“Nuclear energy remains an important element in India’s energy mix for sustaining rapid economic growth. India remains firmly committed to its indigenous nuclear programme and is planning a major expansion of nuclear installed capacity to 20,000 MWe by 2020 and to reach about 60,000 MWe during the early 2030s.”

Address by Dr. Srikumar Banerjee, Chairman Atomic Energy Commission & Leader of the Indian delegation at International Atomic Energy Agency 35th General Conference, Vienna, 21 September 2011
It gives me great pleasure to congratulate you, Mr President, on your election as the President of the 55th General Conference. Under your able leadership and with support from the Agency's Secretariat, we are certain that the current General Conference will be able to accomplish all the tasks before it.

I welcome the entry of Lao People's Democratic Republic, the Kingdom of Tonga and the Commonwealth of Dominica to the Membership of the IAEA. I take this opportunity to congratulate them on the occasion of their joining the IAEA family.

Mr President,

India joins other countries in expressing its deep condolences to the Japanese people for the sufferings in their country due to the terrible twin natural disasters that have struck that country. India also takes this opportunity to convey its appreciation of the efforts of the Japanese Government and people in dealing with the consequences of this tragedy. The IAEA Ministerial Conference on Nuclear Safety during June this year, which followed soon after the Paris Ministerial Seminar on Nuclear Safety, has reiterated the consensus that nuclear safety is a national responsibility. The unanimous adoption of the Declaration at the end of that Meeting shows the importance Member States have accorded to nuclear safety and the role of IAEA in addressing this important topic.

Mr President,

At the cost of a small digression, I may mention that against the backdrop of India’s long standing association with the IAEA, the Comptroller and Auditor General (CAG) of India has presented its candidature for IAEA’s External Auditor for the period 2012-13. An independent constitutional authority, the CAG has wide experience of auditing international organizations. May I request the esteemed delegations present here for favorable consideration of the candidature of CAG of India.

Mr President,

Nuclear energy remains an important element in India’s energy mix for sustaining rapid economic growth. India remains firmly committed to its indigenous nuclear programme and is planning a major expansion of nuclear installed capacity to 20,000 MWe by 2020 and to reach about 60,000 MWe during the early 2030s. This accelerated capacity addition includes installation of large-size water cooled reactors planned under international civil nuclear cooperation. This is being pursued with full regard to safety and environment, and livelihood of the people living around the plants.

Immediately after the accident at Fukushima, Prime Minister of India had underlined that safety of nuclear power plants is a matter of highest priority for the Government while implementing the national nuclear programme. Several actions have been taken in this regard. A bill to confer statutory status to the national safety regulatory authority has been introduced in the Parliament. The results of the safety reviews that were mandated by the Government of India have been made public. Several recommendations have already been implemented and a road map is
prepared for implementing the other recommendations. A decision has been made to invite IAEA missions, namely, Operational Safety Review Team (OSART) and Integrated Regulatory Review Service (IRRS), for peer review of safety of nuclear power plants, and of the regulatory system, respectively. The emergency response and preparedness measures have been further strengthened in our nuclear facilities. India’s National Disaster Management Authority has drawn up a holistic and integrated programme of “Management of Nuclear and Radiological Emergencies”.

Mr President,

While we learn lessons from the accident and take all necessary measures to enhance emergency response to a nuclear accident, we should also be prepared to scientifically examine the substantial data now available from the accidents at Chernobyl and Fukushima, and factor these while establishing new guidelines for intervention limits for emergency response.

As a contracting party to the Conventions establishing international framework on Nuclear Safety, Assistance, and Early Notification, India is committed to fulfill all its obligations and looks forward to participating in reviewing these for effective implementation.

Mr President,

In pursuing India’s 3-stage nuclear power programme formulated under the visionary leadership of Dr. Homi Jehangir Bhabha, we strongly believe in adopting a closed fuel cycle in order to extract the maximum energy from the limited uranium resources and to provide long-term energy security by utilization of the vast resources of thorium.

Let me now give you some of the highlights of the achievements during the last year.

The installed nuclear power capacity in the country has now reached 4780 MWe. The total number of operating reactors is 20 including three new 220 MWe PHWRs, recently connected to the electricity grid. This has elevated India to the sixth rank among nations in terms of the number of nuclear power reactors in operation. I would like to mention here that the Indian PHWRs have a very competitive capital cost and offers a very low unit energy tariff. By now the Indian nuclear power sector has registered over 345 reactor years of safe operation. The nuclear power generation during the year recorded an increase of about 40% over the previous year, due to increased fuel availability, both indigenous and imported. In particular, the average capacity factor is more than 80%, while that of 7 reactors has exceeded 90%. En-masse Coolant Channel Replacement and En-masse Feeder Replacement were completed in unit-2 of Narora Atomic Power Station and unit-1 of Kakrapar Atomic Power Station.

The construction work at two 1000 MWe LWRs at Kudankulam being set up in technical cooperation with the Russian Federation is nearly complete. The commissioning activities in unit-1 have reached an advanced stage and the hot run in this unit has been recently completed. The progress of unit-2 of Kudankulam nuclear power project is closely following that of the first unit.

The 500 MWe Prototype Fast Breeder Reactor (PFBR) is also at an advanced stage of construction. The reactor vault is nearing completion with all major reactor equipment in place. Welding of the Roof slab (Top shield of Reactor) with reactor main vessel has commenced. Installation of steam generator and secondary sodium pump has started. Four indigenously designed 700 MWe Pressurised Heavy Water Reactors, two each at existing sites of Kakrapar in Gujarat and Rawabhatla in Rajasthan, were launched during the last year, thus raising the number of reactors under construction to seven.

