New Trombay Crop Varieties

BARC has so far released 35 Trombay crop varieties for commercial cultivation. These include eight new Trombay Crop varieties released during 2007 which are Cowpea-TRC (Trombay Raipur Chowli), Khalleshwari for Chhattisgarh – this variety matures in 90 days and is suitable for rice based cropping system of Chhattisgarh, TJM-3 (Trombay Jawahar Mungbean) for Kharif and summer seasons in M.P., TM-96-2 (Trombay Pesara) mungbean for Rabi and rice fallows seasons in Andhra Pradesh based on its high yield, synchronous maturity and resistance to powdery mildew disease, TLG-45 (Trombay Latur Groundnut) – a large seed groundnut variety and TAM 98-21 (Trombay Amaravathi Soyabean) a high yielding disease resistance variety for Maharashtra for kharif season, Mustard-TPM 1 (Trombay Phule Mustard) a yellow seed coat mutant with high yield and oil content and Sunflower- TAS 82 (Trombay Akola Sunflower) a dark black seed coat colour mutant with high seed and oil yield potential even under low rainfall condition in Maharashtra.

In groundnut, one mutant TG-18A and in sesame, two mutants, tall seedling and polypetalous corolla mutants were registered with the National Bureau of Plant Genetic Resources, New Delhi. More than 600 quintals of breeder seed of Trombay groundnut varieties was produced and supplied to different seed agencies and farmers. Several state agricultural universities are multiplying breeder seed of Trombay crop varieties.
Summary of the Activities of Department of Atomic Energy during 2007-08

For the Department of Atomic Energy, the year 2007-08 was eventful with successes in all the domains of its mandate.

Kaiga Atomic Power Project Unit-3 in Karnataka was declared commercial on May 6, 2007. The first open-pit uranium mine at Banduhurang in Jharkhand was commissioned. The Waste Immobilization Plant, Trombay produced 200th canister of vitrified waste product. A Spent Fuel Storage Facility (SFSF) was commissioned at Kalpakam. Seventy five monitoring stations of the Indian Environmental Radiation Monitoring Network (IERN) were installed. Heavy Water Board exported 4400 kg of heavy water to a US firm and more export orders for heavy water are in the pipeline.

The Fast Breeder Test Reactor (FBTR) at Kalpakam was successfully operated, meeting its objectives and achieved a peak burnup of 154 GWd/t without any fuel failure.

A new RF cavity for Indus-1 was designed, built and commissioned at Indore.

Eight new Trombay crop varieties -- two in Mungbean and one each in Groundnut, Soybean, Mustard, Sunflower, Cowpea and Pigeonpea, were released for commercial cultivation.

More than 51,000 consignments of various isotope products and processing services were provided. Bhabhatron-II, an advanced indigenously developed teletherapy machine was supplied to Vietnam.

The latest supercomputer, A N U P A M - A J E Y A, was commissioned at Trombay.

National Institute of Science Education and Research (NISER) was set up at Bhubaneswar, Orissa.

Towards the DAE's societal initiative, three AKRUTI nodes were set up in Amravati, Raigad, and Ratnagiri districts of Maharashtra.

Following is the summary of the major achievements and activities of the Department during the year 2007-08.

**NUCLEAR POWER PROGRAMME**

The Nuclear Power Corporation of India Ltd. registered more than 275 reactor years of safe and radiation accident free experience of operation.

The 17 operating nuclear power reactors (two boiling water reactors and fifteen pressurised heavy water reactors) of the Corporation performed satisfactorily. Construction works on its five nuclear power reactors, totaling 2660 MWe capacity, progressed as scheduled.

During the calendar year 2007, generation of electricity from the operating nuclear power plants was 18,030 million units.

Unit-2 of the Kaiga Generating Station recorded over 500 days of continuous operation as on January 1, 2008. Unit-4 of the Rajasthan Atomic Power Station and Unit-1 of the Kakrapar Atomic Power Station also recorded uninterrupted operation for more than a year.

Kaiga Generating Station-2 (KGS-2) achieved 100% availability factor. Nine out of fifteen nuclear power reactors in operation registered availability factors above 80%.

Enmasse Coolant Channel Replacement (EMCCR) and safety upgradation jobs at Unit-1 of Narora Atomic Power Station are continuing for which the Unit is under planned shutdown. The Unit-2 of this station and Unit-2 of Rajasthan Atomic Power Station were also brought under planned shutdown for taking up EMCCR and upgradation and Enmasse Feeders Replacement jobs respectively.

The releases of radioactivity and effluents from the Nuclear Power Plants were far lower (less than 1%)
than the limits specified by the Atomic Energy Regulatory Board (AERB). The occupational exposures of the employees were maintained within the stipulated limits of exposures.

WANO (World Association of Nuclear Operators) peer reviews of MAPS-1&2 were completed. Similar reviews were also conducted earlier for the power stations at Kakrapar, Narora, Kaiga, Rawatbhata and Tarapur. These reviews indicated operating stations performance to be comparable to the world level.

Kaiga Atomic Power Project which had achieved criticality on February 26, 2007, was declared commercial on May 6, 2007. For Kaiga Unit-4, commissioning activities are progressing. This unit is planned to achieve first criticality by mid 2008.

Unit-5 of the Rajasthan Atomic Power Project-5&6 was undergoing commissioning. It is expected to achieve criticality by March 2008. Civil works in RAPP-6 are also nearing completion.

