India Seeks 'Atoms For Peace'

With the Third World's most developed atomic energy sector, the developing sector's largest pool of civil engineers, scientists, physicists, and industrial engineers, the nation of India has today a pivotal role in transforming the developing sector.

The story of India's fight to create a skilled labor force able to use modern technology is, after the development of the Soviet Union and the U.S., the most explosive example of a transformation in economic and social life on a massive scale in this case affecting the lives of 600 million people. For the last 30 years, the Atomic Energy Commission (AEC) and the government of India have struggled to accomplish this task by applying science to every sector of development. Today, the results of this effort can be proudly exported as India's contribution to other developing nations.

The political fight over whether to accept U.S. President Carter's nonproliferation crusade or to continue on the nuclear energy path has become the center of nearly all government decisions in India today. For this reason, the "myth" of India's 1974 development of the "bomb" must be debunked. One look at India's atomic energy program and its extensive effort to utilize Soviet, U.S. and European collaboration to obtain "atoms for peace" provides a moving model for other developing countries.

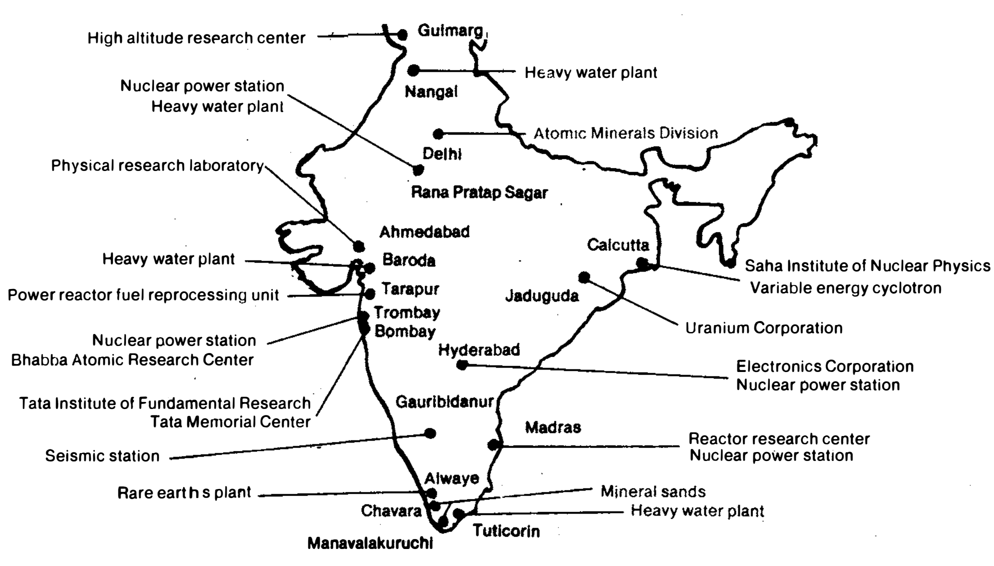
India's program to promote science and the development of atomic energy culminated on May 18, 1974 when the country broke into the select group of "nuclear weapons states" by exploding a 15 kiloton plutonium-based bomb in the Rajasthan desert. The Indian government, a leader of the Non-Aligned Movement, announced as its reasons for proceeding with the underground explosion that research into the peaceful uses of atomic energy had reached the point where an explosion was necessary to examine the effects of its use in civil engineering. Radioactivity, the fracturing efforts on rocks, the ground motion, and last but not least the ability to use such peaceful nuclear explosions for turning the Rajasthan Desert into an irrigated agricultural heartland, were all at issue.

But across the world denunciations were heaped on the Indian Pokharan experiment. Averell Harriman in the U.S., the British and Canadian governments, the prime donors to the labor-intensive Rajasthan World Bank's canal project, rejected the Indian government explanations, imputing the explosion of the "bomb" a covert military rationale. Canada suspended nuclear-related contracts and sales, and a round of conferences were quickly called to ensure that other "threshold" developing countries would be contained.

While the military implications of developing sector nations changing the strategic balance of power are very real, India's contention that peaceful nuclear explosions (PNE) are intimately tied to an economic growth strategy cannot be dismissed.

