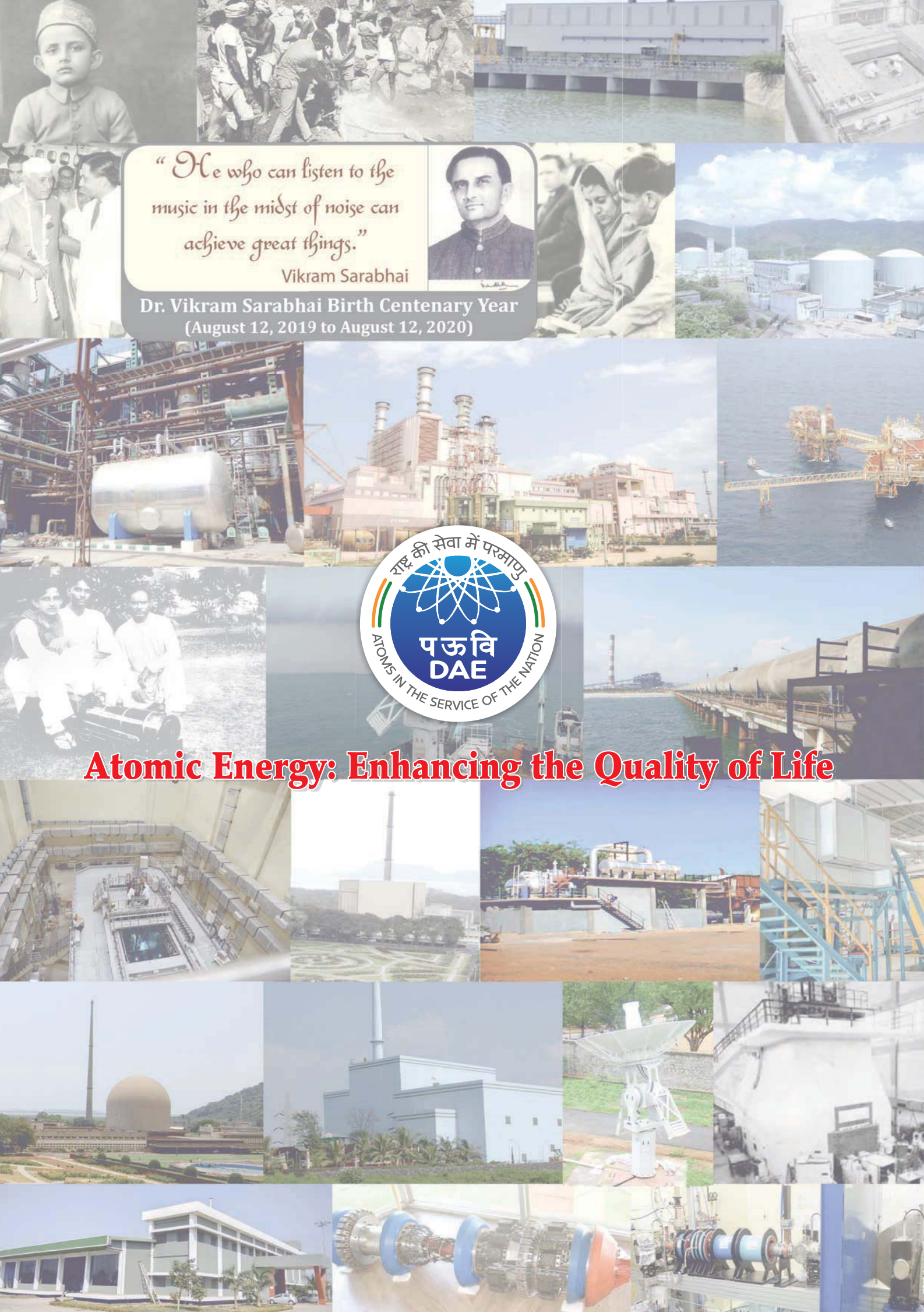


"He who can listen to the music in the midst of noise can achieve great things."

Vikram Sarabhai

Dr. Vikram Sarabhai Birth Centenary Year
(August 12, 2019 to August 12, 2020)

राष्ट्र की सेवा में परमाणु

पऊवि
DAE

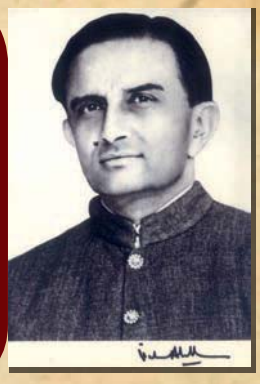
ATOMS IN THE SERVICE OF THE NATION

Atomic Energy: Enhancing the Quality of Life

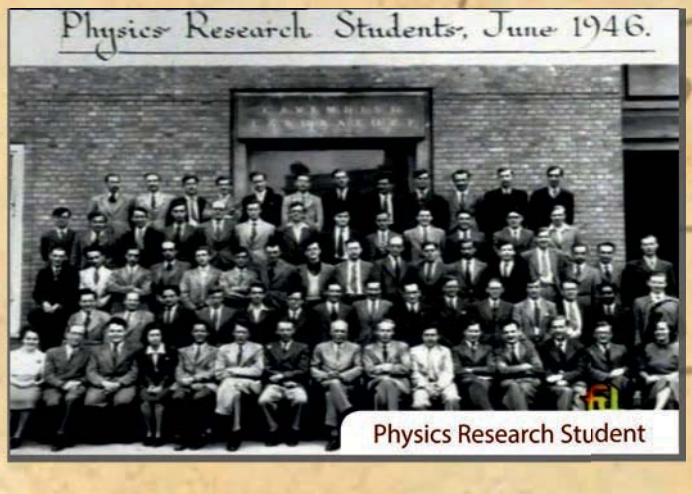
A GREAT SCIENTIST & TECHNOCRAT
Dr. VIKRAM SARABHAI

Dr. VIKRAM SARABHAI - THE FIRST CHAIRMAN,
HEAVY WATER PROJECTS BOARD
(CONSTITUTED ON MAY 01,1969)

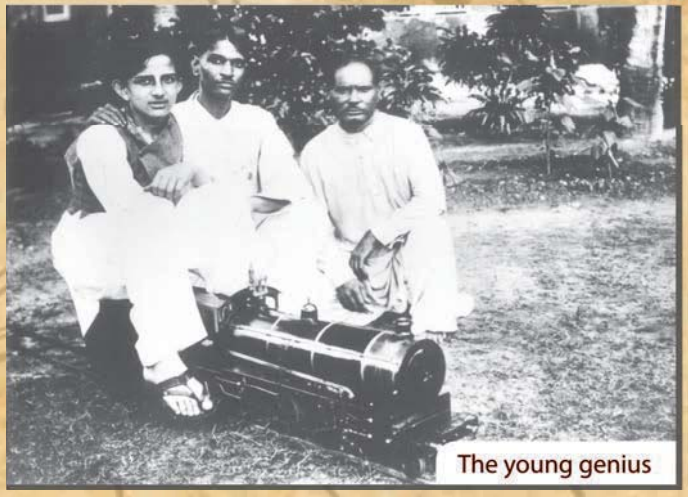
"He who can listen to the music in the midst of noise can achieve great things."
Vikram Sarabhai



Scientist In Making



Physics Research Student


The young genius


A child prodigy with Shri. Rabindranath Tagore

Dr. Vikram Sarabhai addressing gathering speaking on Heavy Water

Indigenous production of Heavy Water on a large scale is essential to meet the requirements of Heavy Water Moderated Reactors

August 07, 1969
Signing of contract for HWP Baroda

May 1970
Sanction of HWP Kota (100 Te/year)

April 10,1971
Signing of agreement for HWP (Tut)

Pearls of Wisdom given to a Young Scientist of HWB from a Golden Heart Dr. Vikram Sarabhai (Probably his last ones)

Young man, have you people made Heavy Water earlier? No. Isnt it? When the country can put faith in the project team for making Heavy Water for the first time, why cant you put faith in the new company for fabricating exchangers for the first time

THERE IS ALWAYS A FIRST TIME WHICH SHOULD NOT COME IN THE WAY FOR DEVELOPING PEOPLE AND TECHNOLOGY.

HEAVY WATER BOARD (HWB) HAS FULFILLED THE DREAM OF THIS VISIONARY

India formally joined the ITER Project in 2005 with Institute of Plasma Research, DAE being the nodal organisation where R&D and experimental activities are being carried out.

DAEs Contributions to ITER

- Cryogenic Systems
- Sub-systems
- RF Heating Systems
- Power Supplies
- Diagnostic Tools

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY (LIGO)
Sensing Ripples in Space Time

An observatory to detect gravitational waves from the most violent events in the Universe. Enriches multi messenger astronomy complementing the conventional means using visible Gamma and Cosmic Ray Observations.

Objectives

Setting up an Advanced Gravitational Wave Detector to increase sensitivity and positional accuracy of gravitational wave detections in India at Hingoli, Maharashtra.

Establishing Neutron Research Facilities for studies in Condensed Matter Physics, Biology, Material Sciences & Engineering and energy security of the country and paving the way for future advances in Accelerator Technology.

INDIAN INSTITUTES AND FERMILAB COLLABORATION (MFC)
Pushing The Boundaries in Particle Accelerator Technology

IIFC is a collaborative R&D programme on Accelerator and Particle Detector Research and Development for Discovery Science to be undertaken by four U.S. Laboratories (including Fermilab) and four Indian Institutions.

Powerful particle beams generated from the most advanced accelerators will help solve the mysteries of the basic building blocks of the Universe and the forces between them.

Scope

Development of the accelerator physics designs for superconducting LINACS, Cavities and Cryomodules, Superconducting Radio Frequency (SRF) infrastructure, RF Power Sources, Instrumentation, Controls and Cryogenics.

