Founder's Day Address

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By

Dr.Srikumar Banerjee

Director, BARC

Dr.Kakodkar, Chairman, Atomic Energy Commission, senior members of DAE family present here and dear colleagues.

It is indeed a matter of great pleasure and proud privilege for me to extend a warm welcome to you all to celebrate the 100th birth anniversary of Dr.Homi J. Bhabha – the founder of this great institution, Bhabha Atomic Research Centre.

We celebrate Homi Bhabha's birthday every year on 30th October by taking stock of our achievements during the previous year and rededicating ourselves towards our mission oriented tasks related to the development of nuclear science and technology.

Launching of Arihant

As you all know, the nuclear submarine Arihant has been launched by India in August this year. BARC had a significant role in this major project. The steam generating plant of this submarine was designed, developed and built by BARC. The compact Pressurised Water Reactor was designed for this purpose with several special features ; such as, very quick response for power ramping, extremely stable under ship motions and resistance against exposure to very high acceleration, resulting from eventual depth charges. Since the nuclear reactor is fuelled with high fissile containing fuel, it can supply energy in the submerged condition for an extended period without refueling. Many systems and equipment designed and built were first of its kind in the country. The entire steam generating plant has been designed to give highly reliable offshore operation in a completely isolated environment. Control and instrumentation design is fault tolerant and requires minimum operator interventions. An elaborate diagnostic system enables a very high availability factor. Many new materials and technologies have been developed and new infrastructure has been created for this project. The development of the steam generating plant of Arihant was preceded by setting up of the land based prototype system at Kalpakkam known as PRP. The reactor in PRP has been working since last three years and has served as a technology demonstrator for the compact pressurized water reactor with a load following capability. This has proved several design features including fuel performance and established the reliability of various systems and equipment. The entire propulsion plant with primary, secondary, electrical and propulsion system along with its integrated control was packed in the aft end of a land based submarine hull designed and built specifically for this purpose. This prototype is serving as a training centre for the crew for the nuclear submarine. The crew training is further facilitated with the help of an indigenously designed and built full scope simulator.

With the successful development of compact pressurized water reactor, BARC has ushered in the field of PWR technology in the country. In future, the experience gained in this project will go a long way in the indigenous development of an Indian Pressurised Water Reactor system for large scale electricity generation. This landmark achievement has been possible due to a sustained team work by a group of dedicated engineers and scientists in our centre.

In the uranium enrichment programme, we have succeeded in improving the separating work unit of gas centrifuges manifold. The production capacity has also been substantially enhanced to meet the requirement.

About 1.1 MT of low enriched uranium has been processed by liquid-liquid blending. The material is converted into nuclear fuel bundles for irradiation testing in PHWRs.

Reprocessing Programme & KARP recommissioning

The second major achievement during this year has been bringing back the reprocessing plant KARP into operation at Kalpakkam. We took up the arduous task of renovation and upgradation of this Reprocessing Plant and after nearly five years of hard work, we have succeeded in our task. The plant is now performing extremely well since March, 2009, when the spent fuel chopping was resumed. The entire off-grade uranium stored in waste tank farm has already been processed. The commissioning of automatic charging facility has helped in enhancing the throughput and lower the radiation exposure to the operating personnel in the plant. With the commencement of reprocessing at KARP and continued operation of reprocessing plants at Tarapur and Trombay, our rate of production of fuel material for fast reactor is substantially enhanced.

Some of the other important achievements in the back-end of the fuel cycle during the year are : i) encapsulation and transportation of eleven alpha contaminated glove boxes from Radiological Laboratories to our Interim Storage Facility in Trombay, (ii) processing of 200 m^3 of intermediate level waste using ion exchange based mobile module (TRIX), (iii) safe transportation of vitrified waste products and interim storage of overpacks in Solid Storage Surveillance Facility (S3F), Tarapur, (iv) augmentation of Ammonium Di-uranate (ADU) facility by installation of new furnaces and continued supply of Depleted Uranium (DU) & Deep Depleted Uranium (DDU) to NFC, Hyderabad, and (v) successful commissioning of the state-of-the-art Spent Fuel Chopper for gang chopping of fuel bundles in one stroke to enhance the production rate by four times.

