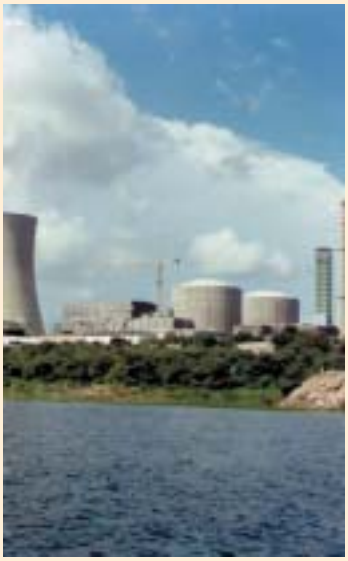
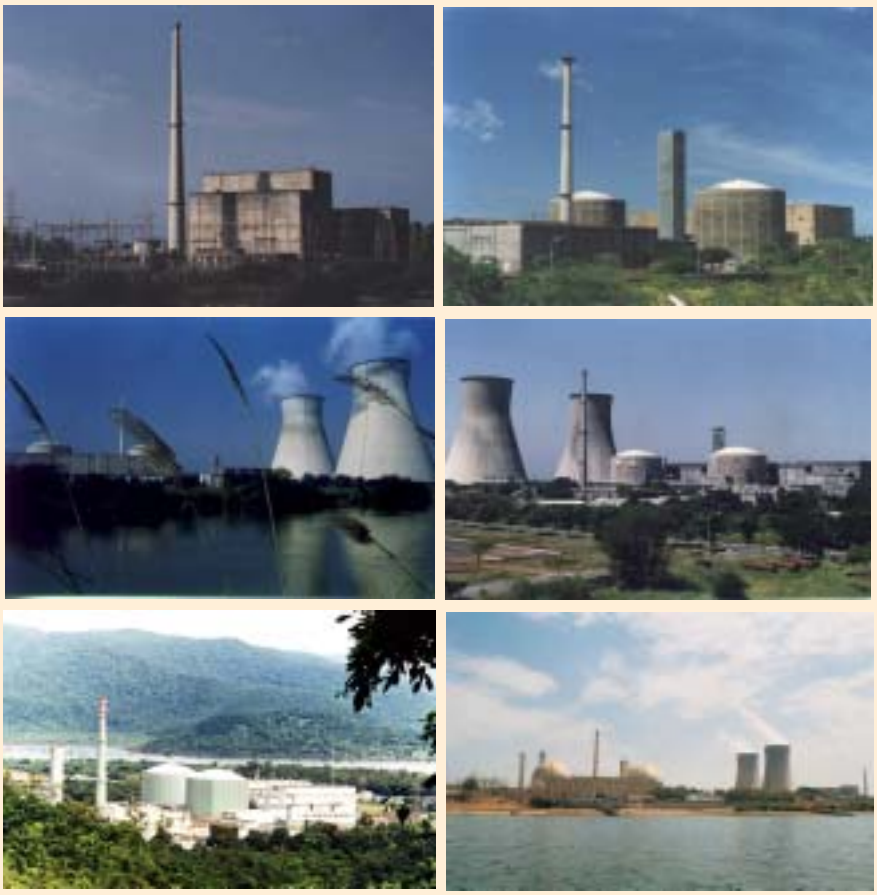



Nuclear Energy and Societal Development




Government of India
Department of Atomic Energy

Nuclear Power Programme



Atomic Power Stations (left to right) at Tarapur, Kalpakkam, Narora, Kakrapar, Kaiga and Rawatbhatta

India has limited reserves of uranium but its thorium reserves are very large. In view of this resource position, India has chalked out a three-stage programme which aims at the development of :

- Pressurized Heavy Water Reactor (PHWR) that uses natural uranium as fuel (Stage-I),
- Fast Breeder Reactor (FBR) that uses plutonium and depleted uranium fuel (Stage-II), and
- Advanced Heavy Water Reactor (AHWR) that will use thorium and Uranium-233 as fuel (Stage-III).

Pressurized Heavy Water Reactor (PHWR)

The PHWR based power programme has attained commercial maturity. The 220 MWe PHWR design has been standardised and scaled up to 540 MWe. Self-reliance has been achieved in the whole ambit of PHWR technology, and associated fuel cycle, starting from mining and ore processing, fuel fabrication, fuel reprocessing and waste management, including heavy water production.

With a total capacity of 2720 MWe, 14 atomic power stations are operating in the country – two each at Tarapur (Maharashtra), Rawatbhatta (Rajasthan), Kalpakkam (Tamil Nadu), Narora (Uttar Pradesh), Kakrapar (Gujarat) and Kaiga (Karnataka). Of these, 12 reactors are of PHWR type and the other two reactors are of boiling water type. The latter reactors were set up at Tarapur with foreign support on turn key basis, to gain experience in building and operation of nuclear reactors.

