ACHIEVEMENTS OF DAE 2015-16

During the year 2015-16, the programmes of the Department achieved impressive growth in all the segments and domains. These are described below.

NUCLEAR POWER PROGRAMME: STAGE 1

PRESSURISED HEAVY WATER REACTORS

The Nuclear Power Corporation of India Ltd. (NPCIL) is a dividend paying company with AAA credit rating by CRISIL and CARE and is responsible for siting, design, construction, commissioning and operation of nuclear power reactors. It operates 20 nuclear power reactors with installed capacity of 5680 MWe. The second unit of Kudankulam Nuclear Power Project (KKNPP-2) in Tamilnadu is under commissioning. First pair of indigenously designed 700 MWe Pressurised Heavy Water Reactors (PHWRs) at Kakrapar in Gujarat (KAPP-3&4) followed by second pair at Rawatbhata in Rajasthan (RAPP-7&8) are under construction.

Power Generation

During the calendar year 2015, NPCIL recorded highest ever generation of 38364 Million Units (MUs) which was about 3% higher than the generation of 37146 MUs in the last calendar year 2014 (including 2984 MUs in firm power of KKNPP-1). During the financial year 2015-16, NPCIL registered power generation of 27813 MUs till December 31, 2015. During the financial year 2015-16, the overall Plant Load Factor (PLF) and Availability Factor (AF) for all the reactors in operation were 74% and 77% respectively till December 31, 2015. During the year 2015, the following power stations achieved continuous run for more than a year: RAPS-4- 412 days, KGS-1-481 days, KGS-4- 419 days and NAPS-2-518 days. So far, this feat has been achieved 20 times by various reactors operated by NPCIL.

Projects under Commissioning

Kudankulam Nuclear Power Project (KKNPP) Unit-2 (1000 MWe)

The unit is under commissioning. Important commissioning milestone “Hot Run of Nuclear Steam Supply System” has been completed. Subsequent to Reactor Pressure Vessel (RPV) top head opening and removal of dummy fuel assemblies, Pre-service Inspection (PSI) of Reactor Pressure Vessel (RPV) and primary circuit is in advanced stage of completion. Preparation for next commissioning milestone i.e. Initial Fuel Loading (IFL) is in progress. The physical progress of the unit is 98.69% as on December 2015. The reactor criticality followed by connection to grid is expected in first quarter of 2016-17.

Projects under construction

Kakrapar Atomic Power Project (KAPP) Unit-3&4 (2x700 MWe)

In Unit-3, civil construction and finishing works of all major buildings are nearing completion. Inner Containment Wall (ICW) concreting is completed and ring beam construction is in progress. In Unit-4, ICW concreting is completed and ring beam construction is in progress. A major critical path activity, “Erection and Welding of End Shields & Calandria” is completed and preparatory work for Calandria Tubes rolling is in progress.

Rajasthan Atomic Power Project (RAPP) Unit-7&8 (2x700 MWe)

In Unit-7, ICW of Reactor Building (RB) has been constructed up to ring beam bottom. A major critical
path activity, “Erection, alignment & welding of End Shields & Calandria” has been completed. In Unit-8, ICW up to 111.7M EL has been constructed and a major milestone “Construction of Calandria Vault” has been completed. Both the End Shields are received at site, subsequently ball filling has been completed and preparation for lowering them in calandria vault is in progress.

Sanctioned Projects

Kudankulam Nuclear Power Project (KKNPP) Unit-3&4 (2x1000 MWe LWRs)

Government has accorded administrative approval and financial sanction for the project. Environmental clearance and CRZ clearance from MoEF are obtained. Atomic Energy Regulatory Board (AERB) Siting consent and Excavation consent have been obtained. General Framework Agreement (GFA) for setting up of KKNPP Units-3&4 has been signed with M/s. Atomstroyexport (ASE) and is made effective. Manufacturing of equipment/components under contract “supply of Long Manufacturing Cycle Equipment & First Priority Equipment (LMCE & FPE)” is started in Russian Federation (RF).

Gorakhpur Anu Vidyut Pariyojana Harayana (GHAVP) Units-1&2 (2x700 MWe PHWRs)

Land acquisition for the plant is completed. Government has given administrative approval and financial sanction for the project. Environmental clearance from Ministry of Environment, Forests and Climate Change (MoEFCC) has been obtained for project site. Haryana State Pollution Control Board has granted consent to establish GHAVP. Siting consent from AERB is received. Site Geotechnical studies are in advanced stage of completion. Boundary wall construction is in progress and site mobilization by contractor for Site Management Building is in progress. Trendering action has been initiated for long delivery equipments.

New Project / Sites

In respect of Jaitapur Nuclear Power Project (JNPP), land is acquired and site office is established. Environmental clearance is obtained from MoEFCC and Siting clearance is under review by AERB. Pre Engineering Agreement (PEA) for the Engineering Services is signed between NPCIL and AREVA and contract has commenced. The techno-commercial discussions with AREVA/ALSTOM are in progress. Land acquisition, environmental studies, public outreach activities, various site studies to the extent possible etc. are under various stages at new sites namely Chutka and Bhimpur, Madhya Pradesh, Mahi Banswara in Rajasthan, Mithi Virdi in Gujarat, Kovvada in Andhra Pradesh.

FRONT END FUEL CYCLE

Front-End Fuel Cycle comprises operations such as mining, milling and processing of ore, and fabrication of fuel. In addition, production of heavy water, used as moderator and coolant in pressurized heavy water reactors, also constitutes a major programme segment of the Nuclear Power Programme.

Heavy Water Production

The Heavy Water Board has contributed successfully to the first stage of Nuclear Power Programme by producing Heavy Water for all Pressurised Heavy Water Reactors in a cost effective manner. HWB has emerged as the largest global producer and a trusted supplier of this strategic material. Realizing the large potential for non-nuclear applications of deuterium and heavy water in life sciences, pharmaceuticals and technology areas, HWB is also nurturing R&D activities in this area. Performance of the Board during the period was excellent with respect to production, specific energy consumption, on stream factor and plant safety. The plants could achieve nearly continuous run with an on-stream factor close to 1, excluding the planned shutdown periods. Consequently, during the period Board could surpass the production target by more than 12% and also achieved 113.7% of overall capacity utilization.

The Heavy Water Board achieved more than 112% of targeted production for the financial year 2015-16 and the specific energy consumption was 28.6 GJ/Kg.
India’s position as a trusted supplier of high quality heavy water in the international arena, was further strengthened by bagging one more export order for supply of 15,000kg Heavy water worth 5.16 Million USD from M/s Linde Electronics & Specialty Gases, USA for non-nuclear applications. Recently, HWB has also received request for supply of 20,000 Kg heavy water for making deuterated drugs by a leading Pharmaceutical Research and Development company in USA. The Board has also received an enquiry from US Department of Energy Science for supply of heavy water for Neutron Spallation Studies.

In the area of solvents, both the industrial facilities at HWP, Baroda and Talcher for production of TBP (Tributyl Phosphate) and D2EHPA have performed very well enabling HWB to meet the entire requirement of NFC, NRB and all other units of DAE.

In consonance with the material input required for second stage of NPP based on FBRs, HWB, with its decades of experience of handling isotope separation process, took up development, demonstration and deployment of indigenous technologies for production of enriched Boron. Boron Enrichment Exchange Distillation (BEXD) plant at HWP Talcher and Boron Enrichment Plant (BEP) based on Ion Chromatography at HWP, Manuguru are operating very well. HWB has now acquired comprehensive capability in this area achieving enrichment levels beyond 95% in multiple chemical forms. To support the second stage of NPP, HWB has successfully delivered the entire quantity of enriched Boron for the 1st core of PFBR. India has thus found a place in the handful of countries possessing such capability.