Statements by scientists internationally since the 1950s for the utilization of science in industrial development, have pointed to the fact that nuclear engineering, particularly where heavy earthmoving or irrigation works

Location Of India's Nuclear Power Reactors



are involved, is at least ten times cheaper and faster than any conventionally applied approaches. That this was a primary purpose behind India's "bomb" development is proven by a discussion of the origins of the Indian atomic energy program. For example, India, after the U.S. and the Soviet Union, has today the largest pool of scientists, nuclear engineers, physicists, and mathematicians of any nation in the world! Why?

India's Scientific History

The fundamental principle guiding India's commitment to industrial development since India's first Prime Minister Jawaharlal Nehru was the need to produce scientists to provide the technologies needed to catch up with the advanced sector. In 1945, even before independence, the late Dr. Homi Bhabha, the country's foremost scientist, appeared before the nation's leading capitalist family, the Tatas, and demanded that they, as promotors of development in steel and hydroelectric power, make a major investment in creating India's first fundamental science research institute.

"An institute is needed as an embryo from which I hope to build in the course of time a School of Physics comparable to the best in the world. When nuclear energy has been successfully applied to power production, in say a couple of decades from now, India will not have to look abroad for its experts, but will find them ready at hand." Bhabha's speech was delivered a year before the first atom-bomb was used over Hiroshima.

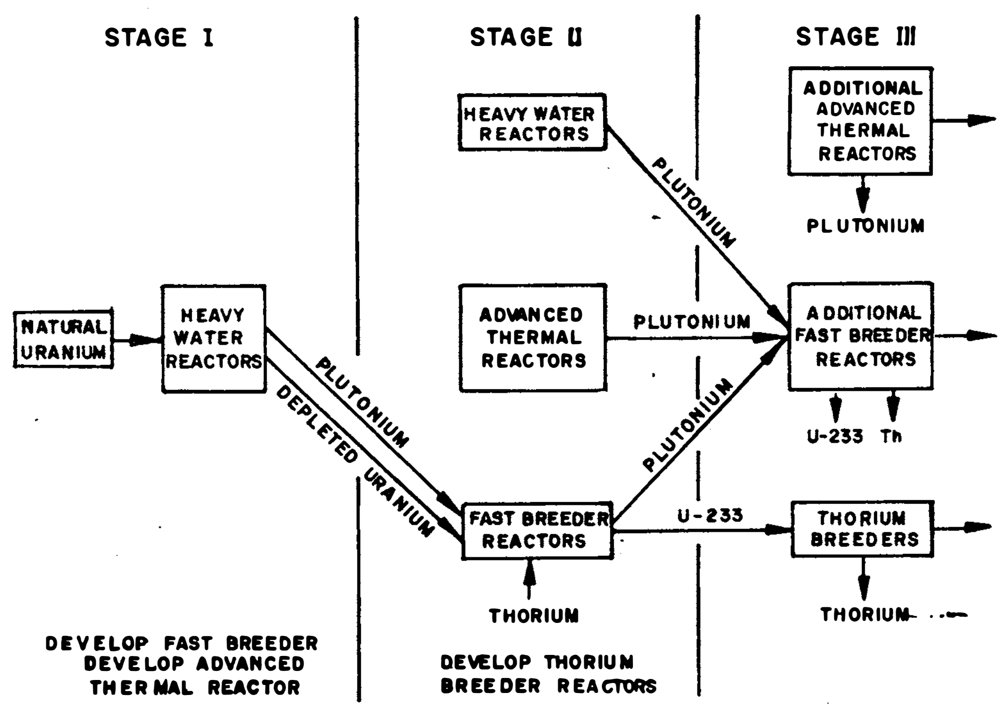
In 1945 Bhabha thus founded the Tata Institute for Fundamental Research, the "cradle of Indian science." He explained its first task to both industrialists and politicians on the day of the institute's inauguration:

"It is absolutely in the interest of India for such a school to form the spearhead of research, not only in the advanced branches of physics but also in the problems of immediate practical application to industry."

