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UNIT-3 OF KAIGA ATOMIC POWER PROJECT-3&4 DECLARED COMMERCIAL

The 220 MWe Unit-3 of Kaiga Atomic Power Project went into commercial operation at 1800 hrs on May 6, 2007. The Unit was successfully synchronised with the Southern grid on April 14, 2007 at 0024hrs. The period between sysnchronisation and commercial declaration taken by Kaiga Unit-3 is one of the shortest among the Indian Nuclear Power Plants and comparable to international benchmarks. Earlier, the unit had achieved its first criticality on February 26, 2007. The first pour of concrete, making the zero date of construction, was held on March 30, 2002. The criticality was achieved in less than five years, which is comparable with the international benchmarks.

The Kaiga Site, in district Uttar Kannada of Karnataka comprises four units, each of 220 MWe pressurised heavy water reactor, that use natural uranium as fuel and heavy water both as moderator and coolant. Kaiga Units 1 & 2 have been in operation since the year 2000, and Unit-4 is at an advanced stage of construction.

Continued...

Tarapur and Kaiga N-Plants Excel in Performance, Win Gold Shield

The twin 160 mega watt (e) units of the Tarapur Atomic Power Station-1&2, that is India's oldest nuclear power plant, along with Kaiga Generating Station-1&2 of 220 mega watt (e) each, have been awarded Gold Shields for the years 2004-05 and 2005-06, respectively. The Gold Shields were given away by the Honorable Prime Minister of India at a function held on March 21, 2007 in New Delhi.

These annual awards have been instituted by the Ministry of Power, with a view to inculcate a competitive spirit and to motivate to achieve high level of performance among the power utilities, which include coal, lignite, gas and nuclear power stations. The evaluations are carried out by the Central Electricity Authority (CEA).

Tarapur-1&2 generated 2587 million units of electricity during the year 2004-05 with an average availability factor of 93 %. The two units of Kaiga produced 2860 million units of electricity during 2005-06 with an average availability factor of about 93%.

Nuclear Power Corporation of India Limited is unique in having built, under one roof, comprehensive capability in all facets of nuclear technology namely - site selection, design, construction, commissioning, operation, maintenance and life extension of nuclear power plants.

From previous page :

The Kaiga site is unique among all the nuclear plant sites in India, as it has an annual rainfall of about 4000mm, which needs special arrangement and planning for continuous construction.

It is the seventeenth nuclear power reactor of NPCIL and the total installed nuclear power capacity has been increased from 3900 MWe to 4120 MWe. It has alrerady generated more than 30 million units of electricity. The elctricity from Kaiga-1to3, with a total installed capacity of 660 MWe, is supplied to the sourthern grid with Karnataka, Tamilnadu, Andhra Pradesh, Kerala and Pondicherry being the beneficiary states.

Five more units (2x1000 MWe PWRs and 3x220 MWe PHWRs) are under construction at different parts of the country and are expected to be connected to the grid sequentially within the next two years.

A Prototype Fast Breeder Reactor of 500 MWe capacity is also under construction at Kalpakkam, Tamil Nadu, by the Bhartiya Nabhikiya Vidyut Nigam (BHAVINI).

KRUSHAK Enables Export of Indian Mangoes to the United States of America

On April 26, 2007, KRUSHAK Radiation Processing Facility at Lasalgaon, in Nashik District of Maharashtra, 250 km east of Mumbai, became the first cobalt-60 gamma irradiation facility in the world to be certified by the United States Department of Agriculture-Animal & Plant Health Inspection Service (USDA-APHIS) for phytosanitary treatment of mangoes, enabling export of mangoes from India to the United States of America.

KRUSHAK

Research and development work on understanding the benefits of radiation processing like delay in ripening of tropical fruits and quarantine treatment of mangoes, was carried out in the Food Technology Division, BARC, in early seventies through eighties. It was established that doses between 250-350 Gy could delay ripening and inactivate fruit flies and stone weevil, the pests in Indian mangoes that USDA feared would enter United States with the imported consignments, and therefore the ban. In 1998, radiation processing of mango was approved under the Prevention of Food Adulteration Act Rules. However, a large-scale feasibility study on mangoes could be carried out only with the commissioning of KRUSHAK irradiator in the year 2003. KRUSHAK Irradiation facility was set up by BARC primarily as a technology demonstration unit for low dose applications of radiation such as sprout control during long-term storage of onion, potato and garlic and disinfestation of agricultural commodities such as cereals, pulses and their products for their long term storage.

Irradiation as a quarantine treatment

The most important single pest group of quarantine importance present in fruits and ornamental flowers is the fruit fly. A dose of 75-150 Gy has been found to prevent emergence of adults from the eggs of fruit fly. Gray (Gy) is the unit of absorbed dose equivalent of 1 Joule of energy per kg of material. Radiation is also equally effective against pests other than fruit flies. These include moths, weevils, beetles, and mites. A dose of 300 Gy has been found to be highly effective in destroying the reproductive capacity of these pests. The doses recommended for quarantine applications do not affect the freshness and organoleptic quality of fresh fruits and vegetables. USDA has been extra careful in recommending a higher dose of 400 Gy for the treatment of mango.

KRUSHAK Radiation Processing Facility

Mangoes being irradiated at BARC's Krushak Plant, Lasalgaon, Nasik, Maharashtra

The Animal and Plant Health Inspection Service (APHIS) of the USDA issued a Final Rule on 'Irradiation Phytosanitary Treatment for Imported Fruits and Vegetables' in 2003. In the same year Food Standards Australia and New Zealand (FSANZ) permitted use of irradiation as quarantine treatment for the import of tropical fruits. In 2004, International Plant Protection Convention (IPPC) also included irradiation as a quarantine treatment. These regulations have opened up the markets for agricultural commodities.

In the year 2004, on the request of the Department of Atomic Energy, the Ministry of Agriculture & Co-operation, Government of India, amended the plant quarantine regulations, Plant Quarantine (Regulation of Import into India) Order, 2003, to include irradiation as a phytosanitary treatment. This enabled in February 2006 signing of a framework equivalence work plan agreement between USDA-APHIS and the Ministry of Agriculture & Co-operation, Government of India, that set in motion the process further for irradiation phytosanitary treatment of mango for export to US. Though the negotiations between the Ministry of Agriculture & Co-operation, Government of India and the USDA were initiated as early as 2004, the USDA-APHIS final rule 'Importation of Mangoes From India' was published on March 12, 2007.

Technology Demonstration

In 1986, a National Monitoring Agency was constituted by the Government of India to oversee commercial applications of radiation processing technology. Atomic Energy Act was amended in 1991 to include Atomic Energy (Control of Irradiation of Food) Rules, later amended again in 1996. In 1994, the Government of India amended Prevention of Food Adulteration Act Rules to permit radiation processing of onion, potato and spices, that were subsequently amended in 1998 and 2001 to include more commodities in the approved list. Among the fresh fruits only mango has been approved in 1998. A proposal for generic approval of food items for radiation processing such as fruits & vegetables and cereals, pulses and their products is pending with the Ministry of Health & Family Welfare.