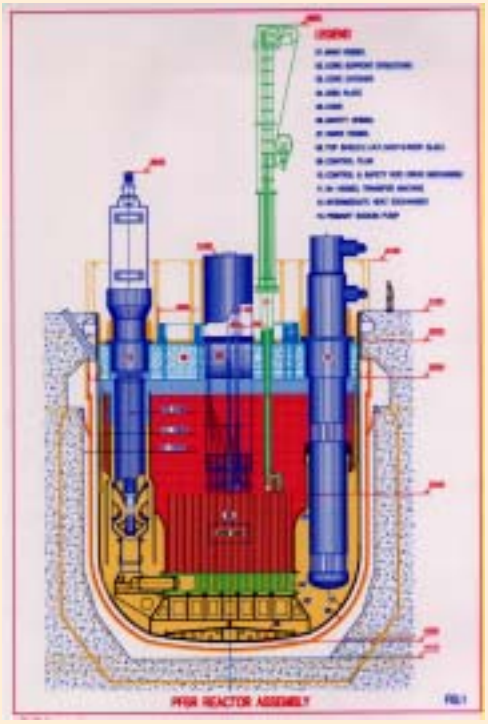
The atomic power stations generate over 19,000 units of electricity per year that flows in the power grids of the country, and is used by lakhs of farmers, industries and homes.

Currently, 8 nuclear power stations are under construction--two each at Tarapur, Rawatbhatta, Kaiga and Kudankulam (Tamil Nadu). The reactors at Kudankulam are pressurized water reactors being set up in collaboration with the Russian Government. On completion, these reactors will add 3960 MWe to the power generating capacity.

Fast Breeder Test Reactor at IGCAR, Kalpakkam, Tamil Nadu

Breeder Reactors

Under its endeavour to develop FBR technology, the Indira Gandhi Centre for Atomic Research (IGCAR) of DAE, had commissioned in 1985, the Fast Breeder Test Reactor (FBTR) at Kalpakkam (Tamil Nadu). The major components of FBTR were manufactured in the country. The mixed carbide fuel for FBTR



Schematic of Prototype Fast Breeder Reactor being developed at Indira Gandhi Centre for Atomic Research, Kalpakkam

was developed and fabricated indigenously. The fuel has attained a burn-up of 10,3000 megawatt day/tonne which is much above the set target. The reactor, which has been using mixed carbide fuel core, for the first time in the world, has operated at 17 MWt level and produced 12 lakh units of electrical power.

With the success of FBTR, the Centre has embarked on the development of a 500 MWe Prototype Fast Breeder Reactor (PFBR). The technology development for the reactor has been completed and construction of the reactor will commence soon at Kalpakkam.

Thorium based reactors

Towards utilisation of thorium, the successful endeavour made by DAE includes Kamini reactor operating at Kalpakkam. This reactor uses Uranium-233 fuel produced from thorium.

An Advanced Heavy Water Reactor (AHWR) is being developed at Trombay that will use thorium oxide fuel, light water coolant and heavy water as moderator. It incorporates several passive safety features.

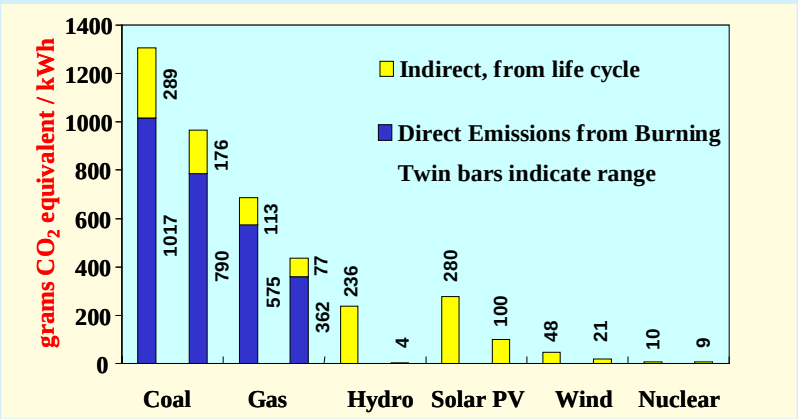
A programme to design and develop a high temperature reactor system, that can serve as compact power pack in remote locations, has been initiated. Also on the anvil is the development of accelerator driven systems for electricity generation, fissionable material production, and nuclear waste incineration applications.

Schematic of Advanced Heavy Water Reactor being developed at BARC

Nuclear Power Generation by 2020

The Department aims at installing 20,000 MWe of power generation capacity by the year 2020. This capacity will be attained by a mix of pressurised heavy water reactors, light water reactors, and breeder reactors.

Greenhouse Gas Emissions from Electricity Production



Nuclear Energy is a clean source of power generation.

