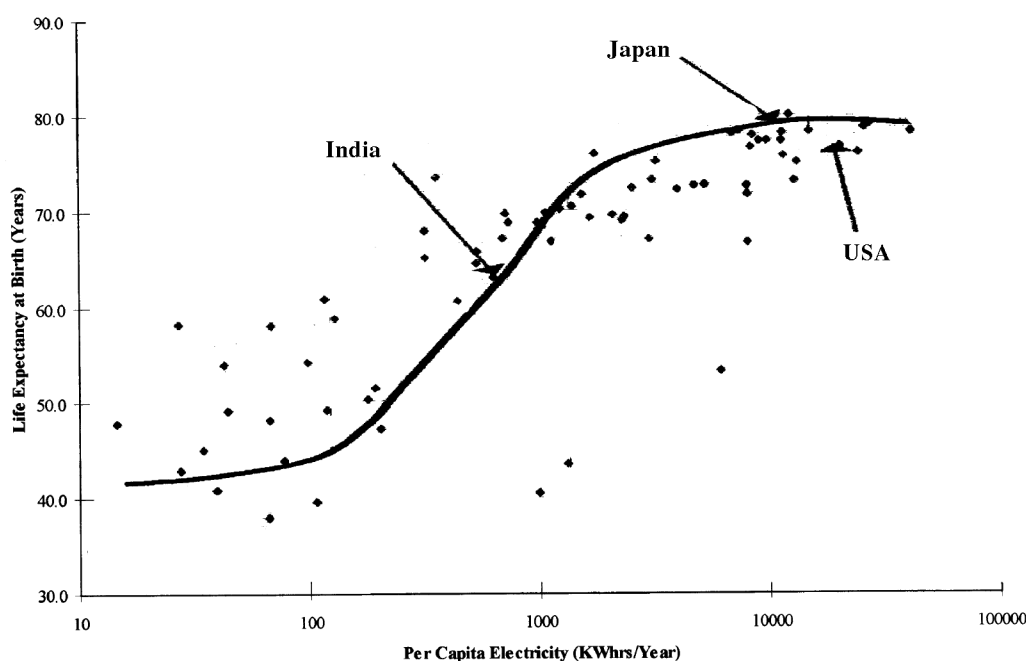
India, given its large nuclear market, the present NSG guidelines, which ask for 'full-scope' safeguards as a pre-condition for international co-operation in reactor construction, also have negative consequences for the commercial interests of potential supplier countries.

NPT is only one of many treaties and agreements in the world. It is a treaty to which many countries have become signatories voluntarily as NNWS, in the hope of achieving global nuclear disarmament. Many others joined NPT, as NNWS, convinced that their security concerns will be addressed by one or another State with nuclear weapons, and that they will be sheltered under the so-called 'Nuclear Umbrella'. The treaty left the security concerns of India unaddressed. India exercised self-restraint for a long time but had to finally weaponize in the context of a sharply deteriorating security environment in its neighbourhood. Clearly the only long-term solution of the problem is to eliminate all nuclear weapons – meaning, universal nuclear disarmament. Any lesser solution must still take into account the genuine security concerns of all nations.

In the write up for Session I of the Tokyo Symposium, the NPT is referred to as an 'inherently unfair' treaty. It also has an arbitrary cut-off date of 1 January

1967 for carrying out of a nuclear explosive test, for designation as a NWS. This is equivalent to saying: 'you may have a post-graduate degree, but if you got it after 1 January 1967, you will still be presumed to be uneducated!' After the May 1998 nuclear tests, Prime Minister Vajpayee declared that India is a Nuclear Weapon State and that it will maintain a credible minimum nuclear deterrent. In an article by Paine and Mckinzie⁴, which discusses, among other things, sharing of nuclear weapons knowledge in the world, it is clearly evident that India's nuclear weapons programme is based on self-reliance. India also exercises excellent physical protection on materials and strict export controls so that no equipment, materials or technology from India has ever been misused.

When the number of nuclear weapon states in the world was just two in the fifties, if the advice of India on stopping of nuclear tests had been heeded, there would be lesser number of nuclear weapons in the world today and also lesser number of States with nuclear weapons. The Mutually Assured Destruction (MAD) doctrine between USA and Soviet Union (now Russia) has fortunately been abandoned now and there is some agreement between these two countries to reduce their arsenals from the high astro-



Source Data: Human Development Report 2000 (Each point represents one country)

Figure 1. Correlation of life expectancy with per capita electricity consumption.

nomical figures they reached to somewhat lower astronomical figures!