The work on Kudankulam Project (2×1000 MWe VVER), being implemented with Russian cooperation, achieved cumulative physical progress of 79% as on December 31, 2007. Its Unit-1 is expected to attain the first criticality by December 2008 followed by Unit-2 criticality within a year.

The pre-project activities were initiated for the new projects at Rawatbhata, Rajasthan (RAPP-7&8, 2×700 MWe PHWRs), Kakrapar, Gujarat (KAPP-3&4, 2×700 MWe PHWRs), Kudankulam, Tamilnadu (KK-3&4, 2×1000 MWe LWRs) and Jaitapur, Maharashtra (JNPP-1&2, 2×1000 MWe LWRs). The conceptual design of KAPP-3&4 was completed and detailed engineering made progress.

**FRONT END FUEL CYCLE**

The Front End Fuel Cycle comprises ancillary operations namely Mineral Exploration, Mining and Processing of ore, and Fuel Fabrication. Heavy water is used as moderator and coolant in pressurized heavy water reactor.

**Heavy Water Production**

The Heavy Water Board (HWB) of DAE is responsible for design, construction and operation of heavy water plants in the country. The Board operates six heavy water plants.

During the period of report, the performance of the Board in terms of production, specific energy consumption and safety was very good.

The Heavy Water Plant, Manuguru achieved 120% of the rated production capacity and completed all the scheduled major turn around jobs ahead of scheduled time.

The Heavy Water Plant, Kota is expected to register excellent performance by achieving maximum ever production and minimum ever specific energy consumption.

Performance of Heavy Water Plant, Thal was excellent. It achieved a capacity utilisation of more than 124%.

The revived Heavy Water Plant, Baroda was running continuously and its performance during the report period was good.

However, the performance of the Heavy Water Plant, Hazira was affected due to flooding problem in its exchange tower. The problem was rectified and the plant is expected to achieve 85% of targeted production.

The Heavy Water Plant, Tuticorin remained shutdown due to non-availability of feed synthesis gas from M/s SPIC’s ammonia plant. At present the plant is kept on preservation.

Besides meeting the domestic needs of heavy water, the Board has been exporting heavy water from time to time. Recently the Heavy Water Board successfully executed an export order of 4400 kg of nuclear grade heavy water to the Spectra Gases Inc., USA. The company has further requested the Board for export of 11 MT of heavy water to be delivered to them shortly. The Cambridge Laboratories Inc (CIL), USA also requested the Board for the supply of high quality heavy water. DAE has entered into contracts with CIL for the supply of 4.6 MT, and with South Korea for supply of 4 MT of heavy water.

HWB has been developing alternative applications of Deuterium/heavy water in life
science as well as technological fields. Supply of 3% Deuterium-Nitrogen gas mixture continued from the Heavy Water Plant at Baroda, to an optical fibre manufacturer. Small quantities of heavy water were also supplied to R&D organizations such as Indian Veterinary Research Institute, Izatnagar, Central Glass & Ceramic Research Institute, Kolkata and the Centre of Plasma Physics, Assam.

HWB also took up various R&D and process development activities essential for Nuclear Power Programme like production of enriched Boron. The plant based on exchange distillation process developed by BARC was commissioned at Talcher.

To achieve further reduction in internal dose to occupational workers of Nuclear Power Station, setting up of a Technology Demonstration Plant for Heavy Water clean up continued.

Mineral Exploration

Exploration of nuclear minerals is done by the Atomic Minerals Directorate for Exploration & Research (AMD). The major activities relating to exploration were as follows:

190 tonnes (UO₃) of additional uranium resources were established in Sikar district (Rajasthan) and Loston and Wakhyn (Meghalaya).

Significant mineralised intercepts/bands were identified at Dshur, Belgaum district in Karnataka; Chitrial, Nalgonda district, Koppumuru, Guntur district, Tummalapalle, Kadapa district in Andhra Pradesh; Darshanapur, Guiburg district in Karnataka; Rohil, Sikar district in Rajasthan; Raghunathpura-Khalsa, Mahendragarh district in Haryana; Burhbjata (Silekhjodi fault zone); Bastar district, Gotumuru, Durg district in Chhattisgarh; Wakhyn North Block, West Khadi Hills district in Meghalaya, and Balia-Rankia, Jajpur district in Orissa.

Reconnaissance survey resulted in discovering promising uranium anomalies in Mahadev basin, Meghalaya, Tertiary basin, Himachal Pradesh, Tamil Nadu alkaline belt, Tamil Nadu, Delhi Super Group, Rajasthan and Haryana, Cuddapah Super Group, Andhra Pradesh and Satpura-Gondwana Basin, Madhya Pradesh.

The investigations of AMD for the Rare Minerals and Rare Earths resulted as follows:

About 3 tonnes of columbite-tantalite and 2 tonnes of beryl were produced as by-product at Pandikimal-Jangapara and Bodenar recovery units, Jharsuguda district, Orissa and Bodenar, Bastar district, Chhattisgarh.

Additional reserves of 490 kg of columbite-tantalite were estimated in the extension areas of Kotwalpara-Usapara pegmatites, Dantewada district and 51 kg in Bodenar South pegmatite, Bastar district, Chhattisgarh.

