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GOVERNMENT OF INDIA

DEPARTMENT OF ATOMIC ENERGY

ANNUAL REPORT 2024-25

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DAE

ATOMS IN THE SERVICE OF THE NATION

GOVERNMENT OF INDIA
DEPARTMENT OF ATOMIC ENERGY

ANNUAL REPORT
2024-25

Cover page caption: Kakrapar Atomic Power Project (KAPP) – 3 & 4

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EXECUTIVE SUMMARY

The Department of Atomic Energy's vision is to empower India through technology, creation of more wealth and providing better quality of life to its citizens. DAE is engaged in the design, construction and operation of nuclear power/research reactors and the supporting nuclear fuel cycle technologies to achieve these objectives.

Advanced technologies such as accelerators, lasers, supercomputers, advanced materials and instrumentation are developed and transfer of technology to industry is encouraged which contributes to the national prosperity.

In addition, the Department is engaged in the development of radiation technologies and their applications for better crop varieties, techniques for crops protection, radiation based post-harvest technologies, techniques for radio-diagnosis and radiotherapy of diseases particularly cancer, technologies for safe drinking water, better environment and industrial growth.

DAE actively contributes to knowledge enrichment by way of support to basic research in nuclear energy and related frontier areas of science; Interaction with universities and academic institutions; Support to research and development projects having a bearing in DAE's programmes, and international cooperation in related advanced areas of research.

During the year 2024-25, the programmes of the Department achieved impressive growth in all these domains. These are described below:

NUCLEAR POWER PROGRAMME

NUCLEAR POWER PROGRAMME STAGE-1

Power Generation

Nuclear Power Corporation of India Limited (NPCIL), operates 25 nuclear power reactors with an installed capacity of 8880 MW. This includes Rajasthan Atomic Power Project (RAPP) Unit-7 [indigenously designed 700 MW Pressurized Heavy Water Reactor (PHWR) with state-of-the-art technology incorporating enhanced safety features]

Performance Highlights

Generation Performance

During the Financial Year (FY) 2024-25, NPCIL registered total power generation of 56713 MUs (including infirm power generation of 32 MUs from RAPP Unit-7). In the previous FY 2023-24, the total power generation was 48801 MUs (including infirm power generation of 830 MUs from KAPP Unit-3&4).

Kakrapar Atomic Power Project (KAPP) – 3 & 4

During the FY 2024-25, the overall Availability Factor (AF) and Plant Load Factor (PLF) for the reactors in commercial operation were 88% and 87% respectively (excluding the capacities of units under long shutdown in project mode). Both these figures for last FY 2023-24 were 85%.

During the Calendar Year (CY) 2024, NPCIL registered highest ever power generation of 54817 Million Units [including infirm power (non-commercial power) generation of 110 MUs from KAPP Unit-4]. In the previous CY 2023, the total power generation was 49146 MUs (including infirm power generation of 911 MUs from KAPP Unit-3).

Continuous, safe and reliable operation of reactor unit for more than a year

During the FY 2024-25, the feat of continuous, safe and reliable operation for more than a year has been achieved by five reactor units viz. NAPS-1, TAPS-3, KGS-1, NAPS-2 and MAPS-2. Further, RAPS-6 registered continuous operation for a year on April 1, 2025, and with this, so far, the continuous, safe and reliable operation for more than a year has been achieved 52 times by various reactors operated by

NPCIL. Out of these, four reactors KGS Unit-1, NAPS Unit-2, RAPS Unit-3 and RAPS Unit-5 have operated continuously for more than two years. The continuous operation for 962 days registered by KGS Unit-1 is second longest continuous operation in world among all reactor technologies. Nuclear power reactors in operation registered cumulative 635 reactor years of safe operation as on March 31, 2025.

Capital Expenditure

NPCIL has achieved highest ever CAPEX of ₹ 17984 Cr. during FY 2024-25.

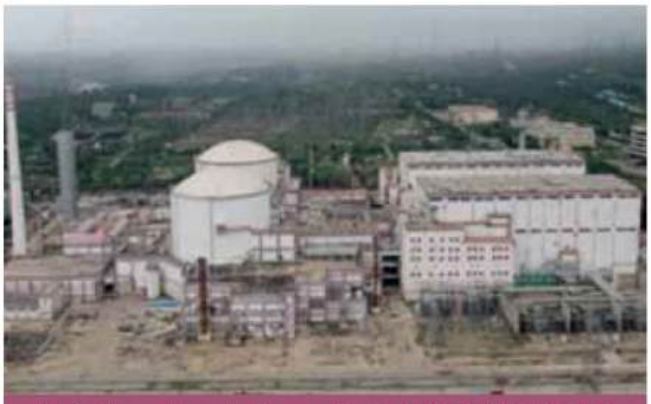
Operating Units taken in Project mode

RAPS Unit-3 (220 MW PHWR) resumed operation on July 24, 2024 after successful completion of Renovation and Modernization (R&M) activities. This unit was under shutdown in project mode since October 28, 2022. The R&M activities were completed in the shortest time among Indian Reactors in which similar activities were taken up. MAPS Unit-1 (220 MW PHWR), TAPS Unit-1 (160 MW BWR) and TAPS Unit-2 (160 MW BWR) are under long shutdown and have been taken in project mode for ageing management and safety upgrades. In addition to these units, recently, KGS Unit-1 (220 MW PHWR) has been taken under shutdown in project mode since 01.04.2025 for EMCCR, EMFR and other safety upgrades. Various studies/works are in progress at these units.

Nuclear Power Plants under construction

Rajasthan Atomic Power Project (RAPP) Unit-7&8 W(2x700 MW PHWRs)

RAPP-7&8 is India's second pair of indigenous 700 MW PHWRs being set up at Rawatbhata, Rajasthan. RAPP-7 achieved Synchronization with the grid on March 17, 2025 and the Unit has been declared commercial with effect from April 15, 2025. In RAPP-8, "Primary Heat Transport (PHT) system Hydro test" is already completed and preparatory activities for "Hot Conditioning" are in progress. The overall Physical Progress of RAPP-7&8 as on end March 2025 was about 96.68%.



Rajasthan Atomic Power Project (RAPP) Unit-7&8

Kudankulam Nuclear Power Project (KKNPP) Unit-3&4 (2x1000 MW LWRs)

KKNPP-3&4, located in Tirunelveli district of Tamil Nadu, is an expansion project of KKNPP Units-1&2. This project is being implemented with technical cooperation from Russian Federation. Civil works and mechanical erection works are in progress in KKNPP - 3 & 4. In KKNPP-3, a major milestone namely, "Concreting of Outer Containment (OC) dome in Reactor Building-3", is achieved. In KKNPP-4, an important milestone "Erection of Nuclear Safety, Security and Safeguard equipment (RPV, SG, RCP, PRZ)" is completed. Towards manufacture of Long Manufacturing Cycle equipment and components, 433 out of 444 manufacturing milestones have been completed till March 31, 2025.

Physical Progress of KKNPP-3 as on end March 2025 was 79.45% and that of KKNPP-4 was 74.73%.

Kudankulam Nuclear Power Project (KKNPP) Unit-5&6 (2x1000 MW LWRs)

This is the third pair of KKNPP projects located in Tirunelveli district of Tamil Nadu where first two units KKNPP-1&2 is in operation and second pair KKNPP-3&4 is under construction. Civil works are in progress in KKNPP-5&6. Important milestones such as "Erection of Core Melt localizing facility (core catcher)" and "Erection of Truss cantilever" in reactor cavity of Reactor Building are completed in KKNPP-6.

Physical Progress of KKNPP-5 as on end March 2025 was 37.70% and that of KKNPP-6 was 32.65%.

Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP) Unit-1&2 (2x700 MW PHWRs)

GHAVP-1&2 Project is located in Fatehabad district of Haryana. Construction of various civil structures like Fire Water Pump House, Safety Related Pump House, Fuel Oil Storage Area, D2O Upgrading Building, Switchyard Control Building, Fire and Industrial Safety House, Tunnels, Emergency Makeup Water Pond Area, Retaining wall, WMP tunnel, Stack, Induced Draft Cooling Towers (IDCTs), Plant Drain Storage Pond etc. are in progress.

Manufacturing and delivery of various equipment and components are in progress. End shields (Unit-1), all Steam Generators (Unit-1), one Steam Generator (Unit-2), Moderator Storage Tanks (Unit 1 & 2), Test Station of Reactivity drive (Unit-1), Top Hatch Beams & Deck plate assembly from KAPP-4, Fuelling Machine Head (Unit 1&2), Three FM Bridge & Column (Unit-1&2), Roll on Shield (Unit 1&2), Fixed Shield (Unit 1&2), Shield plug (Unit-1), Seal Plug (Unit-1), Fuel Locator (Unit-1), Canned motor pumps (Unit-1&2), Grid condenser (Unit-1) and Pressuriser (Unit-1) have been received at site. Progressive manufacturing and delivery of balance equipment and components are in progress.

Project under launch (having administrative approval & financial sanction from Government of India)

1st fleet of Ten 700 MW PHWRs

The Government of India has accorded administrative approval and financial sanction for taking up construction of 10 indigenous 700 MW PHWRs in Fleet Mode. These reactors are being set up at Kaiga in Karnataka (Kaiga-5&6), Gorakhpur in Haryana (GHAVP-3&4), Chutka in Madhya Pradesh (Chutka-1&2) and Mahi Banswara in Rajasthan (Mahi Banswara-1 to 4).

Fleet mode construction commenced with 'Ground Break' of Kaiga-5&6 project after obtaining AERB clearance. At Kaiga-5&6, Confirmatory Geotechnical investigation in main plant area are nearing completion. Further works are in progress towards First Pour of Concrete. Contract is awarded for Nuclear Island Mega EPC Package. At GHAVP-3&4, land is available. Siting consent from AERB and Environmental Clearance from MOEFCC are available. EPC package for Turbine Island has been awarded.

At Chutka-1&2, Environmental Clearance has been accorded by MOEFCC, Water agreement between MP State Govt. and NPCIL has been signed and possession letter has been issued for all types of land. Construction of all 330 dwelling units for R&R colony has been completed and ready for shifting of PAPs. At Mahi Banswara site, land acquisition is in advanced stage and Environmental Clearance from MOEFCC is in process. Stage-2 forest clearance is received from MOEFCC. Construction of R&R colony & approved infrastructure has been completed and allotment is completed. Construction of plant boundary wall and installation of concertina fencing has been completed. Pressure Metre test (PMT) is in progress in main plant area. The Government accorded approval to the Anushakti Vidhyut Nigam Ltd. (ASHVINI), a Joint Venture (JV) of NPCIL and NTPC Ltd. to take up nuclear power generation and associated activities in accordance with the Atomic Energy Act, 1962. Proceedings for implementation of the Mahi Banswara 1 to 4 project by NPCIL-NTPC JV Company are in progress.

New Sites (having in-principle approval of the GoI)

Light Water Reactors (LWRs)

Jaitapur, Maharashtra

Land has been acquired. Statutory clearances are available. Techno-commercial discussions with Electricite de France (EDF), are in progress. NPCIL has initiated the process for revalidation/ renewal for CRZ/EC clearance. Revised application is to be submitted for Siting consent. A special task force is constituted to look into all aspects of the project including financial validity, before taking decision on Pre-Engineering Contract (PEC).

Kovvada, Andhra Pradesh

Land acquisition and R&R is in advanced stage. Land acquisition for R&R colony is completed and land

is handed over to NPCIL. EIA studies are under progress. Discussions on CLND issues are in progress at Government-Government level for further techno-commercial discussions with Westinghouse Electric Company (WEC) to setup large sized imported Light Water Reactors (LWRs).

Pressurized Heavy Water Reactors (PHWRs)

Honourable Prime Minister Shri Narendra Modi visited Kakrapar Atomic Power Project (KAPP) on February 22, 2024, and dedicated KAPP-3 and KAPP-4, the two largest frontrunning nuclear reactors among the fleet of 700 MWe indigenous PHWRs of NPCIL, to the nation.

Honourable Prime Minister, Shri Narendra Modi dedicated Units 3&4 of Kakrapar Atomic Power Station (KAPS-3&4) to the nation on 22/02/2024

Sites for 2nd Fleet Mode PHWRs (10x700 MW PHWRs) have been identified viz. KAPP-5&6 (2x700 MW PHWRs) at Kakarapar in Gujarat, RAPP-9&10 (2x700 MW PHWRs) at Rawatbhata in Rajasthan, NAPP-3&4 (2x700 MW PHWRs) at Narora in Uttar Pradesh and Bhimpur-1 to 4 (4x700 MW PHWRs) at Bhimpur in Madhya Pradesh. In-principle approval of the Government exists for NAPP-3&4 and Bhimpur-1 to 4 sites, and the same is in process for KAPP-5&6 and RAPP-9&10.

Bhimpur-1 to 4, Madhya Pradesh (4x700 MW PHWRs)

In-principal approval from GoI exists and AEC has given approval to undertake pre-project activities. Commitment for water is confirmed by Madhya Pradesh State Government. Further pre-project activities are initiated with State Govt. agencies.

Narora Atomic Power Project (NAPP)-3&4 (2x700 MW PHWRs)

In-principal approval from GoI exists and AEC has given approval to undertake pre-project activities. NAPS Unit-1&2 (2 x 220MWe, PHWRs) are already in operation and land is available for NAPP-3&4.

220 MW Bharat Small Reactors (BSR)

BSRs are 220 MW PHWR with an impeccable safety and excellent performance record, which are compact and tailored for captive use. These reactors can provide a sustainable solution for decarbonization of hard to abate industries and help these industries to secure economic benefits resulting from savings in carbon emission related taxes thus increasing competitiveness of their products in the global markets. These reactors are planned to be set up with private capital, within the existing legal framework and approved business models.

NPCIL invited Request for Proposals (RFP) from visionary Indian industries for setting up 220 MW Bharat Small Reactors (BSR) for captive use.

Initiative for Hydrogen Generation

Nuclear power is a clean base load source of electricity and can be used to generate clean Hydrogen. Considering the emerging business opportunities in production of Hydrogen from nuclear power, NPCIL has resolved to take enabling steps for entering into the business of clean Hydrogen generation from nuclear power at an appropriate time. NPCIL had framed its Hydrogen policy. In this context, to gain experience in Hydrogen production and related aspects, NPCIL has set up a Hydrogen Generation Unit (Alkaline Electrolyzer) with 25 Nm^3 per hour capacity at Tarapur site and made it operational. One more Hydrogen Generation Unit (Polymer Electrolyte Membrane Electrolyzer) and it's associated systems is being set up at Rawatbhata site.

Front-End Fuel Cycle comprises operations such as mining, milling and processing of ore, and fabrication of fuel. In addition, production of heavy water, used as moderator and coolant in pressurized heavy

water reactors, also constitute a major programme segment of the Nuclear Power Programme.

DAE has wide-ranging capabilities in uranium mining and mineral processing, and is self-sufficient in the production of heavy water, zirconium alloy components and other materials and supplies, for pressurised heavy water reactors. The Nuclear Fuel Complex at Hyderabad manufactures fuel assemblies for pressurised heavy water reactors, boiling water reactors and fast breeder reactor.

Heavy Water Production

HWB is mandated to produce Heavy Water to support PHWR program of INPP. Accordingly, Heavy Water is recently supplied to RAPS-7 for initial inventory and also regularly supplying Heavy Water as make-up to PHWR's under operation.

HWB is known worldwide, for its supreme quality product and hence could bag an agreement with Argentina for supply of Heavy Water for its Nuclear Power Program.

Along with nuclear applications, HWB is encouraging institutions / industries / research academics for pursuing developmental work in non-nuclear application of Heavy Water. Around 80 MT of Heavy Water has been supplied to domestic and international entities for non-nuclear applications during report period. HWB is also regularly supplying Deuterium Depleted Water (DDW) for non-nuclear application in Healthcare industries / institutions.

Diversified Projects at HWB

Developmental project for Synthesis and biological evaluation of deuterated analogs of some antineoplastic drugs is under progress with MS University, Vadodara. MSU has synthesized 2 nos. of Dasatinib, which are under biological evaluation. The project is progressing as envisaged and is likely to earmark a milestone development in Healthcare industry and open-up future avenues for Deuterated Active Pharmaceutical Ingredients (APIs).

HWB also is working with Advanced Centre for Treatment, Research and Education in Cancer, Navi Mumbai (ACTREC), for Evaluation of anticancer potential of Deuterium Depleted Water (DDW) on human breast and lung cancer cells. The project has concurrence of Ethics committee. HWB has supplied desired quality of DDW for carrying out clinical trials on Humans. DDW production facility is augmented at HWP-Kota, and the facility has been inaugurated by Secretary, DAE. Plant is under continuous operation.

Mineral Exploration and Mining

The Atomic Minerals Directorate for Exploration and Research (AMD) with a major mandate to identify and evaluate mineral resources of Uranium (U), Thorium (Th), Niobium (Nb), Tantalum (Ta), Beryllium (Be), Lithium (Li), Zirconium (Zr), Titanium (Ti) and Rare Earths Elements (REE) containing uranium and thorium, has carried out integrated multi-disciplinary exploration in various geological domains in the country to support the Nuclear Power Programme of India.

Uranium investigations were continued in the thrust areas for establishing Proterozoic unconformity, Granite-related, Carbonate, Metamorphite, Palaeo-QPC and Metasomatite type uranium deposits in Proterozoic Basins; and Sandstone and Surficial types of Uranium deposits in Phanerozoic Basins. Similarly, substantial exploration inputs were deployed for augmentation of Rare Metal and Rare Earth mineral resources in Pegmatite Belts of Chhattisgarh, Odisha and Karnataka as well as Ambadungar Carbonatite Complex, Gujarat and Siwana Ring Complex, Rajasthan. In addition, collection of columbite – tantalite (Nb-Ta mineral) and xenotime (REE mineral) bearing heavy-mineral concentrate was continued in the units established in Odisha, Karnataka and Chhattisgarh. The coastal beach and inland placers in parts of Tamil Nadu, Odisha, Karnataka and Andhra Pradesh were explored for augmentation of heavy minerals.

During the year 2024, substantial inputs in form of radiometric survey and geological mapping (9,978 sq km), geochemical survey (5,394 sq km), heliborne (12,032 line km) and ground (1,461 km) geophysical survey and drilling {Total: 1,67,843m (Departmental: 78,204m and Contract: 89,639m)} were given for exploration of U, Th, Ti, REE, Nb-Ta, Li, Be and Zr. The summary of the work accomplished during the course of

exploration and related significant activities during the period January-2024 to December-2024 are summarized below:

A total of 12,478 tonne in-situ uranium oxide (U_3O_8) resource has been augmented during the period in the states of Andhra Pradesh, Jharkhand and Rajasthan through sustained exploration inputs in potential geological domains of the Country.

A total of 74,900 tonne in-situ Rare Earth Oxide (REO) has been augmented in hard rock terrains of Rajasthan and country's total RE-oxide in hard rocks is updated to 1.23 million tonne (Mt). In addition, 8,570 tonne Nb_2O_5 (Niobium Oxide) is also estimated in these hard rocks.

A total of 1,800 tonne lithium oxide (Li_2O) in G-2 category has been established from pegmatite (hard rock) terrain of Karnataka.

An agreement has been signed with Council of Scientific & Industrial Research (CSIR) and National Geophysical Research Institute (NGRI) for Extension of Memorandum of Understanding (MoU) between DAE, AMD and CSIR-NGRI for carrying out heliborne geophysical survey.

Rare Earth Metal production started for the first time in the Country with operationalization of facility for Cerium and Lanthanum metal in the Rare Earth & Titanium Theme Park at Bhopal. Facility for production of Neodymium metal and recovery of Rare Earths from end-of-life cycle magnets have been operationalized. Other plants (Lamp & LED Phosphor Plant) are under various stages of engineering/procurement/installation.

With regard to Safety against radio activity and long-term storage of Thorium Oxalate- Phase II (2022-29) at OSCOM, Odisha & Rare Earth Division, Kerala, activities such as construction of approach road, sealing of Trenches are underway.

Commissioning & trial run of equipment is in progress for Pilot Plant Facility/ Technology Demonstration Plant (TDP) for Producing 4N Pure Titanium Dioxide and 4N Pure Zirconium Oxychloride in OSCOM, Odisha.

The JV Company 'IREL TAMIN Limited" with Tamil Nadu Minerals Limited (TAMIN) has been incorporated on 26.06.2024 for harnessing the mineral sand deposits viz. the Sathankulam and Kudiraimozhi deposits in the state of Tamil Nadu. The pre-project activities and preparation of DPR for the project are under way.

Joint Venture (JV) Agreement was signed on 04.11.2024 between M/s IREL (India) Limited and M/s Ust-Kamenogorsk Titanium and Magnesium Plant JSC, Kazakhstan (UKTMP) for production of Titanium Slag in India and incorporation of company by the name 'IREUK Titanium Limited' and the work is in process.

IREL has entered into MoU with Sultanate of Oman for Co-operation on Rare Earths. Further, in this regard, prospecting activities are planned at Khour grama deposit, the potential REE prospect. Site activities were undertaken in month of October 2024. Lab analysis of geological samples collected during field work is underway.

All the mines and mills of UCIL are continuing to operate satisfactorily.

The Tummalapalle unit of UCIL has demonstrated remarkable progress during FY 2023–24 and produced U_3O_8 around its annual name plate capacity.

A Magnetite by-product recovery plant has been successfully commissioned at Uranium Ore processing Plant, Turamdih for recovery of Magnetite from Uranium Ore tailings. Daily about 52.00 MT of Magnetite can be recovered from the tailing.

UCIL has taken various initiatives for expediting the opening of different Greenfield projects and expansion of brownfield projects. The District Administration, Government of Karnataka, has completed the demarcation of the proposed mining lease area of the Kanchankayi Project and submitted it to the Dept. of Mines & Geology, Bangalore. DMG has been entrusted with DGPS survey & Preparation of Land schedule, Cadastral Map etc.

District Administration, Yadgir, has completed the cadastral map and preparation of land schedule for

Gogi Project. Submission of final report to the Director, Mines & Geology is awaited.

The mining plan for the Rohil Project located in Sikar district of Rajasthan has been approved by AMD during April 2024 as per the terms and conditions of the LOI issued by the Government of Rajasthan. Obtaining the environmental clearance for this Project is in process. Term of reference (ToR) has been received from Ministry of Environment, Forest and Climate Change (MoEF&CC) for grant of environmental clearance.

For expediting the pre-project activities of various Green field & Brown Field Uranium projects, an Expression of Interest (EOI) has been floated for Exploring Competent Indian Environmental, Mining, Mineral processing Project management consultants for South Project, which is under evaluation.

The techno-economic feasibility study for the utilization of mill tailings, produced at Tummalapalle mill, in the cement manufacturing industry has been initiated by BARC in collaboration with M/s. National Council for Cement and Building Materials (NCCBM). Similarly, R&D for utilization of mill tailings from Jaduguda and Turamdih mills for manufacturing of bricks for use in the construction industry has also been initiated.

Fuel Fabrication

Nuclear Fuel Complex (NFC), an ISO 9001, 14001 & 45001 organisation under Department of Atomic Energy (DAE), is engaged in the production of natural Uranium fuel bundles for Pressurized Heavy Water Reactors (PHWRs), enriched Uranium fuel assemblies for Boiling Water Reactors (BWRs), Reactor Core Structural (Calandria tubes, Coolant tubes, square channels etc.), Reactivity Control Mechanisms and special materials like Tantalum, Niobium etc. In addition, for Fast Breeder Reactors, NFC produces all the core sub-assemblies and other critical components like fuel clad tubes, hexagonal wrapper tubes etc. made out of special stainless steels / D9 materials. NFC also caters to the demand of high-quality stainless-steel tubes/pipes, Steam Generator tubes, Super Ni tubes, Zr 1%Nb and titanium alloy products etc., for other nuclear and non-nuclear applications.

Some of the significant achievements of NFC during the year includes the indigenous development and manufacture of Monel 400 (Nickel & Copper alloy) tubes of size 38 mm OD, 3 mm WT & 33.6 mm OD, 0.3 mm WT meeting all the required quality parameters for LPSC, ISRO. These tubes are supplied for Cryogenic applications; In-house development of automated end cap welding machine reduced maintenance and element rejection in PHWR fuel bundle manufacturing; In-house development of an automated "PHWR Fuel Element End Cleaner and Stack Length Measurement System" for detection of missing pellets during PHWR fuel bundle manufacturing; Implementation of thyristorised Power Control System for Split Reaction Zone in Kroll's Reduction Furnaces at ZSP enabling uniform temperature distribution (<40°C) and improved purity of Zirconium; Modification of Billet Cu-jacketing method to eliminate the overlap of Cast iron over the Zirconium alloy at the discard end of the extruded tube during extrusion process. This has improved the recovery up to 2% of Zr-alloy in the form of re-meltable discards & nearly 10T per year of re-meltable Zr-alloy is unlocked for recovery; Installation & Commissioning of CNC Centerless Bar Grinding Machine with automated Loading, Feeding and Unloading of finished bars. This has improved productivity by approx. 30% and reduction of manpower by 50%; Automated Eddy Current System for Testing of Bar Material with high throughput owing to High test speed (15m/min), automated defect marking and sorting; Development of Computer Radiography Facility for Reactivity Mechanism and Other Special Assemblies has eliminated dark room film processing & improved inspection environment; Integration of ECT with high-speed probe rotating UT system for tube testing at QA-SSTP. With this, inspection time and material handling are reduced considerably and resulted in saving of significant man-hours; Indigenous development of Non-Contact Out Of Roundness online Measurement system of tubes with an accuracy of +/- 0.1 %. This has eliminated conventional contact based and destructive type measurement for determining OOR of tubes; Modernization of Control System of 3x3 Roller Straightening Machine with advanced PLC and HMI based system; Development of Machine Vision System and Data Acquisition Systems for End Plate Welding Machine. Machine vision software logic was built to identify the defects in the end-plate welding process;

Installation of Advanced OD grinding machine comprising four stations with a pressure grinding arrangement featuring pressure rollers for high material removal rates, along with two stations designed for slack grinding to polish tubes; Installation & Commissioning of fully automated CNC Tube bending machine & Grit blasting machine for SG tubes; Installation & Commissioning of 5T Capacity Precision Triple Tube Draw bench with automatic tube unloading system; Installation of Higher Capacity Low Temperature Calciner & High Temperature Calciner in Oxide Production Facility (ZC) to enhance the Reactor Grade Zirconium Oxide production; Revamping of Spacer Welding Machine for Liquid Zone Control (LZC) assembly tube with advanced state of the art features for weld quality improvement and Installation & Commissioning of new Graphite Coating Machines with 50% improved productivity.

NUCLEAR POWER PROGRAMME STAGE-2

Fast Reactor Program

For the second stage of the Nuclear Power Generation Programme, the Indira Gandhi Centre for Atomic Research (IGCAR) is pursuing development of sodium cooled fast breeder reactors and associated fuel cycle technologies. Breeder reactors produce more fuel than they consume.

The Fast Reactor Programme of IGCAR is supported by its research and development endeavour in a range of disciplines such as reactor engineering, metallurgy, materials science, instrumentation, safety, and others. The Fast Breeder Test Reactor (FBTR), operating at Kalpakkam for over 25 years, also caters to technology development related to fast reactor.

Based on the fast breeder reactor technology developed by IGCAR, a 500 MWe Prototype Fast Breeder Reactor (PFBR) is coming up at Kalpakkam. The project is being executed by the Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI), a public sector undertaking of DAE.

BARC contributes to the research & development and manufacture of fuels for fast reactors, technology for reprocessing of fuels, waste management and health and safety of the work force. The Fast Breeder Test Reactor (FBTR), the flagship of IGCAR, continues to serve as a test bed for the irradiation of fuel and structural materials in fast neutron flux, as well as a training hub for fast reactor operators. The 33rd Irradiation Campaign at FBTR was completed on July 23, 2024, at 40 MWt, with a total operating time of 2,664 hours and the electrical energy generated was 15.49 million units.

After filling of 1150 t of sodium in Main Vessel, primary sodium temperature was raised to 200°C by operating both the secondary sodium pumps. The indigenously designed and developed Primary Sodium Pumps meant for pumping the primary sodium through the reactor core for removing the heat has been commissioned and put into operation. With this, all the four primary and secondary sodium pumps are in operation. Purification of Sodium in Main vessel at 200°C was completed and the plugging temperature of sodium in Main Vessel was brought down to less than 105°C (impurity level less than 1 ppm) which shows that the Main Vessel & associate circuits and sodium stored in storage vessels were maintained in ultra clean condition over the years.

Later, primary sodium temperature was raised to 400°C and the sodium was purified up to 400°C with Initial sodium purification circuit. Performance testing of all the 12 nos of Absorber rod drive mechanisms was carried out at 400°C followed by isothermal testing of various systems. All the four Safety Grade Decay Heat Exchanger (SGDHR) Loops were filled with sodium, purified and sodium flow was established to meet the design intent. With this all the sodium loops (primary, secondary and SGDHR) were commissioned.

BHAVINI has submitted application for regulatory clearance for carrying out initial fuel loading and first approach to criticality in three phases. They are Phase-1: Loading of Absorber Rods; Phase-2: Loading of Blanket SAs and Phase-3: Loading of other sub-assemblies including Fuel SAs followed by First Approach to Criticality (FAC) and zero power tests. On obtaining Phase – 1 regulatory clearance, core loading was started with loading of first Control & Safety Rod Sub-assembly in the core in the august presence of

Honourable Prime Minister on 4th March 2024. Later, loading of all the remaining eight nos. of Control & Safety Rod & three nos. of Diverse Safety Rod sub-assemblies was completed. On obtaining regulatory clearance for Phase – 2 activities, 114 nos. of Radial Blanket Subassemblies (BSAs) were loaded in the Reactor.

With respect to Phase-3, multi- tier review by AERB was conducted and clearance has been obtained for Initial Fuel Loading, First Approach to Criticality and to carry out Low Power Physics Experiments. During the trial operations it was observed that Transfer Pot (one of the components of Fuel Handling machines) was not getting fully lowered in the Primary Tilting Mechanism. Since Liquid sodium is opaque, direct inspection is not possible which makes viewing as well as repair more difficult. Hence, a full-size mock-up of the desired region with a spare Primary Ramp & Primary Tilting Mechanism (PR- PTM) was established and Demineralised water was filled in it. An Ultrasonic Inspection (USI) imaging tool was developed and the same was deployed in mock-up facility to validate its performance and record the baseline data under water. Further this tool was deployed in the reactor and scanning was done in the problematic region under sodium and data was captured.

As part of the metal fuel development programme, the 'Sub-assembly level Metal Fuel Fabrication Facility' was inaugurated by Dr. Ajit Kumar Mohanty, Chairman, AEC & Secretary, DAE, on May 28, 2024. On the same day, a new experimental facility for pyro-processing operations using U-Pu-Zr alloy (up to 250g per batch) was also inaugurated.

Towards R&D on Reprocessing, the indigenously developed Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP) at IGCAR was dedicated to the nation on January 2, 2024, by Honourable Prime Minister, Shri Narendra Modi. The plant was hot commissioned during April 2024, and two successful campaigns for processing FBTR spent fuel were completed. The third campaign of limited hot run commenced in December 2024, processing 60 FBTR spent fuel pins with a burnup of 155 GWd/ton. Chopping and dissolution of 60 pins in a single batch was carried out for the first time at DFRP, achieving its full design capacity.

The Compact Facility for Reprocessing Advanced Fuel (CORAL) completed 66 reprocessing campaigns for FBTR spent fuel and was relicensed by AERB until 2028.

NUCLEAR POWER PROGRAMME STAGE-3

The Uranium-233 fuelled Kalpakkam Mini Reactor (KAMINI) continued its successful operation for neutron radiography of irradiated fuels, active and inactive components, activation analysis, neutron detector testing, and other plant-related experiments. During 2024, KAMINI was operated several times at power levels up to 20 kWt for various user requirements and plant-related experiments.

HEALTHCARE

BRIT continued to supply affordable radiopharmaceuticals for Nuclear medicine sector in India using its novel IT- enabled Pan India door delivery logistics services in the year 2024-2025. BRIT has supplied 18186 Nos. of Technetium Cold Kits, 459 Nos. of Technetium-99m Generator, 465.38 Ci of Lu-177 and 581.48 Ci of I-131 to various hospitals for both diagnostic and therapeutic purposes. 341.81 Ci of FDG-F18 have been supplied to various hospitals for PET scanning. 21.95 kCi of Ir-192 sources (538 Nos.) were supplied for radiography cameras. 61 Nos. of ROLI radiography camera(s) were supplied for NDT, 6 Nos. of Cobalt-60 teletherapy sources were supplied for cancer therapy. 840 (Pcs.) Tritium filled sources have been supplied to defence organisation. 4 No. of Blood Irradiators were supplied to hospitals and 5 No. of orders were executed for chemical and fabrication industry for column/pipe scanning/radiometry using radio isotope.

Commercial launch of nutraceutical chlorophyllin tablets (Aktocyte) was done by Shri Vivek Bhasin, Director, BARC on 10th June 2024. The medicine was developed in collaboration with BARC,

ACTREC, TMH and Bengaluru based pharma company.

Diagnostic and Therapeutic services for patients commenced at RMRC, Kolkata from Jan, 2024.

Approval was received from Drugs Controller General of India (DCGI) for the manufacturing & commercialization of coat effective, BARC developed NOx releasing dressing for the treatment of diabetic foot ulcer and other chronic wound.

SPF (Special Plate Facility) is fully commissioned & is delivering targets for fission moly programme.

The cancer centres & hospitals under the DAE, Government of India (GoI) & the Tata Memorial Centre (TMC) provided comprehensive care to all its cancer patients through its motto of excellence in Early Detection, Service, Education and Research in cancer. In the past decade, the TMC sprouted from a Mumbai & its Metropolitan Region based two-hospital organization to an eleven-hospital institution in seven states of India (Maharashtra, 3; Punjab, 2; Andhra Pradesh, 1; Uttar Pradesh, 2; Assam, 1; Bihar, 1; and, Odisha, 1). Construction is set to begin soon for the hospital in Jatni, Odisha.

During the year 2024, with total beds of over 2200 pan India, there were 129000 new cancer patients who registered for diagnosis & treatment for cancer (~9% of the annual cancer incidence of India). This was an increase of > 10% over the figures in year 2023. An additional figure of over 30,000 was of those who had registered to rule out cancer as part of TMC's early cancer detection & preventive services. Almost 100,000 patients were admitted in the hospitals across India for cancer treatment in year 2024.

All the hospitals under TMC offered Preventive Oncology services and conducted regular community screenings for early detection of cancer. Patients across all the TMC hospitals were encouraged to avail of the various Central and the local State government's health subsidies.

Some of the major achievements of TMC during the year 2024 includes the increase of capacity by 10% in new patient registration pan India; India's first Proton Beam Therapy centre (in Public sector) at ACTREC was fully functional from last quarter of 2023 and offered subsidized treatment to Indian citizen; The Homi Bhabha Cancer Hospital & Research Centre (HBCHRC) in Visakhapatnam & New Chandigarh, and the Dr B Borooah Cancer Institute (BBCI) in Guwahati performed the first Bone Marrow Transplant in their respective States; The HBCHRC in Muzaffarpur, Bihar has the first LINAC radiotherapy machine in Northern Bihar to treat cancer; A new 44-Bed Palliative Cancer Centre, "Karunatirtha" was commissioned at BBCI, Guwahati; a first in Assam State; The Consortium of Accredited Healthcare Organizations (CAHO) conferred the Awareness Compliance Excellence Certification to the Central Sterile Supply Department (CSSD) of Tata Memorial Hospital; The Newsweek Statista recognized Tata Memorial Hospital (TMH) as the "Best Specialized Hospitals Asia Pacific 2024 for Oncology; To offer state-of-the-art in cancer management, the TMC management replaced many outdated equipment with the most advanced ones (Linear Accelerators, SPECT scanners, Gamma cameras, etc) at a cost of almost INR 100 crore. The International Atomic Energy Agency (IAEA) selected TMC as Anchor of IAEA Flagship of Cancer Care Initiative, the 'Rays of Hope" to train foreign doctors in radiotherapy.