The greenhouse gas emissions are lowest in case of nuclear energy as shown in the chart.

Environment around the nuclear sites is well conserved. All the nuclear power stations have obtained Environmental Management System Certification under ISO 140001.

With over 200 reactor years of safe operation in India, atomic power stations are a proven reliable source of power generation.

Radiation Technology and Crop Improvement

India is a leading producer of radioisotopes in the world. A wide range of radioisotopes is produced by the research reactors DHRUVA, CIRUS and APSARA at Trombay. The power reactors of the Nuclear Power Corporation of India Ltd. and the accelerator at the Variable Energy Cyclotron Centre at Kolkata also produce radioisotopes .

In the field of agriculture, radiation technology is contributing to the development of high yielding crop seeds, optimizing use of fertilizers, pest control and preservation of food items.

Nuclear technology is an important means in modifying the properties of seeds at genetic level. Out of these, good quality seeds are chosen.

Improved pulse varieties developed at Trombay

The research endeavour of BARC in the field of crop improvement, has led to the development of 23 high yielding varieties of various crops which have been released for commercial agriculture. These are 10 pulses, 9 groundnut varieties, 2 mustard varieties, and one variety each of jute and rice.

Some atoms, called radioisotopes, emit different types of radiations. The radiation, which either consists of particles such as electrons, neutron etc., or photons like X-rays, Gamma rays etc., is the work-horse of many technologies.

These technologies have many applications in the fields of agriculture, medicine, industry and other areas.

From left to right : Groundnut , Rice mutant, Greengram (Mung), Blackgram (Urid), Tur (Arhar) & Jute varieties developed at Trombay

During the year 2002-2003, the groundnut and blackgram varieties developed at Trombay made up to 30% and 40% of national indent for breeder seed. The groundnut variety TAG-24 has been identified as national check variety for Rabi/summer. The new large seeded confectionary grade Trombay groundnut variety TPG-41 has been identified for release for Rabi/summer cultivation in the country, and is awaiting notification.

Ten promising cultures of groundnut, pigeon pea, mungbean, blackgram, soyabean and cowpea developed at BARC, have reached ICAR- Advanced Varietal Trials.

The research and development done at Trombay has resulted in the optimization of the use of water and fertilizer by plants, monitoring of pesticides in the ground water, and understanding the role of pheromone chemicals in the insect control.

Some of the major research and developments at BARC are :-

- Biopesticide bacillus thuriengiene to control crop insects, and poly-ammonium phosphate fertilizer,
- Development of improved photo-period insensitive

variety of green manure Sasbania Rostrata.

- Synthesis of several insect pheromones, and techniques for determination of nutrients in soils, and
- Cheap and effective pheromone chemicals for controlling sweet-potato moth and cotton moth.

Tissue culture is the technology for growing tissues artificially in a culture medium. BARC is a major research and development node for this technology. The seed development technology based on tissue culture has been passed on by BARC to the Maharashtra State Seed Corporation, Akola. This Corporation has set up a tissue culture laboratory, and is distributing saplings to farmers. The tissue culture technology has also been transferred to Pondichery Government. The Centre has standardised large-scale multiplication of pineapple by micro-propagation. The banana varieties developed at Trombay by tissue culture technique have given encouraging yields in farm conditions. A protocol has been developed to cultivate commercially important 12 varieties of banana.

The species of dessert plant Acasia Victoriea developed at Trombay can withstand dry desert atmosphere and salinity in soil. A collaborative programme between BARC and the Rajasthan Agricultural University, Jaipur, is aiming at combating desertification by planting this tree.

CROP VARIETIES DEVELOPED AT BARC USING MUTATION BREEDING

	CROP	NO.	CHARACTERISTICS
	GROUNDNUT	9	High yielding, improved quality
	PIGEON PEA	2	High yielding, disease resistant, early maturing improved quality
	BLACK GRAM	4	High yielding, disease resistant
	MUNG BEAN	4	High yielding, disease resistant
	RICE	1	High yielding, improved quality
	MUSTARD	2	High yielding, improved quality
	JUTE	1	High yielding, fibre yielding

Synthesized pheromones for insect control

A variety of banana developed by tissue culture

Radiation Technology for Food Preservation

The research and development in the field of radiation technology applied to agriculture and food processing, being carried out at BARC, has been contributing significantly towards the food security of the nation.

Radiation processing of food involves treatment of food items by ionising radiation, mainly the gamma rays.

Gamma rays destroy or inactivate organisms, thereby extend the shelf life of certain foods. Processing with low dose radiation is used for sprout inhibition in onion, potato, ginger, garlic and yam; insect disinfestations of cereals, pulses and their products as well as spices and dry fruits, and making meat and meat products pathogen free.

Radiation processed products remain closer to the fresh state in flavour, colour and texture. The process does not cause loss of natural juices. The technology is effective, clean and very safe.