DAE had set up two radiation processing units to demonstrate the applications of the technology on a commercial scale. One unit, Radiation Processing Plant, Vashi, Navi Mumbai, for foods requiring medium and high doses of radiation such as spices, dry ingredients and vegetable seasonings, commenced operations in January 2000. The other, a low dose irradiation facility, KRUSHAK (Krushi Utpadan Sanrakshan Kendra), Lasalgaon, for radiation processing of onion and potato for controlling sprouting, insect disinfestation of agricultural

India exported the first consignment of 720kg Alfonso and Kesar mangoes to the US on April 26, 2007. The mangoes were irradiated at BARC's KRUSHAK Plant at Lasalgaon , Nashik at the insistence of American officials and cleared for exportation. "This is a symbolic event promising of more agricultural trade between the two countries," said Economic Counsellor William Klien (second from Left.) at the flagging off ceremony at Sahar airport. Dr. S. Banerjee, Director, BARC (extreme right), said that more irradiation centre were being opened in the country.
[Photo Courtesy: Daily News Analysis (DNA)]

commodities, including quarantine treatment of mango, became operational in 2003. This year the facility was upgraded to meet the USDA-APHIS specifications to process mango for export to the US.

Commercial Processing

For commercial processing of mango the KRUSHAK facility has to work in tandem with the Agricultural Product Export Development Authority (APEDA), Ministry of Commerce, National Plant Protection Organization (NPPO), Directorate of Plant Protection, Quarantine & Storage, Ministry of Agriculture & Co-operation, Government of India, the Board of Radiation & Isotope Technology, and the export houses. The export consignments are processed at KRUSHAK under a pre-clearance programme in the presence of the inspectors of the USDA-APHIS and the NPPO with a prior schedule. The pre-clearance programme ensures that a consignment treated at the facility, officially sealed and certified, can directly land in the US and delivered to the consignee without an elaborate inspection by the USDA-APHIS inspectors in the US.

All exporters interested in processing mango for exports to the US need to approach APEDA and bring mangoes to the facility only through APEDA approved orchards and packing houses.

On a visit to India in March 2006, President George W. Bush had cheered the news media as he announced a pact on nuclear energy and trade. "The United States is looking forward to eating Indian mangoes", he said. Indeed KRUSHAK has its proudest moments.

ECIL's IT Solutions for Rural Sector

Electronics Corporation of India Ltd. (ECIL) has developed various IT solutions useful to the rural areas particularly farmer community. One of the applications is "Farmer Information System" (FIS) that directly helps rural user in knowing the farming related technologies/information developed by various government departments, agricultural universities in local language. The system is designed with multimedia techniques to deliver multilingual text, audio/video, pictorial information and easily navigatable to their choice of information on their own. FIS will be established at market yards/mandal offices, agricultural seed supply centres, district agricultural offices etc.

The information dissemination will be on the following topics.

- Technology transfer from various government departments /agricultural universities.
- Crop selection & cultivation based on soil types, water recourses.
- Seed selection based on soil and weather condition.
- Suggested intercrops and advantages.
- Pests and pest control methods.
- Government schemes – Insurance,credit, loans, subsidies etc.
- Latest implements and their usage.
- Farmer education video programs.
- Daily weather, commodity arrival and price information.
- Addresses of soil testing laboratories, cold storage units etc.

Farmer Information System

- Local soil terrines with full details for selection of crop.
- Expert advises to the queries raised by farmers on various subjects.
- News flashes.
- Health Care & Nutrition Awareness Topics.
- Entire cultivation technology transfer in local language.
- Instant independent access of desired information such as Government schemes, subsidies, loan / insurance facilities etc.
- Timely alerts and flash news.
- Expert advices and Best Management Practices on cultivation.
- Interactive farmer education video / audio programs.ECIL has also developed -

- An integrated "Farmers' Information Centre" system for Technology Mission on Cotton for cotton farmers, implemented at 95 sites all over India. Phase II implementation at 138 sites is in progress. This system is aimed to transfer cotton technology to improve the yield and quality.

- A stand-alone Kiosk application for DAE to disseminate information related to DAE organizations, services to rural sector, food technology developed by BARC, seeds developed by BARC, community development activities by UCIL, Information collected from local agricultural universities and health care information to rural people.

ECIL studied the farmers' basic requirements and systems, which benefit them based on their convenience time and place. Accordingly, following four models of sub systems are developed to cover needs of all types of farming community.

Shri Sharad Pawar, Union Minister for Agriculture, appreciating the ECIL Kiosk at New Delhi during Federation of Farmers' Association meeting

Dr. Y S Rajashekhar Reddy, being shown the Kiosk at the Cotton Market Yard

Dr. Anil Kakodkar, Chairman, AEC, intently watching the Kiosk at ECIL, Hyderabad

Sub Systems of Farmer Information System

1. IVRS: Interactive voice response system for online dynamic commodity price & arrival information in local languages over local telephone. This helps distant farmers to know daily price and arrival trends. IVRS covers daily price data over local phone.

2. Kiosk: Touch screen based Interactive information in detailed, graphical / pictorial display with voice enabled in local languages on Kiosk and printouts. This system enables the farmers to know the timely remedial actions, detailed information on all topics of cultivation with voice enable for illiterate farmers.

The Kiosk provides detailed interactive information and is placed at market yards.

3. DAS: It is an Automatic Display and Announcement System that displays price, arrivals, best management practices in scrolling mode, farmer education video and entertainment programs etc. DAS provides information in broadcasting mode for large groups. These are placed at market yard sheds.

4. Web Portal: Accessible to all users over Internet. Every market yard will upload their price and arrival data and download same information of all other market yards for automatic dissemination on DAS, IVRS and Kiosk.

All above sub items of FIC can work independently to implement at different types of Market Yards.

ECIL is proposing these IT solutions to other state/central governments and boards to spread the IT benefit to rural community at large.

DAE's laudable contributions to LHC bring acclaim from CERN

Department of Atomic Energy (DAE) has been a partner of the European Organization for Nuclear Research (CERN), Geneva, which is building the world's biggest particle accelerator, the Large Hadron Collider (LHC). DAE had joined the LHC programme in 1996 through a protocol signed by the Secretary, DAE and Director-General, CERN, paving the way for DAE's laboratories to participate in the construction and utilization of LHC. The protocol provided a framework to deliver an 'in kind' Indian contribution, (valued at 34 million Swiss Francs i.e. US $25 million at 1994 rates which was later raised to 60 MCHF in 2001/02) in the form of hardware and expert manpower. The lead-DAE lab for this collaboration is the Raja Ramanna Centre for Advanced Technology (RRCAT), Indore, Madhya Pradesh. A partial list of Indian contribution is given in the Table. After successful completion of LHC related contributions, CERN has signed another protocol with DAE that envisions collaboration in projects, like Super Conducting Proton LINAC (SPL) and Compact Linear Collider Test Facility CTF-3.