The Fast Breeder Test Reactor (FBTR) at IGCAR completed 25 years of successful operation in last October. The process for life extension of FBTR up to the year 2030 is progressing well. The test fuel subassembly for the prototype fast
breeder reactor (PFBR) was irradiated in FBTR; after seeing a peak burn up of 112 GWD/t, as against the target burn up of 100 GWD/t, it is now undergoing post irradiation examination. A test loop called SADHANA has successfully demonstrated the natural convection in sodium to air heat exchange for validating the decay heat removal process in PFBR. In the domain of fast reactor safety, a test facility for molten fuel coolant interaction to understand the severe accidents has been commissioned.

Detailed engineering design of advanced heavy water reactor, AHWR, has now been initiated so as to enable launching the construction of the plant during the next plan period 2012-2017.

India is a founder member of INPRO. We are glad to see its progress during the last decade. India has rich experience in the entire gamut of activities related to nuclear power plants and associated fuel cycle, which places it in a position to export reactors, equipment and components, as well as services to the global nuclear energy market. We possess all technologies and infrastructure relevant to small and medium sized PHWRs of 220 MWe, 540 MWe and 700 MWe capacities, which would be a safe, proven and cost-effective option for countries with small grids planning to start their nuclear power programme. In this context, India is looking forward to exporting its proven Small and Medium Sized Reactors (SMR).

Mr. President,

India assigns equal emphasis to non-power applications of nuclear energy. Applications in the areas of health care, agriculture, hygienisation of municipal waste and water-desalination are making greater impact in India. Nuclear desalination plant at Kalpakkam with a capacity of 6.3 ML per day employing the hybrid technology of multi-stage flash evaporation and reverse osmosis technique is currently the largest nuclear desalination unit in the world.

Isotope hydrology is being used more broadly to improve the understanding of climate change on water resources. In one such effort, India is among the 17 research groups who participated in an Agency coordinated research project on designing a global network of isotope monitoring in large rivers. It is a matter of great satisfaction that the theme of the Scientific Forum of this General Conference is related to application of nuclear techniques in water.

Indian health authorities attach great significance to fighting the cancer menace and several cancer care institutes have been expanding their facilities and treatment capabilities. A national cancer grid network initiative has also been launched. For example, the facilities at the Tata Memorial Centre (TMC) under the aegis of the Department of Atomic Energy, which provides services to nearly 500000 patients per year, have been expanded with a new block equipped with several sophisticated facilities. An International Peer Review conducted in October 2010 has rated the services of TMC at par with the global standards. The IAEA’s Programme on Action for
Cancer Therapy (PACT) enables the channeling of the resources and expertise to the needy and developing countries. India has been an active supporter of PACT initiative. The Bhabhatron Teletherapy machine, donated to Sri Lanka under the PACT last year, is expected to be commissioned shortly. Arrangements are underway for providing the next machine to Namibia.

In our continuing support to nuclear medicine practices in India, a new facility for production of Technetium-99m generators has been set up at the laboratories of the Board of Radiation and Isotope Technology in Navi Mumbai. In order to further enhance our self-reliance, we will set-up a new facility for production of fission-produced Molybdenum-99 in Trombay. In view of India’s large interest in electron accelerator based applications, we are developing competencies and building facilities to address several aspects of accelerator technologies.

Mr. President,

India’s nuclear programme attaches high importance to R&D work and some recent achievements are as follows:

• The Advanced Heavy Water Reactor, AHWR, has been designed to address siting and safety-related issues relevant for future large-scale deployment of nuclear power in a densely populated country like ours. Its design was revisited to understand and confirm its robustness against events such as earth-quake, flooding and extended Station Black Out.

• India has taken an important step in assessing the behavior of containment under 'beyond-design-basis' accident conditions. A one to four scaled down reactor primary containment test-model of the 540 MWt PHWR, with extensive instrumentation is being subjected to a series of tests leading up to its ultimate failure. The results are being analyzed as an International Round Robin exercise involving fifteen participants from various countries. This is one of the largest containment test facility in the world.

• More than 100 solar powered Environmental Radiation Monitors have been deployed at various locations in India covering Nuclear Power Plant sites, uranium mining sites, major metropolitan cities etc. under the Indian Environmental Radiation Monitoring Network (IERMON).

A Global Centre for Nuclear Energy Partnership, GCNEP, is being set up near New Delhi to pursue studies in the field of Advanced Nuclear Energy Systems, Nuclear Security, Radiological Safety, and Applications of Radioisotopes and Radiation technologies. MOUs are already signed with USA, Russia and will soon be signed with the IAEA. France has also expressed a desire in signing an MOU.

To mark the launch of GCNEP, a regional training course on Nuclear Security - “Physical Protection of Nuclear Facilities against Sabotage, Assessing Vulnerabilities and Identifying Vital Areas” is scheduled at New Delhi during 14-18 November this year.

Mr. President,

The role of nuclear power as a safe, clean and viable source to meet the energy needs, as well as to adequately address the concerns of global warming and climate change, cannot be undermined. This is all the more so for developing countries and emerging economies, which aim to provide a better quality of life for their people. As regards safety, we must recall that the world has logged over 14,000 reactor-years of nuclear electricity generation in about 30 nations, with far fewer fatalities compared to any other energy generating technologies over a sustained period. This in itself testifies to the strength of nuclear technology, which must be further pursued to provide an important part of sustainable energy solution for the future.

Thank you.
Address by
Dr. Srikumar Banerjee
Chairman, Atomic Energy Commission &
Secretary to Government of India, Department of Atomic Energy

Dear Colleagues,

I extend my warm greetings and compliments to all of you on the occasion of the 102nd birth anniversary of our beloved founder Dr. Homi Jehangir Bhabha. As is customary on this day, we take stock of the year gone by and re dedicate ourselves for the cause of strengthening the Nation through various facets of our activities. As you know, our activities are directed towards meeting the national needs and priorities while maintaining excellence by global standards. The last year has been quite eventful with several achievements setting all time records in electricity generation, in nuclear fuel production and in reprocessing of spent fuel while facing some new challenges. I intend to share some of these with you in the next few minutes.

