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SCIENTIFIC INTELLIGENCE REPORT

INDIAN NUCLEAR ENERGY PROGRAM

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CENTRAL INTELLIGENCE AGENCY

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Scientific Intelligence Report

INDIAN NUCLEAR ENERGY PROGRAM

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CENTRAL INTELLIGENCE AGENCY

OFFICE OF SCIENTIFIC INTELLIGENCE

PREFACE

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INDIAN NUCLEAR ENERGY PROGRAM

PROBLEM

To assess the Indian nuclear energy program in terms of its personnel, facilities, resources, accomplishments, and plans; to determine possible relationships with the Soviet atomic energy program; and to evaluate indications of development of military applications.

CONCLUSIONS

1. India has made a small beginning in the nuclear energy field with a realistic program which is within her capabilities and well supported by an abundance of necessary raw materials. Her apparent aims are the training of scientific and technical manpower as needed; the domestic production of radioisotopes for use in medicine, agriculture, and industry; and the long-term development of nuclear power.

2. India will advance her program as rapidly as will be permitted by an acute shortage of trained scientists and technicians, a lack of foreign exchange to import needed equipment, and financial restrictions on the program occasioned by more urgent undertakings of the new government. Nevertheless, India will not have a significant capability for organized research in nuclear energy for 5 to 10 years.

3. Although India hopes to rely on domestic manpower and resources to develop her nuclear energy program, she has already found, and will probably continue to find, it necessary to accept technical and financial assistance, primarily from other Commonwealth countries.

4. India has refrained from accepting offers of Soviet aid in her nuclear energy program and probably will continue to refrain so long as necessary assistance can be obtained on her own initiative, and on terms satisfactory to India, from the Commonwealth countries and the International Atomic Energy Agency.

5. It is estimated that India will not direct any effort toward the military application of nuclear energy.

6. The standing of India in the nuclear energy field in Asia is challenged now only by Japan. It is expected that Japan will surpass India within the next 5 years.

SUMMARY

The Indian nuclear energy program is aimed at fundamental research; the application of nuclear science in agriculture, industry, and medicine; and, ultimately, the production of electric power.

India has substantial deposits of thorium, beryl, and zirconium. Recent discoveries of uranium appear quite promising. India is gradually broadening her industrial base to permit exploitation of these materials since a

ready international market exists for most of them. A heavy water manufacturing plant is under construction at Bhakra-Nangal with an annual rated capacity of 10 to 15 tons. The output of this plant will facilitate an expansion of Indian research and power reactor capacity.

To support her nuclear energy program, India is encouraging scientific education, building a substantial nuclear energy training and research center, and offering attractive salaries for graduate scientists. The number of qualified personnel is currently extremely limited but is expected to increase steadily.

Existing research and training facilities are already handicapped by the strained Indian economy. There are few institutes of higher learning in the physical sciences, and the teaching burdens leave little time for research activities. There are no industrial research and development laboratories in the nuclear energy field. First steps are being taken to remedy the situation by according maximum priority to the expansion of the Atomic Energy Establishment at Trombay and improving the facilities at the Tata Institute of Fundamental Research.

The first reactor in Asia became critical at Trombay on 4 August 1956. This reactor is of Indian design and construction and uses enriched uranium fuel elements supplied by the United Kingdom. Two more research reactors are scheduled for completion by 1958 with electric power reactors following at a later date. Except for the possibility that India will import one or two relatively small reactors for prestige as well as practical purposes, no large-scale nuclear power program is expected in India for the next 10 years.

There is no active relationship between the Indian and Soviet nuclear energy programs. Visits have been exchanged by scientists of both countries, but no formal collaboration has resulted. India has declined the Soviet offer of a bilateral research agreement and of teaching and training exchanges. India will continue to seek foreign financial and technical assistance in those areas where domestic capability is lacking and will probably continue to obtain the benefits of favorable offers from the United Kingdom and from Canada. Future international cooperation will probably be carried out for the most part through the International Atomic Energy Agency.

There are no indications of Indian interest to exploit the military applications of nuclear energy. The government is pledged to devote its entire effort to the peaceful uses of nuclear energy and no divergence from this pledge is anticipated.

India established an Atomic Energy Commission in 1948 to develop and control atomic energy application and research. Her early lead in this field in Asia has been undisputed until the past year when the Japanese program has become of sufficient magnitude to offer a serious challenge.