Sodium is another important input for FBRs, used as coolant in the reactor. Networking with the Indian R&D organizations, HWB has developed indigenous and safer closed electrolytic cell technology for production of nuclear grade Sodium. Successively larger size cells are tested with the ultimate intent of an industrial scale set up.

Mineral Exploration and Mining

Atomic Minerals Directorate for Exploration and Research (AMD) continued the accelerated pace of exploration activities during the year which resulted in the augmentation of additional uranium oxide \((UO_3)\) reserve of over 15,775 tonnes in the areas of Andhra Pradesh, Meghalaya, Rajasthan and Jharkhand. The country’s uranium reserve has been updated to 2,29,936 tonnes of Uranium Oxide \((UO_3)\) as of 31st December 2015.

Significant uranium anomalies were located in Uttar Pradesh, Uttarakhand, Tamil Nadu, Chhattisgarh, Madhya Pradesh, Odisha and Arunachal Pradesh. Significant mineralized intercepts/bands have been identified in boreholes drilled at Andhra Pradesh, Jharkhand, Meghalaya, Karnataka and Chhattisgarh. Potential/significant blocks have also been identified at Haryana, Rajasthan, Jharkhand, Meghalaya and Chhattisgarh.

Mining and processing of uranium ore in India is done by the Uranium Corporation of India Ltd. (UCIL). The corporation operates in Jharkhand state with seven mines at Jaduguda, Bhatin, Narwapahar, Turamdih, Bagjata, Banduhurang, Mohuldih and two processing plants at Jaduguda and Turamdih. A new mine and a processing plant are also under construction at Tummalapalle, Andhra Pradesh. The Indian Rare Earths Limited (IREL) is a Mini Ratna (Category-I) Company and it is engaged in mining and production of beach sand minerals and rare earth compounds.

The overall performance of UCIL during the year was satisfying. The Tummalapalle Uranium Project at Andhra Pradesh is readying for commissioning in 2015-16. The mine has achieved the desired ore production capacity and adequate ore has been stockpiled. During the year, “Incidental production” has gone up by 35.67% with respect to previous year.

The major achievement of IREL was the commercial production of the 10,000 tpa monazite processing plant at OSCOM, Odisha which commenced on 1st January 2015 after obtaining clearance from AERB.
Project report prepared by IREL for setting up of the technology demonstration plant for producing nano titanium and zirconium oxy-chloride has been vetted by the consultant. Draft EIA/EMP report prepared by the environment consultant has been submitted to OSPCB seeking suitable date for public hearing.

Licensing Agreement for Transfer of Technology has been signed with Defence Metallurgical & Research Laboratory (DMRL), Hyderabad for transfer of rare earth based magnet making technology to IREL. Agreement for transfer of process for preparation of Sm-Co magnetic alloy powder technology has been signed with Bhabha Atomic Research Centre (BARC), Mumbai. Based on the above technologies available, IREL is contemplating to set up a rare earth based permanent magnet plant. For this, preparation of detailed project report is under way. During the year, two patents covering a process for production of pure Zirconium oxide from Zircon and a process for the production of thorium phosphate from thorium oxalate and recovery of oxalic acid have been filed.

An improved precipitation technique for recovery of U with improved particle size and settling rate of precipitate was developed and demonstrated at Tumallapalle.

**Fuel Fabrication**

Nuclear Fuel Complex (NFC) manufactures and supplies fuel bundles for Pressurised Heavy Water Reactors (PHWRs) and Boiling Water Reactors (BWRs) of NPCIL. Highest ever production of PHWR fuel bundles, PHWR fuel tubes, Niobium metal and SS tubes & job orders was achieved during the year. Production of the final set of UNS 8800 U-bend Steam Generator tubes for 700 MWe PHWRs was completed.

NFC launched 19 new projects during the XII plan and 3 new projects during MTA. These projects were launched to meet the fuel and zircaloy requirements of forthcoming 700 MWe PHWRs and 300 MWe AHWR, in addition to augmentation and modernisation of the present production facilities, in line with the demand from M/s NPCIL.

**BACK END FUEL CYCLE**

**Fuel Reprocessing and Waste Management**

All the fuel reprocessing plants are operating at their design capacity. Warm commissioning of Power Reactor Fuel Reprocessing Plant-3A commenced. Power Reactor Thoria Reprocessing Facility (PRTRF) was hot commissioned to recover $^{233}\text{U}$ from irradiated Th. Demonstration of reprocessing of irradiated thoria bundle and quantitative separation/recovery of $^{233}\text{U}$ is an important milestone in the 3 stage nuclear power program. Centralized Waste Management Facility, Kalpakkam continued to provide uninterrupted radioative waste management services & filter testing services to various units of DAE at Kalpakkam. Plutonium Plant, Trombay continued processing of the spent fuel from Dhruva to fissile and fertile material.

**HEALTH SAFETY & ENVIRONMENT**

NPCIL has recorded about 430 reactor years of safe operation of reactors by the end of December 2015. Review of safety of operating stations was carried out on a regular basis. All safety significant proposals and documents were reviewed by a multidisciplinary Safety Review Committee (SRC) to meet the regulatory compliance. The individual and collective doses of radiation workers at various NPPs were maintained within the budget approved by Atomic Energy Regulatory Board by following the principles of ALARA (As Low as Reasonably Achievable) and maintaining the highest standards of safety within the Nuclear Power Plants (NPPs). The radioactive effluents discharged from NPPs to the environment were maintained well below the authorized limits specified by AERB.

NPCIL continued to maintain low radiation exposure in the public domain due to operation of nuclear power stations. At all operating stations of NPCIL, certified Environmental Management System (EMS) as per ISO-14001: 2004 and Occupational Health and Safety Management System (OHSMS) as per IS-18001: 2007 are maintained and regular audits (internal, external and management) were carried out for continual improvement.

**NUCLEAR POWER PROGRAMME: STAGE 2**

**FAST BREEDER REACTORS**

For the second stage of the Nuclear Power Generation Programme, the Indira Gandhi Centre for Atomic Research (IGCAR) is pursuing development of sodium cooled fast breeder reactors and associated fuel cycle technologies. Breeder reactors produce more fuel than they consume.
Based on the fast breeder reactor technology developed by IGCAR, a 500 MWe Prototype Fast Breeder Reactor (PFBR) is coming up at Kalpakkam. The project is being executed by the Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI), a public sector undertaking of DAE.

Prototype Fast Breeder Reactor

PFBR is a pool type reactor using mixed oxide of uranium and plutonium as fuel. The coolant used is liquid sodium. The project is located 500m south of the existing Madras Atomic Power Station. At BHAVINI, the major systems of PFBR were identified and primary focus was given to these systems. Commissioning activities have been finalized in three stages: Preheating of Main Vessel, Sodium filling in Main Vessel and fuel loading towards approach to criticality. Presently, PFBR is in first stage of the commissioning programme which involves sodium filling and engineering experiments with pumps and heat exchangers. All the components & hardware required for fabrication of various sub-assemblies were completed and final assembly fabrication work was completed for most of the sub-assemblies at NFC. The gaps in various mechanical, electrical and instrumentation systems have been identified and taken up on priority. The major activity that governs the project schedule is installation and commissioning of field cabling and associated interface software for transmitting the signals from local control center to main control room. This was successfully accomplished in an accelerated phase involving both ECIL and IGCAR. The project has achieved an overall physical progress of 97.64% at the end of January-2016.