New columbite-tantalite bearing pegmatites were located at Sardhapur, and Kuakhol area Sambalpur district, Orissa and Gaddipara Dantewada district, Chhattisgarh, beryl bearing pegmatite at Sardhapur, Charabati, Barkhol, and Lepidolite bearing pegmatites at Dhunkachcheli and Tandabera, Sambalpur district, Orissa. Cassiterite bearing pegmatites were also located at Pinjopara, Korapal, Kondaras and Turem Metta areas, Dantewada district, Chhattisgarh.

Uranium Mining & Processing

The operating units of the Uranium Corporation of India Limited maintained improved capacity utilization. The company remained engaged in implementing a massive expansion programme of constructing new mines and plants. Commissioning of Banduhurang, the first open-pit uranium mine, and the trial run commissioning of Turamdih plant were the landmark achievements. Construction activities at Bagjata and Mohuldi underground mine were on schedule. The foundation stone of Tummalapalle Uranium Mining and Processing Project was laid on November 20, 2007. Ministry of Environment & Forest issued their clearance for Kylleeng-Pyndengsohiong, Mawthabah (KPM) uranium project in Meghalaya.

UCIL took up exploratory mining at Gogi, Karnataka and the work progressed satisfactorily. The company also took up steps for exploratory mining at Rohil in
HWB is setting up industrial scale Technology Demonstration Plant for recovery of uranium from secondary sources such as phosphoric acid manufactured using rock phosphate at Rashtriya Chemical Fertilizer, Trombay.

BARC made significant progress in its attempts to bio-recover uranium from sea-water and dilute nuclear waste using natural and genetically engineered microbes.

The Indian Rare Earths Ltd. pursued setting up demonstration plants to recover uranium from phosphoric acid, in addition to recovering uranium from various secondary sources such as thorium hydroxide concentrate and other metallurgical process residues.

**Fuel Fabrication**

The Nuclear Fuel Complex manufactures natural uranium oxide fuel bundles for PHWRs, enriched uranium fuel assemblies for boiling water reactors, Reactor Core Structuralis, Reactivity Control Mechanisms and special materials. In addition, NFC produces for Fast Breeder Reactors, core sub-assemblies and other critical components and caters to the demand of high-quality stainless steel tubes/pipes and titanium half alloy products for critical and strategic application in nuclear power plants, reprocessing plants, defence and space establishments.

In addition to fulfilling the reload fuel requirements of all the operating PHWRs of 220 MWe and 540 MWe capacity, NFC manufactured and supplied entire fuel for initial core requirement of NAPP-1. Apart from reload fuel for BWRs, 100 nos. of zirconium alloy square channels were manufactured and supplied.

Fast Reactor Facility at NFC involved in the activities of both PFBR & FBTR requirements, supplied the fuel pin components, upper & lower assembly sets for MARK-1 (mixed carbide) fuel sub-assemblies.

NFC also produced about 1000 nos. of Zr-1%Nb fuel clad tubes for strategic applications. A test sample of Niobium based alloy containing 1% Zr & 0.1% C, required for High Temperature Compact Reactor (HTCR) was produced successfully.

NFC developed superior pilgering process for the manufacture of seamless square channels for boiling water reactors at Tarapur. This process is innovative in nature and is first of its kind in the world.

Hexagonal tubes in D9 grade of Stainless Steel, used as wrapper tubes for fuel and blanket sub-assemblies for prototype fast breeder reactor (PFBR), were successfully fabricated.

Zirconium Complex is being set up by Nuclear Fuel Complex (NFC) at Pazhayakayal, Tuticorin, Tamilnadu to meet the enhanced requirement of zirconium Sponge required for the manufacture of fuel and structural components.

**BACK END FUEL CYCLE**

**Fuel Reprocessing & Waste Management**

The Fuel Reprocessing facilities at Trombay, Tarapur and Kalpakkam were operated for separation of useful materials from the spent fuel. Spent Fuel Storage Facility (SFSF) at Kalpakkam was commissioned. Some of the facilities were augmented for enhancing the reprocessing capacity to meet the demand of fuel for the fast breeder programme. High capacity integrated nuclear recycle plants have been conceived and the design of such plants reached an advanced stage.

The Heavy Water Board has diversified into production of certain solvents needed for nuclear power programme. Organo-phosphorous solvents like D2EHPA (Di Ethyl Hexyl Phosphoric Acid) and TBP (Tri Butyl Phosphate) are required for the back end of the fuel cycle. Production of these chemicals continued at the Talcher facility. HWB also synthesized Tri Alkyl Phosphine Oxide (TAPO) and Tri Octyl Phosphine Oxide (TOPO).

Waste management facilities at Trombay, Tarapur and Kalpakkam were operated safely. Discharge of activity to environment was kept well below the prescribed regulatory limits. At the Waste Immobilisation Plant, Trombay, production of 200° canister of vitrified waste product was achieved.

At Tarapur, Advanced Vitrification System (AVS)
successfully completed one year of safe operation. Work on setting up and additional vitrification train of AVS was initiated at Tarapur.

**HEALTH, SAFETY & ENVIRONMENT**

All exposures of the workers of uranium mining and milling activities were well below the dose limit. In-plant radiological survey and radiation dose evaluations were carried out by BARC for all the units to ensure compliance with regulatory norms.

Level III Probabilistic Safety Assessment (PSA) for the 220 MWe PHWR at the KAPS site was completed.

Seventy five monitoring stations of the Indian Environment Monitoring Network (IENMON) were installed by BARC.

The Nuclear Power Stations achieved improvement in collective exposure and radioactive effluent release.