DISCUSSION

INTRODUCTION

Nuclear energy activity in India is directed solely by the Department of Atomic Energy (DAE). The DAE was established 2 August 1954[5] as an independent agency responsible to the Prime Minister. The government recognized the need for and is placing emphasis on training scientific and technical personnel and providing facilities to develop a strong nuclear power program.

India has a need for nuclear generated power, particularly in light of the relatively high cost of conventional power; but this need is not immediate since the economy is still largely agricultural, and farming is not mechanized. Before large scale nuclear power projects can be justified in India, an industrial complex to utilize the power must be created, and conventional fuel resources must be developed. India has substantial coal deposits; but they are generally remote from consuming industries, creating a need for high-cost transportation facilities. There is a considerable potential for hydroelectric power development, and several power plants are being constructed under the Second Five-Year Plan; but many of India's waterways are largely dependent on the caprices of the monsoons and do not assure constant power sources.

If the Indian plan of rapid industrialization is realized during the next 20 to 30 years, her conventional power resources may be insufficient for her needs by 1980. Taking into consideration the high cost of fuel transportation on India's already overcrowded and obsolete railways, small nuclear power plants would be feasible in some remote regions now.[7]

India is competing with Japan to become the leader in atomic energy research and development in Asia. Currently, her establishment at Trombay is slightly more advanced than the Japanese counterpart; but the entire Indian program could easily be eclipsed by the Japanese because of their industrial superiority, their more favorable financial condition, and their universally literate population. No Asian country other than Japan currently approaches India's standing in the nuclear energy field. In comparison with the technologically advanced countries in the atomic energy field, Indian accomplishment does not rank high; but in comparison with other Asian countries her accomplishment is impressive.

PERSONNEL

The Indian scientist has been given a leading part in the development of the country and realizes that he is expected to make substantial contributions, directly or indirectly, to the economic and social advancement of the country. Nuclear energy development, particularly, has captured the interest of Prime Minister Nehru and therefore enjoys government support, possibly in excess of what is practical for India's immediate needs.[6]

The development of the program has been and continues to be, hampered by the small number of qualified and experienced scientists and technicians available. Scientific personnel must be garnered from approximately one tenth of the entire population, India having over 85 percent illiteracy. India has been obliged to send her students abroad for advanced scientific training, lacking adequate facilities at home. Particularly for those trained in the United States where complex equipment is readily available, the Indian scientist returning from training abroad is under a handicap because the Hindu philosophy does not prepare him for the necessity of building and maintaining his own equipment. Returning to India, the trained scientist must carry a heavy load of teaching and administrative duties, usually in old and poorly equipped facilities. There are no significant industrial research laboratories; consequently, scientific employment is exclusively government and/or university work. Many Indian scientists educated abroad are reluctant to return to their homeland to work and teach under less favorable conditions, and they chafe at what they consider excessive bureaucratic meddling in scientific activities. Salary scales at Trombay are high by Indian standards. An M.S. degree holder receives 250 rupees ($52.50) per month, which is above the national average, and institute directors receive about 3,000 rupees ($600.00) per month. Exact figures for the number of personnel engaged in nuclear energy projects are not available, but estimates are placed at less than 1,000 to serve a population of approximately 390 million. Against such a background, any Indian contribution to the nuclear energy field is a significant achievement.

FACILITIES

Scientific and technological research in India is carried out exclusively by government laboratories and universities, the latter often supported by government subsidy. Of the 33 universities in India, only a small fraction have science departments and there are few graduate schools. The Indian Government is well aware of the limitation imposed by inadequate training facilities in the sciences and is striving to overcome this handicap by the substantial construction and staffing of new facilities during the next 15 years.

Atomic Energy Establishment — Trombay

Setting the pace for expansion, the government's Atomic Energy Establishment at Trombay now is in an advanced stage of construction with many facilities actually in operation. The Establishment is envisaged as a training and research center for all Asian peoples; and students from Egypt, Burma, and Thailand have already availed themselves of the facilities offered. The primary equipment, which went into operation 4 August 1956, is the Indian-built 1,000 kilowatt swimming-pool research reactor (APSARA), fueled with enriched uranium supplied by the United Kingdom. This reactor provides training to many Indian students who cannot afford the luxury of education and living abroad, thereby giving India an advantage over all other Asian nations (except Japan) for the training of atomic energy scientists. The reactor also supplies a limited quantity of radioisotopes for domestic use.

India's second reactor is under construction and is to be completed in the first half of 1958. It is a 10,000 kilowatt NRX-type research reactor and is being jointly constructed and financed by India and Canada under the auspices of the Colombo Plan at a cost of $14,000,000. This reactor will provide an additional training facility, an increased number of radioisotopes, and a more comprehensive facility for research and materials testing.