Fast Reactor Fuel Reprocessing

Towards reprocessing programme, the operation of CORAL (Compact Reprocessing facility for Advanced fuels in Lead cells) facility provided immense experience in the domain of remote handling & maintenance and in achieving product purity in addition to reprocessing the FBTR fuel. In the Fast Reactor Fuel Cycle Facility, civil construction of various buildings is progressing well.

HEALTH, SAFETY & ENVIRONMENT

Effective radiological surveillance and health physics services were provided for the radioactive facilities. TLD (Thermo Luminescence Dosimeters) personnel monitoring services, covering about 2500 occupational workers of IGCAR and BARC facilities, whole body counting, routine and special monitoring procedures for about 800 occupational workers of various active labs of IGCAR, contract workers engaged by active facilities and bioassay services for over 150 occupational workers were also carried out. Dose data and personnel data along with the finger print and photograph of the radiation workers were periodically updated.

NUCLEAR POWER PROGRAMME: STAGE 3

THORIUM BASED REACTORS

Nuclear power employing closed fuel cycle is the only sustainable option for meeting a major part of the world energy demand. World resources of thorium are larger than those of uranium. Thorium, therefore is, widely viewed as the 'fuel of the future'. The Indian Nuclear Power Programme Stage-3 aims at using thorium as fuel for power generation on a commercial scale. In the thorium fuel cycle, thorium-232 is transmuted into the fissile isotope uranium-233 which is a nuclear fuel. As a part of this programme, BARC has been developing a 300 MWe Advanced Heavy Water Reactor (AHWR). Fuelled by thorium and using light water as coolant and heavy water as moderator, this reactor will have several advanced passive safety features.

Advanced Heavy Water Reactor

The Advanced Heavy Water Reactor (AHWR) equilibrium core cluster having (Th, Pu-U) MOX fuel was re-optimized for better performance. A Passive Auto Depressurization System was developed for fast depressurisation of main heat transport system to initiate timely injection of cooling water to ensure safety and integrity of the core. A mock-up facility was developed and installed in BARC to demonstrate all aspects of automatic and remote fabrication of (Th-233U)O2 fuel. Other Thorium Reactor Systems
The refuelling and removal of molten salt fuel from the 850 MWe Indian Molten Salt Breeder Reactor was computed for various burn-ups. A high temperature heat pipe was fabricated with sodium as the working fluid and tested. A process was developed to prepare high purity beryllium oxide and fabrication of rectangular shape high density sintered beryllium ceramic by vacuum hot pressing. A vitrification process was developed for safe disposal of solid waste generated during extraction of Be from its ore by immobilizing the Be value present in waste mud. Boron alloy composites (TiCr)B2+MoSi2 and B4C+ZrO2 for control rods of P-4 facility and shut-off rods of project B-3 were prepared. A carbon vapour deposition spray coating facility using induction heating to coat the internal and external surfaces of CHTR fuel tube with pyrolytic carbon and silicon carbide was commissioned.

**KAlpakkam MINI (KAMINI) Reactor**

KAMINI reactor was operated successfully for neutron radiography of various pyro devices for Department of Space. High temperature fission chambers required for neutron flux measurement of PFBR were successfully tested.

**Research Reactors**

Dhruva operated at rated power of 100 MWe at a high safety level and availability factor. A number of researchers from across the country utilized the neutron beam facility of the UGC-DAE Consortium for Scientific Research. Commissioning of an air cooled adjuster rod with a drive mechanism enabled production of high specific activity 60Co in Dhruva for cancer treatment. Triplicated Trombay Programmable Logic Control (TPLC) based Reactor Trip Logic System (RTLS) was commissioned as a part of the Dhruva Control & Instrumentation up-gradation. Construction of 2 MWe Apsara Reactor is in progress.

**ADVANCED TECHNOLOGIES**

**Accelerators**

A facility for processing of multi-cell 1.3 GHz Superconducting Radio Frequency (SCRF) cavities has been set up at RRCAT. Using this facility a nine-cell 1.3 GHz SCRF cavity has been fabricated and electropolished to remove an average of 50 micron material. A semi-automatic cavity tuning machine has been designed and developed indigenously for the RF resonating frequency and field flatness correction of a multi-cell 1.3 GHz SCRF cavity. A centrifugal barrel polishing machine has been indigenously designed and developed for polishing of the internal surface of multi-cell SCRF cavities.

An innovative laser welding technique for fabrication of SCRF cavities has been developed indigenously. This technique is being used now to fabricate a single-cell 650 MHz SCRF cavity which is much larger in size. Helium liquefaction using a completely indigenous system has now been upgraded with a larger refrigeration capacity expansion engine and state-of-the-art brazed aluminium plate fin heat exchangers. A horizontal test cryostat has been designed for testing two 650 MHz “dressed” SCRF cavities at 2K in a single testing cycle.

A bell-shaped tuneable oxygen-free copper Radio Frequency (RF) cavity and high power input coupler operating at 505.8 MHz for Indus-2 has been indigenously designed, fabricated and tested. All four RF
stations of Indus-2 have been now upgraded with Field Programmable Gate Array (FPGA) based digital Low Level Radio Frequency (LLRF) control system. All the different types of magnets required in the Indus synchrotron sources have been developed in-house. A 10 MeV electron linac suitable for operation under industrial conditions has been developed with mostly indigenous design and component manufacturing. Development of an Infra-Red Free Electron Laser (IR-FEL) designed to lase in a wavelength range of 15 – 50 µm using a 15 – 25 MeV electron beam has been completed.

The 10 MeV Injector Cryo-module (ICM) of the superconducting Electron Linac has been assembled and its first beam test was conducted successfully at TRIUMF, CANADA. The second ICM, which is meant for VECC has been fabricated and is being assembled at TRIUMF. The testing is scheduled at TRIUMF in early 2016. Apart from ICM, the Injector comprises a 300 kV electron gun and low energy beam transport (LEBT) line – which are being indigenously developed by Indian industry.

A 3 axis computerized magnetic field measurement facility using Hall probe has been indigenously developed at VECC to measure the magnetic field upto 3 Tesla with accuracy of ± 1% in a volume of 1.5 m x 1.3 m x 0.15 m with an overall accuracy of better than 0.2 mm over the entire volume. The facility will be able to measure the absolute magnetic field of different types of magnets and validate its design. The control logic and software have been developed for automatic operation of the magnetic field measurement facility. On successful completion of the design of single-cell 650 MHz, β=0.61, Superconducting RF (SRF) linac cavity, fabrication of prototype aluminium cavity and also single-cell niobium cavity was completed. A system to test the performance of 1.3 GHz superconducting RF cavity cryo-module is developed by BARC under Indian Institution and FermiLab Collaboration.

**Electronics & Instrumentation**

The technology of Quadrupole Mass Spectrometer (QMS) was transferred to M/S ECIL by BARC for the development of QMS based Hydrogen and Steam Concentration Measurement System (HSCMS) for NPCIL. Compact +/- 5 kV, 2 mA high voltage modules operating with 24 V dc supply was developed for precision analytical instruments. An improved and compact SMPS based power supply was developed for sputter ion pumps (140 litres/sec) and the technical knowhow was transferred to a private company. A universal vacuum gauge based on a combination of Pirani and hot cathode ionization gauge was developed for pressure measurement from atmosphere to 10-10 Torr. A battery based miniature neutron generator using penning ion source providing 5x10^6 n/s for applications in oil logging, uranium mining etc. has been developed. Continuing the collaborative development of Active Radar Seeker with ECIL, the seeker was set up on the shore to track ships at sea in range and angle.
Robotics

A robot based frameless stereotactic system is developed at BARC for performing neurosurgery which has accuracy and patient comfort level comparable to frame based system. It automates the frameless stereotaxy using a high precision robot (Parallel Mechanism based Robot).