The latter aspect as it relates to nuclear energy has been the most controversial for the entire Third World. From the start, needs of expensive nuclear energy research have been represented as "pie in the sky" while the labor-intensive approaches to "economic development" have been justified as the only alternative. Bhabha polemicized strongly against this approach and the "cow-dung economy." In 1955 he stated, "The total per capita consumption of energy in the U.S. is equivalent to the burning of some nine tons of coal per annuum per capita. The same per capita rate of consumption in India, assuming a population of 400 million or so, would correspond to the burning of 360 million tons of coal per annum. Let us leave out the cowdung economy for the moment. The utilization of a potential 35 million kilowatts of hydroelectric power would make little difference to this arithmetic, since installed hydroelectric capacity of 35 million kilowatts corresponds to an annual goal consumption of 90 million tons. *We therefore come to the inescapable conclusion that the resources of hydroelectric power and conventional fuels in India are insufficient to enable it to reach a standard of living equivalent to the present* U.S. *level. That is what we must strive for.*"

Once the Tata Institute existed, the other mechanisms for science and its applications followed in rapid succession. In 1946, a tentative Atomic Energy Commission, chaired by Bhabha, was created; in 1953 it became a fully empowered partner of the Indian Planning Commission. In 1954, the Atomic Energy Establishment

A Three-Step Program For Reactor Technology



(later named Bhabha Atomic Research Center — BARC) was founded, and by 1955, Asia's first experimental reactor outside of the Soviet Union was built in Apsara, India. Institutions of science (see map page 1) flourished, and by 1958, the Indian Parliament adopted a major resolution on science policy. In part it states,

> "The dominating feature of the contemporary world is the intense cultivation of science on a large scale, and its application to meet a country's requirements. It is this, which for the first time in man's history, has given to the common man in countries advanced in science, a standard of living and social and cultural amenities which were once confined to a very small privileged minority of the population. Science has led to growth and diffusion of culture to an extent never before possible. It has not only radically altered man's material environment, but, what is of still deeper significance, it has provided new tools of thought and has extended man's mental horizon. It has thus influenced even the basic values of life, and given to civilization a new vitality and a new dynamism... The wealth and prosperity of a nation depend on the effective utilization of its human and material resources through industrialization. The use of human material for industrialization demands its education in science and training in technical skills. Industry opens up possibilities of greater fulfillment for the individual. India's enormous resources of manpower can only become an asset in the modern world when trained.
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> "... The Government of India has decided to pursue a policy 'to foster and sustain the cultivation of science and scientific research in all aspects...; to ensure that research scientists of the highest quality are available to the country; and their work is an important component of the strength of the nation; ensure that the creative talent of men and women encourages and finds full scope in scientific activity; encourage dissemination of knowledge, and discovery of new knowledge; to secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge."

International Campaign

India took its fight for peaceful nuclear energy to international forums from the very early 1950s. Following World War II it rejected the "Baruch Plan" with essentially the same arguments India used when refusing to sign the Nuclear Nonproliferation Treaty of 1968. Both were efforts, in different ways, to maintain control on materials and know-how within the nuclear weapons states, according to spokesmen, and India was determined to develop an independent atomic energy capability.

Contrary to most common slanders that this was all a cover to acquire her own "bomb," India in the very same period was in the forefront of the peaceful uses of nuclear energy. When U.S. President Eisenhower first put forward "Atoms for Peace" plan in 1953, India's United Nations spokesman, Krishna Menon (an otherwise acid critic of U.S. cold war policies), hailed it as an "initiative that has caught the imagination of this Assembly and the world." In 1953, Bhabha began the strongest international efforts to bring his projects to fruition. Constantly travelling, in touch with U.S. and Soviet scientists, and British and French nuclear specialists, Bhabba became so well-known that he was unanimously made chairman of the United Nations first Conference on the Peaceful Uses of the Atom in 1955.

In the keynote address to the conference, Bhabha made the first international call for the development of fusion power:

> "It is well-known that atomic energy can be obtained from a fusion process as in the H-bomb, and there is no basic scientific knowledge in our possession today to show that it is impossible for us to obtain this energy from the fusion process in a controlled manner. The technical problems are formidable, but one should remember that it is not yet fifteen years since energy was released in an atomic pile for the first time by Fermi. I venture to predict that a method will be found for liberating fusion energy in a controlled manner within the next two decades. When this happens, the energy problems of the world will truly be solved forever for the fuel will be as plentiful as heavy hydrogen in the oceans. The so-called barriers of science have again and again in the past been proven surmountable by man."