In view of the expanding programme of reprocessing and waste management, the formation of Nuclear Recycle Board is approved. Under the aegis of this Board, several integrated reprocessing and waste management plants of large capacity will be set up to meet the growing demand of Pu fuel for the fast reactors.

Research Reactor operation and refurbishment of APSARA

APSARA, our first research reactor, commissioned in 1956 has served various users for more than five decades with an impressive availability factor exceeding 85%. In view of the ageing of the structures, systems and components, it has been decided to refurbish and upgrade the Apsara reactor. Various non-destructive testings carried out on several structures of Apsara indicated that the reactor pool structure is healthy and can be retained as such. However, the main reactor building structure does not fulfill the minimum requirement of the present day safety norms. After debating over various options, it has been decided to demolish the existing structure and construct a new reactor building while retaining the existing pool structure. The plan for upgradation also includes change over from the highly enriched uranium fuel core to a low enriched uranium fuel core in line with the global norms. The reactor power of Apsara will also be enhanced to 2 MW (th) and the maximum thermal neutron flux will increase to 6.5 x 10^{13}. The upgraded reactor will provide enhanced facility to carryout beam tube research, radioisotope production, calibration and testing of neutron detectors, material irradiation and bulk shielding experiments. All the process and nuclear control systems will be modernized.

Basic design of the new reactor core and various reactor systems for the refurbished Apsara has been completed. Apsara was shutdown in the first week of June, 2009 and the core has been defueled completely as a part of the decommissioning activities, prior to refurbishment. Reincarnated Apsara is expected to be available for the users by 2012.

Research reactors Cirus and Dhruva were operated at availability factor of around 80%. More than 1000 isotope samples have been produced in these reactors during the year. A neutron radiography set up was commissioned satisfactorily for materials testing in one of the beam lines at Cirus.

A number of research scholars from various academic institutions in the country continued to utilize the reactor under the aegis of the UGC-DAE Consortium for Scientific Research.

The conceptual design of a high flux Multi Purpose Research Reactor (MPRR) has been completed. A feasibility study for incorporation of an external spallation neutron source in the MPRR core so as to operate the reactor as an accelerator driven sub-critical reactor system in future is in progress.

Critical Facility after attaining its first criticality in April 2008 is being operated regularly at the designed power of 100 watts to facilitate various physics experiments, including estimation of the worth of the shut-off rods and adjuster rods.

In P-4 Facility, re-criticality of burnable poison rod calibration facility was successfully achieved as a first step towards undertaking testing of BPRs and other components.

Fuel Fabrication for Fast Reactors

BARC has the responsibility for supplying nuclear fuels for the Fast Reactors FBTR and PFBR (under construction) at Kalpakkam. As part of the continued production of Uranium Plutonium mixed carbide fuel for FBTR, fuel pins worth seven fuel sub-assemblies have been shipped to IGCAR during this year. This included one Fuel Sub-assembly pins made with reprocessed plutonium from FBTR fuel as part of the fuel cycle closure. The PFBR experimental MOX Fuel pins fabricated at AFFF, Tarapur loaded in the very centre of FBTR core has now reached a burn up exceeding 92,000 MWd/T.

The manufacture of MOX fuel pins for PFBR first core is continuing at our facility in Tarapur and has crossed the land mark of one thousand full length MOX fuel pins. Fabrication of Six million DD UO_2 pellets required for Axial breeder blanket of the first core of PFBR has also been completed. End plug welding of D-9 clad tubes using Nd – Yag laser has been qualified.

BARC is also involved in R&D on metallic fuel for the advanced fast breeder reactors with high breeding ratio. A new thermophysical property evaluation lab has been set up in BARC where evaluation of thermophysical and thermomechanical properties of several Uranium Plutonium alloys and fuel-clad chemical compatibility studies are in progress.