For radiological emergencies, a real time Decision Support System was developed and demonstrated for the first time at IGCAR.

TAPS, RAPS, NAPS, KAPS and KGS bagged a number of awards for safety, and KAPS was given AERB green site award.

**R&D SUPPORT TO POWER TECHNOLOGIES**

BARC continued its research and development support to the national nuclear power programme and extensive efforts were pursued in the field of reactor technology, advanced fuel development, research reactor operation and up-gradation and waste management and storage. A number of gadgets were developed for use in PHWR nuclear power plants.

Ultrasonic Measurement of Axial Creep System was developed and qualified for measuring axial creep of coolant channel of reactors. PHWR fuel handling training simulator (Initial phase) was developed and commissioned at the Nuclear Training Centre, Tarapur. An innovative hydraulic remotely operable three leg micrometer (HYRIM) was developed and deployed at RAPS-2 for measurement of internal diameter of pressure tubes of coolant channel. A hot cell fuel pin gamma scanner for linear manipulation of irradiated fuel pins was designed and developed with precision fuel pin movements and computerized auto-operations. Symptom based Diagnostic System was developed for evaluation of accident scenarios in 220MWe PHWRs. Other devices developed at Trombay included Absolute Pressure Sensor with remotely mounted electronics, Temperature Sensors for reactor coolant temperature measurements inside the reactor pressure vessel and flow measuring devices for measurement of flow in reactor process systems were developed.

R&D efforts of the NPCIL were focused on reducing unit energy cost by improving plant availability factors & efficiency, reducing project gestation period and improving plant safety.

The Electronics Corporation of India Ltd. is a multi-technology, multi-product company serving various sectors of the Indian economy. During the report period, ECIL supplied a number of equipment and complex instruments for the Nuclear, Defence, Security and Space sectors. For the Defence Sector ECIL successfully executed Samyukta, Divyadrishhti, and PJ10 projects. It supplied VSAT Network Equipment to Project Divyadrishhti and BrahMos of Ministry of Defence, Security Systems to RAPP-5&6 and Kaiga-3&4 to NPCIL, and Earth Station Antennae to Space Sector.

**NUCLEAR POWER PROGRAMME-STAGE-2**

**Fast Reactors**

Design and development of liquid sodium cooled fast breeder reactors, along with associated fuel cycle technologies is carried out by the Indira Gandhi Centre for Atomic Research (IGCAR) at Kalpakkam. A Fast Breeder Test Reactor (FBTR) is also in operation here. During the report period, FBTR was successfully operated, meeting its objectives. The indigenous fuel reached a peak burn-up of 154 Gwd/t, without any fuel failure.

The MOX test fuel for Prototype Fast Breeder Reactor (PFBR) attained a burn-up of about 67 Gwd/t. The core of FBTR was
uranium fuel rod clusters for the Reference Core were loaded into the Critical Facility at Trombay. Installation of all the process system piping & components for heavy water, nitrogen systems at the critical facility were completed, and software for on-line flux mapping system for AHWR/PHWR critical facility was developed.

**Accelerator Driven Sub-critical Systems and Innovative Reactors**

Design of critical systems for Acceleration Driven Subcritical System (ADS) such as Micro-wave Ion source, its Beam diagnostic chamber and Beam Dump chamber for the Electron Cyclotron Resonance (ECR) Micro-wave Ion Source for delivering 50 mA of Proton beams was completed at BARC. Manufacturing of these systems progressed.

A Coupled Thermal Neutronic Analysis code was developed to study the coupled neutronics-thermal hydraulics behaviour of Compact High Temperature Reactor (CHTR).

BARC is also engaged in the development of 600 MWt Innovative High Temperature Reactor (I-HTR). This reactor is based on pebble bed configuration, cooled by molten metal or salt-based coolant. Various aspects related to reactor physics,

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**Nuclear Island containment buildings of Prototype Fast Breeder Reactor**

expanded to achieve the major mission of FBTR to irradiate the fuel simulating PFBR fuel composition to burn-up of 100 GWd/t.

Construction of 500 MWe Prototype Fast Breeder Reactor at Kalpakkam continued. The civil construction of Nuclear Island Buildings progressed at various elevations. The construction of Reactor Vault which houses all the nuclear components was completed up to first vessel (Safety Vessel) erection level. Manufacture of Nuclear Steam Supply System components was completed and the components were delivered to site. The project achieved an overall physical progress of 32.5% as on December, 2007.

The design review of the 500 MWe Prototype Fast Breeder Reactor was continued at IGCAR. This reactor's safety vessel was manufactured successfully.

The Augmented Boron Enrichment Plant was commissioned at Kalpakkam and an enrichment of 40% was achieved.

**Nuclear Power Programme Stage-3**

**Thorium Based Reactors**

For providing energy security on sustainable basis, Thorium utilization is the focused objective of the Stage-3 of the Indian Nuclear Power Programme. BARC is developing a 300 MWe Advanced Heavy Water Reactor (AHWR) that aims at developing expertise for thorium utilization and demonstration of advanced safety concepts.

The AERB Pre-Licensing Design Safety Committee for AHWR completed the preliminary review of AHWR design, and the potential issues related to licensing of the AHWR design were resolved. A number of passive systems were incorporated in AHWR.

All the fifty-five natural metallic
motion related behaviour of pebbles and thermal hydraulics design of the reactor were under study at Trombay.