DAE's four facilities for radiation processing for food, have been operating as follows :

- The research and development radiation processing facilities at Trombay and the Defence Laboratory in Jodhpur Rajasthan.
- A high dose Plant set up by BRIT at Navi Mumbai for radiation processing of spices and other products.
- Krushak (Krushi Utpadan Sanrakshan Kendra), a low dose radiation processing facility for sprout control in onion, and preservation of agricultural produce, at Lasalgaon, district Nashik, Maharashtra.

BRIT's Plant for radiation processing of spices at Navi Mumbai

Krushak (Krushi Utpadan Sanrakshan Kendra) at Lasalgaon, district Nashik, Maharashtra

Spices processed by radiation

Radiation-processed spices being sold in and around Mumbai

Radiation processing controls sprouting. The pictures show radiation processed and unprocessed (with sprouts) onion

Some food items approved for radiation processing

Radiation processed potato (left)

Radiation processing slows down ripening of fruits. The picture shows radiation processed (left) and unprocessed banana.

Radiation processing keeps cut-flowers fresh

Food items permitted for radiation processing under the Indian Preservation of Food Adulteration Act (PFA) Rules of India

Item of food	Purpose
Onion, Potato, Shallots (small onion)	Sprout inhibition
Rice, Semolina (sooji or rawa), Wheat Atta and Maida, Pulses	Insect disinfestations
Dried sea-food, Raisins, Figs and dried Dates	Insect disinfestations
Mango	Shelf-life extension and quarantine treatment
Meat and Meat products including chicken, Fresh sea-food	Shelf-life extension and pathogen control
Frozen sea-food	Microbial pathogen control
Spices	Microbial decontamination

Radiation Technologies in Health Care

Radioisotopes are processed and supplied to medical users across the country by the Board of Radiation and Isotope Technology (BRIT) - an industrial unit of DAE. It also offers radiation sterilization services.

Radiopharmaceuticals are a special class of radiochemical formulations for carrying out organ investigations. Technetium-99m is the main workhorse of diagnostic nuclear medicine practice. Iodine-131, as sodium iodide, is used for diagnosis and treatment of thyroid disorders. BRIT supplies radiopharmaceuticals and allied products to nearly 120 nuclear medicine centres in the country.

Radioimmunoassay (RIA) is an important medical application of radioisotopes. RIA services are offered by nearly 650 laboratories in India. BRIT provides RIA kits to these centres.

Hot-Cells : Radioisotope production facility at BARC

Radioimaging being done by gamma camera at the Radiation Medicine Centre, Mumbai

Brain Scan (SPECT image)

Technetium-99m generator

Labelled Compounds Laboratory of BRIT at Vashi, Navi Mumbai(left) and Radiopharmaceuticals being dispatched

Blood Irradiator

For cancer treatment, there are 225 teletherapy units set up in 62 cities in India, and BRIT supplies brachytherapy sources and injection for pain palliation in severe bone cancer cases and Samarium-153-EDTMP for treatment of cancer patients.

The Board's regional centres at Bangalore and Delhi provide Technetium-99m radiopharmaceuticals for use in hospitals in these regions. The centres at Dibrugarh and Bangalore offer radio-immunoassay service to local hospitals.

JONAKI laboratory of BRIT produces labelled nucleotides for research in modern biology, biotechnology and genetic engineering.

The Radiation Medicine Centre of BARC in Mumbai, is the nucleus for the growth of nuclear medicine in India. In the field of radio-diagnosis and therapy, it is a regional referral centre of the World Health Organisation for South East Asia. Here, about 8.5 lakh patient investigations are carried out every year.

The Regional Radiation Medicine Centre of VECC at Kolkata meets the requirements of the Eastern Region of the country for radiodiagnosis and therapy. It provides therapy, and scanning and radio-immunoassay services.

A number of technologies and products have emerged from the biomedical research carried out in the DAE research centres. BARC has developed a new radiopharmaceutical namely, Holium-166 labeled hydroxyapatite, for treating rheumatoid arthritis. The technology developed at Trombay for Hydrogel, which is used in the treatment of burn-injuries, has been transferred for commercial production. Over the years, various other units of the DAE have developed several low cost equipment for health care and some of these technologies have been transferred to entrepreneurs.

Medical products sterilized by gamma rays (top) and Isomed plant at Trombay that offers sterilization services to medical industry

BRIT has developed a gamma irradiator, known as blood irradiator, for hygienisation of blood in hospitals and blood banks.

The Centre for Advanced Technology (CAT) at Indore has developed lasers for medical applications. The surgical carbon dioxide laser system developed by CAT is useful for a range of surgical modalities such as ENT, gynaecology, general surgery, dermatology, plastic surgery, and other areas. Some such systems have been supplied to hospitals in the country.

