# India's HANUMAN leap to NUCLEAR NIRVANA

focus

S. Raghotham

**INDIA IS** set to take a giant step — a "Hanuman jump" as Dr Baldev Raj, director of the Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, described it — in its nuclear power programme, regardless of whether its nuclear deal with the US is realised or not.

A 500 MWe Prototype Fast Breeder Reactor is under construction at the Kalpakkam. It will be commissioned in September 2010. India will then build a series of at least four FBRs by 2020.

Homi Jehangir Bhabha, who was asked by Jawaharlal Nehru to start the nuclear programme even before Independence in 1947, set the roadmap for the programme in the 1950s.

Bhabha studied the resources he had. Not much was available — there were no dedicated institutions for nuclear science, there were not enough scientists, engineers and workmen trained in nuclear physics and the building of nuclear reactors, and the country did not have enough uranium reserves that would be required for the heavy and light water reactors that the technology of the day could build.

Bhabha could solve the first problem — of building dedicated institutions — because of his close relationship with Nehru. Bhabha asked, and got, a separate department and a commission for the development of the nuclear programme, which would be under the Prime Minister's charge.

He could solve the second problem — of lack of scientific manpower and experience in building nuclear reactors — partly by bringing in foreign collaboration and partly by recruiting the brightest men of science he could find in the country. He sought out the likes of Meghnad Saha, Vikram Sarabhai, Raja Ramanna and many others.

But the third problem — lack of uranium reserves — required quite an ingenous solution. It took Bhabha and his scientists until 1959 to come up with a roadmap that would work in India's unique situation. India does not have large uranium reserves, but has abundant thorium. So, for the nuclear power programme to achieve a significant scale, a plan had to be devised by which India could start off using natural uranium oxide and gradually move over to build and run thorium-based reactors. Nuclear physics allows that, but it can be achieved only by going through a three-stage programme, each of which would have to run for a few decades before the next one could kick in.

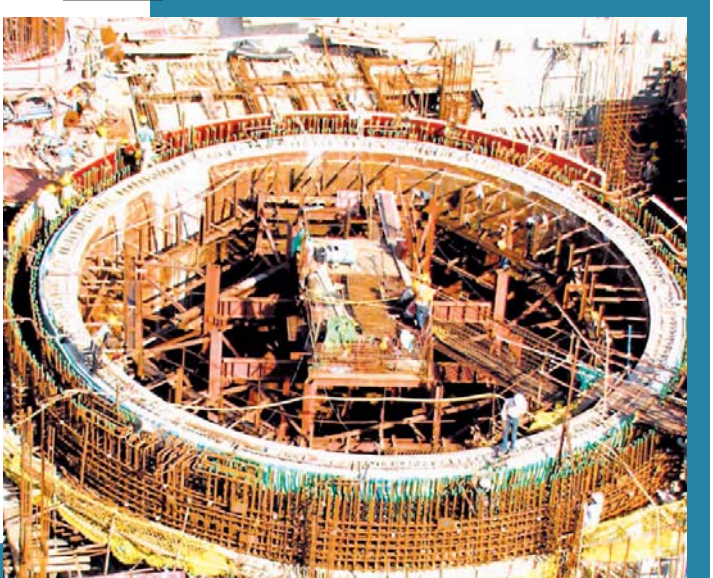
Here is what Bhabha's three-stage programme to achieve nuclear energy self-sufficiency envisioned: In the first stage, utilising the reactor technology and foreign assistance available at the time, India would build a series of pressurised water reactors that would run on natural uranium oxide. These reactors would take in uranium and give out plutonium. Over a few decades, enough plutonium would accumulate to be able to move to the next stage — Fast Breeder Reactors (FBR). India built a 13.2 MWe test FBR in 1985 and has been operating it since then. The 500 MWe FBR being built at Kalpakkam requires two tons of plutonium and seven-eight tons of natural uranium oxide at each fuelling. Thorium Oxide is fed in the periphery of the reactor.

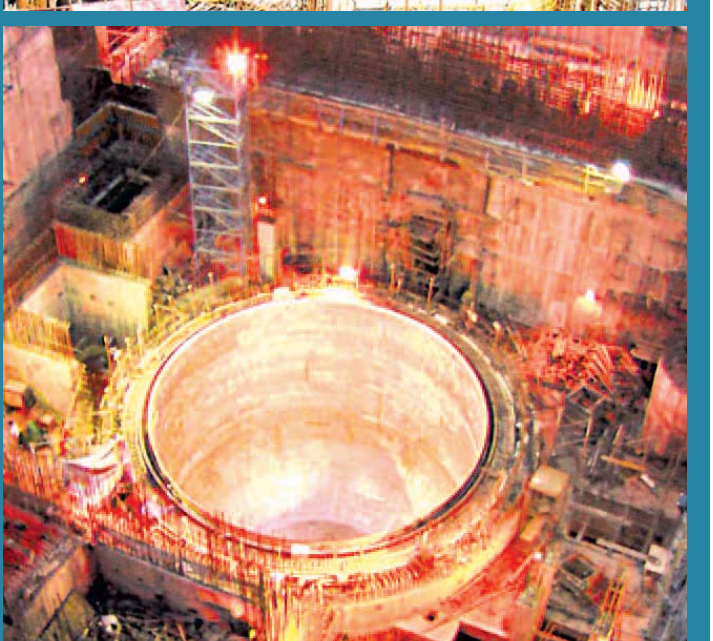
The FBR returns more plutonium than it consumes — but estimates vary as to how much; some say it returns almost twice the amount of plutonium than it consumes. Thus, once the FBR becomes operational, there is no worry so far as fuelling it is concerned provided one has enough plutonium stocks for the initial fuelling of a reactor. Meanwhile, the Thorium Oxide is irradiated into uranium-233, which is required for the thorium reactors of the third stage.

Given the plutonium breeding in the FBR and the abundant thorium reserves, India can achieve nuclear nirvana once it enters the second and third stages of the three-stage plan.

India is the only country building an FBR in the 21st century. Although FBRs and thorium reactors were the dream of a number of nuclear nations, the easy availability of uranium weaned them away from taking the risks of the very complex technologies and requirements of these advanced reactors. But India's uranium situation, complicated by the refusal of the Nuclear Suppliers Group led by the US to sell uranium and nuclear technologies to India following the 1974 nuclear test, spurred the country to take those risks in view of the large benefits they promise.

There are many who question the ability of Indian scientists and the nuclear establishment to realise the dream of nuclear energy self-sufficiency.





**Reactor vault (top right) of the Prototype Fast Breeder Reactor under construction at the Indira Gandhi Centre for Atomic Research at Kalpakkam in Tamil Nadu and the safety vessel (bottom right) being installed.** *— Bharatiya Nabhikiya Vidyut Nigam Limited*

Especially given the fantastic promise of a perpetual nuclear reactor programme that is held out by the FBR and thorium reactors, detractors of the programme tend to dismiss it as a foolish dream.

Indian scientists, however, say all that has happened until now is preparation to enter the next stage.

"We are the world leader in many areas of FBR technology — high temperature design, the world's best sensors, reactor-grade materials such as high-grade steel, high-efficiency metallic and non-metallic fuels, the robotics to handle it all, etc," said Dr Baldev Raj at his recent Prof. Brahm Prakash Memorial Lecture at the Indian Institute of Science in Bengaluru.

"We have studied the reasons why other FBR projects failed and we have ironed out issues. France, for instance, drew on our hydrogen sensors when it went looking for the world's most powerful sensors for its Phoenix reactor. We are confident that the PFBR will be safe and will work efficiently," Dr Raj said.