Deliverables

Contributions to the High-intensity superconducting proton accelerators including the Proton Improvement Programme PIP-II project of Fermilab and two accelerators to be constructed in India.

Establishing Neutron Research Facilities for studies in Condensed Matter Physics, Biology, Material Sciences & Engineering and energy security of the country and paving the way for future advances in Accelerator Technology.

THIRTY METER TELESCOPE (TMT)
Astronomys Next-Generation Observatory

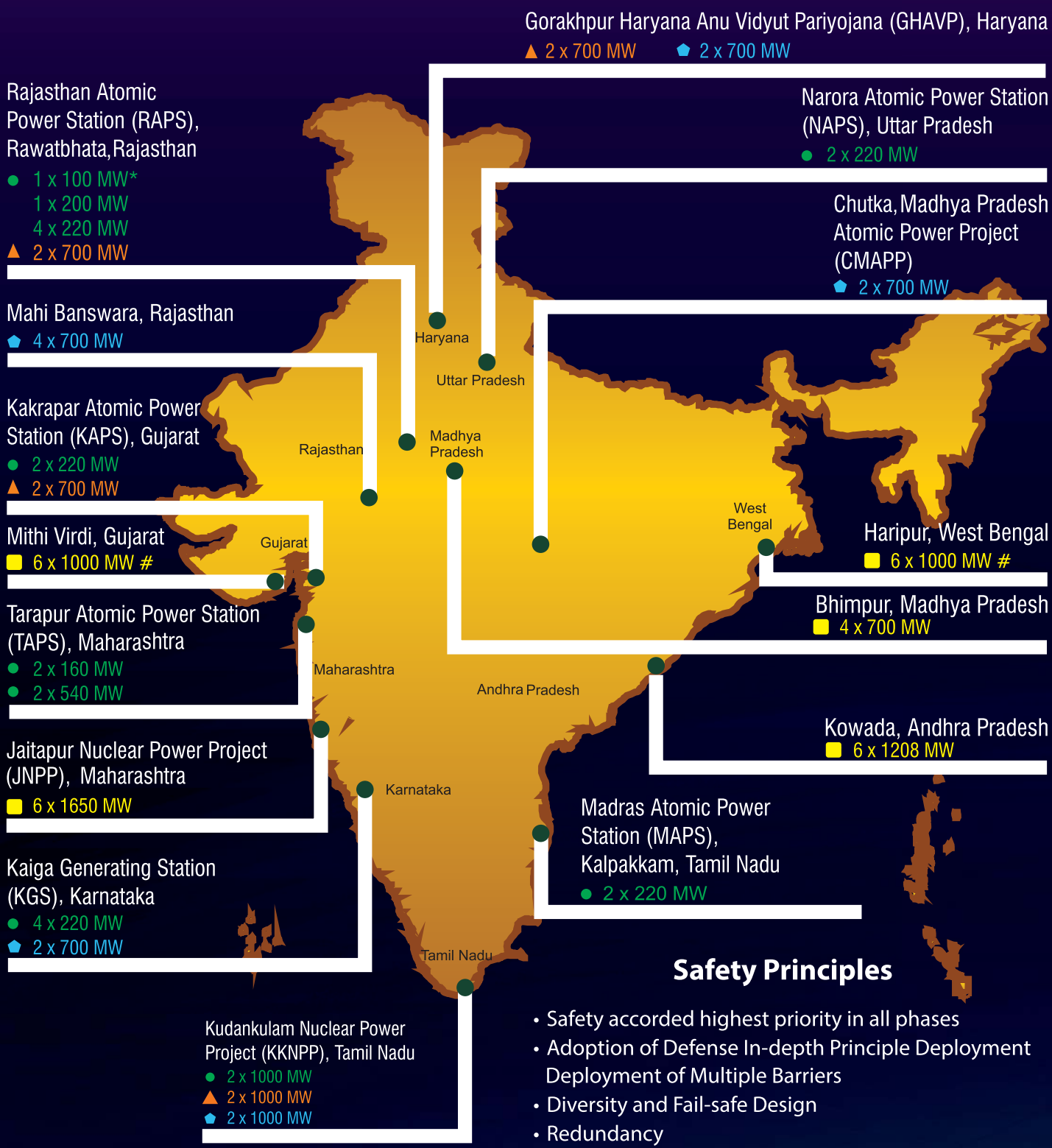
Very large aperture (30 metre) telescope being built by an international consortium of institutes and universities in Canada, China, India, Japan and the USA at Mauna Kea in Hawaii.

India-TMT Coordination Centre (ITCC) is established at IIA, Bengaluru with ITCC as its implementing body. It will allow us to see deeper into Space and observe cosmic objects with unprecedented sensitivity.

- TMT will explore and provide hitherto unavailable information on The mysterious period of the first stars and galaxies in the life of the Universe
- The formation and development of the large- scale structures
- The physics of the early Universe and the nature of Dark Matter
- The study of Black Holes
- Exoplanets leading us closer to finding out if life exists beyond the Earth

RESHAPING OUR ENERGY FUTURE

NUCLEAR POWER CORPORATION OF INDIA LIMITED



Safety Principles

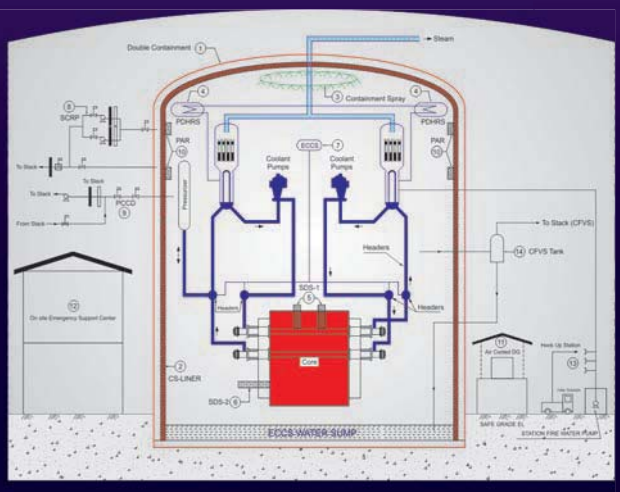
- Safety accorded highest priority in all phases
- Adoption of Defense In-depth Principle Deployment Deployment of Multiple Barriers
- Diversity and Fail-safe Design
- Redundancy
- Robust Regulatory Mechanism
- Operation by Trained and Licensed Manpower

● Plant Under Operation
▲ Plant Under Construction
⬟ Projects Accorded Administrative Approval & Financial Sanction
■ Sites Accorded in Principle Approval
Nominal Capacity

Capacity in Operation (6780MW)
Capacity Under Construction (6200MW)
*Out of these units, RAPS-1 (100 MW) is owned by the DAE and managed by NPCIL

Safety Features in 700 MW PHWRs

- Double Containment
- Carbon Steel Liner
- Containment Spray System
- Passive Decay Heat Removal System
- Shut Down System-1
- Shut Down System-2
- Emergency Core Cooling System
- Secondary Containment Recirculation Page System
- Primary Containment Controlled Discharge
- Passive Autocatalytic Recombiner
- Air Cooled Diesel Generator
- On-site Emergency Support Centre
- Containment Filtered Venting System

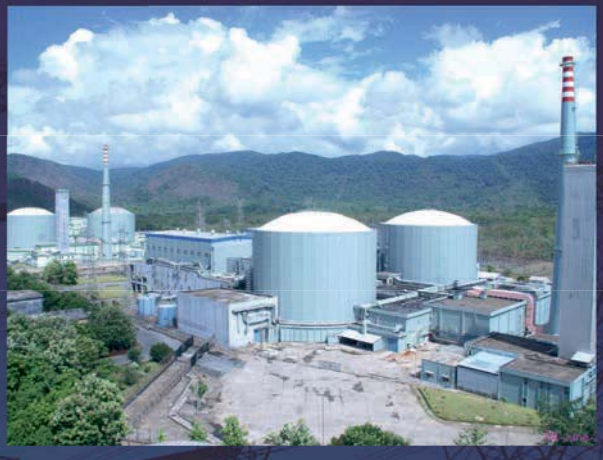


TAPS-1 & 2 Complete 50 Years of Operation

Tarapur Atomic Power Station Units 1 & 2 (TAPS 1 & 2 - 2 X 160 MW) at Tarapur, Maharashtra were the first Nuclear Power Reactors to be set up in the country, which were connected to the grid on April 01, 1969 and May 05, 1969 respectively. They were also the first Nuclear Power Plants in Asia and the Largest Electricity Generation Units in the country at that time. The units have since completed 50 years of safe, accident free operation and are currently the oldest operating reactors in the world. Continuing to operate at their rated power, they stand testimony to the achievements of our operations and maintenance practices, ageing management and life extension measures.

KGS-1 sets World Record in Continuous Operation of 962 days

"Unit-1 of the Kaiga Generating Station (KGS 1 - 220 MW) at Kaiga, Karnataka, an indigenously developed Pressurised Heavy Water Reactor set the World Record in continuous operation of 962 days on December 31, 2018. The unit had surpassed the earlier World Record in continuous operation record of 940 days held by Heysham-2 Unit-8 of the United Kingdom on December 10, 2018. During its 962 days continuous run, it generated about 5 billion Units of electricity at a Plant Load Factor of about 99.3%. The record unbroken run of 962 days demonstrates Indias pre-eminence in the design, construction and operation of PHWRs with unprecedented levels of efficiency and safety."



MEGA SCIENCE PROGRAMS OF DAE

Unravelling the Mysteries of Nature

Multilateral collaborations such as MFC, CERN, FAIR, INO, ITER, LIGO, SKA and TMT are facilitated towards path breaking scientific discoveries. Department of Atomic Energy is in the forefront of Discovery Science endeavours in the country. The collabrations led to development of many indigenous high precision state-of-the-art technologies. Indian participation in the collaboration has led to the growth of an ecosystem of scientific research and technological innovations spanning across Universities, Research Centres and Industries.