Radiation Technology Based Equipment

Two nos. of Gamma chambers (GC-5000) were supplied to research/education institute and Two Gamma Chamber (GC-1200) units were supplied to RSSD, BARC and RPAD, BARC. Production details and QC studies on ^{18}F-FDG production from enriched ^{18}O-H_2O supplied from Heavy Water Board and RPC proposal has been submitted for routine production and supply of ^{18}F-FDG to hospital. Pilot study for standardization of ^{99}mTc labelling of carbon nanomaterial was initiated in collaboration with BRIT RPh Vashi and CSIR-IICT. User manual and work plan for real time TB PCR kit using magnetic beads is under preparation.

Indigenous Remotely Operated Tungsten Shielded Exposure Device (ROTEX-I) an Industrial Radiography Device was launched. ROTEX-I is a cutting-edge industrial portable radiography device Category II, and designed to hold a source capacity of

2.405 TBq (65 Ci) of Ir-192. Total 405 radiography sources were supplied for refurbishment of radiography equipment.

ADVANCED TECHNOLOGIES

Research Reactors

Dhruva reactor was operational for all the 3 months. Month-wise Availability Factor was 80.2%, 89.7% & 52.8% and corresponding average reactor power was 74.98 MW, 73.65 MW & 72.6 MW, for January, February & March, respectively.

Dhruva & Apsara-U operated at 74 & 86.6 % Availability Factors, respectively. Total of 128 & 2 radioisotope samples were irradiated, respectively.

Rehabilitation of civil structures for strengthening seawater pump chambers (Caisson) & Jetty road and revamping of electrical system (panels, SPPH, power supply cables etc.) of Dhruva were completed.

Critical Facility reactor was operated six times each in January & February, and four times in March.

Hot water layer simulation piping installation of HFRR experimental loop at BARC (V) is in progress. Installation of Heat Transfer Experimental Loop (HELP) loop at BARC(V) was completed and commissioning of the loop is in progress.

Accelerators

At RRCAT, under proton accelerator activity, brazing of all the components of first segment of 3 MeV, 325 MHz RFQ structure was done. Brazed structure was tested for vacuum leak tightness and found to be satisfactory. Horizontal Test Stand (HTS-2) Cryostat and feedcan units (along with accessories) have been shipped to Fermi lab USA as R&D phase PIP-II deliverable to Fermi lab USA. A five-cell 650 MHz cavity HB650-RRCAT-505 was jacketed and subjected to cold tests to verify its performance. Cavity was tested up to accelerating electric gradient of up to 20.4 MV/m, with final quality factor of 2.37E10. A prototype sputter ion pump (SIP) of 20 l/s capacity made of Aluminium body has been developed in-house.

A Constant Gradient (CG) type traveling wave (TW) electron accelerating structure has been designed and developed for electron linac rated for 15 kW average power. A klystron amplifier based compact pulsed microwave system has been developed for the linac. The electron linac facility is used for irradiating 1.9 million medical devices this year and 7.5 million devices in total, for the industry. The facility is also used for colour modification of precious gem stones by the industry.

At SINP, facilities were developed for augmentation and utilization of FRENA facility such as, beam lines and related controls, necessary scattering chambers (both small and large 1-meter diameter), various spectrometers, detectors and their arrays, compatible electronics, and data acquisition systems. The accelerator has now been commissioned and the beam energy calibration has been completed.

Laser Technology

Development of 2 kW average power and 40 kW peak power long pulse Nd:YAG laser has been carried out at RRCAT. This laser has potential for remote cutting SS sheets of ~40 mm thickness and welding up to 8 mm thickness in SS.

Electronics & Instrumentation

Some of the products introduced / projects undertaken by ECIL (by in-house and collaborative R&D efforts) have resulted in the successful realisation /implementation of many things which includes, Commissioning of Beetle Monitoring systems (BMS) for RAPP-3; Ion Chamber Amplifier (ICA) for RAPP 3&4; Start-up Instrumentation system for First Approach to Criticality (FAC) after a prolonged shutdown; Boron-10 coated proportional counters; Alpha, Beta and Radon Monitor (Aerosol Monitor); Extended range Inert Radioactive Gas Monitor for LWR plants; Installation & Commissioning of Neutron Detectors and Neutronic channels at PFBR, BHAVINI; Plutonium in Air Monitor for timely detection of Plutonium in air to prevent hazards; Supply of Ultra stable power converters for FAIR Programme; Upgradation of Disturbance Recording System (DRS) for NAPS 1&2; Bulk supply of Process Media Monitors and Radiation Monitors to KKNPP-3&4; Spectroscopic Iodine Monitor to measure different types of Iodine

Isotopes; Liquid Effluent Monitor; Installation & Commissioning of Nuclear Instrumentation Package at RAPS-7; Installation & Commissioning of Radiation Monitoring Systems at PFBR, BHAVINI; Development & Supply of PLC with 10ms Cycle Time for IPRC, ISRO; Supply of IC based Logic cards -TL (N) to RAPS-2; Bulk supply of Process Media Monitors and Radiation Monitors to KKNPP-3&4; Inert Radioactive Gas Monitor; Extended IRG Monitor (Extended range) and Development & Supply of Indigenous PLC& SCADA system with dual Fibre Ring to SHAR.

Mega Science Projects

As part of the Tri-partite contract-III, 39 nos. of HB.C2 type power converters, 28 nos. of HB.Q10 units, 1 no. of HB.Q15 unit and 4 nos. of S2 units have been manufactured by ECIL, tested and accepted by the customer and the same have been dispatched to FAIR, Germany.

MACE was deployed for observations of gamma ray sources and ~150 hours of data was collected. A tool developed, to analyse wobble data from the MACE, is used to analyze Mrk 421 data. A gamma ray signal at a statistical significance of $\sim 6\sigma$ was detected in ~ 6 hrs of observation.

At VECC, the R&D of p-type detector arrays on 6 Si wafer of 8*9 array (element dimension 1cm^2) was carried out under India-ALICE collaboration, with the technical help from BARC.

NISER is involved in research activities related to ALICE and STAR experiment under this project. In ALICE, NISER group was involved in various physics analyses related to resonance production, correlation & fluctuations, and ultra-peripheral collisions. In addition to data analyses the group was also involved in detector R&D for ALICE upgrade project Forward Calorimeter (FoCal).

Clearance for procurement of feed pumps, make up pump, drain pump, tube & fittings, filters, strainers, etc. were obtained from Commissariat à l'Energie Atomique (CEA) for the Joule Horowitz Reactor (JHR).

Institute participated in various experiments at CMS at LHC, CERN to study various aspects of the standard model, specifically the SM and MSSM Higgs boson.

NISER participated in multiple fronts in the CMS experiment at CERN. It included, experimental data collection, detector performance study, CMS physics data analysis leading to journal publications, building detector for CMS phase-II upgrade which will start in 2026.

LIGO-India Vacuum Integrated System Test Assembly (LI-VISTA) facility has been setup at LIGO-Lab in IPR for evaluation of 80K Cryopump efficacy in trapping water molecules moving along the length of assembly.

At RRCAT, the Civil Design Basis Report (DBR) in collaboration with LIGO-US is completed. A draft of request for Expression of Interest for EPC contract of civil and vacuum infrastructure is completed.

At IPR, all six Torus Cryo-Pump Housings (TCPH) have been successfully manufactured, factory tested, and supplied to the ITER site for acceptance testing. The Cooling Water System (CWS) supplied by India is now operational at ITER. Site Acceptance Testing (SAT) of Diagnostic Neutral Beam Line Components (BLC) and high-resolution spectrometers has been completed. The final design of the Ion Cyclotron High Voltage Power Supply has been completed. A High-Power Amplifier (HPA) of 120kW operating at 36 to 60 MHz has been indigenously developed by IPR. The Decoupling Spool (~8.3m long, ~9T weight) supplied by India was successfully installed at the ITER site.

Characterization of indigenously developed 105 l/s cryosorption pumps for hydrogen pumping has been completed.

RADIOISOTOPE & RADIATION TECHNOLOGY AND THEIR APPLICATION

Agriculture

Eight new crop varieties including 2 wheat, 3 rice and 3 oilseeds (one each in groundnut, mustard &

sesame) were Gazette notified for commercial cultivation. Thus, till date BARC has developed and released total 70 new crop varieties for commercial cultivation.

Food Processing

4564 kCi of Co-60 Irradiator sources were supplied by BRIT to various Gamma Irradiators for food & allied products irradiation. 4059.39 Tons of materials (spices, pet feed, herbal raw material, and colour powder etc.) have been processed using gamma radiation processing. Radio analytical analysis certification was carried for 5661 Nos. of test samples received including human food, water, animal feed, medicines, bakery, agriculture, dairy and other products. Supply of 65,100 numbers of ceric cerous sulphate dosimeters was carried out to various gamma irradiators.

Alternative Applications of Heavy Water

HWB is also successful in developing technology for production of O-18 enriched water, which is used as pre-courser to F-18, required in PET scanning, a non-invasive technique for diagnosis and staging of malignancies/cancer cells. Till date, the O-18 water was being imported and HWB has now set-up its production facility at HWP-Manuguru and supplied the product water to RMC, Parel and to VECC, Kolkata, through BRIT. Based on success, HWB has obtained concurrence of its Board council for capacity augmentation of O-18 water production, to support domestic users as-well-as to exploit export potential.

Radiation Procession Services

Ten MoUs were signed by BRIT for setting up gamma radiation processing facility and they are with M/s Anjaneya Agro Tech., Vijaywada; M/s. NDR Infrastructure Pvt. Ltd., Karjat, Raigad; M/s District Project Livelihood College Society, Dantewada, Chhattisgarh; M/s Fanidhar Mega Food Park Pvt. Ltd., Mehsana, Gujarat; M/s Gujarat Agro Industrial Corporation Ltd., Rajkot, Gujarat; M/s H K Food Park, Eluru, Andhra Pradesh; M/s Naso Industries Pvt. Ltd., Kathua, Jammu & Kashmir; M/s Sri Varsha Food Products India Pvt. Ltd., District YSR Kadapa, Andhra Pradesh; M/s RCC Nutra Fill Pvt. Ltd. Ernakulam, Kerala and M/s Gamma Agro Medical Processing Pvt. Ltd. in Bengaluru, Karnataka.

The Alumina CRM was produced as per ISO 17034: 2016 and ISO guide 35:2017 and the certified values are traceable to SI units. BARC - B1301, was released at NRTC- NALCO Bhubaneswar by BARC and NALCO authorities.

Water Management

BARC developed water purification units have been implemented in 64 equivalent villages in various states to provide safe drinking water including BSF Posts at border areas of Rajasthan & Gujarat, railways platforms at Mumbai and Deen Dayalu Coach in railways. Thus, 200 equivalent villages are benefitted from the scheme till date.

A hybrid sea water desalination plant comprising of 4.5 MLD sea water reverse osmosis (SWRO) and 0.5 MLD Multi-Effect Distillation – Thermo Vapor Compression (MED-TVC) plants at IREL, OSCOM, Odisha were commissioned and dedicated to the nation by the Hon'ble Prime Minister of India on March 5, 2024.

Capacity upgradation from 30 KLD to 75LKD of textile dye effluent treatment demonstration plant was completed at M/s Joharilal Sanchenti & Company (JSC), Jodhpur, Rajasthan. The plant is based on BARC developed Ionic Dye Effluent Loaded De-colouration Technology.

One 1500 KLD plant based on HgSBR technology has been operationalized at Kalpakkam. Three nos. of HgSBR based temporary STPs have been deployed in Kumbh Mela organized during this year.

Indian patent (No. 531960) was granted for the BARC developed modular and compact helical biodegradable waste converter.

BASIC & DIRECTED RESEARCH

Mathematics

At HRI, in Mathematics, a factorization formula for a certain triple product p-adic L-function guided by

the Artin formalism has been obtained. Selmer groups of elliptic curves defined over general p-adic Lie extensions of number fields, algebraic stacks and matrix factorization categories have been analysed. A fluid-structure interaction model has been studied, as well as the inverse scattering problem for the fractional Schrodinger equation and for the fractional Laplace-Beltrami operator. The group explored Ricci solitons and Ricci Bourguignon solitons and its variants. Finally, the idea of n-isoclinism of skew left braces was extended, and a classification of integrable representations of loop of full toroidal Lie algebras with finite dimensional weight spaces was done.

Physics

MACE telescope was inaugurated by Secretary, DAE in October 2024. Observation of galactic events continued with MACE. Results from the data of six high redshift blazars obtained from MACE and Fermi-LAT were published in a peer-reviewed journal.

Synthesis of 12N pure Germanium (Ge) by zone refinement process was successfully established and 50 cc HPGe detector was developed, fabricated and tested.

A portable Cold Atom Gravimeter is developed and launched at RRCAT for precision measurement of earth's gravitational acceleration with potential applications in exploration of underground minerals/oil-fields/gases, monitoring seismic activities, studying geophysics, detecting underground structures, etc.

Other than experiments, several theoretical studies have been carried out at VECC, such as, different fission modes and their probabilities from effective nucleon-nucleon interactions, Exploration of medium effects in strange quark matter with self-consistent thermodynamic treatment, thermodynamics of quark matter, effect of dark matter in core of neutron stars etc.

Scientists from the TIFR, in a three-way collaboration between TIFR, DRDO Young Scientist Lab-Quantum Technologies, and Tata Consultancy Services, have completed end-to-end testing of a 6-qubit quantum processor based on cryogenic superconducting circuit technology.

An international research team, including scientists from TIFR, used the Dark Energy Spectroscopic Instrument (DESI) to constrain the gravitational constant to within 4.7% across billions of light-years and set an upper limit on the sum of neutrino masses at 0.071 eV.

TIFR researchers, using the computational facility of the Indian Lattice Gauge Theory Initiative, predicted the existence of a novel tetraquark, a subatomic particle called Tbc: the beautiful-charming tetraquarks composed of a beauty and a charm quarks along with two light anti-quarks.

Researchers offered a possible resolution of the information paradox in a simple setting by considering a toy model of a gas released from a box into a vacuum.

The GRAPES-3 experiment in Ooty, India, discovered a kink in the cosmic-ray proton spectrum at around 166 tera-electron-volt (TeV). The new feature will advance our understanding of the origin and propagation of cosmic rays, which is a century-old unresolved problem.

TIFR researchers pioneered a method to capture the profile of a single femtosecond laser pulse in a single shot simultaneously across its spatial area. This method was demonstrated by capturing the ultra-rapid variations of a high-temperature plasma mirror that can be used to generate next-generation, ultrahigh-power femtosecond laser pulses.

Researchers developed a low-cost compact inertial nano-positioner with 2-axis movement along with full computer-interfaced open-source electronics and software, operating down to 2 K.

At SINP, probing the origin of high energy cosmic rays via analysis of GeV-TeV data from Fermi-LAT, MAGIC and MACE telescopes through observations of supernova remnants, pulsar wind nebulae and active galactic nuclei was carried out. Multi-wavelength and multi-messenger data analysis was performed to foster synergies between very high energy gamma rays, X-rays, radio waves, etc.

Frontline research in Nuclear physics was undertaken at various national and international accelerator centres using stable ion beams. Indirect measurements to study low energy astrophysical reactions have been carried out in the framework of the asymptotic normalization technique using transfer reactions. Studies were carried out on quasi-elastic scattering of heavy systems at near-barrier energies, and deep sub-barrier fusion of heavy systems with the primary motivations for understanding the reaction mechanisms, and investigate the nuclear potential.

Facilities are developed for high efficiency, high energy fast timing photon spectrometer and advanced gas detectors. Theoretical expertise is developed to analyze and explain data of on-going and future large-scale national and international experimental facilities in High Energy physics, Nuclear physics, Cosmology and Astroparticle physics.

At HRI, the High Energy Physics group carried out research on beyond the Standard Model, and also studied dark matter, gravitational waves, and primordial black holes and also explored the efficacy of machine learning techniques.

The Quantum Information Computing group at HRI has worked on quantum heat transformers, factorization surfaces of many body systems using machine learning, measurement-induced continuous-time quantum walks, Stark localization near Aubry-Andre criticality, quantum batteries and implications of noisy unsharp measurements on quantum resources. It was proved that even-body interactions favour asymmetry as a resource in metrological precision, and that one can have dimensional gain in sensing through higher-dimensional quantum spin chain and that minimal error quantum state discrimination versus robustness of entanglement can lead to more indistinguishability with less entanglement. The group also analyzed achieving quantum advantage in energy storage and power extraction in the design of quantum-based batteries.

Research in string theory has been done on string thermodynamics and possible applications to cosmology.

Chemistry

At TIFR, the Scientists have developed a completely water-soluble, reversible, fluorescent turn-on, Mn(II) selective sensor that could enter living cells within 15 min and enabled the Mn(II) dynamics visualization.

TIFR, in an international collaboration, prepared the first Fe (IV)-superoxo species trapped inside a water-soluble capsule at room temperature that readily functionalizes the C-H bond on call.

Researchers reported the functionalization of donor-stabilized monoatomic carbon-based carbodicarbene in terms of coupling reactions with various aryl chlorides, bromides, and iodides.

At SINP, research in computational atmospheric chemistry has successfully proposed a plausible model for the tropospheric fate of methylhydroxycarbene (one of the products of ultraviolet photodissociation) and the ability of a single water molecule to efficiently promote its isomerization into acetaldehyde – this in fact adds to the amount of aldehyde in the atmosphere.

Established and standardized a single cell for fuel cell application and looking forward to develop a stacked fuel cell for real life application.

Biology

At TIFR, researchers conducted sequence and structural analysis of potential prolyloligopeptidase enzymes in gut bacterial genomes, forming a basis to offer probiotic solutions to Celiac disease patients.

TIFR Scientists studied the elephant population in India, classified as endangered in the IUCN Red List since 1986, by analysing the whole genome sequences from blood samples of elephants. Their study identified five genetically distinct populations of elephants, significantly more than had been earlier believed to exist.

TIFR researchers, using animal models, identified the precise part of the brain and the specific types of nerve cells targeted by the psychedelic DOI to decrease anxiety.

At SINP, a path-breaking innovation has been achieved in biocomputer technology development and multicellular synthetic biology to design and establish multicellular artificial neural network-type architectures to solve multiple computational decision problems.

Research on mitochondrial dynamics has shown that mitochondrial DNA escapes when these organelles are stressed; this is a common occurrence in neurodegeneration.

A study on epigenetic regulation of chromatin architecture unravels significant implications of post-translational modifications in effectively curbing matrix stiffness to reinstate an anti-metastatic phenotype.

At SINP, robust research has demonstrated how the epigenetic landscape modifies itself during cancer progression, also the effect of drugs and tumour adaptability on epigenetic reprogramming in chemo-resistant tumours.

Research has identified new mechanisms of DNA repair and unwinding that may be utilized to design drug targets for cancer therapeutics.

Synchrotron

RRCAT houses indigenously built Synchrotron Radiation Sources (SRS), 450 MeV Indus-1 and 2.5 GeV Indus-2. Both the sources were operated as National facility on round the clock mode. At present 7 beam lines in Indus-1 and 20 beam lines in Indus-2 respectively are operational. The average availability of synchrotron radiation beam for users has been 20 hours/day in Indus-1 and 17 hours/day in Indus-2.1059 user experiments have been carried out with more than 200 research publications during the year. Users from more than 140 different universities, national labs, institutes and researchers from more than 20 industries have been regularly using the Indus beamlines for research activities.

Up gradation of Indus-1 storage ring was undertaken with the installation of new vacuum chambers, additional diagnostics devices and magnets to facilitate implementation of Closed Orbit Distortion (COD) correction scheme and deployment of slow orbit feedback. This up-gradation was aimed at improving the operational performance and providing stable beam to users.

Tuning of the machine for the operation of Indus-2 in low emittance (~ 45 nm rad), has resulted in a significant improvement of the X-ray beam quality. Five Beam Position Indicators (BPI) were replaced in Indus-2 ring with upgraded version, aimed at improving the Slow Orbit Feedback (SOFB) system. Some major experiments carried out at the Indus beamlines by users included in-operando studies on charging and discharging of batteries, in-situ studies on the functioning of catalysts including those helpful for water splitting, determination of stress in mechanical and welded components, structural studies on multifunctional materials, structure determination of several biologically important proteins etc.

Cyclotron

During the year 2024, the most important progress at VECC is the successful delivery of beams from K-500 Super Conducting Cyclotron (SCC) at VECC, to the users for conducting experiments. ^{16}O, ^{14}N and ^{20}Ne beams upto 22 MeV/nucleon have been delivered to the users for experiments. This is the highest energy for beams delivered in India so far. This provides an opportunity to study reaction dynamics and fragment emission mechanism at this intermediate energies, non-equilibrium fission process in pre-actinides and actinides. Several experiments have been carried out in this direction during this year.

K-130 room temperature cyclotron has delivered both light and heavy ion beams. A successful experimental campaign of Indian National Gamma Array (INGA) has been completed. This year, total 20 experiments, using Alpha beam of energies 28-45 MeV and ^{16}O, ^{14}N, ^{20}Ne beams of energies 7-8 MeV/nucleon, have been performed with INGA setup by users from various national institutes and universities, as well as VECC internal groups.

Several other proton irradiation experiments were carried out on candidate structural materials for Isotope production reactor. Irradiation experiment was carried out by CSIR-AMPRI, Bhopal, to irradiate the radiation hard materials by neutrons produced in the reaction of Alpha beam on Tantalum.

The most important progress in accelerator side at VECC is the development of 18 MeV Medical cyclotron. Magnet iron has been forged and proof machined. Fabrication of coils for switching magnet and fabrication of Glaser magnet are also completed. Machining of cyclotron magnet and fabrication of RF system are at advanced stage.

ANURIB project at VECC has been also initiated this year after obtaining the regulatory clearance for construction of pre-engineered building (PEB-2) at Rajarhat site. Indigenously developed cryogenic transfer line for liq. Helium, Liq. Nitrogen and sub-atmospheric helium has also been commissioned.

Radio-isotope production at 30 MeV Medical Cyclotron Facility (MCF) of VECC is continuously done and delivered to various hospitals/Nuclear Medicine Centres at Kolkata and other parts of the country, for cancer diagnosis of patients.

Plasma & Fusion Technologies

The Hon'ble Prime Minister laid the foundation stone for a plasma pyrolysis-based biomedical waste disposal plant, "RAUDRA," at Varanasi. Procurement of major subsystems has been completed, and site acceptance testing is underway. A Letter of Understanding (LoU) was signed with TMC, and environmental clearances have been obtained for the project. The installation and commissioning of plasma carburizing & nitriding systems have been completed. Plasma-activated water production systems with a 20 l/hr capacity have been developed. Nano-scale plasma surface modification techniques have been developed for silicone catheters, reducing bacterial adhesion by 99%. A plasma-based air sterilizer has been developed in collaboration with CCAMP, Bangalore.

Operations of the accelerator-based 14 MeV neutron facility, with a maximum output of 5x1012 n/sec, have commenced.

A 12-turn D-shape coil (1.17m×0.78m) fabricated using second-generation REBCO superconducting cables has been tested at 200 A, generating ~162G at 77 K. The patent on 'Development of flexible High Temperature Superconductor (HTS) cable for shaped coils' has been secured. Development of NbTi cable insertion & jacketing of a 1 m long Cable-In-Conduit Conductor (CICC) with a central cooling channel has been successfully completed in collaboration with BARC. High-pressure, high-temperature bellows-sealed valves have been designed & tested under tight shut-off conditions at 10MPa & 400°C.

A 25kV, 100mA power supply has been developed for ECRH systems. High Voltage Transformer Rectifier Units (HV-TRU) for High Voltage Power Supply (HVPS) have been developed and tested up to 213 kV DC. A vacuum test facility with Xenon Cryopumps has been commissioned, and the ion source has extracted a xenon ion beam with 60 mA current, 1.8 eV energy, and 3.5 mN thrust. AI-based screening tool DeepCXR has been deployed and integrated at multiple sites in Himachal Pradesh for India's National TB Elimination Program, with IPR recommendation for further deployment across 800 sites.

Capacity enhancement of the SST-1 Water Cooling Plant has been completed. New Wi-Fi infrastructure and 1.7 PB centralized storage have been installed at IPR Data Centre. A High-Performance Computing (HPC) facility rated at 10 PetaFlops AI capacity has been installed. A large plasma thruster facility achieved a thrust of 95 mN with a 5-kW source. Upgradation of 200 kJ PPS to 300 kJ PPS and plasma-matter interaction studies have been completed. A compound pendulum capable of measuring thrust up to 1N has been fabricated and calibrated.

A Fast Response Bipolar Power Supply (FRBPS) with ramp rates >1 MA/s has been developed & tested for Aditya Tokamak plasma control. Plasma discharge studies in ADITYA-U with pellet injection have analyzed radiation evolution using lithium-titanate & lithium carbonate particles. Transition from circular to shaped plasmas has been achieved, & integration of a 1.5 MW RF generator with SST-1 has been completed. The site acceptance test of the 82.6GHz Gyrotron is complete.

Materials Science

At RRCAT, a facility for nitride Molecular Beam Epitaxy (MBE) has been established for development of semiconductor quantum structures. A low temperature

Fourier Transform Infrared (FTIR) spectroscopy system is made to characterize the semiconductor materials whose optical/vibrational transition energy falls in the infrared (IR) region.

SINP has developed butylammonium lead halide perovskite materials and studied the structure and optical properties which exhibit sharp band-edge transition suitable for lasing application from a single material without an external cavity. The material under investigation is a potential candidate for optoelectronic applications. The nano-films prepared using the Langmuir-Schaefer (LS) deposition technique on a silicon substrate show broad-band white light emission across the entire visible range, which is suitable for solar cell application.

In the direction of green energy research, SINP has successfully synthesized Au@AgPd core-shell nanorods as a versatile alcohol oxidation reaction catalyst that could be used for industrial-scale direct alcohol fuel cells. It has invented ultra-high sensitive Hydrogen gas sensor based on Graphene field effect transistor decorated with thin film of Palladium. ZnSnP2, which is a new kind of promising material for photovoltaic applications, have also been grown and characterized.

SINP has reported a new multiferroic double perovskite material Dy2MnCoO6, where coexistence of ferromagnetic ordering with insulating behaviour and ferroelectricity brings new opportunities and improvements in next generation applications for information storage, spintronic, and sensor applications. This study on Sr2FeIrO6 and Sr2CoIrO6 shows antiferromagnetic nature with exchange bias that opens up new avenues for achieving exchange bias in spin-compensated systems, offering potential for low power and ultra-fast antiferromagnetic spintronic applications in future research endeavours.

The Condensed Matter Physics Group of HRI has worked on correlated systems, non-equilibrium dynamics of many body systems, and the dynamics of periodically driven quantum systems and has developed protocols to generate many-body entangled states in these systems. A protocol to engineer exact Floquet flat bands and realize dynamical many-body freezing in periodically driven quantum systems has been developed. Work on exciton¬ polaron coupling and interface mechanism for emerging materials to be used in solar cells has been done. Much work has been done to analyze the hybrid perovskite system. Additionally, the correlation between Rashba spin splitting and photocatalytic activity in two-dimensional materials along with their heterostructure formation has been investigated.

Hydrogen Energy

At BARC, a pilot scale Cu-Cl facility was successfully operated at design capacity of 150 NL/hr. First of a kind, indigenous 0.5MW cell module stack (~ 1 meter diameter and 2.5 meter long) of alkaline electrolyser was designed, fabricated and assembled under MoU with BPCL for green Hydrogen production for transport sector. Moderate pressure lab scale hydrogen generator, using indigenous PEM based pure water electrolyser cell, was developed and tested. Hydrogen production of 18 NLPH at 5 bar pressures have been achieved. A 1 MW prototype alkaline water electrolyser stack (~ 1.25 m diameter) was fabricated, assembled, integrated with electrolyser plant and trial operations of stack was successfully completed.

International Collaboration

At VECC, under India-ALICE collaboration, R&D of p-type detector arrays on 6" Si wafer of 8*9 array is carried out. Power supply distributor for the Silicon detector has been designed and fabricated and are being used with current test setup.

An off-site facility for Testing and Training of detectors for Laser Interferometer Gravitational Observatory (LIGO) has been established and operationalised at RRCAT. This facility will serve as a staging and testing facility for the LIGO Detector subsystems that will be shared by LIGO US for the Project. The facility also houses a 10 m prototype interferometer that will be used to test various detector components and train on interferometer commissioning. Design and Development of a triangular mode cleaner cavity has been completed. The primary function of this cavity is to enhance the mode quality of the laser light before its transmission into the

10 m interferometer being developed at RRCAT. This interferometer is being developed as a training facility for LIGO-India project.

At IPR, the site installation and commissioning of a 20 m long integrated Vacuum Vessel for the LIGO-India Vacuum Integrated System Test Assembly (LI-VISTA) have been completed, achieving stringent geometric tolerances and ultra-high vacuum (UHV) levels of 9.2x10-8 mbar.

SPONSORED RESEARCH

Board of Research in Nuclear Sciences (BRNS)

The Board of Research in Nuclear Sciences (BRNS), established in 1945 as the Atomic Energy Committee, continued to serve as the Department of Atomic Energy's (DAE) principal extramural funding agency for advancing nuclear science and technology in India. Over the decades, BRNS has fostered a vibrant research ecosystem by supporting fundamental and applied research, promoting science education, and facilitating collaborations across institutions.

In the FY 2024–25, BRNS sanctioned 64 new research projects, reaffirming its commitment to fostering innovation and R&D in nuclear science domain. Maximum number of research projects were sanctioned by the Basic Research & Science Education (BRE) Committee, followed by the Nuclear Power Programme (NPP) Committee. A total of ₹24.45 crore was disbursed to universities and research institutions across the country, enabling them to undertake high-quality research aligned with the mandate of DAE.

BRNS continued to support scientific events through the funding of 136 symposia and 11 theme meetings. These events provided platforms for knowledge exchange and fostered greater collaboration among India's scientific community. The International Science Olympiad programme, a flagship initiative supported by BRNS, continued to bring laurels to the country.

A total of 43 Technical Programme Discussion Meetings were organized to facilitate review and monitoring of research projects.

National Board of Higher Mathematics (NBHM)

The National Board of Higher Mathematics (NBHM) was set up in 1983 to promote development of higher mathematics in the country, to formulate policies for development of mathematics, help in establishment and development of mathematical centres & give financial assistance to research projects & to doctoral & postdoctoral scholars, by the Govt. of India under the Department of Atomic Energy (DAE).

NBHM provides financial supports to various schemes through DAE. All new proposals from Institutes, Fellowship applications, Research Project, etc. for financial support were thoroughly scrutinised by respective committees and based on the recommendations for support, funding is provided.

DAE allocated ₹ 34.00 Crores for various NBHM schemes for the Financial Year 2024-25.

PUBLIC AWARENESS

The Department of Atomic Energy (DAE) carried out a gamut of Public Awareness programmes in order to alleviate unwarranted fears, misconceptions and apprehensions harboured against nuclear energy. To keep the public abreast of the latest developments and contributions of atomic energy towards societal welfare, DAE organized a spectrum of events comprising exhibitions, seminars, workshops, essay and quiz contests in different parts of the country which were well received by the targeted audience.

DAE organized a three-day Journalists Workshop, at RRCAT, Indore during October 3-5, 2024 in collaboration with the NUJ (I) School of Journalism & Communication, Delhi. The objective of this workshop was to reach out to the general public in the right perspective through media. DAE had put up an exhibition on technologies for better quality of life. DAE, along with BARC, IGCAR, BRIT & RRCAT showcased its technologies.

Aligned with the vision of Aatmanirbar Bharat Abhiyan, a mega exhibition 'Radiant Jharkhand' was

Director, RRCAT explaining the nuclear power technologies to the NUJ journalists during the NUJ workshop conducted at RRCAT, Indore

organized at Hotel Ramada, Jamshedpur. The exhibition was held from 20th to 22nd February, 2025.The exhibition was inaugurated by Honourable Member of Parliament Shri Bidyut Baran Mahato. DAE participated in the exhibition along with UCIL to spread awareness regarding the nuclear energy sector, achievements and initiatives in the nuclear sector.

DAE along with BARC participated in the "Pragatishil Chattishgarh - Unnati ki aur Ek Pahal" exhibition organized from 22nd-25th March, 2025. More than 1000 visitors including progressive farmers, students and young entrepreneurs visited DAE stall and appreciated the significant contributions made by DAE for societal benefits.

Visitors being briefed about DAE technologies at the "Pragatishil Chattishgarh - Unnati ki aur Ek Pahal" exhibition

BRIT in association with Assam Medical College Hospital (AMCH), Dibrugarh organized "Awareness Programme on Non-Power applications of Nuclear Energy (APNANE-2024)" at Oil Lecture Hall Complex, Dibrugarh, Assam on 22.11.2024. The program was attended by more than 120 delegates including medical practitioners and university teachers.

A National Conference on Industrial Safety & Hygiene –Zero Incident Vision (IndSHIV-2024) was organized by BARC from 18-20 Jan, 2024 at DAE Convention Centre, Mumbai. HWB officials participated in conference by putting an exhibition stall and showcased its products & activities to various communities and demonstrated the achievements and accomplishments of HWB.

Significant numbers of outreach activities have been conducted this year at VECC. About 545 students from various schools and colleges have visited VECC during this year. National Science Day and National Environment Day have been conducted.

IPR conducted various academic visits and off-campus exhibitions wherein students and teachers from eminent educational establishments participated in the academic visits.

"Science at the Sabha" is a set of four public talks on different aspects of science and is part of the Institute of Mathematical Sciences, ongoing program of outreach to the general public. IMSc conducted the 7th edition of this flagship event in February.

INTERNATIONAL RELATIONS

India, a founding member of the Board of Governors (BoG) of the International Atomic Energy Agency (IAEA), continued to take active part in policy management and programmes of the IAEA. India was represented on a number of IAEA Committees, including those on safety, safeguards, nuclear radiation, nuclear engineering and application, nuclear law etc. India hosted several IAEA Workshops, Technical Meetings etc., and offered the services of its experts under the IAEA Technical Cooperation programme in a number of fields. India made contributions towards Innovative Nuclear Reactors and Fuel Cycles (INPRO), Technical Cooperation Fund (TCF) and Regular Budget of the IAEA.

India participated in the 68th Annual session of the IAEA General Conference, Vienna during 16-20 September 2024.

Bilateral meetings with the international partners were held. This included bilateral meetings with DG, IAEA, DG, ITER and delegations from Argentina, Australia, EURATOM, France, IAEA, Russia, U.A.E, U.K., USA and Vietnam; A Joint Working Group Meeting on GCNEP between India and United States on 12-13 June, 2024; An Indo-US Civil Nuclear Energy Working Group (CNEWG) and Technical Task Group meeting during 25-27.06.2024 at DAE; A meeting between H.E. Mr. Mariano Causino, Ambassador of Argentina to India along with his delegation on 26.07.2024, at OYC, DAE, Mumbai; & A meeting between India and Russia on 12.08.2024, at NCPW Conference Room, OYC, DAE, Mumbai.