ADVANCED TECHNOLOGIES AND RADIATION TECHNOLOGIES AND THEIR APPLICATIONS

DAE's research organizations are engaged in the development of advanced and radiation technologies such as Research Reactors, Radioisotope production, Accelerators, Synchrotrons, Lasers, Beam Lines and others, and their applications. During the report period, following were the major activities in these areas.

Research Reactors

At Trombay, neutron irradiation, radioisotope production and supply were maintained.

The physics design of upgrading the existing Apsara reactor to a 2 MW reactor was completed and level-1 probabilistic safety assessment of CIRUS was carried out.

The conceptual design of a 30 MW Multi Purpose Research Reactor (MPRR) to be set up at Vishakhapatnam, was carried out at BARC.

Metallic fuel assemblies for Dhruva, and CIRUS were fabricated at Trombay and supplied. All the upgrading requirements of Dhruva/Cirus reactors were fulfilled.

Radiation Technologies & Applications

More than 51,000 consignments of various isotope products and processing services were provided by BRIT to institutions all over the country and also to some of them located abroad, bringing in a sales turnover of Rs. 45 crore.

Agriculture

Eight new Trombay crop varieties -- two in Mungbean and one each in Groundnut, Soybean, Mustard, Sunflower, Cowpea and Pigeon pea were released for commercial cultivation in various agro-climatic zones of the country. So far 35 Trombay crop varieties have been released and notified for commercial cultivation.

More than 600 quintals of breeder seeds of Trombay groundnut varieties were produced and supplied to different seed agencies and farmers.

A genetic linkage map of blackgram (urad) was constructed with 428 molecular markers which is the most saturated map for blackgram to date. In wheat, a DNA based marker was developed for Sr26 gene effective against the stem rust to facilitate pyramiding with other stem rust resistance genes.

Biogas Plant

Eight Nisargrrna biogas plants for processing of biodegradable waste became functional since January 2007 bringing the tally to 19 functional plants.

Food Processing

BRIT's Radiation Processing Plant at Vashi, Navi Mumbai continued to offer radiation processing services to its customers spread all over the country. More than 1000 MT of spices and allied products were processed at this plant upto November, 2007.

KRUSHAK (Krishi Utpadan Sanrakshan Kendra) at Lasalgaon, Nasik carried out radiation processing of mangoes for export to USA.

Three radiation processing plants were commissioned in private sector at Bangalore, Vasai and Hyderabad.

Healthcare

Research and development work in the field of nuclear medicine continued and clinical services were extended to a large number of patients referred to the Radiation Medicine Centre of BARC.

Bhabhatron-II, an advanced teletherapy machine developed by BARC, was supplied to Vietnam under an agreement with IAEA.

BRIT supplied 14,000 consignments of ready-to-use radiopharmaceuticals of 131I, 137Cs, 153Sm and 152Sm to various nuclear medicine centres. 455 Ci of 99rMo was supplied for extraction of 99mTc at hospitals. Various accessories of 99mTc Solvent extraction generator system and other products were also supplied. About 48,000 Cold Kits for the formulation of 99mTc radiopharmaceuticals were supplied to various nuclear medicine centres.

A product 32P Samarium Phosphate colloid-injection useful in the treatment of joint disease, was developed. The ongoing work of monoclonal antibody (ch TNT 1/B) labeling with 131I for a US company, continued. During 2007, BRIT extended its labeling services worth USD 1,50,000.

In 2007, for the production and supply of 111mIn (therapeutic doses) infrastructure and logistics preparation were completed at BRIT and the first therapeutic dose trial consignment was supplied to the Radiation Medicine Centre. The Board also supplied more than 9,688 kits of RIA and IRMA to 300 immunoassay laboratories throughout the country.
Dish of the Deep Space Antenna System (IDSN32) developed & supplied by DAE to ISRO for India’s Chandrayaan-I Project

Antenna Control Servo System
India exported the first consignment of 720kg Alfonso and Kesar mangoes to the US on April 26, 2007. The mangoes were irradiated at BARC’s KRUSHAK Plant at Lasalgaon, Nashik, Maharashtra.

Bhabhatron-II: Cobalt-60 Teletherapy Machine developed at BARC, for cancer treatment.
Handing over of the BraMos System to the Army (New Delhi, June 21, 2007). The system was manufactured at ECIL.

Indigenously developed Supercomputer Anupam-Ajeya at BARC. This version has a sustained speed of 9.036 TeraFLOPs which is five times more than that of its previous version.
AKRUTI - NIRMITEE PROJECT: Foldable Solar Drier Demonstration

Nisargruna: Kitchen Waste (Bio-Degradable Waste) based Bio-Gas Plant
Nuclear & Biotechnological Tools
BRIT remained engaged in the synthesis and supply of a variety of ¹³C, ¹⁷O and ³²P-labelled products and oligonucleotides (DNA primers). Production and supply of tritium filled sources of various types were carried out to meet the demand of defence establishments and army workshops.

Sealed Radiation Sources
Sealed radiation sources of about 600 kCi activity were fabricated, processed and loaded for use in various types of industrial applications. Cobalt-60 sources were supplied for blood irradiators, gamma chambers and industrial irradiators. Cobalt-60 Teletherapy sources were also fabricated and supplied to a number of hospitals.

Gamma Radiation Processing Services
BRIT's plant ISOMED for irradiation of medical products expects to process around 8200 cubic metres of medical products during the financial year 2007-08, yielding a revenue of Rs. 3.5 crore. For radiation processing of onion and potato, a low dose loop in ISOMED was commissioned.