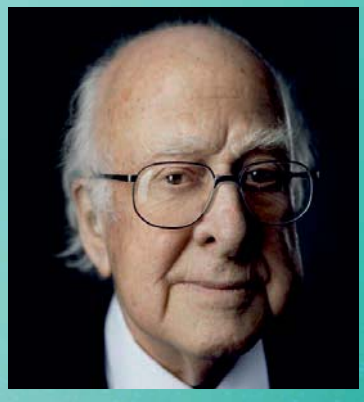
EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)
Understanding The Universe

India is an associate member of CERN since 2016 and a partner of the Large Hadron Collider (LHC) project since its inception and has made significant contributions to the Two Large Scale Experiments at LHC-ALICE and CMS.

LHC is housed in a 27km underground tunnel 100 m below the surface. Designed for high energy collisions ofTeV range to create controlled conditions existing soon after the Big Bang, 13.5 billion years ago.

Important Discoveries

Higgs Boson



Postulated by Peter Higgs in 1964, to explain why particles have mass. The experiments in LHC, CERN confirmed the existence of the Higgs Boson fetched him the Nobel prize in 2013.

Formation of Quark Gluon Plasma (QGP)

Studies on Quarks and Gluons at extremely high temperatures attained in LHC experiments are crucial for understanding evolution of our Universe and Grand Unification Theory.

Important Technological Contributions ALICE DETECTOR

- Photon Multiplicity Detector (PMD) for measurements of Photons
- A Cathode Pad Chamber for Muon Measurements
- Readouts: 16 Channel ASIC named Manas, FPGA based PLC e40, Electromagnetic Calorimeters

CMS DETECTOR

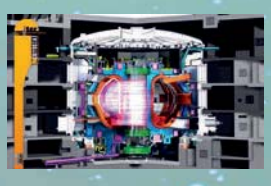
- Design, manufacture and bulk supply of high technology niche items for detection and measurements such as Calorimeters, Sensors, Resistive Plate Chambers, Multipliers, Trackers and associated Electronics Upgrade Boards and Casings etc.
- CMS Detectors fabricated in BARC are operational in CERN since 2008.

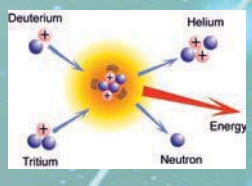
GRID

Major contributions to the GRID Computing Facility include software tools for Monitoring, Visualisation, Resource Management and Integration into Cloud Computing Resources.

INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR (ITER)
The Way to New Energy

An Experimental Fusion Reactor Facility being constructed in France to establish the feasibility of Nuclear Fusion as a future source of energy.





Radiation Processing Facility

Electron Beam processing is used for sterilization of disposable medical devices, and processing of agricultural and food products. RRCAT has set-up an Agricultural Radiation Processing Facility near Devi Ahilya Bai Holkar Fruit and Vegetable Mandi Complex, Indore for processing of agricultural products.

10 MeV, 6 kW Electron Linear Accelerators

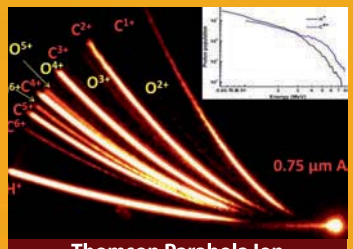
Indigenous 10 MeV, 6 kW Electron Linear Accelerator developed for Electron Beam Processing Applications.

LASER PROGRAMME

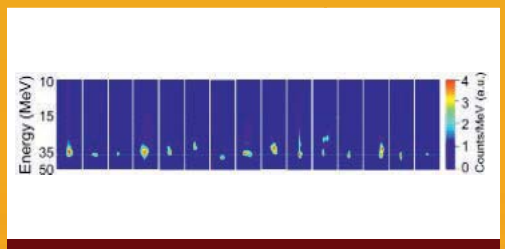
RRCAT has a vibrant programme on the development of Lasers and their utilization in Industrial, Biomedical, Nuclear and Plasma Fields.The centre has developed several Laser Systems that include Nanosecond and Picosecond Solid State Lasers, high power continuous and pulsed C02, Nd:YAG and Nd:Glass Lasers, Copper Vapour Lasers, Dye Lasers, etc. Home-made and Commercial Lasers are being used for research in the areas of Laser Plasma Interaction, Laser-Based Charged Particle Acceleration, Laser Cooling and Trapping of Atoms, Non-linear Optics, Ultra-fast Dynamics, Laser Fluorescence Spectroscopy of Tissues, etc.

A High Power Green Laser Set-up

10 kW Peak and 500 W Average Power Industrial Nd:YAG Laser



Thomson Parabola Ion Spectrometer (TPIS) image using 150TW Laser at RRCAT



Energy Spectra of the Quasi-monoenergetic Electron Beam

Lasers for Nuclear Industry

RRCAT has indigenously developed Robust Nd:YAG Lasers of up to 1 kW average power and 20 kW peak power with fiber optic beam delivery for refurbishing and maintenance of Pressurized Heavy Water Reactors (PHWRs). Various Laser-based instruments such as Uranium Analyzer, Land Leveler, Compact N2 Laser, Photocoagulator, Fibre Based Temperature Sensor, etc., were developed. RRCAT has deployed Laser Cutting & Welding Techniques in Indian PHWRs and FBTR with enormous reduction in MANREM consumption (-40 times), time and cost. Laser Welding Technology for fabrication of Heart Pacemaker and high dose rate Brachytherapy Assembly for cancer treatment have been developed and deployed.

Indira Gandhi Centre for Atomic Research

Dr. Vikram Sarabhai was a man of many talents, but science was his passion. He was a remarkable scientist and a great visionary in his merit. Vikram was committed to fulfilling the vision of Dr. Homi Bhabha.

Fast Breeder Reactor Programme was one amongst the many programmes that he initiated in the view of its capability to extract more energy many times from the same resource.

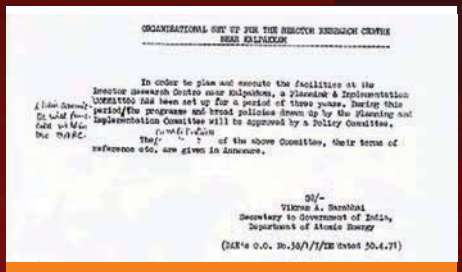
Dr. Vikram Sarabhai and Second Stage of Nuclear Power Programme at Kalpakkam

Fast Breeder Reactor Programme came into being as early as 1965 with the creation of Fast Reactor Section at BARC and the preliminary design of a 10 MWe experimental fast reactor was initiated.

Dr. Vikram Sarabhai, as Chairman AEC in 1966 took a bold and decisive step to speed up the introduction of the Fast Reactor Technology in India, by collaborating with CEA, France that had rich experience with respect to design, construction and operating experience.

A bilateral agreement, with CEA, France was signed in 1969 to build Fast Breeder Test Reactor (FBTR), on the lines of RAPSODIE with modifications in the secondary sodium circuit similar to PHEONIX.

History Made at Kalpakkam Due to Efforts of Dr. Vikram Sarabhai



ORGANISATIONAL SET UP FOR THE REACTOR RESEARCH CENTRE
NEAR KALPAKKAM

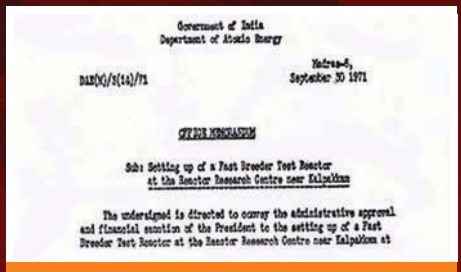
In order to plan and execute the facilities at the Reactor research Centre near Kalpakkam, a Planning & Implementation Organisation has been set up for a period of three years. During this period the programme and broad policies drawn up by the Planning and Implementation Committee will be approved by a Policy Committee.

Their ... of the above Committee, their terms of reference etc. are given in Annexure.

Sd/-
Vikram A. Sarabhai
Secretary to Government of India,
Department of Atomic Energy

(DAE's O.O. No.36/1/71/IE dated 30.4.71)

Order for Setting up of Research Reactor Centre at Kalpakkam was Signed on 30 April, 1971



Government of India
Department of Atomic Energy

DAE(G)/8(14)/71 Madras-6, September 30 1971

OFFER MEMORANDUM

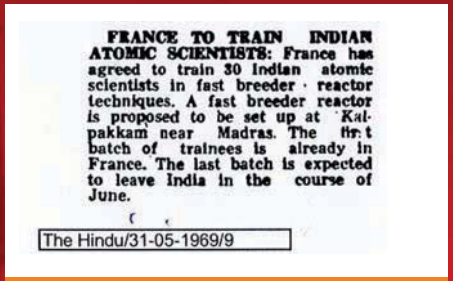
Sub: Setting up of a Fast Breeder Test Reactor at the Reactor Research Centre near Kalpakkam

The undersigned is directed to convey the administrative approval and financial sanction of the President to the setting up of a Fast Breeder Test Reactor at the Reactor Research Centre near Kalpakkam at

Administrative Approvals and Financial Sanction

Dr. Sarabhai, holistically nurtured not only the Fast Breeder Programme, but also envisaged all the associated facilities required to take forward the programme. With qualified manpower shifted from BARC, Mumbai, parallely the construction of all the facilities commenced at Kalpakkam.

Rock Breaking at Fast Breeder Test Reactor Construction Site



FRANCE TO TRAIN INDIAN ATOMIC SCIENTISTS: France has agreed to train 30 Indian atomic scientists in fast breeder reactor techniques. A fast breeder reactor is proposed to be set up at Kalpakkam near Madras. The first batch of trainees is already in France. The last batch is expected to leave India in the course of June.