On the sidelines of the 68th General Conference held during September 16-20, 2024, an Amendment to renew the Memorandum of Understanding between Department of Atomic Energy (DAE) and Commissariat A L'Energie Atomique et Aux Energies Alternatives (CEA), France was signed.

A bilateral arrangement between the Atomic Energy Regulatory Board of India (AERB) and The United States Nuclear Regulatory Commission (USNRC) for the Exchange of Technical Information and Cooperation in Nuclear Safety and Nuclear Radiation Protection Matters, was signed.

CRISIS MANAGEMENT

CMG-DAE has been entrusted the role of all the facets of preparedness, planning, capacity building and response to any NRE situation in the country. A network of 25 Radiation Emergency Response Centers (RERCs) has presently been established at 25 locations across the country to deal with any radiation emergency in public domain. The responsibilities of the RERCs are to provide field response comprising of radiation monitoring, radiological assessment, provide the technical inputs to CMG-DAE for decision making and provide technical advice to the first responders and the local authorities.

CMG-DAE also acts as National Contact Point under International Atomic Energy Agency's conventions of 'Early Notification' and 'Assistance' to which India is a signatory.

During the year, the Crisis Management Group (CMG), DAE participated in five International Convention Exercises (ConvEx) conducted by the IAEA which were designed to assess and enhance the international Emergency Preparedness and Response (EPR) framework. CMG coordinated India's active and satisfactory participation in these exercises and provided exposure to personnel from NPCIL, BARC, and AERB through these exercises.

Hands on Training of Radiation Detection Equipment during IMPACT-NRE Program

CMG-DAE conducted the IMPACT-NRE capacity-building program which was held at Mahakumbh Mela Kshetra on January 2-3, 2025, in coordination with UPSDMA. More than 500 participants, including decision-makers, responders, and medical personnel, received training and awareness for handling radiological incidents.

VIGILANCE

The overall responsibility for vigilance in any unit of the Department of Atomic Energy rests with the Chief Vigilance Officer (CVO). To ensure effective functioning of the vigilance machinery, a senior level officer in each of the Constituent Units and Aided Institutions of the Department has been designated as part time Vigilance Officer/ Chief Vigilance Officer. In the case of Public Sector Undertakings of the Department, full-time Chief Vigilance Officer discharges these responsibilities.

During the year, "Vigilance Awareness Week 2024" was observed in DAE and its Constituent Units/PSUs/Aided Institutions from 28th October, 2024 to 03rd November, 2024 on the theme of "सत्यनिष्ठा की

संस्कृति से राष्ट्र की समृद्धि / **Culture of Integrity for Nations Prosperity".**

As a part of the three-month campaign from 16th August, 2024 to 15th November, 2024, the Department had organized "DAE 2nd Annual Vigilance Conclave on 21st and 22nd October, 2024 at DAE Convention Centre, Anushaktinagar, Mumbai.

TECHNOLOGY TRANSFER & TRANSLATION

Sixty-three (63) BARC developed technologies were transferred to sixty-one (61) private firms on non-exclusive basis for commercialisation. Incubation agreement for technology translation has been signed for incubation of ten (10) technologies at AIC BARC.

At IGCAR, seven MoUs were signed with educational institutions and industries, enhancing collaborations for advancing research and technology development.

To align with our Nation's key missions of Atmanirbhar Bharat and Viksit Bharat-2047, the DAE Incubation Centre of IGCAR functioning since October, 2020 has been registered as an Atal Incubation Centre with the name "AIC-IGCAR-FAST Foundation" on October 08, 2024, and as a 'Section-8 Company' under Companies Act, 2013. Several technologies, including the Ultra Sensitive - Flexi Range Pulsating Sensor based Conductivity Meter, High Efficiency Particulate Filter Test Rig, Autonomous Gamma Dose Logger, and Leak Tight Flange and Gasket assembly, were transferred to private entrepreneurs.

A chassis mounted 32' reefer has been developed by M/s. Tata Motors Ltd. under technology incubation. The reefer, equipped with a 585 litre capacity liquid N2 tank, was able to maintain the chamber temperature of – 20 ºC for ~ 35 hrs. This product is being developed under incubation activities of RRCAT.

AIC π-Hub Foundation, RRCAT has launched three incubated products, signed two incubation agreements with industrial partners for development of thrust chamber for LoX Methane rocket engines using Laser Additive Manufacturing and development of Sealed CO_2 laser. Technology of indigenously developed 30 K class single-stage cryocooler was transferred to Indian industry.

A separate Section-8 company, Atal Incubation Centre (AIC-IPR Plasmatech Innovation Centre), has been established to support plasma technology start-ups, with three technology transfer agreements and six incubation agreements signed.

INTELLECTUAL PROPERTY RIGHTS

DAE-IPR Cell constituted by the Department, works as a nodal agency for all Intellectual Property Rights (IPR) related matters including filing of patents within India and abroad for all the Units including Public Sector Undertakings and Autonomous Institutions under DAE. During this period, six DAE-IPR cell meetings were held, where twenty-two new patent proposals were reviewed along with one Patent Cooperation Treaty (PCT) international applications for filing the national phase applications.

Seventeen patent applications were filed during this period. This includes fifteen in India and two PCT applications.

Fifteen patent applications were published during the year. All the applications were published in India.

During this period, twenty-seven of the previously filed patents were granted to the Department. These include twenty-one in India and one each in Australia, France, UK, Japan and USA and one PTC application.

PUBLIC SECTOR UNDERTAKINGS
(Financial Performance)

Financial performance of DAE's public sector undertakings namely, the Nuclear Power Corporation of India Ltd., Uranium Corporation of India Ltd., Indian Rare Earth Ltd. and Electronics Corporation of India Ltd. are given below. (BHAVINI is yet to commence commercial operations).

Nuclear Power Corporation of India Ltd.

The Profit After Tax (Total Comprehensive Income) for FY 2024-25 was ₹ 4343 crore. The net profit after tax (Total Comprehensive Income) for previous FY 2023-24 was ₹ 6486 crore. NPCIL Bonds are rated 'AAA' (Highest Safety) by CRISIL, CARE, ICRA and India Rating.

Uranium Corporation of India Ltd.

The performance of all major units of UCIL during the year 2024-25 remained excellent. The total income of the company during the year 2024-25 was ₹ 2356.26 Cr as against ₹ 2472.64 Cr during the previous year. The Company has registered a Profit before Tax of ₹ 188.51 Cr in the year 2024-25 as against ₹ 322.13 Cr in the previous year.

Indian Rare Earths Ltd.

During the financial year 2024–25, the Company achieved a total revenue of ₹ 2,036.43 crore as against ₹ 2,264.68 crore in FY 2023–24, reflecting a decrease primarily due to lower operational income. Revenue from operations stood at ₹1,843.44 crore as compared to ₹ 2,102.84 crore in the previous year. The decline in revenues was primarily due to a reduction in product prices, as the average mineral prices fell from ₹ 30,000 per tonne to ₹ 28,000 per tonne, and chemical prices registered a significant decline of about 31.1%.

Profit before depreciation, finance cost, exceptional items and tax stood at ₹ 1,165.90 crore as against ₹ 1,388.72 crore in the previous year. After providing for depreciation of ₹ 62.89 crore and finance cost of ₹ 0.17 crore, the Profit Before Tax was ₹ 1,102.84 crore in FY 2024-25 as compared to ₹ 1,344.84 crore in FY 2023–24.

The Company recorded a Profit After Tax (PAT) of ₹ 797.95 crore as against ₹ 1,012.21 crore in the previous year.

The Company continued to maintain a strong net worth position, amounting to ₹ 3,546.82 crore as against ₹ 2853.62 crore in the previous year.

The Board of Directors has recommended a final dividend of ₹ 239.39 crore for FY 2024–25, in line with DIPAM guidelines applicable to CPSEs.

Overall, despite a reduction in turnover and profitability compared to the previous year, the Company sustained healthy financial performance with robust operational efficiency and strong dividend payout.

Electronics Corporation of India Ltd.

As of 01 Apr 2024, ECIL's order book was ₹ 4,998 crores. Key projects include Military Communication Radios, DDP Upgradation, Command Control Systems for Missile Programs, SATCOM Terminals, Antenna Systems and Gyros for Defence and Space sector. ECIL is also working on Advanced Radiation Detectors & Monitoring Systems and Control & Instrumentation systems for the Nuclear Sector along with Vehicle-Mounted and Classroom Jammers for Government security agencies, Integrated Security Solutions for NPP, strategic & vital locations as well as other critical installations, IT infrastructure upgrades for ESIC and High Voltage Power Supplies for International Science Programs.

DPE had set a Production Realizable Value target of ₹ 3618 crores for the year Financial Year 2024-25 and ₹ 2296 crores achieved by ECIL. The evaluation of the MoU is currently in progress.

AWARDS & PRIZES

Indian students excelled at the international Olympiads in every subject as follows: 35th International Biology Olympiad (1 Gold and 3 Silver medals), 54th International Physics Olympiad (2 Gold and 3 Silver medals), 56th International Chemistry Olympiad (1 Gold, 2 Silver and 1 Bronze medals), International Mathematics Olympiad (4 Gold, 1 Silver, and 1 Hon Mention India's best performance to date at the International Mathematics Olympiad), 17th International Olympiad on Astronomy and Astrophysics (1 gold medal and 4 silver medals).

AMD has been conferred with Excellence Award in the category for 'Best Heavy Mineral Exploration of the

Year' at the International Conference on Heavy Minerals and Lithium for Energy Security (REES – 2024) at Kochi, Kerala on 29th August 2024.

ECIL received prestigious Gold Trophy of SCOPE Meritorious Award for R&D, Technology Development & Innovation for the year 2023. Company's Corporate Office, has been awarded Rajbhasha Shield for 10th time in a row under big PSUs category by TOLIC (PSUs), Hyderabad, Secunderabad.

Tummalapalle Mine has won second prize in medium size metal-mine category and received Mines Safety Award 2024 on 28.07.2024 from Directorate General of Mines Safety, Ministry of Labour & Employment, GoI. Turamdih Mine also won the first prize in small size metal mine category and received Mines Safety Award 2024. UCIL, Tummalapalle was awarded with Certificate of appreciation under the category of Manufacturing Sector (Group-B), by Director General, National Safety Council of India-2023. in recognition for appreciable achievement in Occupational Safety & Health during 2020-2022.

Scientists from TIFR won prestigious awards during this period. Prof. Vivek Polshettiwar has been awarded the Rashtriya Vigyan Puraskar: Vigyan Yuva - Shanti Swarup Bhatnagar award for the year 2024 in Chemistry. Prof. Adimurthy Adi, Prof. Jayant B. Udgaonkar (a former member of TIFR), and Prof. Naba Kumar Mondal (a former member of TIFR) were awarded the Rashtriya Vigyan Shri Award for 2024. Prof. Prahlad Chandra Agrawal (a former member of TIFR) received the prestigious COSPAR Harrie Massey Award 2024 for Space Research.

Department of Atomic energy has been awarded the Rajbhasha Kirti Puraskar (First Prize) for the year 2023-2024 on 14th September 2024 by the Department of Official Language, Government of India for the excellent implementation of the Official Language Policy.

CHAPTER 1

NUCLEAR POWER PROGRAMME STAGES

Overall view of Kudankulam Nuclear Power Project (KKNPP) Unit-3&4

Rare Earth Recovery Plant

NUCLEAR POWER PROGRAMME STAGE-1

Power Generation

Nuclear Power Corporation of India Limited (NPCIL), formed in 1987, is a Public Sector Enterprise under the administrative control of Department of Atomic Energy (DAE). NPCIL is a dividend paying company with highest credit rating of 'AAA' (Highest Safety) by CRISIL, CARE, ICRA and India Rating. NPCIL is responsible for obtaining siting consent, design, construction, quality assurance, commissioning, operation and upgradation of nuclear power reactors. Safety is given overriding priority in all facets of nuclear power plants. At present, NPCIL operates 25 nuclear power reactors (including Rajasthan Atomic Power Station Unit-1, 100 MW PHWR, owned by DAE and managed by NPCIL, which is under long shutdown) with an installed capacity of 8880 MW. This includes Rajasthan Atomic Power Project (RAPP) Unit-7 [indigenously designed 700 MW Pressurized Heavy Water Reactor (PHWR) with state-of-the-art technology incorporating enhanced safety features]

Performance Highlights

Generation Performance

During the Financial Year (FY) 2024-25, NPCIL registered total power generation of 56713 MUs (including infirm power generation of 32 MUs from RAPP Unit-7). In the previous FY 2023-24, the total power generation was 48801 MUs (including infirm power generation of 830 MUs from KAPP Unit-3&4).

During the FY 2024-25, the overall Availability Factor (AF) and Plant Load Factor (PLF) for the reactors in commercial operation were 88% and 87% respectively (excluding the capacities of units under long shutdown in project mode). Both these figures for last FY 2023-24 were 85%.

Kakrapar Atomic Power Project (KAPP) – 3 & 4

During the Calendar Year (CY) 2024, NPCIL registered highest ever power generation of 54817 Million Units [including infirm power (non-commercial power) generation of 110 MUs from KAPP Unit-4]. In the previous CY 2023, the total power generation was 49146 MUs (including infirm power generation of 911 MUs from KAPP Unit-3).

Continuous, safe and reliable operation of reactor unit for more than a year

During the FY 2024-25, the feat of continuous, safe and reliable operation for more than a year has been achieved by five reactor units viz. NAPS-1 (registered continuous operation for 457 days and continuing to operate as on March 31, 2025), TAPS-3 (registered continuous operation for 399 days and continuing to operate as on March 31, 2025), KGS-1 (registered continuous operation for 439 days), NAPS-2 (registered continuous operation for 394 days) and MAPS-2 (registered continuous operation for 366 days). Further, RAPS-6 registered continuous operation for a year on April 1, 2025 (the unit is continuing operating), and with this, so far, the continuous, safe and reliable operation for more than a year has been achieved 52 times by various reactors operated by NPCIL. Out of these, four reactors KGS Unit-1 (962 days), Narora Atomic Power Station (NAPS) Unit-2(852 days), RAPS Unit-3 (777 days) and RAPS Unit-5 (765 days) have operated continuously for more than two years. The continuous operation for 962 days registered by KGS Unit-1 is second longest continuous operation in world among all reactor technologies.

Nuclear power reactors in operation registered cumulative 635 reactor years of safe operation as on March 31, 2025.

MoU Rating

NPCIL achieved "Excellent" MoU rating for the year 2023-24.

Capital Expenditure

NPCIL has achieved highest ever CAPEX of ₹ 17984 Cr. during Financial Year 2024-25.

Operating Units taken in Project mode

RAPS Unit-3 (220 MW PHWR) resumed operation on July 24, 2024 after successful completion of Renovation and Modernization (R&M) activities En-masse Coolant Channel Replacement (EMCCR) En-masse Feeder Replacement (EMFR) and other safety upgrades. This unit was under shutdown in project mode since October 28, 2022. The R&M activities of RAPS Unit-3 were completed in the shortest time among Indian Reactors where similar activities were taken up. These activities were completed within budget.

Madras Atomic Power Station (MAPS) Unit-1 (220 MW PHWR), Tarapur Atomic Power Station (TAPS) Unit-1 (160 MW BWR) and TAPS Unit-2 (160 MW BWR) are under long shutdown and have been taken in project mode for ageing management and safety upgrades. In addition to these units, recently, KGS Unit-1 (220 MW PHWR) has been taken under shutdown in project mode since 01.04.2025 for EMCCR, EMFR and other safety upgrades. Various studies/works are in progress at these units.

Projects under construction

Rajasthan Atomic Power Project (RAPP) Unit-7&8 (2x700 MW PHWRs)

RAPP-7&8 is India's second pair of indigenous 700 MW Pressurized Heavy Water Reactors being set up at Rawatbhata, Rajasthan. RAPP-7 achieved Synchronization with the grid on March 17, 2025 and the Unit has been declared commercial with effect from April 15, 2025. In RAPP-8, "Primary Heat Transport (PHT) system Hydro test" is already completed and preparatory activities for "Hot Conditioning" are in progress. The overall Physical Progress of RAPP-7&8 as on end March 2025 was about 96.68%.

Rajasthan Atomic Power Project (RAPP) Unit-7&8

Kudankulam Nuclear Power Project (KKNPP) Unit-3&4 (2x1000 MW LWRs)

KKNPP-3&4, located in Tirunelveli district of Tamil Nadu, is an expansion project of KKNPP Units-1&2. The project is being implemented with technical cooperation from Russian Federation within the framework of the Inter-Governmental Agreement (IGA) signed between Russian Federation and Republic of India in December 2008. Civil works and mechanical erection works are in progress in KKNPP-3&4. In KKNPP-3, major milestone "Concreting of Outer Containment (OC) dome in Reactor Building-3", is achieved. In KKNPP-4, an important milestone "Erection of Nuclear Steam Supply System (NSSS) equipment Reactor Pressure Vessel (RPV) Steam Generator (SG) Reactor Coolant Pump (RCP) Pressurizer (PRZ)" is completed. Towards manufacture of Long Manufacturing Cycle equipment and components, 433 out of 444 manufacturing milestones have been completed till March 31, 2025.

Overall view of Kudankulam Nuclear Power Project (KKNPP) Unit-3&4

During the year 2024-25, around 16000 Freight Ton (FRT) of project cargo is dispatched/delivered to the Site. Balance supplies from Russia and Third Countries are being expedited to reduce overall project delay. Physical Progress of KKNPP-3 as on end March 2025 was 79.45% and that of KKNPP-4 was 74.73%.

Kudankulam Nuclear Power Project (KKNPP) Unit-5&6 (2x1000 MW LWRs)

The project is being implemented with technical cooperation from Russian Federation, within the framework of the Inter-Governmental Agreement signed between Russian Federation and Government of India. This is the third pair of KKNPP projects located in Tirunelveli district of Tamil Nadu where first two units KKNPP-1&2 are in operation and second pair KKNPP-3&4 is under construction. Civil works are in progress in KKNPP-5&6. The important milestones "Erection of Core Melt localizing facility (core catcher)" and "Erection of Truss cantilever" in reactor cavity of Reactor Building are completed in KKNPP-6. Towards manufacture of Long Manufacturing Cycle Equipment, 269 out of 450 Numbers manufacturing milestones have been completed till March 31, 2025. During the year 2024-25, about 28,000 freight ton (FRT) project cargos are dispatched/delivered to site for KKNPP-5&6. Supply of priority item / equipment from Russia are being expedited to reduce delay in project progress. Physical Progress of KKNPP-5 as on end March 2025 was 37.70% and that of KKNPP-6 was 32.65%.

Kudankulam Nuclear Power Project Unit-5&6

Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP) Unit-1&2 (2x700 MW PHWRs)

GHAVP-1&2 Project is located in Fatehabad district of Haryana. Construction of various civil structures like Fire Water Pump House, Safety Related Pump House, Fuel Oil Storage Area, D2O Upgrading Building, Switchyard Control Building, Fire and Industrial Safety House, Tunnels, Emergency Makeup Water Pond Area, Retaining wall, WMP tunnel, Stack, Induced Draft Cooling Towers (IDCTs), Plant Drain Storage Pond etc. are in progress.

Towards resolving the issue of localized settlement at site, work is awarded to consultant and works are in progress in phases. Work of Additional Geotechnical Investigations, Dewatering/ Ground Improvement Trials and its qualification for remedial actions at site is completed and reports are submitted to AERB for review. Manufacturing and delivery of various equipment and components are in progress. End shields (Unit-1), all Steam Generators (Unit-1), one Steam Generator (Unit-2), Moderator Storage Tanks (Unit 1 & 2), Test Station of Reactivity drive (Unit-1), Top Hatch Beams & Deck plate assembly from KAPP-4, Fuelling Machine Head (Unit 1&2), Three FM Bridge & Column (Unit-1&2), Roll on Shield (Unit 1&2), Fixed Shield (Unit 1&2), Shield plug (Unit-1), Seal Plug (Unit-1), Fuel Locator (Unit-1), Canned motor pumps (Unit-1&2), Grid condenser (Unit-1) and Pressuriser (Unit-1) have been received at site. Progressive manufacturing and delivery of balance equipment and components are in progress.

Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP) Unit-1&2: view of emergency makeup water pond

Project under launch (having administrative approval & financial sanction from Government of India)

1st fleet of Ten 700 MW PHWRs

The Government of India has accorded administrative approval and financial sanction for taking up construction of 10 indigenous 700 MW PHWRs in Fleet Mode. These reactors are being set up at Kaiga in Karnataka (Kaiga-5&6), Gorakhpur in Haryana (GHAVP-3&4), Chutka in Madhya Pradesh (Chutka-1&2) and Mahi Banswara in Rajasthan (Mahi Banswara-1 to 4).

Fleet mode construction commenced with 'Ground Break' of Kaiga-5&6 project after obtaining AERB clearance. At Kaiga-5&6, Confirmatory Geotechnical investigation in main plant area are nearing completion. Further works are in progress towards First Pour of Concrete. Contract is awarded for Nuclear Island Mega EPC Package. At GHAVP-3&4, land is available. Siting consent from AERB and Environmental Clearance from Ministry of Environment, Forest and Climate Change (MOEFCC) are available. EPC package for Turbine Island has been awarded.

At Chutka-1&2, Environmental Clearance has been accorded by MOEFCC, Water agreement between MP State Govt. and NPCIL has been signed and possession letter has been issued for all types of land. Construction all 330 dwelling units for R&R colony has been completed and ready for shifting of PAPs. Meeting held with District administration Mandla to resolve long pending issues of Chutka Madhya Pradesh Atomic Power Project (CMPAPP) with respect to Shifting of Project Displaced Persons (PDPs) to R&R Colony. At Mahi Banswara site, land acquisition is in advanced stage and Environmental Clearance from MOEFCC is in process. Stage-2 forest clearance is received from MOEFCC. Construction of R&R colony & approved infrastructure has been completed and allotment is completed. Construction of plant boundary wall and installation of concertina fencing has been completed. Pressure Metre test (PMT) is in progress in main plant area. The Government accorded approval to the Anushakti Vidhyut Nigam Ltd. (ASHVINI), a Joint Venture (JV) of NPCIL and NTPC Ltd. to take up nuclear power generation and associated activities in accordance with the Atomic Energy Act, 1962. Proceedings for implementation of the Mahi Banswara 1 to 4 project by NPCIL-NTPC JV Company are in progress.

New Sites (having in-principle approval of the GoI)

Light Water Reactors (LWRs)

Jaitapur, Maharashtra

Land has been acquired. Statutory clearances are available. Techno-commercial discussions with Électricité de France (EDF), France are in progress. NPCIL has initiated the process for revalidation/ renewal for Coastal Regulation Zone / Environmental Clearance (CRZ/EC). Revised application is to be submitted for Siting consent. A special task force is constituted to look into all aspects of the project including financial validity, before taking decision on Pre-Engineering Contract (PEC).

Kovvada, Andhra Pradesh

Land acquisition and R&R is in advanced stage. Land acquisition for R&R colony is completed and land is handed over to NPCIL. Environmental Impact Assessment (EIA) studies are under progress. Discussions on Civil Liability for Nuclear Damage (CLND) issues are in progress at Government-Government level for further techno-commercial discussions with Westinghouse Electric Company (WEC) to setup large sized imported Light Water Reactors (LWRs).

Pressurized Heavy Water Reactors (PHWRs)

Honourable PM Shri Narendra Modi visited Kakrapar Atomic Power Project (KAPP) on February 22, 2024, and dedicated KAPP-3 and KAPP-4, the two largest frontrunning nuclear reactors among the fleet of 700 MWe indigenous PHWRs of NPCIL, to the nation. Speaking on the occasion, Prime Minister said that the role of nuclear power in electricity generation is going to increase in 21st century India, and it is a matter of pride that India is AtmaNirbhar in this advanced technology.

Sites for 2nd Fleet Mode PHWRs (10x700 MW PHWRs) have been identified viz. KAPP-5&6 (2x700 MW PHWRs) at Kakarapar in Gujarat, RAPP-9&10 (2x700 MW PHWRs) at Rawatbhata in Rajasthan, NAPP-3&4 (2x700 MW PHWRs) at Narora in Uttar Pradesh and Bhimpur-1 to 4 (4x700 MW PHWRs) at Bhimpur in Madhya Pradesh. In-principle approval of the Government exists for NAPP-3&4 and Bhimpur-1 to 4 sites, and the same is in process for KAPP-5&6 and RAPP-9&10.

Honourable Prime Minister, Shri Narendra Modi dedicated Units 3&4 of Kakrapar Atomic Power Station (KAPS-3&4) to the nation on 22/02/2024

Bhimpur-1 to 4, Madhya Pradesh (4x700 MW PHWRs)

In-principal approval from GoI exists and AEC has given approval to undertake pre-project activities. Commitment for water is confirmed by Madhya Pradesh State Government. Further pre-project activities are initiated with State Govt. agencies.

Narora Atomic Power Project (NAPP)-3&4 (2x700 MW PHWRs)

In-principal approval from GoI exists and AEC has given approval to undertake pre-project activities. NAPS Unit-1&2 (2 x 220MWe, PHWRs) are already in operation and land is available for NAPP-3&4.

220 MW Bharat Small Reactors (BSR)

BSRs are 220 MW Pressurized Heavy Water Reactors (PHWR) with an impeccable safety and excellent performance record, which are compact and tailored for captive use. These reactors can provide a sustainable solution for decarbonization of hard to abate industries and help industries to secure economic benefits resulting from savings in carbon emission related taxes thus increasing competitiveness of their products in the global markets. These reactors are planned to be set up with private capital, within the existing legal framework and approved business models.

NPCIL invited Request for Proposals (RFP) from visionary Indian industries for setting up 220 MW Bharat Small Reactors (BSR) for captive use.

Initiative for Hydrogen Generation

Nuclear power is a clean base load source of electricity and can be used to generate clean Hydrogen. Considering the emerging business opportunities in production of Hydrogen from nuclear power, NPCIL has resolved to take enabling steps for entering into the business of clean Hydrogen generation from nuclear power at an appropriate time. NPCIL had framed its Hydrogen policy. In this context, to gain experience in Hydrogen production and related aspects, NPCIL has set up a Hydrogen Generation Unit (Alkaline Electrolyzer) with 25 Nm3 per hour capacity at Tarapur site and is made operational. One more Hydrogen Generation Unit (Polymer Electrolyte Membrane Electrolyzer) and associated systems is being set up at Rawatbhata site.

NPCIL, in all its endeavours, is committed towards up-gradation and continuous improvements in Quality Management Systems which includes; Quality Assurance (QA), Quality Surveillance, Pre-Service Inspection/In-Service Inspection and Software Quality Assurance (SQA) activities.

Financial Performance of NPCIL

The Profit After Tax (Total Comprehensive Income) for FY 2024-25 was ₹ 4343 crore. The net profit after tax (Total Comprehensive Income) for previous FY 2023-24 was ₹ 6486 crore. NPCIL Bonds are rated 'AAA' (Highest Safety) by CRISIL, CARE, ICRA and India Rating.

Electronics & Automation Support for Stage-1

Hydrogen Steam Concentration Monitoring

System (HSCMs) for Kakrapar Atomic Power Plant

A first of its kind, the Hydrogen Steam Concentration Monitoring system (HSCMs) has been successfully commissioned by ECIL and it has been handed over at KAPP Unit-3 & Unit-4.

Boiler Pressure Control system for KAIGA-1 & 2

This was originally designed & supplied to NPCIL plants during 1990's. The system is tweaked for better performance and supplied & commissioned at RAPP-3 & 4 and KAIGA-1 &2 successfully.

Upgradation of Beetle Monitoring systems (BMS) for RAPP-3 &4

The legacy BMS system is being upgradated using NPCIL PRAN CPU based I/O system along with ECIL upgraded SMPs.The Manufacturing, Testing, Qualification & Supply has been completed. The Commissioning of the system at RAPP-3 & 4 sites is planned during Shut Down.

Transmitter Power supplies (TPS: I/P48VDC & O/P 28V,50 ma DC)

The Legacy TPS system was 230V AC Input is being up gradated for DC-DC operation. The manufacturing, Testing, qualification & supply of Two systems comprising 300 Nos of TPS modules has been completed.

Automated Radiation Monitoring System (ARMS) for KKNPP Unit 3 & 4

The Automated Radiation Monitoring System (ARMS) is designed and developed by ECIL specifically to ensure radiation safety at Kudamkulam Nuclear Power Plants (KKNPP-3&4). It operates by continuously receiving and processing data from monitored parameters, which provides insight into the radiation conditions at the NPP. This includes all operational modes, ranging from standard operation to design-basis and beyond design-basis accidents.

The system comprises 14 different types of Radiation Monitors, each accompanied by accessories. Following a successful evaluation under the expert guidance of BARC, the initial batch of bulk supply units has been delivered to the KKNPP-3&4 in Mar 2024. The remaining supply items are currently at various stages of fabrication and testing, with completion anticipated by Dec 2024.

Commissioning of Beetle Monitoring systems (BMS) for RAPP-3

The legacy BMS system is being upgraded using the NPCIL PRAN CPU-based I/O system along with ECIL upgraded SMPs. The commissioning along with independent verification and validation of the system at the RAPP-3 site has been successfully completed.

Ion Chamber Amplifier (ICA) for RAPP 3&4

The legacy ICA system for RAPP 3&4, originally supplied in the early 90s, is being upgraded. The manufacturing, testing, qualification and supply processes have been completed.

Start-up Instrumentation system for First Approach to Criticality (FAC) after a prolonged shutdown

This Start-up Instrumentation system is developed for monitoring neutron flux in the range of 10^{14} to 10^{-6} FP to attempt the FAC after a prolonged shutdown in nuclear power plants. This system includes two groups of monitoring channels, in-core channels (10^{-14} to 10^{-9} FP) and out-core channels (10^{-11} to 10^{-6} FP). Each group covers five decades of neutron flux with an overlap of two decades. In the in-core startup range, the reactor power and the thermal neutron flux density is very low. Therefore, to detect neutrons in the presence of high gamma background, Fission Counter detectors are used. These detectors have low gamma sensitivity and a high absorption cross-section for thermal neutrons. To capture and amplify these short pulses of the detector, special fast-responding amplifiers are used. These amplifiers minimize the possibility of losing neutron pulses and provide accurate count rates. The system is supplied to RAPS-3.

Boron-10 coated proportional counters

Boron-10 coated proportional counters are also standard products which were designed and developed in collaboration with BARC for the purpose of neutron flux monitoring for physical/normal start-up of nuclear power reactor. The signal from these detectors is fed to start-up electronics system. These detectors are used for criticality of the reactor. Sensitivity of these detectors is 4 CPS/nV. 8 Nos of these detectors were recently supplied to KAPP-3&4 site and 4 Nos to RAPP-3&4 site.

Alpha, Beta and Radon Monitor (Aerosol Monitor)

The Aerosol Monitor is developed for continuous measurement of volumetric activity of radioactive aerosols containing artificial Alpha and Beta emitting nuclides from stacks, ducts and in controlled areas of Nuclear Power Plants. It also measures effective equivalent in air for Rn-222 concentration for indoor application. It displays and transmits this concentration level, and generates audio visual alarms, when radiation level exceeds a limit set by the user. Prototype units were supplied to KKNPP-3&4.

Alpha, Beta and Radon Monitor (Aerosol Monitor)

Upgradation of Disturbance Recording System (DRS) for NAPS 1&2

The legacy DRS system is being upgraded using NPCIL PRAN CPU based I/O system along with ECIL upgraded Switched Mode Power Supplies (SMPS). The Manufacturing, Testing, Qualification & Supply has been completed. The Commissioning of the system at NAPS-1&2 sites is planned during Shut Down.

Bulk supply of Process Media Monitors and Radiation Monitors to KKNPP-3&4

The second lot of Process Media Monitors, Area Gamma monitors, Portal monitors, Hand & Foot monitor were supplied to KKNPP-3&4. These monitors were indigenously designed and developed in collaboration with BARC for Automated Radiation Monitoring System (ARMS) of KKNPP-3&4. The instruments operate by continuously receiving and processing data from monitored parameters, which provides insight into the radiation conditions at the NPP.

Spectroscopic Iodine Monitor to measure different types of Iodine Isotopes

The monitor is intended for continuous measurements of the volumetric activity of radioactive Iodine isotopes I-131, I-132, I-133 and I-135 contained in the air drawn from stacks, ventilation ducks, working areas, pipes, chambers etc., at radiochemical production facilities in nuclear power plants. A Ceisium Iodine scintillator (CsI) measures radioactive iodine trapped in activated charcoal cartridge. A separate CsI detector is used for background gamma compensation. The measurement with the dual detectors limits lead shielding 4π/1cm thickness in the proximity of the detector to get optimum detection efficiency. This enabled to build the monitor in compact size. A radioactive Am-241 source built into the CsI scintillator allows compensation against temperature, aging

Spectroscopic Iodine Monitor to measure different types of Iodine Isotopes

related drifts and to implement spectrum stabilization algorithms.

Liquid Effluent Monitor

The Liquid Effluent Monitor is used for continuous measurement of volumetric activity of gamma emitting radio-nuclides present in liquid of different process systems like liquid radioactive waste processing system, contaminated section of active laundry, automated chemical monitoring system & discharge channel etc. A scintillation detector is used to measure the sample of effluent liquid from a tank or a pool. The Monitor provides output proportional to volumetric activity of gamma emitting radio-nuclides present in liquid media for local indication and transmit the data over wired communication channel for remote display and further utilisation of data in the operation of plant.

Liquid Effluent Monitor

Installation & Commissioning of Nuclear Instrumentation Package at RAPS-7

The installation and commissioning of Nuclear Instrumentation package at RAPS-7 is completed. The plant attained criticality in September 2024.

Supply of IC based Logic cards -TL (N) to RAPS-2

The fuel handling system comprises various actuators, valves, cylinders, and other components that must operate in a predefined sequence to ensure safe refuelling operations. For the operation of these valves, several interlocks must be satisfied. These interlocks ensure sequential operations, safety, and logical control. In the RAPP-2 FH control system, these interlocks and logic functions have been implemented using transistor-based transistor logic (TL) cards, which perform functions such as NOR gates, timers, shift registers, etc.

Due to the obsolescence and aging of components, these TL cards need to be replaced with functionally equivalent IC-based logic cards, referred to as TL (N) cards. ECIL has successfully developed, prototyped, manufactured, and supplied eight types of TL(N) cards as part of an order from the site. These newly designed cards are built with the latest SMD-based CMOS ICs, while maintaining the original form factor of the older TL cards.

PLC LAN upgradation at RAPP-3&4

The Main Plant Distributed PLC system at RAPS-3&4 consists of 10 PLCs, each with redundant CPUs. The existing PLCs and EC communication utilized a Token Bus architecture, which is facing obsolescence issues.

The LAN of the Distributed PLC system, along with the Engineer's Console (EC) at RAPS-3&4, has been upgraded as follows. The commissioning and Independent Verification and Validation (IV&V) were successfully carried out on the SR PLCs during the BSD, and the upgraded system has been found to be operating satisfactorily.

The 10 PLCs were divided into two groups: SR PLC network (4 PLCs) and NSR PLCs (6 PLCs). The existing LAN Token Bus architecture was upgraded to an Ethernet-based architecture (IEEE 802.3), using ECIL-made ECVME-8260 PowerPC boards and necessary networking hardware, along with the required software upgrades.

