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Nuclear India

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Madras Atomic Power Station : 25 years of Successful Operations

The Unit-1 of the Madras Atomic Power Station (MAPS) is completing 25 years of safe and successful operation on July 23, 2008. The unit was synchronized to the grid on July 23, 1983, in the presence of the then Prime Minister of India late Smt. Indira Gandhi.

The station, that comprises two units of 220 MWe each of pressurized heavy water reactor, is located at Kapakkam, near Channai, Tamilnadu. These reactor units are the first indigenously built nuclear power reactors in India. The successful completion of project engineering, design, construction, commissioning and operation of MAPS-1 laid a strong foundation for the first stage of the Indian nuclear power programme.

So far, MAPS has supplied more than 45,000 million units of electricity. The current tariff is Rs. 1.89 per unit. The station has earned a profit of Rs. 1125 crore. Tamil Nadu has a share of 330 MWe out of the station's capacity of 440 MWe. The remaining power is shared by the other states that are beneficiary of the southern electricity region.

In the recent past, the Unit-1&2 of MAPS have undergone major renovation and modernization, safety upgradation and enmass coolant channels replacement. Replacement of "Feeders" in the primary heat transport system and hairpin type steam generators have been an engineering feat in their own right. This endeavour has extended the plant life by 25 to 30 years.

Evolving Indian Nuclear Programme: Rationale and Perspective

Dr. Anil Kakodkar,
Chairman, Atomic Energy Commission, India

Background

The Indian Department of Atomic Energy (DAE) was established more than five decades ago. Its activities encompass Research and Development in areas relating to nuclear sciences and technologies, industrial scale manufacture of critical raw materials, components, equipment and systems needed for Indian nuclear programme, production of nuclear power, and support of research, academic activities and services associated with nuclear energy and allied subjects within the country. In each of these areas, the required domestic infrastructure, including the human resources have been progressively developed. A capability based on self-reliance has been acquired to take up newer challenges, as and when they arise.

The main drivers of DAE's activities have been: relevance to meet the national needs and priorities, and excellence by global standards. For a large country like India, it is considered strategically important to develop core capabilities in critical areas to reduce vulnerabilities to external pressures. Incidentally, technology denial regimes have been operational through a major part of the DAE's history. The achievements of DAE, in a wide range of fields, have to be viewed from this perspective as well.

Reaching global levels of excellence in relevant scientific and technological disciplines : Some recent examples

R&D areas relevant to nuclear power

India is the only country in the world that has accorded a high priority to the use of all the three main fissionable materials, uranium-235, plutonium and uranium-233, to meet the challenge of reaching energy independence through a well calibrated deployment of domestic uranium and thorium resources.

India started with building Pressurised Heavy Water Reactors (PHWRs) in the country in the first stage of its domestic nuclear power programme. The magnitude of research and development in the field of PHWRs is best represented by the number of scientific publications in the area. As can be seen in Figure-1, India has progressively reached world leadership in this area. Nearly 55% of the scientific publications in the field of PHWRs originated from India in the year 2006.

We can see similar performance statistics in respect to publications for Fast Breeder Reactors (FBRs) and Thorium. As seen from Figure-2, in the area of FBRs, the Indira Gandhi Centre for Atomic Research (IGCAR) brought out the largest number of publications by any single institution in the years 2005 and 2006

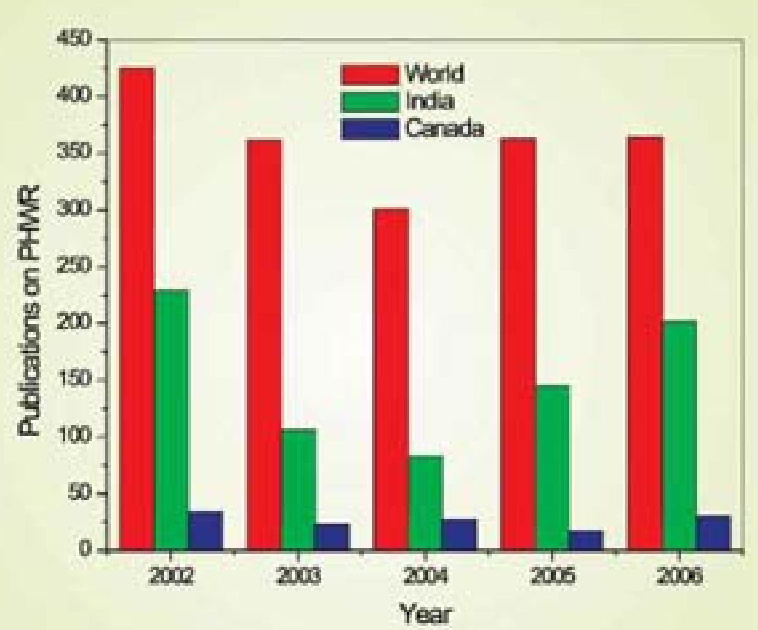


Figure 1: Publications on PHWR

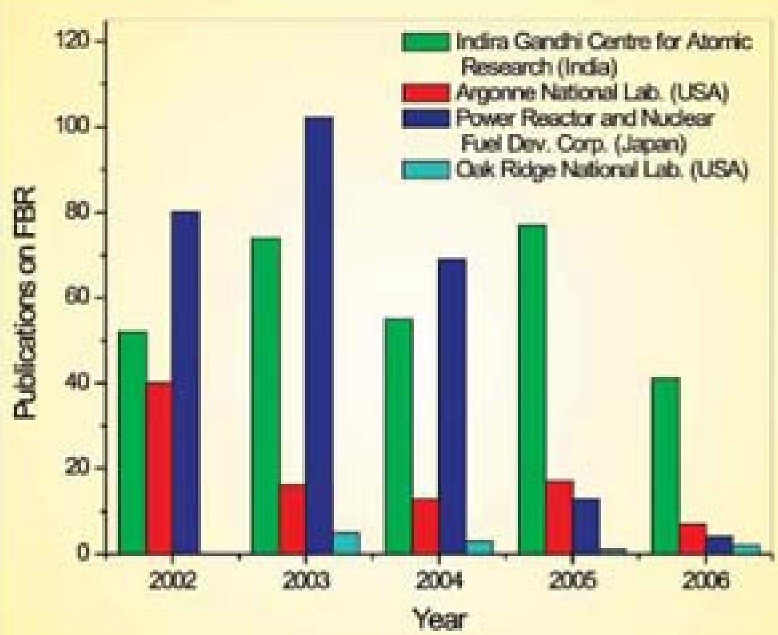


Figure 2: Publications on FBR

(the latest years for which complete data is available). In the area of thorium research, on the basis of International Nuclear Information System (INIS) database, India stands at the top (Figure-3).

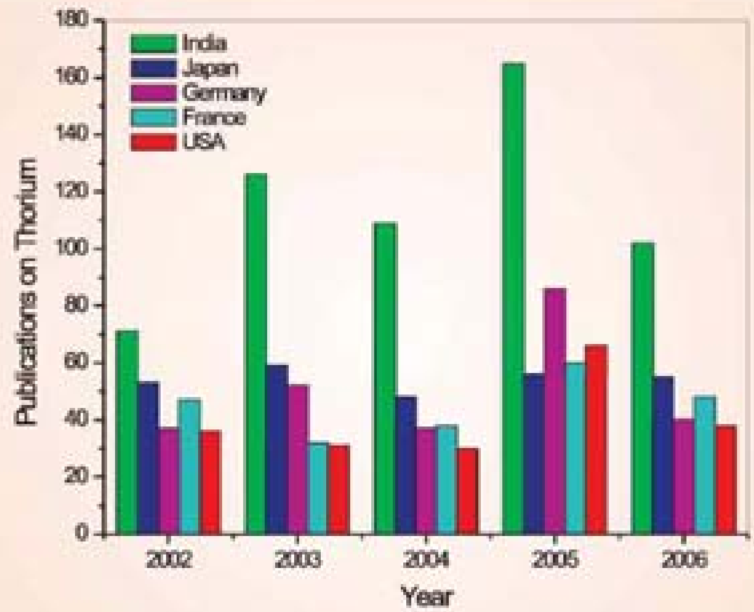


Figure 3: Publications on Thorium

Applications of radio-isotopes

Apart from nuclear power, the programmes of DAE address the conversion of research into societal values for meeting different needs. Large contributions have been made in the field of application of radio-isotopes in industries, health-care, hydrology, food preservation and agriculture. For example, in the field of nuclear agriculture, the mutant groundnut seeds developed at BARC contribute to nearly 25% of total groundnut cultivation in the country.

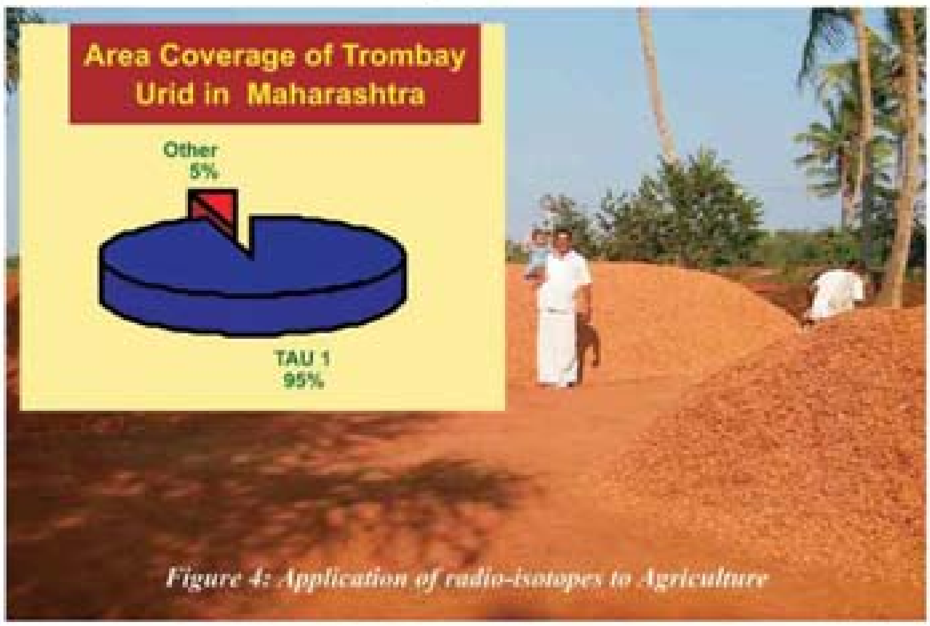


Figure 4: Application of radio-isotopes to Agriculture

Similarly, in the area of black gram (urad) production, the BARC developed mutant seeds contribute to 22% of the national cultivation. In the state of Maharashtra, this percentage is as high as 95% (Figure 4).