Bhabha's initiatives were constantly to link the advanced sector's existing nuclear technological capability with India's emerging scientific expertise. Through 1956, he was received receptively by Soviet scientists and some of the other European nations, such as France and in British nuclear energy circles. But in 1956, British policy went into a strongly anti-plutonium utilization mode, leaving Bhabha's out in the cold. It had been Bhabha's belief that only the construction of numerous plutonium plants such as the later Trombay Plant, could increase the total resources of nuclear fuel developed initially from a fixed amount of uranium. In 1956, Bhabha turned to his U.S. collaborators to begin work on the Tarapur Atomic Energy Plant. The Tarapur plant today provides the entire electricity grid for the Maharastra state.

There were two major international programs that left their imprint on the Indian programs. One was Operation Plowshare, a U.S. Administration program to utilize nuclear explosions for civil engineering purposes. Among the operations conceived of in this strategy, was

1958's "Project Chariot" where the feasibility of building deep-water harbors by means of nuclear detonations was demonstrated. Following this U.S. investigative effort, Bhabha worked closely with another fusion power proponent, the former U.S. Atomic Energy Commission chairman, Glenn Seaborg. In the Soviet Union, the use of nuclear explosions for construction of water storage in the Central Asiatic Republics was watched closely for application in India.

Bhabha's contributions to Indian science were abruptly ended when he died in a 1966 crash of an Air India plane that left no survivors. However, the motion that he began for utilizing the atomic energy sector as the essential vehicle of international collaboration with the developing and advanced sectors was carried forward by his successors, including the current Chairman of the Atomic Energy Commission, H. Sethna.

India today has agreements for peaceful nuclear energy applications with two neighbors, Bangladesh and Sri Lanka. An agreement with Sri Lanka for PNE applications to port development is under consideration, while with Bangladesh the larger issue of water control for both the Ganges and Brahmaputra is the first item on the agenda. Similar agreements exist with Brazil, Iran, Egypt, Indonesia, among other Third World countries, with Indonesian and Iranian scientists using Indian AEC facilities as training centers.

In the advanced sector nations, agreements for fast breeder development exist with France, including a 1971 agreement for fast-breeder technology transfer. The blueprint was drawn up by Indian scientists examining the French Project Phénix. Research agreements also exist with the socialist sector, with the Soviet Union having played a big role in the development of Indian scientific research. U.S. and Canadian bilateral agreements have been in cold storage since the Pokharan experiment.

In 1968, on the eve of the takeoff of India's atomic energy program as a commercially viable proposition, the World Bank released a special study dissuading developing nations from proceeding on this "dangerous" course of development. In India, the World Bank's project is the multi-million dollar labor intensive canal-digging project in Rajasthan which began as a food-for-work program. It has yet to be finished and Rajasthan remains an unarable desert.

The Necessity For Nuclear Power

The Indian Atomic Energy Commission's publicly stated task is the following: India, with small and only recently discovered oil resources desperately needs alternative fuel sources. Coal reserves are large, but not big enough. Cowdung has been the energy basis for the village-level economy (the largest part of India) but its viability as an abundant energy source is highly debatable despite World Bank investments in biogas plants.

This picture, presented by the AEC, has led to the emphasis on nuclear energy on a commercial basis as a necessity, even though the major development question has up to now relied on the commitment of the scientists, rather than in the actions of politicians.

The moment peaceful nuclear explosions are implemented on a wide scale, two policies must be revised.

Commercial Reactors

NAME	LOCATION	DATE OF COMPLETION	COLLABORATION	TYPE	SIZE AND USE
Tarapur	Bombay	1969	(General Elec.) Indo-U.S., 1963-completed	enriched uranium based	420 MWe electricity grid for Maharastra industry
Raps I*	Rajasthan	1972	Indo-Canadian Atomic Energy of Canada Ltd	natural uranium CANDU System	440 MWe electricity grid for Rajasthan
Raps II*	Rajasthan	1978**	Indian commissioned	natural uranium CANDU-Heavy Water	400 MWe
Kalpakkam	Madras	1976	Indian-French	natural uranium CANDU-Heavy Water	470 MWe
Narora	Uttar Pradesh	1981-82	Indian	same as above	2 units, each 220 MWe

***Rana Pratap Sagar**

** 2 yrs. behind schedule due to supply problems. Originally scheduled for 1976

First, where is the labor displaced to go, and second, where are the capital investments needed for crash nuclear development to come from ?