A zero-energy reactor (ZERLINA) is currently under construction at Trombay. It is to be used for studies in lattice spacing, fuel elements, and reactor design and is scheduled for completion by mid-1958.

The Atomic Energy Establishment inaugurated a training school for nuclear scientists and engineers on 13 August 1957 with an enrollment of 170 students.[23] At Trombay will be located the research laboratories as well as pilot plants for development of some of the processes in which DAE is interested. Plans include a plant for fuel element fabrication and a radiochemical laboratory for plutonium study. A uranium-thorium processing plant has been in operation at Trombay since September 1955.

Tata Institute of Fundamental Research — Bombay

The Tata Institute was founded by private grant in 1947 and has concentrated during the past 10 years in research in the physical sciences. In February 1956, it was made officially a joint facility of the Government of India, the Government of Bombay, and the Tata Trust. There has always been an interlocking directorate of the Tata Institute and the DAE. The entire research effort of the atomic energy program has been conducted at the Tata Institute under the direction of Dr. Homi J. Bhabha, and a considerable portion of the DAE work is still carried on there, awaiting complete removal to the Trombay site. Now housed in cramped quarters, the Institute itself is building new facilities scheduled for completion in 1959–60. The present staff comprises approximately 200 research and technical people, many of them at the student level. The Institute has both a school of mathematics and a school of physics with departments of theoretical physics, cosmic rays and geophysics, nuclear physics, and electronics and instrumentation. Interest is concentrated on cosmic ray research, reflecting Dr. Bhabha's interest in this activity and supplying Indian researchers with a relatively cheap means of studying high-energy particles without having to finance the expensive equipment necessary for their production. Other activities include research and development work in nuclear physics instrumentation, collection of data and study of problems connected with design of reactors, studies in meson theory, and proton-neutron interactions. The following equipment is available: 12-inch cyclotron and a 100 to 200-Kev (thousand electron volts) Van de Graaff accelerator, both of which are used primarily for studies of machine properties; a 1.2-Mev (million electron volts) Cockcroft-Walton accelerator; a beta-ray spectrograph; and a mass spectrometer. The accelerator is being used to study the neutron moderating properties of beryllium oxide in collaboration with the French Atomic Energy Commission. The Tata Institute encouraged foreign lectures in the physical and chemical sciences, and professors have been recruited from the United States, France, West Germany and Japan. None have come from the USSR although India would accept Soviet lecturers if the USSR agreed to send them.

University Facilities

Research activities at all Indian universities are restricted by over-crowded facilities, insufficient and poor equipment, and an overburdened teaching staff. Nonetheless, there is active interest in physics research and some progress has been made despite the handicaps.

Institute of Science, Bombay — The University of Bombay's School of Science for both undergraduate and graduate teaching. Physics research has been largely in spectroscopy. There is a staff of about 40.

Institute of Nuclear Physics — (Also Saha Institute of Nuclear Physics). A school of the University of Calcutta, carries out graduate teaching and research programs. The Institute has installed a 400,000 volt accelerator from which neutron time-of-flight studies are made. Also in operation are a 38 inch, 4-Mev cyclotron, a beta spectrometer, and an electron microscope. The latter two are of Indian manufacture.

University of Delhi — The Physics Department is doing research on fundamental particles and is studying origin of cosmic rays in nova outbursts. The combined departments of the university have an enrollment of over 2,000 graduate students.

NATURAL RESOURCES

India is well supplied with a number of natural resources necessary in nuclear energy research and development and plans ultimately to support her program entirely independent of foreign assistance. In this planning, she relies heavily on the domestic production of heavy water and primarily on the development of thorium as a reactor fuel. Since the thorium process is still in the experimental stage even in the advanced countries, it is obvious that an entirely independent Indian program lies far in the future.

Uranium and Thorium

The DAE sponsors an exploration program for minerals suitable for atomic energy application and offers monetary rewards for discovery of substantial deposits. Although some uranium deposits are known to exist in India, no exhaustive geological survey has been completed to determine their exact extent and commercial significance. Consequently, no definite estimate of reserves can be made. India has produced small, sporadic quantities of uranium minerals as byproducts from pegmatites which have been mined chiefly for beryl or mica. Most of the country is geologically similar to important uranium-producing areas elsewhere in the world, and it is reasonable to assume that noteworthy quantities of uranium ore may be produced from Indian deposits. New discoveries in the Ranchi Plateau area of Bihar appear very promising, but no official statement is available on estimated reserves.