Recently, Dr. Philip Lebrun presented a memento to Dr. V.C. Sahni with a message from CERN, that "after signing an agreement in 1991 and a protocol in 1996 for participation in LHC, the work took off in 1997 with a number of approved addenda starting with Addendum A.1 (for liquid nitrogen tanks) ending up with 28 Addenda. This DAE-CERN collaboration agreement was extended in 2001 for ten years making it effective till 2011. A lot of work has been carried out by DAE for LHC with respect to thousands of super conducting magnets, several thousands of PMPS jacks, QHPS electronics etc marking a success of the collaboration. since we were able to collaborate on big project like LHC. Thanks to DAE, all of its contributions were very helpful and essential. RRCAT effectively acted as a nodal agency with industry and various institutes and kept the quality assurance on track. This Memento is meant to acknowledge DAE and RRCAT."

Indian Contributions to LHC

50000 litres Liquid Nitrogen tanks - **2**

Superconducting corrector magnets
i) Sextpole (MCS) - **1146**
ii) Decapole and Octupole (MCDO) - **616**

Precision Magnet Positioning System (PMPS) Jacks - **7080**
Quench Heater Protection Systems (QHPS) - **5500**

Integration of QHPS units into racks - **6200**

Control electronics for circuit breakers of energy extraction system - **70**

Local protection units (LPU)- **1435**

SC Dipole magnet tests/measurements, expert support in Man years -**100**

LHC Hardware Commissioning : Cryogenics systems, Power converters, Protection systems, Controls. Man years - **20**
Software development and design analysis projects: Data management software upgrade, data analysis software/ documentation projects, JMT-II software, slow control of industrial systems of LHC, design and calculations for Vacuum system for beam dump line, Analysis of cryo-line jumper and magnet connections - **41 Man years eq.**

To mark the successful completion of DAE's high-tech contributions to LHC, Dr. Philip Lebrun of CERN, gifting a memento to Dr. V.C. Sahni, Director, RRCAT

Our Websites

Research Centres
www.amd.gov.in
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SOME RECENT ACHIEVEMENTS IN THE FIELD OF NUCLEAR AGRICULTURE

During the year 2006, BARC released a new groundnut selection, TG-38 for commercial cultivation in Orissa, West Bengal, Bihar and North Eastern states for Rabi/summer. The area of cultivation of an earlier variety TG-37A was extended for Southern Rajasthan and Gujarat for Kharif to Orissa, West Bengal, Bihar and North Eastern for Rabi/summer seasons. 65 tonnes of breeder seed of groundnut varieties TAG-24, TG-26, TG-37A were produced and distributed to different multiplying agencies. In mungbean, selection TM-96-2 and TM-98-50 (TJM-3) was released for commercial cultivation in Andhra Pradesh and Madhya Pradesh respectively. In Soybean selection TAMS-98-21 was released for commercial cultivation in Vidharbha region of Maharashtra. Different selections of mungbean TM-2000-58 (AVT-2), pigeon pea TT401 (AVT-1) TT402 (AVT-1), black gram TU17-4 (AVT-1) cowpea TCM 148-1(AVT-1) have reached advanced stages of trials.

Seed multiplication of Trombay soybean genotypes TS-13 and TS- 25 were taken on large scale and the seeds were sent for further trials. In mungbean, a high yielding variety was crossed with a mulmarada local, and F_1 to F_5 generations was raised earlier and recombinant inbred lines were developed using single seed decent method. Thirteen selections and mutants developed at BARC were included in initial varietal trials for high yield and disease reactions at Trombay and another twenty five selections were tested at Akola and Jabalpur. Nucleus seed of moong varieties TARM-1, TARM-2 and TMB-37 was multiplied at BARC. Harvesting and collection of morphological data on black gram (urad) germplasm accessions and advanced generation of the cross between TU94-2 x Trombay wild was carried out against powdery mildew disease and disease incidence was recorded. Multiplication of released urad pulse varieties TAU-1, TAU-2, TPU-4 and TU94-2 were undertaken. An advanced selection from the cross

Soybean developed at Trombay

TU94-2 x Trombay wild, TU99-5-1 and TU-26 seeds were multiplied. Selection No. 72 obtained from the cross TU94-2 x Trombay wild was found to have resistance against yellow mosaic virus disease and storage pest bruchid. In sunflower, the selection TAS-82 with black seed coat, high oil content and tolerance to sunflower necrosis disease and in mustard, a high yielding selection TPM-1 was released by Maharashtra State Seed Sub-committee. This is the first variety released for non-traditional area. The mutant of sunflower was registered with the National Bureau of Plant Genetic Resources (NBPGR, New Delhi, INGR No.4100, 2005).

DNA polymorphism was studied at Trombay in 43 rice landraces by molecular marker techniques. Single Nucleotide Polymorphism (SNiP) variability at six loci distributed one each on chromosome number 2, 4, 5, 6, 7 & 8 was studied in 16 landraces using SNAPSHOT method. A genetic linkage map of black gram was constructed based on molecular markers. Investigations on the stress induced alterations of photosynthesis in crop plants were carried out and identified as thiols namely Thiourea (TU) and Thioglycollic acid (TGA) whose foliar spray make the plant more tolerant under the multistress situation. The gene responsible is known to be present in different isoforms, and its over expression can help the plant to combat the harmful effect of salinity stress.

For bio remediation twenty-two microbial strains were isolated from the sludge acclimatized to high concentrations of nitrate waste. Mineral phosphate solubilization was achieved using *Paecilomyces marquandii* in an airlift reactor. A simple technique was developed for ^{60}C activity determination in aqueous samples using *Ocimum* seeds placed in a prototype 'Tea Bag' and used in a dip-

A moong variety developed at Trombay

dip technique. Human hair waste was found to be a suitable adsorbent for low levels of uranium from aqueous medium. It was shown that *Aspergillus fumigatus* offers an eco-friendly route for biosynthesis of silver and gold nanoparticles. Biosensors were developed to measure analytes like glucose, urea, and caffeic acid which are free radical scavengers. The sensors could detect glucose in the range of 5-500 mM, urea in the range of 0.5 to 100 mM and caffeic acid in the range of 0.05 – 0.15 mM. The green fluorescent protein (*gfp*) gene was cloned and expressed in prokaryotic expression systems. Using thioredoxin (*trxA*) fusion expression vector system, cloning and expression of the *cry2* gene was completed. The *floating* type formulation with wooden cork powder (20 mesh) and sunflower oil was found to be the most suitable for mosquitocidal biopesticides based on *B. sphaericus (ISPC*-8). The midge, *Chironomus ramosus* was found to be more radio resistant than other aquatic insects.