Performance in other cutting edge areas

The Tata Memorial Centre, an aided institution under DAE, was recognised as the outstanding cancer organisation for its excellence in cancer control within and beyond India's border, by the International Union for Cancer Control, Washington DC in 2006.

The Giant Meterwave Radio Telescope (GMRT) built by the department for its aided institution Tata Institute of Fundamental Research, has become an international tool for astronomical research. In August 2004, using this facility, the TIFR scientists and their collaborators discovered a new pulsar (Figure-5).

India has an observer status at CERN along with US, Japan, Russia, Turkey and Israel. We are also partners in contributing to the construction and testing of several important systems of this very large international experimental facility now nearing completion. We have made rapid advances on GRID computing technology as a part of our participation in CERN. Today DAE has surged ahead with its own computing grid that connects four DAE sites with 7 clusters containing 266 processors (Figure-6).

We should thus recognise our strengths and move ahead in addressing India's energy security with a degree of confidence.

In his testimony at US Senate Committee on appropriations, Subcommittee on energy and water development on April 20, 2008, Seigfried S. Hecker, former director of LANL said "I found that whereas sanctions slowed progress in nuclear energy, they made India self-sufficient and world leaders in fast reactor technology. While much of the world's approach to India has been to limit its access to nuclear technology, it may well be that today we limit ourselves by not having access to India's nuclear technology developments. Such technical views should help to advice the diplomatic efforts with India".