Bulk supply of Process Media Monitors and Radiation Monitors to KKNPP-3&4

The final lot of Area Gamma monitors were supplied to KKNPP-3&4 in Nov 24. These monitors were indigenously designed and developed in collaboration with BARC for Automated Radiation Monitoring System (ARMS) of KKNPP-3&4. The instruments operate by continuously receiving and processing data from monitored parameters, which provides insight into the radiation conditions at the NPP.

Radiation monitors for NPCIL, KAPP

Three types of radiation monitors have been supplied by ECIL to KAPS-1&2 for On-Site Emergency Support Centre (OESC).

Inert Radioactive Gas Monitor

The Inert Radioactive Gas (IRG) monitor is provided for continuous measurement of the volumetric activity of beta emitting inert radioactive gases (argon, krypton, xenon) in the air of controlled areas as well as in ventilation system, pipelines, stacks etc. The IRG monitor provides output signal on LCD and also generate visual / audio alarm locally for warning the working personnel, whenever pre-set limit is exceeded. It transmits information to upper level of ARMS for remote display.

Extended IRG Monitor (Extended range)

Extended IRG Monitor is used for continuous measurement of volumetric activity of beta emitting inert radioactive gases like argon, Krypton, xenon and also gases containing tritium in the air of controlled areas. The system provides the current values and also generates audio/visual alarms whenever pre-set limit exceeds.

Financial Performance of ECIL

As of 01 Apr 2024, ECIL's order book was ₹ 4,998 crores. Key projects include Military Communication Radios, DDP Upgradation, Command Control Systems for Missile Programs, SATCOM Terminals, Antenna Systems and Gyros for Defence and Space sector. ECIL is also working on Advanced Radiation Detectors & Monitoring Systems and Control & Instrumentation systems for the Nuclear Sector along with Vehicle-Mounted and Classroom Jammers for Government security agencies, Integrated Security Solutions for NPP, strategic & vital locations as well as other critical installations, IT infrastructure upgrades for ESIC and High Voltage Power Supplies for International Science Programs.

DPE had set a Production Realizable Value target of ₹ 3618 crores for the year Financial Year 2024-25 and ₹ 2296 crores achieved by ECIL. The evaluation of the MoU is currently in progress.

Heavy Water Production

Heavy Water Board (HWB) made significant contributions to the I-stage of INPP by providing nuclear-grade heavy water to RAPS-7 for its initial inventory. Additionally, HWB ensured a consistent supply of nuclear-grade heavy water as make-up for operational Pressurized Heavy Water Reactors (PHWRs).

During the reported period, HWB achieved approximately 92% of its targeted heavy water production, reflecting its unwavering commitment to excellence.

Furthermore, HWB expanded its global footprint by entering into a strategic agreement with Argentina to supply heavy water for its nuclear power program, reinforcing its position as a trusted partner in the international nuclear energy sector.

Signing of Agreement with Argentina for supply of Heavy Water for its PHWRs

Efforts are underway to enhance the production capacity at the Heavy Water Plants (HWP) in Hazira and Manuguru, aligning with the goals and vision of the Amrit Kaal initiative.

In parallel, HWB has achieved a significant milestone in the enrichment of ^{11}B to >99.8% purity (semiconductor grade) at the Boron Exchange Distillation Facility. The enriched product has been successfully converted into purified enriched boric acid (^{11}B @ >99.8%) for subsequent transformation into ^{11}B-enriched BF3 gas.

To meet the ambitious objectives of the 'Amrit Kaal' initiative, the augmentation of enriched boron production facilities at HWBF-Talcher and HWP-Manuguru is being actively planned. This expansion will strengthen HWB's capabilities and ensure readiness for future demands.

Inauguration of Electronics Grade Boron-11 (B) Enrichment Facility at HWBF, Talcher

Uranium and Rare Metals-Exploration, Mining & Milling

Augmentation of Atomic Mineral Resources

At AMD, in-situ U-oxide resources (U_3O_8) have been augmented through sustained exploration inputs in potential geological domain of the country.

The Rare Metal and Rare Earth (RMRE) stockpile has been augmented by 1762 kg columbite-tantalite, 145 kg Spodumene (Lithium mineral) and 7500 kg xenotime (Rare Earth Yttrium).

During the month of June 2024, one (01) agreement signed with Council of Scientific & Industrial Research (CSIR) and National Geophysical Research Institute (NGRI) for Extension of Memorandum of Understanding (MoU) between DAE, AMD and CSIR-NGRI for carrying out heliborne geophysical survey.

A total of 74,900 tonne Rare Earth Oxide (REO) has been augmented in hard rock terrains of Rajasthan and country's total REO is updated to 1.23 million tonne (Mt).

A total of 1,800 tonne lithium oxide (Li_2O) has been established for the first time in hard rock (Pegmatite) terrains of Karnataka.

Rare Earth & Titanium Theme Park, Bhopal, MP

First time ever Rare Earth Metal production in the Country with operationalization of facility for Cerium and Lanthanum metals in the Rare Earth & Titanium Theme Park (RETTP) at Bhopal has been setup. Facility for production of Neodymium metal and recovery of Rare Earths from end-of-life cycle magnets are under installation.

Current Status: The facility earmarked for circular economy i.e. recovery of magnetic Rare Earths from end-of life magnets has been operationalized in the Rare Earth and Titanium Theme Park in Bhopal. Around 90% of the Nd Metal Process Plant Equipment are installed. Other plants (Lamp & LED Phosphor Plant) are under various stages of engineering/procurement/installation.

Neodymium Metal Plant at RETTP

Rare Earth Recovery Plant

Safety against radio activity and long-term storage of Thorium Oxalate- Phase II (2022-29) at OSCOM, Odisha & Rare Earth Division, Kerala

Some of the completed activities includes construction of 3 Nos. of Fiber Reinforced Polymer (FPR) lined transit mixer for storage of Thorium Oxalate; Construction of Covering Slab-I; Construction of Internal Dosimetry Lab and EDXRF Spectrometer for element analysis. Approach road to Trench No. 23,24,25 & 26 and Silo 8 & 9 and Sealing of RCC trenches No. 24 & 25.

Internal Dosimetry Lab (OSCOM)

Activities that are under Progress includes Construction of 3 Nos. of FRP lined RCC Trenches for storage of Thorium Oxalate; Construction of RCC Trench no. 07 & 08 and Slurrying, neutralization, pumping and transportation of Thorium Oxalate to trenches and construction of Covering Slab-I.

Construction of RCC Trench no. 07 & 08

Activities under progress includes repair and maintenance of existing RCC silos 1,2,3 & 7; Construction of Approach Road to Trench No. 7 & 8 and Decontamination of Temporary storage sheds of Thorium Oxalate.

Setting up of Pilot Plant Facility/ Technology Demonstration Plant (TDP) for Producing 4N Pure Titanium Dioxide and 4N Pure Zirconium Oxychloride in OSCOM, Odisha

Current Status: Drain & Chemical storage Platform & Dyke- Installation & commissioning are completed. Pit furnace system- Installation & commissioning are completed. ETP System – Installation & commissioning are completed. ETP shed work has been completed. Multi-effect evaporator installation completed. Modules 1 to 10 - Installation & commissioning has been completed. Activities related to the commissioning & trial run of equipment is in progress.

Construction of Module 6-7 (Boiler & scrubber)

Financial Performance of IREL

During the financial year 2024–25, the Company achieved a total revenue of ₹ 2,036.43 crore as against ₹ 2,264.68 crore in FY 2023–24, reflecting a decrease primarily due to lower operational income. Revenue from operations stood at ₹1,843.44 crore as compared to ₹ 2,102.84 crore in the previous year. The decline in revenues was primarily due to a reduction in product prices, as the average mineral prices fell from ₹ 30,000 per tonne to ₹ 28,000 per tonne, and chemical prices registered a significant decline of about 31.1%.

Profit before depreciation, finance cost, exceptional items and tax stood at ₹ 1,165.90 crore as against ₹ 1,388.72 crore in the previous year. After

providing for depreciation of ₹ 62.89 crore and finance cost of ₹ 0.17 crore, the Profit Before Tax was ₹ 1,102.84 crore in FY 2024-25 as compared to ₹ 1,344.84 crore in FY 2023–24.

The Company recorded a Profit After Tax (PAT) of ₹ 797.95 crore as against ₹ 1,012.21 crore in the previous year.

The Company continued to maintain a strong net worth position, amounting to ₹ 3,546.82 crore as against ₹ 2853.62 crore in the previous year.

The Board of Directors has recommended a final dividend of ₹ 239.39 crore for FY 2024–25, in line with DIPAM guidelines applicable to CPSEs.

Overall, despite a reduction in turnover and profitability compared to the previous year, the Company sustained healthy financial performance with robust operational efficiency and strong dividend payout.

Separation and Purification technologies developed for Rare Earth

Leaching studies were conducted on recovery of Rare Earths from Coal Fly Ash of Neyveli Lignite.

Characterization studies of Kudada Uranium ore was completed.

Successful precipitation of uranyl peroxide from carbonated liquor by direct addition of H2O2 followed by reduction of the pH was demonstrated in lab scale.

Selective recovery of Zr and Hf from the leach liquor from roasted mass of Dantala ore was achieved by solvent extraction method.

About 9-10 %wt. magnetite concentrate product was obtained from uranium leach residue of Kudada ore using wet low intensity magnetic drum separator in laboratory.

Performance of UCIL

All mines and mills of UCIL are continuing to operate satisfactorily.

The Tummalapalle unit of UCIL has demonstrated remarkable progress during FY 2023–24 and produced U_3O_8 around its annual name plate capacity.

A Magnetite by-product recovery plant has been successfully commissioned at Uranium Ore processing Plant, Turamdih for recovery of Magnetite from Uranium Ore tailings. Daily about 52.00 MT of Magnetite can be recovered from the tailing. This magnetite is positive revenue generating source from mill tailing as it can be directly sold to the prospective buyers without any further treatment as this Magnetite is readily saleable. Initially Approximate 400MT Magnetite by-product has been produced in month of December 2024.

UCIL has taken various initiatives for expediting the opening of different Greenfield projects and expansion of brownfield projects. The District Administration, Govt. of Karnataka, has completed the demarcation of the proposed mining lease area of the Kanchankayi Project and submitted it to the Dept. of Mines & Geology, Bangalore. DMG has entrusted for Differential Global Positioning System (DGPS) survey & Preparation of Land schedule, Cadastral Map etc.

District Administration, Yadgir, has completed the cadastral map and preparation of land schedule for Gogi Project. Submission of final report to the Director, Mines & Geology is awaited.

The mining plan for the Rohil Project located in Sikar district of Rajasthan has been approved by AMD during April 2024 as per the terms and conditions of the LOI issued by the Government of Rajasthan. Obtaining the environmental clearance for this Project is in process. Term of reference (ToR) has been received from Ministry of Environment, Forest and Climate Change (MoEF&CC) for grant of environmental clearance. Environmental baseline data generation work and various test works for preparation of Environmental Impact Assessment / Environmental Management Plan (EIA / EMP) are under progress. The process of land acquisition under the Rajasthan Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation, and Resettlement (RRFCTLARR) Rules, 2016 has also been initiated. UCIL

has submitted land acquisition application to District Collector, Sikar for conduction of SIA (Social impact assessment) studies for further clearance at state level. This would enable the setting up of a mining and milling facility at Rohil Project, enhancing uranium production in the country.

For expediting the pre-project activities of various Green field & Brown Field Uranium projects, an Expression of Interest (EOI) has been floated for Exploring Competent Indian Environmental, Mining, Mineral processing Project management consultants for South Project, which is under evaluation.

The techno-economic feasibility study for the utilization of mill tailings, produced at Tummalapalle mill, in the cement manufacturing industry has been initiated by BARC in collaboration with M/s. NCCBM. Similarly, R&D for utilization of mill tailings from Jaduguda and Turamdih mills for manufacturing of bricks for use in the construction industry has also been initiated.

Financial Performance of UCIL

The total income of the company during the year 2024-25 was ₹ 2356.26 Cr as against ₹ 2472.64 Cr during the previous year. The Company has registered a Profit before Tax of ₹ 188.51 Cr in the year 2024-25 as against ₹ 322.13 Cr in the previous year.

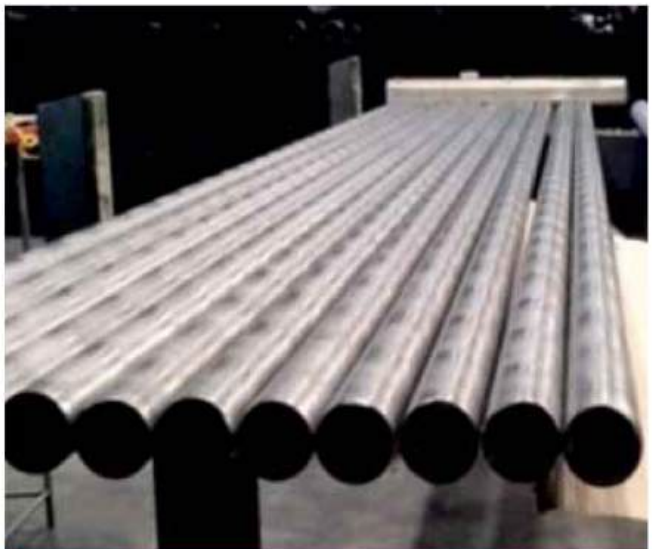
Nuclear Fuel Fabrication

The pelletizer unit at NFC is used for automatic boat charging of pellets into molybdenum boats. The Pelletizer unit compatible for boats of both high capacity walking beam furnace and regular sintering furnace has been indigenized which led to a considerable cost saving of ₹ 4 Cr.

A new solid lubricant in atomized condition was successfully established as an alternate lubricant for use in final compaction of UO_2. The alternate lubricant was developed for improving recovery in high speed compaction press; Better handling strength for automation; Can act as binder as well; Higher melting point to suit granule temperatures and Reducing the criticality of die – punch clearance. The physical, chemical and metallurgical properties of UO_2 pellets produced with this lubricant are meeting all specification requirements.

To enhance the productivity, efficiency and overall performance the new equipment systems that have been inaugurated at NFC include 25-65 tube straightening machine for production of Fuel Tubes; 2 nos. of 4-8 Tube reducing mills in Advanced Tube manufacturing facility; Steam Generator Tube bending machine; Tube drawing & Grit blasting machines for Stainless Steel Seamless Tube products; Instrumentation & Control system of modernized KR 200 Roller Straightening machine towards continual & productivity of Structurals; Automation of pickling activities in Fuel Tubes Production; Autoclave unit for Structural products; Advanced CNC grinding machine and Higher Capacity Low Temperature High Temperature Calciners in Zirconium Oxide Production Facility.

Rotary Press with indigenously developed Pelletizer


Indigenous development and manufacture of Monel 400 (Nickel & Copper alloy) tubes by NFC

At NFC, indigenous development and manufacturing of Monel 400 (Nickel & Copper alloy) tubes of size 38 mm OD, 3 mm WT & 33.6 mm OD, 0.3 mm WT meeting all the required quality parameters for LPSC, ISRO have been done. These tubes are supplied for Cryogenic applications.

Secretary, DAE inaugurated the Advanced Tube Manufacturing Facility on 12th July 2024.

Third consignment of PHWR fuel bundles manufactured at NFC-Kota was flagged off to Rajasthan Atomic Power Plant -7 by Secretary, DAE in the presence of Director-Projects (NPCIL), Chief Executive, HWB & Chief Executive, NFC along with officials from NFC, NPCIL & HWP (Kota).

Secretary, DAE flagging off the 3rd consignment of PHWR fuel bundles manufactured at NFC-Kota was flagged off to Rajasthan Atomic Power Plant -7

In-house development of an automated "PHWR Fuel Element End Cleaner and Stack Length Measurement System" for detection of missing pellets during PHWR fuel bundle manufacturing is carried out.

In-house development of automated end cap welding machine with all the latest features to overcome the limitations of existing machines with respect to their operation, maintenance and element rejection during PHWR fuel bundle manufacturing, is carried out.

Relocation of NUOFP(A) (Assembly Plant) from NUFAP building to the premises of NUOFP(P) Building inside NFC main campus is completed. All the equipment and facilities were shifted, re-commissioned, qualified, and production activities are normalized. The various advantages include Reduced radiation exposure to outside; Enhance security measures and Reduced handling damage and thus improves recovery.

Modification of Billet Cu-jacketing for Zr-Cast Iron Separation after extrusion resulted in complete separation between the Zr-alloy end and deformed cast iron. The various advantages are Upto to 2% of Zr-alloy recovered in the form of re-meltable discards; Nearly 10T per year of re-meltable Zr-alloy is unlocked for recovery; No contamination of Cu-dejacketing bath due to Cast iron and Long term solution for avoiding discard accumulation.

R&D and Technological Support for Power Programme Stage-1

At BARC, design, fabrication and installation of Anti Fouling Test Loop has been completed for testing of the Polydimethylsiloxane (PDMS) foul release coatings for reactor cooling water pipes.

Completed development of five numbers of small size He-3 detectors for Remote Emission Monitors (REM) & Uncompensated Ion Chamber with enhanced coating technique for temperature tolerance up to 600°C.

Prepared Detailed Project Report (DPR) for development of Reactor Pressure Vessel (RPV) nozzle forming technology & weld consumables for Indian Pressurised Water Reactor (IPWR) to launch a new project.

Installation & commissioning of Cobalt X-ray tube & Cobalt X-ray parabolic mirror for X-Ray Diffraction (XRD) studies on irradiated RPV materials, laser-based profiling of irregular fuel pins and furnace for heat treatment of Irradiated Fuel pins have been completed at Post Irradiation Examination (PIE) facility at BARC.

Studies on use of Yttrium (Y) as alloying element in mitigating hydride related issues in pressure tubes is in progress.

Automated tool magazine for handling the top end fittings of active fuel cluster of PHWR is developed.

Th-U fuel cycle for utilisation of fuel in PHWR-220 was analysed.

3-batch fuel management scheme of advanced reactor with 4.95 wt% enriched UO_2 fuel pins for equilibrium cycle was worked out.

A feasibility study to utilize existing primary pumps and steam generator of 220 MWe PHWR for advanced reactor was carried out.

Fabrication of air-cooled condenser for advanced reactor test facility, Tarapur has been completed.

AI based system was developed for identification of defective MOX pellets during fuel fabrication.

Enriched Boron-10 coating on the electrode plates of the detector is in progress & fabrication of the detect or components & MI cable assembly is initiated.

Installation & commissioning of trepanning machine for irradiated pressure tubes inside the cell and installation of burst test set-up for the feeder pipes & steam generator tubes have been completed in Post Irradiation Examination (PIE) facility at BARC, Mumbai.

The adequacy of decay heat removal for RAPS/MAPS through Calandria spray under postulated Loss of Coolant Accident (LOCA) with Loss of Emergency Core Cooling System (LECCS) was demonstrated experimentally by BARC.

A significant reduction in hydride fraction in Zr-2.5Nb pressure tubes was achieved using yttrium-based gettering.

Set of LOCA without ECCS and main steam line break (MSLB) analyses were carried out to assess the peak containment pressure, which decides the design pressure of containment, for Bharat Small Modular Reactor (BSMR) 220 Mwe.

An Automated Guided Vehicles (AGVs) based Automated Pellet Boat Transfer System (ABTS) for handling of PHWR fuel pellet boats between the compaction and sintering areas of the palletisation plant at NFC, Kota is under development. The fabrication and supply of AGVs, 2 Nos., which are central to the ABTS, has been completed.

Fabrication of components of parallel plate gamma compensated B-10 lined ionization chamber and high sensitivity B-10 lined gamma compensated ionization chamber and MI cable assemblies were completed. New improved B-10 coating on the parallel plates is in progress.

Installation and commissioning of fully automatic hardness testing machine with image grabbing, processing & analysis software is completed.

Loss of coolant accident (LOCA) analysis for cold and hot leg break of 200 MWe Bharat Small Modular reactor (BSMR) was carried out to assess emergency core cooling system (ECCS) acceptance criteria. The Accumulator injections are found to be adequate to satisfy all the ECCS acceptance criteria.

Pull out strength of Zr-2.5%Nb 700 MW pressure tube (PT) spools (with 100 wppm H2) and SS403 roll joint was found to be 95 tonnes, indicating insignificant contribution of circumferential hydride on pull-out strength.

Heat treated (450°C, quenched and aged) Zr-2.5%Nb alloy samples exhibit 2-3 times lower creep rate than cold worked stress relieved samples.

Considerable improvement against steam corrosion at 1200 °C was observed in Zr-4 coupon coated with 20-30 μm thick Cr by DC unbalanced magnetron sputtering.

NUCLEAR POWER PROGRAMME STAGE-2

Fast Breeder Test Reactor (FBTR)

FBTR was in shutdown in Jan 2024 and Feb 2024 due to fuel handling operations. 33rd irradiation campaign was commenced on 22nd Feb' 2024.

FBTR operated at power 40MWt and approximately 5.38 Million Units of electrical energy were generated during March 2024.

The Indigenously developed Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP) at IGCAR, Kalpakkam has been hot commissioned, and the first batch of FBTR spent fuel with burnup of 155 GWd/t has been processed.

The 'Sub-assembly level Metal Fuel Fabrication Facility' was inaugurated by Secretary,DAE on 28th May 2024 in the presence of Dr. B.Venkatraman, the then Director, IGCAR. This facility will fabricate 1.0 meter long sodium bonded metal fuel pins for sub assembly level irradiation in FBTR.

A new experimental facility for demonstration of pyro-processing operations using U-Pu-Zr alloy in maximum 250 g per batch was inaugurated by Chairman, AEC on 28th May 2024. Smoothening sharp edges of 109 numbers (Nos.) of Blanket subassembly (BSA) and 41 Nos. of Fuel subassembly (FSA), Discriminator diameter machining of 52 Nos. of Blanket subassembly (BSA) and 24 Nos. of Fuel subassembly (FSA) using automatic machine pertaining to Prototype Fast Breeder Reactor (PFBR) has been successfully completed using approved quality assurance (QA) plan and approved procedures. Radiation safety precautions have been duly adhered to during the operation by following ALARA.

During modification of Intermediate heat exchanger-1(IHX) of PFBR, QA was completed during plugging of 47 Nos. each of the tubes of top & bottom tube sheets after designing an effective QA plan, fabrication & testing procedures.

The 33rd Irradiation campaign at 40MWt was completed on 23rd July, 2024.

The total operating time of the reactor during 33rd irradiation campaign is 2664 hours. And the total electrical energy generated is 15.49 million units

During this report period, the reactor is in shutdown state and the plant shutdown activities are in progress.

High leak rate was observed in one of the sub-loop of the Biological Shield Cooling (BSC) water system and hence a working group has been formed to investigate remote leak sealing options and arrest the leak.

At IGCAR, a conceptual physics design of FBTR-II core (100MWt) has been developed. The core consists of 28 fuel sub-assemblies with active core height of 1000 mm. The core diameter is approximately 750 mm up to fuel region. There are 6 control rods (CSR) and 3 safety rods (DSR) with 90% enriched B4C as absorbing material. To incorporate breeding capability, two rows of radial blanket sub-assemblies have been added following fuel sub-assembly rows. The present design is based on full metal fuel core which can be converted to partial metal along with carbide fuel. The design has been made to achieve peak pin Linear Heating Rate (LHR) of 450 W/cm in the central sub-assembly and first row (6 FSAs). With the proper refuelling scheme, the peak discharge burn-up of 100 MWd/Kg or above can be demonstrated for these sub-assemblies.

A Fission Product Noble Gas (FPNG) monitor is installed in one of the predominant wind sectors of Kalpakkam site and commissioned. This spectrometry-based monitor would provide real-time data on the presence of radioactive gases and their concentrations in atmospheric environment. This system will be integrated with the Online Nuclear Emergency Response System (ONERS) towards real-time monitoring, alarming and to distinguish radionuclide releases in case of accidental conditions for emergency response application.

IFZ-100 (Irradiation Fuel Zone) Sub-assemblies (SA) of modified design are made for the first time in NFC. The SA comprises of several components with intricate geometries and tight tolerances. Manufacturing of the SA involves multiple challenges such as qualification of several critical welds with stringent quality requirements.

These assemblies loaded in the central region of FBTR core, house Yttria capsules for irradiation in fast neutron flux to produce Strontium-89 isotope of high specific activity.

Sr-89 isotope in chloride form is used for palliative care of bone metastases in patients suffering from lung, breast or prostate cancers.

Establishing new process parameters require extensive trials, particularly for thin section welds to achieve full penetration with a limit on over penetration. After fabrication of hardware at NFC, final assembly with 70% PuC fuel pins was carried out at FBTR, IGCAR.

Prototype Fast Breeder Reactor

At BHAVINI, the Prototype Fast Breeder Reactor (PFBR) is in commissioning state with primary sodium temperature at 180°C. Both primary sodium pumps are operating at 98 rpm on pony motor with UPS. Primary sodium purification circuit is in service to maintain the primary sodium plugging temperature at less than 105°C. Secondary Sodium Main Circuit (SSMC) loop-1 and loop-2 are in service. Both Secondary Sodium Purification Circuits are in service and plugging temperature of Sodium is less than 105°C.

All the plant utilities viz., Service Water System, Raw Water System & Fire Water System, Auxiliary Sea Water System, safety and non-safety Chilled Water System, Compressed Air System, Nitrogen plant and Ventilation System are in service. Biological Shield Cooling System is in continuous service. De-Mineralized water plant is in service to cater to all the process water system makeup requirements.

All Emergency Diesel Generators are tested periodically and are available. Dry Chemical Powder based fire-fighting system and fire alarm systems are in poised state. Generator Transformer and Unit Auxiliary Transformer-1 & 2 are in service. Auto bus transfer (ABT) system is in service. Emergency Transfer System (EMTR) Division-1 & 2 is in AUTO. Air washer system in Service building is in service.

After obtaining regulatory clearance for Fuel Loading, First Approach to Criticality & Low power physics experiments from AERB, while carrying out Fuel Handling trial operations prior to actual fuel loading, it was noted that the Transfer pot movement on primary side was not completed and it got stopped at a higher elevation instead of getting lowered completely. Hence, the Fuel loading operations could not commence as planned. Probable causes for the restricted movement of Transfer Pot are chalked out and detailed investigations are being carried out systematically to ascertain the cause towards resolving the issue. Since Liquid sodium is opaque, direct inspection is not possible which makes viewing as well as repair more difficult. Hence, a full-size mock-up of the desired region with a spare Primary Ramp & Primary Tilting Mechanism (PR-PTM) was established and De-mineralised water was filled in it.

An Ultrasonic Inspection (USI) imaging tool with four probes was developed and the same was deployed in the above mock-up facility to validate its performance and record the baseline data under water. Further this tool was deployed in the reactor and scanning was done in the problematic region under sodium and data was captured. The preliminary scanning results indicated that the tilting rail at the 90□ region inside PTM body has slid down by 300 mm from its original position and moved inwards by 90 mm at the bottom region.

Currently, a task Force comprising of officials from BARC, IGCAR & BHAVINI is formed to troubleshoot the issues encountered and to restore the functioning of Transfer Pot. On successful lowering of Transfer Pot into primary ramp, Inclined Fuel Transfer Machine trials will be conducted and fuel loading will commence towards First Approach to Criticality.

At IGCAR, modifications in 376 nos. of Actual Subassemblies (SAs) of PFBR to address the issues like higher extraction force and hexcan scoring observed during the handling of dummy subassemblies was successfully completed.

The NDE inspection module of the DISHA - V2 in-service inspection vehicle consisting of eight ultrasonic transducers and one eddy current probe for inspecting the dissimilar weld between the main vessel and the roof slab of PFBR, has successfully completed both at the room temperature (RT) and high temperature(HT) (120 degC) qualification on a 1:1 mock-up facility at BHAVINI. DISHA V2's NDE inspection module has performed adequately at RT and HT, and is ready for reactor deployment at PFBR.

A 205 MHz Mid-Tropospheric Wind Profiler (MTWP) Radar is installed and commissioned at IGCAR Kalpakkam in collaboration with ISTRAC-ISRO under ministry initiative "Application of Space Technologies in DAE". Site Acceptance Testing of radar, endurance test and GPS Sonde Validation experiments were completed.

In order to make PFBR critical, Sub-Assemblies (SA) are to be loaded into the core. The SA is supported axially on the sleeve & supported laterally at the bottom of the foot by a sleeve guide. During the handling trials of the SA with Transfer Arm (TA), it was observed that some SAs could not be lifted (stuck condition) by TA. Based on several in-pile tests, IGCAR came out with an action plan to avoid the stuck of SAs i.e, smoothening the

vertical sharp edges of the discriminator guide in the foot and increasing its clearance with the sleeve guide by reducing the guide diameter by 20-100 microns. This ensures smooth entry & avoid stuck-up of SAs.

NFC took the responsibility and developed special purpose equipment for carrying out the aforesaid modifications on all the radioactive 365 Sas.

NFC developed suitable Concept, Designed & Manufactured an equipment, conducted trials and the results were submitted to AERB with procedure. The process was cleared by AERB. The equipment is made suitable to remove the material in-situ on radio -active Sub-Assemblies at IFSB section of IGCAR.

NFC successfully delivered the equipment, installed, commissioned & established the process at IGCAR.

Heavy Water Board has produced B-10 enriched Boron carbide and supplied to FBTR, which was acceptable for its intended application as CSR & DSR.

Nuclear grade Sodium has been successfully produced by HWB, supplied to FBTR and is found to be acceptable for its intended application as coolant.

Efforts are in progress at HWB to begin the process of augmenting production of B-10 enriched Boron carbide and nuclear grade Sodium which are required for utilisation in upcoming Fast Breeder Reactors (FBR).

Electronics & Automation Support for Stage-2

Field Signal Simulator (FSS) for BHAVINI

This simulator will be used for logic validation of application software pertaining to Computer based supervisory & Data acquisition systems. All the field inputs & outputs can be simulated using FSS.

Commissioning of Local Control Panelsw (LCP) for Fuel Handling Control systems of BHAVINI

LCP's are located in vicinity of Fuel Loading area (Reactor Building). These panels accommodate instruments for the purpose of measurement, monitoring, protection, detection, control and manage the processes of fuel loading.

Installation & Commissioning of Neutron Detectors and Neutronic channels at PFBR, BHAVINI

The installation and commissioning of High Temperature Boron Counters (HTBC) has been completed by ECIL. The High Temperature Fission Counters and Neutronic channels commissioning is in progress. The commissioning of three out of sixteen channels is completed. All the Radiation monitoring systems installation and commission is completed.

Plutonium in Air Monitor

ECIL with the technical know-how from BARC and IGCAR has developed Plutonium in Air monitor for prompt and timely detection of air-borne plutonium to minimize the inhalation hazards and also to investigate the source of plutonium leak in reactors and facilities such as Fast Reactor Fuel Fabrication facilities. The monitor is a critical component of the air monitoring program in such reactors and facilities dealing with Plutonium (Pu) in powder form. The monitor detects the Plutonium in the presence of short-lived Radon and Thoron daughter products with the help of high-resolution semiconductor detector based spectroscopy.

Installation & Commissioning of Radiation Monitoring Systems at PFBR, BHAVINI

The installation and commissioning of Neutronic channels is in progress, commissioning of seven types out of sixteen type of channels is completed. All the Radiation monitoring systems installation and commission is completed.

ECIL has developed simulation kits and supplied to M/s. BHAVINI. These kits are designed to facilitate the debugging of 20 different types of boards, supporting various protocols. The three kits named as Versa Modular Euro, Remote terminal Interface and Switch over logic controls have been manufactured and supplied.

Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP)

The Indigenously developed Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP) at IGCAR, Kalpakkam was dedicated to the Nation on 2nd Jan 2024 by Honourable Prime Minister Shri Narendra Modi.

Demonstration fast reactor Fuel Reprocessing Plant (DFRP) is the first industrial scale plant for processing spent carbide fuel from Fast Reactor and towards demonstrating the reprocessing of commercial oxide fuel from BHAVINI. This plant will be a fore-runner for the Fast Reactor Fuel Cycle Facility (FRFCF). Several unique and novel equipments like fuel pin chopper, titanium dissolver, high speed centrifuge, centrifugal extractors, automated remote sampling system, special in-cell cranes, remote handling equipment like master slave manipulators, etc have been indigenously developed, manufactured by Indian industries and have been successfully deployed and are "Atma Nirbhar" deliverables. The design and construction of the plant is very complex. The plant houses about 150 km of stainless-steel piping, with about 60,000 weld joints which were all qualified by radiography (requiring about 2,00,000 exposures), within a very limited space inside concrete cells, which was very challenging.

In the DFRP facility, cold-commissioning with processing of 3 batches of Uranium pins has been completed.

At DFRP, as a part of the first campaign processing of 20 pins of FBTR spent fuel, monitoring of undissolved clad tubes (hulls) has been completed and subsequently material balancing and nuclear material accounting has also been completed.

The second campaign for processing of 40 pins of FBTR spent fuel as a part of limited hot runs has commenced. Chopping of the 40 fuel pins of FBTR spent fuel with 155 GWd/t burnup followed by dissolution and feed clarification has been completed.

The Conceptual design of Carbide fuel pin spacer wire removal mechanism has been completed.

At Demonstration Fast Reactor Fuel Reprocessing Plant (DFRP), the second campaign for processing of 40 pins of FBTR spent fuel with 155 GWd/t burn up, has been completed.

The second batch of solvent extraction was completed and the recovered material is converted into final product form by reconversion process.

The third campaign of limited hot run was commenced in the Demonstration Fuel Reprocessing Plant (DFRP) during December 2024. As part of the campaign, 60 nos. of FBTR spent fuel pins of burnup 155 GWd/ton has been transported from Radio Metallurgy Laboratory (RML) to DFRP and was transferred into the hot cell.

Chopping and dissolution of 60 nos. of pins in a single batch has been carried out for the first time at DFRP, thereby reaching its full design capacity since the start of hot commissioning.

Subsequent to the process steps, feed clarification and conditioning has also been completed.

CORAL

At CORAL (COmpact Reprocessing facility for advanced fuels in Lead shielded cells) Facility, preparatory work has been continued for taking up 67th reprocessing campaign. For the first time, the Organic waste solution has been transferred to waste disposal agency for further management.

Radioactive Waste Management

At BARC, intermediate Level Liquid Waste (ILLW) processing from WTF tank is continued and 200m3 of ILLW was treated safely. Plasma incineration for combustible solid wastes are continued.

One full scale in-drum geo-polymerization trials of low-level waste including technetium completed.

Development of Radioisotope Thermoelectric Generator (RTG) using radioisotopes was completed.

Direct de-nitration of uranyl nitrate in fluidized bed reactor was successfully demonstrated by processing more than 1000L of quality uranyl nitrate solution at Direct Denitration Demonstration Plant at Tarapur.

Intermediate Level Liquid Waste (ILLW) processing from WTF tank is continued, around 204 m3 of ILLW has been treated safely. Polishing of low-level effluents by Ion Exchange and plasma incineration of combustible solid wastes is continued.

Volume reduction was demonstrated on samples of solid waste generated from Fast Breeder Test Reactor (FBTR) fuel fabrication.

Separation of Am(III) from Eu(III) in TEHDGA strip product solution using CA-BTP has been demonstrated in solvent extraction process.