Nisargruna biogas plants were commissioned at five locations. The State Government of Maharashtra has recommended the installation of Nisargruna plants by urban local bodies. The predigester slurry was analyzed and cultivable and non-cultivable bacteria were identified. The adenylate cyclase encoding gene of *Trichoderma virens* was cloned and sequenced. Studies on fertilizer use efficiency of molasses based sludge enriched with $^{65}ZnSO_4$ showed that sludge and Zn-enriched sludge(up to 2.5 kg Zn/ha soil) significantly enhanced the dry matter yield (DMY) of maize crop. Phosphate enriched manure was prepared by using Lalitpur rock phosphate (11% P) and biogas manure generated from Nisargruna plant. Result showed that electrical conductivity, nitrogen and water-soluble P content increased whereas total carbon and C/N ratio of the final products decreased in manure treated soils. A putative Zinc transporter gene was isolated from *Neurospora crassa* and cloned. Cloning and complete sequencing of the Copper Transporter gene from *Neurospora crassa* was completed. Cloning, amplification and confirmation of complete sequence was done of Human Cytochrome *p450 2e1* gene. Phenol removal using hairy roots of *Helianthus annuus* was carried out for different phenol concentrations. Plants of *Vetiveria* were found to remove phenol with good efficiency. Field grown plants of *Vetiveria zizanoides* were tested for the potential to remove radionuclides from the low level nuclear waste in field conditions.

Banana, pineapple and sugarcane tissue culture raised plants have been cultivated in the fields at the atomic power stations at Tarapur and Kaiga, P.D. Krishi Vidyalaya, Akola, NRCB, Trichy and Maharashtra Agricultural University, Parbhani. The *in vitro* established micro propagation protocol has been extended to new cultivar grape varieties. Sugarcane embryogenesis protocol was refined and cultures were raised against abiotic stress conditions. Radiation induced mutagenic experiments were conducted using embryogenic cultures in sugarcane and banana. The irradiated plant population was field evaluated at PDKV, Akola. Pineapple and potato were transformed with an antimicrobial peptide (magainin) for disease resistance. Genetic transformations of Banana, Potato, Tomato and Tobacco have been accomplished with the expression of HBsAg. Attempts have been made to obtain higher-level expression of HBsAg by modifying the expression cassettes and four new expression cassettes were constructed. Tobacco NT-1 cells and banana embryogenic cells have been transformed with these modified vectors.

Nisargruna biogas plant

Inauguration of the Radiation Processing Plant at Vadodara, Gujarat

FOOD PROCESSING

Synergistic effect on the antibacterial activity of irradiated chitosan when used in combination with lysozyme was established. An aminopeptidase from chicken intestine (serine protease) and stable against trypsin degradation was effectively used for debittering casein hydrolyzate. Application of chicken intestinal protein hydrolyzate as a source of nitrogen in bacteriological media was demonstrated. A method for retrieval of proteins from oil seed (groundnut, cottonseed, and coconut) cakes using chicken intestinal protease was standardized. A method for preparation of microbially safe salted (3%) and dried (50% moisture level) mackerel (*Rastrelliger kanagurta*) was standardized. Coating of these products with shark gel dispersion followed by radiation treatment (1-5 kGy) resulted in a product that could be stored at room temperature for 4 months. Hygienization of frozen surimi blocks that were free of *Salmonella* could be achieved by treatment with gamma radiation at doses of 4 and 6 kGy. Studies on radiation hygienization of minimally processed sprouts and fresh pre-cut fruits and vegetables continued. A shelf life extension of 2 weeks without changes in the organoleptic and nutritional quality of matki sprouts was noted in radiation processed (1 and 2 kGy) samples. No significant changes in color attributes were observed in irradiated (2 kGy) pineapple stored for 12 days at 8-10 ^{0}C. A process for obtaining ready-to-cook white pumpkin with extended shelf life was developed using a combination of radiation (2 kGy) and cling film wrapping. A 20% sucrose solution was found to preserve Ester Lilies for 20 days at 10 ^{0}C and extend its vase life. A process for preparation of jackfruit and raw mango juice using pectinolytic enzyme was standardized.

Use of radiation processing in enhancing functional properties of legumes was investigated. In green gram, a radiation dose of 2 kGy resulted in a 30% reduction in cooking time and a significant decrease in sprout length without affecting germination rate and texture. Total carbohydrates remained unchanged despite an increase in reducing sugars and a decrease in oligosaccharides after radiation processing (5-30 kGy) of chick pea (*Cicer arietinum*). A significant decrease (33%) in compression force and a doubling in extractable protein in soymilk were observed when this legume was irradiated at doses between 10-30 kGy. A high acceptability of radiation processed (1-5 kGy) secondary products from cereals and legumes such as papad, idli rawa and broken wheat suggests the use of this technology for improving the functional properties along with shelf life of these and related commodities. A method based on detection of volatile phenol liberated from its glycosidic precursors during radiation processing was validated for the detection of irradiated fenugreek and papaya. The method could accurately estimate the absorbed dose *in situ* in the dose range of 100 Gy to 15 kGy. A phenyl b-D-glucoside dosimeter for food irradiation was developed for estimation of absorbed dose. The dosimeter covers a dose range of 50 Gy – 10 kGy and is stable at temperatures between 0-60 ^{0}C. Gamma and electron beam radiation (2.5 –7.5 kGy) demonstrated similar efficacy in extending shelf life of cashew, triphala churna and jackfruit papad without significantly affecting their chemical constituents. A radiation specific carbon centered cellulose free radical that exhibited good linearity with radiation dose was used to monitor irradiated soybean and tea. Jemonila plant extracts (100- 500 mg/ml) were shown to possess high radical scavenging activity. Nearly 300 tonnes of onion from private entrepreneur were irradiated at KRUSHAK. All nine ^{60}Co source pencils were reloaded. Large-scale marketing trials were carried out with onion, potato and garlic in collaboration with an NGO, Fresh-O-Veg, Indore.

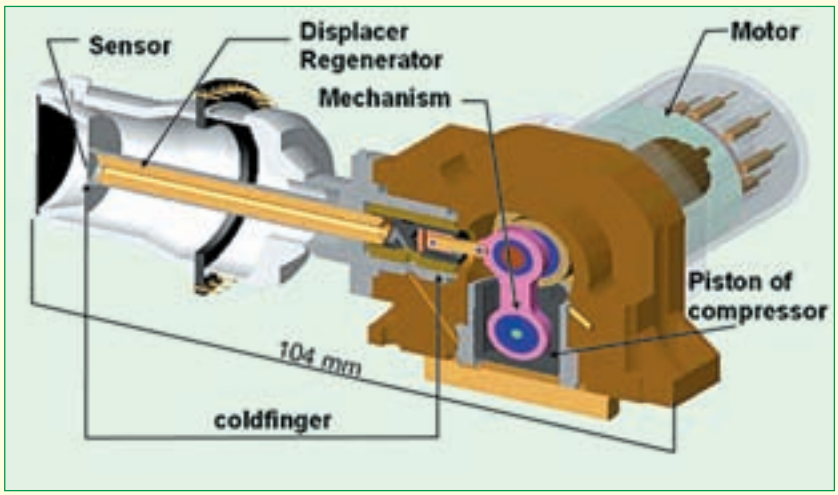
10MeV / 10 kW Electron LINAC

The 10 MeV/10kW LINAC for food irradiation was installed and commissioned at RRCAT. Characterization of the facility was performed in accordance with the ASTM standards. Various irradiation experiments e.g. food grain irradiation, sterilization, irradiation of packing materials, were carried out using a small material handling system installed in the facility. Development / procurement of full fledged conveyor system progressed.