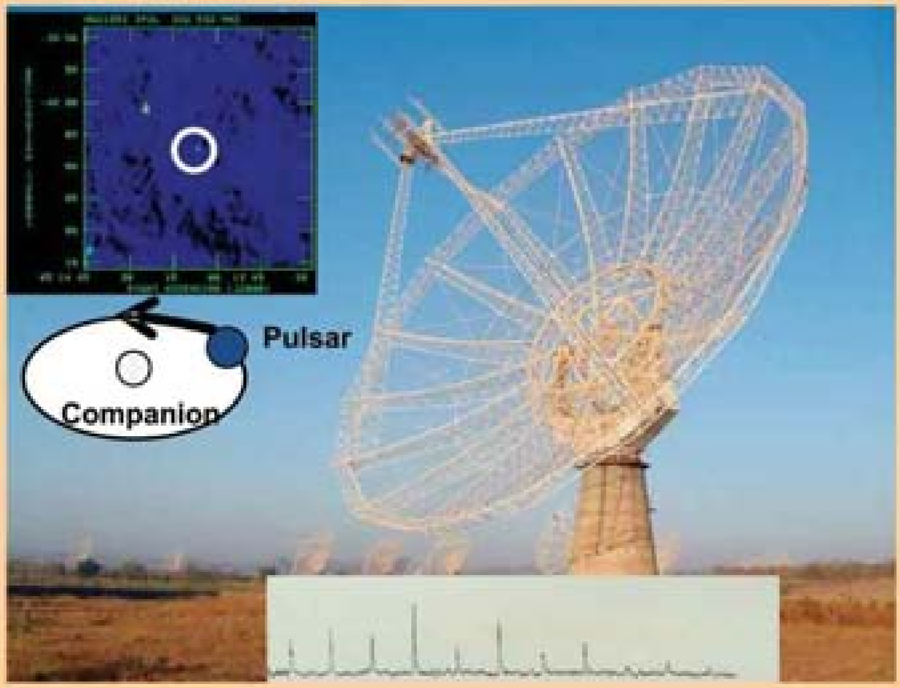


Figure 5: Giant Metrewave Radio Telescope

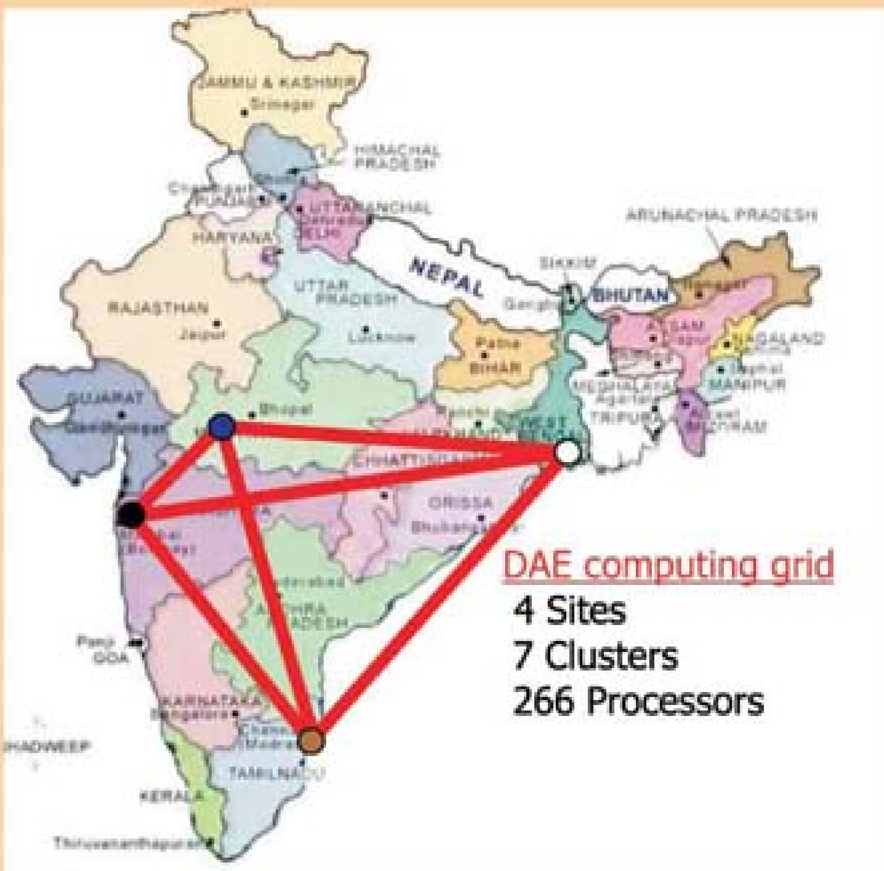


Figure 6: DAE Grid computing

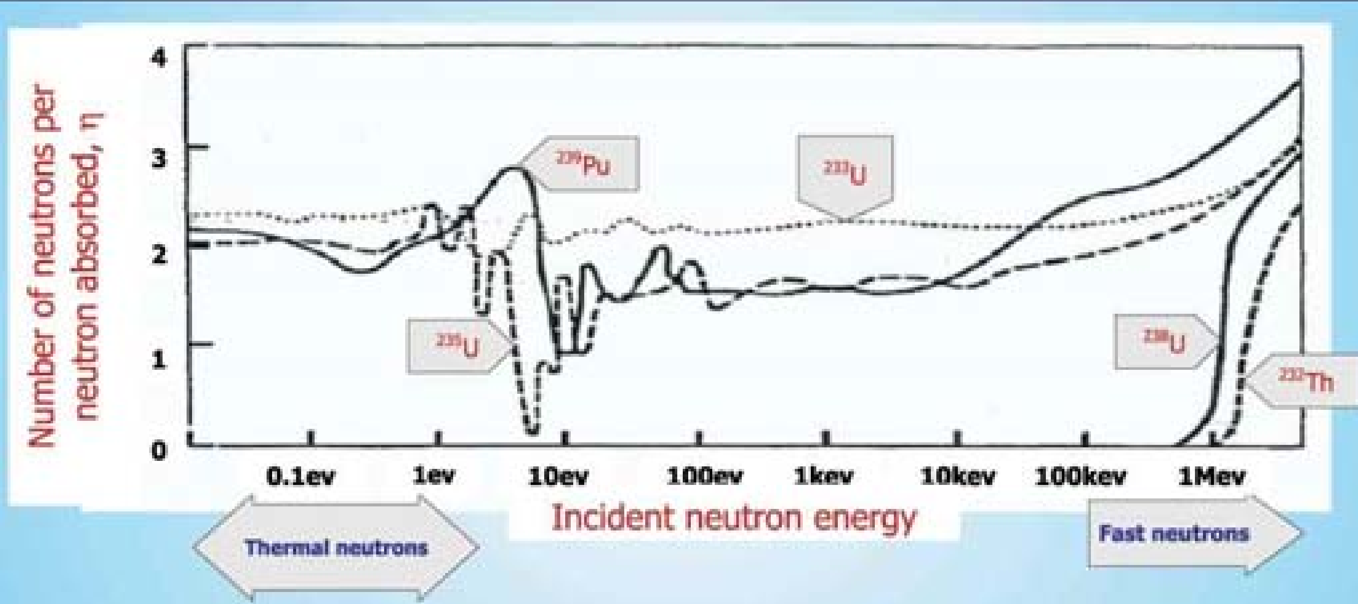


Figure 7: Eta values for various materials

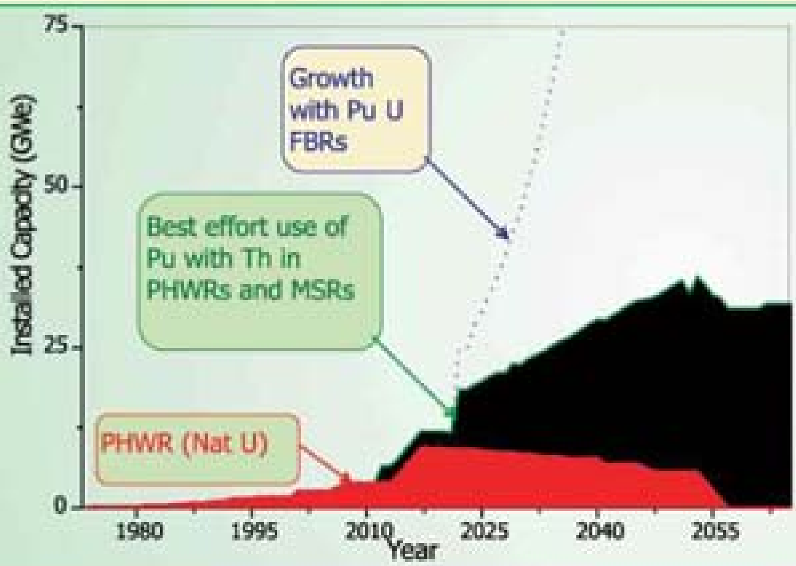
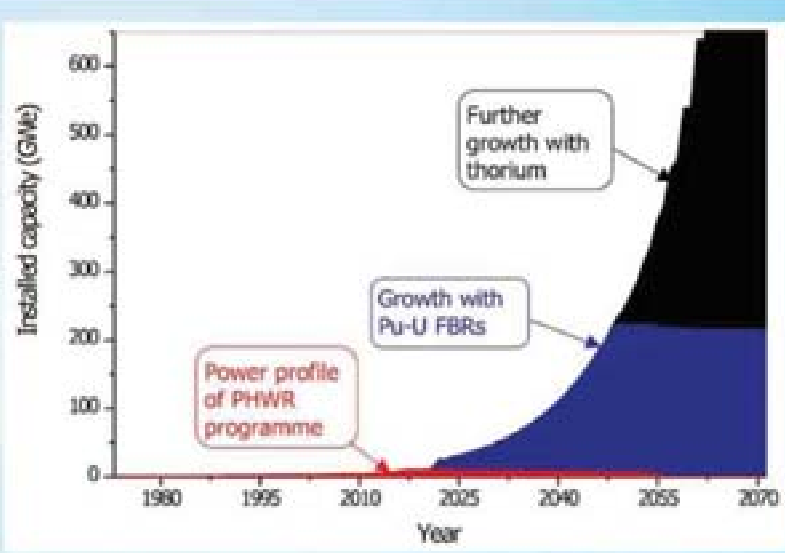


Figure 8: Negative effects of early thorium introduction

Figure 9: Optimum Strategy for thorium introduction in the third stage



Three Stage Indian Nuclear Power Programme

The currently known Indian nuclear energy resources comprise 61,000 tonnes of uranium and more than 225,000 tonnes of thorium. An aggressive effort for further exploration of uranium is being pursued. Natural uranium contains only 0.7% of ^{235}U, the only fissionable material available in nature. In principle, however, the entire quantity of uranium (^{235}U and ^{238}U) and thorium available in nature can be converted to fissionable form that can be used for contributing to energy security of the mankind for a few millenniums.

With the above-mentioned perspective, the Indian nuclear power programme is based on closed nuclear fuel cycle, in which the spent fuel of the first stage PHWRs is reprocessed to obtain fissionable plutonium. The choice of PHWRs in the first stage is driven by the fact that in PHWRs, on account of the use of heavy water as moderator and on-power refuelling, more neutrons are available to convert ^{238}U to Pu than in the case of Light Water Reactors (LWRs). In other words, for the same amount of mined uranium, power produced as well as plutonium generated is higher for PHWRs than in the case of LWRs, where the light water moderator absorbs more neutrons and batch-mode refuelling necessitates placing burnable neutron absorbers in the core along with fresh fuel.

For the second stage reactors, based on plutonium, once again, the unique characteristic of plutonium, with the highest value of eta (η) of all fissile materials in the fast spectrum (Figure-7), led to a logical decision to use plutonium based FBRs. Neutron economy does play an important role in deciding the breeding ratio. This consideration favours the use of metallic fuel compared to other forms of fuel in these FBRs for a faster growth. The current Indian programme in the second stage starts with the well proven oxide fuel based FBRs and subsequently, at an appropriate stage, when all the new necessary technologies have been developed and demonstrated, metallic fuel based FBRs will be introduced.

The highest breeding ratio in FBR is achieved with plutonium-uranium based metallic fuel in the core and uranium in the blanket. The introduction of thorium in the blanket of a plutonium-uranium fuelled FBR slightly increases the doubling time, that has an adverse impact on the rate of growth of the installed FBR capacity in the initial part of the second stage. Hence, in the second stage, the introduction of thorium has to be done in a timely manner, starting with its use in the blanket and much later in the core. DAE studies indicate that, it would be most appropriate to introduce thorium in this manner, in the third decade after the launch of metallic fuel based FBRs.

Introduction of thorium without going to FBRs is extremely counter productive, since the installed power capacity with thorium and plutonium being used together in thermal reactors will be unable to rise beyond a rather insignificant value, considering the total Indian requirement. This is illustrated in Figure-8. The peak power level achieved briefly, with such premature use of thorium is very low (typically 36 GWe for a brief period) as compared to very high levels reachable through an optimum deployment strategy shown in Figure-9.

Thorium is an immense source of energy. The Indian resources of thorium, are easily one of the largest and of the best quality available in the world. Studies indicate that once the FBR capacity reaches about 200 GWe, thorium-based fuel can be introduced progressively in the FBRs to initiate the third stage, where the ^{233}U bred in these reactors is to be used in the thorium based reactors. DAE is also envisaging use of Accelerator Driven Sub-critical Systems (ADS) for facilitating an early introduction of thorium.

DAE's performance in the three stages

The DAE's performance in each of the three stages has been of world standard. The PHWRs have consistently achieved availability factors of about 90% in the recent past along with an excellent safety record consistent with the best performing reactors in the world. Indeed, in the year 2002, Kakrapar Atomic Power Station (KAPS-1) was adjudged the best PHWR in the world for the period from October 2001 to September 2002. Two of the Station Directors of Nuclear Power Corporation of India Limited (NPCIL) received the prestigious WANO excellence award in the year 2003 and 2007 respectively.

> *"At the end of 2002 average annual CANDU/PHWR performance continued to show a gradual improvement, led by the units of NPCIL (India)..." The NPCIL PHWRs showed a major improvement in GCF in 2002, exceeding US light water reactor performance by almost 1%..."*
>
> *Brian MacTavish,*
> *President, COG.*

The commercial performance of the Indian PHWRs has been generally at par, if not better, than that of comparable modern reactors in the world. Table-1 illustrates this point for new designs.

On account of its excellent performance consistently, NPCIL has been given a 'AAA' grading by CRISIL for ten years in a row.

Currently, the construction activity for a 500 MWe Prototype Fast Breeder Reactor (PFBR) is in full swing. Russia is the only other country with a larger FBR currently under construction/operation. Inspite of being first of a kind in our country, the currently estimated economic parameters of PFBR are

Table-1: Commercial performance of Indian PHWRs

	Indian PHWRs (700 MWe)	Global Range
Capital cost $/kWe	1700	2000 - 2500
Construction period	5 - 6 years	5 - 6 years
*UEC $/MWh	60	60 - 70

* *Unit Energy Cost*

Table-2: Important economic parameters for PFBR

	PFBR (500 MWe)
Capital cost $/kWe	69840
Construction period	7 years
UEC $/MWh	3.22

fairly attractive, as indicated in Table-2.

R&D efforts are currently underway to further improve economics of FBRs

Thorium utilisation has received a high priority right from the early days of the Indian nuclear power programme. DAE has been working on different aspects of utilisation of thorium, and for this purpose irradiation of thorium was carried out in research reactors, in PHWRs as well as in the Fast Breeder Test Reactor (FBTR). Associated aspects of manufacture and reprocessing of thorium based fuels have also been the subject of R&D programmes in DAE.

The Advanced Heavy Water Reactor (AHWR) has been designed to produce most of its power from thorium. The reactor also provides a platform to demonstrate several unique passive safety features which are introduced in this reactor to achieve the highest levels of safety along with superior economics. Technologies thus demonstrated in AHWR will be relevant for future next generation reactors that will meet the further enhanced safety requirements for being built in large numbers in close proximity to population centres. This latter capability is considered important in the third stage of the Indian nuclear programme, when the deployment of thorium will need to be carried out in a very large population of nuclear reactors. AHWR has been one of the few reactors in the world that have already strived to meet the requirements of innovative next generation nuclear reactors as has been spelt out in several international forums. The AHWR design has reached a level of maturity, and the reactor is ready for launch of construction.