CAT has also developed nitrogen laser system for medical use. This laser helps in drug penetration in the cavities that are formed in lung cancer patients, and in faster healing of burn wounds. These lasers have been given for trial to hospitals in Indore and Patna.

Electron accelerators are being widely used for radiotherapy. CAT is developing electron accelerator based teletherapy machine. In this machine, a microtron — a type of electron accelerator, accelerates electrons to an energy, which depending on the depth of the tumour, varies.

Using property of gamma rays of killing micro-organisms, a number of products such as disposable syringes, surgical sutures, cotton dressing, drugs and related products etc. are sterilised. The Irradiation Sterilisation of Medical Products (ISOMED) Plant at Trombay was the first unit to be pressed into this service by the DAE for this purpose. The plant, which has acquired ISO 9002 accreditation, has been in the service of medical industry for almost three decades. It sterilises about 15,000 cubic metres of medical products.

Similar to ISOMED, radiation sterilisation plants are operating in Bangalore and New Delhi. For research and development purposes, a plant has also been set up at Jodhpur, Rajasthan for Defence Research and Development Organisation (DRDO) for R&D purposes.

Radiation Technology in Diagnosis and Treatment of Cancer

Cancer is a major health scourge of the society. But today, due to the fast advancements in radiation technology based diagnostic and therapeutic tools and techniques, the scenario is changing from that of despair to of hope.

Teletherapy , that uses gamma rays produced by a cobalt-60 radioisotope in a teletherapy machine or high energy X-rays from a linear accelerator, is the most widely used technique.

DAE is providing necessary technology regarding these machines, to the Indian manufacturers. Radiation sources of Cobalt-60 are manufactured in BARC. These sources are supplied to 166 teletherapy units at 62 places on the country. These units treat 20 lakh cases including 1,20,000 cancer patients.

In ***brachytherapy***, radioisotopes are brought in direct contact with tis

Brachytherapy being given to a patient.

Cancer diagnostic facility based on magnetic resonance imaging facility at Tata Memorial Hospital, Mumbai

Intensive Critical Care Unit of the Tata Memorial Hospital

Linear Accelerator Clinac-2100C, installed at the Tata Memorial Hospital. This accelerator is used in radiodiagnosis and surgery.

Camp for diagnosis of cancer, organised by Tata Memorial Centre at Barshi village, Maharashtra

Body frame (Elekta) being given to a patient at the Tata Memorial Hospital, Mumbai

sues. This technique has given encouraging results in the treatment of breast, oral, uterine and prostate cancer. In brachytherapy, radioisotopes are used in the form of needles, tubes and other forms. These radioisotopes are produced at BARC.

Tata Memorial Centre

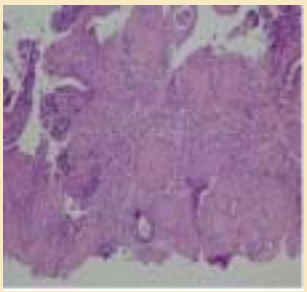
The **Tata Memorial Centre**, an autonomous and fully aided institution of DAE, provides comprehensive treatment for cancer and allied diseases. It is one of the best radiation oncology centres in the country. For keeping pace with the advances in cancer research and train its scientists in upcoming technologies, TMC has set up a new Advanced Centre for Treatment, Research and Education in Cancer (ACTREC) at Navi Mumbai. The Centre, which is comparable to any similar centre in the world, has been engaged in the prevention, treatment, and research and education on cancer. The Tata Memorial Hospital is equipped with latest sophisticated machines.

Annually, nearly 25,000 patients from India and neighbouring countries, visit the clinics of the Tata Memorial Hospital; over 4500 patients are treated with teletherapy, and about 1000 patients undergo brachytherapy procedures. The hospital, where the country's first bone operation was done in 1983 on an 8-year child, is now conducting such complex operations routinely.

Under its Telepathology Programme, the Tata Memorial Hospital has brought the state-of-the-art cancer diagnosis and treatment at the doorsteps of villagers. This programme has taken shape at Barshi - a small town in district Sholapur of Maharashtra.

Through the tele-link, Barshi and the hospital exchange slide-images for expert opinion. For cancer detection and treatment of patients, this remote town has now become an important centre, catering to a large number of surrounding villages and towns.

The World Health Organisation has recognised the cancer control module developed at Barshi, as a prototype for the outreach-programme of global control of cancer.



A slide for telepathology diagnosis

Advanced Centre for Treatment, Research and Education in Cancer (ACTREC), at Owe village, Navi Mumbai comprises basic and clinical research wings and an educational complex. The first phase of the project has been commissioned. ACTREC will carry out mission oriented research and development on cancer types common to the Indian sub-continent.

Keeping in view the role which radiation technology plays in the field of cancer diagnosis and treatment, DAE has been giving grant-in-aid to various cancer hospitals in the country.