The Hindu/31-05-1969/9

News Clip from "The Hindu"

Dr. Sarabhai's Initiatives:

A design team of 30 engineers and scientists including draftsmen were sent to Cadarache Nuclear Centre in France.

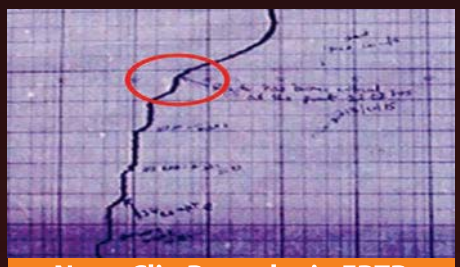
A group of about 50 engineers and draftsmen with a Principal Design Engineer were shifted to Research Reactor Centre, Kalpakkam from BARC, Mumbai in 1971.

Construction of Fast Breeder Test Reactor commenced in 1972. All the components were successfully manufactured for the first time indigenously (except Grid Plate, Control Rod Drive Mechanism and Primary Sodium Pump).

FBTR Attains Criticality in 1985


FBTR goes critical

News Clip



News Clip Recorder in FBTR indicating Criticality

Dr. Raja Ramanna, Dr. M.R. Srinivasanand and Dr. C.V. Sundaram on the Occasion of Criticality of FBTR

Fast BreederTest Reactor (FBTR) Today

- 33 years of successful operation without any major incidence
- Only reactor in the world to use unique High Pu Content U-Pu mixed Carbide as driver fuel. This fuel has seen world-record burn-up of 165 GWd/t
- Four sodium pumps have been in trouble-free cumulative service for > 8,70,000 hours
- Generates steam at highest temperature & pressure among all Nuclear Reactors in India
- Operated at the highest reactor power level of 32 MWt; a major milestone in its history, during the 27th irradiation campaign, Electrical Power (generated): ~7.0 MWe
- Logged > 60,000 hrs of operation, with > 40,000 hrs at high power
- Irradiation of yttria yielded ^{89}Sr, for the first time in India, used as a palliative for cancer patients

Fast Breeder Test Reactor

Production of 89Sr in FBTR

Prototype Fast Breeder Reactor

The experience with FBTR and the broad, multidisciplinary R&D base in the Centre has provided the confidence to launch the Prototype Fast Breeder Reactor (500 MWe) as the next step in the development of Fast Reactor Technology.

WE LASE AND ACCELERATE

Raja Ramanna Centre for Advanced Technology (RRCAT)

RRCAT, a unit under the Department of Atomic Energy is engaged in front line research on Lasers and Particle Accelerators. Since its inception in February 1984, the centre has grown into a premier institute for research and development in Lasers, Accelerators and their applications.

SYNCHROTRON RADIATION SOURCES

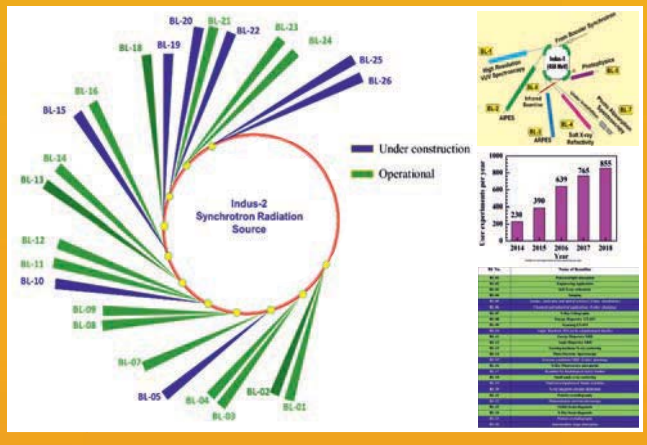
RRCAT is home to the countrys only two Synchrotron Radiation Sources: Indus-1 (450 MeV) and Indus-2 (2.5 GeV), both operating round the clock. The 172.5 m long Indus-2 is the largest accelerator built in the country, mostly with indigenous efforts. During the year 2018, the Synchrotron Beams were available for about 7350 hours to the users of Indus-1 and 5533 hours for the users of Indus-2.

Indus-1 Storage Ring

Part of Indus-2 Ring

Infrared Free Electron Laser (IR-FEL)

Utilization of Indus-1 and Indus-2



At present 6 beamlines on Indus-1 and 14 on Indus-2 are operational and available to the scientific community. Further, three insertion devices have been installed in Indus-2, which are expected to provide flux 2-3 orders of magnitude higher then the persent.

The beamlines are extensively used by academic institutions, national laboratories and industries for a variety of experiments in diverse areas of basic and applied research, such as Materials Science, Microfabrication and Protein Crystallography. The beamlines were also used to calibrate gas-cell for Mangalyaan mission and detectors for Chadrayaan-1 and 2 missions and for characterization of optics for X-ray Telescope.

Indian Spallation Neutron Source

The Centre has set-up the infrastructure and initiated the development of high energy proton accelerator for future projects like Indian Spallation Neutron Source.

650 MHz five-cell SCRF cavity in VTS

Helium Liquefier

Prototype RF based H-ion Source

Multicusp Arc Discharge H-ion Source coupled with LEBT

Brass Valves

Plasma surface modification of brass valves improves rubber to brass bonding. This process uses only air and electricity and therefore eco-friendly. Further, the plasma process is cheaper compared to wet ch emical process.



Mass Spectrometry

Mass Spectrometry is a versatile tool to measure relative chemical and isotopic composition of solid, liquid or gaseous samples and other materials used in nuclear applications.

Mass Spectrometers are routinely used to analyse H_20 and D_20 in Heavy Water Plants and to analyse Uranium and Plutonium in Nuclear Waste processing. Further, they are most sensitive in characterising sample surfaces down to ppb level and are ideally suited for elemental analysis, oxidation state studies, impurity detection and depth profiling.

Qupe Mass Spectrometer

A Quadrupole Mass Spectrometer is a low-cost machine and is of great value in process industry for **IP** compositional analysis of gaseous and volatile liquids, fiHjt *i* where high resolution isnt very important.

Time Of Flight (TOF) Mass Spectrometers separate ions without the need of magnetic field, which make them more compact and lighter than the traditional machines.

Perimeter Intrusion Detection System

Plasma Nitriding

Institute for Plasma Research (IPR) has developed technology using plasmas to improve different properties of materials for industrial applications.

Component Arrangement for Plasma Nitriding Process

Components being processed under Plasma

Large chamber with extended height

Component under Plasma in extended chamber

Plasma Nitriding process is one of the best technologies to improve the wear resistance, strain limit, fatigue strength and tensile strength by increasing the surface hardness of components and increase their life by 2-3 times. This leads to reduction in material cost and breakdown time.

Plasma Nitriding process diffuses nitrogen atoms into the surface of steel, where nitrogen reacts with elements present in steel and make the surface harder by 2-3 times. IPR also developed variants of plasma nitriding process like plasma nitrocarburizing and plasma oxidation for improving corrosion resistance.

IPR has a large plasma Nitriding Chamber (900 mm diameter and 800 mm height) as working volume and facility to increase the height of the chamber up to 1.4 meter.

A Novel Plasma System for In-line Treatment of Textiles

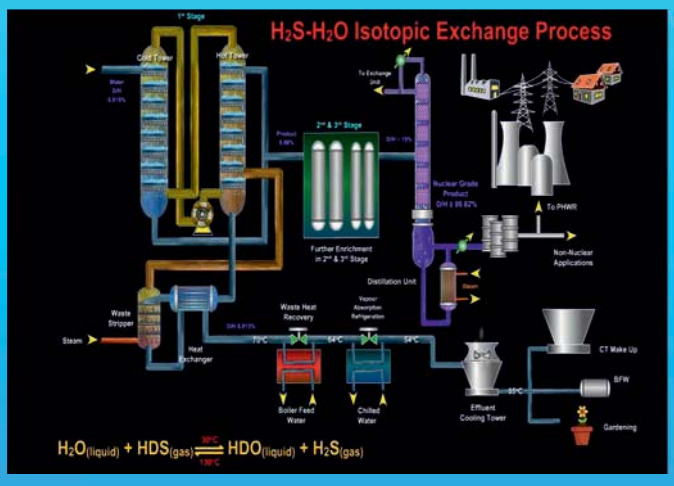
With financial support from DST, New Delhi, a Plasma System was developed for in-line treatment of textiles. In this system, uniform Dielectric Barrier Discharge Plasma (DBD Plasma) was generated using air.

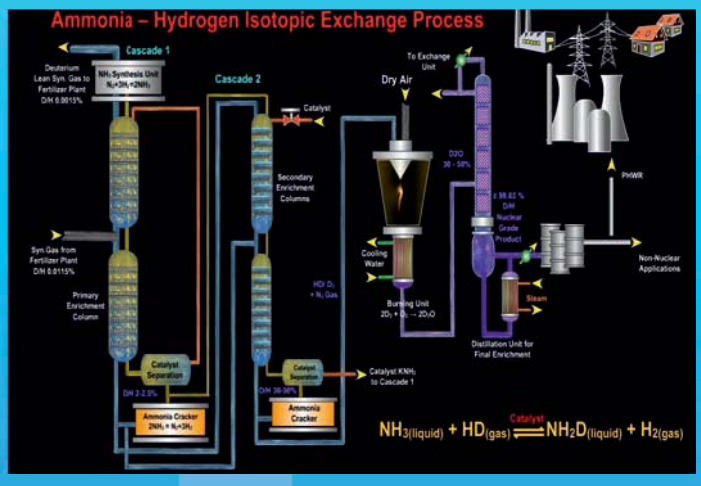
The system was demonstrated to industries during the workshop on Applications of Plasma for Textile Processing The system has been successfully installed and commissioned at MANTRA (ManmadeTextile Research Association), Surat for demonstration to textile industries.

The system developed under this project is apparently the worlds first Large Scale Air Plasma Treatment System for in-line processing of textiles.