Cryogenics

A cryogenic system consisting of cryogen distribution lines for liquid helium and liquid nitrogen, sub-atmospheric vacuum jacketed lines for helium, warm helium lines between the helium buffer tanks and compressors, and a 500 watt helium liquefier is being set-up for the superconducting electron and heavy-ion linacs at VECC. The design of the cryogenic system has been finalized.

RADIOISOTOPES & RADIATION TECHNOLOGY AND THEIR APPLICATIONS

Radioisotopes are produced in the Dhruva research reactor at Trombay, accelerator at Kolkata and the various nuclear power plants of NPCIL. During the report period, a wide variety of radioisotopes for medical, industrial and research applications were produced and supplied by BARC. The Board of Radiation and Isotope Technology (BRIT) produced and supplied a wide range of radioisotope products, and radiation technology equipment for medical and industrial uses.

Agriculture

Trombay Groundnut (TG) varieties TG 79 and TG 80 entered for evaluation in Indian Council of Agricultural Research trials all over the country. 340 quintals of breeder seed of TG varieties were produced in BARC, Gauribidanur & from contract farming and distributed to seed agencies in various states. Seed multiplication of black gram varieties TAU-1, TAU-2, TPU-4, TU94-2 and TU-40 was done. Protocol for the preparation of biomass for the uptake of U and suitable colour reagent for its detection was established. A gel-free protocol has been developed for rapid assessment of single band DNA markers and to expedite selection of desired traits in wheat plants. 148 new indigenous and exotic germplasm lines of sorghum were evaluated for their synchronous flowering, seed set and potential to be used in the hybrid development. A purely organic, seed dressing biofungicide formulation of an improved Trichoderma virens mutant strain was developed.

Food Technology

The potential of using irradiated onion scales as a source of natural food additive was evaluated. Methods were standardized for the preparation of ready to eat (RTE), shelf stable mutton masala using gamma radiation. A procedure was standardized for ready to bake chapattis by radiation processing at 1 kGy dose and heating at 800°C for 15 minutes in water bath. Silver nanoparticles synthesized using mint extract were found to be bactericidal against E. coli, S. aureus, B. cereus and P. aeruginosa. Copper nanoparticles were incorporated in PVA films to develop active antimicrobial films. Improvement and modification of litchi preservation technology was effected by replacing hydrochloric acid treatment with tartaric acid doing away with the ascorbic acid treatment making the process more cost effective.

Nuclear Medicine and Healthcare

More than 12,000 patients were benefitted from nuclear medicine diagnosis and therapy for various ailments such as thyroid, heart, etc. The Scintigraphy and PET-CT Section performed nearly 12,000 diagnostic scans. Facility for indigenous sourcing of expensive and clinically relevant peptides such as DOTA-TATE, HYNIC-TOC, cyclic-RGD, etc., using solid phase peptide synthesis has been developed. A two-vial kit for the preparation of 188ReN-DEDTC/lipiodol (DEDTC–diethyl dithiocarbamates) for inoperable liver cancer as a cost-effective alternative to imported 90Y-based products was developed. The Medical Cyclotron Facility was extensively used for the production of 18F and its conversion to 18F-Radiopharmaceuticals was carried out and supplied to 11 nuclear medicine centres. More than 50,000 analyses for TSH, T4, fT4, Thyroglobulin and
anti microsomal antibodies were carried out using in-house developed kits. 142 Ci of 99mTcO4- was extracted from 99Mo and various 99mTc-radiopharmaceuticals were prepared for diagnostic studies. 68Ga- DOTA-peptides were prepared and supplied for diagnostic scans. 50 Ci of 177Lu-DOTATATE was prepared for neuroendocrine tumour therapy. Around 4 kCi activity of radioisotopes 131I, 99Mo, 153Sm, 177Lu, 32P, etc. were chemically processed. Laboratory reference sources, custom-made sources, 125I brachytherapy seeds and TRODAT-1 and HYNICTOC freeze dried kits were supplied to BRIT.

More than 20,000 consignments of ready to use Radiopharmaceuticals of Sodium Iodide (Na131I) in the form of both solution and capsules for diagnosis and therapy of thyroid disorders, 131I–meta Iodo Benzyl Guanidine (miBG) for neuroendocrine tumor detection & therapy, 32P, 153Sm and 177Lu for bone pain palliation were supplied to various nuclear medicine centres & hospitals all over India in the form of ready-to-use injectables. Total number of therapeutic treatments based on supplies are estimated to be more than 20,000. This major product included doses of Na131I for treatment of thyroid cancer & hyperthyroidism. More than 75,000 cold kits for the formulation of 99mTc-Radiopharmaceuticals (15 products; BRIT Code-TCK) were supplied to nuclear medicine centres.

Cancer Diagnostics & Treatment Services

During the period, TMC acquired around 140 equipment. Installation of major equipment like Surface Plasmon Resonance System, refrigerated shaker Incubators, Tabletop Centrifuges, Inverted Microscope, Thermal Cycler, Water Purification System, Micro plate Reader, Gel Documentation System, Real Time PCR Machine etc. has been done. Household survey was continued for screening of eligible women for breast, uterine, cervix and oral cavity cancers. Construction work has commenced for the establishment of Cancer hospital in Andhra Pradesh. For the Cancer Hospital in Chandigarh, work order has been issued. Clinical Research Secretariat (CRS) and Department of Atomic Energy Clinical Trials unit (DAE-CTC) has continued to play a key role in facilitating research in the field of oncology at the Hospital. The number of patients referred to and registered at ACTREC has increased over the years. A new state-of-the-art linear accelerator (Varian True Beam) was installed and commissioned for clinical use towards the year-end. The indigenously developed Multi Leaf Collimator (MLC) system installed on the Bhabhatron-II telecobalt unit received regulatory approval for clinical use. About 2000 major surgical procedures were performed in ACTREC. The achievement of Clinical Pharmacology lab involved in drug development included the encouraging preclinical findings of chlorophyllin as a radio protective agent and its technology transfer to an industry partner.

Industrial Applications of Radioisotopes & Radiation

Eleven Cobalt Teletherapy Sources (CTS) containing 98,300 Ci of 60Co were supplied to different cancer hospitals till December 2015. Sixty six Irradiator sources in seven consignments with total activity of 10, 66,498 Ci were supplied to various radiation processing plants within the country and also exported. More than 850 192Ir & 60Co Radiography sources containing 37,460 Ci of activity was supplied to NDT users. Reference and Custom Made Sources (CMR) of 46Sc and 137Cs in 975 consignments containing 5.67 Ci of radioactivity were also supplied to various organizations.

Ahmedabad Municipal Corporation and BARC signed MoU to set up a first of its kind Sewage Sludge Hygienisation Plant to treat sewage sludge at Ahmedabad using Radiation Technology as a part of the Clean India initiative (Swachha and Swastha Bharat). The treated sludge will be inoculated with useful bacteria to convert into manure.

Radiation Processing

About 5116 Cubic meters of healthcare products were processed using radiation for terminal sterilization at ISOMED, BRIT upto December 2015. Gamma Radiation Indicator Buttons were developed indigenously as an import substitute (Made in India) for qualitative indication of low and medium range gamma radiation dose delivery to the products. About 2933 Tons of spices and other products like nutraceuticals and colour pigments were processed during the report period.

