Q&A

INTERVIEW OF THE MONTH

DR ANIL KAKODKAR

Former Chairman, AEC
Former Director, BARC

‘Nuclear Tests Proved Game Changer in India’s Global Identity’

Three-stage nuclear programme is critical for India to achieve energy security with zero carbon footprint, says the country’s premier nuclear scientist

■ **Debobrat Ghose**

At the helm of India’s nuclear research programme since its inception, Dr Anil Kakodkar, former chairman of Atomic Energy Commission and former director of Bhabha Atomic Research Centre, has seen it grow despite infinite challenges to reach the present stage when India has a fleet of 22 operational nuclear power units with nine under construction and 12 more planned. Though nuclear energy production continues to contribute a meagre, less than 2% to the country’s total energy requirement, Dr Kakodkar feels that nuclear energy is the most feasible solution for India to achieve energy independence.

He speaks to Science India *at length about the current state of India’s nuclear research programme, why it needs to be accelerated, how nuclear technology can improve the lives of people in rural India, why the country continues to be outside the influential NSG, and more. Excerpts:*

With two nuclear tests carried out in 1974 and 1998, India entered the elite club of nuclear-capable states. It was a moment of pride for Indians. Did the tests help in changing the world’s perception about the nation, the perception of our adversaries, from viewing us as a soft target to a strong nuclear power?

Most certainly. Look at the general perception of people before and after the

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tests. Post-test, there was a much larger acceptance of India as a responsible and strong country, with advanced technologies. Respect for India and Indian products grew, significantly improving exports as well.

A classic example is access to technology like computer chips. In those days, at most chips like 286, 386 or 486 were available in India but high end chips and products in which these chips were embedded were not available. But after these tests, better equipment became available. It made a lot of difference in general.

Specifically about nuclear tests, of course, it enabled the country to declare itself as a de facto nuclear state, but more than that, I have seen that even before the 1998 test, there was tremendous respect for India's nuclear technology. In those days, several things were not permissible, yet we used to have interactions with advanced countries.

Post-1998 test, we got exemptions from NSG (Nuclear Suppliers Group) — a big change in perception again. A lot of nuclear commerce opened for India but certain elements were still not open. But that's true even for two allies — while certain things are allowed, some are not.

What is India's roadmap on nuclear energy programme and where do we stand today?

Initially after 1974, the challenge was to develop nuclear power technology in spite of embargos. We did it and made reactors, which worked very well. While we solved the technology problem, there was still the fuel problem — the uranium needed to fuel the reactors in the first stage of the power programme. There was a shortage of uranium in the country at that time.

After exemptions from NSG, we started getting uranium from outside. Our reactors started working at near maximum possible capacity. We simultaneously increased our domestic exploration of uranium. Today, our uranium reserves are three-four times the past. Now, the challenge was to implement the capacity addition very fast.

As per our three-stage programme, we started with uranium reactors but ultimately we have to reach the thorium reactors.

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Then President of India, Pratibha Devisingh Patil presenting the Padma Vibhushan to Dr Kakodkar on March 31, 2009

"The only substantial non-fossil energy source that is not variable in nature, acts like a base load and can give steady generation of electricity, is nuclear. Realising sizeable electricity generation capacity in tune with the decarbonised world has become urgent"

That is a multiple technology development related to reactors as well as nuclear recycle technology. The fast reactor has to have a concurrently running recycle technology, which has to be proven on a commercial scale. And then the reactors and recycle plants for thorium.

Just as we went with technology development for heavy water reactors (HWRs), or uranium reactors, we have to go for development in so many other technologies — fast reactor technology, thorium technology, fast reactor recycle technology and thorium recycle technology. There were some important subdivisions within these categories.

Climate change has become very important and that requires non-fossil electricity generation. We lay a lot of emphasis on renewable energy — solar, wind, etc — but most of these are variable in nature. The only substantial non-fossil energy source that is not variable in nature, acts like a base load and can give steady generation of electricity, is nuclear.

The total potential of bio-energy is not small but not large enough to compare with our growing needs. In that context, three major sources to concentrate on are solar, wind (both variable) and for good result at optimum cost to consumer, nuclear energy source.

I think realising sizeable electricity generation capacity in tune with the decarbonised world has become urgent. The Intergovernmental Panel on Climate Change (IPCC) says that by 2030, emission should be reduced by 45% and by 2050, it should be net zero.

In this context, we must focus on rapid ramp up of nuclear generation capacity, by leveraging currently known technologies, even though the three-stage program development still remains a long term goal as thorium is a vast energy source.

How can technology help in ameliorating the lives of people, especially in rural India, where basic infrastructure is still a dream for many?