Since we met last year, construction of Unit 4 of Kalgia Generation Station was completed and it commenced commercial operation in January this year. With this we have 20 nuclear power reactors in the country with an installed capacity of 4780 MWe. The Unit 1 of KAAPS was resynchronised with the grid after completing its upgradation including Enmasse Coolant Channel Replacement and Enmasse Feeder Tube Replacement.

The nuclear power generation during the year recorded an increase of about 40% over the previous year due to increased fuel availability, both indigenous and imported. In particular, the average capacity factor is more than 90%, while that of 7 reactors has exceeded 90%.

Construction of four PHWRs of 700 MWe each at Kalpakkam and Rawatbhata has been launched. The construction of the 500 MWe PFBR at Kalpakkam has attained 80% completion.

In the field of uranium exploration, about 32,000 tonnes of additional uranium resources have been established enhancing the country’s total uranium reserve to more than 1,72,000 t of U3O8 as on date. Tummalapalle uranium deposit in Andhra Pradesh is the flag bearer, which alone has contributed a staggering more than 60,000 t of U3O8, up to a vertical depth of 500m, that too in the limited area of 15 km by 3km explored in detail so far. This stretch with a number of unexplored blocks, once explored up to its full potential may establish Tummalapalle as one of world’s largest deposits. AMD has gone in a big way in Airborne geophysical exploration using Time Domain Electromagnetic system covering more than 80,000 line Kms during the year, in parts of Cuddapah, Kadlagi-Badami, Bijawar-Sonral, North Delhi Fold Belt and Meghalaya Basins, which has identified favourable areas. Apart from uranium, AMD has also achieved augmentation of heavy mineral placer resources, rare minerals and rare metal resources.

The Tummalapalle Uranium Mining & Milling Project in Andhra Pradesh is nearing completion. Currently segment wise trials in the mill are underway and the mill is expected to be commissioned in the early 2012. Shaft sinking is nearly complete at the Exploratory Mining at Gogil in Karnataka. In the Mohudhiah Uranium Mining
Project in the Saraikela-Kharsawan district of Jharkhand, the decline has reached a depth of 50 m and the ore body has been intercepted.

At the Nuclear Fuel Complex, Hyderabad, all its plants have not only achieved the target production, but many of them have surpassed the targets and have established new production records. The Zirconium Complex at Pazhayakayal, in its first year of commercial operation has performed commendably. An all time high recovery exceeding 80% has been achieved in production of PHWR fuel and significant reduction in consumables has been achieved in zirconium oxide production.

A 37 pin MOX Fuel test subassembly of PFBR was successfully irradiated in FBTR to a burn-up of 112.5 GWD/t against the target burn up of 100 GWD/t. The challenging task of circumferential butt welding of PFBR main vessel to roof slab of nearly 13 m diameter was successfully completed. An engineering scale facility was commissioned for demonstration of pyro-processing of uranium on kg scale. The feasibility of producing 89Sr in FBTR by irradiation of yttria was demonstrated and the separation of Sr-89 from irradiated yttria was carried out in hot cells. A unique mini sodium experimental facility was commissioned for sodium fire studies. The Interim Fuel Storage Building for PFBR fuel has been commissioned and handed over to NFC for manufacturing fast reactor fuel subassemblies. The success of the fast reactor programme hinges on building capacity for reprocessing of spent fuel for closing the fast reactor fuel cycle. Towards this goal, a project on setting up of Fast Reactor Fuel Cycle Facility is cleared by AEC and is awaiting Cabinet approval. Realising the importance of the development of fast breeding fast reactor fuel in the rapid growth of fast reactor programme, development of metallic fuel has been initiated. Just a few days back, the first set of Sodium bonded U-Zr alloy test fuel pins has been fabricated in a joint programme between BARC and IGCAR and assembled into a capsule for irradiation in FBTR. The capsules will be loaded shortly in FBTR for testing.

Performance of all the heavy water plants, has been excellent and the Heavy Water Board achieved more than 100% capacity utilization. High grade enriched boron produced by HWB is being regularly supplied to BARC for conversion in to boron carbide pellets for PFBR control rod application. About 2/3rd of the total requirement of PFBR has already been met. At HWP, Baroda, a 130 MT per annum TBP plant has been commissioned and target production has been achieved. An industrial scale technology demonstration plant for recovery of uranium from phosphoric acid has been commissioned at RCF, Chembur. Towards alternate uses of Heavy Water and deuterium, laboratory scale preparation of D-labelled compounds is being continued at HWP, Baroda.

INDUS-2 Synchrotron has been operating regularly on round the clock basis at 2 GeV at 100 mA current. It has achieved beam life time of 20 hours. With the help of 30 kW RF power from solid state amplifiers developed indigenously, the INDUS operation has been enhanced to 2.3 GeV and 100 mA current.

The Homi Bhabha National Institute has completed five years of its existence. During the last year, more than 100 degrees and diplomas were awarded. In the Ph.D. programme more than 50 students completed their academic requirements. The number of enrolments has increased to nearly 3000 including more than 1200 for Ph.D.

I am happy to inform you that the Government of Tamil Nadu has recently allocated land for the India based Neutrino Observatory programme in Theni district near Madurai. This will immensely help the High Energy Physics Community to achieve their cherished goal of setting-up this unique underground laboratory.
This year in March, Japan was hit by a twin tragedy in the form of an earthquake of level 9 on the Richter scale followed by tsunami of unprecedented height causing wide ranging damages to human lives and property. The tragedy was followed by accidents in four of the 10 nuclear power reactors located at Fukushima. After the accident at Fukushima, Prime Minister of India had underlined that safety of nuclear power plants is a matter of highest priority for the Government while implementing the national nuclear programme. Several steps have been taken in this regard and many of the recommendations of the safety reviews conducted by the NPCIL task forces and by AERB have already been implemented. A road map has also been prepared for implementing the remaining recommendations. It has been decided to invite IAEA missions, namely, Operational Safety Review Team (OSART) and Integrated Regulatory Review Service (IRRS), for peer review of safety of nuclear power plants, and of the regulatory system, respectively. The emergency response and preparedness measures have been further strengthened in all our nuclear facilities. A bill to confer statutory status to the national safety regulatory authority has been introduced in the Parliament.