Sometimes, it is asked why the use of thorium has not been taken up in countries where the urgency to multiply fissile resources is not as high as that in India. The main reason seems to be that, while one can start a nuclear power programme with nuclear fuel containing ^{235}U mixed with either ^{235}U (enriched uranium) or with thorium, the real benefit of using thorium accrues only when the fuel achieves rather high levels of burn-up. It is possible to achieve criticality in a nuclear reactor with only 0.7% ^{235}U (as in natural uranium with heavy water as moderator). In the case of thorium, the required enrichment level to get a reactor critical is nearly 1.8%, for a specific case given in Figure-10, for example. As indicated in this figure, in this case, for thorium based fuel to reach the same level of discharge burn-up, it would need to have a higher enrichment of ^{235}U unless the levels of burn-up exceed about 40 GWd/tonne. In the early period of nuclear power deployment, such high burn-ups could not be readily achieved on account of materials related constraints. Currently, burn-ups higher than 40 GWd/tonne are readily achievable for several LWR designs. Therefore, with these capabilities existing now, it is possible to introduce thorium in current generation reactors where thorium offers several advantages, as listed below:

- Energy advantage (higher burn-ups for similar enrichment)
- Relatively stable core reactivity (depletion of fissile component compensated to a larger extent by generation of fresh ^{233}U)
- Low minor actinide generation (since the mass number of Thorium is 232 as compared to 238 for Uranium-238)
- Proliferation resistance (On account of very high gamma radioactivity associated with daughter product of radiation decay of ^{232}U, that will be always associated with ^{233}U)
- Rapid disposition of plutonium (on account of large neutron absorption cross section of thorium)

In view of these advantages, now there is a growing global interest in thorium. Thus while we are progressing in our development related to thorium on a continuously

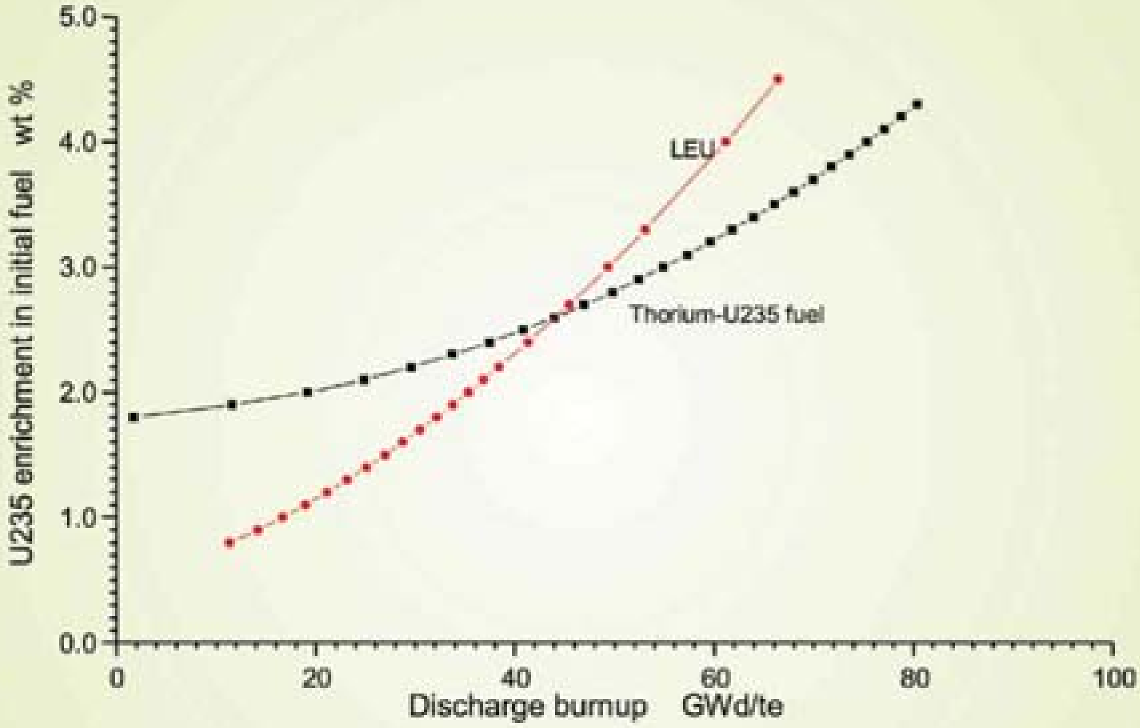


Figure 10: Performance potential of homogeneous mixture of fertile materials with ^{235}U in a PHWR

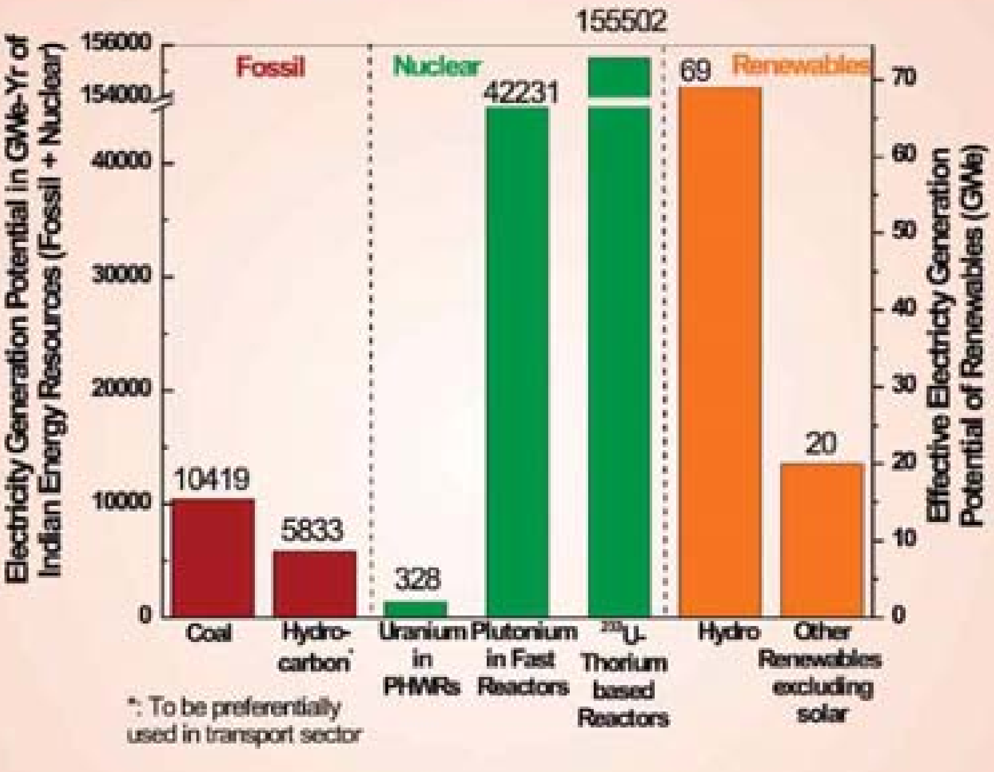


Figure 11: Current Indian Energy Resources

evolving technological front, and large scale deployment of thorium in India will take a while, we are in a unique position to collaborate with other interested countries.

Strategy for Long Term Energy Security

Figure-11 indicates the current Indian energy resources. The units used are in terms of effective electricity generation potential. It is obvious that the total energy content in the currently known Indian nuclear resources is at least twenty times higher than that in other non-renewable resources. This data has been converted to indicate years of depletion for electricity generation, if only a single source is to be used. This information is shown in Table-3. It may be noted that, in this table, the target electricity generation capacity in 2052 is indicated as 7957 TWh. This figure is based on a projection of needs for our growing economy. Similar estimates have also been made by Planning Commission with different GDP growth rates. According to DAE projections, India needs to reach a per capita electricity consumption of nearly 5000 kWh/y by the year 2050. A profile of this growth requirement is included in Figure-12.

Figure-12 shows a case, in which best use is made of all available non-conventional, hydro-electric, domestic coal, domestic hydrocarbon as well as domestic nuclear resources (in three stages). It may be noticed that, even after making use of all available domestic resources, it is impossible to meet the required electricity generation requirement profile. One could, of course, stretch the time line beyond 2050, and it would emerge that the exponential growth of contribution of nuclear power should eventually catch up with the requirement a few decades later. However, during the coming few decades, in order to meet the energy requirement driven by the Indian economy, there is a huge energy gap that needs to be filled. DAE has estimated that this deficit would be of the order of 412 GWe in the year 2050. If India is unable to import nuclear reactors or nuclear fuel under international co-operation, India must necessarily go for the import of coal to the tune of 1.6 billion tonne in the year 2050 alone, unless solar capacity grows at even large levels. Depending on external sources for a huge requirement of supply of coal on a regular basis would make a large country like India vulnerable to supply shocks.

Another study (Figure-13) shows that the gap between requirement and supply can be easily met if about 40 GWe capacity LWRs* are imported during the period 2012 2020. While this 40 GWe additional capacity, on its own, appears to be only a small fraction of the required capacity to meet the deficit, with the use of spent fuel of these LWRs for launching a series of FBRs, the deficit is practically wiped out in the year 2050. One may also note that, on account of exponential nature of the growth, in case the import of these LWRs (40 GWe) is delayed by a decade, the energy deficit in the year 2050 would be 178 GWe and the corresponding requirement for coal import will be 0.7 billion tonne (Figure 14). The latter is approximately twice the annual coal requirement in our country today. With this logic, it is obvious that with the import of LWRs (or, PHWRs, or uranium) as an additionality in the nearer term India can achieve full energy independence in a shorter time. Even much after the imported reactors reach the end of their life, the additional fuel inventory remaining in the country would help in satisfying our future energy requirements for a very long period in a sustainable manner.

Having stated the rationale behind the benefits of international co-operation to facilitate transfer of nuclear fuel/reactor to India, it must also be emphasised that DAE is leaving no stone unturned for extensive exploration of new uranium deposits in the country and also identify other avenues for securing a supply of uranium. Figure-15 indicates the major areas currently being explored in the country, including the thrust areas in Cuddapah basin in Andhra Pradesh, Mahadek Basin in Meghalaya and North Delhi Fold belt, Rajasthan and Haryana. The technologies to discover deep seated uranium deposits are also under development and deployment. A sufficiently large investment has been made for this

Table-3: Years of depletion for electricity generation by a single source

	Coal	Uranium in PHWR	Plutonium in Fast reactors	^{233}U-Thorium based reactors
Current rate (697 TWh)	130	4.12	211	>1950
2050 rate (7957 TWh)	11.5	0.36	18.5	>170