The Department has signed a memorandum of understanding (MoU) with the North Eastern Council and Assam Government for strengthening cancer treatment facilities in the North Eastern part of the country. This endeavour aims at strengthening cancer treatment and control in the North-Eastern Region.

The cyclotron at the Variable Energy Cyclotron Centre, Kolkata, produces Gallium-67 radioisotope which is extensively used in the diagnosis of soft tissue tumours. The VECC had also set up a Regional Radiation Medicine Centre at Thakurpukur, Kolkata, in collaboration with Cancer Centre Welfare Home. This Centre utilises gamma cameras and radio-immunoassay (RIA) for diagnostic purposes and a medical linear accelerator for cancer therapy.

Industrial Applications of Radiation Technology

The Board of Radiation and Radioisotopes (BRIT) of DAE provides radioisotope based products and services for industrial use on commercial scale. These cover products such as radiosources, radiochemicals and labeled compounds; equipment such as radiography camera, gamma chambers and others, and services such as radiation processing for sterilization of medical products.

Initially radioisotopes were used as radiation sources in radiography cameras for nondestructive testing only. Now their use has spread to gauge measurement, thickness measurement of plates and pipes, leak detection; sensors in automotive equipment, and other applications in industry.

In the field of radiotracer technology, BARC is considered as a leading centre in Asia and the Pacific.

Radiotracers are extensively used for locating leakages in oil and gas pipes and seepages of water from dams and water-bodies; study of sediment transport at ports and harbours, flow measurements and water resource management.

The services using radiation technology in the areas of sediment transportation, gamma scanning, leakage detection and others have led to considerable economic benefits to the nation.

The radiotracer based studies conducted by BARC on sediment transport at almost all the major ports and harbours, have resulted in increasing the intervals between desilting campaigns. These studies have saved huge cost of desilting operations. The studies on the direction of bed load transport at Kolkata and Karwar (Karnataka) ports have helped in port-expansion programmes. A nucleonic suspended sediment concentration gauge developed at Trombay, has proved to be a useful tool for the dredging operation in ports.

Radioisotope tracer techniques were also used in the study of dilution and dispersion of sewage disposed off into sea at the Colaba outfall in Mumbai.

BARC has done extensive studies relating to detection and recharge conditions of ground water bodies. The major ones include evaluation of the groundwater recharge conditions in the Delang-Puri sector of coastal Orissa, determination of the origin of thermal waters in the geothermal areas in Madhya Pradesh, Uttar Pradesh and Himalayas, and establishing the ancient course of the legendary 'Saraswati' river in Western Rajasthan.

Radioisotope production facility at BARC

Roli camera for radiography. The camera is being marketed by BRIT

BARC's expertise in gamma scanning are used by almost all the major petrochemical industries for troubleshooting in process equipment. The Centre does about 20 such scannings every year. These scannings have resulted in minimizing downtime and production losses, which could be of the order of several crore of rupees per day for big units. The Centre had earlier carried out studies with Cobalt-60, to detect leakage points in a 350 km long natural gas pipeline of the Gas Authority of India.

BRIT provides radiation sources to over 1470 user organizations. For radiography examinations of industrial components, BRIT supplies Iridium-192 sealed sources and remotely operated radiography cameras. Over 700 consignments of Iridium-192 sealed sources, totaling over 900 terra Becquerel are annually supplied by BRIT.

The Board has also exported radioisotopes and related equipment to a number of countries such as United Kingdom, Germany, Bangladesh, Egypt, Myanmar, Nepal, Sri Lanka, Syria and Tanzania.

Radioisotopes made their initial appearance in the Indian industry when they were introduced for industrial radiography. Industrial radiography gave new dimensions to the Indian fabrication industry by helping them to elevate their quality standards. This interaction with industry also led to the creation of skilled man power to use radioisotopes safely. Today several Indian industries have been recognised internationally for their quality fabrication.

Radioisotopes as tracers are unique tools for diagnosis of problems in industrial processes ranging from leak detection in buried pipelines to assessment of functioning of chemical reactors.

Isotope hydrology has emerged as a separate discipline and has proved to be of great value in the field of water resources management.

To sum up, the radiation technology in India is fully geared in the present context of liberalization, to provide support to the Indian industry to face international competition.