India has the world's largest thorium reserves, estimated to be about 200,000 tons in monazite sands. Principal deposits occur in the beach sands of Travancore-Cochin (Kerala).

A monazite processing plant at Alwaye began operation in December 1952 and is reported to be treating 1,500 tons of monazite a year. It is currently undergoing modification to double this capacity. This government-owned factory was constructed with the technical aid of a French rare-earths firm. A plant to extract uranium and thorium salts (sodium uranate and thorium nitrate) from the residue of the Alwaye process went into operation in August 1955 at the Trombay site.

Design of a uranium processing plant to produce uranium metal suitable as reactor fuel has been completed, and the plant is expected to go into operation in 1958. It will be built and operated by Indian Rare Earths, Ltd. as agents of the DAE.

India has adopted the policy of stockpiling materials useful in an atomic energy program. Consequently, the DAE has first claim on monazite and its products. Surplus monazite and some thorium nitrate have been exported, principally to the United States, in an effort to gain much-needed foreign exchange.

Beryl and Zirconium

India ranks third or fourth in beryl reserves and production in the world and is known to have substantial deposits of zirconium. The Indian DAE and the French AEC are engaged in joint research on the development and use of beryllium metal and beryllium oxide as a moderator and reflector.

Heavy Water

India has planned a combined fertilizer and heavy water plant in the Bhakra-Nangal area in East Punjab. Plans call for the production of about 200,000 tons of fertilizer and about 10 tons of heavy water annually. The factory expects to utilize power supplied by the proposed 160,000-kilowatt hydroelectric plant at

Bhakra-Nangal. The entire factory is scheduled to go into production by 1960. The current critical foreign exchange situation and the cut-back in economic development in the Second Five-Year Plan will probably delay completion date of the project.

The 21 tons of heavy water to be used in India's second research reactor (patterned after the Canadian NRX) have been purchased from the United States.[5]

MILITARY APPLICATIONS

Prime Minister Nehru pledged that neither his government nor any future government of India will use atomic energy for other than peaceful purposes. India has continuously urged the cessation of nuclear weapons testing through her representatives at the United Nations and has sent official appeals to the United Kingdom, the United States, and the Soviet Union to suspend such tests pending their total abandonment. There is no indication in government or scientific circles of a change from the traditional Indian pattern of passivity and mediation. [redacted]

INTERNATIONAL RELATIONSHIPS

India and the United Kingdom signed an agreement in December 1955 providing for close cooperation between the two countries in the promotion and development of the peaceful uses of atomic energy. The United Kingdom supplied India with enriched uranium fuel elements for her first reactor under the terms of this agreement.

The Indian and French Atomic Energy Commissions are carrying on joint research on the use of beryllium oxide as a moderator and reflector. It is assumed that most of this work is in progress at Saclay [redacted]

On 28 April 1956, Canada and India signed an agreement of cooperation to cover the installation of a $14,000,000 NRX (National Research Experiment) reactor as a Colombo Plan project. Cost will be equally divided; Canada will supply the basic reactor parts with as much ancillary equipment as possible being constructed in India. Thirty-five Indian scientists and technicians are currently training at Chalk River, Ontario, on the NRX reactor in operation there.

India has declined to accept the U.S. offer of a bilateral research agreement providing for financial assistance in the amount of $350,000 toward the purchase of a research reactor, but Indian students have accepted ICA sponsorship to the International School of Nuclear Science and Engineering in the United States. India did not support the U.S. proposed Asian Regional Nuclear Center in the Philippines, declaring that her finances and manpower were only sufficient to serve a domestic program. It cannot be discounted that India sees the Manila Center as competition to the AE Establishment at Trombay. [redacted]

Offers of Soviet assistance to India have been discussed with Indian scientists visiting Moscow [redacted] and Nehru has repeatedly stated that India favors scientific cooperation with all nations. Nonetheless, no agreement has been signed with the Soviet Union and there are no joint Indian-Soviet undertakings in the atomic energy field. Cooperation with Soviet Bloc countries is limited to an occasional exchange of students or visiting professors. A common language, favored financial arrangements within the sterling bloc area, and membership in the Commonwealth direct India's bilateral or international activities into English or Canadian channels.

India has been a staunch supporter of the International Atomic Energy Agency (IAEA), taking an active part in the United Nations' discussions creating the Agency.

The Indian program could be realized more rapidly through cooperative endeavor than through independent effort and India may turn more willingly to the IAEA than to bilateral agreements. She is in a good position to barter her radioactive materials for use of equipment and facilities she does not yet possess.