BASIC & APPLIED RESEARCH

Synchrotrons and their Applications

The Raja Ramanna Centre for Advanced Technology (RRCAT) has set up Synchrotron Radiation Sources Indus-1&2 for carrying out advanced basic research.
During the year, both the synchrotron radiation sources, Indus-1 and Indus-2, were operated round-the-clock. Indus-2 was operated at beam current up to 200 mA and 2.5 GeV energy while Indus-1 was operated at 100 mA current and 450 MeV energy. The Indus-2 storage ring is operating with a highly stable electron beam. The improved performance of the Indus synchrotron radiation sources is reflected in a substantial increase in the number of users. The user experiments have doubled from 190 in 2013 to 390 in 2015. The availability of 13 beamlines in Indus-2 for user experiments was about 4370 hours.

A beam based alignment system has been installed in Indus-2 to minimise the closed orbit distortion of its orbit. A control system for beam based alignment was developed to control 72 active shunt power supplies. Prototype processing electronics using an embedded web server for monitoring the beam position monitors of the booster synchrotron at a higher repetition rate of 1 kHz was developed.

An upgraded version of horizontal and vertical stripline kicker magnets has been developed. These kicker magnets have been installed in the Indus-2 ring. With improved features like higher transverse shunt impedance, optimum coupling impedance and higher power handling capacity of up to 125 W, these kickers will enhance the performance of the transverse bunch-by-bunch feedback system being used to suppress coupled bunch instabilities. Upgrades were carried out in the Indus-2 Low Conductivity Water (LCW) plant which has resulted in achieving temperature stability of better than ±0.7°C as compared to the earlier stability of ±1°C of the supply cooling water. This has helped in improving the stability of Indus-2 operation.

A new, improved 20MeV injector microtron has been developed for Indus synchrotron radiation source facility of RRCAT. The beam was accelerated up to 22nd orbit where the beam energy is 20 MeV. A beam current of 30 mA was measured in the 22nd orbit.

The Indus synchrotron radiation sources, a national facility, are being used by scientists and students from various universities, national institutes and research laboratories all over the country. A soft x-ray reflectivity beamline (BL-3) has been commissioned recently, which is the 13th beamline on Indus-2 and operates in the energy range of 100 eV to 1500 eV.

Some of the operating beamlines have been equipped with advanced user facilities. A Closed Cycle Cryostat (CCR) based cooling system and a high temperature stage have been installed in the image plate of the Angle Dispersive X-ray Diffraction (ADXRD) beamline (BL-12). A new high temperature stage (upto 1100 K) has been commissioned which can be used both in the scanning Extended X-ray Absorption Fine Structure (EXAFS) beamline (BL-9) as well as the dispersive EXAFS beamline (BL-8). A Fourier Transform Infrared (FTIR) system with a closed cycle cryostat has been installed at the photo-physics beamline at Indus-1 (BL-5).

Using the x-ray lithography beamline (BL-7) of Indus-2, X-ray lenses for use in the hard X-ray regime have been fabricated in a new antimony free material, code named SUEX. A focal beam diameter with Full Width at Half Maximum (FWHM) of 0.8 micron was obtained when this lens was used at the Diamond Light Source, UK. Next, Fresnel Zone Plates (FZP) with a focal length of 25 mm have been fabricated in Polymethyl Methacrylate (PMMA) on ultra-thin titanium film using 30 keV electron-beam lithography. These have been designed for focusing of capillary discharge based argon X-ray laser (wavelength: 46.9 nm).

Fusion and Other Plasma Technologies

At the Institute of Plasma Research (IPR), the Steady-state Superconducting Tokamak-1(SST-1) has completed the 1st phase of upgradation with successful installation and integration of all its First Wall components. For Aditya Upgrade, the decommissioning of the existing machine was done with accurate documentation for understanding and rectifying the problems faced before in machine operation. The new circular vessel along with the tested and refurbished Toroidal Field coils have been integrated to the upgraded machine. The new SS grill antenna designed for launching Lower Hybrid Current Drive (LHCD) power has been fabricated and installed in SST-1. The 1:1 prototype Edge Localized Coils for the Joint European Torus (JET) at United Kingdom has been successfully realized. State-of-the-art copper sheathed MgB2 strands are now manufactured in-house in several meters of single length. Tungsten was studied for radiation damage and fuel retention.

Chemistry

BARC has developed the material technology for the anode (nano lithium titanate) and cathode (nano
lithium iron phosphate carbon composite) materials of lithium ion battery. BARC in collaboration with National Physical Laboratory, New Delhi has prepared the first quartz certified reference material of the country following the international guidelines.

A high end two-dimensional infrared spectrometer for advanced studies in chemistry and biology was developed. NCCCM, Hyderabad has been validated as a supplier by European Commission for homogeneity, stability and characterization of major element content in food and trace element content. Time resolved laser induced fluorescence spectrometer, for studying speciation of lanthanides and actinides, with different complexing agents, sorbents and host matrices, has been installed and commissioned. A new type of biocompatible and task-specific hydrogel beads were synthesized for controlled and sustained delivery of the anticancer drug doxorubicin. At TIFR, a technique was developed to determine the conformation of membrane proteins in physiological conditions using Surface Enhanced Raman Spectroscopy. Different architecture of nanomaterials have been developed at SINP which include tunable gold nano-flowers, silver nano-wires, selenium nano-spheres etc and successfully used in effective drug delivery and bioanalytical detection. The nuclear chemistry group along with the international collaboration working at GSI, Germany independently confirmed new element 117 and discovered new isotope 266Lr.

**Materials Science**

Several functional and energy conversion ceramics such as beta-alumina, BeO and Solid Oxide Fuel Cell (SOFC) ceramics have been fabricated at BARC. Ni-Cr based alloys were indigenously developed for high burn up clad applications. Composite fibres have been prepared by dispersing Carbon Nanotubes (CNTs), developed in-house, in polymeric fibres with improved toughness. Aluminide coating on Ni-Cr-Fe based superalloys was developed for high temperature application. A methodology for joining stainless steel 304L to Zircaloy-4, based on a novel Ga-assisted diffusion bonding technique was developed using Ni and Ti inter-layers.

At IGCAR, in the materials development front, a high chromium oxide dispersion strengthened ferritic steel clad tube has been realised and use of zirconia as an alternate dispersoid to yttira were explored. Non-contact electromagnetic acoustic transducers and eddy current array sensor probes were developed for detection of sub-surface defects in austenitic stainless steel. The electron back scattered diffraction tomography, a state-of-the-art technique for study for 3-dimensional grain morphology and orientation was established.

At RRCAT, a new indigenous process has been developed to produce Nb pipe/316L stainless steel flange joints suitable for use in low-beta SCRF cavities. An experimental facility based on the resonant ultrasound spectroscopy technique was designed and developed for the measurement of the elastic constants materials at low temperatures (2-300 K) and in high magnetic fields (up to 70 kOe). Several high-quality crystals have been grown by different techniques for various photonic applications. These include Er and Cr co-doped YVO4 for lasers, Cr doped Strontium Barium Niobate (SBN) crystals for pyroelectric infrared sensors and trans-stilbene for scintillation detectors.

A key achievement in materials research at TIFR was the engineering and assembly of atomically thin layers of grapheme allowing them to be used for novel energy and sensing applications through doping. Also, an ammonia sensor—which can detect both ionized and disorders, the haematological and neurological. New initiatives were taken to study epigenetic regulator proteins and nuclear lamins and their involvements in disease processes.