INDUSTRY WITH INNOVATION
HEAVY WATER BOARD
Making Nation Self Reliant in Deuterium

HEAVY WATER PRODUCTION





NON-NUCLEAR APPLICATIONS OF HEAVY WATER/DEUTERIUM

Collaborative Agreement

For Development of Deuterated Compounds and Deuterated APIs

M/s Clearsynth Pvt Ltd & M/s SYNMR Pvt Ltd

PAN India Presence

HWP Baroda, Gujarat
•Nuclear Solvents
•Sodium Metal
•Potassium Metal
•D_2 Gas

HWP Kota, Rajasthan
•Heavy Water

HWP Hazira, Gujarat
•Heavy Water

TDP, RCF, Chembur, Mumbai

HWP Thal, Maharashtara
•Heavy Water

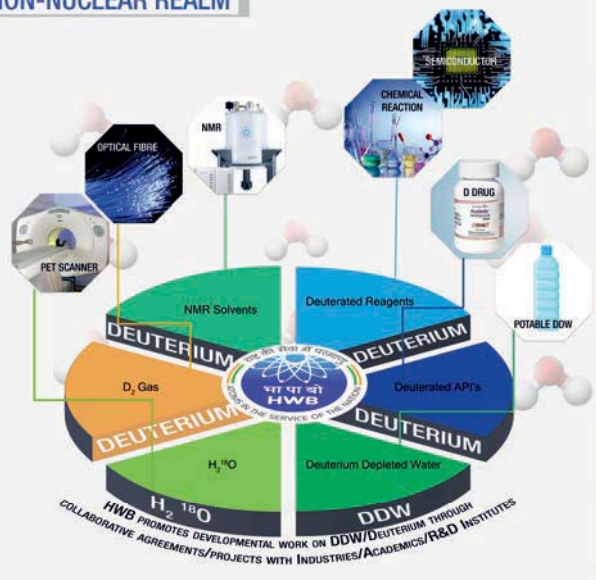
HWP Manuguru, Telangana
•Heavy Water
•Boron Compounds
•O^{18} Water
•Solar Unit

HWP Talcher, Orissa
•Nuclear Solvents
•Boron Compounds
•BF_3 Gas

HWP Tuticorin, Tamil Nadu
•Heavy Water
•Nuclear Solvents
•Rare Material

राष्ट्र की सेवा में परमाणु
भा पा बो
HWB
ATOMS IN THE SERVICE OF THE NATION

EXPLORING NON-NUCLEAR REALM



HWB promotes developmental work on DDW/Deuterium through collaborative agreements/projects with Industries/Academics/R&D Institutes

CONSPICUOUS NICHE IN NUCLEAR ARENA

DAE Advanced Technologies

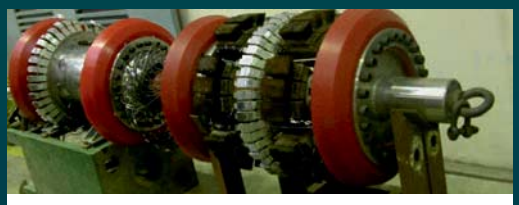
Pipeline Inspection Gauge

Using the expertise in the area of in-line inspection, an External Pipeline Inspection Gauge (EPIG) was developed for inspection of pipelines.

12 inch Instrumented Pipeline Inspection Gauges (IPIG)

A 12 IPIG was developed jointly by BARC and Indian Oil Corporation (IOC) for inspection of 12 NB cross-country buried petroleum pipelines, which includes some of the oldest pipelines of our country. IPIG has successfully identified several corrosion effected parts of the pipeline and few pilferage points. IPIG is now commercialised and deployed for inspection of oil pipelines in India.

18 inch Instrumented Pipeline Inspection Gauges (IPIG)



24 inch Instrumented Pipeline Inspection Gauges (IPIG)

BARC also developed IPIG Versions of 18 and 24for inspection of petroleum pipelines. This development resulted in a huge benefit to the pipeline industry.

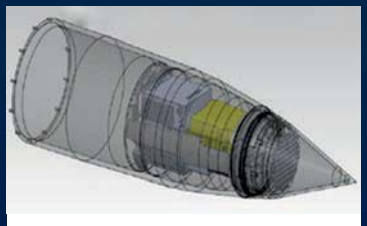
Ship Borne Terminal

BARC and ECIL developed a Ship Borne Antenna Terminal (SBT) to support ISRO missions which include tracking of re-entry vehicles for future Indian Manned Missions to Space. SBT can be deployed on a ship positioned on high seas.
The SBT can continuously point at the commanded angles and mono-pulse tracking even in the presence of ships rocking movements.
The antenna is actively stabilized against ship movements using an Inertial Measurement Unit. The SBT is mounted on a rugged chassis which is designed to be easily transported in standard ISO shipping containers. The reflector of the SBT can be quickly disassembled for swift relocation and redeployment

Radio Frequency Seeker

DRDL (DRDO) along with Indian Army, BARC and ECIL successfully test fired the Brahmos Cruise Missile fitted with an indigenously developed Active Radar Seeker at the Pokhran Test Range. BARC has developed a precision servo control mechanism for stabilization and positioning of the Seekers Two Axis Gimbal Mechanism to steer the Radar Antenna precisely on the designated target.

RF Seeker



Seeker mounted in Missile Nose Cone

Physical Intrusion Detection System (PIDS)

PIDS detects intrusions at the perimeter of important establishments like nuclear installations and generates an alert in real-time. The detection algorithm can discriminate human intrusion events like climb, cut and fence lift from all other environmental disturbances.

Perimeter Intrusion Detection System

Brass

Brass Artefacts

Brass objects get corroded due to exposure to moisture. Traditionally, lacquer finish is provided to brass objects to prevent corrosion. However, lacquer is environment unfriendly. BARC developed SiOx coatings using a plasma process, which protect brass objects against corrosion. This is a clean and environment friendly process.

Radiotracers were used to identify leaks in heat exchangers resulting in process improvements and shortening of shutdown times of the Panipat refinery.

Radiotracer dilution technique helps in accurate measurement of flow rate in Pipelines, Canals, Mountainous Rivers and Streams.

Applied successfully to estimate measurement of water flow in a branch canal of Sardar Sarovar Narmada Nigam Limited (SSNNL) dam in Gujarat.

Applied successfully to estimate measurement of water flow in 2x520 MW Thermal Power Plant of Hinduja National Power Corporation Limited (HNPCL) in Vishakhapatnam, Andhra Pradesh.

Indira Gandhi Centre for Atomic Research

NUCLEAR FISSION REACTION

In a **Nuclear Fission Reaction,** nucleus of an atom such as Uranium and Plutonium splits into lighter Nuclei. The fission process produces free neutrons, which sustain the chain reaction. A large amount of energy is also released in the form of Heat and Gamma Radiation.

A **Nuclear Reactor** is a machine that controls the Fission Reaction to generate energy in a steady and sustainable manner. Most Nuclear Reactors are used to produce electricity.

Neutrons generated in Nuclear Fission Reactors can also be used to produce various radioisotopes, which find many applications in Medicine, Industry and Agriculture.

Neutron beams produced in reactors are exquisite probes for carrying out research in a variety of branches of science and technology such as Physics, Chemistry, Materials Science and Biology and Medicine including Drug Design.

- India's first Nuclear Reactor, attained criticality on August 4,
- The 1-MWth Swimming Pool Reactor, loaded with enriched Uranium-Al alloy fuel and light water as both moderator and coolant enabled our scientists and engineers to gain insights into the complexities of design and construction of a nuclear reactor and to learn the intricacies of controlling the Nuclear Fission Chain Reaction.

APSARA August 4,1956

CIRUS July 10,1960

- The reactor was also used for production of Radioisotopes, study of Neutron Activation, Neutron induced Fission and Nuclear Reactions produced by Tritium, Shielding Experiments, Beam Tube Research and for training of scientists and engineers.
- CIRUS, a joint Indo-Canadian project, reached criticality on July 10,1960.
- The 40-MWth CIRUS was the biggest Research Reactor in Asia and was one of the largest isotope producers in the world at its peak power.
- Modelled on the Canadian Chalk River National Research X-perimental (NRX) Reactor, CIRUS used natural Uranium as fuel and heavy water as a moderator.
- CIRUS was extensively used for research in Nuclear and Reactor Physics, development of fuel and materials for use in future reactors, production of Isotopes among others.
- ZERLINA (Zero Energy Reactor for Lattice Investigations and New Assemblies) was wholly designed and built indigenously. It attained criticality on January 14,1961. It was a valuable experimental tool for examination of various combinations of nuclear fuels and moderators.
- ZERLINA is a very low power reactor (100 watts) with Heavy water as the moderator.
- 80 fuel elements required for ZERLINA were fabricated at Trombay from Uranium produced here.

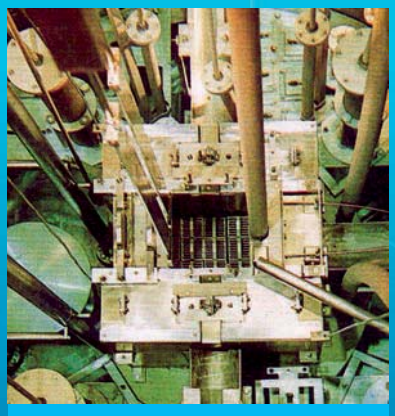
ZERLINA January 14,1961

PURNIMA Series 1972 to 1990

- The 1 Watt Thermal Purnima Fast Reactor powered by Plutonium Oxide Fuel reached criticality on May 18,1972. This was a stepping stone for the future Fast Reactor Programme of India. It was decommissioned in 1973.
- Important milestone in the development and implementation of indigenous Nuclear Technology in India.
- A Vertical Tank Type 100 MWth Research Reactor with higher Neutron Flux, attained criticality on August 8,1985.
- Production of Radioisotopes of high specific activity.