We are coming to the end of the XI 5-year plan. The total outlay of the XI plan was around Rs. 46,000 Crores. Many of the projects in the XI plan have been completed and some of them are being continued in the next plan. We are currently finalising the proposals for the XII Plan. The emphasis while preparing the XII plan proposals has been – pursuit of multiple reactor technologies, safety upgrades to address beyond design basis external events, increased emphasis on applications of nuclear technology for societal benefits, outreach programmes to enhance public acceptance and strengthening of linkages with universities and national laboratories.

During the year, India has entered into bilateral agreement with Republic of Korea for cooperation in peaceful uses of Atomic Energy. Global Centre for Nuclear Energy Partnership being set up at Bahadurgarh, Haryana will focus on development of proliferation resistant reactor technologies, nuclear security technologies, radiological safety and radiation technology applications. DAE also signed tripartite MoU with IAEA and Government of Namibia for supply of a Bhabhatron Tele-theraphy machine to Namibia. An Implementing agreement between DAE and DOE, USA was signed for cooperation in the area of accelerator and particle detectors R&D for discovery science.

Dear colleagues,

I have just highlighted some of the major achievements that have been accomplished by the Department during the last year. Through your dedicated and untiring efforts, the Department of Atomic Energy, is pursuing its programme with full vigour and has been successful in realising most of the dreams our founder Dr. Bhabha. If you recall, while talking to you last year from this very podium, I had painted a scenario of our future and had mentioned that we will have to convert this scenario in to a reality. This scenario included large scale deployment of nuclear science and technology in sectors like nuclear power including the entire fuel cycle, food security, health care, national security and research opportunities to fresh talents in the country. We are in fact poised to move forward in all these areas. Similarly in the global arena, Nuclear power plants all-over-the world recorded a very impressive performance in the last three decades. The resurgence of nuclear power has been in the horizon in many countries. After the Chernobyl accident which occurred a quarter of Century back, the confidence in the safety of the nuclear power plants was building up in the minds of people. At this juncture, the Fukushima accident has shaken the confidence on the safety of nuclear power plants when exposed to
an external event of a very high magnitude. We are now facing a new challenge to restore this confidence. Safety statistics is all in favour of nuclear industry as we may recall that the world has logged 14000 reactor years of nuclear electricity generation in about 30 nations. Major accidents and casualties caused are far fewer when compared to any other energy generating technology over a sustained period. India has recorded over 350 reactor years of safe operation of nuclear power plants with only one event, namely Narora fire which was of level-III on IAEA event scale. In Fukushima, there has been no casualty due to radiation exposure though the total causality in Japan exceeded 20,000 due to earthquake and tsunami. These statistics will not satisfy a common man and it is our duty to explain issues related to safety of nuclear power plants and to regain their confidence. We must ensure that nuclear installations have no adverse impact on the livelihood of the people around while they can bring about significant improvement in the quality of life of the people in the region and an all-round development of the country.

Let me do a loud thinking on how to enhance our outreach programme so that a greater appreciation comes from our neighbourhood in all our operating as well as our proposed plant sites. First and foremost, we must integrate ourselves with the people around. To achieve this, it would be necessary for us to be proactive in providing education, healthcare and other social services in the neighbourhood, participation of large number of our scientific and other staff in the neighbourhood activities, initiating our departmental activities having social relevance such as nuclear agriculture, food preservation, waste-to-wealth programme, etc. for the benefit of the people. I must mention here that several such activities are already in place in many of our operating plant sites. What is needed is to multiply them manifold so that the benefit reaches a much larger community. We have our own education and healthcare programmes. Though difficult, but it may not be impossible to extend some of these facilities at least to a limited number of people in the neighbourhood. Such an enormous task cannot be fulfilled unless all of us including our family members take interest in the activities having social relevance. We do have structured programmes such as education through our Atomic Energy Education Society, healthcare through the medical facilities, providing extra-mural support through Board of Research in Nuclear Sciences, development of neighbourhood through AKRUTI, links with educational institutions, agricultural programme through distribution of radiation mutated seeds for multiplication and management of municipal waste. For an inclusive growth of neighbourhood, there is a need to intensify these activities to a great extent and that is possible only if all of us participate in social service and awareness programmes. On the occasion of Founder's Day, I make an appeal to all of you in this regard and I can assure you that by involving ourselves in imparting education, supporting healthcare facilities, helping employment generation and most importantly integrating ourselves with the local population will enrich our own lives and we will achieve a sense of fulfilment over and above our professional accomplishments.

Let us therefore, on this auspicious day, rededicate ourselves to the cause of nation building through the nuclear energy programme and meet the great aspirations of our fellow countrymen. This would in fact be the most fitting tribute to our founder Dr. Homi Bhabha and other pioneers of our programmes.

Thank You

Jai Hind.
Founder’s Day Address
Friday, October 28, 2011
By
Dr. R.K. Sinha
Director, BARC

Dr Banerjee, Chairman, AEC, Senior Members of the DAE Family, Esteemed Colleagues, Ladies and Gentlemen,

It is my proud privilege to extend a warm welcome to all of you to the Founder’s Day functions scheduled today, to commence with this morning’s event here. It has been our tradition to pay respectful homage to our Founder, Dr Homi Jehangir Bhabha, on his birth anniversary, the 30th October every year. The 102nd Birth Anniversary of Dr. Bhabha falls over the weekend this year and hence we are assembled here on this Friday morning for an introspection on our performance and achievements of the past year, as well as to rededicate ourselves to continue to do our best in providing the maximum benefits of all nuclear-related services to our nation and its very large population. I will try to project a few glimpses of what BARC has achieved during the recent past, in various areas of our mandate, just to cite the typical range and nature of our work.