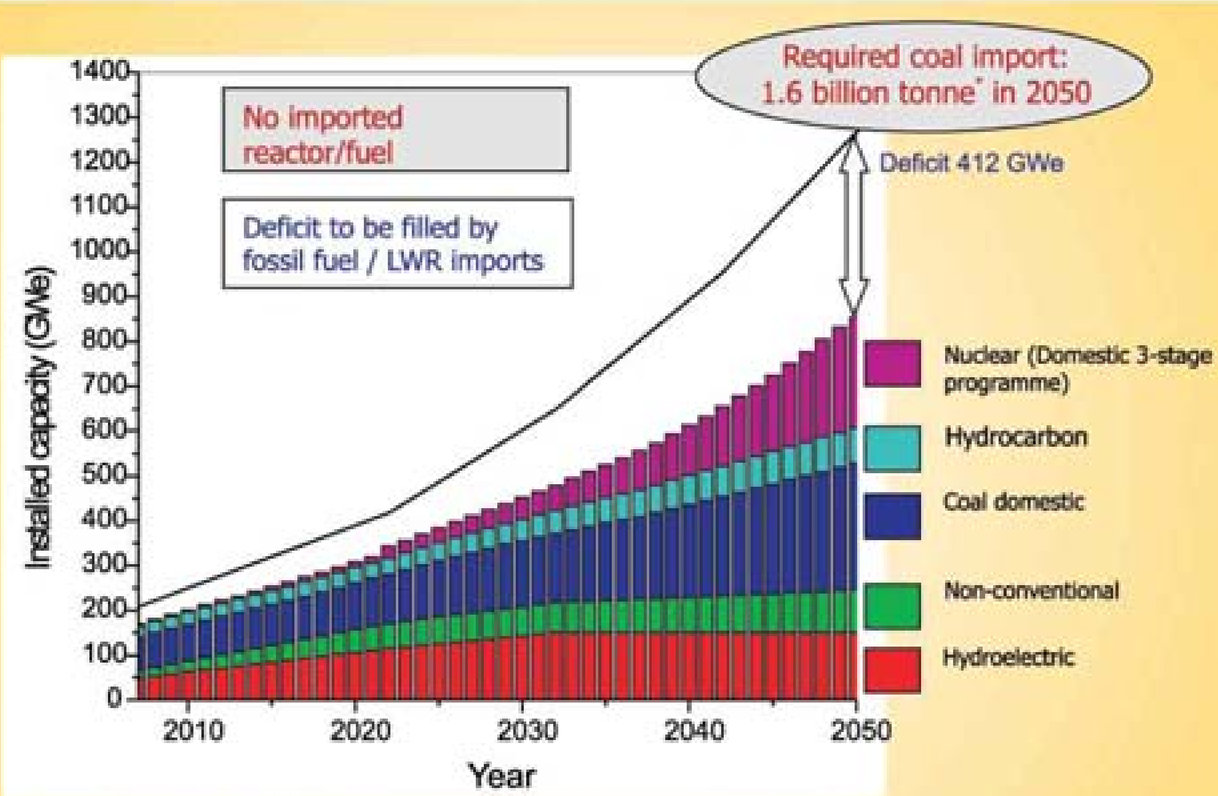


Figure 12: Profile of growth requirement

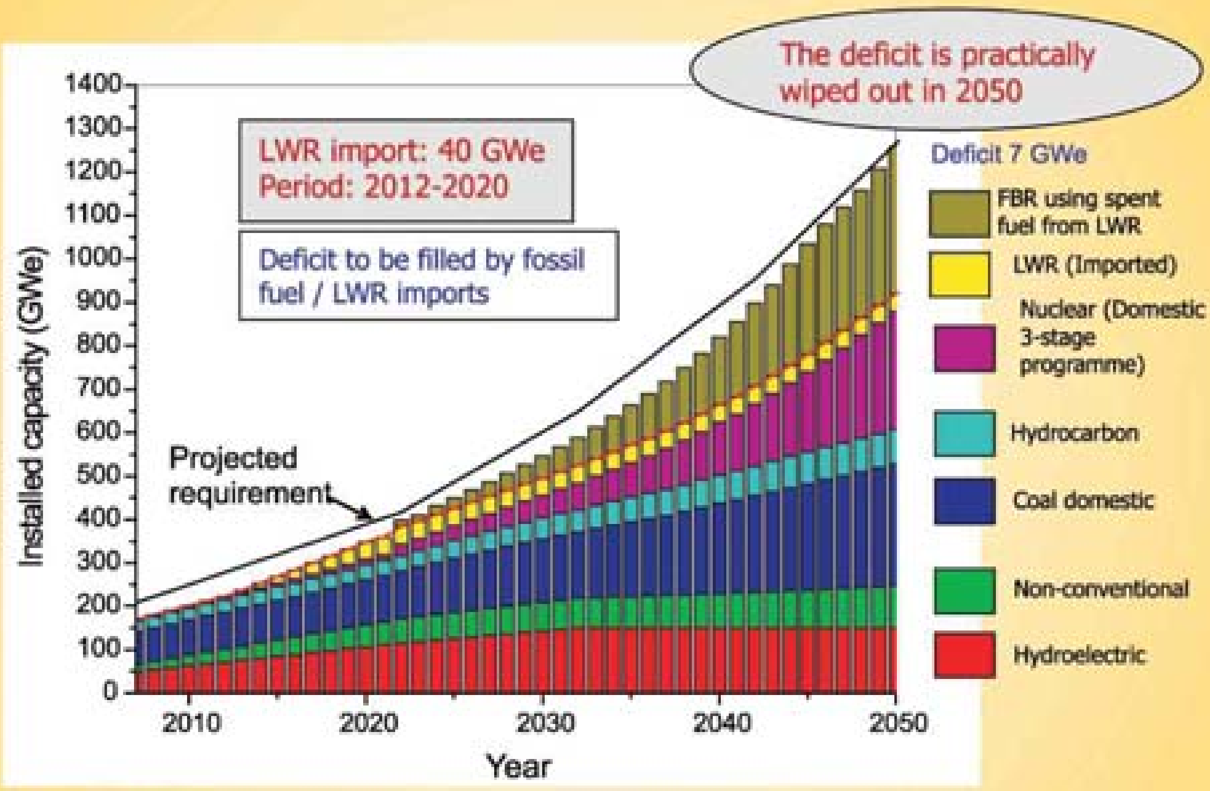


Figure 13: Import of 40 GWe LWR and the multiplier effect

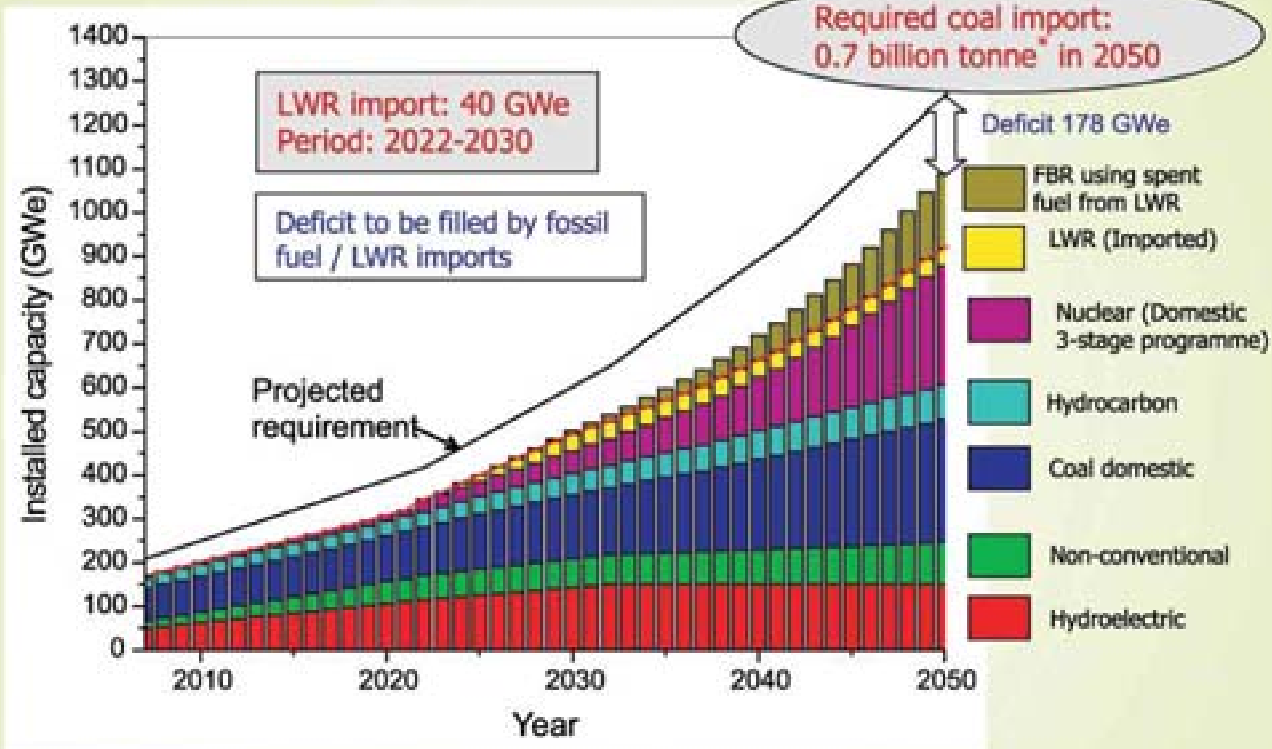


Figure 14: Effect of ten year delay in import of nuclear fuel/reactor

THRUST AREAS

(a) Cuddapah basin, Andhra Pradesh

(b) Mahadek Basin Meghalaya

(c) North Delhi Fold belt, Rajasthan and Haryana

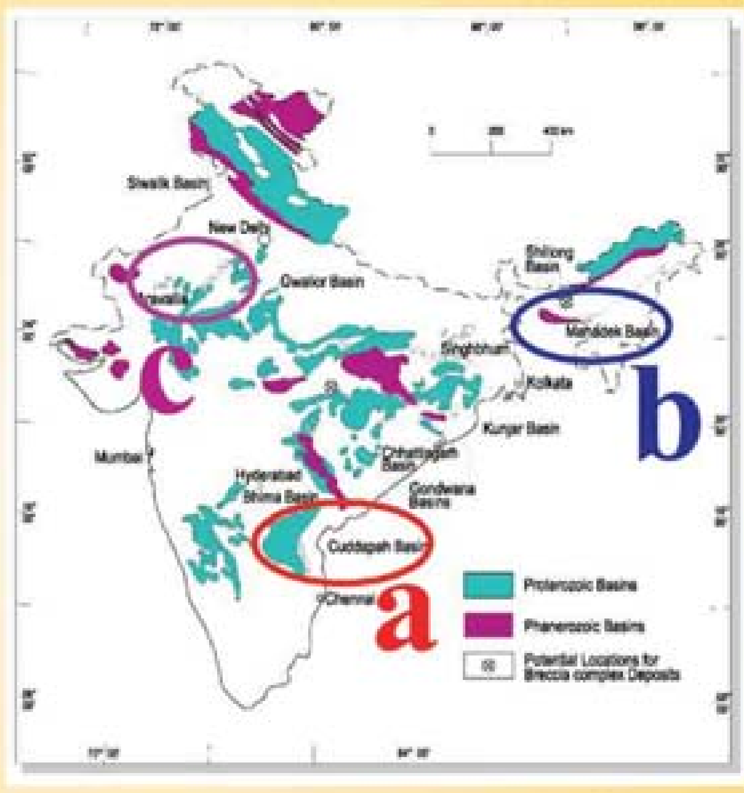


Figure 15: Augmentation of uranium resources

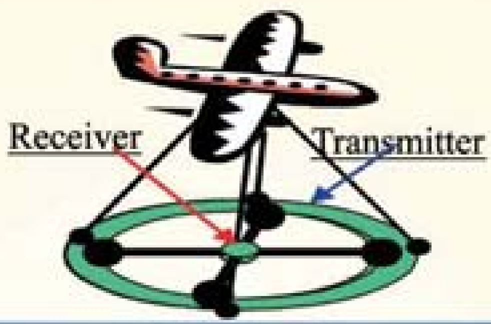


Figure 16: Time Domain Electro Magnetic System being tested at Rohil, Rajasthan

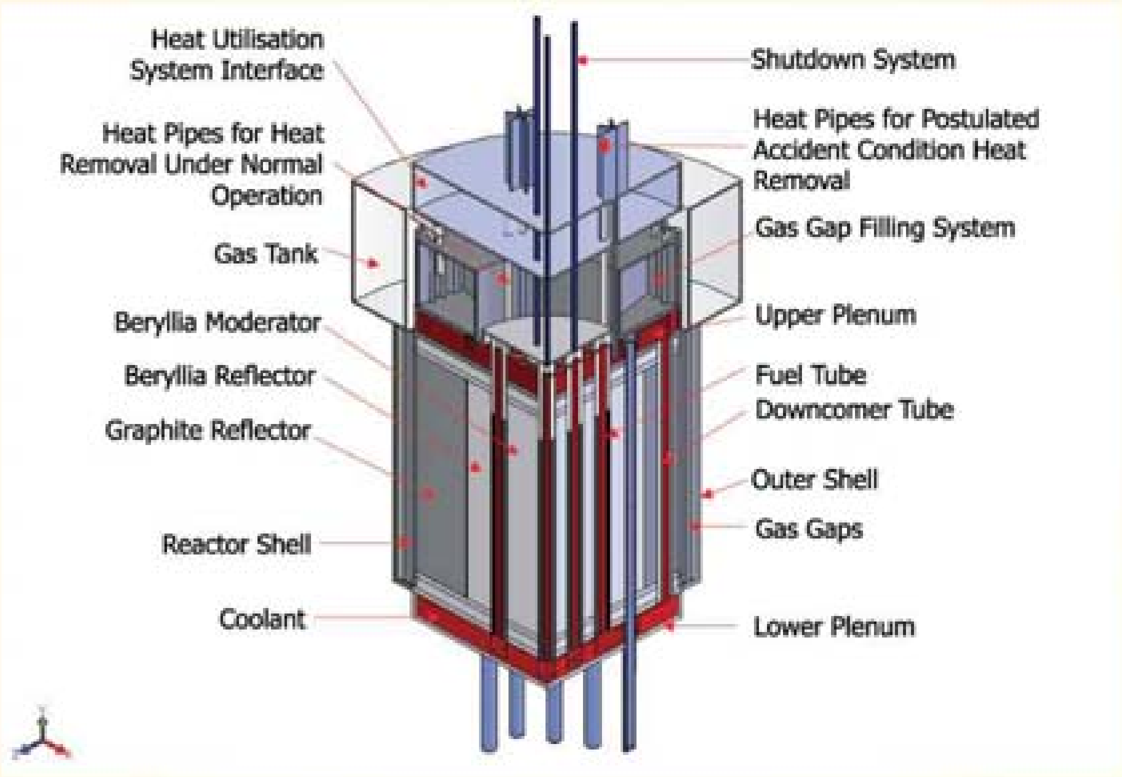


Figure 17: Compact High Temperature Reactor

purpose. New technologies in drilling and time domain electro magnetic survey are being implemented (Figure-16).

Advanced new technologies: Thorium and beyond

As discussed earlier, for the successful growth of our nuclear power programme, it is essential to deploy FBRs with short-doubling time. Use of metallic fuels is considered a very attractive approach to get short-doubling time in FBRs.

DAE has launched a programme for the timely development of the required technologies and the characterisation of metallic fuel before its deployment. For the purpose of reprocessing of these fuel materials, without leading to large releases of chemical waste, pyro-chemical technique offers a good solution. With this objective, a new focus on R&D in relevant molten salt technologies has been planned. Incidentally, molten salt is also one of the candidate coolant materials for the large-sized Indian High Temperature Reactor (HTR) for commercial level hydrogen production.

In the discussion so far, the thrust has been on the use of nuclear energy for meeting the electricity needs. It is, however, well known that the availability of oil and natural gas on a sustainable basis, and at affordable prices, will be severely jeopardised in the context of countries like India with a huge demand and very small domestic availability of these important natural resources. For meeting the requirement of fluid fuel for transport, it is therefore very important to develop alternate solutions that will reduce the dependence on imported oil and natural gas, with commensurate economic benefit in the longer run, and reduced vulnerability to supply shocks. Use of nuclear energy for the generation of fluid fuel is therefore an attractive option that is engaging the attention of researchers all over the world. DAE has focussed its attention on a range of technologies that are important for generation of hydrogen using water-splitting reaction. On one end, small scale efficient units for production of hydrogen using electrolysis have already been developed and deployed in BARC. For large scale production of hydrogen in a commercially viable manner, the high temperature processes for water splitting, having a high efficiency for energy conversion, are being considered. To drive this process, heat at the required temperature, of the order of 800 to 900°C, is needed. With this objective, a High Temperature Reactor programme has been initiated. The most important challenge for such reactors is the development of materials that can survive the aggressive environment for sufficiently long time. The development of the required refractory materials as well as the coolant (expected to be molten salt or molten lead) is in progress. At the same time, high temperature processes for hydrogen generation are being studied in BARC. A Compact High Temperature Reactor (CHTR) (Figure 17) has been designed to serve as a technology demonstrator for the production of high temperature process heat using nuclear energy. This reactor is proposed to be fuelled with the unique thorium ^{233}U based particle type fuel that has a capability to withstand temperature as high as 1600°C. The reactor is cooled with molten lead-bismuth alloy to deliver process heat at about 1000°C at the exit from the reactor core. This small demonstration reactor with a 100 kWth capacity has a core with a life of 15 years without refuelling.