These questions are at the center of the current national debate. The Janata government has put forth a program that proposes to dismantle institutions such as the Center for Scientific and Industrial Research (CSIR) and decentralize the CSIR's role as a "link" between business, government and the AEC. Here are the facts that belie the political rhetoric.

What India Has

The "star" of India's atomic energy effort is the Bhabha Atomic Research Center (BARC), the national research and development institution for energy and related disciplines. It includes within its facilities four research reactors (see chart below), a uranium metal plant, a fuel elements fabrication plant, a plutonium plant, and a large civil engineering staff. The total strength of the BARC facility in Trombay, as of 1973, was 10,276 science-related personnel, about half being skilled scientists and technicians. It is here that Third World scientists come to train and partake of India's expertise in applying nuclear energy to developing sector conditions, and also here that the government sends its development blueprints to be processed, critiqued, and finalized. BARC in essence is the school Bhabha built to compare with Princeton or Cambridge, according to his own words.

As of 1977, India has 2 completed commercial reactors and 3 which will reach completion within the next 5 years. The system used initially in Tarapur in 1969 utilized enriched uranium — all of which must be imported from a select group (U.S., Great Britain and USSR). According to Indian government sources, following a major debate in the 1960s on whether India should deplete her scarce resources to acquire the European centrifugal enriching capacity, it decided against further enriched uranium-based atomic plants. Instead, the Canadian CANDU model has been chosen as the principal design for future projects. India has some 3.5 mn. tons of provable, minable natural uranium resources to make it viable.

Current scientific debate in the country revolves around two issues. The first, is the issue of the fast breeder reactor. With the world's largest thorium deposits, the Bhabha Atomic Research Center (BARC) is currently engaged in designing a mini-research reactor using uranium-233 from thorium. The chemical separation of the "breed" uranium-233 is to be carried out in a fuel reprocessing plant; its transformation into fuel elements for use in reactors is to be a major step in utilization of the thorium reserves. The experimental reactor Kalpakkam—a fast breeder operating on a plutonium-fuelled, sodium-cooled basis is the other model under consideration. Besides plutonium, or uranium-233, either depleted uranium or thorium could also be applied.

The choice of what fuel cycle to choose for long-term development, given an availability of some resources and not others and tight economic constraints, has not been easy. A faction of the AEC in India, and many within the Carter Administration have been promoting the development of thorium based cycles, at the expense of the other so-called "dangerous" plutonium and enriched uranium based reactors. India has huge thorium reserves and has become a major target for this thorium propaganda.

Experimental Reactors

NAME	LOCATION	DATE OF COMPLETION	COLLABORATION	SIZE AND TYPE
Apsara	Barc*	1956	Indo-Canada	1 MWe
Zerlina	Barc*	1961	—	Zero-energy thermal reactor
Purnima	Barc*	1972	—	Zero-energy fast reactor
Cirus	Barc*	1960	Indo-Canadian	40 MWe
Kalpakkam	Madras	—	—	Fast breeder — experimental
Trombay Plutonium Plant	Bombay	1964-5	—	Plutonium Separation and reprocessing plant

*BARC — Bhabha Atomic Research Center. Heavy water program geared to augmenting production to 400 tons per year.

But the facts belie this strategy. Scientific calculations are that the doubling time — the time in which input fuel is fully reproduced by the plant — for the thorium plant is some 300-400 years; the uranium or plutonium based breeders are some 10 years. Further the thorium cycle, barely in its research phases, remains a far slower plant. For India and the developing sector, with or without thorium reserves, development tasks and strategies do not give that open-ended time for completion.

This was Bhabha's own view when he proposed the need for international collaboration in atomic energy rather than a slow, "self-reliant" strategy replicating failures and successes again and again in each country. Bhabha proposed the fast breeder as a transition to a fusion-based economy. BARC has now kept the thorium research going, but has committed the future plants to the CANDU model until the enriched uranium supply problems can be solved internationally. Another level of research going on is the fusion-fission hybrid system and the utilization of thermonuclear fusion reactors as a means of converting thorium into uranium 233.