1. Research Reactors

The year ending December 2010 was a landmark year for the research reactors Cirus and Dhruva. The Golden Jubilee of Cirus operations and Silver Jubilee of Dhruva operations were celebrated in a befitting manner. All the reactors of this centre were utilised well for isotope production, material testing, research and human resource development. Research reactor Dhruva continued to operate with a high level of safety and availability of about 70%, in spite of the additional shutdown requirements this year for several upgradation tasks, that included the replacement of main control room panels and fuelling machine control panels by modern instrumentation. To take care of prolonged station black out scenario, trolley mounted diesel engine driven pumps have been commissioned and are maintained in poised state. Dhruva continues to be the major facility for radioisotope production and national facility for neutron beam research. A total of 786 radioisotope samples were delivered last year. To further augment the radioisotope production, an additional tray rod has been incorporated. One hundred and twenty four samples were irradiated in pneumatic carrier facility for various research purposes. The facility continued to be utilised under the aegis of the UGC-DAE Consortium for Scientific Research and by a number of research scholars from various academic institutions. After its permanent shutdown on 31st December 2010, the Cirus reactor has been defuelled and the heavy water moderator transferred to storage tanks. Various systems Decommissioning of the Apsara reactor systems was completed. Activities pertaining to building a new pool type research reactor with 2 MW(th) rated power at the site of Apsara are in progress. A recent evaluation has indicated that it will be necessary to construct a new reactor pool block, to be consistent with a design for increased static and seismic loading conditions,. The basic design of the new 30 MW thermal High Flux Research Reactor (HFRR) has been completed.

2. Nuclear Power Related R&D

NPPs Under Operation and Construction Bhabha Atomic Research Centre had successfully commissioned BARC Containment (BARCOM) test model at Tarapur last year. During the year, four sequential overpressure tests culminating in the
functional failure of the containment have been successfully completed. The results have been made available for post-test analysis to fifteen Round Robin Participants, including 11 International Participants from seven countries. Such an extensively instrumented experiment has been done for the first time in the world. An important finding is that, even after the functional failure of the primary containment, the leakage from primary containment with inherent tight cracks characteristics due to pre-stressing, the leakage rates are within manageable limits and the shielding cover will be retained in a stable manner. Ultrasonic Phased Array technology has been developed to achieve better sensitivity and reliability in flaw detection and characterisation in critical nuclear power plant components such as PHWR pressure tubes, turbine blades, BWR pressure vessel and primary pipelines. A test section for generation of two-phase pressure drop data for 700 MWe PHWR fuel channel components, including fuel bundles, has been installed. Advanced In-service Inspection probes were designed and tested for assessment of hydrogen ingress in pressure tubes. Scrape sampling for determination of hydrogen in operating pressure tubes was carried out in Kaiga-1.

An analysis has been carried out to study the behaviour of TAPS 1 & 2 under prolonged station blackout condition, to obtain information on gross behaviour of fuel temperature, RPV pressure, extent of clad oxidation and hydrogen generation during the progression of severe accident. Based on the analysis, the time line of the progression of accident was estimated and the findings indicated the availability of adequate time margins for external intervention. The effectiveness of water injection into moderator side to mitigate the consequences of Station Black Out was assessed for a large PHWR. AHWR Programme To assess the robustness of AHWR design against any foreseeable accident scenarios, an extensive exercise was carried out. It was determined that on account of its advanced passive safety features, accidents such as those at Fukushima, Chernobyl and Three Mile Island would have practically no effect on fuel integrity. The experimental programmes towards evaluation of design margins for AHWR continued with setting up of several new facilities and conduct of experiments in the existing ones. For example, an air-water loop has been installed and commissioned to study various thermal hydraulic phenomena associated with the steam drum of AHWR. The Critical Facility (CF) for Advanced Heavy Water Reactor (AHWR) was operated on fifty seven occasions for various experiments. Reactivity measurements due to loading of a cluster containing Thoria and uranium (Th-U) pins and (Th-1 % Pu) MOX fuel at various lattice positions were carried out satisfactorily.

HTR Related Developments:

Towards evaluation of alternate coolants for Indian High Temperature Reactor, a Molten Salt Natural Circulation Loop has been fabricated and installed to generate data on heat transfer and pressure drop. A computer code incorporating molten salt properties has also been developed.

3. Advanced Nuclear Fuels

Several new activities were carried out in BARC towards the development of advanced fuels for the FBRs, and the thorium fuelled AHWR. This work has covered the development of an innovative metallic fuel fabrication facility, characterisation of U-Pu metallic fuel and assessment of its compatibility with zirconium liner bonded clad material. We are also working on the development of cermet fuels for FBRs. For the AHWR programme, ThO2 –UO2 pellets of different compositions having Uo2 from 8 to 22.5% were fabricated by powder metallurgy route. The evaluation of thermophysical properties of these fuels is in progress. A new technique called Impregnation Agglomerate Process (IAP) for fabrication of thorium based mixed oxide fuel pellets using ThO2 spheroids and uranium nitrate solution as the starting materials has been initiated, with encouraging results. The use of this process will reduce powder handling and associated personnel radiation exposure when Uranium-233 is
handled. The Post Irradiation Examination (PIE) of experimental thoria-plutonia MOX fuel elements irradiated in CIRUS Pressurised Water Loop was completed. The findings demonstrate better retention of fission products in irradiated thoria (relative to uranium oxide based fuel elements).