It is useful to remember that there are today more countries with nuclear weapons and also that the nuclear weapon-related status of all countries in the world is now defined. The nuclear world order has to recognize these ground realities and not operate from the mindset which created and expanded the earlier non-proliferation regime.

Stockpile increase significance coefficient – A new parameter

I would like to introduce in this context a new parameter, which I shall call the Stockpile Increase Significance Coefficient (SISC). I define it as a measure of the significance of a unit increase in the number of nuclear weapons with a country (counting also weapon-intended fissionable material as part of the stockpile, *à la* FMCT), i.e. the significance of x weapons going to $x + 1$.

The SISC is plotted in Figure 2 as a function of x . I have deliberately not marked numbers in the x -axis because there is some subjective element here. It is obviously maximum when $x = 0$ and this situation applies now only to the non-nuclear weapon states, as defined by the NPT. As x increases, the coefficient approaches zero asymptotically and, beyond a certain value of x , the country ceases to be of interest in the context of nuclear weaponization and the hurdles to international co-operation are likely to disappear.

The SISC versus x curve would be different for a country whose possession of nuclear weapons is not based on a self-

reliant programme but on clandestine acquisition of weapons design, weapon-related technology, materials and equipment or, in fact, the weapons themselves. The SISC in the latter case would start at a higher maximum value and perhaps still decreases as x increases but levels off at a higher value and can, in fact, go up again if the country also indulges in illicit trafficking, a matter of great international concern. In my opinion, proliferation has a special connotation in the context of only such countries and of countries which clandestinely help them, though such nuclear weapon capability is not likely to be sustainable over a period of time in the absence of self-reliant materials development, equipment servicing and aging management capabilities.

Asian nuclear power expansion

While one hears a great deal about the flattening out of the nuclear power growth in the United States and Western Europe, this is not a global phenomenon. This is seen from Figure 3, which plots the growth of the number of operating nuclear power reactors in the world, regionwise⁵. While there is a slowdown in growth in North America and Western Europe – driven, I think, by the fact that their levels of energy consumption are already very high, and, therefore, there is no significant demand for more energy and they are also now conscious about the need for energy conservation so the number of reactors in Asia is continuously growing. Nuclear power grows where there is an energy need and also the necessary industrial and scientific infrastructure to support this high technology. Asia (including

India) always had the energy need but the requisite infrastructure is growing only in recent years – of course, Japan is an exception.

In a meeting in Seoul, organized in 1997 by the Atlantic Council of USA, the Asian commitment to nuclear power was identified as being motivated by the following considerations: nuclear power seen as an important option to satisfy rapidly growing energy needs, energy security, non-uniform geographical location of coal and its future exhaustion, air quality improvement and greenhouse gas benefits, technological spin offs of high technology and, in general, a supportive public environment (see ref. 6).

The Indian nuclear programme

In five decades of development, India has created a wide-ranging multi-disciplinary and self-reliant infrastructure in nuclear science and technology. Initiated with Canadian collaboration, our own developments in the Pressurized Heavy Water Reactor (PHWR) technology over three decades have been so extensive that our PHWRs were referred to in a recent IAEA document as INDU, rather than CANDU! Almost all the equipment and components for PHWRs – both 220 Mwe and 500 Mwe – are manufactured by Indian companies. The 14 reactors operating in India are currently running at an average capacity factor of over 82 per cent. Of these, 4 were commissioned over a fourteen-month period during 1999–2000. For the last reactor in Rajasthan, the period between first criticality and synchronization to the grid was just 14 days. The production at the Nuclear Fuels Complex at Hyderabad is now at record levels. The Heavy Water Plants are doing extremely well. Both of them have also reduced the energy consumption rates and this has brought down costs. We are able to undertake major plant-life extension jobs like *en-masse* coolant channel replacement. Our track record in safety is excellent, with more than 160 safe reactor years of operation. Thus the PHWR technology in India has matured and has, in fact, enabled us to develop the next-generation Advanced Heavy Water Reactor⁷. The rapidly developing industrial infrastructure in India synergises effectively with this nuclear capability.