A radiation processing facility for agriculture products based on this LINAC is planned to be set up near Subzi Mandi (vegetable wholesale market) in Indore.

ADVANCED TECHNOLOGIES RECENTLY DEVELOPED AT BARC AND RRCAT

Helium Refrigerator Cold box showing the turboexpanders, valves and associated piping



Schematic of the miniature cryocooler

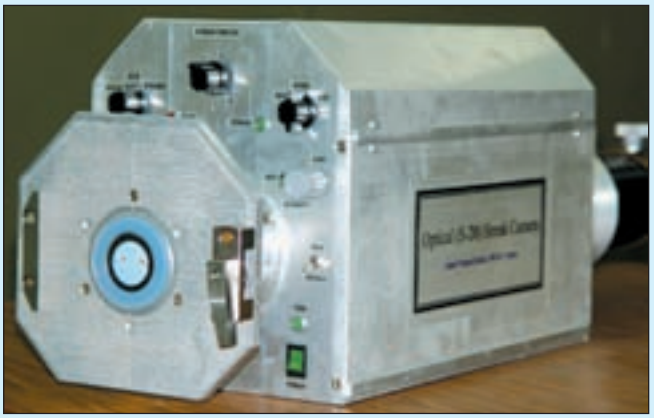
Laser welded automobile transmission gear assemblies

100 Watt kinetically enhanced copper vapour laser developed at RRCAT

Thermal Plasma Reactor set up at Trombay

Multi-collector, magnetic sector isotopic mass spectrometer at Trombay

Nd glass disk amplifier module for high power laser chain developed at RRCAT



S-20 optical streak camera developed at RRCAT

DAE'S FINANCIAL SUPPORT TO RESEARCH

DAE encourages and promotes scientific research, in the areas of relevance to the Department, through the Board of Research in Nuclear Science (BRNS) and the National Board for Higher Mathematics.

The Board of Research in Nuclear Science (BRNS) is an advisory body of DAE. Besides funding research projects, BRNS provides financial assistance to organise symposia/ conferences/workshops on topics of relevance to the programmes of DAE. BRNS also awards 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) is meant for inducting Graduate Level students doing M.Tech. at the IITs. While the Visiting Scientists programme of BRNS is meant for promoting short term in-house interactions amongst senior level experts, the Raja Ramanna Fellowship of BRNS is for reasonably long-term involvement of the eminent scientists and engineers in the various on going programmes of the Department. The Homi Bhabha Chair sponsored by BRNS is instituted to avail the honorable services of scientists and technologists who have distinguished themselves at national and international levels.

During the year 2006-07, 90 new research projects were sanctioned by BRNS. Financial sanctions were also issued for the various on-going research projects. Two fellowship was awarded under the Homi Bhabha Chair Scheme, Twelve fellowships were offered/awarded under the Raja Ramanna Fellowship Scheme (Senior Scientists Scheme), thirteen fellowships were awarded under the K.S. Krishnan Research Associateship Scheme and twenty-four fellowships were offered/ awarded under the DAE Graduate Fellowship Scheme. Financial supports were extended to fully funded BRNS seminars as well as to partly funded seminars conducted by professional organisations on various topics of relevance to DAE.

To mark the Golden Jubilee of BARC, during the year 2006, the Science Research Council (SRC) of DAE launched a unique programme to encourage exceptionally innovative research and development activities named as DAE-SRC Outstanding Research Investigator Award.

The National Board for Higher Mathematics (NBHM) was established under the aegis of DAE in the year 1983 with the objective of promoting excellence in higher mathematics education and research in the country. The Board initiated several schemes such as support for development of mathematical centres, giving scholarships to postgraduate students and researchers at the doctoral and postdoctoral levels, travel assistance to mathematicians for participating in conferences/seminars, visiting professorships, assistance to conferences etc..

In the year 2006-07, one third of the budget of about Rs. 12 crore allocated to NBHM, was released to mathematics departments of about 80 institutions to enable them to purchase the latest books and journals in mathematics. In addition to this, NBHM distributed selected books to various colleges and universities under its book distribution scheme. A recurring grant of Rs. 2 crore was released to the Chennai Mathematical Institute (CMI) that runs a high level undergraduate programme in mathematics.

NBHM was incharge of Mathematics Olympiad contests for talented young students at the plus two (+2) level. The Indian National Mathematics Olympiad (INMO) at the national level is a step towards selection for the International Mathematics Olympiad (IMO). This activity is currently undertaken by NBHM in collaboration with the Homi Bhabha Centre for Science Education (HBCSE).

NBHM financially supported 13 international conferences held in India, 13 national conferences and 9 Advanced Training in Mathematics schools. Eleven research projects were funded by NBHM. Travel grants were provided to 32 mathematicians to enable them to participate in conferences held in India and abroad. 6 retired professors were provided visiting professorships to strengthen research and teaching at university mathematics departments in the country. An eminent mathematician, visited and delivered a series of lectures during the year at various institutions in India under the Ramanujan fellowship programme of NBHM.

Under a special scheme, NBHM supported a team of 100 mathematicians to take part in the International Congress of Mathematicians (ICM 2006) held in Madrid, Spain. In a major development, the bid spearheaded by NBHM to host the next International Congress (ICM 2010) in India was accepted by the International

The funds (Plan & Non-Plan) allocated to these Aided Institutions by the Department of Atomic Energy during the financial year 2006-2007 are as under :

(Rs. in crore)

Sr. No.	Name of the Institutions	Budget Provision BE 2006 - 2007
1.	Tata Institute of Fundamental Research (TIFR), Mumbai	151.23
2.	Tata Memorial Centre (TMC), Mumbai	158.44
3.	Saha Institute of Nuclear Physics (SINP), Kolkata	46.90
4.	Institute of Physics (IOP), Bhubaneswar	14.92
5.	Institute of Mathematical Sciences (IMSc.), Chennai	13.27
6.	Harish-Chandra Research Institute (HRI), Allahabad	12.24
7.	Institute for Plasma Research (IPR), Gandhinagar	109.81
8.	Atomic Energy Education Society (AEES)	25.50

Mathematical Union (IMU) and the announcement was made at ICM 2006. Organizational work for this prestigious event has already been initiated. NBHM is supporting 40 participants to take part in the International Congress on Industrial & Applied Mathematics (ICIAM 2007) to be held in Zurich, Switzerland in the year 2007.