4. Reprocessing and Waste Management

Exactly one year ago, on the same occasion, I had announced the start of cold run of PREFRE-2 Reprocessing Plant at Tarapur. The hot run with spent fuel was inaugurated by the Hon. Prime Minister of India on 7th January 2011. All systems in the plant are performing well and this plant is now producing plutonium for our programme. Additional Waste Tank Farm has also become operational at Tarapur. Construction activities for reprocessing plant PREFRE-IIIb at Kalpakkam are progressing in full swing. Infrastructure development for first Integrated Nuclear Recycle Plant, Tarapur is in progress.

The remote decommissioning of first Joule melter (AVS-I) at Tarapur has been completed. The second Joule melter AVS-II is being taken up for commissioning. Various waste management facilities at Kalpakkam are going through cold commissioning. The Plutonium Plant (PP) at Trombay and Kalpakkam Reprocessing Plant (KARP) at Kalpakkam also continued to operate safely and efficiently. In addition, processing of Thoria waste was carried out and modification and augmentation work at Waste Immobilisation Plant (WIP), Trombay was completed. In the field of R&D, one of our responsibilities is to recover useful materials from spent fuel, which is internationally a very advanced field of research. Towards this end, we have made important achievements during the year with demonstration of recovery of strontium from thorium lean waste and synthesis of associated specific crown ether. A process has also been developed for production of caesium specific crown ether. Advances were made also in the development of continuous rotary dissolver and cold crucible induction melter.

5. Environmental Monitoring and Radiation Safety

Assessment of the Impact of the Fukushima Event:

Using our computational models, preliminary estimates of the release rates of different radionuclides into the atmosphere and into the Pacific Ocean due to Fukushima Nuclear Accident were derived. Reasonable matching of the estimated release rates is observed with the values reported by different agencies. All the Environmental Survey Laboratories in the country carried out special campaign to monitor very low level of radioactivity in the environmental matrices. The data from IERMON network was also analysed continuously at all the locations for atmospheric radioactivity. We were able to confirm that the Fukushima event has not caused any noticeable impact on India.

Monitoring of Environment:

Environmental Radiation Monitors with solar powered systems, and GSM and LAN based communication have been developed. Mass production of 250 units has been completed with the help of ECIL, Hyderabad. The units will be installed at various locations in the country under the Indian Environmental Radiation Monitoring Network (IERMON) programme of DAE. Detailed baseline data for Atmospheric, Aquatic and Terrestrial Environment have been collected for the proposed BARC Campus at Vizag. Health and demographic status survey and marine survey, within an area of around 30 km radius, have been completed.

Instrumentation for Radiation Detection:

Inhalation dosimeter badges have been developed for directly monitoring the cumulative doses due to radon, thoron decay products using direct progeny sensors. These badges have been deployed in about 2000 places within the country and also in about 1000 locations in Europe, based on the request from several foreign institutions. Natural radiation burden from radon and thoron,
especially in poorly ventilated dwellings is a known problem in several parts of the world, and the simple and effective development done at BARC is an important contribution.

6. Physical Sciences

Single crystals of copper and silver doped lithium-tetra-borate have been grown and they have been found suitable for dosimetry applications based on the optically stimulated luminescence technique.

7. Chemical Sciences

The feasibility study of in-house developed nano-diamond film as monitor of alpha activity of plutonium, in highly acidic medium, has been successfully completed. A simple and inexpensive hydrogel-based material has been developed, which consists of nitrogen oxides releasing agarose gel, combined with citric acid loaded cotton gauze. It has excellent antimicrobial properties and has potential as a dressing material for ulcerative skin infections.

8. Biological Sciences

Towards developing radioprotector agents, an important finding has been made in experimental studies. 1,4-Naphthoquinone (NQ), a parent molecule for many antitumour natural compounds, protected lymphocytes and intestinal cells from mice against a dose of 4 Gy gamma radiation. In the mice, 2 mg/kg NQ given in-vivo restored radiation-induced bone marrow suppression.

9. Codes Development

A two-dimensional, multi-material Eulerian radiation-hydrocode, using Volume-of-Fluid tracking for material interfaces, has been developed, validated and applied to impact, penetration and ablative acceleration problems. A code has been developed for generating equation-of-state (EOS) data covering orders of magnitude in density and temperature, necessary for radiation-hydrodynamics simulations. High-accuracy EOS data for expanded states of metals, required for modeling exploding wires, has been generated using ab-initio atomistic simulations.

10. Food Technology

The browning of cut fruits and vegetables is reduced in irradiated fruits and vegetables. For the first time, in a study conducted on pre-cut ready to cook ash gourd, it has been shown that gamma resorcylic acid liberated from its precursor during radiation processing acts as a natural inhibitor of polyphenol oxidase, the enzyme responsible for brown discoloration of cut fruits and vegetables. Chips prepared from potatoes irradiated for sprout inhibition showed relatively lower levels of acrylamide (compared to non-irradiated potato controls), which is a neurotoxin and a probable carcinogen.

11. Nuclear Agriculture

A confectionary class large seed Trombay groundnut variety, TG 47, has been released for commercial cultivation in the name of Bheema for early kharif and rabi under irrigated conditions in all agro-climatic zones of Andhra Pradesh. BARC produced 470 quintals of quality breeder seeds of recently released varieties and distributed to several state seed corporations, national institutes, state agricultural universities, NGOs and farmers for further utilisation. Nisargruna technology was developed in BARC not only for disposing biodegradable waste in an environment friendly manner, but also to produce high quality manure and fuel gas very efficiently. This technology has been widely deployed in our country. During the past year, 25 more such plants have become functional. This technology has now been extended to process large quantities of biological sludge generated in Effluent Treatment Plants (ETP) of textile, food and paper industries at Baddi (HP), Anjar (Gujarat), Kochi (Kerala) and Chandrapur (Maharashtra).
12. Isotope Applications

A dedicated 32 detector channel and Cs-137 radioisotope based process tomography imaging system, first of its kind in the country, was designed and developed in collaboration with the Indian Oil Corporation Limited (R&D Centre), Faridabad for applications in a packed cold-bed test reactor. The first clinical use of BARC-produced Iodine-125 seeds for the treatment of prostate cancer was performed at the P.D. Hinduja National Hospital & Medical Research Centre, Mumbai on 29th September 2011 on a patient suffering from adenocarcinoma of prostate. In collaboration with industry, radiation-grafted polypropylene based hydrophilic battery separator was developed by standardising various parameters. The separator was tested by the user industry and found suitable as a cost-effective import substitute.