We believe that the once-through open nuclear fuel cycle, with spent fuel treated

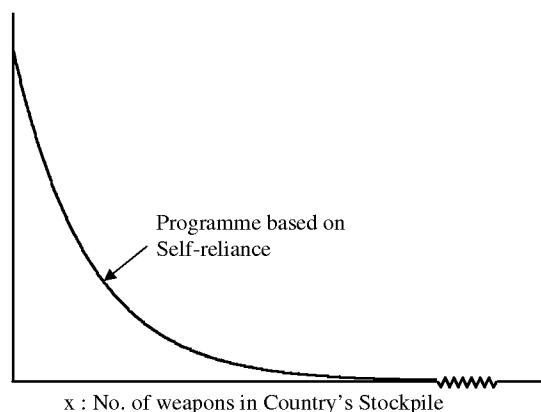


Figure 2. Stockpile increase significance coefficient as a function of the number of weapons in a country's stockpile.

as nuclear waste, cannot sustain nuclear power development over the long term and that closing the nuclear fuel cycle is important. The planning of reprocessing capacity must be such that it facilitates the utilization of plutonium and thorium and reduces the input of natural uranium (in the process realizing the much higher energy potential of uranium). This must be done by using Mox fuel in conventional reactors, plutonium- and uranium-233-based fuels and thorium blankets in Advanced Heavy Water Reactors (AHWRs) and in Fast Breeder Reactors (FBRs), and by finally going over to a thorium-uranium 233 cycle. The fuel needs must be met on 'just in time' reprocessing basis, which is important both from materials management and from radiation safety considerations⁸. All this would, of course, require tremendous R&D efforts in the future. The Fast Breeder Test

Reactor commissioned at Kalpakkam in 1985 has functioned extremely well and has provided valuable design data for the 500 Mwe Prototype Fast Breeder Reactor. Technology development for the latter is nearly complete and construction is likely to start this year.

From the current modest nuclear installed capacity of a little under 3000 Mwe, India plans to go to 20,000 Mwe by the year 2020 which will provide us a platform for future growth. This will be from a mix (see Figure 4) of mostly PHWRs and some FBRs, based on indigenous technology, and the remaining based on Advanced Light Water Reactor technology. For the latter, we plan to start with two VVER-1000 reactors of advanced design, to be built with Russian technical co-operation, for which a detailed Project Report is being prepared. This is only the beginning.

The need for international co-operation

The flattening out of nuclear power growth in the western developed countries I referred to earlier – there are signs of a possible reversal of this trend in the last couple of years – has the natural consequence of stagnation of R&D efforts and of a reluctance of young people to take up careers in this field. As Peter Medawar⁹ has said, young students will be attracted to research in a field only if they think they would be working on 'important' problems. But Grimston and Beck from the Royal Institute of International Affairs in London say¹⁰: 'Spending on longer-term (nuclear) energy R&D has been falling in almost all developed countries, with the exception of Japan, over the last decade or so. Liberalization of electricity supply markets has been