Radiation technology in action for testing of metallic structures

Radiotracer studies on a trickle bed reactor of a factory

Gamma chamber irradiator developed by BRIT

Leakage in pipe being detected with the help of radiotracer

Radiotracer testing in action in a sugar mill

Radiotracers are helpful in checking of inventory of mercury

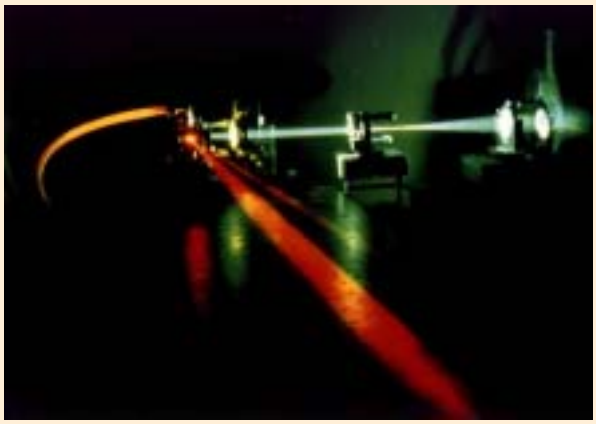
Using radiotracer technique, silt movement is being studied in Hoogly river in West Bengal

Laser and Electron Beam Accelerator : Development and Applications

Laser systems and Electron Beam Accelerators are the areas where India is one of the front runners.

Lasers, because of their precision and power, have innumerable applications. The DAE's research organisations viz. Centre for Advanced Technology (CAT) in Indore, Madhya Pradesh and Bhabha Atomic Research Centre (BARC) in Mumbai, are engaged in the development of applications based on unique properties of lasers

CAT has developed lasers for medical and industrial applications. These include high power continuous wave carbon dioxide lasers, high repetition rate pulsed TEA carbon dioxide laser, Nd:YAG laser, copper vapour lasers, and nitrogen laser. Development of several laser systems and laser-based instruments for industrial and medical applications are also in progress.



Dye laser pumped Copper Vapour Laser. These lasers have been developed at the Centre for Advanced Technology, Indore, Madhya Pradesh

Several units of a surgical laser system, based on a continuous wave carbon dioxide laser and integrated with an articulated arm, have been given to different hospitals in India for their use and evaluation.

CAT has developed nitrogen laser units with fibre optic beam delivery systems. Some such units are in use in hospitals in Indore and Patna.

For early detection of cancers such as oral cancer, breast cancer and uterine cancer, a laser induced fluorescence spectroscopy technique employing nitrogen laser, has given very encouraging results.

Single and multibeam carbondioxide lasers developed at CAT, have been given to different institutes and industries for various material processing applications. High power lasers coupled with CNC workstation, are being regularly used for cutting of metal and non-metal sheets, welding, surface modifications.

CAT has successfully done laser scabbling and drilling of concrete, which can have potential application in decontamination and decommissioning of nuclear facilities.

A Nd:YAG based fully computer controlled laser welding system, developed at CAT, has been in use for many years for welding of the heart pacemaker, by a private company.

Several other systems such as laser marker, micro-drilling system, diamond cutting system incorporating Nd:YAG lasers, have also been developed. Recently, an optical fiber coupled Nd:YAG laser system has been developed for remote cutting & welding of nuclear components in radioactive environment.

Plate cutting by laser (left) and 20kW Laser System, both developed at CAT

Laser equipment developed at CAT for treatment of oral cancer

Many laser based instruments have also been developed. These include laser fluorimeter to detect trace quantities of uranium in water samples; laser based non-contact dimension measuring instruments, and projectile speed monitor and free space laser voice communicator. Units of DAE are collaborating with M/s Bharat Electronics Ltd. (BEL) to produce some of the equipment on a commercial scale.

Electron beam accelerators are finding increasing use in the fields of medicine, agriculture and industry. Beams with varying power and energy are being extensively employed for radiation processing of materials. The technology has totally revolutionized this field.

Electron beam accelerators are used in the treatment of cancer, imaging of organs of the body, and sterilization of medical products and hospital wastes. In developed countries, more than half of medical supplies are sterilized by electron beam processing. In agriculture, these accelerators are being used for preservation, hygienization, quarantine and delaying the ripening of agricultural and food products.

In recent years, Electron Beam accelerators have emerged as a preferred tool in industry for radiation processing. Industry is using electron beam irradiation for improving quality of manufactured goods and making products of entirely new properties. The products range from computer disks, shrink packaging materials, tyres, cables, composites, hot water pipes to cosmetics.

Electron beams are being employed for various uses such as curing of coatings, adhesives and paints on thin films, video/audio tapes, wooden panels, etc.. They are also being exploited for cross linking of polyethylene foam.

Electron accelerators have also found use in pollution control. These accelerators are used for cleaning flue gas from thermal power plants. The irradiation facilities for treatment of sewage from cities are in operation in several countries.

The other beneficiary industries of this technology are the heat shrink materials, diamond industry, rubber industry, irradiation of semiconductors, food preservation, medical sterilization, radiation therapy, and radiography.

More than 1500 electron accelerators are being used in the industry all over the world.

DAE had set up an electron accelerator (ILU-6) based experimental facility in 1987-88 at Trombay. This accelerator has since been shifted to BRIT campus at Navi Mumbai and is extensively used for development of new applications as well as to provide service to industry.