- Dhruva has been declared as a National Facility for Multidisiciplinary Research using Neutron Beams.
- Meeting the growing demand of Radioisotopes and advanced research in Basic Sciences.

DHRUVA August 8,1985



KAMINI October 29, 1996

- KAMINI (Kalpakkam Mini) 30 kWth Reactor, jointly built by BARC and Indira Gandhi Centre for Atomic Research (IGCAR) in Kalpakkam, became critical on October 29,
- KAMINI is cooled and moderated by light water with metallic Uranium-233 as fuel. Uranium-233 is produced in the Fast Breeder Test Reactor using Thorium Fuel Cycle.
- KAMINI is the only reactor in the world designed specifically to use Uranium-233 fuel. It is the precursor to the three-stage power programme of India to exploit the large Thorium Reserves in the country.

APSARA-U September 10, 2018

- Apsara-U Reactor Facility is a 2 MW Thermal Swimming Pool Reactor with compact core loaded with Low Enriched Uranium (LEU) fuel, light water as coolant & moderator.
- The reactor will provide enhanced facilities for various kinds of research, shielding experiments and training of scientists and engineers.
- The Apsara-U Reactor became critical on 10th September 2018.

DISCOVERY OF NEUTRINO

"In 1956 Clyde Cowan and Frederick Reines used the flux from P Reactor at the Savannah River site to perform the first experiment that conclusively detected the Neutrino, there by establishing the existence of the particle postulated 26 years earlier by Wolfgang Pauli to explain the apparent lack of conservation of energy in Beta decay."

1995 Nobel Prize in Physics was awarded with one half to Frederick Reines, University of California, USA for the detection of the Neutrino.

FREDERICK REINES

CLYDE COWAN

The Nobel Prize in Physics 1994

Atomic Nuclei are composed of Protons and Neutrons. Bertram Brockhouse and Clifford Shull developed methods for investigating different materials with beams of Neutrons created in a Nuclear Reactor. When Neutron Beams come in contact with a material, some of the Neutron's energy is converted into vibrations. The vibrations known as Phonons, correspond to fixed energy levels that form a spectrum. During the 1950s Bertram Brockhouse developed methods for using these spectra to chart properties of different molecules BERTRAM N. BROCKHOUSE and materials. etected the Neutrino, thereby establishing the existence of the particle postulated 26 years earlier by Wolfgang Pauli to explain the apparent lack of conservation of energy in Beta decay."

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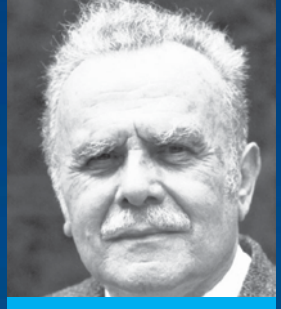


BERTRAM N. BROCKHOUSE

Industrial Applications of Radiotracers

Radiotracers were employed to optimize the process of homogenization of various components in Solar Glass Manufacture in Gujarat Borosil Ltd. This resulted in a significant improvement in the quality of glass produced.

Radiotracers were used to identify defects and malfunctions in the flow pattern of process fluids in the chemical reactor that produces Ethyl Acetate in IOL Barnala (Punjab).

Radiotracers are used to find out interconnection paths of water injection channels and oil production wells and they help in estimating the quantity of oil remaining in a well.

Mosquito Larvicidein

- Sustained-release biopesticide formulation based on Bacillus thuringiensis (Bt) subsp. israelensis ISPC-12 bacterium.
- Effective against Aedes, Anopheles and Culex larvae.
- Posses multiple toxins hence low potential for resistance development.
- Easy to mass produce and amenable to formulation.
- Safe to non-target organisms and mammals.

Electron Beams for Industrial Waste Water and Air Treatment

Discharge of Industrial Waste Water directly to water bodies is harmful to environment. Often it contains Non-biodegradable Industrial Dyes.

Process of Waste Water Treatment under Electron Beams

BARC has developed a 1 MeV electron accelerator of 10 kW power for Waste Water Treatment at the rate of 10 litres per second. The treatment disintegrates the dyes and makes the water more transparent.

Electron Irradiation reduced chemical oxygen demand - a direct measure of the pollution level of water to such an extent that the treated water is fit enough for germination of seeds.

BARC is now developing a 1 MeV, 100 kW electron accelerator for treatment of waste water on industrial scale (1 to 2 million litres per day).

Water becomes more and more clear with increasing dose of Electron Irradiation

Treatment of Flue Gas from Thermal Power plants

In an experiment conducted at BARC using a 1 MeV DC electron accelerator, concentration of NO is brought down from 25 ppm to nearly zero level and that of $S0_2$ from 120 ppm by 50%.

NO and $S0_2$ are harmful substances present in the Flue Gas released by Thermal Power Plants.

Conversion of Waste into Energy through Plasma Gasification

It is used for Municipal and Medical Waste Treatment through Plasma Gasification, Hazardous Waste Destruction and Nuclear Waste Immobilization through melting and volume reduction. It takes air from the atmosphere and converts into a long jet of large volume air plasma with a temperature of around 9000K.

The device produces plasma in form of an intensely luminous extremely hot radiating atmospheric pressure cylindrical plasma jet controlled in terms of its Length, Diameter, Velocity and Pojger Content.

Air Plasma Torch

ENHANCING THE GREEN REVOLUTION NUCLEAR AGRICULTURE

PLANT BIOTECHNOLOGY

A protocol for large scale multiplication has been established using Tissue Culture. This technology has been transferred to user agencies including Entreprenuers, Institutes, Krishi Vigyan Kendra and Farmers.

Radiation induced in vitro mutagenesis using embryogenic callus cultures has been undertaken in Banana, Sugarcane, Grapes, Pineapple, Potato,Turmeric and Ginger and several mutants of agronomic value have been isolated and field tested.

Popularization is done by linkages established with State Agricultural Universities (through Kisan Mela, Frontline Demonstrations / Exhibitions and Awareness Programmes).

Micropropagation in Sugarcane

- Micropropagation protocols have been developed for Banana, Sugarcane, Grapes, Pineapple, Potato,Turmeric and Ginger.
- Protocols for Genetic Transformation using Embryogenic Cell Cultures for Fusarium Wilt Resistance and edible vaccines (Hepatits B) in Banana have been developed.
- Radiation induced in Vitro Mutagenesis using Embryogenic Callus Cultures has been undertaken in sugarcane and several mutants of agronomic value have been isolated and field tested.
- Technology for mass scale cultivation of Ophiorrhiza Cultures for production of Camptothecin - (an anticancer drug) has been standardized.

Regeneration of Ophiorrhiza sps from Hairy Root And Multiple Shoot Cultures

Tissue Culture Propagation of Banana

Micropropagation in Banana

Using radiation induced Mutation Breeding along with Cross Breeding, Bhabha Atomic Research Centre (BARC) developed over 44 new crop varieties, including Groundnut, Mustard, Cowpea, Blackgram, Greengram, Soybean, Rice and Wheat. Mutation Breeding using Gamma Irradiation is an excellent alternative with high yielding, disease resistant varieties and other desirable characters are early maturity and stress tolerance.

Mung Bean: TM-96-2

Mung Bean: TM-2000-2 (Pairy Mung)

POPULAR TROMBAY PULSE VARIETIES

Urad Bean: TU-40

Trombay Mung in Rice Fallows

TROMBAY CHHATTISGARH DUBRAJ MUTANT

Under various environmental conditions, Trombay Chhattisgarh Dubraj Mutant (TCDM-1) rice variety was developed in collaboration with the Indira Gandhi Krishi Viswavidyalaya (IGKV), Raipur and released for commercial production.

Dubraj is a popular aromatic rice variety from Chhattisgarh which normally matures in 155-160 days. It grows to a height of 150-160 cm and therefore prone to lodging, often resulting in crop losses upto 50-70%. TCDM-1 is a high yielding (4.5 t/ha compared to 2.5-3.0 t/ha) dwarf variety (grows only upto 100 cm), which matures in 140 days. TCDM-1 retains the premium aroma and the grain quality of the parent Dubraj variety.

Dubraj TCDM-1 Dubraj

PresentingtheDubrajRice(TCDM-1)tothe Honourable President of India Shri Ram Nath Kovind

44 TROMBAY CROP VARIETIES NOTIFIED FOR COMMERCIAL CULTIVATION

Using radiation, 44 crop varieties were developed for different Agro-climatic Zones with higher yield, early maturity, large seed size & resistant to biotic and abiotic stresses for Soybean, Rice and Wheat.

The new crop varieties have higher yield and resistance to diseases.