Grants to Aided Institutions

The aided institutions of DAE are an integral part of the Department in as much as there is a growing synergy between these institutions and the Research and Development Units of the Department. Several joint projects have been undertaken between the Units and Aided Institutions and there is frequent interaction between the academicians of the aided Institutions and the Scientists of the R&D Units. The Department has eight aided institutions (including one educational society) fully funded in terms of their recurring and non-recurring expenditure. These institutions are growing at a faster pace in terms of the projects undertaken by them.

Grants to Cancer Hospitals

DAE signed a Third Tripartite Agreement with the North-Eastern Council and the Government of Assam, for the revitalization of the Dr. B. Barooah Cancer Institute (BBCI), Guwahati. This hospital is a Regional Cancer Centre for cancer treatment and control in the North-Eastern Region. The Department's total share as per the Tripartite agreement is approximately Rs.10.44 crore for revitalization of the BBCI which includes the cost of construction for expansion of the hospital as well as the procurement of major radiation related equipment during its Revitalization Project-III.

The Department also extends financial assistance to Cancer hospitals located in other parts of the country. The budget provision for the financial year 2006-07 for such partial financial assistance, was to the tune of Rs.6 crore.

An increasing need was also felt to use the expertise available in the DAE funded Tata Memorial Hospital for creating a better network between cancer institutions all over the country. This will include research & development, training and preparation of protocols for treatment as well as incentives for indigenisation of much of the radiation related equipment for cancer treatment. For this purpose, an Apex Committee was formed.

The initiatives taken to achieve the above stated objectives will lead to further gains in the DAE's outreach in the cancer care programme.

Homi Bhabha National Institute

The academic activities of Homi Bhabha National Insitute (HBNI) have started.

On June 4, 2005, Prime Minister Manmohan Singh during his visit to Bhabha Atomic Research Centre had announced the approval of the government for setting up of the Homi Bhabha National Insitute under the aegis of DAE with the status of a 'Deemed-to-be-University' under Section 3 of the UGC Act. The Constituent Institutions of HBNI for the purpose of their academic programmes are four R&D Centres (BARC, IGCAR, RRCAT, VECC) and six grant-in-aid institutions (SINP, IPR, IoP, HRI, TMC, IMSc).

The concept underlying the HBNI is to promote advanced degrees, viz., Masters and Ph.D degrees, largely with the help of the research centres and grant-in-aid institutions of the DAE. HBNI will offer a uniform scheme for such activities in education and research. It is envisaged that such a scheme will concomitantly result in strengthening linkages between the grant-in-aid institutions and the research centres for the benefit of advancing the pace of research in nuclear sciences on the one hand and, on the other, accelerate the process of translating R&D into technology products and their applications.

Symposium on Desalination & Water Reuse

The Trombay Symposium on Desalination & Water Reuse was inaugurated on February 7, 2007 at the Multipurpose Hall, Training School Hostel, Anushaktinagar. In the inaugural function, Dr. Anil Kakodkar, Chairman, Atomic Energy Commission, highlighted the increasing demand for water due to changing lifestyles and increasing population. He referred to the technological innovations from BARC using barge mounted desalination unit, which is useful for supplying safe drinking water along the coastal region. There is a strong need for involving local non-governmental organisations to use the desalination and water purification technologies for common good of people. He referred to the compact high temperature reactor being developed for supplying hydrogen for the transport sector and low-grade heat for desalination.

In the inaugural address Dr. R. Chidambaram, Principal Scientific Adviser to the Government of India, emphasied that energy security and water security are the critical issues in India's development. Dr. Chidambaram referred to the isotope hydrology being applied to address the problem of water scarcity in Gaucher area of Uttarakhand. He also underscored the need for long term R&D studies in the field of advanced membrane development including nanotube embedded membrane for desalination and water purification.

Dr. S. Banerjee, Director, BARC traced the work done by BARC since early seventies which is paying dividends. About 220 scientists and members from industry participated in this Symposium.

Shri D.S. Shukla, Director, Chemical Engineering & Technology Group gave an introduction to the symposium highlighting the need for ecofriendly and economic technologies to address the problem of water availability. Dr. P.K. Tewari, Chairman, National Organizing Committee & President Indian Desalination Association welcomed the guests and participants.

International Symposium on Vacuum Science & Technology

To deliberate on the developments in all aspects of the Vacuum Science, Vacuum technology and applications to the related areas, the Indian Vacuum Society (IVS), a member of the International Union of Vacuum Science, Techniques and Applications (IUVSTA), will be organizing an international symposium at the Tata Institute of Fundamental Research,Colaba, Mumbai, during November 28-30, 2007.

The topics to be discussed in the symposium include Large Vacuum Systems, Vacuum Technology, and Vacuum Metallurgy.

The Indian Vacuum Society will also confer Ambasankaran Memorial and Smt. Shakuntalabai Vyawahare Memorial awards on the two best Contributed Papers. It will also felicitate two distinguished scientists/technologists who have contributed significantly for the development of Vacuum Science and Technology in the country.

Frequently Asked Questions : Radio Labelled Compounds

Over the years, Board of Radiation & Isotope Technology (BRIT) has developed state-of-the-art methods and standardized procedures for the synthesis, purification and quality assurance/quality control of the following classes of Labelled Compounds/Labelled Biomolecules:

- ^{32}P-Labelled nucleotides
- ^{33}P-Labelled nucleotides
- ^{35}S-Labelled amino acids & alpha-^{35}S-dATP
- ^{14}C-Labelled compounds including custom synthesis
- ^{3}H-Labelled compounds including T-Labelling service

Following are some of the frequently asked questions about Radiolabelled compounds.

What are Labelled compounds?

Labelled compounds are compounds in which one or more of the atoms of a portion of the molecules is replaced with or substituted by a detectable quantity of stable or radioactive isotope(s) of the elements present in them chemically, enzymatically or biosynthetically, using suitable precursors, reagents, reaction schemes and procedures. The compounds can be labelled at the specific positions or generally labelled (denoted by 'G') or uniformly labelled (denoted by 'U').

What are the applications of Labelled Compounds?