As part of the fuel irradiation programme, (ThO_2-1%PuO_2)MOX fuel pins have been fabricated to be loaded in one of the fuel position of DHRUVA Reactor. The fuel hardware and the pellet geometry will be similar to AHWR fuel.

Post Irradiation examination of (ThO_2-4%PuO_2) fuel pins irradiated upto 21,000 MWd/T burn-up in Ac-6 cluster in CIRUS has been taken up. The tests have confirmed the excellent behaviour of (Th-Pu) MOX fuel including much lower fission gas release compared to similar U based fuels.

The mechanical properties of zircaloy clad of PHWR fuel irradiated to burn-up of 15,000 MWd/T has been evaluated which showed about 30% loss of ductility compared to the virgin material.

Design & Development of Innovative Reactors

Studies were performed for a variant of **AHWR using Thorium / LEU** based fuel. LEU (19.75%) can be used as a good external feed in thorium oxide fuel in AHWR making all reactivity coefficients including channel and moderator temperature coefficients negative. High burn-up of 64000 MWD/T can be achieved and natural uranium resource utilisation would be better than in PHWRs and LWRs. This reactor has an excellent export potential because of its proliferation resistant fuel.

The AHWR core design was re-optimised for achieving self sustenance in ^{233}U. The other developments under this programme were (i) Experimental simulation of postulated Loss Of Coolant Accident (LOCA) in AHWR in Integral Test Loop (ITL), (ii) design & development of the Accumulator Isolation Passive Valve (AIPV) and (ii) development of Water lubricated anti-friction bearings for fuel handling.

In our effort for U^{233} clean up an important experiment has been carried out. The isotope shifts of the optical transitions of ^{232}U and ^{238}U were measured in the entire ultraviolet and visible region for the first time anywhere in the world. After recording the ^{233}U – ^{238}U isotope shifts possible first step transitions were identified for the thee step photo-ionization schemes were for U-233 clean up programme.

The **Compact High Temperature Reactor (CHTR)** is being built as a technology demonstrator for the comprehensive Indian high temperature reactor program. A new feature of Burnup Compensation Rods (BCRs) is introduced in the CHTR core and detailed physics analysis is done. The use of BCRs will help in controlling the excess reactivity during the long reactor core life. This will in turn reduce the worth of each control rod during reactor operation.

Design of heat pipe manufacturing system has been completed and the components are under procurement. Analytical studies for shielding analysis and seismic behaviour of Compact High Temperature Reactor and the design of heat sink (based on passive cooling by air), were successfully carried out. A High Temperature Liquid Metal Loop using Lead Bismuth Eutectic (LBE) as the working fluid was commissioned and steady state and transient thermal hydraulic experiments have been carried out in the loop. A high temperature chemical vapour deposition process has been developed for TRISO coated fuel particles with uniformly thin coatings.

As a part of the hydrogen energy programme, a catalyst has now been developed for the decomposition of HI for the production of hydrogen by thermo-chemical water splitting. It could reduce the HI decomposition temperature from 350^0C to 175^0C. Also a hydrogen skid mounted electrolyser (30 Nm^3/hr) has been designed and fabricated. This 25 cell module, weighing around 1 ton has successfully demonstrated its capability for Hydrogen generation. This is the biggest in-house H_2 generation plant by electrolysis process in the country.

A process for preparation of lithium titanate pebbles (~ 2kg/ batch) has been successfully developed and is one of the material for the test blanket module ITER. The process is based on the solid state reaction starting from lithium carbonate and titanium di-oxide. The product has been characterized and conforms to the specification.

BARC has successfully developed and fabricated Cable In Conduit Conductor (CICC) for various configurations for superconducting magnets required for fusion research work at IPR. The CICC consists of 0.80 mm dia Nb-Ti strand containing 492 filaments each of less than 25 micron size.