500 keV Industrial Accelerator at Navi Mumbai

BARC has been working with major cable manufacturers to indigenously develop formulatins for electron beam crosslinked cables. One cable manufacturer has already set up an accelerator to manufacture cross-linked cables in India. All the technical help was provided by BARC for this purpose. In collaboration with Sriram Institute of Chemical Research, New Delhi, the Centre has developed a special formulation of PVC based material which on radiation cross-linking, leads to a product that can withstand high temperatures. To induce uniform crosslinking, a rotating multi-spindle conveyor system was designed at Trombay. The process has been commercialised.

DAE is currently developing electron accelerators for radiation processing of paints, wires, O-rings, pulp sheets and other industrial products, agricultural produce and sterilization of medical products. BARC has successfully developed a 500 keV Accelerator, now housed at BRIT Complex, Navi Mumbai. Industries such as M/s Reliance India Ltd. are using it for cross linking of plastic sheets and granules. BARC and IIT-Madras, Chenai are pursuing radiation damage studies of materials. In addition to gamma radiation from radioisotopes, electron accelerators can also be used for radiation processing of food products.

In addition to gamma radiation from radioisotopes, electron accelerators can also be used for radiation processing of food products. M/s Hindustan Lever Ltd. are planning to irradiate its brand of wheat flour by utilising this facility.

For commercial exploitation of electron beam technology, BARC is setting up an Electron Beam Centre at Kharghar, Navi Mumbai. SAMEER is also collaborating in the project.

The Centre will house two 3 MeV and 10 MeV electron beam accelerators and laboratories. This facility will be the hub of research and development in the area of industrial accelerators and their applications. To put this technology on a strong footing, other institutions such as CEERI, Pilani will also be the contributing to the programme.

CAT has developed a 750 keV accelerator which will find wide ranging applications where the required depth of irradiation does not exceed 1-2 mm. The Centre is also developing a machine based on microtron for applications in radiotherapy.

Desalination of Water

Towards improving quality of life of people, since seventies, BARC has been engaged in R&D activities relating to desalination. The development activities in the field of desalination was initially based on thermal process that involves evaporating water and condensing the vapours formed. Later the development of membrane processes based on reverse osmosis, was also included in the programme. These efforts have led to the successful development of desalination technologies based on multi-stage flash (MSF) evaporation, reverse osmosis (RO) and low temperature evaporation (LTE).

Based on these technologies, a number of desalination plants have successfully demonstrated their operations during the last few years. These include desalination plants for rural areas, ship mounted plants and plants for other uses.

Work is being pursued on hybrid desalination for producing water for process industries and for potable use, at lower cost.

The research and development work on advanced membrane is underway for widening the scope of membrane technology to include effluent treatment, water reuse and various industrial applications.

Efforts at BARC are also directed towards the utilization of waste heat. Using low temperature evaporation technology (LTE), the Centre has been studying the possibility of use of waste heat of nuclear reactors for seawater desalination. The know-how in this field was developed and a 30 cubic metre/day pilot plant was installed, coupled to CIRUS reactor. Such plants would be ideal for industries where waste heat is available in the form of flue gases and process heat. These plants can also produce pure water from high salinity or sea water for the rural areas where waste heat from DG sets/ solar energy is available.

Based on reverse osmosis technology, BARC had set up a number of small desalination plants. These included a reverse osmosis based plant set up at Sheelgan village, district Barmer, Rajasthan. The plant has been regularly providing drinking water to the villagers.

To demonstrate the utility of RO desalination systems in meeting the drinking water needs of brackishness affected villages, a 40 cubic metre/day seawater RO plant has been setup in Trombay. A brackish water RO plant has been setup in Rajasthan in cooperation with Defence Laboratory, Jodhpur, for providing drinking water to the villagers from high salinity brackish water sources.

In the area of desalination of water, BARC has been working on a number of challenges and innovative concepts, which cover the development of :

- Low temperature vapour compression desalination plants,
- Better quality membranes offering higher output,
- Effluent treatment and zero discharge,
- Barge mounted desalination plants for remote locations and small islands or coastal communities.

BARC has also analysed and monitored the quality of the water samples from Andhra Pradesh, Karnataka, Maharashtra, Gujarat and Rajasthan.

Reverse Osmosis Module (Capacity :25 cubic metre per day) for industrial use

Nuclear Desalination Demonstration Plant (Capacity : 6300 cubic metre per day) set up at Kalpakkam, Tamil Nadu

Low Temperature Evaporation Desalination Plant (Capacity : 30 cubic metre per day)

Reverse Osmosis Plant (Capacity : 30 cubic metre per day) set up at Sheelgan village, district Barmer, Rajasthan

Reverse Osmosis Demonstration Plant (Capacity : 5 kilolitre per day) that runs on solar energy