At BARC, Intermediate Level Liquid Waste (ILLW) processing from WTF tank was continued. About 183 m3 of ILLW was treated safely. Polishing of low-level effluents is continued by Ion Exchange.

Studies for effect of gamma radiation (up to dose of 1 MGy) on CA-BTP/1-octanol solvent system equilibrated with 0.5 M HNO3 were carried out which indicates that CA-BTP degradation products do not have a deleterious effect on selectivity of extractant with respect to Ln-An separation.

Volume reduction of additional packets of solid waste generated from Fast Breeder Test Reactor (FBTR) fuel fabrication has been performed as part of demonstration & validation efforts.

LLW processing campaign from WTF tank continued. Around 182 m3 of ILLW was treated safely. Polishing of resulting raffinate is continued by Ion Exchange.

Diglycolamide (DGA) based polymer beads were developed for the recovery of Am and Pu (at microgram level) in the presence of U (5-6 g/L) for the treatment of highly acidic waste.

The process developed for the recovery of calix-crown-6 (CC-6) from spent calix solution was successfully demonstrated at lab scale. The recovered CC-6 showed good affinity towards Cs with no uptake of alpha activity.

NUCLEAR POWER PROGRAMME STAGE-3

Kalpakkam MINI (KAMINI) Reactor

KAMINI reactor was operated various times at the power level of 15kWt and 20kWt for irradiation of various samples based on the user requirements.

KAMINI Reactor was operated for the following requirements: Irradiation of one lithium aluminate sample for damage studies, 32 numbers of coal fly ash samples at PFTS location to estimate short lived nuclides and a 1 S Aluminium sample at PFTS location to check for impurities present. Neutron Radiography of 3 nos of 14.5% EU-6% Zr irradiated metallic fuel pins and 2 nos. of FBTR PUC+UC (155 GWd/t) irradiated fuel pins at south beam tube location.

CHAPTER 2
HEALTH CARE

Muzaffarpur Hospital Campus

Radiation Therapy (RT) Block (G+1)
at Muzaffarpur, Bihar

RADIOPHARMACEUTICALS

Three Hundred & Twenty laboratory reference sources and 19 custom made sources were supplied to users.

Fifty-six ^{125}I seeds with an average activity of 624.19 MBq were supplied to hospital for brachytherapy treatment of ocular cancer patient.

Second hot commissioning trial of I-131 Processing Facility was completed, about 11Ci of I-131 was produced.

Clinical trials for six different types of cancers were under progress to evaluate the efficacy of Chlorophyllin (AKTOCYTE) tablets.

Chlorophyllin (commercially named as AKTOCYTE) an adjuvant to cancer radiotherapy, regenerative nutraceutical, immune-modular and antioxidant, was launched.

Clinical trials protocols have been approved by hospital ethics committee of Tata Memorial Centre. Integrated analysis of proteomics and metabolomics has highlighted the signalling pathways linked to radio-protective and regenerative action of chlorophyllin in the cancer patients suffering from side effects of radiotherapy.

Approval of a prospective Phase-II study of Chlorophyllin for Management of Brain Radionecrosis in patients with Diffuse Glioma & initiation of clinical trial was obtained.

A protocol for phase-III clinical study to evaluate the efficacy & safety of oral Na-Cu chlorophyllin in patients with hemorrhagic cystitis secondary to radiation therapy for pelvic malignancies was prepared.

PET/CT imaging facility at RMRC became operational in Jan 2024.

Radio-isotope production at 30 MeV Medical cyclotron of VECC (operation by VECC and produced by BRIT) were supplied to various hospitals/Nuclear Medicine Centres at Kolkata, for cancer diagnosis of patients.

Fluor Deoxy Glucose (FDG) production in 106 batches of total activity of 156889 mCi using 4763 μAh of internal beam.

FDG production in 57 batches of total activity of 1009054mCi using proton beam was carried out.

NaF production in 2 batches of total activity of 1505 mCi using 41.4 μAh of internal beam.

Four batch of ready-to-use ^{90}Y-Glass microsphere (Bhabhasphere) was prepared and supplied for treatment of liver cancer patient.

Three lots of clinical grade ^{90}Yttrium were supplied to Radiation Medicine Centre (RMC), Parel, Mumbai.

Three batch of $[^{90}Y]YCl_3$ radiochemical formulation was supplied through BRIT for treatment of rheumatoid arthritis.

Three round and Four notched plaques of Ruthenium Brachytherapy (RuBy) were supplied to BRIT for subsequent delivery to hospital for treatment of eye cancer patients.

One paediatric plaque of Ruthenium Brachytherapy (RuBy) was supplied to BRIT for subsequent delivery to hospital for treatment of eye cancer.

Dhruva was operated at 79.85% availability factor & total of 113 cans were irradiated. Apsara-U operated at an availability factor of 81.55 %.

Ninety-nine (99) batches of radiochemical formulation of 82.32 TBq (2224.7 Ci) radiochemical formulations were produced and total 77.34 TBq (2090.1 Ci) were supplied to various hospitals through Board of Radiation and Isotope Technology (BRIT) for use in human healthcare. The radioisotopes produced and supplied were ^{177}Lu, ^{131}I, ^{99}Mo and ^{125}I.

Ten (10) Cs-glass pencils were supplied to BRIT for blood irradiator.

Isotope Production Reactor & Processing Facility (IPR & PF)

An application to obtain Term of Reference (ToR), required to initiate Environment Impact Assessment (EIA), for Isotope Production & Processing Facility (IPPF) was submitted to Ministry of Environment, Forest and Climate Change (MoEFCC).

In-principle approval for Kakrapar, Gujarat Site for locating Isotope Production and Processing Facility (IPPF) was obtained from Department of Atomic Energy (DAE).

Various reports such as report on estimation of radioactive source term in reflector and reactor pool due to aluminium activation products; Report on thermal-hydraulic analysis for the reflector tank of the Isotope Production Reactor (IPR); Report on the long term statistical analysis of meteorological data observed during 1994-2022 at Kakrapar Gujarat site and Design Information Report (DIR) on the Hot Water Layer System (HWLS) of Isotope Production Reactor (IPR) etc. have been prepared and released.

Analyses were performed and following reports were prepared & released for Isotope Production Reactor (IPR):

1. Safety analysis report on passive decay heat removal system (PDHRS) during station blackout scenario, shutdown cooling system (SDCS) during failure of Class-IV power supply and radiological impact assessment (RIA) for postulated sever core damage scenario.

2. Computation analysis report on cooling performance of irradiation thimbles housing the tray rod assemblies containing target material prepared and released.

3. Thermal-hydraulic analysis report to study the hot water layer formation in the reactor pool.

4. Report on evaluation of nuclear heat generation in the reactor pool water.

Layout for Reactor Building, Reactor Auxiliary Building, Electrical Building, Rad Waste Building and Service Building were carried out with respect to modified reactor core configuration and its associated process system.

R&D in Cancer detection and therapy

Clinical studies with human serum albumin coated [^{177}Lu]Lu_2O_3 nanoseeds, an in-house developed nanoscale brachytherapy agent, was commenced in collaboration with a hospital at Kottayam, Kerala by administering 15 mCi (555 MBq) dose of the agent in a breast cancer patient.

Independent evaluation of toxicity of anti-cancer drug at TMC/ACTREC was completed. The anti-cancer drug, mitocurcumin, showed potent cytotoxicity in cancer cell lines of different origin and also enhanced radiation induced cell death in cancer cells.

Twenty (20) freeze-dried Di Ethyl Dithio Carbamate (DEDC) kits, developed by BARC, were supplied to All India Institute of Medical Sciences (New Delhi) for the formulation of 188Re-DEDC-Lipiodol, which is used for the targeted radionuclide therapy of patients suffering from un-resectable hepatocellular carcinoma.

Prussian blue anchored carbon black based probe developed for sensing prostate specific antigen in human blood serum.

^{68}Ga labelled multimodal nanoformulations were developed for PET coupled with optical bio-imaging and MRI.

Alginate- Cetyl Trimethyl Ammonium Bromide (CTAB) nanoparticles were prepared for surfactant therapy against cancerous cells

Active pharmaceutical ingredient, Prostate Specific Membrane Antigen (PSMA)-617, was synthesised and 30 mg of the same was supplied to BRIT, Vashi.

3 g of [Cu(MIBI)4]BF4 synthesised, purified and supplied to BRIT, for production of 99mTc(MIBI)6, a diagnostic nuclear medicine sufficient for 8000 patients for myocardial perfusion imaging .

Fifteen (15) freeze-dried kits using in-house synthesized HYNIC-TOC were prepared and supplied to

AIIMS (New Delhi) for diagnosis of neuroendocrine cancers.

Launch of nutraceutical AKTOCYTE tablets

Commercial launch of nutraceutical chlorophyllin tablets (Aktocyte) was done by Director, BARC on 10th June 2024. The medicine was developed in collaboration with BARC, ACTREC, TMH and Bangaluru based pharma company.

RADIATION TECHNOLOGY EQUIPMENT

Two nos. of Gamma Chambers (GC-5000) were supplied to research/education institutes. Three orders were executed for chemical and fabrication industry for column/pipe scanning / radiometry using radioisotopes.

RADIO DIAGNOSTIC & TREATMENT SERVICES

BRIT continued to supply affordable radiopharmaceuticals for Nuclear medicine sector in India using its novel IT- enabled Pan India door delivery logistics services in the year 2024-2025. BRIT has supplied 18186 Nos. of Technetium Cold Kits, 459 Nos. of Technetium-99m Generator, 465.38 Ci of Lu-177 and 581.48 Ci of I-131 to various hospitals for both diagnostic and therapeutic purposes. 341.81 Ci of FDG-F18 have been supplied to various hospitals for PET scanning. 21.95 kCi of Ir-192 sources (538 Nos.) were supplied for radiography cameras. 61 Nos. of ROLI radiography camera(s) were supplied for NDT, 6 Nos. of Cobalt-60 teletherapy sources were supplied for cancer therapy. 840 (Pcs.) Tritium filled sources have been supplied to defence organisation. 4 No. of Blood Irradiators were supplied to hospitals and 5 No. of orders were executed for chemical and fabrication industry for column/pipe scanning/radiometry using radio isotope.

Indigenous Remotely Operated Tungsten Shielded Exposure Device (ROTEX-I) an Industrial Radiography Device was launched. ROTEX-I is a cutting-edge industrial portable radiography device, Category II, and designed to hold a source capacity of 2.405 TBq (65 Ci) of Ir-192.

Production of one batch of TCK-5 was completed and the complete batch has been despatched to BRIT Vashi for quality control. Retail sale of TCK kits is continued.

Molecular diagnostics – User manual for real time TB PCR kit using magnetic beads for genomic DNA extraction is under preparation.

Regional Centre, BRIT, Kolkata was involved in the routine production, Quality Control and supply of PET radiopharmaceutical Viz. ^{18}F- FDG at MCF, BRIT, Kolkata. Uninterrupted supply of nearly 18,585 mCi of ^{18}F- FDG was made to various cancer hospitals in and around Kolkata city which has benefitted nearly 1850 patients during the report period.

BRIT has developed a new Molybdenum-99 Transportation Package "MTP-100", specifically designed to efficiently transport and store liquid Mo-99 radioactive material. The use of Tungsten as the shielding material ensures that it remains both lightweight and compact, while providing a maximum design capacity of 3.7 TBq (100 Ci) of Mo-99 radioisotope. The MTP-100 cask will provide an opportunity for exporting fission-generated Mo-99 radioisotopes from India, significantly reducing costs previously associated with importing these casks. Ultimately, this development aims to make healthcare applications more accessible by lowering the cost of treatment for patients in need.

ALTERNATE APPLICATIONS OF HEAVY WATER

Developmental project for Synthesis and biological evaluation of deuterated analogs of some antineoplastic drugs is under progress with MS University, Vadodara. MSU has synthesized small quantity of deuterated analogs (2 nos) of Dasatinib and supplied to BARC during report period for carrying out biological evaluation viz. Cell line studies, BCR-ABL Kinase inhibitory assay, Signaling pathway examination, Absorption Distribution Metabolism & Excretion (ADME)

studies, Secondary screening of promising compounds, etc.

This developmental effort is in its advanced stages, with two molecules successfully synthesized and tested at BARC and ACTREC. Both molecules have shown promising and reasonably acceptable results.

HWB also is working with Advanced Centre for Treatment, Research and Education in Cancer, Navi Mumbai (ACTREC), for Evaluation of anticancer potential of deuterium depleted water (DDW) on human breast and lung cancer cell and experimental tumor model. HWB is supplying required quantity and quality of Deuterium Depleted Water (DDW) for carrying out the studies. ACTREC indicated that result of in-vitro experimental studies carried out during report period, on animals, are very promising. Ethics committee is being approached for carrying out studies on humans. HWB is arranging bottled DDW for taking-up trials on human. Recently, the research has advanced to clinical trials using 70 ppm DDW.

HWB is working on development of DDW production facility of lower deuterium concentrations. The by-product / effluent water of 125 – 130 ppm deuterium is being sold in open market as per demand, mainly for non-nuclear applications in healthcare sector.

128 MT of DDW of 125 ppm deuterium content and 1 MT of 10 ppm DDW has been supplied in FY 2023-24 to Indian industries for making potable quality water.

HWB successfully demonstrated the industrial-scale production of Deuterium Depleted Water (DDW) at HWP-Kota, marking a significant technological achievement. The facility was inaugurated by the Chairman of the Atomic Energy Commission (AEC). Additionally, DDW production is carried out as per demand and available opportunities at other plants, showcasing HWB's adaptability and commitment to innovation.

Inauguration of Deuterium Depleted Water (DDW) unit of 100 Te/Annum capacity at HWP, Kota, for continuous operation

CANCER DIAGNOSTICS AND TREATMENT SERVICES

For the Construction of Hospital building of TMH at Haffkine Campus, Parel the Excavation work has been completed up to 75%; Raft Foundation upto 30% and the Retaining Wall has been completed upto 4%.

TMH Mumbai; ACTREC, Kharghar; HBCH&RC, VIZAG; HBCH&RC, Punjab; MPMMCC & HBCH, Varanasi; HBCH&RC, Muzaffarpur and BBCI, Guwahati continued to provide the cancer treatments to patients. The no. of patients treated for the first quarter was 604405 and the no. of new patients added during the quarter were 30289. The no. of patients treated for the second quarter was 530347 and the no. of new patients added during the quarter were 31262. The no. of patients treated for the third quarter was 596519 and the no. of new patients added during the quarter were 28543.

Homi Bhabha Cancer Hospital in Jatni, Khordha

For the establishment of Homi Bhabha Cancer Hospital in Jatni, Khordha, NOC from DFO, Chandaka for Non eco-sensitive zone for construction of Hospital has been received. AERB Approval for LINAC Bunkers have been obtained. Obtained Environmental Clearance. BDA approval and other statutory approvals are under process. Fire Safety Recommendation - application submitted and is under process. MoU has been signed between TMC & CPWD Bhubaneswar for construction of Boundary Wall, Residential Quarters (Multipurpose) and preliminary estimate for Construction of boundary wall & Residential quarters has been submitted by CPWD A/A & E/S. Completed Fixing of Concrete Pole and Surface Dressing of Demarcation Area work.

GI sheet fencing at construction area at Homi Bhabha Cancer Hospital in Jatni, Khordha

As suggested by CPWD, soil re-investigation done at site to verify the Safe Bearing Capacity (SBC) Value. Final reports submitted to Architect. CPWD is preparing the documents for floating the tender & will float the tender after receiving of approved drawings.

AERB, EC, Fire Safety Recommendation Application, Consent to Establish (CTE) Approval has been obtained for the Homi Bhabha Cancer Hospital in Jatni, Khordha. G.I sheet Barricading at construction area has been completed. Statutory Approvals for Residential Quarters (Multipurpose) is under process.

BDA Final Approval has been obtained for Construction of Hospital Building. Excavation works are under progress. Excavation work at Block-III has been completed upto 95% and about 85% work has been completed at Block-II. Statutory Approvals for Residential Quarters (Multipurpose) – Fire safety Recommendation Certificated has been obtained. BDA approval is under process. About 90% work has been completed for Shifting of Electrical Poles/HT/LT Lines passed through the plots allotted to TMC. CPWD floated the tender for c/o of Boundary Wall & Residential Quarters (Multipurpose). Technical & financial evaluation is completed. CPWD is in the process of issuing the work order to the agency.

Excavation work at Block-III

Medicinal Plant Cultivation Facility on Forest Land in Donavat-Khalapur, Raigad, Maharashtra

About 86% of RCC compound wall construction around the site has been completed. LOA (Letter of Approvability) and Fire Safety NOC obtained from MSRDC for environmental clearance for the proposed structure. Additionally, NOC from the Airport Authority of India and AERB approval have been secured. Structural Design & drawings vetted by VJTI Matunga Mumbai has been received. Notice Inviting Tender for the Ayurvedic Cancer Hospital Construction has been issued by CPWD on 08.08.2024. Boundary demarcation is completed by TILR, Khalapur. Precast poles have been erected around the forest land boundary. Project construction will begin and proceed swiftly once the final approval from the Government of Maharashtra is received. Master Layout Plan and Plantation Zoning Layout finalized by landscape experts from TMC. Tender documentation for the appointment of a civil contractor through CPWD is underway.

National Cancer Grid (NCG)

The project received approval in November 2023. Since the approval the project is making progress as per the milestones listed in the DPR. Some of the activities that have been done incudes organisation of NCG meeting with participation of ASEAN countries, expanding the learnings from various NCG initiatives to ASEAN, and planning of North-east state chapter of NCG to address locally relevant issues in delivery of quality cancer care. The meeting was attended by all the directors of member centres; The health technology assessment unit has initiated two adaptive HTAs for high cost anticancer medicines; Development of online modules for guideline adaptation; Selection of

participants for CReDO 2025 is completed and the participants and faculty have been assigned to nine protocol development groups; The NCG oncology specific Electronic Medical Record (EMR) has been deployed in 2 centres and 16 more centres are in the process; Specifications for pathology synoptic reporting software were developed. The radiology synoptic reporting software is being planned and a total of 24 virtual tumour boards were conducted.

Homi Bhabha Cancer Hospital & Research Centre (HBCH & RC), Muzaffarpur, Bihar

For the Establishment of Homi Bhabha Cancer Hospital & Research Centre (HBCH & RC), Muzaffarpur, Bihar, the construction works of Radiation Therapy (RT) Block has been completed. The construction work for 16 Nos-Type-II residential quarters has been completed. The works related to installation of CT Simulator and Halcyon (Ring Gantry) have also been completed. External Development & road work is in Progress. Construction work of Main Hospital is in progress.

Muzaffarpur Hospital Campus

(G+1) RT Block

Programme to Control Common Cancer Among Women in North and North East India

Since start of the project till December 2024, TMC has organised total 4758 camps under which 4,43,065 women were screened and 12,279 cases have been diagnosed positive, with additional step TMC will complete screening of 5 Lakhs women till 31 march 2025. Consumables and equipment like Storage server with backup solution, Desktop Computer etc. are being procured.

CHAPTER 3

ADVANCED TECHNOLOGIES, RADIATION TECHNOLOGIES AND THEIR APPLICATIONS

Heat Transfer Experimental Loop (HELP) at HFRR

A prototype assembly structure of n-type Si detectors coupled to tungsten plates

RESEARCH REACTORS

APSARA – Upgraded

Reactor was operated with an availability factor of 95.49 %, 95.15% & 68.3%, for January, February & March, respectively.

DHRUVA

Reactor was operational for all the 3 months. Month-wise Availability Factor was 80.2%, 89.7% & 52.8% and corresponding average reactor power was 74.98 MW, 73.65 MW & 72.6 MW, for January, February & March, respectively.

Dhruva & Apsara-U operated at 74 & 86.6 % Availability Factors, respectively. Total of 128 & 2 radioisotope samples were irradiated, respectively.

Rehabilitation of civil structures for strengthening seawater pump chambers (Caisson) & Jetty road and revamping of electrical system (panels, SPPH, power supply cables etc.) of Dhruva were completed.

Critical Facility (CF)

Reactor was operated six times each in January & February, and four times in March.

High Flux Research Reactor (HFRR)

Hot water layer simulation piping installation of HFRR experimental loop at BARC (V) is in progress. Installation of Heat Transfer Experimental Loop (HELP) loop at BARC(V) was completed and commissioning of the loop is in progress.

Heat Transfer Experimental Loop (HELP) at HFRR

ACCELERATORS

Multiwire scanner consisting of 32 wires was installed in LEHIPA LEBT for beam profile measurements for space charge compensation experiments.

Phase stability of LLRF system is analysed and optimized for the desired stability.

Multiwire assembly of LEHIPA

High power coupler test stand for MEHIPA and IIFC couplers (325 MHz) has been tested for 150 kW RF power.

LASER TECHNOLOGY AND APPLICATIONS

RRCAT is pursuing R&D in lasers and associated technologies with their applications including free electron lasers, metrology, laser driven electron acceleration, biomedical applications, non-linear optics and materials processing in nuclear environment, R&D in materials and laser additive manufacturing.

Free Electron Laser (FEL) facility of RRCAT is made open to researchers outside RRCAT. This facility operates in Infra-Red regime and can complement to studies conducted at RRCAT's national facilities Indus-1 and Indus-2 synchrotron radiation sources.

Development of 2 kW all-fiber Yb-doped CW laser, 100 W average power Yb-doped Q-switched fiber laser for cleaning of metal surfaces, Fiber coupled pulsed Nd:YAG laser system for welding of PFBR fuel pins, have been completed. In RAPS-3, in-situ cutting of

all the 612 bellow lip weld joints was carried out successfully during En-masse Coolant Channel Replacement (EMCCR) operation using RRCAT developed laser-based system. Underwater laser cutting of SS 304 metal sleeves in high radiation field (~1000 R) has been successfully performed for retrieval of end shield coupons from optical sight plugs in RAPS-2 reactor using remotely operable fiber coupled pulsed Nd:YAG laser developed at RRCAT. A 10-kW fiber laser based Directed Energy Deposition (DED) System and a 500 W Laser based Powder Bed Fusion (LPBF) system have been developed for laser additive manufacturing applications. An ultrafast fiber Mamyshev Oscillator (MO) has been developed generating stable train of ultra-short pulses with controllable diverse pulse patterns. RRCAT has developed and installed a CO2 Laser based system at VSSC, ISRO Thiruvananthapuram for low power experimental studies.

Development of 2 kW average power and 40 kW peak power long pulse Nd:YAG laser has been carried out at RRCAT. This laser has potential for remote cutting SS sheets of ~40 mm thickness and welding up to 8 mm thickness in SS.

AGRICULTURE

DAE issued license for commercial operation of two new food irradiation facilities at Krishnagiri, Tamil Nadu and Madhupur, Gir Somnath, Gujarat. Total 28 food irradiation facilities are operational in India now.

After successful storage trials of Rabi (summer crop) onion using BARC developed radiation based Standard Operating Procedure (SOP), a large-scale trail for shelf life extension of 'Kharif' (Winter crop) onion has been initiated at KRUSHAK facility, Lasalgaon, Nashik. Till date 20 Tons of onions are stored in the facility under the trial.

Two new crop varieties; Trombay Jodhpur Wheat 153 (TJW153) and Trombay Jodhpur Mustard 2 (TJM 2) were released by the State Varietal Release Committee (SVRC) of Rajasthan.

Trombay groundnut lines, TG 107, 108, 109, 110, 111, 112 and TG 113 are being evaluated in kharif station trial at Anand Agricultural University, Anand, Gujarat. The promising lines that emerge from these trials will be further evaluated in multi-location trials.

Chhattisgarh Trombay Luchai Rice

Eight (8) new crop varieties including two (2) wheat, three (3) rice and 3 oilseeds (one each in groundnut, mustard & sesame) were Gazette notified for commercial cultivation. Thus, till date BARC has developed and released total 70 new crop varieties for commercial cultivation.

One mustard variety (TJM1), previously released in Maharashtra (TAM108-1) has been re-released for cultivation in Rajasthan.

Two new varieties, one groundnut mutant TG 93 and one mungbean genotype TMB-246 entered into initial varietal trials (IVT) for multi-location testing.

FOOD PROCESSING

BARC developed radiation technology for food preservation & its various applications were presented to various officials and agencies.

Standard Operating Procedure (SOP) was finalised for shelf life extension of Hilsa fish using BARC developed radiation technology. The SOP extends the shelf life of Hilsa fish from 3 days to 20 days.

Salt tolerant rice variety 'Trombay Konkan Khara' (BARCKKV 16) was released for Maharashtra State.

Interaction with Food Corporation of India (FCI) is in progress for obtaining land in its premises to construct first commercial Co-60 based grain (cereals and pulses) irradiator.

In order to plan shelf-life extension of 'Rabi' onion in 2024, using radiation technology, a visit of

officials from Department of Consumer Affairs (DoCA), National Agricultural Cooperative Marketing Federation of India Limited (NAFED) and National Co-operative Consumers' Federation of India Limited (NCCF) was organised to KRUSHAK facility, Lasalgaon.

Officials from Department of Industries & Commerce, Government of Assam and private entrepreneurs from Kerala visited BARC for technical discussions pertaining to setting up of BARC developed food irradiation facility in Assam & Kerala respectively. BARC technologies for food irradiation were exhibited to the officials during their visit.

Necessity for establishing integrated food radiation processing facilities comprising cold storage was presented during a meeting convened by Ministry of Food Processing Industries (MoFPI) for making food irradiation technology economically viable. The meeting was attended by officials from National Cooperative Consumers Federation of India Limited (NCCF), Ministry of Consumer Affairs (MoCA) and National Agricultural Cooperative Marketing Federation of India Limited (NAFED).

Studies in progress to overcome moisture accumulation problem during the cold storage for shelf-life extension of litchi resulted in retention of quality attribute even after 15 days of the cold storage. This study is likely to increase the export potential of litchi using radiation technology after overcoming quarantine barrier.

SOP developed for radiation processing of goat and chicken liver resulted in increase of shelf life to 21 days when stored at 6°C. Non-irradiated samples get spoiled in 3-5 days.

Gamma Irradiation of 2280.5 tons of food and allied products were carried out at Radiation Processing Plant, Vashi.

Plant re-commissioning dosimetry of food product was carried out for M/s Innova Agri Bio Park Gamma Irradiation Plant, Bangalore. Supply of 65,100 numbers of ceric cerous sulphate dosimeters was carried out to various gamma irradiators.

Radioanalytical analysis certification was carried for 3423 No. of test samples received including human food, water, animal feed, medicines, bakery, agricultural, dairy and other products.

A grain irradiator is proposed to process loose grain with high throughput (about 6 tons/hr) using Co-60 as source with stationary source and the loose grain passing around the source by gravity with required control mechanism for proper dose. Preparation of preliminary safety analysis report (PSAR) and development of test set-up for study of grain flow pattern are in progress.

Design of source-cum-irradiation chamber has been modified to provide additional source pencil slots for making up of depleted Co-60 source. Dose Uniformity Ratio analysis for this modified design is in progress.

Layout of plant building of grain irradiator was finalized.

About 1360 KCi of Co-60 Irradiator source were supplied to various Gamma Irradiators for food & allied products Irradiation.

Significance of BARC developed radiation technology for long term food preservation was presented to Hon'ble Chief Minister of Maharashtra, in a meeting convened to discuss large scale preservation of onion and creation of Onion Mahabank. The meeting was attended by Director, BARC and senior officials from BARC & Department of Atomic Energy (DAE). Hon'ble Chief Minister suggested to Maharashtra Government officials to develop the proposal for setting of food irradiation plants along the Samriddhi Mahamarg.

Ministry of Food Processing Industries (MoFPI) invited expression of Interest (EoI) from prospective entrepreneurs for setting up of multiproduct food irradiation units, based on BARC developed irradiation technology, under Integrated Cold Chain & Value Addition Infrastructure (Cold Chain scheme), a component of Central Sector Umbrella Scheme-Pradhan Mantri Kisan SAMPADA Yojana (PMKSY).

BARC officials provided vital inputs for finalising the requirement of land for a standalone food irradiation facility considering operation & maintenance (O&M) requirements during an online meeting of the Technical Committee convened by Ministry of Food Processing Industries (MoFPI).

Packing materials for grains and wheat were tested for sealing and radiation compatibility at BARC and suitable packing material was recommended to Food Corporation of India (FCI) for commercial trial for utilisation in grain irradiators.

Standard operating procedure (SOP) involving ultrasonication and radiation was developed to extend the shelf-life of mushroom from three days to twenty-two days retaining its colour, physical, biochemical and organoleptic attributes to acceptable level. The study was concluded.

Information of BARC developed radiation technologies & products pertaining to sea food and Board of Radiation and Isotope Technology (BRIT) developed Marine Irradiator for shelf-life extension of whole fishes were disseminated to the sea food exporters during a meeting organised by Marine Products Exports Development Authority (MPEDA) along with Seafood Exporters Association of India (SEAI), at Mumbai.

Loading of radioactive source was completed in newly constructed food irradiation centre cum pack house at Bihta, Patna, Bihar. The facility is being commissioned.

Mechanical design of Co-60 grain irradiator was completed and the architectural plan of the facility is being revised accordingly.

Irradiated Rabi onions (250 Tons) were successfully marketed after seven months of full-scale storage trails conducted by Farmer Producer Organization (FPO) at KRUSHAK facility Lasalgaon.

Two units of standalone 20 ft. LN2 based Refrigerated Transportable System Sheetal Vahak Yantra (SHIVAY) fabricated by M/s Furmech under technology incubation, are undergoing testing for thermal performance at RRCAT.

Development of 32 ft LN2 based Refrigerated Transportable System Sheetal Vahak Yantra (SHIVAY) by M/s Tata Motors Ltd. has been done. The system has been assembled and it is undergoing testing at Tata motors. Subsequently, it will be sent to RRCAT for testing thermal performance.

Qualification of KIRTI-1010 Linac at 10 MeV, 10 kW beam power at MSSPL, Bengaluru.

Preliminary prototype of 9.5 MeV, 15 kW linac has been assembled from available components and beam has been tested.

Configuration design of high throughput food irradiation facility has been carried out.

RAL, RC, BRIT, Hyderabad participated in Proficiency Testing for the scope "Analysis of 137Cs content in Food and Agricultural Products". Performance of the laboratory was "Satisfactory." Online application with the above scope was submitted at NABL for obtaining NABL accreditation of the laboratory.

BRIT has developed and commissioned a state-of-the-art "Low Temperature Gamma Irradiator," the first of its kind in the world. It is a category-I batch type irradiator designed for 400 kCi of Co-60 sources. This irradiator can irradiate marine products that present maximum challenges in their processing and handling requirements, as they have to be irradiated in the temperature range of +30°C to +10°C for fresh fish and -18°C to -20°C for frozen fish. The plant is integrated with a chilled air unit to maintain the cold chain during the irradiation process. Using a Co-60 radiation source, it can increase the shelf-life of fresh fish by 25-30 days with a dose of 1-3 kGy and eliminate pathogenic organisms with a dose of 1-7 kGy while providing high throughput capabilities to the tune of processing 5-6 tons of frozen fish per day and 10-12 tons of fresh fish per day.

BRIT supplied Cobalt-60 industrial grade sources to M/s. Jamnadas Industries, Indore (330 KCi), M/s. Infrastructure Development Authority, Patna (300 KCi), M/s. Organic Green Foods Ltd., Chanditala, West Bengal (125 KCi) and M/s. Shri Ram Institute for Industrial Research, Delhi (124 KCi).

About 828.37 Tons of materials (spices, pet feed, herbal raw material, colour powder etc.) have been processed using gamma radiation processing.

Radiation Procession Services

New MoU for Radiation Processing Plants in Private Sector

MoU was signed with M/s RCC Nutra Fill Pvt. Ltd. in Jan'2024 to set up a gamma radiation processing plant in Ernakulam, Kerala for treatment of agro products.

A MoU was signed with M/s Solstrale India Pvt. Ltd. in May'2024 to set up a gamma radiation processing plant in Haridwar, Uttarakhand for treatment of Agro products such as spices, herbal products and dehydrated onion powder etc.

BRIT signed a MoU with M/s Gamma Agro Medical Processing Pvt. Ltd. in Sep'2024 to set up a gamma radiation processing plant in Bengaluru, Karnataka for treatment of agro products such as spices, herbal products etc and medical products.

BRIT signed an MoU with M/s Gamma Agro Medical Processing Pvt. Ltd. on September 2024 to set up a gamma radiation processing plant in Bengaluru, Karnataka

BRIT signed MoUs with M/s Anjaneya Agro Tech., Vijaywada; M/s. NDR Infrastructure Pvt. Ltd., Karjat, Raigad; M/s District Project Livelihood College Society, Dantewada, Chhattisgarh; M/s Fanidhar Mega Food Park Pvt. Ltd., Mehsana, Gujarat; M/s Gujarat Agro Industrial Corporation Ltd., Rajkot, Gujarat; M/s H K Food Park, Eluru, Andhra Pradesh; M/s Naso Industries Pvt. Ltd., Kathua, Jammu & Kashmir and M/s Sri Varsha Food Products India Pvt. Ltd., District YSR Kadapa, Andhra Pradesh for setting up gamma radiation processing facility.

WATER & WASTEWATER MANAGEMENT

The 4.5 MLD sea water reverse osmosis (SWRO) plant at IREL, OSCOM is commissioned. The 132 kV switchyard extension work for IREL desalination plants is completed.

Hybrid polymeric sorbents were developed for the selective recovery of precious and toxic elements from the e-waste such as biogenic hydrogel derived from basil seed for recovery of gold from waste Printed Circuit Board (PCB); Amine functionalised bentonite clay hydrogel for selective removal of Cr(III).

Indian patent (No. 531960) was granted for the modular and compact helical biodegradable waste converter.

Around 10 kilolitres textile effluent from industry was treated at electron beam centre. At 5 kGy EB dose, Chemical Oxygen Demand (COD) reduction of 33.4% was observed.

A 150 KLD sewage treatment plant has been handed over to Surat Municipal Corporation.

SHRI facility continued to operate uninterruptedly for routine irradiation of sewage sludge.

Waste water treatment of industrial effluent (10kilolitres) was carried out using a combination of electron beam technology and radiation grafted cloth. A ~73% reduction in COD is obtained. For effective utilisation of radiation grafted cloth, a prototype water agitator system (200 litres) has been designed and installed in EBC, Kharghar.

A 'RAd-TED' based 75 KLD dye effluent treatment plant is being operated at Jodhpur under tripartite MoA. Over ~0.7 Million Litres of dye effluent has been successfully treated and reused.

Magnetic La doped Al2O3 core-shell nanoparticle loaded hydrogel was developed for selective recovery of fluoride from aquatic medium.

Over ~0.85 million litres of dye effluent were treated using a 'RAd-TED' based 75 KLD dye effluent

treatment demonstration plant at Jodhpur site. Rajasthan State Pollution Control Board (RSPCB) granted this technology 'Consent to Establish' to one of the cotton textile printing and dyeing industry in Jodhpur.

MEGA SCIENCE PROJECTS

FAIR Programme

As part of the Tri-partite contract-III, 39 nos. of HB.C2 type power converters, 28 nos. of HB.Q10 units, 1 no. of HB.Q15 unit and 4 nos. of S2 units have been manufactured by ECIL, tested and accepted by the customer and the same have been dispatched to FAIR, Germany. These power converters are used to supply DC power to the warm magnets and operate in both pulse and DC modes.

DAE-Science and Technology Facilities Council (STFC)-UK collaboration project was initiated and discussions on niobium coating technology for superconducting RF cavities were held.