R&D Support for PHWR, FBR and VVERs:

A Sludge Lancing Equipment (SLE) designed and integrated by BARC and supplied to NPCIL was successfully operated for sludge removal from a steam generator of Kakrapar Atomic Power Station for the first time. Developed as an import substitute, this equipment uses high velocity water jets to remove sludge (corrosive deposits) from the secondary side of tube sheet of steam generators, thereby ensuring longer service life of steam generators.

Occasionally, need arises to repair the closure seal face of the end fittings of coolant channels of PHWRs. Conventionally, this work entails defuelling the channel, followed by draining and drying to carry out the lapping of the seal face. A channel isolation plug has been recently developed for the 540 MWe PHWR. The plug can be installed by the fuelling machine in the end fitting. Subsequently, closure seal face can be accessed for lapping operations. The use of this plug does not require the draining and drying of the coolant channel. A prototype of the plug has been satisfactorily tested.

In 37 rod cluster for 540/700 MWe PHWRs, the use of Thorium along with slightly enriched uranium in segregated rods was studied. In these studies, significant saving in natural uranium resource requirement was observed along with production of ^{233}U. .

Two BARCIS systems for in-service inspection of coolant channels of RAPS and Kaiga have been supplied and commissioned at reactor sites. An MoU has been signed with NPCIL for development and supply of BARCIS for 540 MWe PHWRs.

Robotics and Maufacturing:

Based on an MoU signed with NTPC, BARC has developed an **Automation System for Boiler Tube Inspection**. A Magnetic Crawler has been specially developed to carry the EMAT probe for automated inspection. The system has recently been field tested at NTPC's Dadri Plant.

A **prototype Snake Arm Robot** of one meter length and payload capacity of 10 kgs has been developed. The arm consists of four flexible and hollow segments, each segment has four joints, each of which is independently controlled by a servo motor.

The curvature and plane of curvature of each segment is controlled through guide wires by a drive unit at the base. The arm is suitable for inspection and manipulation in tight spaces.

BARC has developed a **Radiotherapy Simulator for diagnosis and localization of cancer**. The simulator is similar to our teletherapy machine Bhabhatron, but uses diagnostic X-rays as the source of radiation. This helps in choosing the radiation beam and aiming it to the target. The machine is installed at Indian Red Cross Society Hospital, Nellore.

First prototype assembly of **Canned motor pump** has been successfully manufactured and delivered. Manufacture of this Pump needed development of many manufacturing processes like Ceramic Metal (CM) Seals for Electrical feed throughs for stator of two speed motor, welding of Can to the inside diameter of the Stator body of the motor etc.

Dual Barker Coil System (BCS) has been developed for Indian Institute of Geomagnetism, New Panvel, Navi Mumbai. The system is completely made up of high purity copper, brass and aluminium, devoid of even the small traces of ferromagnetic elements. It is used to produce magnetic fields of very accurate fidelity over an extended region for measuring the earth's horizontal and vertical magnetic field vectors.

Vibration Monitoring System developed by BARC was successfully used for vibration monitoring of Gas Turbine in Auriaya power plant under an MoU with NTPC. All the objectives of MoU have been fully realised.

The 10 MeV Electron Accelerator set up in Kharghar, Navi Mumbai is now operational at a power level of 3.6 kW. The beam has been employed for process trials for cross linking of polythelene, diamond coloration, Teflon degradation and production of photo neutrons. With the demonstration of steady operation and the availability of material handling system, the electron beam accelerator facility is now ready for providing service to industries.

Electronics

As a focused approach towards the basis electronics, a new Centre for Microelectronics (CMES) has been set up at Prabhadevi, Mumbai and is now fully operational. The centre has a class 10k clean room in which mixed signal IC tester, parametric device characterization set up, noise measurement system, die bonder and a semi automatic wire bonder have been installed. The centre has CAD tools for design and development of semiconductor devices, processes and integrated circuits. Several full custom CMOS ASICs have been developed and tested in the centre.