In the field of nuclear fusion, internationally, a major effort is in hand under the umbrella of the International Thermonuclear Experimental Reactor (ITER) programme. ITER activity has reached a fairly advanced stage and it is planned that the project will be built at Cadarache in France. India has joined a select group of seven partners including the USA, European Union, Japan, Russia, China and South Korea to jointly carry out the work for providing special hardware items and required expertise in some selected special areas of this programme. The Indian contribution to this programme would be approximately Rs. 2500 crore.

While the main deliverables of DAE have focussed on nuclear related areas, the spin-offs arising out of the DAE's activities have also been contributing substantially to meet several national needs. DAE has made major contributions in the field of development and deployment of water desalination techniques. The work on hydrogen generation has been linked to the development of fuel cells, on which a programme is in an advanced stage. Our capability for high temperature heat removal using natural circulation, and also the capabilities in control and instrumentation, have been used for the design of a solar thermal power generation set up.

DAE runs a broad-based comprehensive scientific programme which includes setting up of large facilities for research thanks to the technological capability that has been built up. DAE's capability in the area of accelerators, super conductivity, cryogenics, radiofrequency (RF)/microwave, plasma technology, laser photochemical processes etc. is of vital importance in development of future technologies that would make increasing use of these technologies in programmes such as Accelerator Driven Systems and Fusion.

Special challenges

The entire saga of the growth of nuclear energy programme in India has an underlying thread of continuing emphasis on self-reliance. This strategy will continue in the future. For a large country like India, we need to preserve our knowledge and protect and enhance our capabilities, while remaining immune to the vulnerabilities. We further need to make sure that the required human resource support for the DAE programmes remains available at the required levels, in terms of numbers as well as quality. In view of this, we have laid further enhanced emphasis on education and training in the recent past. These new initiatives have taken the form of, for example, National Initiative in Undergraduate Sciences, University Grants Commission-DAE consortium for Scientific Research, DAE Graduates Fellowship Scheme (DGFS), DAE-MU CBS, National Institute of Science Education and Research (NISER) etc. It has also been recognised that it is important to promote basic research in a focussed manner, so that strong bridges are built between basic research and technology. Several initiatives in this direction have been already in place. Homi Bhabha National Institute and Board of Research in Nuclear Sciences are two examples.

Technology News

Micropropagation of Banana

Banana is a globally important fruit crop with 97.5 million tones of annual production. In India, banana contributes 37% of the total fruit production and ranks second in importance next to mango. The state of Maharashtra ranks second with respect to the land under the cultivation but first in its production of banana with 60 T/ha per annum.

Edible bananas do not produce seeds and are traditionally grown vegetatively through suckers (5 to 10 in number depending on the variety). Thus low rate of multiplication limits this method severely. In the recent years, tissue culture propagation of banana through shoot tip as well as floral aspices has been utilized to increase banana production.

The process involves initiation of cultures from sterilized shoot tips obtained from the parent banana plant, shooting and rooting in the test tube, primary hardening in the laboratory, secondary hardening in the nursery and plating in the field.