The scarcity of investible resources has frequently been the constraining factor. This is demonstrated vividly by the fact that while India has more experimental reactors (see chart p. 5) than any other developing country, making them commercial is a different story. A fine balance currently exists between the utilization of domestic resources and foreign collaboration. The World Bank recently released reports calling for liberalization of regulations governing the atomic energy sector, a policy which would mean dilution of the BARC research programs. Beginning with the first Tarapur plant, Bhabha's decision to enlist foreign collaboration as necessary at various phases with domestic training has reaped major benefits for the AEC, and progressively turned the whole operation over to Indian hands. Tarapur took 66.3 percent; Kalpakkam 20.3 percent, and Narora will be fully Indian built.

French collaboration will continue on the fast breeder technology, and while certain equipment is produced indigenously; the major delays on the schedules have been caused by the suspension by Canada (in particular) of needed supplies.

Peaceful Uses

At any point over 600 miles from coal deposits, it has been proven that PNE is the cheapest and effective way to begin on major development projects, according to BARC estimates. The Rajasthan Pokharan explosion had no radioactive contamination. In the 1960s, the AEC used the best estimates of U.S. and Soviet efforts in this direction to draw up blueprints for other areas where it would be useful. The following are several highlights:

**India has a huge coastline but few natural harbors. BARC estimates are that PNE can create several new harbors along the western coast. Cost estimates indicate that harbor excavation, etc. through PNE is ten times cheaper than conventional methods — by 1973 figures, $5 million compared to $55 million. The speed of the programs is also accelerated ten fold.

**The Subcontinent's priority problem is irrigation combined with a feast-or-famine monsoon uncertainty. In 1969, Glenn T. Seaborg of the U.S. AEC outlined the following proposal. Rubble-filled chimneys can be created by underground nuclear explosions for developing and managing ground water. Such chimneys and cavities in rocks of low porosity could store water preventing loss by evaporation. Such chimneys may also partition a compartmentalized acquifer system increasing the potential utility of the acquifer system. Seaborg's proposal was applied to the Ganges plain by Dr. Rama of the Tata Institute for Fundamental Research, who did the extensive analysis of such storages to hold water along the delta. Withholding a portion of the monsoon rains, in artificially created reservoirs could as well be done by current tubewells pumping system.

The principle of filling up reservoirs in the rainy season and emptying them in drought periods has also been applied to the southern Indian Ocean plateau, where the rivers (unlike the Himalayan originated rivers) are more seasonal. It has been estimated by TIFR that 200 such "chimneys" could effectively develop and manage ground water for the entire peninsula. Cost estimates reflect the needs for such a program: the Ganges-Cauvery "link" project by conventional methods is calculated at Rs. 25 billion. The PNE based project is Rs. 2 billion.

By far the most significant project for international study is the Rajasthan project itself. Where the Pokharan bomb test took place, close to the Pakistan border (perhaps too close according to uncomfortable Pakistani spokesmen), a desert region can be rapidly irrigated. Its feasibility provides the model for large parts of Africa and Mideast.

Nuclear Complexes

The potential scope of utilization of nuclear power plants in India is best demonstrated by examining the 1966 BARC-initiated projects for the "Nuclear-Powered Agro-Industrial Complex— Nuplex." BARC proposed it for two areas, the Ganges plain and the Saurastra dry region. In the Ganges plain it involved a nuclear energy plant of a capacity of 3000 Megawatts (CANDU model) around which would be organized the agricultural and economic activities of the region. The first block of the complex would consist of a nuclear energy center with fertilizer and aluminum plants in its vicinity and the second block a similar agricultural complex. The two blocks would be linked by a power transmission and distribution system and rail and road transportation networks. The industrial block would produce fertilizers for agriculture and power for tubewells. BARC estimates that through double and triple cropping, availability of water, this complex could feed 30 million people.

The Nuplex has been named by many Indian scientists the "strategy for survival" for agriculture. More appropriately, Bhabha pointed out its true purpose when he first conceptualized the need for something of its type in discussions with Oak Ridge U.S.A. scientists. "What the developed nations have, and the underdeveloped lack is modern science and an economy based on modern technology. The problem of developing countries, is, therefore the problem of establishing modern science in them, in their thoughts and in their actions to transform their economies to one based on these notions."

— Leela Narayan