13. Materials Programme

To qualify long design life of SS welds in advanced nuclear reactors (e.g. AHWR) and for life extension of existing reactors, the kinetics of low temperature embrittlement (LTE) was established for austenitic stainless steel welds. The electrochemical techniques developed to characterise the degree of LTE can be applied in a nondestructive manner and for in-situ use in plants. In connection with the Indian contributions to the ITER project through Test Blanket Module (TBM) programme, BARC has developed pump-driven liquid metal loops for Pb-17Li and successfully operated them continuously for over 1000 hours. Pump and many of the key components for the loop have been fabricated in-house. Towards commercial level development of Indian rare earth products, Nd-Fe-B alloy powder was synthesised for making permanent magnets in molybdenum crucible involving reduction-diffusion process.

14. Electronics & Instrumentation

Three new ASICs - ANUSPARSH, ANUDRISHTI and ANUSUCHAK in 0.35 µm CMOS technology were designed, developed and tested successfully. The ANUSPARSH is front-end readout for Resistive Plate Chamber detectors of INO (India based Neutrino Observatory), the ANUDRISHTI is a monolithic photodiode and readout electronics for compact gamma detection probes and the ANUSUCHAK is low power front-end readout for silicon PIN Detectors. To facilitate electromagnetic survey of deep seated mineral deposits, a Time Domain Electromagnetic (TDEM) system with 22 m dia transmitter coil and 1.1 m dia receiver coil has been tested using military helicopter DHARUVA of HAL for its airworthiness and found satisfactory. This is an important indigenous development to accelerate and support the expanded exploration of uranium in the country.

Face Recognition System:

Face recognition systems developed by BARC for access control have shown highly promising results (with only 0.7% false acceptance). This is of high importance for a variety of integrated biometric access control systems as defence in depth.

Differential Micro Barometer:

As an important import substitute, a Differential Micro Barometer to measure very small atmospheric pressure variations of the order of microbars around the mean atmospheric pressure in infrasonic range has been developed. This important challenging development, benchmarked against intervening specifications in time-domain and frequency domain, has given highly satisfactory performance on evaluation under varying temperature and wind conditions.

15. Accelerator & High Power Electronics

Dual Energy Compact Linear Accelerator:

A 3/6 MeV dual energy compact linear accelerator for X-ray cargo scanning applications is in an advanced stage of development. The sub-systems consisting of a 85kV electron gun and its modulator power supplies, Linac cavity, magnetron source and modulator, focusing magnet, X-ray
target and collimator have been developed and sub-system integration is in progress.

**Electromagnetic Manufacturing System**

A 20kV, 40 kilo-joule Electromagnetic Manufacturing System for use in cold welding of dissimilar metals has been developed. The system consisting of several special components and features will be used for joining FBR clad tubes of D9 alloy with SS end plugs, and future applications of joining ODS clad tubes and end plugs.

**16. Advanced Technologies**

**Cryo-Technology**

In-house developed micro cryo-cooler unit was integrated successfully with Hand Held Thermal Imager meant for night vision device to provide 250 mW cooling for the sensors at 77 K and handed over to EME School, Baroda, along with supporting hardware.

**Desalination**

Towards building indigenous capability for Thin Film Composite Polyamide membrane technology, the first batch of such membranes for reverse osmosis has been prepared and spirally rolled to commercial size elements. Six of these elements are now ready for replacing the membrane elements in reverse osmosis plant at NDDP, Kalpakkam.

**17. Robotics and Remotisation**

**Automated Material Transfer System (AMTS)**

An Automated Guided Vehicle (AGV) based material transfer system has been designed and developed in BARC. It performs continuous real-time assessment of demand for transfer of materials between various processing units in a manufacturing plant, and accordingly plans, prioritises and executes transfers autonomously. The system demonstrated to potential users, manufacturers and media will be deployed shortly on an experimental basis at Bajaj Auto Plant at Akurdi, Pune.

**Four-Piece Servo Manipulator (FPSM)**

Four-Piece Servo Manipulator (FPSM) recently developed by BARC is a novel design of servo manipulator, that can be used in place of any telescopic mechanical master slave manipulator. Using this easily maintainable FPSM, operators can handle objects in hot cells with less effort, compared to mechanical manipulators.

**Contribution to Indigenous Teletherapy System**

Prototype of a fully automatic, Multileaf Collimator (MLC) has been designed and developed for Bhabhatron-II telecobalt machine. The performance of the MLC was comprehensively tested on Bhabhatron-II telecobalt machine at ACTREC.

**18. Societal Outreach and Technology Transfer**

**Technology Transfer**

Two new technologies, namely, Quadrupole Mass Spectrometer and Dip and Drink Membrane Pouch were transferred to industry. Eight technology licenses to industry were renewed.