This is an important question. First, electricity is important both in urban and rural India. Although electricity grid has reached everywhere, it doesn't mean you are able to supply electricity everywhere

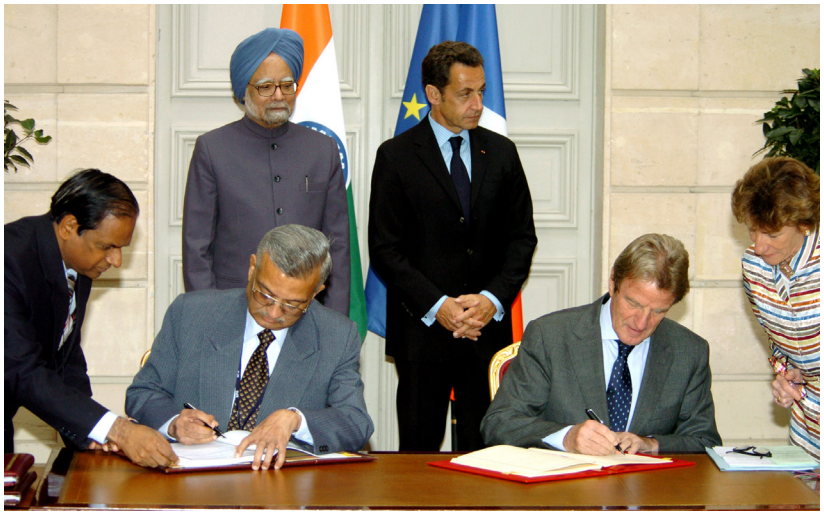

Image Courtesy: Internet

Chairman of Atomic Energy Commission Anil Kakodkar signs agreement on civil nuclear cooperation with French Foreign Minister Bernard Kouchner on September 30, 2008, in the presence of Manmohan Singh and Nicolas Sarkozy

as our grids are still weak. In this context, nuclear energy is very important.

There is a kind of perception that you can generate all your requirement using solar and wind energy, and variability can be addressed by deploying battery capacity. This is not a cost-effective solution.

Studies conducted at MIT and other institutes have shown that a zero-emission electricity system comprising a mix of only variable, renewable energy sources like solar and wind — increases the tariff for consumers two to four times due to various factors related to transmission and distribution as well as system related costs including fuller asset utilisation.

Since we are also heading towards zero carbon emission, a model has to be worked out that takes care of all these aspects at minimum cost to the consumer.

Theoretically, it is possible to generate all necessary electricity by wind and solar energy in a decarbonised world but it will cost us several times our GDP.

For rural India, quality of power is very important and there is a cost to that quality of power. So, if there is a significant fraction of nuclear energy, then you get a good quality of power at optimum cost. This is one way of improving the lives of people.

The other part is utilising nuclear

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technology to improve agriculture such as in the quality of seeds. A good variety of oilseeds and pulses in India come from nuclear mutants developed at BARC (Bhabha Atomic Research Centre) and several agricultural universities.

Radiation is used in other fields such as in preservation of perishable food items, in healthcare, medical products, cancer treatment, sewage treatment, etc.

In general, best technology is not always available for asking. Investing in technology is very important but it also has to be appropriate to the needs of the country. For example, Artificial Intelligence solutions, a prime technology today, is coming out of products developed abroad. It may or may not be appropriate for rural India as the data set from foreign cultures may have an in-built bias.

Power production in India is through nuclear fission only. Are we pursuing power generation through fusion?

Surely. As I said for addressing the climate change concern that has become an urgent issue, we should enhance capacity through available technologies, but there is merit to continue work on a three-stage nuclear programme — which is still fission.

That is because thorium has a large energy potential. Similarly, fusion constitutes even a larger energy potential. Energy is going to be a perpetual requirement for sustaining humanity. Unfortunately, we're still not there and are still working on its development. Indian is an equal partner in ITER project — the largest international project on fusion energy. India is manufacturing and supplying some of the largest components to the ITER programme.

The institute for plasma research in Gandhinagar and a few others are working on our domestic programme. Electricity generation from fusion is still sometime away. Fusion may not be able to contribute by 2050 but that doesn't mean it's not important, because fusion energy potential is large and human beings will survive far beyond 2050.

Dr Homi J Bhabha had mentioned three stages of Indian nuclear programme —- Uranium-fuelled HWRs; Plutonium-fuelled Fast Breeder Reactors; and Advanced Thorium-based Reactors. Where is India in this plan today and when can the nation be Atmanirbhar in energy by using our available thorium resources?

Uranium fueled HWRs are already being commercially deployed. Commercial prototype of 500 MWe FBR is under commissioning. On a smaller scale we have done everything connected to thorium — we have irradiated thorium; separated Uranium-233; and we have created a mini reactor out of U-233, which is called 'Kamini' and has been running in Kalpakkam for more than two decades.