The technology of silicon PIN detectors developed by BARC is now well established at BEL foundry. The latest development is a quad 20mm x 20mm PIN detector which is ready to be commercially supplied to GANIL, France. This activity will get a further boost from development of the technology of high resistivity single crystal silicon by float zone process in the new Si crystal growth facility. 100 mm dia and 500 mm long Si single crystals have been successfully pulled.

In the ANUPAM series of supercomputers, development of 35 Teraflops machine having about 4500 CPUs interconnected through a network of multi level infini-band switches with specialized heat removal systems, is completed. A new 4.5 teraflop computational system has also been set up at Facility for Electromagnetic systems (FEMS) Autonagar, Vizag for simulation of pulse power experiments.

10 MeV Electron Accelerators are also being developed as a source of energy pack for container scanner. In this programme, which is being pursued in collaboration with ECIL, a high power pulsed 9 MeV electron beam has already been obtained.

Materials & Chemistry

Process development studies on laboratory and pilot plant scale have been nearly completed to evolve a technoeconomic flowhseet for the processing of uranium deposits from Gogi in Karnataka. Simultaneous pre project related data are being generated to set up a 500 T/day mill for production of uranium from this deposit.

Thorium-Uranium alloy has been produced by metallothermic reduction on laboratory scale.

Beryllium pilot plant at Vashi has been refurbished and most of the unit operations have been started on a campaign basis. A pilot plant for production of nuclear grade beryllia has been commissioned.Vacuum hot pressed beryllium sleeves and large number of beryllium pellets have been fabricated for departmental use. Rotating electrode process has been developed for fabricating beryllium pebbles.

Lithium titanate has been prepared by various synthesis techniques and ceramic pebbles of lithium titanate are being evaluated for meeting the specifications for test blanket module.

A process flowsheet has been developed on laboratory scale to fabricate heat-treated Zr – 2.5 Nb alloy for AHWR pressure tubes. The material has been fully characterized.

Photocatalytic water splitting using solar energy has shown promising catalytic effects of doped titania and titanates in their nano states. Hydrogen yield out of water splitting has been as high as one standard litre per hour per square meter exposure to the solar light.

A carbon analyser for the measurement of carbon in uranium metal at trace levels has been designed and fabricated. The set up is based on the measurement of carbon dioxide resulting due to combustion of sample in oxygen-rich atmosphere, using an IR detector. This system gave a measurement reproductibility of 2%. The system was standardized and validated and is being employed for routine analysis of samples.

DAE's Societal Initiatives

BARC Centre for Incubation of Technologies (BARCIT) is being set up in the old Training School Complex, South site. The work on four technology incubation cells is initiated in the area of water, biotechnology, scientific & medical equipment and E-beam applications. This will enable expeditious conversion of BARC R&D know-how to commercialization with industry participation.

Ten **Advance Knowledge and Rural Technology Initiative (AKRUTI)** centres have been set up in Maharashtra (7), Andhra Pradesh (1), Karnataka (1) and Madhya Pradesh (1). Two more AKRUTI centres are being set up in Meghalaya North Eastern region and one at BARC, Vizag.

In the field of **Nuclear Agriculture**, two new Trombay crop varieties were notified. TG-39, a confectionary grade groundnut variety was notified for cultivation in Rajasthan as TBG-39 (Trombay Bikaner Groundnut) and as TDG-39 (Trombay Dharwad Groundnut) for Karnataka. TG-51, an early maturing groundnut variety was notified for West Bengal, Orissa, Bihar and North Eastern States. With this, the total number of Trombay crop varieties released and notified by the Ministry of Agriculture, Government of India for commercial cultivation has reached 37.