Water
Seawater desalination technologies for production of ultrapure water (>10 mega-ohm-cm) based on Multi Effect Distillation-Vapour Compression and Low Temperature Evaporation integrated with Cooling Tower were successfully developed and commissioned by BARC. Ultrafiltration membrane based techniques were also developed for removal of fluoride and iron from contaminated water.

Accelerators
During the report period, the projects Radioactive Ion Beams (RIB), Heavy Ion Experimental Facilities, and Advanced Computational Facility were completed by the Variable Energy Cyclotron Centre (VECC) at Kolkata. The RIB Project at VECC aims to accelerate radioactive and stable isotopes for their use in research in nuclear astrophysics, material science, and atomic and nuclear physics. The major activities included acceleration of Iron Beam to 30 keV/u.

The Centre is setting up a Superconducting Cyclotron for basic and applied research in nuclear physics, condensed matter, biology, etc. The Superconducting Magnet of the Cyclotron remained energized for over one year for magnetic field measurements, and over one million data points were recorded and analyzed. A 50-detector array for high energy gamma detector array was also completed and commissioned.

Synchrotron Radiation Source
At the Raja Ramanna Centre for Advanced Technology (RRCAT), a new RF cavity for Indus-1 was designed, built and commissioned leading to a greatly improved performance of the storage ring.
Synchrotron radiation source Indus-2 at RRCAT, made steady progress. Its ring was operated with stored current ∼50mA at 2 GeV. Alignment work on two beam lines also advanced substantially.

R & D activities related to Linac subsystems at Indore were started.

Laser Technology Development and Applications
A low temperature (500°C) HyBrID (Hydrogen Bromide In Discharge) version of Copper Vapour Laser giving 50 W average power was developed at RRCAT. A flash lamp pumped Nd:phosphate glass based Q-switched and cavity dumped laser oscillator was built to generate stable, synchronizable laser pulses of ~800 ps duration. This will be used in a pump laser system for development of optical parametric chirped pulse amplification based high-power laser.

A fast capillary discharge set up, to serve as a coherent X-ray source being built at RRCAT, was integrated and undergoing tests.

A compact laser marker system based on all solid state diode pumped Q-switched Nd:YVO₃ laser, was built. A continuous wave Nd:YAG laser with 880 W output power and high electrical to laser conversion efficiency (4.4%) for material processing, and Red diode lasers,
Red laser diode showing emitting light from both facets. The laser has been developed at RRCAT.

operating at 670 nm wavelength were developed. A single frequency all solid-state diode pumped Nd:YVO₄/KTP green laser emitting more than 700 mW power in single longitudinal mode with a line-width of 12.3 MHz was fabricated for spectroscopic applications. An all solid-state diode pumped and intracavity frequency doubled Nd:YVO₄/KTP green laser with 50 nsec pulse duration and average output power of 40 W at 6 kHz repetition rate was developed for efficient pumping of tunable lasers.

Laser based cutting for dismantling highly radioactive fuel subassemblies of FBTR, was successfully carried out in hot cell at Kalpakkam using a fibre coupled industrial Nd:YAG laser that was developed at RRCAT.

The Centre made a laser-produced plasma narrow band X-ray source at 25Å+1Å in the water window range (i.e.24-26Å). The source provided adequate X-ray flux for imaging of live biological samples with high contrast.

For applications in photochemistry, a high repetition rate, high pulse energy line tunable TEA CO₂ laser of industrial standards was developed. A 3.5 kW cw CO₂ laser was built for laser based rapid manufacturing of bimetallic tubular components. This technology has potential to make crucial components for fast breeder nuclear reactors.

At Trombay, Pulsed Laser Deposition technique was successfully employed to generate thin film coating of Lanthanum Phosphate on various substrates.

**Other Advanced Technologies**

At BARC, a 5-Axis Dynamic Sub-reflector Pointing Mechanism with five degrees of freedom for carrying the payload of 750 kg for 32 meter DSN Antenna (ECIL-ISRO) for Chandrayaan Project was developed.

An Advanced 16-Channel Acoustic Emission Analysis System to detect crack initiation and growth measurement, and a system based on non-intrusive technique for monitoring blade vibration during plant operation in a steam turbine were developed. The latter system can be installed in a running plant without any site preparation.

BARC developed a 40-420 keV Constant Potential X-ray based Direct Digital Radiography and Volume Tomography System for research and advanced non-destructive imaging applications.

A novel technique of synthesizing arc generated carbon nano-tubes (MWCNT & SWCNT) was evolved.

During the report period, BARC commissioned its latest supercomputer, Anupam-Ajeya, that attained a sustained speed of 9.036 Tera Flops (floating points per second).

The India based Neutrino Observatory (INO) project is a multi-institutional national effort to build a world class underground research laboratory. This large experimental set up at Singara in Nilgiris, will consist of a 50 kton Iron Calorimeter for precision measurements of neutrino properties using atmospheric (cosmic ray induced) neutrinos. Work on a prototype Iron Calorimeter detector reached completion.

Development work on hybrid nano-electronics continued and demonstrated that organic molecules exhibiting different electronic functionalities could be deposited on Si substrates by self-assembly and electro-grafting processes.

**Cancer**

At the Tata Memorial Hospital, Mumbai, over 26,500 new cases were registered and work relating to diagnosis, treatment and research in cancer continued, and highest standards of patient care were maintained.