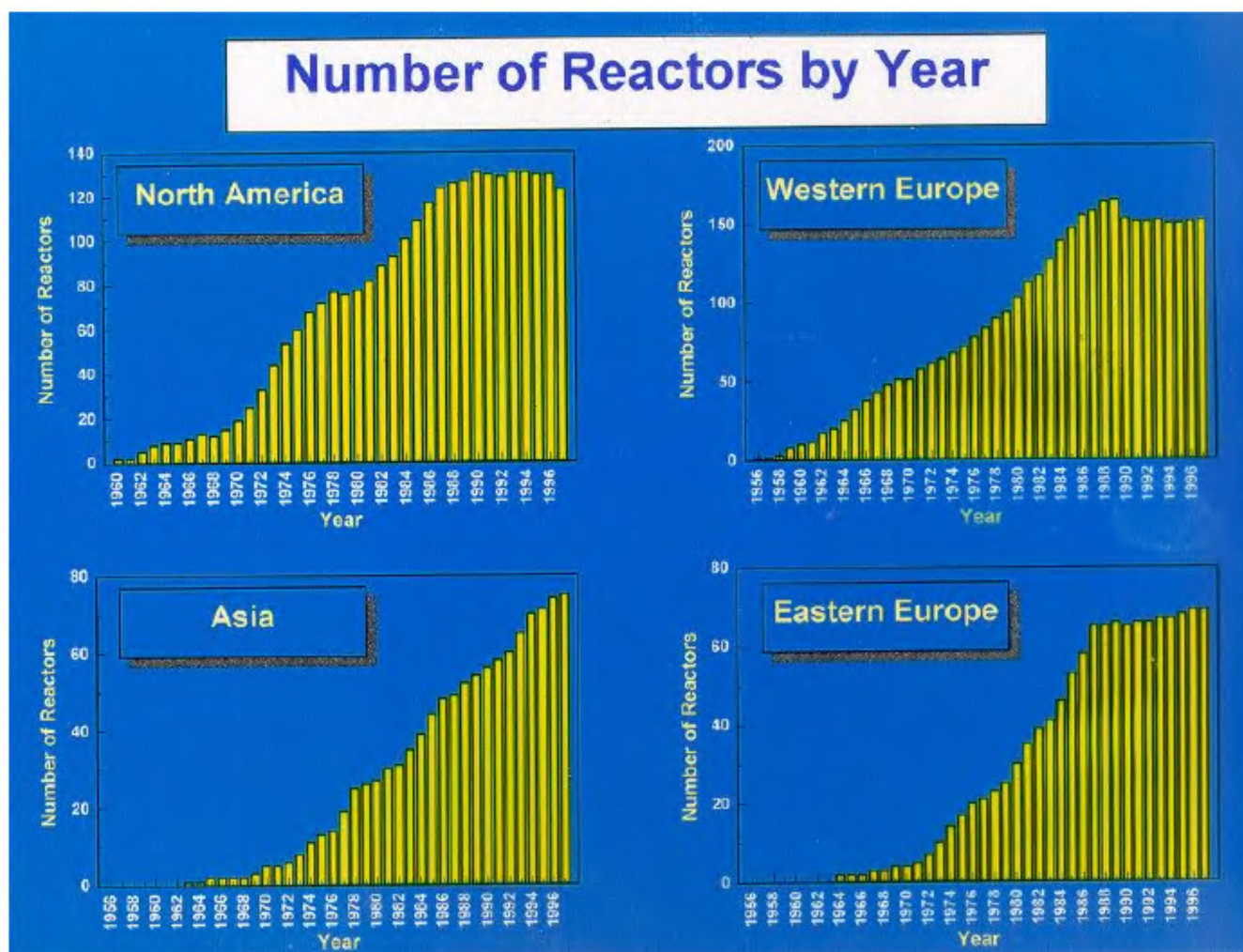


Figure 3. Regionwise nuclear power growth in the world.

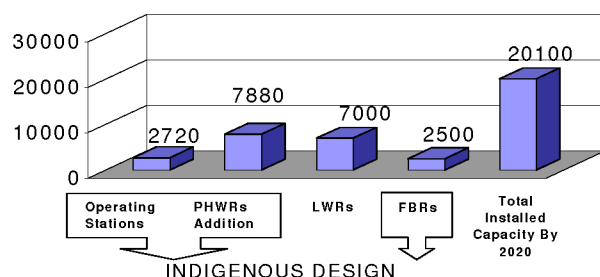


Figure 4. Indian nuclear power projection for the year 2020.

accompanied, on the one hand by governments taking the view that R&D is now the responsibility of commercial companies, to be carried out on commercial grounds, and on the other by a growing unwillingness of private power utilities to spend shareholders' money on speculative R&D projects.' This is not a happy situation because knowledge, when stifled, atrophies and the world's nuclear heritage is too precious a resource to be allowed to dissipate. Fortunately this is not happening in Asia.

The nuclear R&D should be directed towards developing Advanced Reactor Systems, which could be of evolutionary design with improvements in existing plant designs or of developmental design based on existing design philosophies but incorporating significant departures (like the Indian Advanced Heavy Water Reactor) or of completely innovative design incorporating radical changes to existing design. IAEA has an important role to play in developing a strategic plan for an international R&D project on innovative nuclear fuel cycles and power plants. The advanced reactor designs must have fault tolerance and enhanced levels of safety, including passive safety, so that they can be introduced widely and economically, even in the small and medium size ranges,

in developing countries initiating a nuclear power programme. This would be helpful even though the existing modern nuclear reactor designs and the current strategies for nuclear waste management are, I think, technically satisfactory from a safety point of view.

Nuclear R&D areas that need to be looked into are not restricted to advanced reactor systems but include advanced materials – both fuel and structural; non-destructive testing, in-service inspection and plant life extension; accelerator-based systems both as an energy amplifier and for nuclear waste transmutation; environmental safety-related technologies; fusion-fission hybrid reactors; etc.

Conclusion

In conclusion, I would like to say that we must seek a nuclear world order where, while moving towards global nuclear disarmament and addressing genuine proliferation concerns, the coercive content of technology controls are eliminated. This would ensure that the growth of safe nuclear power is accelerated and that the world's nuclear heritage is preserved. This would be in the interest of all concerned countries, because nuclear energy is going to be an increasingly important

option – in fact the inevitable option – to satisfy the future energy needs of the world.

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ACKNOWLEDGEMENTS. I am very grateful to Shri R. K. Sinha, Shri Kiran Doshi and Dr K. Raghuraman for going through the manuscript and making valuable comments.

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