Groundnut (15)

Mustard (3)

Sunflower (1)

Cowpea (1)

Mung Bean (8)

Urad Bean (5)

Rice (1)

Jute (1)

Soybean (2)

Pigeon Pea (5)

Trombay Groundnut Varieties

TAG 24 TG 37A TG 38 TG 41 TG 51

Andra Pradesh

Gujarat

Rajasthan

Karnataka

Maharashtra

West Bengal

Presenting the Groundnut Seeds (TG - 42) to the Honourable Former President of India, Bharat Ratna, Shri Pranab Mukherjee

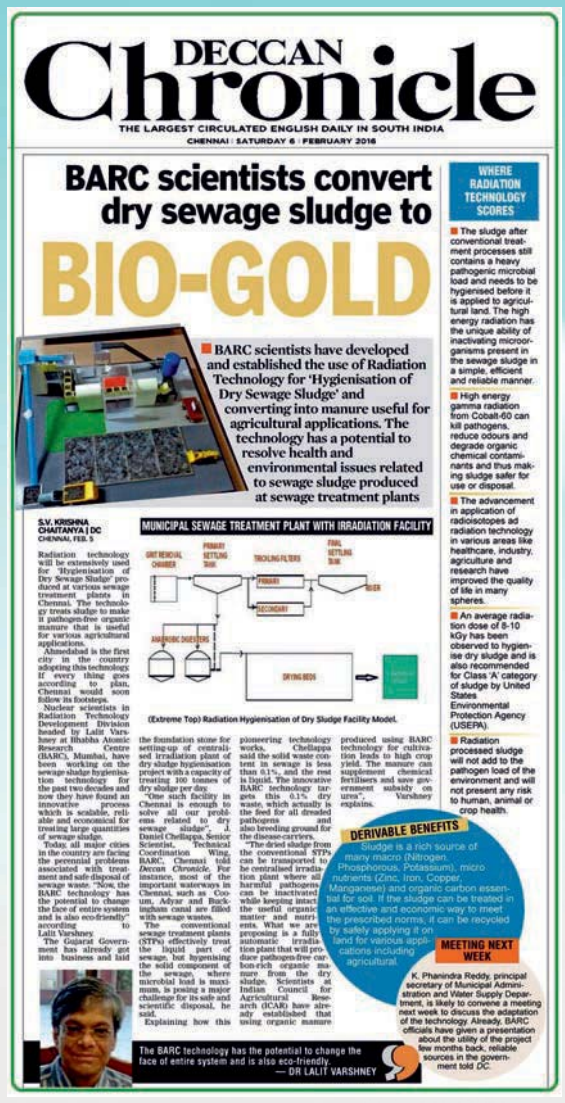
Towards Sustainability

Contributing to Environment Sustainability is an important mission of DAE. Efforts towards Solid Waste Management suitable for Rural and Urban spaces is taken up vigourously.

First Sludge Hygienisation Plant is operational at Ahmedabad Municipal Corporation

A 100 ton per day Sludge Hygienisation Plant for radiation processing of sewage sludge using High Energy Gamma Radiation has been set up at Ahmedabad and **operational since January 2019.**

The radiation kills Pathogens, Reduce Odour and Degrade Organic Chemical Contaminants. The sludge is then fortified by BIO-NPK (Nitrogen Phosphorus Potassium) microorganisms to make it a biofertilizer.



DECCAN Chronicle

THE LARGEST CIRCULATED ENGLISH DAILY IN SOUTH INDIA

CHENNAI | SATURDAY 6 | FEBRUARY 2016

BARC scientists convert dry sewage sludge to BIO-GOLD

BARC scientists have developed and established the use of Radiation Technology for 'Hygienisation of Dry Sewage Sludge' and converting into manure useful for agricultural applications. The technology has a potential to resolve health and environmental issues related to sewage sludge produced at sewage treatment plants

WHERE RADIATION TECHNOLOGY SCORES

The sludge after conventional treatment processes still contains a heavy pathogenic microbial load and needs to be hygienised before it is applied to agricultural land. The high energy radiation has the unique ability of inactivating microorganisms present in the sewage sludge in a simple, efficient and reliable manner.

High energy gamma radiation from Cobalt-60 can kill pathogens, reduce odours and degrade organic chemical contaminants and thus making sludge safer for use or disposal.

The advancement in application of radioisotopes ad radiation technology in various areas like healthcare, industry, agriculture and research have improved the quality of life in many spheres.

An average radiation dose of 8-10 kGy has been observed to hygienise dry sludge and is also recommended for Class 'A' category of sludge by United States Environmental Protection Agency (USEPA).

Radiation processed sludge will not add to the pathogen load of the environment and will not present any risk to human, animal or crop health.

S.V. KRISHNA CHAITANYA | DC
CHENNAI, FEB. 5

Radiation technology will be extensively used for 'Hygienisation of Dry Sewage Sludge' produced at various sewage treatment plants in Chennai. The technology treats sludge to make it pathogen-free organic manure that is useful for various agricultural applications.

Ahmedabad is the first city in the country adopting this technology. If every thing goes according to plan, Chennai would soon follow its footsteps.

Nuclear scientists in Radiation Technology Development Division headed by Lalit Varshney at Bhabha Atomic Research Centre (BARC), Mumbai, have been working on the sewage sludge hygienisation technology for the past two decades and now they have found an innovative process which is scalable, reliable and economical for treating large quantities of sewage sludge.

Today, all major cities in the country are facing the perennial problems associated with treatment and safe disposal of sewage waste. "Now, the BARC technology has the potential to change the face of entire system and is also eco-friendly" according to Lalit Varshney.

The Gujarat Government has already got into business and laid the foundation stone for setting-up of centralised irradiation plant of dry sludge hygienisation project with a capacity of treating 100 tonnes of dry sludge per day.

"One such facility in Chennai is enough to solve all our problems related to dry sewage sludge", J. Daniel Chellappa, Senior Scientist, Technical Coordination Wing, BARC, Chennai told *Deccan Chronicle*. For instance, most of the important waterways in Chennai, such as Cooum, Adyar and Buckingham canal are filled with sewage wastes.

The conventional sewage treatment plants (STPs) effectively treat the liquid part of sewage, but hygienising the solid component of the sewage, where microbial load is maximum, is posing a major challenge for its safe and scientific disposal, he said.

Explaining how this pioneering technology works, Chellappa said the solid waste content in sewage is less than 0.1%, and the rest is liquid. The innovative BARC technology targets this 0.1% dry waste, which actually is the feed for all dreaded pathogens and also breeding ground for the disease-carriers.

"The dried sludge from the conventional STPs can be transported to be centralised irradiation plant where all harmful pathogens can be inactivated while keeping intact the useful organic mater and nutrients. What we are proposing is a fully automatic irradiation plant that will produce pathogen-free carbon-rich organic manure from the dry sludge. Scientists at Indian Council for Agricultural Research (ICAR) have already established that using organic manure produced using BARC technology for cultivation leads to high crop yield. The manure can supplement chemical fertilisers and save government subsidy on urea", Varshney explains.

MUNICIPAL SEWAGE TREATMENT PLANT WITH IRRADIATION FACILITY

(Extreme Top) Radiation Hygienisation of Dry Sludge Facility Model.

DERIVABLE BENEFITS

Sludge is a rich source of many macro (Nitrogen, Phosphorous, Potassium), micro nutrients (Zinc, Iron, Copper, Manganese) and organic carbon essential for soil. If the sludge can be treated in an effective and economic way to meet the prescribed norms, it can be recycled by safely applying it on land for various applications including agricultural.

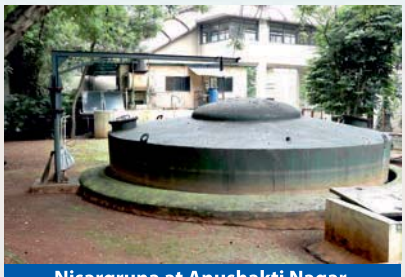
MEETING NEXT WEEK

K. Phanindra Reddy, principal secretary of Municipal Administration and Water Supply Department, is likely to convene a meeting next week to discuss the adaptation of the technology. Already, BARC officials have given a presentation about the utility of the project few months back. reliable sources in the government told DC.

The BARC technology has the potential to change the face of entire system and is also eco-friendly.
— DR LALIT VARSHNEY

Nisargruna Repaying Our Debt to Nature

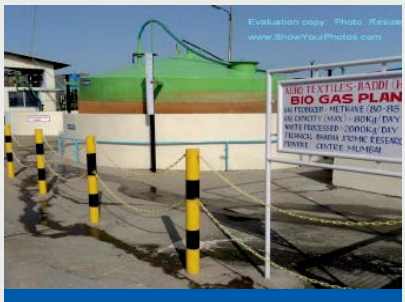
Nisargruna is an environment friendly technology to decompose any biodegradable waste into biogas and organic manure. Hundreds of such plants have been installed across the country.



Nisargruna at Anushakti Nagar, Mumbai

Nisargruna at NABARD, Mumbai

Nisargruna at Symbiosis University, Pune to process waste food from the canteens



Nisargruna in Himachal Pradesh

In Nisargruna, waste is first crushed into a paste while it is mixed with hot water from a Solar Water Heater and compressed air. This process breaks down complex biomolecules into smaller organic molecules. The slurry formed is digested by methanogenic bacteria to produce methane rich biogas.

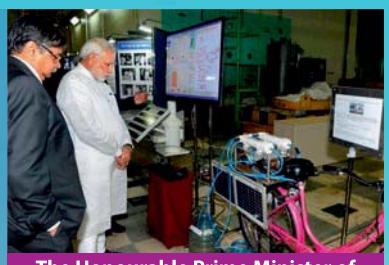
The biogas generated is recirculated through multiple chambers in the second stage resulting in biogas with a high concentration of methane.

Nuclear Desalination Demonstration Plant Kalpakkam

An Industrial scale 4500 m3/d Nuclear Desalination Demonstration Plant uses waste heat from Madras Atomic Power Station to produce fresh water from seawater.

Technologies for Remote Areas

Solar Powered based Water Purifiers



The Honourable Prime Minister of India visiting the Potable Water Purifiers Exhibition

A Domestic Water Purifier utilizes non-toxic, reusable photocatalyst and sunlight to produce potable water without suspended particles, dissolved organic matter and bacteria. The purifier does not require electricity.

Filter for Arsenic Contaminated Water

Water free of contaminants and toxic impurities is a universal necessity. Several technologies have been developed for both the detection and removal of contaminants such as Arsenic, Uranium, etc., to make water safe for domestic consumption.

Rejuvenation of Drying Springs

Rejuvenation of Drying Springs in Gaucher Area, Uttarakhand

17 springs have been recharged with flow rates increased by 3 to 9 times. About 5,000 villagers in Uttarakhand get 24 hours of water throughout the year.

Food Preservation Technologies

Minimising Wastage

Radiation Processing Plant

Exposure to Ionizing Radiation such as Gamma Rays

- Destroys insects and other micro-organisms responsible for their spoilage of food products.
- Has negligible effect on taste, appearance, texture and nutritional value of food products unlike Traditional Food Preservation Techniques.
- Delays the ripening in fruits and vegetables and extends their shelf life.