The Telemedicine project of TMH reached the final phase of linking Regional Cancer Centres and other centres in a network for cancer care, education and research.

TMH provided cancer screening services for common cancers, appropriate methods and strategies for cancer prevention and screening, creating a model for cancer control programmes for the country. Under the Rural Outreach Programme of TMH over 1.07 lakh persons were screened for oral, breast and cervical cancer. The study under the Urban Outreach Programme covered 1.5 lakh women of low socio-economic
group and residing in the slums of Mumbai.

In 2007, all the basic, translational and clinical research facilities in Advanced Centre for Treatment, Research and Education in Cancer (ACTREC) were made fully operational. Bhabhatron-ll, an improved version of indigenously developed Cobalt machine, was installed at ACTREC.

Fusion & Other Plasma Technologies

The Institute for Plasma Research carries out experimental and theoretical research in plasma physics with emphasis on the physics of magnetically confined hot plasmas and non-linear plasma phenomena. Following were the major activities:

Aditya Tokamak

Following a change in schedule of experiments, short pulse (~30 kA, ~30 ms) plasma discharges were initiated in Aditya to study various other physics issues that were still unexploited.

The installation of a multi-grating VUV spectograph on Aditya was nearing completion. Impurity transport studies in Aditya using STRAHL code were progressing.

A Two-point Correlation Reflectometer, with two microwave sources, was designed, developed to study plasma density fluctuations on Aditya Tokamak.

The work continued to do ion Bernstein wave heating experiments on Aditya tokamaks.

Steady State Superconducting Tokamak (SST-1)

Following the cool-down attempt during 2006, some shortcomings were observed hampering the successful commissioning of SST-1. A Standing Expert Committee, set up to determine the future course of action, recommended that it was necessary to cut open the cryostat. After opening the cryostat, a thorough leak testing of the helium circuit was undertaken. Work on overcoming the problems encountered during the last commissioning attempt was initiated.

For smooth operation of SST-1, central control synchronizes the operation of SST-1 subsystems. In line of this, a pressure transducer was installed to monitor the pressure required to operate various neumatic valves of the subsystems.

National Fusion Programme

The major aim of this programme to develop all the necessary fusion related technologies in India. Under this programme, 12 proposals worth of Rs.1.75 crore were funded.

RESEARCH EDUCATION LINKAGES

The Homi Bhabha National Institute (HBNI) concluded satisfactorily its first year of operation. During the report period, the National Institute of Science Education and Research (NISER) under Institute of Physics was set up, HBNI-Visiting Professorship scheme was instituted, and approval of Medical Council of India was obtained to conduct Diploma in Radiation Medicine (DRM) at Radiation Medicine Centre of BARC and Post Graduate Medical Courses at the Tata Memorial Centre under the auspices of HBNI. The Diploma in Radiological Physics, which is a programme in BARC conducted so far under University of Mumbai, was brought under HBNI.

The University Grants Commission-DAE Consortium for Scientific Research (UGC-DAE CSR) node Kalpakam commenced its operation to strengthen research in various Indian universities in the areas of physical, chemical and engineering sciences, and also to provide inputs to the mission programmes of IGCAR.

Research scholars from various academic institutions in the country utilized Dhruva at Trombay.

Sponsored Research

DAE promotes scientific research, in collaboration with universities, educational / research institutes and laboratories, through the Board of Research in Nuclear Science (BRNS) and the National Board for Higher Mathematics.

The Board of Research in Nuclear Science (BRNS), an advisory body of DAE, besides funding research projects, offers a number of fellowship schemes, and provides financial assistance to organise symposia / conferences / workshops on topics of relevance to the programmes of DAE.

During the period of this report, 126 new research projects were sanctioned. Financial sanctions were also issued for the various on-going research projects.

Fellowships were offered under the Raja Ramanna Fellowship Scheme (Senior Scientists Scheme), K.S.Krishnan Research Associate-ship Scheme and the DAE Graduate Fellowship Scheme. Financial supports were extended to seminars conducted by professional organisations on various topics of relevance to DAE.

The National Board for Higher Mathematics (NBHM) initiated several schemes geared to promote the education and research in Mathematics. NBHM provided financial support to institutions for the purchase of the latest books and journals in mathematics. Under its book distribution scheme, selected books were distributed to various postgraduate institutions. A recurring grant of Rs.2.50 crore was released to the Chennai Mathematical Institute. A financial support of Rs.1.50 crore was provided for setting up the Kerala School of Mathematics.

India was chosen to organise the International Congress of Mathematicians (ICM 2010). The venue was fixed as Hyderabad.

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Outreach Programmes

The 4th Science Expo took place at the Nehru Science Centre, Mumbai during January 11-15, 2008. The DAE exhibition elucidated the Department's contributions towards societal development. IIT-Bombay, Tata Institute of Fundamental Research, Tata Memorial Centre, National Institute of Oceanography, Indian Space Research Organisations were some of the organizations that participated in the event. Over 40 schools from Mumbai visited the DAE pavilion, apart from members of the general public.

A seminar and exhibition on the Applications of Radioisotopes and Radiation Technology (ARRT-2008) in collaboration with National Applications of Radioisotopes and Radiation Technology in Industry (NAARRI) was held at the Guru Nanak Dev University (GNDU) Amritsar, Punjab in February 2008. While the seminar specifically focused on the applications of radioisotopes in the areas of healthcare, agriculture, food processing etc, the exhibition brought out the complete gamut of activities of the Department.