Major Atmospheric Cerenkov Experiments (MACE)

MACE was deployed for observations of gamma ray sources and ~150 hours of data was collected. A tool developed, to analyse wobble data from the MACE, is used to analyze Mrk 421 data. A gamma ray signal at a statistical significance of ~6σ was detected in ~ 6 hrs of observation.

MACE observed 13 gamma-ray sources for ~85 hrs. Analysis of radio galaxy NGC 1275 data with the maximum viewing angle constrained to ~30 degrees is published in the prestigious Astrophysical Journal Letters (impact factor ~9). Analysis of MACE data collected on blazar Markarian 421 shows detection of the source at 31σ level in ~18 hrs. Analysis of six high redshift blazars observed with MACE as well as Fermi-LAT was completed.

MACE observed 7 gamma-ray sources (2 galactic and 5 extra galactic) for ~105 hours. Three-fold intra-night flux increase was estimated from Markarian 501 using MACE data, correlated with an X-ray flare. Results from the data of six high redshift blazars obtained from MACE and Fermi-LAT were published in a peer-reviewed Journal.

A Large Ion Collider Experiment (ALICE)

At VECC, R&D of p-type detector arrays on 6" Si wafer of 8*9 array (element dimension 1cm2) is carried out under India-ALICE collaboration, with the technical help from BARC. The detector simulation (TCAD) has been completed and performances are accessed as per available results. Process simulation was finalized after several rounds of check and scrutiny. First batch (4) of test detectors has been fabricated and I-V, C-V characteristics have been checked to validate the design and process. Fabrication of 25 nos. complex 11-layer detector PCB and Interface board completed. The design was made by CERN FoCaL collaboration and VECC explored the Indian company (Micropack Private Limited, Bangalore) to fabricate it.

R&D of p-type detector arrays on 6 Si wafer of 8*9 array (element dimension 1cm2) is carried out under India-ALICE collaboration, with the technical help from BARC.

Three more iterations apart from previous iterations have been performed for p-type silicon detector towards achieving desired specifications of the detector like full depletion voltage, leakage current etc. The efforts will be continued to achieve final detector development.

Power supply distributor for the Silicon detector has been designed and fabricated and are being used with current test setup. Indian Industrial Company Berylline Labs, Kolkata was explored for this purpose.

NISER is involved in research activities related to ALICE and STAR experiment under this project. In ALICE, NISER group is involved in various physics analyses related to resonance production, correlation & fluctuations, and ultra-peripheral collisions. In addition to data analyses the group is also involved in detector R&D for ALICE upgrade project Forward Calorimeter (FoCal).

In collaboration with Bharat Electronics Ltd. (BEL), Bangalore several n-type Si pad array detectors

A prototype assembly structure of n-type Si detectors coupled to tungsten plates

were fabricated and assembled with complex readout electronics consisting of application specific integrated circuit and compact FGPA based data acquisition system.

For the first time in India, in collaboration with Semiconductor Laboratory (SCL), Mohali, NISER group has developed a large area Silicon (Si) pad array detector on 6-inch p-type Si wafer. The detector array is being developed for ALICE Forward Colorimeter and medical imaging application. The signals of the detector array are processed using a highly complex application specific integrated chip (HGCROCv2). The PCBs hosting HGCROCv2 are indigenously fabricated and assembled in Micropack Pvt Ltd. and Karnataka Hybrid Micro Devices Ltd. (KHMDL), Bangalore, India, respectively. The above detector assemblies are successfully tested using 10 GeV pion beams and 2 to 4 GeV electron beams at the Proton Synchrotron test facility at CERN, Geneva, Switzerland during October – November 2024.

A photograph of a p-type Si pad array detector (in centre) on 6-inch Si wafer

Joule Horowitz Reactor (JHR)

Technical discussion with CEA & Framatome for detailed design and procurement readiness of CLOE components continues. Clearance for procurement of feed pumps, make up pump, drain pump, tube & fittings, filters, strainers, etc. were obtained from CEA.

Large Hadron Collider (LHC)

Significant contributions were made by the Institute of Physics (IoP), Bhubaneshwar in the development and operation of the high-level trigger system in the CMS experiment at CERN-LHC.Research activities on the classical and quantum properties of black holes, Cosmology, Ads/CFT, symmetries of string theory, interface of information theories etc. were undertaken. Studies of the details beyond Standard Model and Quark Gluon Plasma from the on-going experiments at LHC, CERN were also carried out. Major contributions were made to the understanding of active matter, biological or artificial complex systems that are driven out of equilibrium in smallest scales using methods of statistical mechanics. Institute participated in various experiments at CMS at LHC, CERN to study various aspects of the standard model, specifically the SM and MSSM Higgs boson.

NISER has been participating in multiple fronts in the CMS experiment at CERN. It includes, experimental data collection, detector performance study, CMS physics data analysis leading to journal publications, building detector for CMS phase-II upgrade which will start in 2026.

NISER has the responsibility to assemble and integrate ~1104 (+spares) 2S Outer Tracker modules in connection with the CMS Phase 2 Tracker Upgrade programme. The CMS Outer Tracker assembly activities are getting ready for the production. However, the due to the delay in production of the associated hybrids (surface cleanliness and light yield), the hybrid production is delayed and at present there is no supply of modules parts to any of the CMS centers. NISER has built 5 pre-production modules (see the attached figure)

Five Outer Tracker 2S pred-production modules have been assembled in Dec, 2024 using the module components provided by CERN in October, 2024

using the parts provided by CERN in October 2024. The activities related to the integration of modules into the ladder is also delayed due to the non-availability of integrated modules.

Laser Interferometer Gravitational–wave Observatory (LIGO)

LIGO-India Vacuum Integrated System Test Assembly (LI-VISTA) facility has been setup at LIGO-Lab in IPR for evaluation of 80K Cryopump efficacy in trapping water molecules moving along the length of assembly. One of the major components of this set-up is 20 m long cylindrical Integrated Vacuum Vessel (IVV) having internal diameter of 1.24 m.

Operation of 20 m integrated Vacuum Vessel and Testing

At RRCAT, the Civil Design Basis Report (DBR) in collaboration with LIGO-US is completed. A draft of request for Expression of Interest for EPC contract of civil and vacuum infrastructure is completed.

At RRCAT, the Expression of Interest for EPC contract of civil and vacuum infrastructure has been reviewed by the expert committee constituted by Chairman, Empowered Board.

Preparation for shipping of the first subsystem PSL (Pre-stabilized Laser) from LIGO Hanford to the Testing & Training Laboratory at RRCAT Indore has been completed.

Approval of competent authority has been received from DAE for signing of the MoU with LIGO Lab (Caltech + MIT, USA) for the transfer of the Advanced LIGO Detector components from US to India.

The first meeting of LIGO-India Empowered board was convened on 6th September 2024. The Board concurred the processing of LIGO-India Civil and Vacuum Infrastructure tender as Quality Oriented Procurement (QOP). Proposal for the formation of Special Technical Committee (STC) for evaluation of QCBS criteria has been put up for approval of the Competent Authority. The board also approved the LIGO-India project management structure, SOP for funds transfer to IPR and IUCAA and delegation of financial powers for execution of the project.

MoU between DAE-DST and LIGO Lab (Caltech + MIT, USA) for the transfer of the Advanced LIGO Detector components form US to India is signed by competent authorities on both sides. The STC (Special Technical Committee) is constituted by the Empowered Board for formulating the QCBS parameters for evaluation of the bids.

International Thermonuclear Experimental Reactor (ITER)

IPR has indigenously developed 120 kW High-Power Amplifier (HPA) and tested it successfully upto 50 MHz. The HPA indigenously developed by India will be used in Ion Cyclotron RF heating. On successful completion of characterization at 60 MHz, this HPA will be delivered to ITER as an in-kind contribution.

Shipment and acceptance of all 6 cubicles of Cryostat instrumentation and control system has been completed. The cryostat instrumentation and control system will contribute to machine operation and data acquisition for the behaviour of the cryostat during all operation phases of ITER machine.

Contract has been awarded for Diagnostic Neutral Beam (DNB) and HNB3 Vessel. ITER India has

achieved a significant contract milestone by awarding the manufacturing of these safety-critical components to an indigenous manufacturer, meeting French nuclear requirements. Completed Integrated Site Acceptance Test of DNB Beam Line Component at ITER-INDIA and completed the manufacturing of the 2nd calorimeter.

Site acceptance test for High resolution spectrometers has been completed. This spectrometer, part of India's contribution to ITER, aims to measure plasma ion temperature and impurity concentration. It's a crucial component of the X-Ray Crystal Spectrometer.

Site acceptance test for Pilatus 2 for x-ray crystal spectrography has been completed. Pilatus 2 detector received from CCMB has been tested successfully at ITER-India lab and the same will be used in prototype X-Ray spectrometer for measurement of X-Rays in high energy range.

Quality and Safety audit for ITER Organization has been completed. IO regularly audits DAs and suppliers to ensure adherence to approved quality plans.

Application program in Laboratory Virtual Instrument Engineering Workbench (LabVIEW) has been developed as replacement of IDLE s/w package for operation of FT-Spectroscopy. A LabVIEW program has been developed to operate the FT-Spectrometer and handle data acquisition, reducing reliance on the supplier's provided software.

All (six) Torus Cryo-Pump Housing (TCPH) have been manufactured and successfully tested at the factory. The main function of TCPH is to enclose torus cryo-pumps. These TCPHs will soon be delivered to ITER as an in-kind contribution. Site Acceptance test is on-going for all Tokamak Cryo Pump House (TCPH) delivered to IO.

Cooling Water System (CWS) supplied by INDIA, has become operational at ITER-Site. The cooling tower of heat rejection capacity ~510 MW, part of CWS, designed, manufactured and supplied by India, was operated for the first time to remove heat generated by LHe compressors.

Installation of the seismic decoupling spool being carried out at ITER site

Decoupling Spool (~8.3m long, ~9 T weight) supplied by India has been successfully installed at ITER Site. This seismic decoupling spool will take care of high relative movements between Tokamak building and cryo-bridge during seismic event.

Site Acceptance Test of Diagnostic Neutral Beam Line Components (BLC) has been completed. BLCs were integrated and successfully tested at the test facility at Institute of Plasma Research (IPR). The BLCs are part of ITER Diagnostic Neutral Beam which will be used to diagnose He ash content of the plasma.

Characterization of indigenously developed 105 l/s cryosorption pumps using cryocooler for hydrogen pumping has been completed. The characterization established the desired pumping speed required for operation of the Positive ion Neutral Beam (PNB) system. The demonstration provides low-cost solution, alternative to LHe cooled cryo-condensation pumps and also has applications in other areas of fusion and accelerators.

The installation of Group-X cryolines has been completed in the Cryo-bridge. These cryolines, part of ~5 kms of cryolines supplied by ITER-India, will carry liquid Helium at 4 K to cool magnets.

The manufacturing and integration of the remaining two Auxiliary Cold Boxes (ACBs) has been completed. The final acceptance of warm panels has been completed. The delivered three ACBs have been successfully installed at ITER site.

The Front-end sight tube, a part of the XRCS Survey system, has been delivered at ITER site. XRCS survey diagnostic system will monitor intrinsic and extrinsic plasma impurities in the plasma core region.

As a part of indigenous development of Direct Cavity Coupled Solid State Power Amplifier (DCC-SSPA), modelling, fabrication and validation of the concept at 500 MHz was completed.

The final Design of the IC High Voltage Power Supply (HVPS) has been completed. This is an important milestone to start manufacturing of eight units of power supplies, of 3 MW each, to be supplied to ITER as in-kind delivery.

Completed factory acceptance test (FAT) of Warm Panel (WPs) of all ACBs and Thermal Shield Cold Valve Box (TCVB) Vacuum Shell.

Liquid nitrogen supply and return line for LHe Cold Box-3 was successfully cooled down and achieved required performance of s4.5K.

Completed 85% Installation of Group-Y cryo-lines and Warm lines at ITER site.

W lines (on top) in cryo-bridge leg connecting B11

Successfully tested Inhouse fabricated 1st HPA-2 at manufacturing site for 120kW/2000s in frequency range of 36 - 60 MHz & Bandwidth checked at 100kW and Completed technology transfer of Combiner & RF Switch to Indian Industry.

CHAPTER 4
BASIC AND DIRECTED RESEARCH

Cryogenic stage of a superconducting quantum computer, which cools down to -273.13°C

SMARTEX-C Upgrade with steady state TF coil

MATHEMATICS & COMPUTATIONAL SCIENCES

At HRI, a factorization formula for a certain triple product p-adic L-function guided by the Artin formalism has been obtained. The key ingredients used are a) the explicit reciprocity laws governing the relationship of diagonal cycles and generalized Heegner cycles to p-adic L-functions; b) carefully comparing Chow–Heegner points and twisted Heegner points in Hida families, via Gross–Zagier type formulae. The article has been submitted for the publication.

At HRI, in number theory, work is done to analyse Selmer groups of elliptic curves defined over general p-adic Lie extensions of number fields. In another work, the average rank of 2-Selmer groups of elliptic curves related to theta congruent numbers are obtained. It is long standing and difficult question to understand the set of integers consisting of those integers which can be written as a sum of three cubes. In another work in number theory, a progress has been made by studying the corresponding problem in a suitable probabilistic model.

In Algebra and Algebraic geometry, HRI is working on algebraic stacks and matrix factorization categories. The thick tensor ideals of these categories are being studied. In analysis, work on some fluid-structure interaction model are being done. The mathematical model, describing interaction between an elastic solid body surrounded by some fluid, coupled with the Navier slip boundary condition at the fluid-solid interface, is highly nonlinear. The coupled problem requires thorough attention due to lack of enough regularity at the interface. The members at HRI are currently trying to understand this long standing open problem from a numerical point of view. In another work, members are also working on the Inverse Scattering problem for the fractional Schrodinger equation and for the fractional Laplace-Beltrami operator. The work done by the members are being finalised and is being prepared for the submission.

Skew left braces are algebraic objects with two groups structures on a given set with certain compatibility condition. HRI continued its research on n-isoclinism of skew left braces (which is not defined in general) and developed new ideas to extend this concept on a bigger class and prove results analogous to the concept in group theory. Obtained a classification of integrable representations of loop of full toroidal Lie algebras with finite dimensional weight spaces in Algebra.

Work on some fluid-structure interaction model, describing interaction between an elastic solid body surrounded by some fluid, coupled with the Navier slip boundary condition at the fluid-solid interface, which is highly nonlinear is continued. Currently, the attempt is to consider a simplified linear model in order to better understand the intricacies involved and possible ways to overcome those.

The Geometry group of HRI explored Ricci solitons and Ricci Bourguignon solitons and its variants in the context of almost alpha cosymplectic manifolds, contact manifolds, Sasakian Manifolds etc. Interestingly, it was found that in some of these cases these spaces are of constant sectional curvature and hence are homogenous.

The complement of the hyperplanes {xi=xj}, for all i≠j, in M^n, where M is an aspherical 2-manifold, is known to be aspherical. Here, the situation when M is a 2-dimensional orbifold is considered. Researchers at TIFR have proved this complement to be aspherical for a class of aspherical 2-dimensional orbifolds and predicted that it should be true in general as well. This question is then generalized in the category of Lie groupoids, as orbifolds can be identified with a certain kind of Lie groupoids.

The dynamics of a general class of antiholomorphic correspondences (i.e., multi-valued maps with antiholomorphic local branches) on the Riemann sphere were studied. These correspondences are defined using univalent restrictions of rational maps. Such correspondences are closely related to a class of single-valued antiholomorphic maps in one complex variable, namely, Schwarz reflection maps of simply connected quadrature domains. This connection was used to prove that matings or combinations of all parabolic antiholomorphic rational maps with connected Julia sets (of arbitrary degree) and

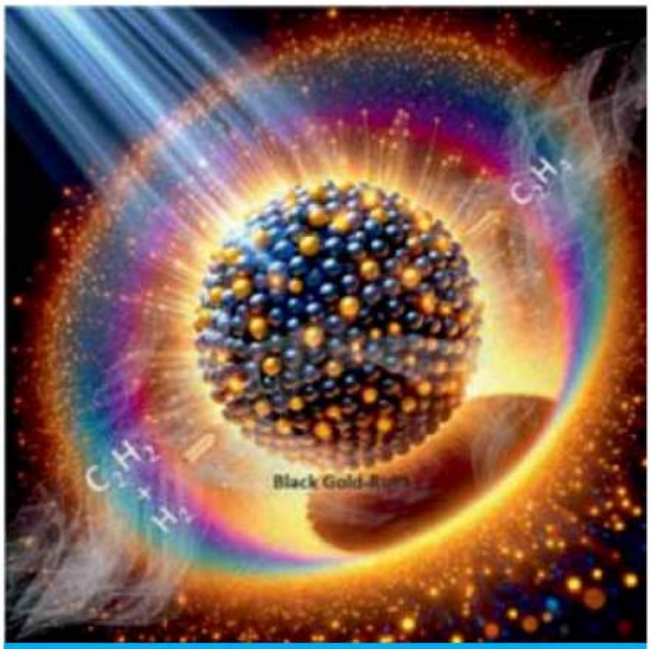
antiholomorphic analogues of Hecke groups can be realized as such correspondences.

PHYSICS

At the TIFR's GRAPES-3 experiment in Ooty, India discovered a kink in the cosmic-ray proton spectrum at around 166 tera-electron-volt (TeV). The new feature will advance our understanding of the cosmic ray origin and propagation which is a century-old unresolved problem. The study was performed using a subset of nearly eight million cosmic ray showers recorded with an array of scintillator detectors and a large muon detector in the energy range of 50 TeV to 1.3 peta-electron-volt.

Very High Energy Gamma-ray Astronomy group in TIFR has developed a 256-pixel Silicon Photomultiplier-based camera for 4m class atmospheric Cherenkov telescope for indirect detection of gamma rays with energies above a few hundred GeVs, originating from various astrophysical sources. Typically, photomultiplier tubes are used as photo sensors in such cameras, but recently silicon photomultipliers have emerged as a viable alternative. This camera is the first of its kind in India with the entire electronic developed in-house. The camera was successfully installed in the focal plane of the vertex element of the TACTIC telescope operated by BARC at GOALS, Mt Abu in December 2023 and several test runs were carried out. The results of these tests confirm the satisfactory performance of the camera.

Researchers at TIFR have developed a novel 'Plasmonic Reduction Catalyst Stable in Air'. The catalyst merges platinum-doped ruthenium clusters, with 'plasmonic black gold'. This black gold efficiently harvests visible light and generates numerous hot spots due to plasmonic coupling, enhancing its catalytic performance. This research marks the first report of a highly efficient, air-stabilized, and plasmonically activated catalyst for acetylene semi-hydrogenation, with potential applications in a variety of other reduction reactions. The findings offer significant contributions to the understanding of plasmonic catalysis and pave the way for developing sustainable and energy-efficient catalytic systems.



The first highly efficient, air-stable, and plasmonically activated catalyst for acetylene semi-hydrogenation

Conventional laser-based electron acceleration schemes hinge on the generation of high accelerating electric fields that require massive and complex lasers. Challenging this limitation of large lasers, researchers at TIFR, Hyderabad have found a ground-breaking way to generate super-fast electrons with table-top laser systems. The technique implements two laser pulses; first to create tiny, controlled explosion in a microdroplet, followed by a second to accelerate electrons to megaelectronvolt (MeV) energies. What's even more exciting is that they achieved this with a laser that's 100 times less than what was previously thought necessary, making it more accessible and versatile for future research.

Among the exotic hadrons are tetraquarks, which are composed of four quarks (more precisely, two quarks and two anti-quarks). They could exist in highly compact forms or as loosely bound molecules of two mesons or something else: the precise structures of them remain a mystery. A study predicted the existence of a novel tetraquark. This new subatomic particle is composed of, a beauty and a charm, quarks along with two light anti-quarks, and it belongs to a family of tetraquarks, called Tbc: the beautiful-charming tetraquarks. The computational facility of the Indian Lattice Gauge Theory Initiative (ILGTI) was utilized to

carry out this calculation. The formation of this tetraquark was investigated using the interactions between, a bottom and a charm, mesons.

Quantum interference in two-photon laser spectroscopy of a forbidden transition was observed for the first time. A forbidden transition, e.g. a S to D transition in a cesium atom, can be excited by two photons with each photon carrying half the energy. The spectrum of the D state consisting of several hyperfine levels can be measured by tuning the wavelength of the excitation laser, resulting in a spectrum that is typically believed to have a Lorentzian or a Voigt line-shape. Researchers showed that this line-shape needs to be corrected because of the presence of quantum interference of optical transition pathways. It was concluded that the line shift due to quantum interference is an important systematic effect that must be accounted for in all precision Doppler-free two-photon spectroscopy experiments, including those on secondary optical atomic clocks.

Young early-type HAeBe stars are still embedded in the molecular clouds in which they formed. They illuminate reflection nebulae, which shape the surrounding molecular cloud and may trigger star formation. In this work, previously published APEX data was analysed to search for and characterize the outflows in the entire NGC2023 region. This was the first systematic search for molecular outflows in this region. Since the outflows were mapped in several CO transitions, their properties could be determined quite well. Four molecular outflows were discovered in the vicinity of NGC2023, three of which are associated with Class I objects and identified the infrared sources responsible for them. It was concluded that the four outflow sources are at a similar evolutionary stage.

TIFR Balloon Facility, Hyderabad designed and fabricated four double-layer oblate spheroid shape balloons using 38-micron Antrix balloon film. These were designed for satellite payload testing applications at the U R Rao Satellite Centre (URSC) in Bengaluru. Fabrication work is going on for four zero-pressure plastic balloons of different sizes (1187 cu.m to 3026 cu.m) for the upcoming BATAL-2024 balloon campaign under collaboration with ISRO and NASA.

Cryogenic stage of a superconducting quantum computer, which cools down to -273.13°C

Scientists from the TIFR have completed end-to-end testing of a 6-qubit quantum processor based on cryogenic superconducting circuit technology. The project being executed at TIFR's Colaba campus is a three-way collaboration between TIFR, DRDO Young Scientist Lab-Quantum Technologies (DYSL-QT) and Tata Consultancy Services (TCS). The qubits were designed and fabricated at TIFR. The DYSL-QT scientists implemented the control and measurement apparatus while TCS developed the cloud-based interface. The team is now working on optimising various aspects of the system's performance before it becomes ready for operation. Plans are underway to provide wider access to this system for education and research and eventually as a test bed for testing superconducting quantum devices for analysis.

Researchers at TIFR have pioneered an innovation in measuring the temporal profiles of femtosecond laser pulses. The method can capture the profile in a single laser pulse simultaneously across the spatial area of the pulse. This method was demonstrated by capturing the ultra-rapid variations of a high-temperature plasma mirror that can be used to generate

next-generation, ultrahigh-power femtosecond laser pulses.

At the GMRT, the upkeep and improvements of various systems happened in this period. In the front-end receiver system, the Walsh modulation system is successfully activated. A new narrow-band low-noise amplifier for 120-260 MHz bands is being tried on a few antennas to suppress the effect of mobile signals. Switchable notch filter banks are being installed to mitigate interference from various man-made signals. In line with the government of India's initiative for green power, solar power generation is being aimed at GMRT, but with an RFI-shielded design that is tailor-made for GMRT. In the GMRT backend system, new features and modes are added to the upgraded backend receiver. Supported test VLBI observations with telescopes from Japan, Australia, and Europe. New SPOTlight hardware in collaboration with CDAC and Ministry of IT installed at GMRT and interface to the upgraded backend completed.

An international research team, including scientists from the Tata Institute of Fundamental Research, used the Dark Energy Spectroscopic Instrument (DESI) to test Einstein's theory of general relativity at cosmological scales. The study constrained the gravitational constant to within 4.7% across billions of light-years. The research also set an upper limit on the sum of neutrino masses at 0.071 electron volts (eV), providing a refined measurement of these elusive subatomic particles.

Researchers from TIFR, in collaboration with an international team of researchers from Germany and Canada, have developed a state-of-the-art method for robust inference of the Hubble constant using observation of jet from the electromagnetic counterpart of binary neutron star mergers in association with the gravitational wave emission from them. This work helps pave the way for solving the decade-long cosmological tension in the value of the Hubble constant between the low redshift and high redshift probes.

TIFR researchers developed a low-cost compact inertial nano-positioner with 2-axis movement along with full computer-interfaced open-source electronics and software, operating down to 2 K. The use of this has been demonstrated in the fully automated needle-anvil type Point Contact Andreev Reflection (PCAR) apparatus. The nano-positioner has a minimum step size of 80 nm and can operate with a load of up to 50 gm. The small footprint of the nano-positioner makes it ideally suited for incorporation in low-temperature scanning probe microscopes. Its design is versatile for various research and industrial purposes.

MACE observed many active galactic nuclei (AGNs) like Mrk 501, RBS 0723 (together with TACTIC), and Dark matter candidates like Segue 1. It detected the flaring activity of Mrk 421. Wobble mode technical runs were conducted. The total observation time includes 225 hours of source runs and 6 hours of pointing runs.

At BARC, Quadrupole doublet is mounted in the 20 MeV LEHIPA beam line along with additional target for irradiation experiments at higher temperature (up to 450 deg C). Experiments were performed to study phase stability of LLRF.

MACE observed 13 gamma-ray sources for ~85 hrs.

Analysis of radio galaxy NGC 1275 data with the maximum viewing angle constrained to ~30 degrees is published in the prestigious Astrophysical Journal Letters (impact factor ~9).

Analysis of MACE data collected on blazar Markarian 421 shows detection of the source at 31σ level in ~18 hrs.

Analysis of six high redshift blazars observed with MACE as well as Fermi-LAT was completed.

Using BARC-TIFR Pelletron Linac Facility, near-scission “polar” and “equatorial” proton emission was observed for the first time in heavy-ion induced fission.

At BARC, experiments were conducted for Improved beam transmission through LEHIPA RFQ with space charge compensation. The hardware and software setup for RFA measurements were tested with multicusp plasma.

Parrondo's paradox refer to a seemingly paradoxical behaviour wherein two strategies which are losing when employed in a sequence on their own, will

become a winning strategy when employed in an alternating manner. Recently, IGCAR demonstrated how Parrondo's paradox could be identified within a model of quantum computation called the "quantum walks". This work has potential applications in developing new quantum algorithms and for getting a better understanding of the dynamics in discrete time quantum walks.

Different fission modes and yields in case of multimodal fission have been obtained for the first time using the state-of-the-art nuclear energy density functional formalism at VECC.

Liquid-gas phase transition temperature was found to be almost independent of isospin asymmetry for finite nuclear systems formed in laboratory experiments.

The relationship between certain key parameters of neutron stars is found to be effectively universal since their variation with different equations of state is minimal.

Study of effect of dark matter in core of neutron stars reveal that increase in mass of dark matter particle leads to decrease in maximum mass of neutron star.

The speed of sound and isothermal compressibility of magnetized nuclear matter were obtained for a wide range of temperature and density.

At VECC, a new regular sequence of excited states in 57Fe has been identified, with unique features of the gamma decay pattern, which provides an understanding of the robustness of the doubly-magic nucleus 56Ni28.

Level lifetime of the excited states in 154Gd has been measured using VENTURE array.

Evidence of octupole-quadrupole & octupole - octupole coexistence has been found in 152Sm through the observations of new gamma ray sequences.

A toroidal resonator has been designed using COMSOL Multiphysics software and this resonator will be used for the detection of light ions in cryogenic Penning trap. The effective capacitance and inductance have been determined.

Langevin dynamical calculations have been performed for a global understanding of the nuclear dissipation strength and the fission lifetime based on the experimental neutron multiplicities. Obtained systematics will be helpful in estimating fission time in heavy ion-induced reactions.

The thermodynamics of quark matter were investigated at various temperatures and magnetic field intensity. The isothermal compressibility and speed of sound showed interesting anisotropic features.

Medium effects in strange quark matter have been studied at finite temperature using a quasi-particle model with self-consistent thermodynamical treatment incorporating chemical potential-dependent quark mass and vector interactions.

Transient electromagnetic (TEM) measurements commonly performed to obtain the distribution of electrical conductivity of ground as a function of depth in mineral exploration. However, the transient responses obtained with SQUID as a receiver are always reached to negative values (sign reversal) which are routinely attributed to induced polarization (IP) effects. The sign reversal is due to the contribution of tertiary magnetic field and proved with experiments performed in the field. Subsequently, the generation of tertiary magnetic field in TEM measurements has been explicitly observed through laboratory experiments. In addition, a novel hypothesis has been proposed for the generation of tertiary magnetic field in geophysical TEM measurements. The occurrence of sign reversal in geophysical TEM measurements is a long-standing scientific issue among the geophysicists using TEM systems either in ground or airborne based.

High pressure high temperature structural stability studies have been carried out on uranium oxide (U_3O_8) and potential detector material (zinc doped cadmium telluride-CZT). In both the systems enhanced kinetics of pressure induced transition was observed at high temperature. In U_3O_8 for the first-time high temperature phase was realized at ambient conditions and its compressibility behavior were elucidated. Cadmium Zinc Telluride (CZT) undergoes polymorphic structural transition with pressure, our experiments bring out the mechanism of structural transition involved and also establishes the presence of cinnabar phase in this system for the first time.

In a new model of Quantum battery, VECC have shown that ergotropy and charging power both can be simultaneously optimized. Moreover, they do not depend on initial condition of the charger.

At VECC, significant qualitative and quantitative differences in photon anisotropic flow in relativistic heavy-ion collisions have been estimated due to the presence of alpha clustered structure in oxygen nuclei, providing valuable insights into the initial nucleon level geometry.

At VECC, measurement of radiative decay of 12C Hoyle state has been completed and published in Phys. Letts B 859 (2024) 139083. Isospin dependence of Nuclear Level Density in Zn-isotopes is published in Phys. Letts B 859 (2024) 139101. First beam characterization of the FRENA accelerator and its terminal voltage calibration have been completed and published in NIMA 1072 (2025) 170179.

The effect of chiral imbalance on the electrical conductivity of hot and dense quark matter was investigated. A significant dependence on the chiral chemical potential was observed especially at lower temperatures.

The effect of modified theory of gravity has been studied on the properties of strange quark stars and it has been demonstrated that negative values of modified gravity parameter results in increase of the mass and radius of the compact objects and are in good agreement with GW190814 and NICER observations of PSR J0030+0451.

Isospin diffusion current density is examined to determine the precise density region probed in heavy-ion reactions around the Fermi energy domain

The initial state and evolution of isobaric collisions at relativistic energies have been investigated using the Glauber model and hydrodynamical framework, providing valuable insights into the structural properties of nuclei and their influence on the collective flow of the produced quark-gluon plasma.

In Condensed Matter Physics, HRI worked on correlated systems studied via pump probe method. Research during this period was also focused on the dynamics of periodically driven quantum systems. It has been developing protocols to generate many-body entangled states in these systems. It has investigated the implication of transition pathway prediction for ion migration not only to envisage the pre-intercalation mechanism in energy storage materials, but also for neuromorphic computing in hybrid perovskite system. It has also investigated the effect of pressure on Rashba band splitting in complex uni-dimensional system, along with its repercussion on water splitting mechanism in two-dimensional materials. Additionally, it has investigated the cationic interplay in theoretically predicted next double oxide perovskite system, while the electronic and optical properties have been investigated in novel quantum dot system, which has been experimentally validated.

The research in Condensed Matter Physics (CMP) during this period was focused on the dynamics of driven many-body systems. HRI have developed a protocol to engineer exact Floquet flat bands and realize dynamical many-body freezing in periodically driven quantum systems. It has also demonstrated the existence of prethermalization in a periodically driven many-body systems. It has continued materials modelling research for different aspect of energy scavenging. HRI has envisaged the excitonic and Schottky barrier solar cells features based on the ultrathin two-dimensional materials. The exciton-polaron coupling in hybrid perovskites, which has been experimentally validated have been explored. In this direction, the charge transfer mechanism in 2D/3D hybrid perovskite system have been recently investigated. Work on the self-trapped exciton in hybrid perovskite system and 2D monolayer of C3N5 for photocatalytic water splitting for efficient hydrogen evolution have been carried out.

In the Condensed Matter Physics, HRI worked on counter-diabatic driving and the many-body physics of ultracold matter. The theoretical crossover between Frenkel and Wannier Mott excitons in emerging perovskite materials have been envisaged. The pressure induced persistent spin texture in a rare nitride perovskite system along with an experiment-theory joint work on Rashba splitting in lower dimensional nanostructured material have been explored. The

correlation between Rashba spin splitting and photocatalytic activity in two-dimensional materials along with their heterostructure formation have been investigated. The theoretical prediction of metal nanocluster for interface engineering for efficient photovoltaic performance has been experimentally validated.

In String Theory, research has been done on string thermodynamics and possible applications to cosmology. In particular, strings in and out of equilibrium and close to the Hagedorn temperature have been studied.

The High Energy Physics group at HRI worked on several beyond Standard Model (BSM) topics and studied their signals at the Large Hadron collider (LHC). The group also worked on aspects of dark matter in the Universe with a focus on the possibilities that involve presence of multi component nature of these invisible particles. The group through its work also explored the efficacy of Machine Learning techniques in improving existing studies of BSM physics, Higgs couplings measurements and employed kinematic features in jet reconstruction to explore new physics at LHC. The group published 3 papers in international journals and submitted 1 preprint on the web-arXiv during Jan-March 2024. The group also organised a workshop from 07-16 March 2024 titled "Sangam@HRI 2024: Instructional Workshop on Particle Physics.

The High Energy Physics group of HRI carried out research on analysing signals for physics beyond the Standard Model at the Large Hadron collider employing machine learning methods and also studied dark matter signal in extended gauge symmetry models. The group published 2 papers in international journals and submitted 2 preprints on the web-arXiv during April-June 2024.

The High Energy Physics group at HRI carried out research on analysing signals for physics beyond the Standard Model at the current and future collider experiments and studies on dark matter, gravitational waves, and Primordial Black Holes (PBH) have been done.

The members of the Quantum Information and Computation (QIC) group at HRI found a way of discovering the factorization surfaces of quantum spin chains with machine learning. In a separate work, the Stark localization near the Aubry-André critical point have been investigated. In yet another work, the ultimate limit on the extractable energy from quantum batteries have been found.

The QIC group at HRI worked on different aspects of quantum information technology. The topics researched on include quantum heat transformers, factorization surfaces of many-body systems using machine learning, measurement-induced continuous-time quantum walks, Stark localization near Aubry-Andre criticality, quantum batteries, and implications of noisy unsharp measurements on quantum resources. The group continued to train human power in the general area of quantum technologies by interacting at HRI with PhDs, postdocs, master's students, and junior visitors. They also made visit to other places to disseminate their research and also created more curiosity and interest in quantum technologies.

Achieving quantum advantage in energy storage and power extraction is a primary objective in the design of quantum-based batteries. HRI recently exhibited that by optimising Floquet driving frequency, the maximum average power scales super extensively with system size when a long-range (LR) interacting Hamiltonian is used as a charger, thereby gaining a genuine quantum advantage. Importantly, such a benefit is not achievable through next-nearest neighbour or nearest-neighbour interactions or traditional unitary charging. On the other hand, to enable the sequential implementation of quantum information theoretic protocols, HRI has proposed two schemes for resource reusability, namely resource-splitting protocol and unsharp homodyne measurements, in the continuous variable (CV) photonic framework. The former protocol splits or distributes the resources of the original state among multiple copies using only linear optical elements and resourceless auxiliary states, whereas the latter scheme exploits weak or unsharp measurements of the CV quadratures to allow for resource reusability.