But that doesn't amount to creating a large thorium-based power reactor. We

have completed the design and development of an advanced HWR which is a 300 megawatt system producing two-thirds of its energy from thorium. And this was developed after the Chernobyl incident. The idea was to incorporate several safety features to rule out the possibility of any impact in the public domain, unlike in the case of Chernobyl and Fukushima.

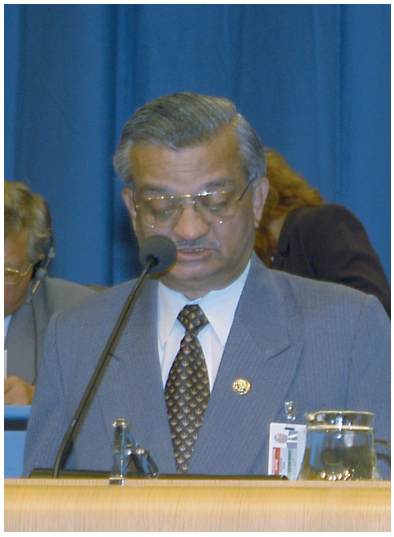
Now, it is upon the government to decide and construct one prototype as the development has reached a mature level. But it's not enough. Ultimately, in the third stage, you may require yet another kind of thorium reactor and most probably, it will be a molten salt reactor. It will give much better performance as far thorium is concerned, particularly in the context of self-sufficiency. Work on thorium has to go on. We have done a lot, we are ready to scale it up, also, more is to be done in a high temperature reactor where also thorium can play a big role.

You have played key roles in several high-tech projects from designing, construction to implementation on ground like indigenous Dhruva reactor, nuclear submarine, etc. Is India capable of building more indigenous devices in future?

Yes, surely. We shouldn't undermine the capability of Indian youth. Dr Bhabha used to say, the problem is that many times people are hesitant in posing a challenge. Besides posing challenges, you find people who are ready to take that challenge and then support them well. That's how so many things got realised. See the start-up culture, how it is rising. Sky's the limit. That's the meaning of demographic dividend — the number of people who can accomplish things at the global level. India has this capability, and the leadership should create the right conditions, provide challenge and support.

Despite following international agreements related to atomic energy and with no embargo unlike in the past, India is still not a part of the Nuclear Suppliers Group (NSG). Why so and will it impact India's growth?

It would have an impact. Now, we have exemptions from NSG, so we are able to get material and technology and we are also talking about setting up reactors, such as in Kudankulam, in cooperation with other countries. But the important thing is that the rules of NSG are set by NSG themselves. If you are not a member of the group, your interests may be in jeopardy. On the other hand, if you are a part of the group, then you are assured of your interests remaining protected. In terms of qualifications necessary for NSG membership, we have it and meet all criteria. India has been identified as a responsible country with advanced nuclear technology. We're exporting heavy water and other nuclear technology items, so we should legitimately be a part of NSG.



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Dr Anil Kakodkar delivering an address

We must be more ambitious. India is the only country which is not exporting reactors unlike other countries that have developed them. Despite hurdles, we should export on a large scale, so that the NSG feels the need to take us in the group. Diplomacy must be at work at all times and look for opportune moment; but also create conditions where the world opinion gets translated in our favour.

How will nuclear energy impact India's future on issues such as energy security, climate change and zero carbon footprint?

To some extent, I have elaborated that earlier. Today the strongest feature of our energy security is coal — in terms of quantity, domestic availability, etc. We also consume a lot of oil that is mostly imported. So, there is significant vulnerability to our energy security and then we have to move towards zero carbon footprint. Nuclear energy is a huge resource. We import uranium but we've one of the largest thorium reserves in the world. If we take thorium technology to its full maturity, we can address energy security issues in full, without significant carbon footprint. Our pursuing three-stage nuclear programme is actually very important.

Now, what if we don't do this? First, our vulnerability to challenges of energy security will go up, and electricity, if derived from solar and wind power, will become more expensive. Nuclear energy is extremely important. There is a perception issue about accidents and safety associated with nuclear plants. But in terms of risk per unit of electricity produced, nuclear energy is the best compared to all other energy sources.

How can research in the nuclear field in IITs and other premier institutions be converted into industrial applications?

To some extent, it has already happened as in the case of HWR. We've done large megawatt scale experiments for the design of HWRs. A lot of research and work have been done on a large-scale at IIT Bombay and BARC. The IITs are doing a great job on industry usable development.

With India's nuclear doctrine based on 'No first use policy', are we prepared to give a quick and befitting reply in case of a nuclear attack?

Yes. Though I am not a part of that system now, what I understand is that India's nuclear doctrine, which is in public domain, says 'no first use'. But part of the same policy also says, should there be an attack on India using weapons of mass destruction, then India will retaliate swiftly to create unacceptable damage to the adversary. The two have to be seen together.

**The interviewer is Editor, Science India*