Advantages of Tissue Cultured Banana are as follows :

- Disease free elite varieties,
- Rapid multiplication & early harvesting,
- Uniform size and age of plants,
- High quality fruit bunches, and
- Available throughout the year

Requirements

Infrastructural requirements:

A tissue culture laboratory, a green house or poly-house facility and an agricultural plot for planting

Equipment Requirement:

Standard glassware for media preparation and sterilization equipment like autoclave required for a tissue cultured laboratory

Manpower Requirement:

Two technicians (preferably trained in a tissue culture laboratory) for laboratory work and other ancillary staff.

Capital Cost :

Approximate cost for setting up of a medium size plant requires around 25 lakhs.

Banana Juice Extraction Process

Banana production in India accounts for over 20% of total banana produced in the world. A comparatively short post-harvest shelf-life of banana coupled with a dearth of sufficient and good quality transportation as well as storage facilities leads to perishing of 35-40% of this highly nutritious fruit before it reaches the consumer. One effective method of reducing this huge loss would be to extract the juice out of the fruit before it perishes and preserve it. As of now, no commercially established process is available to achieve this. A novel lab-scale process has been developed at BARC for extraction of juice from banana and production of banana powder as a by-product.

The Process

The moisture content of banana is in bound form as against that in many other fruits like apples and citrus fruits. The BARC process achieves separation and extraction of juice through a series of operations such as blending, churning, autoclaving and centrifuging. Clear juice with a yield of upto 55%(w/w) is obtained without addition of any enzymes and can be stored upto 3 months inside a cold storage at a temperature below 40C, without adding any preservatives. The remaining pulp is converted into fine banana powder through freeze-drying followed by grinding.

The juice is clear and viscous liquid with a distinct banana flavour. The composition of the juice obtained from fully ripened Cavendish Banana is -- sugar 25 to 35 %, solids 25 to 27%, specific gravity 1.07 to 1.14 and the pH ranging from 4.5. to 4.8. The ripe banana powder, the by-product of the process is a fine and free-flowing hygroscopic powder dark brown in colour. It has a composition of sugar 15-20%, soluble fibre 1.3%, protein 3% and insoluble material 75-80%.

The juice can be used as a beverage base and a health drink. The banana powder can be used as a substitute for flour in cakes and biscuits, as a flavoring agent in milk or for preparing baby food. It can also be a good choice of food-base for patients of diabetes owing to its low sugar content

Requirements

Infrastructure Requirements:

A covered space of around 200 sqm, water supply , 3-phase electricity supply

Equipment Requirement:

Blender, drum rotator, autoclave, centrifuge, cold storage, freeze dryer

Statutory Requirements:

Statutory clearances related to food industry and a minimum of a small scale industries registration.

Manpower Requirements :

Two technicians for handling the equipment and one helper for sundry work.

For details contact :

Head, Technology Transfer & Collaboration Division, Bhabha Atomic Research Centre,
Trombay, Mumbai - 400 085
Tel : 091-022-25505337/25593897
Fax : 091-022-25505151

Technologies for Land Leveling System and Compact Nitrogen Laser Module

The technologies of Laser assisted Land Leveling System and Compact Nitrogen Laser Module, developed at the Raja Ramanna Centre for Advanced Technology at Indore, Madhya Pradesh are also available for transfer to Industry.

Laser Land leveling system is useful for precision Land leveling for agricultural and civil engineering purposes. It consists of a Laser Plane generator, a scale mounted sensor for topography mapping and a control box for mounting on a tractor where it can automatically control the scrapper bucket at a constant level with respect to the laser plane. The system can also be adapted to operate with earth movers.

Technology for this instrument has been transferred by the Raja Ramanna Centre for Advanced Technology to OSAW Udyog, Ambala. As the transfer of technology is non-exclusive in nature, other interested parties may also contact for technology transfer.

Parties with good financial background, experience in mechanical and electronics fabrication, preliminary knowledge for handling optical components, having capability for handling precision tools/jigs, skilled manpower and having or interested in setting-up facilities for production of this equipment can contact the following for transfer of technology :

Dr. P. K. Gupta,
Outstanding Scientist and Head, LBAID,
Raja Ramanna Centre for Advanced Technology,
Indore - 452 013, M.P.
Email: pkgupta@cat.ernet.in

The compact sealed-off Nitrogen Laser module measuring 145mm X 75mm X 50mm is available for transfer to entrepreneurs. The module contains a sealed-off metal-ceramic Nitrogen Laser tube, developed in-house. The laser module is self contained with all the high voltage circuitry integrated in the module and requires a 12V dc power supply for its operation. The technology of this system is available for transfer.

Specifications:

Wavelength : 337 nm
Peak Power : 150 kW
Pulse output : 50 μJ
Repetition rate : 10 Hz
Power Supply : 12 V, 500 mA, DC
Dimensions : 145mm X 75mm X 50mm

Interested parties with experience in vacuum and glass blowing techniques, having expertise in handling optical components, capable of handling precision tools/jigs, can send their enquiries to the address given above.

DAE LINKS

Research Centres

www.barc.ernet.in
www.igcar.ernet.in
www.cat.gov.in
www.veccal.ernet.in
www.amd.gov.in

Industrial units

www.heavywaterboard.org
www.nfc.gov.in/default.htm
www.britatom.gov.in

Public Sector Undertakings

www.npcil.org
www.bhavini.nic.in
www.ucil.gov.in
www.irel.gov.in
www.ecil.co.in

Grant-in-Aid Institutes

www.tifr.res.in
www.saha.ac.in
www.tatamemorialcentre.com
www.mri.ernet.in
www.iopb.res.in
www.imsc.res.in
www.plasma.ernet.in
www.aees.gov.in

20th All India Essay Contest in Nuclear Science & Technology

The Department of Atomic Energy (DAE) invites essays as per following details written in any official Indian language or in English, from regular full time students studying in India for graduation (after 10+2) in any discipline, in a university or an institute deemed to be a university. The essays should be submitted by a single author. Those who have won prizes (including consolation prize) in DAE's earlier essay contests are not eligible.

Topics

In view of the forthcoming "Bhabha Centenary Year (October 30, 2008 - October 30, 2009)", all the participants should write a common essay on "Dr. Homi J Bhabha: Founder and Architect of India's Atomic Energy Programme". This should include a historical account of Dr Bhabha's achievements highlighting: • his early life, education and scientific career, • his personality, love for the Fine Arts, • Dr Bhabha's role in establishing Atomic Energy in India, • his International role in peaceful applications of atomic energy, • his vision and its relevance in today's energy scenario and • tribute to Dr Bhabha going beyond his dreams.

This common essay should not exceed 1000 words and should be followed by a detailed essay not exceeding 1500 words on any one of the following topics:

1. Powering India : Nuclear Power for Sustainable Development

• Introduction : Power scenario, Resources, Importance and inevitability of nuclear power, • Necessary infrastructure : Front and back end of the Nuclear Fuel Cycle including Heavy Water Production and other industrial infrastructure; Strengths and present constraints of the available infrastructure, • Present status and future plans, • Civil nuclear cooperation, • Public perceptions about nuclear energy : Myths and Realities.

2. Nuclear Techniques in the Service of Mankind Indian Scenario

• Radioisotopes and their production, • Applications of Radioisotopes and Radiation in agriculture and food preservation, Water resources development and management, waste and effluent treatment, • Nuclear medicine radiopharmaceuticals in diagnostic and therapeutic applications, • Industrial applications Nondestructive technique, gamma scanning etc, • Status of Nuclear Techniques in India in the global context, • Safety aspects of the use of nuclear techniques in the service of mankind.

3. Electron Beam Technology : Journey from Cathode Rays to Large Accelerators :

• Discovery of cathode rays, early developments and their applications like x-rays, TV etc, • Evolution from cathode rays to Beam Technology, • Industrial Applications of Electron Beam devices for melting, welding, and evaporation of materials (material processing) etc, • Industrial Electron Accelerators and Radiation Processing Applications, water and air pollution control and national security related applications like cargo scanning, • High Energy Electron Accelerators and applications in basic sciences : Current status and future prospects in India, • International collaboration in Electron Accelerators.

How to send the Essay

The essay should be sent to the address given below directly by the contestant, along with bonafide studentship certificate from the principal of his/her College/Institute. No essay will be accepted if sent by E-mail or Telefax. The participant shall write his/her name, College/Institute and address on a separate detachable sheet only. Name or address should not be written elsewhere on the text of the essay.

Note: Essays not conforming to the said guidelines are likely to be disqualified.

Mode of Selection

After initial screening and evaluation, a maximum of thirty six essays will be selected and their authors will be invited to Mumbai in the last week of October 2008 for an oral presentation of the essays. Final selection will be made on the basis of combined performance in oral presentation and quality of the essay. Only the candidates short-listed for oral presentation will be informed. No other correspondence in this matter will be entertained. Those called for oral presentation in Mumbai shall be eligible for:

A) To and fro AC 3-Tier rail fare by the shortest route. Claim for reimbursement of rail fare for journey performed by Rajdhani/August Kranti/Shatabdi Express will be restricted to AC 3-Tier by ordinary Express/Mail train.
B) Boarding and lodging in the Guest House of BARC at Anushaktinagar, Mumbai during the authorized period of stay.

Prizes

First Prize (3 nos.): Rs.15,000/
Second Prize (3 nos.) : Rs 10,000/-
Third Prize (3 nos.): Rs 5,000/-
*Consolation Prizes : Rs 2,000/-

**To all those who make oral presentation but do not secure first, second, or third prize.*

The prizes will be distributed on the Founder's Day (October 30, 2008), which is the birth anniversary of late Dr. Homi J. Bhabha.

THE LAST DATE FOR RECEIPT OF ESSAY IS SEPTEMBER 1, 2008

Address for sending the essays:

Assistant Administrative Officer, Public Awareness Division, Department of Atomic Energy, Government of India, Anushakti Bhavan, CSM Marg, Mumbai 400 001.