HRI continued to work on electron-phonon enhancement in nanohybrid systems and its theory of pump-probe measurements has been published in

Phys Rev Lett. HRI's research was focused on the non-equilibrium dynamics of many body systems. A protocol to realize dynamical many-body freezing in periodically driven systems using counterdiabatic driving have been developed. Prethermalization in a periodically driven systems have also been studied. Extensive work on exciton-polaron coupling and interface mechanism for emerging materials to be used in solar cells have been done. Works on crossover between Frenkel and Wannier-Mott Excitons and van der Waals Heterostructures for Ultrathin Excitonic solar cells got minor revision, have been submitted for publishing. Work on 20/30 interface for hybrid perovskites and van der Waals heterostructures for photocatalytic water splitting have been carried out.

At IoP, significant contributions were made to the frontier areas of Nuclear Physics to identify super heavy isotopes which is very important from astrophysical point of view. Research activities on the classical and quantum properties of blackholes, Cosmology, Ads/CFT, symmetries of string theory, interface of information theories etc. were undertaken.

Significant contributions were made to the studies on non-equilibrium aspects of higher order topological insulators, their superconducting phases hosting Majorana modes and their bulk boundary correspondence and role of symmetry operator. Important contributions were also made to the study of strong correlations on a band topological insulator on the Lieb lattice and effect of interaction and disorder in strongly correlated systems in presence of magnetic field, exploring various aspect of quantum magnetism such as quantum and thermal fluctuations and spin liquid states.

Designed and developed two dimensional heterostructures of MOS2/WS2 phototransistor for optoelectronic applications such as resistive RAM and Neuromorphic Computing. Fabricated a number of Designer Quantum Material heterostructures with exotic properties.

The High Energy Physics Phenomenology group members at the Institute of Physics (IoP), Bhubaneshwar made active contributions in the study of dark matter phenomenology and its direct, indirect and collider probe, application of machine learning in boosted object tagging at the LHC, neutrino and Astroparticle physics atIceCube, in the study of heavy neutral lepton searches at collider and non-collider experiments.

In recent times, the emergence of Majorana modes has been investigated in magnet-superconductor heterostructures both from model and real material perspectives. Also, transport signatures have been explored in connection with Bogoliubov Fermi surface in d-wave superconductors and Fermi arc surface states in Weyl semimetals.

For achieving functional characteristics related to advanced properties of materials large scale, high quality atomically thin 2D layered quantum materials such as MoS2, WS2 are synthesized via a modified CVD technique. Brain-inspired iontronic memristor based artificial synaptic devices were demonstrated for neuromorphic computing architecture using these emerging 2D materials. Novel metal oxide ultra-thin films have also been investigated for resistive random access memory applications.

Institute has strong programme on self-organized pattern formation on semiconductor surfaces and their nanoscale functionalization. Atomic force microscopy-based nanoscale electronic transport property measurements on thin film hetero-structures (mostly oxides) is a unique area where the Institute had a very strong activity.

The Institute has undertaken the development of an ECR ion source-based low-to-medium energy ion-beam facility. Activities related to ultra-low energy ion implantation in diamond and related materials was also initiated to create nitrogen-vacancy centres with good spin properties.

At SINP, facilities were developed for augmentation and utilization of Facility for Research in Experimental Nuclear Astrophysics (FRENA) facility such as, beam lines and related controls, necessary scattering chambers (both small and large 1 meter), various spectrometers, detectors and their arrays, compatible electronics and data acquisition systems. As a follow-up of the calibration program, experiments are performed by the national collaboration to

understand abundance scenarios of low-mass elements, relevant to a wide variety of astrophysical scenarios.

Development of superheated liquid-based DM search experiment with high sensitivity was carried out at 555 m deep underground, JUSL lab. This is the first DM search direct detection experiment in India.

Coherent manipulation of light with potential applications in atomic magnetometry and quantum memory is demonstrated. These studies demonstrate how the atomic states can be engineered by tunning the laser parameters and we can address the transient dynamics of the level population along with steady-state behaviours.

Development of laboratories and infrastructure for visualization of objects using tomographic techniques through naturally abundant cosmic muons is under way with fabrication and characterization of suitable gaseous detectors and associated multi-channel readout, simulation on design optimization and development of suitable image processing algorithms based on Machine Learning (ML) techniques. R&D on an Active Target Time Projection Chamber (ATTPC) can serve as a single compact system for 3D tracking of charged particles.

Probing the origin of high energy cosmic rays via analysis of GeV-TeV data from Fermi-LAT, MAGIC and MACE telescopes through observations of supernova remnants, pulsar wind nebulae and active galactic nuclei was carried out. Multi-wavelength and multi-messenger data analysis was performed to foster synergies between very high energy gamma rays, X-rays, radio waves, etc. Further work was carried out on the design and development of a calibration system for optical calibration of the camera to be used in Cerenkov Telescope Arrays.

Frontline research in Nuclear physics was undertaken at various national and international accelerator centres using stable ion beams. Indirect measurements to study low energy astrophysical reactions have been carried out in the framework of the asymptotic normalization technique using transfer reactions. Direct evidence of merging of nuclear magic shell gap at N=20 and 28 was shown as well as measured capture cross-section of seed nuclei, relevant for r-process. Studies were carried out on quasi-elastic scattering of heavy systems at near-barrier energies, and deep sub-barrier fusion of heavy systems with the primary motivations for understanding the reaction mechanisms, and investigate the nuclear potential.

In Theoretical Physics at SINP, a wide range of theoretical aspects of physics, ranging over a wide length-scale from elementary particles to mega parsecs of the observable Universe, has been explored both from a formal theoretical aspect as well as with observational motivation and footprint. While some of these works are rooted in a traditional framework, several others are highly synergetic in ideas, techniques and the corresponding framework.

In order to conduct cutting-edge research to understand the abundance of various light and heavy mass elements in the universe, Facilities for Research in Experimental Nuclear Astrophysics (FRENA) at SINP has started conducting several experiments. A new beam line has been installed with an end station of a 1-m diameter vacuum chamber.

Several electromagnetic radiation and particle detector systems have been developed, including fast-timing detectors and gas detectors. A fast data acquisition system has been implemented at FRENA to provide national users with the most modern tools to investigate various open problems in nuclear astrophysics

In Condensed Matter Physics at SINP, a detailed investigation of the crystal structure, magnetic, magnetocaloric, magneto-transport and electrical polarization properties of a new multiferroic material in the polycrystalline and nanocrystalline form of the Dy2MnCoO6 double perovskite have been reported.

The generation of polarons in CeO2 thin-film deposited on a Silicon (Si) substrate using the resonance photoemission spectroscopy (RPES) study have been probed.

Successful synthesis of Dy2IrSi3 with fully stoichiometric ratio of constituent elements have been reported.

A tailored fabricated Ag-core–AuAg-sandwiched –Ag-shell [(Ag@AuAg)@Ag] nanoscale material for application as a catalyst of an efficient Oxygen Reduction Reaction (ORR), in fuel cells via a stepwise template-mediated process have been reported.

Theoretical understanding of various aspects of soft matter and biologically relevant systems has been broadly studied under Theoretical Physics at SINP. These include hydrodynamic study of membranes, turbulence, aspects of scaling and long-range order in a wide variety of theoretical models.

Various and exotic phases of matter, including spin liquids, fractionalized degrees of freedom and topological orders, are being explored beyond the Landau-Ginzburg paradigm. Modern understanding of quantum entanglement has also been analyzed in this context.

Magneto-transport properties of transition metal oxides have been explored, especially to explore the connection between the electronic and magnetic properties. A wide variety of theoretical methods, eg Spin-Fermion Monte Carlo methods have been used towards this.

Various aspects of Many-body localisation, unconventional superconductivity, pair-density wave have been explored from a theoretical perspective. These include several aspects of MBL phases in the presence of long-range interactions and hopping, for example.

Several theoretical aspects of gravitational waves and multi-messenger astrophysics were explored. In particular, neutron stars and black holes are explored within the observational window of gravitational waves. Large-scale computing is used for both simulations and the search for new gravity-wave signals.

The equation of state of dense neutron star is explored from a theoretical nuclear physics perspective. Understanding of several key aspects of the equation of state are the primary motivation and goal of this effort. This is expected to shed light on nuclear matter, equations of state and physical properties of neutron stars.

Quantum Field Theory and state-of-the art computational techniques are used to understand non-perturbative aspects of particle physics as well as condensed-matter systems. These methods include Markov chain Monte Carlo as well as quantum algorithms across a wide and generic class of physical system.

Phenomenological aspects of Particle Physics is also explored. In particular, composite Higgs models, Z' phenomenology, Dark-matter freeze-in scenarios are also explored using theoretical framework and techniques.

Quantum aspects of gravity are also actively explored. Especially the interplay between Gauge-gravity duality, the role of quantum entanglement and other fine-grained quantum aspects in gravity are actively explored within top-down string-theory models, as well as effective bottom-up descriptions. These are expected to shed light on various formal and theoretical aspects of physics.

Quantum mechanical micro state description of black holes are being explored. While conceptually this is close to the activities above, there are important technical differences that stem from providing a different theoretical formulation of quantum gravity. Relatedly, also various aspects of horizons are explored as well.

At SINP, a new beam line has been installed in FRENA (Facilities for Research in Experimental Nuclear Astrophysics) with an end station of a 1-m diameter vacuum chamber to conduct cutting-edge research to understand the abundance of various light and heavy mass elements in the universe.

Several detector systems have been deployed and a fast data acquisition system has been implemented at FRENA to provide national users with the most modern tools to investigate various problems in nuclear astrophysics.

Coherent optical interactions with hot atoms were studied in different types of hyperfine levels and Zeeman sub-levels of Rubidium atoms.

At SINP, the FRENA accelerator has now been commissioned and the beam energy calibration has

been completed. The results have been published in an internationally reputed peer-reviewed journal. More than 10 experiments were performed in order to calibrate the terminal voltage. Several new developments have been taken up at FRENA, including a computer-controlled moving detector system and nitrogen cooled target system in order to assist the national base of nuclear astrophysics researchers.

At IMSc, a new study shows that the density-wave mode of Girvin, MacDonald, and Platzman also splits into a ladder of neutral excitations, namely composite-fermion excitons. This results in many experimentally verifiable consequences, including splitting the so-called "graviton" at certain fillings, experimental confirmation of which would shed fundamental new light on the correlations responsible for the fractional quantum Hall effect.

The Electron Ion Collider being built at the Brookhaven National Laboratory, USA is a particle accelerator that will collide electrons with protons and nuclei and to understand their internal structure. It will help us understand how gluons, strong nuclear forces, bind quarks together within protons and neutrons. A recent paper provides a framework to study experiments at the EIC, where deep inelastic scattering is used to study nuclei by colliding polarized beams of electrons and ions.

At IMSc, the effect of ring stiffness and pressure on the glassy dynamics of a thermal assembly of two-dimensional ring polymers is investigated using extensive coarse-grained molecular dynamics simulations [Ghos]. In all cases, dynamical slowing down is observed with increasing pressure, and thereby, a phase space for equilibrium dynamics is identified in the plane of the obtained monomer density and ring stiffness. When the rings are highly flexible, i.e., have low ring stiffness, glassiness sets in via the crowding of crumpled polymers, which take on a globular form. In contrast, at large ring stiffness, when the rings tend to have large asphericity under compaction, we observe the emergence of local domains having orientational ordering at high pressures. The simulations highlight how varying the deformability of rings leads to contrasting mechanisms in driving the system toward the glassy regime.

The Institute of Mathematical Sciences (IMSc.) have developed a novel formalism to study momentum diffusion for quark masses in the range of charm and bottom, in a non-Abelian plasma away from thermal equilibrium. their life-times and the momentum diffusion coefficients, showing significant departure from the infinite mass limit calculations done so far have been measured for the first time. The results have shed new light on the dynamics of heavy quarks in a non-Abelian plasma far away from equilibrium and have important consequences for modelling of heavy quark dynamics in experiments.

Researchers at IMSc have developed an analytical framework for studying rare events in aggregation, a phenomenon that drives the formation of clouds and coagulation of proteins. A branch of probability theory dealing with rare events, known as large deviation theory, has been used as the framework of their study. The findings may allow the study of rare aggregation events, such as extreme climatic events and neurodegenerative diseases, with important human consequences.

CHEMISTRY

Low-energy free electrons are ubiquitous in the upper atmosphere of planets where the high-energy radiations cause their formation. These electrons can attach to molecules present in the planetary atmosphere, resulting in the fragment anions. This process is called the Dissociative Electron Attachment (DEA). Researchers studied the dynamics of the DEA to aliphatic thiols that are found in the upper atmosphere. The DEA process in thiols results in the formation of excited SH- ions that further break into S- ions. These ions are found to have about 1 eV kinetic energy sufficient to cause further chemical reactions. Such an energetic multiple-bond dissociation in DEA has been observed for the first time. These radicals are important in the sulphur budget of the planetary atmosphere.

Researchers at TIFR have studied the mechanism of deformylative C-C bond formation between O-hydroxy aromatic aldehyde & cyclic diazo compound to generate bialy diols employing a Ru(II) catalyst. Computational studies revealed a few key features: the reaction barrier for the deprotonation of the

aldehyde group is similar to that of the CO elimination step, & the CO elimination is favoured over the direct C-C bond formation with CO retention even though the latter generates thermodynamically more stable product. This kinetic preference is presumably the reason for the exclusive formation of the deformylative product.

Active materials are a novel class of systems that consume and dissipate energy at the level of the individual units. Researchers probed the non-equilibrium nature of a heat bath composed of active particles by studying the emergent dynamics of a larger polar inclusion embedded in the system. It was found that the emergent motility of the inclusion depends on its shape as well as the properties of the active bath.

Utilising the abundant resource of naturally available O2 in the air for driving reactions in water will lead to the development of green technologies in catalysis and synthesis of useful chemicals. The scientists, in collaboration with colleagues from IISER Kolkata, ICMM Madrid and MPI, Mulheim, have prepared the first chemistry example of a Fe(IV)-superoxo species trapped inside a water-soluble capsule at room temperature. The encapsulated metal-superoxo species is stable in the water yet ready to react "on call" for C-H bond functionalization reactions in water, thereby leading to advancement in industrial catalysis and environmental chemistry.

An efficient electrochemical technique was developed to remove fixed radioactive contamination from metal and high decontamination factor (DF) was demonstrated in tests with alpha planchets.

At TIFR, a chemical strategy has been invented for chemical isomer diffusion control into nanoporous metal-organic thin film. Using this methodology, halogenated alkane isomers' diffusion selectivity could be inversed. In another study, anisotropic MOF membrane was fabricated. This anisotropic structure could exhibit improved CO2/N2 permselectivity.

Many light-induced phenomena require proper alignment of bands between two or more semiconducting materials. Computing this band alignment correctly is difficult within the density functional theory (DFT) framework using computationally tractable functionals (GGA). Researchers introduced an artificial layering scheme for layered 2D transition metal dichalcogenides that provides the correct band alignment with GGA functionals.

BIOLOGY

Immunogenicity of SARS-CoV-2 vaccines BBV152 (COVAXIN®) and ChAdOx1 nCoV-19 (COVISHIELD™) in seronegative and seropositive individuals in India: A multicentre, nonrandomised observational study was carried out at TIFR. This study presents comparisons of Covaxin® and Covishield™ assessing both humoral and cellular immune responses, stratified by pre-vaccination serostatus. Participants were in the age group 18–45 years across four clinical sites in India. In this non-randomised and laboratory blinded study, participants received either two doses of Covaxin® (4 weeks apart) or two doses of Covishield™ (12 weeks apart) as per the national vaccination policy. The primary outcome was the seroconversion rate and the geometric mean titre (GMT) of antibodies against the SARS-CoV-2 spike and nucleocapsid proteins post two doses. The secondary outcome was the frequency of cellular immune responses pre- and post-vaccination. In effect, Covishield™ elicited immune responses of higher magnitude and breadth than Covaxin® in both seronegative individuals and seropositive individuals, across cohorts representing the pre-vaccination immune history of most of the vaccinated Indian population.

Single-stranded RNA viruses are primary causative agents for pandemics, causing extensive morbidity and mortality worldwide. The study aimed to identify markers for mutations with the highest probability of emergence in these pandemics, focusing on the SARS-CoV-2 spike protein, an essential and therapeutically significant viral protein, starting from sequence information from the onset of the pandemic until July 2022. Researchers of TIFR have developed a comprehensive computational pipeline to explore and predict the subsequent effects of mutations on viral fitness.

For the study on understanding fundamental aspects of intracellular flows and transport in large egg cells of the fruit fly Drosophila melanogaster,

researchers of TIFR have developed reduced-order models, computational methods, and analytical frameworks to understand a broad class of boundary-driven flows in biological systems.

Researchers of TIFR, in collaboration with colleagues at Cornell, Yale and Columbia University, identified the precise part of the brain and the specific types of nerve cells targeted by the psychedelic DOI to decrease anxiety using animal models. This work showed that the brain region targeted by psychedelics to reduce anxiety is the ventral region of the hippocampus, a brain structure involved in learning, memory and navigation. The research team mapped how brain activity in the ventral hippocampus changes under the influence of the psychedelic DOI via serotonin2A receptors expressed by neurons in this region. This work identified a cellular trigger for the psychedelic-induced relief of anxiety. This study provides a framework to understand how psychedelics influence mood-related disorders.

A study explored how conditions in our cells, like salt levels and temperature, influence the behavior of Aß40—a protein linked to neurological diseases. Using computer simulations, scientists found that at low salt levels, Aß40 proteins stick together, but as salt increases, they separate, showing a unique "reentrant" behavior. Such findings reveal that Aß40's behavior isn't solely due to its structure; it also depends on external conditions, suggesting that small shifts in the cellular environment could impact disease-related protein behaviors.

The elephant populations in India began their migrations 100,000 years ago, gradually settling in different parts. Researchers of TIFR, in collaboration with the Indian Institute of Science and others, analyzed these elephants' whole genome sequences from blood samples to study their ancestry. They identified five genetically distinct populations. Two of these populations are located in Northern and Central India, while the other three are in Southern India, separated by the Palghat and Shencottah Gaps in the mountain ranges of the Western Ghats.

Due to reduced clinical testing and monitoring challenges, tracking the emergence and evolution of SARS-CoV-2 variants has become increasingly complex. To address this gap, the study investigated the utility of wastewater-based epidemiology (WBE) as a complementary tool for SARS-CoV-2 variant surveillance in sewage treatment plants (STPs) across Pune, India. It revealed silent waves with elevated viral load despite minimal clinical cases, suggesting potential cryptic transmission, demonstrating WBE's remarkable value as an early warning tool for SARS-CoV-2 variants.

At SINP, research on mitochondrial dynamics has shown that mitochondrial DNA escapes when these organelles are stressed; this is a common occurrence in neurodegeneration.

A study on epigenetic regulation of chromatin architecture unravels significant implications of post-translational modifications in effectively curbing matrix stiffness to reinstate an anti-metastatic phenotype.

A comprehensive study to understand how the cumulative charge distribution on the outer surface of a specific serotype of dengue virus (DENV) regulates infectivity.

At SINP, a combined bioinformatics and experimental study for the first time explored the regulation of IGF1R through ncRNAs from the perspective of neurodegeneration.

A study established a dataset for analysis of metabolic pathways and their reversibility associated with anti-proliferative effect of metformin in liver cancer cells.

Researchers analyzed the crystal structure of the complex between cyclic-di-inosine monophosphate and the Vibrio cholerae standalone phosphodiesterase (VcEAL) at 2.2 Å.

A path-breaking innovation in biocomputer technology development and multicellular synthetic biology to design and establish multicellular artificial neural network-type architectures to solve multiple computational decision problems have been done.

At SINP, a collaborative study analyses the inhibitory effect of an antiamyloid peptide, which could be an important step towards inhibiting A beta

amyloidosis or disrupting the matured fibrils is the primary target to combat progressive Alzheimer's disease (AD) pathogenesis.

Scientists at IMSc have discovered that common design principles underlie the connections within brains of varying complexity. This map of brain organization can help us understand the routes taken to process information, which allow organisms to respond to the world around them. A recent study has come up with a robust method to detect hierarchical organization in complex networks. Applying this metric to worm, macaque and human brain networks, the team discovered common patterns of brain organization. They found a signature of 'modular hierarchy', where the brain network is organized into individual well-connected groups, each of which is made up of layers with sequential connections. This common blueprint suggests that animal brains may process information in parallel, while also integrating outputs across them. From this study, we know that adjacent layers in a network hierarchy are, in fact, neighbouring regions in the brain. And their sequence of arrangement matches our current knowledge of how information flows in the brain. The method developed in this study would be useful for understanding the structure of other complex networks with similar properties.

Routine ultrasounds of an expectant mother can now be used to predict the weight of her new born baby using a growth model developed by a recent study. This allows for early interventions during pregnancy as weight deviations linked to risks of neonatal complications and stillbirth can be detected in advance. Using measurements from at least three routine ultrasound scans across hundreds of pregnant women, the researchers at IMSc modelled the growth of a foetus over time. They used this to estimate foetal measurements at term, which in turn were used to predict the weight of a baby at birth. The model is simple and intuitive in capturing foetal growth and more accurate than existing models despite needing lesser data. In the future, this model can be incorporated into ultrasound machines and its predictions used in the clinical assessment of expectant mothers.

SYNCHROTRON & THEIR UTILISATION

Indus-1 storage ring had limited diagnostic capabilities, posing difficulties in the machine operation and optimization. This has been upgraded incorporating closed-orbit-distortion (COD) correction scheme with new ultra-high vacuum (UHV) system, new magnetic elements and their power supplies, upgraded ion clearing system, better diagnostic devices & upgraded control system to facilitate stable & repeatable operation of the machine. Beam trials for restoration of normal operation were started with effect from 1/3/2024. Subsequently, smooth beam accumulation upto 125mA has been restored in Indus-1.

At Synchrotron Radiation (SR) facility Indus-2, SR beam availability for user experiments was for 1462 h in round the clock mode while operating for 89 days.

The total number of user experiments at the 19 operational beamlines of Indus-2 was 250. Beamline BL-05, (Atomic Molecular and Optical Sciences beamline) got the regular operational permission from AERB. Besides DAE institutes, researchers from various universities, national laboratories and Indian industries came to Indus beamlines for their experiments. Among others, important experiments related to rechargeable battery development, were carried out by users.

CYCLOTRONS & THEIR UTILISATION

The experiments carried out at the Superconducting Cyclotron Centre (SCC) at VECC, Kolkata included study of isoscaling and fragment emission mechanism in the nuclear reactions using ^{16}O beam (343 MeV) on $^{58}Ni/^{56}Fe$ targets and ^{20}Ne beam (360 MeV, 440MeV) on $^{56}Fe/^{58}Ni$ targets and study of fragment emission mechanism in nuclear reactions using ^{14}N beam (270, 292 MeV) on ^{56}Fe target and ^{20}Ne beam (360 MeV, 440 MeV) on 51V target.

For the experimental campaign of Indian National Gamma Array, three experiments of external users using Alpha beam were conducted.

Ion implantation and materials science experiments using ion and molecular beams of nitrogen, oxygen and argon were done.

Proton irradiation experiments were carried out on candidate structural materials for Isotope production reactor i.e. Al-6061T6 and SS316L at different doses for both square samples and miniature tensile samples. Samples are kept in hot stores for decay down of radioactivity. Characterisation of these materials with dose will be carried out after activity comes down to permissible limit.

Irradiation experiment carried out by CSIR-AMPRI, Bhopal, to irradiate the radiation hard materials by neutrons produced in the reaction of Alpha beam on Tantalum.

Theoretical research

Presence of different fission modes in a single nucleus and their relative probabilities have been investigated from effective nucleon-nucleon interactions using self-consistent density functional theory.

Correlation of density fluctuation in magnetized QCD matter near the critical end point has been investigated.

Electrical conductivity and shear viscosity of a magnetized hot pion gas have been obtained.

Exploration of medium effects in strange quark matter with self-consistent thermodynamic treatment, focusing on bag pressure and quark mass.

Study of the effect of symmetry energy parameters on structural properties of hadronic and hybrid stars.

For the experimental campaign of Indian National Gamma Array at K-130 cyclotron, two experiments using heavy ion beam (16O) and five experiments using Alpha beam have been carried out by external users, as well as by users from VECC

Stable isotope beams of carbon, nitrogen, oxygen and argon were utilized for materials science experiments by VECC and external users (user from IIT Bhubaneswar and St. Joseph College, Trichy via UGC-DAE-CSR Kolkata centre).

Experiments have been conducted at the K500 Superconducting Cyclotron facility to explore non-equilibrium fission processes that hinder the formation of super heavy elements (atomic number ≥ 104). 16O beams, at energies of 330 MeV and 363 MeV, and 20Ne beams, at 360 MeV and 396 MeV, were used to bombard the pre-actinide targets (^{181}Ta, ^{197}Au, ^{109}Bi, ^{124}Sn) and actinide targets (^{232}Th, ^{238}U). The resulting fission-like fragments were detected using two large Multi-wire Proportional Counters (MWPC) developed at VECC.

Towards the experimental campaign of Indian National Gamma Array at K-130 cyclotron, two experiments using heavy ion beam (14N) have been carried out to investigate the excited states in actinium isotopes near the N = 126 shell closure and wobbling mode of excitation in La isotope. One experiment using 20Ne beam was performed by external user to investigate the different nuclear shapes in Iridium isotopes. Two experiments using Alpha beam have been carried out by VECC users, to search for tetrahedral band structures in 64Zn and 156Gd.

The K-500 Super Conducting Cyclotron (SCC) at VECC is currently delivering the most energetic heavy ion beams in the country. This provides an opportunity to study fission like phenomena in medium mass nuclei, as well as non-equilibrium processes in reactions with pre-actinides and actinides.

^{16}O and ^{20}Ne beam of energy 18-22.7 MeV/A were bombarded on the isotopic enriched targets. For the detection of fission like fragments, indigenously developed multi wire proportional counters (MWPC) were used Fission like fragments were observed in the reaction ^{16}O+^{124}Sn, which populates a composite of mass≈140u. The folding angle distribution & the angular correlation between the fragments points to a competition between full linear momentum transfer events & incomplete momentum transfer events. The fission like fragments present in both the pre-actinides & actinides nuclei suggests the presence of fast fission process.

Towards experiments at K-130 cyclotron, one experiments was carried out to investigate the

spectroscopy of fission fragments using 140 MeV 16O beam on 209Bi target, with the Compton suppressed Clover detector array of Indian National Gamma Array (INGA) setup. Three experiments were carried out using 14N and 16O beams in 100-140 MeV range and 20Ne beam in 140-160 MeV range, to study Giant Dipole Resonance (GDR) at high temperature and angular momentum in different mass region, with in-house developed Large Area Modular BaF2 Detector Array (LAMBDA). One experiment was performed using 20Ne beam of energy 120 MeV to study the decay rate change of 97Ru.

Machining of cyclotron magnet is going on at CDM, BARC and Workshop, VECC for 18 MeV Medical Cyclotron – Continuing. Present status – 70% completed. Reference photographs are shown in following picture.

Pole cap machining in progress

Fabrication of RF system is going on for 18 MeV medical cyclotron – Continuing. Present Status – 60% completed.

Construction of stable RCC foundation for test-setup for 18 MeV medical cyclotron – continuing. Present status: piling completed and excavation is to start.

Fabrication of Glaser magnet for 18 MeV Medical Cyclotron is complete. It will be installed inside the main-magnet of the cyclotron along its axis. It is part of beam injection system.

Fabrication of beam chamber of MC18 cyclotron is complete. Fabrication of Stripper drive mechanism completed.

Assembly of Stripper drive mechanism completed

Site Evaluation Report (SER) for proposed ANURIB project at Rajarhat campus has been discussed in the in the 18th meeting of ALSC (Accelerator and Laser Safety Committee) held on 5th Nov. 2024 at Niyamak Bhavan, AERB Mumbai. Construction of road around the ANURIB building cluster has been started at Rajarhat campus. Letter of intent for construction of sub-structure of PEB-2 has been issued.

PLASMA & FUSION TECHNOLOGIES

At IPR, Large Plasma Thruster facility is operated with 1400G permanent magnets and 1kW RF Power. Thrust sensor has been integrated. Antenna for ICRF power has been fabricated.

High power laser is installed and tested with various optical components in dusty plasma system. The study on the estimation of thermodynamic parameters has been performed and the findings are communicated.

Remote Handling and Robotics Technology

Dual arm Manipulator (DAM)

The purchase order for the fabrication and assembly of the DAM system has been released. The final fabrication drawings have been received from the vendor. The system is planned to be delivered and commissioned by June 2025.

Hyper redundant Inspection System (HyRIS)

The purchase order for the supply of the Vacuum compatible HyRIS system has been released. The kick off meeting has been concluded. The system is planned to be delivered and commissioned by June 2025.

RHRTD lab development

Design of a Gravity compensated haptic arm prototype has been completed and its fabrication has been initiated. Also, a SCARA end effector prototype for ARIA arm has been designed.

Development of electronics for various laboratories

Development of 16 channel signal conditioning electronics for Electron Cyclotron Emission (ECE) Radiometer diagnostic is completed.

Deep Learning/AI

A SaaS solution for the AI-based screening tool DeepCXR, under India's National TB Elimination Program, is operational at IPR. AI-generated reports, ensuring timely results for clinics. MoHFW has recommended IPR to scale the use of medcloud based DeepCXR to about 800 sites across different states of India.

SaaS solution for TB screening has been integrated with Himachal Pradesh sites, which have started uploading daily CXR images for AI reports. Patent 202421058089 filed for AIbacilli, an AI tool for rapid bacilli detection in smear sputum tests for TB.

IPR in collaboration with TMC Varanasi is developing AI for oncology. IPR has received data for onco pathology to classify the different classes of cancerous cells. IPR has shared the results with TMC Varanasi to detect and count malignant cells from the given whole slide image.

High Temperature Superconducting (HTS) cable and test facility

IPR has received a patent on 'Development of flexible high temperature superconductor (HTS) cable for shaped coils' (patent # 501364). This novel high temperature superconducting cable has spin off applications for loss less power transmission, high power electrical machines such as motor, generators, and defence sectors. The fabrication, factory and site acceptance tests of cold bore high temperature superconducting magnet cryostat of size 1.8 m X 0.8 m completed at IPR to be used for characterization of superconducting tapes and magnets. Successfully fabricated a 30 m long HTS cable capable of operating at over 1 kA. Fabrication of a meter-long NbTi CICC with a central cooling channel is developed with AFD, BARC.

Fabricated A 12-turn D-shape coil (1.17 m × 0.78 m) at IPR using second-generation REBCO superconducting cable was fabricated, addressing winding and electrical challenges.

This was cooled to 77 K and tested at 200 A, generating a magnetic field of ~162 Gauss. Preparations for testing above 1 kA are underway, with technical issues to be resolved in the next prototype.

High current testing of D-shape HTS coil

D-shape high temperature superconducting (HTS) coil has been integrated with high current power supply, cooled down to 77 K, and charged up to 1.22 kA. The peak field of 0.1 kG generated at the straight edge of the winding pack of this coil at the operating current of 1.22 kA.

Acceptance testing of 132 channel PXIe DAQ system

The factory and site acceptance testing of 132 channels PXI express (PXIe) DAQ system is completed. The block diagram and integrated testing of this DAQ system for helium mass flow, current, voltage, and temperature measurement for Cable In Conduit Conductor (CICC) and 1 T HTS test facility at R&D lab of IPR are shown in figure.

Helical Plasma Thruster

In the prototype Thruster system, experiments with a Permanent magnet based operation were carried out using Langmuir probe and Mach probes. Supersonic flows (M>1) were observed with densities

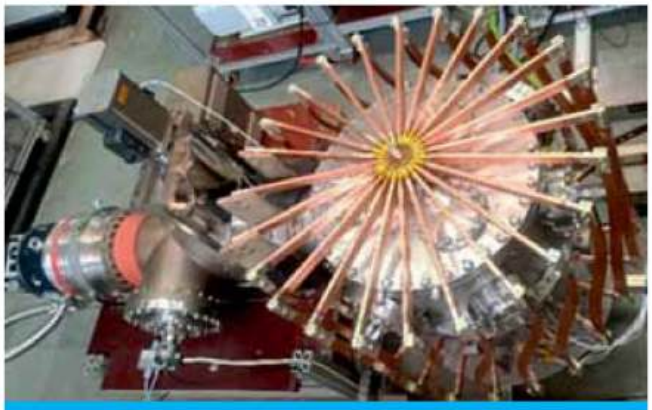
ranging from 4x1011 to 6x1012 cm-3. OES data was extracted and analyzed for Te measurements. Data acquisition and control systems are being developed for remote operation facilities in Thruster system.

Toroidal Non-Neutral Plasma Experiment, SMARTEX-C

In SMARTEX-C, plasma temperature measurement and its evolution for longer plasma hold time using evaporative dump technique has been established. The plasma temperature is found to be cooling from 9 eV to 4.5 eV in a few seconds. Figure 1 shows the SMARTEX-C Upgrade, capable of performing steady state experiments for a few hundred seconds.

IMPED Experiment

Installation of multiple probe diagnostics for wave studies has been carried out in IMPED. Data synchronization between installed 12 probes is important for coherent analysis across the diagnostic



SMARTEX-C Upgrade with steady state TF coil

array. Analog signal conditioning of raw signals, i.e. amplification & filtering has been carried out.

Installation and commissioning of Cryopumping Test Chamber

Installation and commissioning of Cryopumping Test Chamber (CTC) having 1.25 m diameter and ~3.5m length is completed for the development of large cryopumping test facility at IPR. Cryopumping Test Chamber (CTC) is evacuated using the TMP and the pressure requirement of ≤ 5E-6 mbar is achieved within the pump down time in 6.5 Hour (390Min), Leak rate: < 5E-10 mbar-l/s. Pressure in the CTC with LN2 in bath: 3.8E-8 mbar. (Achieved).

Nuclear and Safety analysis of Fusion Devices

Work under contract with ITER-IO on "Radiation calculations support for Penetration Working Group"

Improvement of radiation shielding for ITER Neutral Beam High Voltage lines crossing through the shielding wall and Estimation of the biological dose rate at ground due to sky-shine if penetrations above the 16N gamma source is not back-filled.

High Pressure High Temperature Helium Gas Technology

In a first of its kind, high pressure high temperature bellows sealed valves were designed and tested for tight shut-off conditions (Class VI category of valve seat) in metal sealing at 10 MPa and 400°C. The valves seat reported a leak rate of 2.5×10-6 mbar-l/s at 10 MPa and 400°C conditions for several operational cycles.

Development of Ultra High Voltage Power Supply

High Voltage Transformer Rectifier Units (HV-TRU) for High Voltage Power Supply (HVPS) System have been design & developed at IPR. The output of two units are connected in series and tested up to 213 kV DC under lightly loaded condition using a 30 M□ resistive load bank.

Tokamak & Auxiliary Systems

Development of Bi-Metallic Joints for Cryogenic, Fusion & Space Applications

Using cryogenic grade epoxy resin, joints in sizes like ¾" and 1" NB have been fabricated and tested at liquid nitrogen temperatures.

After many trials one module of the Fast Response Bipolar Power Supply (FRBPS) has been

successfully tested. After completing all modules, this power supply will be used in the Aditya (Tokamak) for the horizontal position control of the plasma column.