The interest of entrepreneurs in using radiation technology for **Food Preservation** and allied products is increasing. For the past three years, radiation technology has been used for overcoming quarantine barriers for export of mango from India. During the last three years, 562 tons of mango were radiation processed (157 tons in 2007, 275 tons in 2008 and 130 tons in 2009) at Krushak, Lasalgaon. This year, using a combination of radiation and low temperature, it was possible to successfully tranship 14.3 tons of mango to US by sea route. The trial was successful. This will make mango more cost competitive in the U.S.market.

The Multi Stage Flash unit of Nuclear Desalination Demonstration Plant (NDDP) has produced high quality distilled water having 2 ppm TDS from seawater suitable for high end industrial use. Along with MSF plant, the Sea Water Reverse Osmosis (SWRO) plant continued its operation and now the RO plant is being operated on round-the-clock basis. The RO plant is producing potable water of about 200-300 ppm TDS, at its rated capacity. Dr. Mohamed ElBaradei, Director General, International Atomic Energy Agency (IAEA) visited NDDP on 28th September, 2009.

Tera Becquerel amounts of **Radiochemicals** were produced and supplied to BRIT for further processing and supplying to the user institutions. Iodine-125 brachytherapy sources were continued to be produced and supplied to the 3 collaborating Eye care Hospitals for treatment of ocular cancers, benefiting nearly 15 patients in the past year.

P-32, a beta emitting nuclide was tested for **treatment of superficial cancers by mould brachytherapy** for the first time in the world. Based on the excellent results in small animals, limited clinical trials were conducted at AIIMS, at their behest. 7 patients with basal cell carcinoma lesions in the face, which were otherwise not treatable have been treated with the P-32 brachytherapy moulds, prepared at the Radiopharmaceuticals Division, each one custom made to match the size, shape and the activity needed by the patient.

The indigenous production of ^{177}Lu in high specific activities and optimization of procedures to label molecules with ^{177}Lu, has resulted development of ^{177}Lu based **therapeutic radiopharmaceuticals**.

At the request of NFC, Hyderabad, BARC undertook **development of Promethium-147 sources,** to be used in an instrument for measurement of graphite coating thickness. The backscatter of beta particles from ^{147}Pm is used to gauge thickness of coatings. The ^{147}Pm sources prepared on Aluminium matrix by anodization-cum-adsorption method has been tested at NFC with satisfactory results.

A new technique in surgery, viz. Cochlea, which is done in selected hospitals in India was successfully performed in BARC Hospital by our ENT surgeons. A new instrument – Remote Control Digital Radiofluoro System Flexavision has been installed in the Radiology Unit of BARC Hospital.

Homi Bhabha had a dream of making our country advanced in the field of nuclear science and technology. He sketched a plan for a comprehensive growth in different aspects of nuclear science and technology for improving the quality of life of our people. On this occasion of Bhabha centenary, let us examine as to what extent we have been successful in realizing the dreams of Bhabha. The first objective of his plan was to achieve the competence in the total technology development of a reactor system. No doubt, this has been achieved. The best testimony is the development of the Indian Pressurised Heavy Water Reactor system of 220 MWe and 540 MWe capacity which has been designed and constructed indigenously and operated with a record capacity utilization factor. Two generations of scientists and engineers of BARC and NPCIL have relentlessly worked for perfecting the PHWR technology which has received recognition all over the world. In Bhabha's grand scheme of things, he wished that the country should become self-sufficient in the entire fuel cycle technology. In spite of the fact that the uranium ore in Singhbhum District is not of very high grade, Dr.Bhabha took the bold decision in opening up the Jaduguda mines and the uranium mill. Today, the entire fuel cycle which include mining of uranium ore, the subsequent processing of nuclear fuel, utilization of the fuel in reactors, reprocessing of the spent fuel to extract plutonium, utilization of plutonium in fast reactors and vitrification of high level radioactive waste has been mastered by us. We are among a few countries in the world to operate the closed fuel cycle, a concept which is gradually being accepted world over for a sustained energy supply for centuries to come. Successful operation of PHWR system requires availability of high quality heavy water in adequate quantity. Not only the technology of heavy water production has been mastered in India, our colleagues in the Heavy Water Board have steadily improved the energy efficiency resulting in our being able to produce heavy water at a competitive rate even for export.