**Biology**

An advanced and economic Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) Cascade based tool was developed at BARC and used for genome editing and gene silencing in Mycobacterium tuberculosis (Mtb).

Advances were made at TIFR in the field of malaria research with the identification of a protein that could be a candidate for a malaria vaccine. At the National Centre for Biological Sciences, advances were made in understanding cellular organization and signaling, genetics and development and in understanding ecological processes across multiple scales.

A two color Single molecule FRET imaging set up for real time monitoring of complex macromolecular systems has been developed at SINP. Research in the area of Disease Biology continued to focus on two major
un-ionized ammonia in sub-pico molar level, was developed using fluorinated graphene.

**Cancer Research**

ACTREC, located at Navi Mumbai, comprises of two sub-units the Clinical Research Centre (CRC), 111 bed Research Hospital that focuses on research and treatment of cancer patients and the Cancer Research Institute (CRI) that focuses on basic and applied research on cancer. During the year, the CRI’s 20 Principal Investigator led laboratories remained engaged in a large number of basic and applied research projects.

**INTERNATIONAL RESEARCH COLLABORATIONS**

The experimental data on piping components and systems generated by BARC has been selected by Organization for Economic Co-operation and Development-Nuclear Energy Agency for the benchmark exercise on Metallic Component Margins under High Seismic Loads. Corrosion Loop Experiment is designed to study the phenomenon of Irradiation Assisted Stress Corrosion Cracking in LWR operating conditions for installation in Jules Horowitz Reactor, France as a part of Indian In-kind contribution in the JHR Programme.

Two large-size advanced types of gaseous detectors i.e., Gas Electron Multiplier (GEM) and Resistive Plate Chamber (RPC) have been built and tested successfully at VECC during 2015. The GEM chamber of trapezoidal shape (length 80cm and larger width of 40cm) is a real-size prototype module built for the Compressed Baryonic Matter (CBM) experiment in the upcoming FAIR facility at Darmstadt, Germany.

The bulk viscosity of the hadronic medium has been evaluated along the chemical freeze-out curve of the QCD phase diagram. Elliptic and triangular flow for photon and their correlation with initial eccentricity measures have been studied. Pb+Pb collisions at Future Circular Collider at 39 TeV/A energy have been simulated.

For the Large Hadron Collider and Compact Muon Solenoid (CMS) Experiment, TIFR has participated in data collection, data quality monitor and data analysis. Also, several analyses based on Run I data are being collated.

International Collaborations were continued at SINP with CERN in ALICE and CMS experiments and with SNOLab in PICASSO experiment. The two experiments, ALICE and CMS collected data with a very high efficiency and members of SINP took active parts in the data collection, data analysis and extracting important physics results from these experiments.

The Institute of Physics (IOP) remained actively involved in the International Collaborations with CERN (Switzerland), BNL (USA), ANL (USA), GSI (Germany) and other laboratories abroad. The Institute is also participating in various research activities related to India based Neutrino Observatory.

For the Indo-Italian program on investigation of local structure and magnetism properties of, most of the experimental part has been completed at the Institute of Plasma Research (IPR). For the Indo-UK DST program Plasmonics based CZTS Solar Cells, IPR has successfully demonstrated that silver nanoparticle arrays are suitable as back reflectors and performed the MD simulation for the nanoparticle self-assembly.

IMSc continued the joint projects with International Institutes on India based Neutrino Observatory (INO) and DINO (Darkmatter at INO), EU-FP7 Indo-European Network on Mathematics in Health and Disease and Belle & Belle II Collaboration.

**ITER-Project**

Institute of Plasma Research (IPR), Bhabha Atomic Research Centre (BARC) and Indira Gandhi Centre for Atomic Research (IGCAR) are involved in the design, material development, thermo fluid MHD analysis and various aspects of Lead Lithium cooled Ceramic Breeder (LLCB) Test Blanket Module (TBM) for ITER.

Total 14 out of 15 Procurement Arrangements (PA) have been signed. Pre-procurement activities for remaining PAs are going on. Eleven major contracts have been signed till date for the manufacturing of ITER components. Good progress is made at the manufacturing site and some components are delivered to ITER and also to other Domestic Agencies sites. Quality audits were done regularly at the manufacturing sites by both ITER-India and ITER Organization teams. Good progress has been achieved and various other R&D activities necessary are being done at the ITER-India laboratory, which will then be transferred to the
vendor site after due process and approval.

Cryostat Base section Tier-1 manufacturing is completed and delivered at ITER site at France and manufacturing of Lower Cylinder is in progress. Manufacturing of first Lot of Cooling Water piping is completed and delivered at ITER site, France. Manufacturing of Acceleration Grid Power Supplies (AGPS) for SPIDER facility has been completed and will be shipped soon to Padova, Italy. Manufacturing of Prototype Grid for DNB Accelerator and for Prototype Post Insulators has been completed.

Prototype Cryoline installation at ITER-India lab is completed and qualification test is in progress. Vacuum vessel for Diagnostic Neutral Beam (DNB) is successfully installed and commissioned with all the interface needs for Operating components at ITER-India lab. Design and procurement activities for Gyrotron Test Facility at ITER-India lab is in progress. Preliminary Design of Cryostat Instrumentation is nearing completion.

For the Test Blanket Module (TBM) Program, Lead-Lithium R&D activities are focused towards the development of precise diagnostics for measurement of Pb-Li pressure, flow rate, and Pb-Li level in various tanks etc. for prolonged operation. In this connection, a sensitive flowmeter using water cooled Hallbach magnet has been developed, calibrated and successfully tested in Pb-Li environment. Pb-Li production system has also been developed and trails run have been started for indigenous development of Pb-Li eutectic alloy.

OTHER ACTIVITIES

Research Education Linkages

The Department of Atomic Energy supports the research education linkages mainly through grants-in-aid to institutes of national eminence, funding of extramural research, DAE-UGC consortium for scientific research and others. Research reactor Dhruba at BARC continued to serve as a national facility for neutron beam research. A number of research scholars from various academic institutions in the country utilized the reactor under the aegis of the UGC-DAE Consortium for Scientific Research. The Variable Energy Cyclotron were utilized by in-house experimental groups of VECC, as well as by experimentalists from several national laboratories and academic institutions for conducting experiments in the various fields of research. Nuclear counting and calibration facilities of IGCAR were extended to various institutions involved in BRNS projects, researchers and industries in the southern region. The Indus synchrotron radiation sources, a national facility, was used by scientists and students from various universities, national institutes and research laboratories all over the country.

HUMAN RESOURCE DEVELOPMENT AND KNOWLEDGE MANAGEMENT

Homi Bhabha National Institute

The Homi Bhabha National Institute (HBNI) accredited as a deemed to be university by Ministry of Human Resource and Development (MHRD) completed ten years of its existence. HBNI continued its academic programmes by offering various courses with its eight Boards of Studies namely as Chemical Sciences, Engineering Sciences, Health Sciences, Life Sciences, Mathematical Sciences, Physical Sciences, Strategic Studies and Undergraduate Studies. Degrees and Diplomas including Ph.D. were awarded to students. HBNI continued to strengthen its linkages with premier research and academic institutes in the country and abroad.