This advertisement is also available on www.dae.gov.in

BARC Transfers Know-how of "Back Washable Spiral Ultrafiltration Technology for Domestic & Industrial Water Purification"

The Back Washable Spiral Ultrafiltration Technology for Domestic & Industrial Water Purification, developed by the Desalination Division of BARC, was transferred by BARC to M/s Concord Enviro Systems Pvt. Ltd., Mumbai, on March 19, 2008. The technology consists of preparation of ultrafiltration membrane, its assembly in spiral configuration and finally making of backwashable spiral ultrafiltration membrane device for water purification.

The backwashable spiral ultrafiltration device has got a membrane of average pore size <10 nm (nanometre) and can be used at community level water purification for removal of microorganisms like bacteria, viruses etc. and colloidal species. In view of its relevance in providing safe drinking water, particularly for waters contaminated with microbiological organisms and turbidity, the technology is useful for societal applications. This technology can also be used for industrial effluent treatment and in Reverse Osmosis Plants for pretreatment. The key features of this technology are : i) Preparation of polysulfone UF membrane in sheet form having width up to 1000 mm, ii) Assembly and housing of these UF membranes in a compact spiral configuration which allows the operation of module in large capacities, and iii) Backwashing procedure for its repeated use without the loss of productivity by restoring stabilized pure water flux.

Photograph after the signing of the agreement with M/s Concord Enviro Systems Pvt. Ltd., Mumbai.

Inside the frame (left to right) : Shri A.M. Patankar, Head, Technology Transfer & Collaboration Division, BARC, Shri Kamlesh Goel, Managing Director, Concord Enviro Systems Pvt. Ltd., Shri B.P. Sharma, Director, Chemical Engineering Group, Shri Prayas Goel, Vice President, Concord Enviro Systems Pvt., Ltd., and Dr. P.K. Tewari, Head, Desalination Division, BARC.

Outside left of frame (left to right) : Shri V.S. Somarajan, Smt. Payel Sarkar, Shri Sushil Tiwari, Dr. R.C. Bindal, and Shri D.D. Goswami, all from Desalination Dn., BARC.

Outside right of frame (left to right) : Dr. S. Prabhakar, Head, STS, Desalination Dn., Smt. S. Mule, Shri T.H. Salunke, Shri V.K. Upadhyay, all from Technology Transfer & Collaboration Dn., BARC.

Those Years... These Months...

A compilation of important events during these months in the history of DAE.

Ravi Shankar, Hd AVORP, PAD,DAE

June 1, 1945

Tata Institute of Fundamental Research (TIFR) is set up at Mumbai as a result of the initiatives of Dr. Homi J.Bhabha. On December 19, 1945 TIFR is inaugurated.

June 1, 1967

Power Projects Engineering Division (PPED), Mumbai is formed. The Division is subsequently converted to Nuclear Power Board on August 17, 1984.

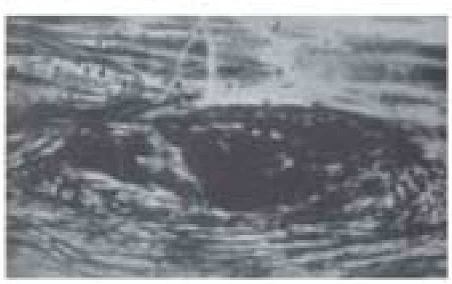
May 01, 1969

Heavy Water Projects is constituted in Mumbai. Later this becomes Heavy Water Board.

May 18, 1972

Research Reactor PURNIMA-I attains criticality.

May 18, 1974



Peaceful underground Nuclear Experiment is conducted at Pokhran, Rajasthan.

June 16, 1977

Variable Energy Cyclotron becomes operational in Kolkata.

May 10, 1984

Research Reactor PURNIMA-II, a Uranium-233 fuel based reactor attains criticality.

May 16, 1991

First Electron Cyclotron Resonance (ECR) heavy ion source of the country becomes operational at the Variable Energy Cyclotron Centre, Kolkata.

1992

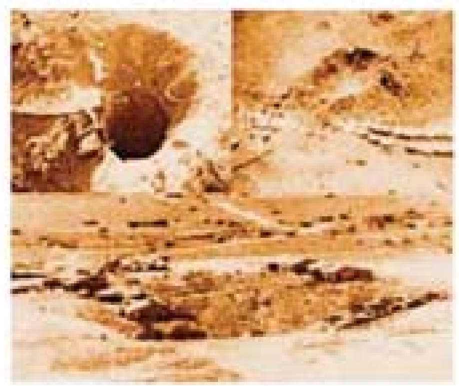
Mehta Institute of Mathematics and Mathematical Physics, Allahabad, Uttar Pradesh, (now Harish Chandra Institute of Mathematics and Mathematical Physics), comes under the DAE umbrella, as a grant-in-aid institute.

1992

First remotely operated radiography camera is launched.- Significant heavy mineral concentration along the East Coast, Andhra Pradesh, is identified.

- New Thorium Plant at OSCOM, Chhattrapur, Orissa is commissioned by IRE.

May 11 & 13, 1998



Five underground nuclear tests are conducted at Pokhran Range, Rajasthan.

May 27, 1998

Unit-2 of Rajasthan Atomic Power Station is recommissioned after enmasse replacement of coolant channels .

March 30 & May 10, 2002

First pours of concrete respectively of Unit-3 & Unit-4 of Kaiga Atomic Power Project-3&4 are carried out.

June 4, 2005

Setting up of Homi Bhabha National Institute (HBNI) at Mumbai is announced. The institute a deemed university under the aegis of DAE is formed with the objective of accelerating the pace of basic research and translation of basic research into technology development.

June 4, 2005

TAPS 4 synchronised to the grid

May 21, 2006

The 540 MWe Unit-3 of Tarapur Atomic power Project (TAPP-3) attains criticality.

May 6, 2007

Unit-3 of Kaiga Atomic Power Project declared commercial.

June 25, 2007

The first Opencast Uranium Mine of Uranium Corporation of India Limited (UCIL), inaugurated at Banduhurang. A Uranium Ore Processing Plant, also of UCIL inaugurated at Turamdih in Singhbum (East) district of Jharkhand.

Nuclear Fuel for Kudankulam N-Plant arrives

The first consignment of Uranium fuel for unit-1 of Kudankulam Nuclear Power Project (KKNPP), arrived on May 25, 2008. KKNPP comprising two units of 1000 MWe each are at an advanced stage of completion in technical collaboration with the Russian Federation. The two units belong to advance design of VVER family, a pressurized water reactor constituting majority of power reactors in the world. These reactors use light enriched uranium (LEU) as fuel. This kind of fuel is in use in VVER 1000 MWe units in several countries around the world since 1980s and has given excellent performance. The life time fuel supply for Kudankulam reactors is covered through a sovereign guarantee of Russian Federation.

The KKNPP is under construction at Kudankulam in Radhapuram taluk of Tirunelveli district of Tamilnadu. The Kudankulam Nuclear Power Project is being set up through a bilateral agreement between the former USSR and the Republic of India. The construction activities are being carried out round the clock for an early completion of the project. A physical progress of about 86% has already been achieved. All the major components have already been erected at site. Concurrently the pre-commissioning activities have already commenced. Indian engineers and scientist have also been trained and qualified for commissioning, operation and maintenance activities.

R. No. 9002/62

Symposia News

National Symposium on Science & Technology of Glass and Glass-Ceramics

The Materials Research Society of India (MRSI) Mumbai-Chapter, in association with Bhabha Atomic Research Centre (BARC), Central Glass & Ceramic Research Institute (CGCRI) and Indian Society of Scientific Glassblowers (ISSG) Mumbai-Chapter will be organizing a National Workshop on Glass-to-Metal and Ceramic-to-Metal seals (NWGCS) and a National Symposium on Science & Technology of Glass and Glass-Ceramics (NSGC-08) in BARC Mumbai during October 13-17, 2008.

The Workshop on Glass-to-Metal and Ceramic-to-Metal seals will provide an opportunity to scientific glassblowers to have interaction with eminent glass technologist in the country and practical training and exposure in the various aspects of glass-to-metal and ceramics-to-metal seals.

The Workshop will cover lectures on :

- General introduction to glass,
- Fabrication processes in Glass-to-Metal seals,
- Fabrication processes in Ceramic-to-Metal seals,
- Inspection and testing, and
- Safety procedure /gadgets

In addition, the Workshop will organise practical training / demonstration, and a Factory visit.

The Symposium on Science & Technology of Glass and Glass-Ceramics will have special emphasis on glass and glass-ceramics materials having applications in laser, radioactive waste management, radiation shielding, space research, communication, sealants, biomaterials etc. It will provide a common platform for different researchers/technologist and industry to share their experiences/expertise related to these technologically important areas.

Following aspects of glasses and glass-ceramics will be discussed in the Symposium:

- Physics/ Chemistry and Engineering,
- Laser applications-materials, properties, devices,
- Radiation resistance shielding /optics,
- Radioactive waste management-materials, properties, long term behaviour,
- Encapsulation/sealing materials, properties, interface behaviour,
- Biomedical and energy related applications,
- Space applications,
- Glass fibers and applications,
- Synthesis/production-techniques, new methods/ issues,
- Devices and related instrumentation, and
- Industrial perspective in Indian context.

For further details, please contact :

Dr. G. P. Kothiyal,
Convener, NSGC-08,
Technical Physics and Prototype Engineering Division, Bhabha Atomic Research Centre
Trombay, Mumbai-400 085.
Phone: 91-22-25595652

Fifth International Conference on Creep, Fatigue and Creep-Fatigue Interaction

The Fifth International Conference on Creep, Fatigue and Creep-Fatigue Interaction will be organized during September 24-26, 2008, at the Indira Gandhi Centre for Atomic Research, Kalpakkam, Tamilnadu.

For further details please contact:

Dr. M.D. Mathew,
Convener, CF-5,
Head, Creep Studies Section,
Indira Gandhi Centre for Atomic Research,
Kalpakkam - 603 102, Tamil Nadu.
Tel: +91 - 44 - 2748 0500 Extn.22271(Office)
Fax: +91 - 44 - 27480075
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