The isotopically labelled compounds have numerous and varied applications as tracers. They are versatile research tools, which can be advantageously employed in studies pertaining to chemistry, biology, medicine, agriculture, biotechnology and genetic engineering. Of late, there has been an upsurge of interest and activities amongst researchers, especially in life sciences to study the various fundamental phenomena, hitherto not unravelled fully, involving in the synthesis, uptake, fate and function of amino acids, polypeptides, proteins, nucleic acids and their components (DNA & RNA), fatty acids (lipids), carbohydrates (sugars), prostaglandins, steroids, pheromones, neurotoxins, anti-aging compounds and a multitude of various other compounds of interest. For obtaining metabolic and pharmaco-kinetic data, a widely used method, often the method of choice, is that of radio labelling the compound to be studied. This is mainly due to the fact that pico-moles to femto-moles of a substance in question can be detected and quantitated using this technique with comparative ease and precision. Some of the important applications of labelled compounds and labelled biomolecules are the following :

Important Applications of Labelled Compounds

Agriculture : Plant physiology, crop improvement, plant nutrition and metabolism, pesticide management, mechanism of photosynthesis, plant morphogenesis, etc.
Animal Husbandry : Dairy research, biochemistry of lactation, animal physiology, etc.
Biochemistry : Studies of life processes at cellular levels, biosynthesis of proteins carbohydrates, lipids, steroids, nucleic acids, etc., metabolic pathways, transmethylation studies, enzymatic synthesis of RNA & DNA, etc.
Entomology : Insect metabolism
Environmental research : Residue studies, pollution and its control.
Enzymology : Radiometric assay of enzymes, important metabolites such as ATP, biogenic amines, etc.
Fisheries : Biological productivity in sea water, etc.
Forensic sciences : DNA finger printing, paternity tests, investigations and proof on criminals, etc.
Medicine : Drug metabolism, Radio immuno assay, cancer research and chemotherapy, contraceptive research, drug development, radio receptor assay, etc.
Molecular Biology : Recombinant DNA technology, genetic engineering, Transcription and translation mechanism of DNA , RNA, Protein.
Nutrition : Utilisation of dietary components
Organic Chemistry and other branches of chemistry : Reaction mechanism studies, Reaction kinetics, biogenesis, etc., self-radiation decomposition (auto radiolysis), etc.

Applications of Labelled Compounds & Biomolecules

Basic Sciences Research: 5'- & 3'-End labeling of nucleic acids, Sequencing of nucleic acids, Nucleic acid hybridization, Making of labelled hybridization probes, Gene cloning, Studies on mechanism of DNA repair and DNA replication, Transcription of genetic message to RNA, Translation of genetic information from RNA to protein.

Medical Sciences: Diagnosis of genetic disorders such as thalassemia, sickle cell anaemia and genetic muscular dystrophy. Identification of specific genes like onco genes. Screening of population for infection by bacteria, fungus and virus using labelled probes. Human gene mapping.

Agriculture : Engineering plant cells to introduce desired characteristics such as yield, nutritional value, stress tolerance, etc. (Genetically modified-GM). Development of plants resistance to frost and herbicides. Development of plants resistance to pests. Biological nitrogen fixation.

Industry : Development of suitable microbial systems for the industrial production of antibiotics, vaccines, interferons, amino acids, alcohols, growth hormones, etc.

What are nucleotides?

Nucleotides are the basic unit of nucleic acids just as aminoacids are the basic unit of proteins and monosaccharides (carbohydrates) are of polysaccharides (sugars). Nucleotides are obtained on hydrolysis of deoxyribonucleic acid (DNA) and ribonucleic acids (RNA) under controlled conditions. They essentially contain a phosphate group, ribose or deoxyribose (pentose) sugar and purine (adenine or guanine) or pyrimidine (Cytosine, uracil or thymine) nitrogenous base attached together in a specific well defined way. The five important ribonucleotides are adenylic acid, guanylic acid, uridylic acid, cytidylic acid and thymidylic acid.

What are nucleosides?

A heterocyclic nitrogenous base - a purine (adenine or guanine) or pyrimidine (cytosine, uracil or thymine) in N-glycoside linkage with a pentose (ribose or deoxyribose) sugar is called a nucleoside. The five important ribonucleosides are adenosine, guanosine, uridine, cytidine and thymidine. In short, a base linked to a sugar is called a 'nucleoside'; and when a phosphate group is added, the base-sugar-phosphate is called a 'nucleotide'.

What are 'cold' molecular biology kits?

Molecular biology 'cold' kits (as they do not contain any radioactive material) are ready-made kits, which contain all the materials; chemicals and biochemical components required for readily carrying out the specified reaction for number of experiments. They can be employed in conjunction with radio-labelled products (to obtain radiolabelled DNA / RNA probes) or with non-radioacive products (to obtain fluorescent or chemi-luminescent labeled DNA /RNA probes). e.g. using a Nick translation kit in conjunction with a labelled ^{32}P or ^{33}P deoxyribo nucleotide, one can introduce radioactively labelled nucleotides into DNA 'in vitro'.

What are synthetic oligonucleotides?

Synthetic oligonucleotides are single-stranded DNA fragments assembled from mononucleotide units by chemical synthesis according to a defined sequence and are generally 20-30 base long (i.e. low molecular weight). The base sequence is easily programmed in the computer of the gene assembler machine, which then determines the addition of reactants in the desired order. Synthetic oligonucleotides (DNA primers) are widely used in the study of genes, especially by researchers of ^{32}P and ^{35}S biomolecules in reactions such as DNA sequencing, polymerase chain reaction (PCR), etc.

Nuclear India says adieu to its Editor

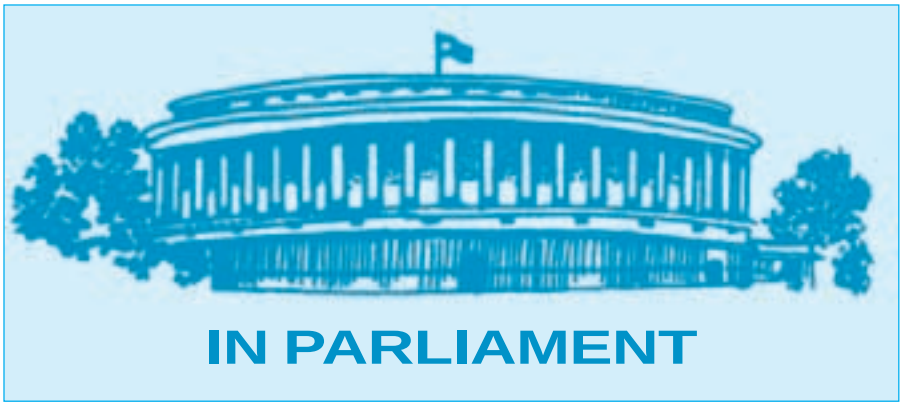
Shri R K Bhatnagar, Scientific Officer-H and Head, Publication Division, DAE, who had been editing Nuclear India since 1983, has relinquished the charge of his office on March 31, 2007.

Besides Nuclear India, he had also been editing and publishing Parmanu, a quarterly Hindi newsletter of DAE, and a host of other publications in English, Hindi and other Indian languages that included public awareness literature on various facets of atomic energy, literature for employee's enrichment, and official documents, books and manuals.

A compilation of the correspondence between Homi Bhabha and Pt. Jawaharlal Nehru, Atomic Energy in India-50 Years (both in English and Hindi), and Commemorative Volumes narrating the Saga of 50 years of Atomic Energy in India, are some of memorable publications under his editorship.