Training

Selection of trainees under Orientation Course for Engineering Graduates & Science Post-Graduates (OCES) and DAE Graduate Fellowship Schemes (DGFS) at BARC were pursued with high standards. The Continuing Education Programme QUEST offering advanced courses to DAE staff located in Mumbai and to HBNI students continued. National Training Course on “Physical Protection of Nuclear Material and Nuclear Facilities” for security personnel and a 2 week National Training Course on “Design & Evaluation of Physical Protection System for Nuclear Material and Nuclear Facilities” were held at Mumbai. At IGCAR the Training programmes for Trainee Scientific Officers (TSOs) and doctoral programmes in the frontier areas of engineering & basic sciences for the inducted Research Scholars were continued. The employees, who are pursuing higher studies under the aegis of Homi Bhabha National Institute also underwent coursework at the Training School. BARC Training School AMD Campus, Hyderabad continued its activity in the sixth year by imparting induction training to Trainee Scientific Officers (TSO) in Geology and Geophysics. Human
resource development activities at RRCAT were continued to be enhanced by extending the available research facilities for training of university students in the areas of accelerators, lasers and their applications. A large number of students carried out research work for their Ph.D. degree under the framework of Homi Bhabha National Institute. Opportunities were also provided to M.Tech / M.Sc. students to carry out their one-year / six-months project work towards partial fulfilment of their degrees.

**SPONSORED RESEARCH**

**Promotion of Extra-mural Research in Nuclear Science**

The Board of Research in Nuclear Sciences (BRNS) continued to award projects to young scientists to initiate them in a career of research and Dr. K. S. Krishnan Research Associateship to identify and encourage highly talented young scientists and technologists. The DAE Graduate Fellowship Scheme (DGFS) for inducting Graduate Level students doing M.Tech. at the IITs, Visiting Scientists programme for promoting short term in-house interactions amongst senior level experts and the Raja Ramanna Fellowship for reasonably long-term involvement of the eminent scientists and engineers in the various ongoing programmes of the Department were continued. The Homi Bhabha Chair was instituted to avail the honourable services of Scientists and Technologists who have distinguished themselves at national and international levels.

Under DAE Graduate Fellowship Scheme (DGFS), fellowship was offered/awarded to M.Tech. students studying in different IITs. New students were inducted under DGFS-Ph.D programme.

Financial support to the tune of ₹ 230 Lakh was extended for conducting 121 seminars, which were conducted by professional organizations on various topics of relevance to DAE. Out of these, fourteen symposia were solely organized by the DAE fraternity and they were fully funded by BRNS. About 73 fellowships were offered under the Raja Ramanna Fellowship Scheme (Senior Scientists Scheme) & 3 Homi Bhabha Chairs were awarded.

**Promotion of Mathematics**

The National Board for Higher Mathematics (NBHM) continued to provide grants for promotion of activities in pure and applied Mathematics, under several schemes, including support to research projects, travel grants for participation in workshops, conferences, and undertaking collaborative research, funds for organizing conferences etc.

NBHM continued to be in charge of the Mathematics Olympiad activity for talented young students at higher secondary (the plus two) level. This year six-member team secured 1 Silver medal and two Bronze medals and three Honourable Mentions at the 56th International Mathematical Olympiad held at Chiang Mai, Thailand.

NBHM continued to conduct Madhava Mathematical Competition for the undergraduate students. NBHM gave grants to various mathematical centres such as The Chennai Mathematical Institute, The Kerala School of Mathematics, Calicut, The Institute of Mathematics and Applications, Bhubaneswar and the Bhaskaracharya Pratisthana, Pune, engaged in activities of promoting higher mathematics. The Board provided scholarships and fellowships to the students, selected through nationwide competitive tests, to pursue studies at masters and Ph.D. levels.

This year NBHM has sponsored 51 delegates for participation in the prestigious International Congress of Industrial and Applied Mathematics (ICIAM) - 2015 event, held in Beijing, China during August 10-14, 2015.

**GRANTS-IN-AID**

**Grants to Aided Institutions**

University of Mumbai & Department of Atomic Energy Centre for Excellence in Basic Sciences (UM-DAE-CBS) has been recently granted the status of Aided institution of the Department of Atomic Energy w.e.f. 1st January, 2016.

**Grants to Cancer Hospitals**

The Department of Atomic Energy (DAE) is releasing grant to Dr. B. Barooah Cancer Institute (BBCI), Guwahati through Tripartite Agreement (which was signed among DAE, the North Eastern Council (NEC) and the Government of Assam). This hospital is a Regional Cancer Centre (RCC) for cancer treatment and control in the North Eastern Region (NER). During the year 2015 – 16, an amount of ₹12.36 crore has been released to
the institute by the Department. The Department also extends financial assistance to Cancer hospitals located in other parts of the country. The budget provision for the year 2015-16 for such partial financial assistance is to the tune of ₹ 20.00 crore.

Olympiad Programme

The Homi Bhabha Centre for Science Education (HBCSE) successfully hosted the International Physics Olympiad. Several teacher professional development workshops were conducted in mathematics and science, including one for physics teachers from Karnataka. In the learning sciences laboratory, a multi-touch interface was developed.

INFORMATION TECHNOLOGY APPLICATION DEVELOPMENT

The highlights of the Information Technology Application Development at IGCAR included Integration, Testing & Commissioning of BHEL steam water system / turbo generator Simulator; Deployment of Wireless Sensor Network for Radiation Monitoring; 3D Modeling and Animation of Power manipulator and Containment Box of Pyroprocessing R&D facility; Advanced IT Enabled Customizable Knowledge Management Portal for IGCAR and Development of continuous air monitoring system.

Software for RRCAT Secure Cloud Drive has been developed, deployed and released to senior scientists. The facility enabled access to large files over internet with necessary data security mechanisms in place. Workflow based software for activity management related to Indus upgradation/ maintenance/ shutdown has been developed and deployed on RRCAT Infonet for use by all concerned officials working for Indus operation and maintenance.

TECHNOLOGY TRANSFER

A total of 26 technologies have been transferred till December 2015 to 40 Parties. Eight new technologies introduced into public domain during the year were Optical spectrometer, Compact Full Range Vacuum Gauge with Electronic Control Unit (FRVG), ANUSPECT Gamma Spectrum Analysis software, Peripheral Pulse Analyzer, Hydrogen Sulfide Sensor, Compact SMPS based Sputter Ion Pump Power Supply, Biopesticide Based on Bacillus Thuringiensis Subsp. Kenyae HD-549 and Partially hydrolyzed guar gum for dietary fiber application.

Licenses for the 5 technologies that were renewed during the period were for “Rig Testing of Combined Particulate & Iodine Filters”, “Production of CaSO4 : TLD Card & Production of Dy. Doped Calcium Sulphate TLD Powder”, “Auto TLD Badge Reader”, “Spectroscopy Amplifier” & “Digital Pocket Radiation Dosemeter (DIGIDOSE)” and Renewal of MoU for incubation of Biodegradable and Edible films for Food and Pharmaceuticals.

Solar Energy driven portable domestic Brackish Water Reverse Osmosis (BWRO), Stand-alone solar Photovoltaic (PV) driven battery-less Ultrafiltration system and Bicycle mounted water purification (RO/UF) unit driven by hybrid power system were transferred to private entrepreneurs for commercial deployment.

COLLABORATIVE PROGRAMMES


In order to promote technologies developed by BARC for rural populace, establishment of DAE Technology Display & Dissemination Facility (DTDDF) centres all over India are proposed under XII Plan in collaboration with educational institutes. Out of 24 proposals received from all over India, preliminary meetings and site visits to 7 institutes have already been concluded. Further, MoUs with two institutes have been finalized.