Food Irradiation has been declared **Safe and Wholesome** by World Health Organisation (WHO) and United States Food and Drug Administration (USFDA)

In India, Ministry of Health & Ministry of Agriculture have approved the use of Radiation for Food Processing.

***Irradiated food will not be radioactive.**

Radiation Processing of packed spices substantially increases their shelf life and keeps them fresh. Irradiation is widely used for sterilizing various healthcare products such as Surgical Material and Equipment and Vaccines.

Preservation of Agricultural Products

Exposure to a low dose of Ionising Radiation inhibits sprouting in Onions and Potatoes and keeps them fresh for much longer time. Krushak (Krushi Utpadan Sanrakshan Kendra) at Lasalgaon near Nashik, Maharashtra is one of the Low Dose Radiation Processing Facilities set up to process different Agri Products - Onions, Potatoes and Mangoes.

Left: Unirradiated Onions
Right: Onions after Low Gamma Ray dose

Left: Unirradiated Potatoes
Right: Potatoes after Low Gamma Ray dose

Preservation of Seafood, Meat and Poultry

Exposure to Ionizing Radiation eliminates Pathogens such as E.Coli, Listeria and Salmonella in Seafood, Meat Poultry to a large extent and extends their shelf life.


A total number of 19 Irradiation Plants are conceived and operational

New Protocol for Treatment of Kesar Mangoes



A novel treatment procedure for enhancing shelf life of Mangoes upto 40 days clears the deck for surface transportation to all corners of the globe at one tenth of the cost.

BARC successfully conducted a joint exercise with Maharashtra State Agricultural Marketing Board (MSAMB), Agricultural and Processed Food Products Export Development Authority (APEDA), National Plant Protection Organization (NPPO) and MAERSK Ltd in demonstrating enhanced shelf life of 8 tons of Kesar Mangoes.

Preservation Technology Developed for Litchi

India accounts for about 22% of Global Litchi Production while our share of exports is merely 1% of the annual production of 5 Lakh tons. Fruit Deterioration due to Peel Browning is responsible for Poor Export Performance and Post-harvest losses estimated at 2030% of the harvest.

BARC developed a technology to preserve Litchi up to 60 days at 4°C while retaining its taste, nutrition and appearance. This treatment involves washing the plucked Litchis with three solutions containing food preservatives. The technology has been transferred to 8 entrepreneurs including a firm from Madagascar.

A 1 tonne per hour facility at ICAR-National Research Centre on Litchi (NRCL), Mushahari, Muzaffarpur has been operational.



THE ELIXIR OF LIFE

WATER TECHNOLOGIES DEVELOPED AT BARC

Urbanization is rapidly depleting groundwater resources in India. Growing industrial activity is contaminating water sources including groundwater. Unpredictable rainfall patterns go on to compound the water stress in the country. Numerous health related problems can be traced to poor water quality. BARC has developed several technologies to treat water for Domestic, Community and Industrial scales.

Ground Water Purification

Field Testing in 6 districts of Punjab for removal of Uranium from Groundwater

Domestic Water Purification

Candle used in Domestic Water Purifiers

Domestic Ultrafiltration Water Purifier

Domestic RO Water Purifier

Offline Domestic Water Purifier

Desalination and Water Purification Technologies including Membrane Making Technologies have been transferred to private parties for wider deployment in a commercially viable manner.

Community Level Desalination Plant

Spiral Ultrafiltration (Uf) Membrane based Community Scale Water Purification Plant

Community Scale Water Purification Plant

Industrial Scale Desalination Plant

Multi-effect Distillation (MED) is a Thermal Desalination Technology that produces distilled quality water directly from seawater using low/medium pressure steam and electricity.

BARCs MED Technology demonstrated production of 240 m 3/day low conductivity distilled water from seawater. The plant has been operational at BARCTrombay and producing distilled water (<10 |jS/cm) from seawater.

The first unit of Bhabhatron was commissioned at Advanced Centre for Treatment, Research and Education in Cancer (ACTREC), Navi Mumbai. So far, more than 60 units of Bhabhatron have been manufactured and supplied to various hospitals, including seven machines abroad.

Recently, a Multi-Leaf Collimeter was incorporated into the Bhabhatron to enable focusing the radiation only only cancerous tumour without damaging the healthy cells.

Dr. A. P. J. Abdul Kalam, former President, Inaugurating Bhabhatron at IRCS Hospital, Nellore, AP (2006)

Honourable Prime Minister Shri Narendra Modi handing over a Bhabhatron-II model to Mongolia (2015)

Radiation Medicine Centre (RMC), BARC Patient Services:

Nearly 10,000 patients referred annually to RMC for Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT) studies.

Radionuclide therapies:

- 1-131 for Thyroid Cancer (-700 patients)
- 1-131 for Thyrotoxicosis (-400 patients)
- [1-131]MIBG for Neural Crest Tumors (-35 pts)
- [Lu-177]DOTATATE for Neuro-Endocrine Tumours (-200 patients)
- [Sm153]EDTMPforBone-Pain Palliation

Brachytherapy

In this process, source of radiation is located within the body. For example, a patient drinks a solution containing radioactive substance loaded onto drug molecules that have affinity to the cancerous cells. Alternatively, a tiny radioactive source is placed inside or close to a tumor.

Brachytherapy Sources for Cancer Treatment

Tiny Low Energy Photon emitting radionuclide ^{125}I sources encapsulated by titanium are used for Brachytherapy to treat Eye and Prostate Cancers.

Radioactive ^{125}I Seeds

Construction of a ^{125}I Seed

Gold Plaque containing 125I Seeds

Clinical trials using ^{32}P-skin patches in AIIMS, New Delhi were successful in treating superficial cancer.

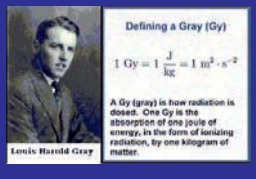
Radiopharmaceuticals

^{177}Lu-DOTATATE for the treatment of Endocrine Tumors. Somatostatin is a harmone produced in the pancreas, which inhibits the secretion of other pancreatic hormones such as Insulin and Glucagon. Some Endocrine Tumours cause excessive secretion of Somatostatin (somatostatinoma) resulting in suppression of insulin secretion from the pancreas leading to raised blood glucose levels (diabetes) and may also result in the formation of gallstones, intolerance to fat in the diet and diarrhoea.

^{177}Lu-DOTATATE is a radiopharmaceutical consisting of beta and gamma emitting ^{,77}Lu designed to target Somatostatin receptors and treat the tumor when injected intravenously.

Louis Herald Gray (1905-1965)

Devised the first 400 kV neutron generator with which he could directly measure the effects of ionizing radiation on biological matter.



This innovation resulted in the development of Radiotherapy of Cancer. He gave the definition of radiation dose which was later named after him i as the Gray in the SI system of units.

PET scan uses a special dye containing Radioactive Tracers, which are either swallowed, inhaled, or injected into a vein. Certain organs and tissues then absorb the tracer. Certain diseases produce a higher level of chemical activity, which will show up as bright spots on the PET scan.The PET scan can measure blood flow, oxygen use, how your body uses sugar, and much more.

SPECT is a Nuclear Imaging Scan that integrates Computed Tomography (CT) and a Radioactive Tracer. The tracer is what allows doctors to see how blood flows to tissues and organs. Before the SPECT scan, a tracer is injected into the bloodstream.

FROM DIAGNOSTICS TO THERAPY

ATOMS in HEALTHCARE

Medical Electronics

12-Channel Tele-ECG

Tele-ECG Instrument in Action

Tele-ECG Instrument

- Generates report on a mobile.
- Battery operated.
- Around 300 records per recharge.
- Lead Fail Alarm to indicate faulty lead connection.
- Heart Rate Variability for disease characterisation.

Body Composition Analyser

- **BONE MINERAL CONTENT** for early detection of Osteoporosis.
- **BODY FAT MASS** to determine the risk of Coronary Artery Disease, Hypertension, Diabetes & Osteoarthritis.
- **PROTEIN** to determine Protein Energy Malnutrition, Anemia and Proteinuria Diseases.
- **BODY MASS** Index for Coronary Heart Disease & Stroke.
- **BODY CELL MASS** to determine TB and Terminal Cancer.
- **INTRA** and **EXTRA CELLULAR WATER** to monitor Electrolyte Imbalance.
- **MINERAL CONCENTRATION** of Sodium, Iron & Potassium.
- **SKELETAL MUSCLE MASS** to predict Bone Strength
- **WAIST HIP RATIO** for Cardiovascular Disease.
- **VISCERAL FAT AREA** to determine risk of Heart Diseases.

Measures body impedance using an alternating current (below 1 mA) at 6.25kHz, 50kHz and 250kHz frequencies. Calculates body parameters using the Principle of Bioelectric Impedance Analysis. The technique is non-invasive, safe and inexpensive.

Honourable President of India getting examined on Body Composition Analyser

Radiation in Cancer Treatment

Two Ways of Radiotherapy

Teletherapy

Source of radiation is located outside the body. Radiation can be X-rays, Gamma Rays, Electrons and Protons. Cobalt-60 produced in Nuclear Reactors such as DHRUVA is the source of Gamma Rays in Bhabhatron, which is a Teletherapy Machine developed by BARC for cancer treatment.

Bhabhatron The Teletherapy Machine

Radiation Therapy Machine for Cancer Treatment

- Cobalt-60 Radiation Source
- Computer Controlled Radiation Exposure to a Cancerous Tissue
- Enhanced Radiation Safety
- Battery Back-up
- Collimator Auto Set-up
- Remote Monitoring

DR. VIKRAM SARABHAI

Birth Centenary Year

(August 12, 2019 to August 12, 2020)

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