A 5-day programme 'Anu Week' was organized in collaboration with the PSG College of Technology, Coimbatore, Tamil Nadu, during February 15-19, 2008. Dr Baldev Raj, Director IGCAR and Dr M R Srinivasan, former Chairman AEC were also present at the inauguration of the event. The programme comprised an exhibition on the peaceful uses of atomic energy, a seminar for science teachers, quiz contests for teachers and students. The exercise proved to be immensely fruitful, since students at the high school, undergraduate and post graduate levels and teachers/faculty
Science Fiesta at Goa Science Centre

benefitted from it. Some school students also put up models prepared by them in the exhibition.

DAE also participated in the Science Fiesta-2008 at the Goa Science Centre during February 26-28, 2008. An interactive exhibition was put up which was visited by several schools.

A quiz on Atomic Energy for school students from the ninth to eleventh standard was also conducted.
1950
January 11: The Institute of Nuclear Physics Kolkata, is inaugurated by Prof Mme Irene Joliot Curie.

1957
January 20: Atomic Energy Establishment, Trombay (AEET) is inaugurated. It is named as Bhabha Atomic Research Centre (BARC) on January 22, 1967.

1959
January 30: Uranium Metal Plant at Trombay produces Uranium.

1960
February 19: First lot of 10 Fuel Elements for CIRUS reactor, is fabricated at Trombay.

1961
January 14: Research Reactor ZERLINA attains criticality. (Decommissioned in 1983).

1965
January 22: Plutonium Plant is inaugurated at Trombay.

1966
January 24: Dr. Homi Jehangir Bhabha founder of the Indian Atomic Energy Programme passes away in an air crash.

1965
February 19: Centre for Kalpakkam starts commercial operation.

1968
January 17: DHRUVA the 100 MWt Research Reactor attains full power.

1972
February 3: DAE Safety Review Committee is formed.

1973
February: Rakha Uranium Recovery Plant of UCIL is commissioned.

1983
February: Rakha Uranium Recovery Plant of UCIL is commissioned.

1984
January 27: Madras Atomic Power Station-Unit I at

1988
January 3: Regional Radiation Medicine Centre (RRMC) at Kolkata is inaugurated.
1991

February 01: Heavy Water Plant at Hazira, Gujarat is commissioned.

1995

January 1995: Narwapahar, the third uranium mine of UCIL is inaugurated.

January 08: Unit-II of the Kakrapar Atomic Power Station attains criticality.

2000

January 1: BRIT’s Radiation Processing Plant at Vashi, Navi Mumbai is commissioned.

2002

February 12: India signs contract with the Russian Federation for setting up 2x1000 MWe Nuclear Power Station at Kudankulam, Tamil Nadu.

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The organizational work was in progress.

Aided Institutions

Under its aegis, the Department has eight aided institutions, including one Educational Society. These are fully funded in terms of their recurring and non-recurring expenditure.

During the report period, several joint projects were undertaken between the DAE Units and Aided Institutions. These institutions are growing at a faster pace in terms of the projects undertaken by them.

The funds (Plan & Non-Plan) allocated to these Aided Institutions by DAE during the financial year 2002-2003 were: Tata Institute of Fundamental Research (Rs.162.20 cr), Tata Memorial Centre (Rs.149.60 cr), Saha Institute of Nuclear Physics (Rs.122.50 cr), Institute of Physics (Rs.40.75 cr), Institute for Plasma Research (Rs.201.64 cr), Institute of Mathematical Sciences (Rs.19.92 cr), Harish-Chandra Research Institute (Rs.26.46 cr), Atomic Energy Education Society (Rs.32.74 cr).

Grants to Cancer Hospitals

DAE signed a Third Tripartite Agreement with the North-Eastern Council and the Government of Assam, for the revitalization of the Dr. B. Barooah Cancer Institute (BBCI), Guwahati. As per the agreement, the Department's share is about Rs.10.45 crore for revitalization of the BBCI.

The Department also extended financial assistance to Cancer hospitals located in other parts of the country. The budget provision for the current financial year for such partial financial assistance was Rs.20 crore.

Olympiad Programme

The International Olympiads in mathematics, physics, chemistry and biology are annual academic competitions for students all over the world.

The Indian Science Olympiad Programme is supported by DAE, Department of Science and Technology and Ministry of Human Resources Development.

DAE provided financial support for organizing Olympiad programmes and for participation in International Olympiads in Physics, Chemistry, Biology and Mathematics. 15 students secured medals and 4 students secured Honourable Mention in the final Olympiad.

Technology Transfer & Collaborative Programmes

During the report period, a number of technologies developed in DAE organizations as their programme spin offs, were transferred to entrepreneurs and industry. These included Particle Aerodynamic Size Separator, Non-Invasive Blood Pressure Module, Soil Organic Carbon Detection Kit, Manual Liquid Scintillation Counting System, Foldable Solar Dryer, Kitchen waste based Bio-gas Plant, and Fluoride Detection Kit.

Twenty MoUs were executed by BARC with different organizations for the development/fabrication of technologies/instruments. Hi-tech products such as Anu-photo Rheograph, Medical Analyser Software, proportional counters, and CAMAC controllers were supplied to academic institutions. Hi-tech services were also provided to industry.

Towards the DAE’s societal initiative, three AKRUTI nodes were set up at Amravati, Raigad, and Ratnagiri districts of Maharashtra.