Spent fuel reprocessing for extracting plutonium is the key element both in the Fast Reactor and the strategic programmes. The reprocessing activity which started with the setting up of a Plutonium Plant in Trombay has now expanded manifold and we have accomplished the objective of supplying fuel to the Fast Breeder Test Reactor which has been running since 1985. In fact, the courage BARC scientists and engineers have shown in introducing the mixed carbide fuel for the FBTR for the first time anywhere in the world is indeed exemplary. The fuel performance stood the test of time by achieving nearly 165,000 MWd/T of burn up. Today, a bigger challenge lies ahead of us to supply the mixed oxide fuel requirements for the Prototype Fast Breeder Reactor.

Bhabha outlined the three-stage nuclear power programme considering the modest uranium resource and the large thorium reserve in the country. We are moving ahead in this chartered path and are on the threshold of the second stage of nuclear power production. Through the development of Advanced Heavy Water Reactor technology, we will be proving several technologies meaningful for the large scale utilization of thorium.

Bhabha also visualized the importance of nuclear radiation in the food and health care. The contribution we have made in nuclear agriculture by developing 37 different types of radiation mutated seeds has made a very significant impact. The Indian farmers have reaped the benefits of radiation mutated seeds which have been developed by the scientists working in the area of nuclear agriculture. Food preservation and radiation processing plants have been steadily multiplying during the last few years.

Our research reactors have been continuously supplying radioisotopes for a variety of health care applications. Our technologies have been developing newer health care facilities such as Bhabhatron, Plethysomography, Tele ECG equipment which are benefiting a large section of our population.

Bhabha also desired that all these developments should come on a firm footing of basic sciences. The wide ranging programme on advanced physics, chemistry, biology, engineering science and material science which we are pursuing today are being globally acclaimed.

In the area of Human Resource development, in 1944, Bhabha had made the prophetic observation that "when nuclear energy has been successfully applied for power production, in say, a couple of decades from now, India will not have to look abroad for its expertise, but will find them ready at home". Since 1957, when the first batch of BARC Training School was inducted, we have been running this education programme for preparing our scientists and engineers to get oriented in the field of nuclear science and engineering. Today, HBNI is not only giving degrees to the gradating trainees, but also helping in providing continuing education to a large section of DAE employees.

Time has come for us to have fresh dreams. I am sure, many of our young colleagues have their own dreams. Scientists can explore new ways of harnessing nuclear energy, new means of energy conversion and storage, new methods of using radiation in food, health care and environmental control, while engineers can give shape to these ideas into robust technologies which can spread all over the world. Today, India has a leading position in several areas such as information technology, iron and steel, pharmaceuticals and service sectors. I see no reason why we cannot occupy a pre-eminent position in the energy sector and in several other hi-tech areas. We have mastered the heavy water reactor technology today. Tomorrow, we may have to compete with the world with our own design of Light Water Reactors. We already have an eminent position in Fast Reactor technology and we may have to lead the path to show the world that Fast Reactors not only provide energy at a competitive cost in a safe manner but also provide fuel reserves for the future by converting fertile material to fissile. The current work being pursued both in BARC and IGCAR on developing Fast Reactor fuel with short doubling time is of great significance in this respect. We must fulfill our cherished dream of providing long term energy security to the country by utilizing our vast reserves of thorium after establishing a substantially higher capacity of nuclear power.

While concluding my address, I would like to emphasize that we have plenty of challenges ahead. With the synergetic effort of all of us in BARC, scientists, engineers and administrators, I am sure, we will be able to rise to the occasion to meet the future challenges in a manner consistent with the tradition of BARC.

Friends, finally on this very special day, let us firmly resolve and rededicate ourselves to continue our pursuit of excellence in the frontier areas of nuclear science and technology for the betterment of life of our people.

Thank you.