**DAE Societal Initiative and Infrastructure Programme**

i) Underground water source with capacity of 30,000 l/h has been identified, using Isotope Hydrology technique in a village called Nimkhed in Amravati District, a water-scarce area (under AKRUTI Programme).

ii) Tissue culture laboratory with field hardening facility of 50,000 banana plantlets has been made operational and first batch of hardened plantlets have been sown in the field in Akurdi, Maharashtra.

iii) A Brackish Water RO plant with 300 l/h capacity has been set up in a coastal village
called Farare in Dapoli through AKRUTI programme. The villagers have been trained to operate, run and maintain the plant.

iv) To promote AKRUTI programme in the rural sector in a more structured way, BARC has signed MoU with Shri Vithal Education Research Institute-‘SVERI’ Pandharpur to set up DAE Outreach Centre in the form of Rural Human and Resource Development Institute (RHRDI) at Pandharpur in SVERI campus.

19. Medical Services

Medical Division, BARC is providing healthcare facilities to entire Mumbai based CHSS beneficiaries through its 390-bed hospital, 12 zonal dispensaries, 2 occupational health centers, and 24-hour Casualty facility. New facilities and upgrades continue to be added at the BARC hospital. The total number of beneficiaries as on 30th September 2011 stands at 87,080.

Dear Colleagues,

Coverage of the highlights of contributions by more than 15,000 persons, spanning across all scientific and technological disciplines, and even without a mention of our considerable role in the strategic domain, is impossible in a short time. All omissions in my speech are purely due to time constraints and do not in any way undermine the importance and the value of all such work.

The year 2011 has been a challenging year for the entire nuclear programme and industry, not only in India, but also the world over. This has been mainly due to the unfortunate events in Japan – Fukushima Dai-ichi that was a consequence of the unprecedented natural twin disasters - massive earthquake, (9.2 on Richter scale), and Tsunami (of over 15 m height) - that struck Japan in March this year. While we need to remain fully cognizant and objectively responsive to these developments, it is imperative yet that we remain firmly committed to our well-established programmes and strategies based on our scientific and technological strengths and core competencies in the nuclear field. This is extremely essential to meet the country’s growing energy demands as well as making sustained advances in the standard of living and quality of life for the society at large. Recent events have also highlighted the necessity to further strengthen our societal outreach programme. We are active in this direction and taking new initiatives.

We have recently finalised XII-plan project proposals for submission to the Planning Commission. The envisaged targets and plans can only be achieved by dedicated team efforts and multi-disciplinary collaboration and co-operation. I would like to reiterate that we have plenty of challenges ahead in effectively contributing to the envisaged massive growth in the nuclear power and radiation technology applications sector in the country. The history of our Department bears ample testimony to the fact of our coming on top of all hurdles that came our way through determination and strength borne out of our ingrained culture of self-reliance. With the synergetic effort of all of us, I am sure, we can, and we shall rise to the occasion to meet these challenges in a manner consistent with our professional and cultural tradition.

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

Thank you

Jai Hind
The Bharat Utsav 2011, an event focusing on India's achievements in Science & Technology, Industry and Management was held at Hyderabad during August 18-24, 2011. The event comprised a Science & Technology Expo, seminars, competitions for students etc. DAE participated in the expo highlighting all its activities. Over 40,000 visitors to the DAE pavilion, mainly students and faculty members from various schools and colleges, benefitted from this event. Several other government departments like ISRO, CSIR, DRDO, DST, ICMR etc also took part in this event.

DAE took part in the 17th All India National Expo at Kalyani, Nadia, West Bengal during August 24-28, 2011. The theme of the event was 'Science, Agriculture, Environment and Communication'. Information on the uses of atomic energy towards societal benefit was displayed in Bengali & English.

The 15th National Exhibition with theme as 'Evolution of India as a Great Nation in the 21st Century' was held during September 7-11, 2011 at Belghoria, Kolkata. DAE along with VECC Kolkata, participated in this exhibition. Information (in Bengali & English) and several working models were displayed in this expo.
At the instance of Shri Satpal Maharaj, Member of Parliament (Lok Sabha) and Chairman, Standing Committee of Defence, Member, Public Accounts Committee, DAE Participated in the Exhibition cum Fair on Multidimensional Development & Technology during September 15-18, 2011 at Pokhran, Garhwal, Uttarakhand. Information about DAE’s activities was displayed in Hindi. Students from over 240 schools visited the DAE pavilion. Some of the other major government organizations that participated were ISRO, DRDO and DST.
India Nuclear Energy 2011 – 3rd International Exhibition and Conference was held at Mumbai during September 29 to October 1, 2011. The event was a unique platform for showcasing latest cutting edge nuclear technology. DAE exhibited all its achievements related to the Indian Nuclear Power Programme comprising the three stage programme, the closed nuclear fuel cycle, fuel reprocessing, nuclear waste management, safety etc. Several other countries like France, USA, Russia, Finland etc also participated in this event. In addition, many Indian companies supplying nuclear components towards our nuclear power programme also took part in the exhibition.

The International Atomic Energy Agency (IAEA), in co-operation with the Indian RareEarths Limited, organised the ‘International Technical Meeting on World Thorium Resources’ at Thiruvananthapuram, Kerala during October 17-21, 2011. DAE put up an exhibition on the Indian Nuclear Power Programme with special focus on the available thorium resources in India and the future significance of thorium for India’s three stage Nuclear Power programme. Professionals engaged in thorium exploration and production, safety experts, researchers and officials from Member States interested in thorium resources also participated in the event.

The 21st International Conference on Structural Mechanics in Reactor Technology (SMIRT 21) was held at the India Habitat Centre, New Delhi, during November 7-11, 2011. The DAE pavilion showcased its achievements in the area of Nuclear Power, application of radioisotopes etc. Dr. A.P.J. Abdul Kalam, former President of India, inaugurated the conference.

DAE participated in the 5th Science & Technology Expo – 2011 during December 11-13, 2011 at Bhopal, M.P. The theme of the event was ‘Infrastructure, Education, Healthcare, Science & Technology’. Information on the contributions of the department towards societal development was displayed in Hindi and English. Members of the general public and students visited the DAE pavilion.