Shri Bhatnagar has passed on the Editor's pen to Shri S. K. Malhotra, Scientific Officer-H and Head, Public Awareness Division, DAE.

Nuclear India wishes Shri Bhatnagar an active life and tranquil time ahead.



IN PARLIAMENT

Power Generation from Atomic Energy

(Question 2050, Lok Sabha, March 14, 2007)

(a) the details of the atomic energy sources for power generation during the last three years;

(b) the details of Central/State/ Private Sector participation in power generation from atomic energy sources; and

(c) the scheme of the Government for augmentation of power generation capacity from atomic energy sources?

Answer

(a) Current nuclear power capacity in the country is uranium based. While two reactors TAPS 1&2 (320 MWe) use imported light enriched uranium, the remaining fourteen reactors (3580 MWe) use indigenous natural uranium.

(b) The nuclear power generation in the country is in the Central Sector. State/private sector participation has been indirect, as support/ manufacturing of equipment/ execution of EPC packages etc. to the Central Government companies engaged in nuclear power generation.

(c) The current installed capacity of 3900 MWe will reach 7280 MWe progressively by March 2011 by completion of projects under construction. The XI Plan proposals envisage start of work on 5600 MWe capacity based on indigenous design. The current initiatives for international co-operation in nuclear energy are aimed at accessing the international market for technologies and fuel, for setting up additionalities to the domestic programme to enable larger capacity addition to meet the electricity demand in the near term.

Memorandum of Understanding with France

(Question 2056, Lok Sabha, March 14, 2007)

(a) whether the Government has signed any Memorandum of Understanding (MoU) with France to set up the first International Thermo-nuclear Energy Reactor (ITER) at Marseles region of France; and

(b) If so, the salient features thereof including the details of cooperation to be extended by India in this regard?

Answer

(a) The Government of India along with six other Parties, has signed a Joint Implementation Agreement on November 21, 2006 for establishing the ITER International Fusion Energy Organisation at St.Paul-les-Durance (Bouches-du-Rhone) near Marseles, France. The other six Parties to the agreement are European Union represented by the European Atomic Energy Community (EURATOM), the Government of the People's Republic of China, the Government of Japan, the Government of the Republic of Korea, the Government of the Russian Federation and the Government of the United States of America.

(b) The salient feature of ITER project is to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes, an essential feature of which would be achieving sustained fusion power generation. The aim of ITER project is to show that fusion could be used to generate electrical power and to gain the necessary data to design and operate the first electricity producing plant. The resources of the ITER organisation shall be from contributions of member states in agreed proportions. Each member including India shall contribute:

1) Equipments (in-kind contribution) to build the machine as agreed to in the Joint Implementation Agreement.
2) Staff to this project and
3) Cash contribution to meet the cost of some systems at the ITER International Organisation level.

The approximate financial implication on the part of India is estimated at Rs.2500 crores over a period of ten years, which will be largely in the form of in-kind contribution.

Increasing Power Generation with Atomic Fuels

(Question No. 264, Rajya Sabha, March 01, 2007)

(a) whether Government propose to increase power generation with atomic fuels;

(b) if so, the proposed investment requirement for per MW Unit of atomic energy;

(c) whether Government undertook any cost benefit analysis of atomic power generation in comparison with that of coal, hydro, naptha and other such fuels;

(d) if so, the findings thereof; and

(e) if not would Government undertake such an exercise before finalizing investment proposals for atomic power generation?

Answer

(a) Yes Sir.

(b) Capital investment requirement is indicated in terms of installed capacity which is Rs.5.5 crore per MWe at 2006-07 prices.

(c) Yes, Sir.

(d) The capital costs of Nuclear Power Stations are 25 to 30% higher than that of coal fired plants while the fuelling costs for Nuclear Power Stations are lower. At about 800 km from coal pitheads nuclear power generation costs are competitive with coal based thermal power generation in view of the additional cost for transporting coal. The cost of generation of nuclear power is comparatively cheaper than that of naphtha and gas based power. Hydro electric power being location specific cannot be compared.

(e) Cost benefit analysis in respect of specific proposals is undertaken before investment decisions are made.

Increasing Power Generation Through NPC

(Question No : 265 Rajya Sabha, March 03, 2007)

(a) whether Government are expecting to increase power generation with atomic fuels;

(b) if so, the investment requirement according to the generation target;

(c) whether Government are increasing the investment through Nuclear Power Corporation; and

(d) if not, the plans contemplated to meet the expenditure?

Answer

(a) Yes, Sir. The current nuclear power capacity of 3900 MWe will increase to 7280 MWe on completion of the projects under construction. The projects which are planned to be taken up in the XI Plan, on completion, will further add15900 MWe to the capacity in the XII Plan.

(b) The investment requirement in the XIth Plan is estimated at Rs.11409 crores for projects to be completed in XI plan and Rs.23776 crores for new projects which are planned to be completed in XII plan totaling to Rs.35185 crore at 2006-07 price level.

(c) Expenditure towards the capacity addition will be met through internal surpluses of NPCIL, market borrowings and through foreign credit in

(d) respect of imported Light Water Reactors. Investments in respect of Fast Breeder Reactors will be met through Domestic Budgetary Support and market borrowings.

Attainment of self-sufficiency in Nuclear Power Prodcution

Question No. 266, Rajya Sabha, March 01, 2007, (Shri B. J. Panda)

(a) whether the Nuclear Power Corporation of India(NPCI) proposes to add nuclear power capacity of 50,000 MW by 2032;

(b) if so, the details thereof; and

(c) how far this would help to attain self-sufficiency in power production in the country?

Answer

(a) & (b) The present nuclear power capacity of 3900 MWe in the country is expected to increase to 7280 MWe by the end of XIth Plan on completion of projects already under construction. The XIth plan proposals envisage commencement of work on 8 x 700 MWe of indigenous reactors totaling 5600 MWe capacity by Nuclear Power Corporation of India Ltd. (NPCIL). Four 500 MWe Fast Breeder Reactors (FBRs) by Bharatiya Vidyut Nigam Limited (BHAVINI) are also planned. Thus, a capacity of about 15000 MWe is planned to be reached by 2020 through indigenous efforts. This capacity will be achieved by the two Government Companies namely NPCIL and BHAVINI Ltd. set up for this purpose. Setting up of 10000 MWe through PHWRs and large capacity through FBRs are pre-requisite for setting up large scale power capacity in the third stage using Thorium as fuel. The efforts of the Government to access nuclear reactors and fuel through international cooperation open up the possibility of further capacity addition taking total capacity to 50000 MWe by 2032. However, achieving of such capacity will depend upon the developments in regard to international civil nuclear cooperation.

(c) The proposed capacity addition will supplement the efforts made in augmenting the power capacity by other conventional/non-conventional sources of power and help attainment of self-sufficiency in power production in the country.

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