SOCIETAL INITIATIVES

Four agreements were approved for signing with Companies/ Organisations and Individuals to promote rural entrepreneurship with BARC technologies under Advanced Knowledge & RUral Technology Implementation (AKRUTI) Tech Pack. The agreements provide a perpetual license for exclusive rural deployment of the technologies like Foldable Solar Dryer, Domestic Water Purifier, Soil Organic Carbon Detection and Testing Kit, Nisargruna, Vibrothermal disinfestor, Solar BWRO, Dip N Drink Membrane Pouch, Litchi Preservation and Banana Tissue Culture.
PUBLIC SECTOR UNDERTAKINGS

Financial performance of DAE’s public sector undertakings namely, the Nuclear Power Corporation of India Ltd., Uranium Corporation of India Ltd., Indian Rare Earth Ltd. and Electronics Corporation of India Ltd. are given below. (BHAVINI is yet to commence commercial operations).

Nuclear Power Corporation of India Ltd.

The expected net profit after tax (PAT) for the year 2015-16 is about ₹ 2300 Cr. The net profit after tax for previous FY 2014-15 was ₹ 2201 Cr. NPCIL bonds continued to be rated at AAA (Highest Safety) by CRISIL and CARE.

Uranium Corporation of India Ltd.

The overall performance of the company during the year 2014-15 was satisfying. The total income of the Company during the year 2014-15 was ₹ 890.24 Cr. (Previous year ₹ 814.30 Cr.). The profit before tax during the year 2014-15 was ₹ 11.34 Cr. Performance of the Company in terms of MoU signed with DAE is expected to be “Good” for the year 2014-15.

Indian Rare Earths Ltd.

During the year 2015-16, the Gross Sales Turnover anticipated is ₹ 434.64 crore (provisional) against ₹ 420.97 crore of previous year. Anticipated loss in 2015-16 is ₹ 22.67 crore (provisional) compared to profit before tax of ₹ 3.15 crore in 2014-15.

Electronics Corporation of India Ltd.

Against the MoU target of ₹ 1620 crore each for production and net sales, the Company achieved a production of ₹ 721 crore and a net sale of ₹ 690 crore upto December 2015.

INTERNATIONAL RELATIONS

India, a founding member of the Board of Governors (BoG) of the International Atomic Energy Agency (IAEA), continued to take active part in policy management and programmes of the IAEA. India was represented on a number of IAEA committees including those on safety, safeguards, nuclear radiation, nuclear engineering and application, nuclear law etc. India hosted several IAEA Workshops, Technical Meetings etc., and offered the services of its experts under the IAEA Technical Cooperation programme in a number of fields. India made contributions towards Innovative Nuclear Reactors and Fuel Cycles (INPRO), Technical Cooperation Fund (TCF) and Regular Budget of the IAEA.

India also actively engaged in nuclear security issues through the Nuclear Security Summit process, the Global Initiative to Combating Nuclear Terrorism and India’s own Global Centre for Nuclear Energy Partnership (GCNEP).

Cooperation at the multilateral level in peaceful uses of nuclear energy was also promoted through the European Organisation for Nuclear Research (CERN), the International Thermonuclear Experimental Reactor (ITER), and the Nuclear Energy Agency of OECD. Significant achievements were made in India’s bilateral international engagement in civil nuclear cooperation with major partners. The fuel supply arrangements with Canada, Kazakhstan and Australia have been made which will bolster energy security by supporting the expansion of nuclear power in India. Civil nuclear cooperation with neighbouring partners Sri Lanka, Bangladesh & Mongolia was also promoted.

In an important legislative development, the passage of the Atomic Energy (Amendment) Act, 2015 by the Parliament in December 2015 created the legal basis to enable NPCIL to enter into joint ventures with other Indian PSUs, thus paving the way for new equity to meet the additional funding requirements for expanding India’s nuclear power programme and augmenting the nation’s nuclear power generation capacity.

For GCNEP, the Phase-I construction activities were under progress. Construction work is in progress for SNSS Building in the Campus site and Wing-A of Guest House in the Township site. GCNEP continued to conduct national and international training programs. In terms of international collaborations, in November, DAE and Department of Energy and Climate Change (DECC), United Kingdom, announced the signing of a Memorandum of Understanding (MoU) between the two countries concerning cooperation on the Indian Global Centre for Nuclear Energy Partnership. The agreement will provide a framework for further cooperation. A MoU has been signed with USA, Russia, France, UK and the IAEA.

NPCIL continued to participate in various programmes of World Association of Nuclear Operators (WANO), Candu Owner’s Group (COG), Institute of Nuclear Power Operations (INPO) and World Nuclear Association (WNA) to enhance the safety and reliability of its nuclear power plants.
PUBLIC AWARENESS

During the year, DAE participated in and organized several events such as the 103rd Indian Science Congress at Mysuru; “Indian Technology Congress 2015” at Bengaluru; “Vigyanene Tu Kausalam” at Varanasi; The International Conference on Science, Technology and Applications on Rare Earths (STAR-2015) at Trivandrum; a two day seminar on “Applications of Radioisotopes and Radiation Technology in Agriculture, Industry & Healthcare” at Bhopal; “11th Food & Technology Expo & Concurrent Show – Government Achievement & Schemes Expo 2015” at New Delhi; a seminar on “Benefits of Nuclear and Material Sciences in day to day life” at Mysore; National Conference on Analytical Science and Technology was held at Munnar; “Parmanu Urja Janjagruti Abhiyan” at Jabalpur; “Thorium Energy Conference 2015 (ThEC2015) at Mumbai; The 35th India International Trade Fair 2015 organised by the ITPO at New Delhi; 9th National Seminar on Peaceful Uses of Atomic Energy organised by United Schools Organisation of India (USO) at New Delhi; The 7th edition of AGROVISION held at Nagpur and many others.

The 27th All India Essay Contest on Nuclear Science and Technology was held in October 2015. A total of 307 essays were received out of which the authors of twenty nine were selected for making an oral presentation at Mumbai.

In addition to above events, several public awareness lectures/workshops on atomic energy were conducted by DAE in different regions of the country throughout the year. Many of these were in the vernacular medium.

NPCIL has set up permanent nuclear galleries at Science Centres in Mumbai and New Delhi and nuclear gallery set up at Chennai is in advanced stage of completion. NPCIL is also in the process of setting up of nuclear galleries at other science centres across the country to allay the apprehensions of public on nuclear power and other associated aspects.

SOCIAL WELFARE

Corporate Social Responsibility

Under CSR programme, NPCIL has taken up the activities in the five identified thrust areas as education, healthcare, infrastructure development, skill development and sustainable development. Support to education was extended through implementation of projects such as construction of school buildings and class rooms, scholarships to students and development of Anganwadis. Educational items were provided to the school children for motivational purpose. Based on need, transport facility was provided for the school children and teachers. Under healthcare category, primary health centres, mobile medical van services and medical camps were operated and funds were provided for extension of hospital buildings. Construction of roads, community halls, bus stop sheds and drinking water facility etc. were taken under infrastructure development. Skill development programmes were implemented by imparting livelihood generation skills such as welder training, masonry, computer skills, tailoring and stitching etc. Sustainable development initiatives were taken through implementation of projects like installation of solar street lights and biogas plant, conservation of turtles, rain water harvesting, artificial reefs for augmenting fish production etc.

Swachh Bharat Mission

The Department of Atomic Energy (DAE) and its constituent units continued its activities for the “Swachh Bharat Mission”. As a part of Swachh Bharat Mission, total four hundred and seventy five (475) toilets and urinals have been constructed in nearby villages by NPCIL and construction of another fifty three (53) toilets and urinals are expected to be completed by March 2016. In addition to this, contribution amounting to ₹ 10 Cr. to Swachh Bharat and ₹ 10 Cr. for Clean Ganga Kosh was also made.