Design of new top port bolometer camera on Aditya-U with Rotary Motion feedthrough for detector protection during GDC/PDC

Bolometer diagnostics on the Aditya-U radial port include a protective shutter. A new camera with a rotary motion feedthrough is being fabricated at IPR to address space constraints on the top port.

Real-time plasma position estimation in Aditya-U uses 7 magnetic probes with integrators for field measurements. Radial (ΔR) and vertical (ΔZ) positions are calculated from the measured field. The plasma is found to maintain a radial position within -1 cm to -5 cm during the current flattop and moves inwards and upwards during disruptions.

Study of plasma discharges containing pellet injection using fast captured visible images

Plasma discharge studies with pellet injection used fast visible imaging to analyze radiation evolution during plasma-pellet interactions with lithium-titanate (Li_2TiO_3) and lithium carbonate (Li_2CO_3) particles (50-80 microns). Image processing techniques examined the plasma column's dynamics and inboard movement, showcasing the effects of different payloads.

Development of a re-entrant port for Aditya-U tokamak

A re-entrant port has been developed to get a complete tangential view of the poloidal cross-section of the plasma column to monitor two-dimensional plasma profiles. The work includes design and fabrication of a rectangular flange with oblique inclined hole and re-entrant viewport of 50 mm diameter to be UHV welded with the rectangular flange. The re-entrant port will be installed at Adiya-U tokamak for the operation of Fast Visible Imaging Diagnostic (FVID) system consists of a high speed camera, fiber optic bundle, and lenses. The spatial resolution of the system at the tangency plane is 2.9 mm.

Fast Response Bipolar Power Supply (FRBPS)

A Fast Response Bipolar Power Supply (FRBPS) has been developed for the Aditya Tokamak plasma control coil. It uses H-bridge IGBT circuits for precise current tracking, with a peak rating of 5 kA and 500 VDC. Designed for rapid current reversal and ramp rates >1 MA/s, it has been tested in both standalone and tokamak coil configurations, showing strong performance in managing electromagnetic coupling and induced voltages from mutual inductance.

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Testing of prototype ITER HXR-Monitor and Boronization experiments on Aditya-U Tokamak

The Hard X-Ray Monitor (HXRM) has been developed by ITER-IO for detection of Run-away electrons (RE) generated during tokamak operations. Under Task Agreement (TA) for "The testing of prototype ITER HXR-Monitor on Aditya-U tokamak" signed with ITER-IO, a HXR-monitor was successfully installed, tested and the first two deliverables under the TA were completed, the last phase of the testing is ongoing installed on Aditya-U tokamak.

An indigenously developed inductively-driven micro-particle injector is used to inject Boron into

ADITYA-U for developing novel disruption mitigation schemes for tokamaks. The Boron injection can also be used for boronization of vacuum vessel walls, which is one of the major requirements in ITER plasma production and control.

Small scale spherical tokamak

To explore the advantages of Spherical Tokamak (ST), a small-scale ST has been designed at IPR to produce low aspect ratio plasma and perform various basic plasma experiments. The subsystems of the machine are under advance stage of fabrication. A Prototype of the Center Stack assembly, a critical and challenging system of Spherical Tokamak from magnetic and mechanical point of view, was designed and is under fabrication presently. It consists of components such as Toroidal Field (TF) coils (ETP Copper), Ohmic Heating (OH) coil (ETP Copper), tension cylinder (SS304), center stack casing (SS304), support structure (SS 304) in a stringent limited volume. Fabrication of OH coil assembly integrated on Toroidal Field (TF) Inner Bundle has been completed and it has cleared the necessary electrical tests and mechanical checks at this stage. Integrated Vacuum Vessel (SS304L) with Support structure (SS304L) for machine & coils was designed. Presently, it has been fabricated and has completed all factory acceptance tests (baking, leak tests pre & post-baking, dimensional checks etc). Toroidal Field (TF) coils were designed to provide the required magnetic field for SS-ST machine. These TF coils (8Nos; 4 of each type, 2 such types; ETP Copper) have been manufactured as per the required design and delivered at IPR. Copper bus bars fixed with appropriate supports and insulation were installed in SS-ST Lab at IPR.

Upgradation and successful testing of 200 kJ Pulse Power System (PPS) to 300 kJ PPS was carried out by adding a newly fabricated 100 kJ PPS. Three capacitor banks individually delivering peak discharge current of 28.88 kA, 27.51 kA and 28.88 kA current respectively, the integrated effect of all three bank in between the electrode assembly is obtained as 83.71 kA.

Negative hydrogen ions were successfully extracted using the new experimental setup at Negative Hydrogen Ion Extraction Laboratory. Negative hydrogen ions were produced with W dust particles coated with Cs. Once the dust particles were introduced into the plasma, the current measured by the electrometer increased to 2.21 mA. The observed difference in current values, with and without Cs coated tungsten dust ~ 2.17 mA, is attributed to the presence of negative hydrogen ions.

MATERIAL SCIENCE

A new alloy Nb-55%Ti alloy was successfully made for the first time in India for Superconducting Radio Frequency (SCRF) application. The alloy was produced by making electrode using Electron beam melting followed by two stage Vacuum arcs melting to get 240 mm dia final ingot.

An apparatus where many species of ultracold atoms can be simultaneously trapped and overlapped with many species of ions in a Paul trap was reported. Several design innovations were made to increase the versatility of the apparatus while keeping the size and cost reasonable. Operation of a three-dimensional (3D) magneto-optical trap (MOT) of Lithium using a single external cavity diode laser was demonstrated. The Li MOT was loaded from an atomic beam, with atoms slowed using a Zeeman slower designed to work simultaneously for Li and Sr. The operation of a 3D MOT Cesium, loaded from a 2D MOT, was also demonstrated. The apparatus was used to demonstrate the trapping of Li+ and Cs+ in the Paul trap. The ion detection using an integrated time-of-flight mass spectrometer was also demonstrated. Results on low energy neutral-neutral collisions and charge-neutral collisions were reported. Evidence of sympathetic cooling of Li+ due to collisions with the ultracold Li was reported for the first time.

SINP has demonstrated giant magnetocaloric effect (ΔSM = 25 J kg-1K-1& ΔT = 14.8K) in BiGdO3 compound at cryogenic temperature and explained its origin due to the existence of short-range magnetic correlation. A complex magnetic phase diagram of the single crystalline $Sm_{0.50}Ca_{0.25}Sr_{0.25}MnO_3$ compound is constructed using magnetocaloric effect. Large magnetocaloric effect without long-range magnetic order in Ho2NiSi3 is also demonstrated. Enhancement of the magnetoresistance just by tuning the strain (strain engineering) in oxide epitaxial

$Sm_{0.5}Ca_{0.25}Sr_{0.25}MnO_3$ thin films prepared by PLD have been done. $(Sm_{1-y}Gd_y)_{0.55}Sr_{0.45}MnO_3$ ($y = 0.5$ and 0.7) compounds prepared and shown that the Spin-Polarized Tunnelling (SPT) transport mechanism at the grain boundaries plays a crucial role in the enhancement of low-field magnetoresistance in the compound.

The dominant role of short-range magnetic interaction between core and surface spins in exchange bias and memory effect in nanocrystalline doped manganite have been shown. A robust fractional edge mode of conductance 1/3 (e^2/h), at unity and 4/3 Landau level filling, having equilibration length of the order of mm is observed, which is useful for quantum information processing.

Butylammonium lead halide perovskite materials have been developed and studied the structure and optical properties which exhibit sharp band-edge transition suitable for lasing application from a single material without an external cavity have been developed. The nano-films prepared using the Langmuir-Schaefer (LS) deposition technique on a silicon substrate show broad-band white light emission across the entire visible range, which is suitable for solar cell application. We have also grown and characterized $ZnSnP_2$, which is a new kind of promising material for photovoltaic applications.

Developed an epitaxial growth technique for synthesizing Au@AgPd core-shell nanorods via a precisely controlled galvanic replacement reaction to demonstrate the potential for developing highly efficient and versatile alcohol oxidation reaction catalysts that could be used in the construction of industrial-scale direct alcohol fuel cells with superior performance. Strong metal supported interaction effect is observed in silver nano-cluster (NC) deposited CeO_2 samples where the bandgap of cerium oxide decreases to 2.42 from 2.60 eV in presence the silver NCs that again decreases to 2.05 eV under heat treatment at 250 °C due to an increase in polaron density (Ce^{3+}) in CeO_2 film.

An innovative and simple strategy to prevent atomic disorder by replacing 50% of the magnetic element Fe by a large, isoelectronic, non-magnetic element: Ru in Fe_2VSi have been proposed at SINP. The present work sheds light on the complex interplay between structural disorder and magnetic properties in Heusler alloys and provides insights for future design strategies in the pursuit of robust half-metallic ferromagnets.

A new ternary compound, $Gd_2Co_{0.90}Si_{2.90}$ in a chemically single phase by deliberately introducing lattice vacancies in the Co and Si sites have been synthesized.

$GdFe_2Al_{10}$, one of the promising members of a rare-earth based aluminide series with the capacity to manifest giant MR have been explored. This material, beyond being a simple antiferromagnet, possesses short-range ferromagnetic interactions and undergoes a paramagnetic to antiferromagnetic and an antiferromagnetic to ferromagnetic transition at low temperatures. Our analysis of electrical magnetotransport uncovers the emergence of a superzone gap due to incongruity in magnetic lattice periodicity with the crystal lattice, leading to a remarkable giant MR effect of 33%. This exploration opens up new possibilities for a series of materials displaying giant MR.

A detailed investigation of the crystal structure, magnetic, magnetocaloric, magneto-transport and electrical polarization properties of a new multiferroic material in the polycrystalline and nanocrystalline form of the Dy_2MnCoO_6 double perovskite have been reported.

Antiferromagnetic materials offer potential for spintronic applications due to their resilience to magnetic field perturbations and lack of stray fields. Achieving exchange bias in these materials is crucial for certain applications. The quest for antiferromagnetic materials with exchange bias became a reality through experimental study and theoretical simulation on Sr_2FeIrO_6 and Sr_2CoIrO_6 at SINP. This study also unveils the impact of ionic disorder and lattice distortion on magnetic properties. The presence of exchange bias in both materials, given their antiferromagnetic nature, is intriguing. This study opens up new avenues for achieving exchange bias in spin-compensated systems, offering potential for low power and ultra-fast antiferromagnetic spintronic applications in future research endeavours.

At VECC, irradiation experiments using low energy heavy ion (320 keV Ar8+ ion) were carried out on square samples of candidate structural materials for Isotope production reactor i.e. Al-6061T6 and SS316L. The irradiation was done at 5 different doses to achieve very high dpa levels (upto 120 dpa in case of SS316L and 150 dpa in case of Al6061-T6). The samples have been sent to PIED, BARC for further characterization.

Characterisation of proton irradiated Incoloy 800H samples have been carried out using detailed XRD line profile analysis to assess the microstructural changes caused by the irradiation. The mechanical property changes have also been evaluated using microhardness measurements on these samples. Further characterization using FESEM-based EBSD measurements will also be carried out.

At VECC, proton irradiation has been carried out on SS316L and Al-6061 T6 samples using 16 MeV, 10 microA beam at L4 – MSBL, DAE-MCF. Both square samples and microtensile coupons have been irradiated to achieve does of 1E17 and 1E18 p/cm2. The microtensile samples have been irradiated from both sides to achieve bulk damage in the specimens. This work is in collaboration with PIED, BARC, Mumbai.

Zr-alloy samples have been irradiated using degraded 16 MeV Proton beam at the L4- MS beamline of DAE-MCF. Square samples have been irradiated to doses of 1E17, 3E16, 6E17 and 1E18 p/cm2. This work has been carried out in collaboration with NFC, Hyderabad.

All samples will be characterised using various tools to access the microstructural changes caused by the irradiation. Mechanical properties will also be evaluated to establish the structure-property correlation in the irradiated materials.

INTERNATIONAL RESEARCH COLLABORATION

IREL UKTMP Joint Venture Agreement for setting up of a Joint Venture Company with M/s Ust-Kamenogorsk Titanium and magnesium Plant JSC, Kazakhstan (UKTMP) for production of Titanium Slag in India has been approved by PMO and under Inter-Ministerial consultation.

IREL has entered into MoU with Sultanate of Oman for Co-operation on Rare Earths. Further prospecting is planned at Khour grama deposit, the potential REE prospect. Further site activities will be undertaken after obtaining clearance from Oman.

BRIT received a Purchase Order of the value of 4459 USD from M/s Ansell Lanka (Pvt) Ltd, BPEZ, 11672, Colombo, Sri Lanka to provide ISO 11137 training services to M/s Ansell Lanka at Colombo, Sri Lanka.

Cobalt-60 industrial grade source (625 kCi) for export to Research and Development Centre for Radiation Technology – VINAGAMA (Vietnam) is fabricated and procedures are completed for despatch.

DIRECTED RESEARCH

As a part of BRNS project with CGCRI, Kolkata, radiation stability studies of six RSW glass samples (density 4.77g/cc and 3.6 g/cc) at a dose of 10Mrad were completed. Optical parameters are being measured after irradiation.

Plasma gasification facility at PRIP Shed operated to mitigate around 215kg of mixed ion exchange resins from Dhruva reactor.

Review of Preliminary Safety Analysis Report (PSAR) for HFRR is in progress.

Up-gradation of Dhruva reactor continued; alternate downcomer line from overhead storage tank to Dhruva Emergency Cooling System (ECW) system was commissioned and core structural cooling line strainer housing was modified.

Synthesis of 12N pure Germanium (Ge) by zone refinement process under optimized conditions was successfully established. The zone refinement unit is being upgraded by the incorporation of additional safety features for the continuous production of 12N pure Ge without manual surveillance. The upgraded automated zone refinement system was tested for continuous operation for four weeks. The unit was found to perform

satisfactorily for continuous refinement without manual surveillance. The zone refinement unit for purification of the Ge was fully commissioned. Growth of a diameter-controlled Ge single crystal (50 mm feed x 150 mm length) was carried out in the TPD developed puller.

50 cc HPGe detector was developed and demonstrated. The energy resolution of the fabricated detector was ~ 0.3% @ 662keV gamma radiation.

Growth of 75 mm diameter and 100 mm length CsI:Tl single crystal is initiated for detection of rare-events like neutrino.

Fully automatic mode operation of Linac has been demonstrated for Indian Cargo Scanner.

For the development and up-gradation of Accelerators and SRF Infrastructures at VECC, Magnet iron has been forged and proof machined for 18 MeV Medical Cyclotron and Solid target set-up has been fabricated and tested for 18 MeV Medical Cyclotron.

Indigenous development of liquid helium and liquid nitrogen cryogenic transfer line for the Superconducting LINACs and R&D on gap areas of ANURIB Project.

As a part of BRNS project with CGCRI, Kolkata, the composition of stabilized glass of 3.61 g/cc density was finalized after radiation stability studies. Two compositions of 4.77 g/cc density were identified for further radiation stability studies.

The 3 inch diameter CsI:Tl single crystals was mounted on photo multiplier tube (PMT) and tested at APASRA-U for its performance and the output is being analysed.

A 2 inch x 2inch CsI(Tl) single crystal was mounted on PMT and PSD spectra were measured inside and outside the shielding hutch. The major dominating peaks from Bi and Tl radioisotopes from U/Th decay chain and Cs-137 from intrinsic impurity of the crystal were recorded.

Preparatory activities for installation of the residual stress measurement facility are in progress.

Conceptual layout of Spent Fuel Storage Building (SFSB) for a 5MWth Gas Cooled Reactor was completed considering storage requirements for spent fuel assembly, seal plug and shield plug, transportation casks and pool water cooling & chemistry control systems etc.

Initial core physics studies for a low power Molten Salt Reactor with Pu fuelled FLiBe salt have been carried out.

Field intensive surveys have been carried out for Demographic and Epidemiological data collection around upcoming uranium mining site Rohil, Rajasthan to obtain statutory clearances.

Tailings waste from UCIL and Processed Uranium Cake waste from IREL were successfully converted to GeoPolymer for infrastructural applications.

Technologies for Industrial & Societal Applications

Honourable Prime Minister, Shri Narendra Modi, laid the foundation stone for "RAUDRA," a Plasma pyrolysis-based Bio-medical waste disposal plant at Ramana, Varanasi on 23rd February 2024. The technology, developed by IPR, utilizes high-temperature plasma torches in an oxygen-starved environment to efficiently and eco-friendly dispose of bio-medical waste. Jointly executed by IPR, Tata Memorial Centre (TMC), Varanasi Divisional Commissioner's office, and Varanasi Nagar Nigam. The facility will handle bio-medical waste from various hospitals and healthcare units in Varanasi, with an operational capacity of ~5 tonnes per day, serving approximately 10,000 beds. It is set to become fully operational in 2025, contributing significantly to Aatmanirbhar Bharat and Swachh Bharat Mission.

Installation of Plasma carburizing system has been completed at FCIPT.

Indian patent is granted for Atmospheric pressure plasma jet for biomedical application, this system can be used for treating cancer.

Plasma can be used for reducing air drag in automobile, High precision lift measurement system along with drag measurement system is developed with required data monitoring interface for optimization of this system.

Plasma antenna can be used in place of metal antenna for various strategic purposes, Field testing of plasma antenna and water column for the wireless communication was successfully demonstrated at Barmer range.

Patent No. 202421057885 (2024): Superhydrophobic copper surfaces for water harvesting, with 45% improved collection.

Conducted 140 ceramic erosion tests at 300 eV, comparing VSSC/ISRO's BN with commercial BN for plasma thrusters (July 2024, IPR-VSSC MoU).

Patent Application No. 202341063140 (2024): Plasma-based air sterilizer developed with C-CAMP, Bangalore.

Developed a 20 L/hr plasma-activated water system.

Tested the Raudra 200 plasma pyrolysis system's secondary combustion chamber.

Developed a 500 ml/hr underwater plasma jet system for pathogen inactivation.

Signed Incubation agreements for 3 plasma technologies with Startups, viz., M/s LBIS, Exx Carbon, and Ecoplaswa.

Delivered DAC system for the Electro Magnetic Launcher project after successful testing.

Fusion Technologies

For the diagnostics of plasma in Aditya-U, a single-diode bolometer for 8 channels has been developed and installed. The validation process has also been successfully completed. Signal conditioning electronics for 4 channels of Soft-x-ray diagnostics is also completed.

IPR has fabricated a 232 mm long HTS solenoid magnet with inner & outer diameters 200 mm and 260 mm using REBCO (Rare-Earth Barium Copper Oxide) tapes. The magnet has been tested in cryogenic condition and central magnetic field of 3.52 T at 4.2 K for over 360 sec demonstrated, maintaining excellent cryostability.

Under the technologies development of magnet for fusion applications, NbTi Cable insertion and Jacketing of 1 m long with central cooling channel, cable in conduit conductor (CICC) is successfully completed in collaboration with BARC first time India.

IPR developed a 25kV, 100mA power supply for ECRH systems, featuring PSM technology for both pulsed and CW modes. It offers precise control over a voltage range of 10 kV to 25 kV with ±1.25% accuracy, programmable rise/fall times (1-5ms), voltage modulation capabilities (0-100% of set voltage), and fast cut-off (~10μs). Successfully tested upto 25kV for 1s, it establishes self-reliance for RF power sources at IPR.

IPR's patented "CVPS" innovation, branded AGASTYA, is a cryogenic vacuum pumping system (Patent No. 504062) with wide applications in space, thin film, semiconductor, and defence sectors. Offering a pumping speed of approximately 4000 l/s for Nitrogen gas and 16000 l/s for water vapour, it surpasses 6000 mbar-l pumping capacity. Notably, SAC-ISRO has already installed three AGASTYA units.

A Vacuum test facility with the Xenon Cryopumps commissioned, where gridded ion source and power supplies are integrated with the test facility. This ion source has been operated for the extraction of xenon ion beam with current 60 mA and energy of 1.8 eV. The equivalent thrust is 3.5 mN. Ion beam profiles are recoded using faraday cup array.

IPR in collaboration with TMC Varanasi is developing AI for oncology.

Approval of Health Technology Assessment (HTA) committee of ICMR has been obtained for using the DeepCxR (AI) as screening tool for TB/non-TB using chest X-rays images, Presently It has been installed at 14 remote places for ICMR Delhi.

For Screening Tool under National TB elimination program of India (Ntep) Standard Operating

Procedure (SOP) for Cloud based analysis at IPR using DeepCxR with Central TB Division of MoHfW has been finalised.

Applications development for the VR Facility - RH compatibility of systems, walkthroughs etc. completed.

A 500 kV Resistive Voltage Divider has been developed indigenously as a substitute of import, for high voltage measurement.

Faraday Cage for 200 kV/100mA (AC) Partial Discharge Test Set-up is installed, tested and commissioned.

Integrated operation of Pb-Li MHD loop, secondary oil cooling loop and water loop completed. MHD assisted heat transfer experiments with circular mock up were performed at B ~ 1.0 T.

Tokamak & Auxiliary Systems

After installing 3 more sets of divertor plates, Aditya-U tokamak restored standard discharges (~300 ms) with a negative convertor at 1.2 - 1.4 T magnetic field. The newly-developed PAM (Passive Active Multi-junction) antenna, a first in India, enabled LHCD at 1.4 T, achieving 180 kA discharges lasting 450 ms. This also demonstrated non-inductive current drive in Hydrogen/Deuterium plasma with low reflection coefficient. Additionally, ECRH wave at 42 GHz was launched simultaneously with LHCD for the first time in ADITYA-U Tokamak.

IPR has developed a fast response bi-polar power supply (FRBPS) rated at 500V/±5kA, successfully tested on a dummy load of 150μH, 6.8m. Indigenously designed and fabricated, DSP, analog controller, and protection circuit. Costing 75% less than commercially available options, it's earmarked for use as the Divertor power supply in Aditya-U tokamak.

Development of Radiation Shielding Window (RSW) glass

As a part of BRNS project with CGCRI, Kolkata for Radiation Shielding Windows (RSW) glass radiation stability studies of one batch of samples (density: 3.61 g/cc, and with varying CeO2 upto 0.9%) were completed and RSW glass containing 0.9% CeO2 was found to be stable even after 10 MRad gamma radiation exposure.

Radiation stability studies of RSW glasses were carried out. RSW glass samples (density 4.77g/cc and 3.6 g/cc), synthesized at CGCRI Kolkata, were subjected up to 10 MRad gamma radiation dose and radiation stability of indigenously made glasses were found to be comparable with imported glasses.

After multiple trials, a glass slab of 800 mm 800 mm x 230 mm thickness was successfully casted without any cracks and major optical defects.

Development of Plasma based incinerator system for incineration of mixed solid wastes

The gas cleaning system was refurbished and air delivery system was incorporated with new rotameters.

Incinerator at gamma field was operated to for mitigation of 1200 kg Bituminous waste, 250 kg resin and 170 kg office waste.

HFRR at Vizag

Installation of Prototype vertical flywheel pump at Vizag site is completed. Installation of heat transfer experimental loop (HELP) is in advanced stage of completion. Review of Preliminary Safety Analysis Report (PSAR) for HFRR by Working Groups of DSRC-HFRR is continued.

Preparation of engineering procurement and construction (EPC) document and safety review of HFRR is in progress.

High Temperature Gas Cooled Reactor programme

Layout of reactor building & service buildings was conceptualised and reactor physics parameters were evaluated. Preliminary design of control, primary and secondary shutdown devices were completed. Preliminary scheme for handling fresh as well as irradiated fuel was worked out.

Site Information Report (SIR) and Pre-feasibility Report (PFR) were prepared for obtaining regulatory and environmental & coastal (EC) clearances for establishing high temperature gas cooled reactor (GCR) at BARC campus, Vizag. Compilation of meteorological, geological and seismic data of Vizag site was compiled. Source-term calculations were carried out to estimate radioactive release from GCR during routine discharge under normal operation and public dose at the site boundary was assessed.

Molten Salt Reactor technologies

The uniform corrosion rate of Hastelloy N in FLiNaK at the temperature range of 550-750°C was determined and corrosion studies on Hastelloy weldments were completed.

Reactor physics experiments to study fluoride salts were conducted at Critical Facility, BARC. Thermophysical properties of alternate fuel salt NaF-MgF_2-ZrF_4-UF_4, NaF-LiF-ZrF_4-UF_4 and coolant salt NaF-CaF_2-ZrF_4 were studied by TG-DTA analysis. Eutectic temperature of coolant salt NaF-CaF_2-ZrF_4 was found to be 505°C. A lab-scale facility for preparation of FLiBe based salt, for initial studies, was commissioned.

DHRUVA upgrade

Rehabilitation of civil structures for strengthening seawater pump chambers (Caisson) & Jetty road is in advanced stage. Jetty power supply LT panels were replaced. TRF (Hot-cell) gate operation was motorized. One Helium purification Charcoal adsorber bed was refurbished.

The activities that were completed includes Desilting of seawater jetty area to maintain uninterrupted supply of sea water to Dhruva; Commissioning of Pressure Swing Adsorption based Nitrogen gas production plant at Dhruva and Geotech investigation for the proposed new sea water intake structure.

Development of large size single crystals, Caesium Iodide (CsI)/ High Purity Germanium (HPGe) detectors and sensors

Crack & inclusion free CsI crystal of 3-inch diameter 4-inch length was grown indigenously at BARC. Incubation for CsI:Tl scintillators and portable gamma spectrometer with private entrepreneur was completed under Atal Incubation Centre.

Digital signal processing multi-channel analyser (DPS-MCA) was tested with HPGe detector.

Certified Reference Material (CRM) Program

Nine property values (Na_2O, Cao, MgO, MnO, Ga_2O_3, V_2O_5, Fe_2O_3, LOI and surface area) in alumina CRM were found to be homogeneous in 200 bottles of the CRM material. Indigenous ferrocarbonatite CRM was produced using SI traceable method.

Total 274 laboratory reference sources were supplied to various users. Inter laboratory comparison exercise (ILCE) of the candidate CRM (DMRL-BARC-HSLA-01) was carried out by analysing 8 elements using ICP-OES.

Higher energy accelerators program

Studies on beam instabilities in high intensity linacs has been carried out and published.

Development and up-gradation of Accelerators and SRF Infrastructures at VECC

Machining of cyclotron magnet is going on at CDM, BARC for 18 MeV Medical Cyclotron. Fabrication of RF system is going on for 18 MeV medical cyclotron. Work for construction of stable RCC foundation for test-setup for 18 MeV medical cyclotron has started. Design and development of stripper system is ongoing for 18 MeV medical Cyclotron

Superconducting LINACs and R&D on gap areas of ANURIB Project

Site evaluation report (SER) for the proposed ANURIB project has been submitted to AERB for evaluation as a part of regulatory clearance process.

Augmentation and renovation of Civil and other infrastructure at various campuses of VECC

Renovation /roof treatment of RTC building at Bidhan Nagar campus has been completed. Maintenance work for existing systems / establishments going on.

Laser Glass Improvement Project

Procurement and setting up of the automated weighing, blending and mixing setup for the melt raw material has been completed at RRCAT. Design and fabrication of Platinum liners, stirrers, homogeniser elements of the melting and refining setup have been completed.

Thermal modelling and structural integrity FEM simulation results were utilised for estimation of ratings for the high current power supply for direct heating, the insulating material, and its geometry. The geometry/flow velocity of the refiner for required degassing rate have been modelled for gas bubble size as low as 50 microns. Validation of low shear and high shear mixing has been done using glycerine of 10 centipoise viscosity as surrogate for laser glass melt at 980 °C.

At RRCAT, Directed Heated Platinum test bench has been setup. Procurement of equipment and components has been completed. The mechanical fabrication of the plant is in progress.

Advance Optics for Laser and Synchrotron Radiation

Design and modelling for a 500 mm dia. float polishing machine have been completed. Based on the design for the long trace profilometer procurement has been initiated for the same. Indent for a 5-axis grinding machine to fabricate the preforms for the 5-axis aspheric polisher has been initiated.

Fabrication of 500 mm diameter float polisher is in progress. Indents for Long Trace Profilometer and 5-axis Aspheric Polisher have been floated on GeM portal. The building construction is in progress.

Bids against tenders of Long Trace Profilometer and 5-axis Aspheric Polisher has been received. The technical evaluation is in progress. Fabrication of 500 mm diameter float polisher has been completed. Design of Aperture Stitching Interferometer is completed. Building construction work under progress.

Material and Component development

Successful demonstration of the development of Inconel 718 clad layer on tubular Cu substrate using laser additive manufacturing process is carried out. This will be used to explore the feasibility of development of the Liquid oxygen methane for ISRO using laser additive manufacturing.

To repair the rocket steering engine chamber shell made of Cu-Cr-Zr alloy using Laser Directed Energy Deposition process is carried out by developing suitable compact nozzle for laser cladding from the inner surface where ID is about 40 mm for LPSC ISRO. Further studies are currently underway to qualify the repair.

Using in-house developed LAM-PBF system, a cemented acetabular component of pure Titanium has been developed for the trial studies for future prosthetic applications.

Customization and integration of the software for LAM-PBF system is carried out as per the requirement of BARC to builds the intricate structure of different engineering materials. The system will be dispatched after final testing in the consultation with BARC team.

Decommissioning plan of a 2-kW fiber laser based Directed Energy Deposition (DED) System is prepared with proper labelling of each component and decommissioning of the machine will start soon in consultation with BARC team.

Fabrication of 3.6 cell Photo-cathode RF Gun of OFHC copper with dimensional tolerances within 5 μm and surface finish better than 0.2 μm is carried out in the workshop. This has been tuned to resonate for pi mode frequency of 2855.98 MHz at 26 deg C, with a field flatness of 99.57% and RF power coupling coefficient of 0.83.

A new engineered version of channel system for 800W CW Nd:YAG laser was fabricated for applications in laser cutting and welding applications in nuclear reactors and research.

Commissioning of CO2 laser based cutting machine for acrylic sheets.

Brazing of 505.8 MHz Co-axial RF coupler in the hydrogen atmosphere for the use in RF cavity of Indus II was carried out.

Development of Ti- SS joint with Cu and Ni interlayer in lap and butt condition is performed using Laser Directed Energy Deposition System (LDED). For crack and defect free deposition different process parameters were optimized. This study will open avenue for development of components with dissimilar joint for different industries.

Deposition of Cu clad layer on large plate of Ti with diameter 450 mm and thickness 5 mm is performed using Laser Directed Energy Deposition System (LDED) with minimum distortion and uniform thickness of Cu clad. For minimising the distortion tool path and scan strategy are suitable chosen with optimum laser power and scan speed. This is useful for power industries under corrosive environment.

Development of 90° bend tube with proper tool path design is successfully carried out using Laser Directed Energy Deposition System (LDED). This will pave the way for replacing the conventional forming process where unwanted distortion and generation of tensile residual stress are inevitable.

Commissioning of new 5-axis Laser Directed Energy Deposition System is carried out by integration of 20 kW fibre laser, beam delivery system, 5 axis workstation, and twin powder feeder in a controlled atmosphere chamber. This will be used for research and development of different materials and components for various application within the department and other R&D institutes.

Using Laser Directed Energy Deposition System hemispherical Dome Structure of Inconel 718 with diameter of 60mm and thickness 5mm is built without any support structures. The dome structure is built using non-parallel slicing methodology with adaptively varying scanning speed and tool orientation. This has potential application is space industries.

Laser surface cleaning and polishing of Inconel 625 alloy is carried out using nanosecond pulsed fibre laser for decontamination and improvement of surface properties.

Hydrogen atmosphere brazing of 505.8 MHz Co-axial R F coupler for use in RF cavity of Indus II is carried out. Brazing is carried out in three stages by using brazing alloys of different melting points. Heating and cooling cycles were designed to minimize onset of thermal stresses in the alumina ceramic window. The coupler was found to have a leak rate of 1 x 10-10 mbarlt/sec.

Fotofuse 0.7515 portable Laser Powder Bed Fusion (LPBF) System is developed for process demonstration and unveiled during the AIC-π-Hub Day on 04-09-2024.

Demonstration of quantum coherence in metal chalcogenides using ultrafast optical techniques

The study aims to demonstrate quantum coherence in transition-metal di-chalcogenide materials using a microscopic photoluminescence (PL) setup integrated with a low-vibration cryostat to cool samples to 5 K. Polarization-resolved PL measurements are performed on 2-dimensional (2D) MoS2 at cryogenic temperatures, chosen due to minimal dephasing and longer coherence lifetimes. The PL signal is detected using a cooled electron-multiplying charge-coupled device (EMCCD) for high sensitivity and low noise. A two-color pump-probe setup with helicity control is also developed to study valley dynamics in 2D materials, using optical parametric amplifiers (OPA) for varying pump and probe laser beam wavelengths. Experiments show that excitonic PL in 2D MoS2 retains quantum coherence with minimal dephasing, providing insights into exciton dynamics and valley coherence.

X-ray imaging using indigenously developed GaAs detector

Gallium Arsenide (GaAs) based X-ray detectors are highly efficient for X-ray imaging, particularly for

energy ranges above 10 keV, due to their high quantum efficiency, radiation hardness, and fast timing response. GaAs-based p-i-n structures were grown using metal-organic vapor phase epitaxy and fabricated using standard semiconductor device techniques. The indigenously developed GaAs detector was used to capture X-ray images of metallic objects in transmission mode at the imaging beamline (BL-4) of Indus-2, utilizing 16 keV X-ray energy. The detector's high quantum efficiency and dynamic range enabled good contrast image capture.

Development of graphite coating on Ni based super alloy and Stainless Steel

Successful graphite layers were deposited on a 70 mm x 70 mm area on both Hastelloy-X and SS 316LN substrates, encompassing both flat surfaces and channelled structures. The samples were subsequently transferred to the Bhabha Atomic Research Centre (BARC) for further electrochemical evaluation. The graphite deposits need to be further improved to avoid micro cracks and porosities.

Development of Clad layers of IN 718 on simulated Cu Channels

This work is a part of the collaborative work being carried out with Liquid Propulsion Systems Centre, ISRO. Laser Directed Energy Deposition (LDED) was employed to deposit IN 718 clad layers on these simulated channels. Key process parameters, including laser power, powder feed rate, and scan speed, were systematically optimized. A detailed analysis was conducted to determine the influence of these process parameters on the distortion levels observed in the Cu channels.

Process development of hemispherical dome for potential aerospace application

Hemispherical dome structures on Ni-based super alloy has important applications in the aerospace industry. In this context, an IN 718 super alloy hemispherical dome was fabricated using 5-axis Laser Directed Energy Deposition (L-DED) with a diameter of 60 mm and a thickness of 2.5 mm.

Development of transition joint of SS 316 L with Ti based (Ti6Al4V) and Al (Al6061) alloys

Developing transition joints between SS 316L steel and Ti or Al-based alloys are crucial for various industries. Laser Directed Energy Deposition (LDED) based additive manufacturing was employed to create transition joints. All joints were produced using optimized LDED process parameters.

Development of Fused Silica - SS Graded sealed cavity for BARC Beamline at Indus-2

A hermetic seal was successfully developed between fused silica and stainless steel for Indus-2 beamline. To overcome the significant disparity in thermal expansion coefficients between these dissimilar materials, a graded sealing technique was implemented.

Glass moisture traps for holding moisture of different nano materials

Nano Insulation Materials (NIMs) are widely employed in applications demanding high thermal insulation performance and enhancing the overall performance of insulation system. In this context, specialized traps were fabricated utilizing borosilicate glass tubes. These materials are strategically incorporated into the traps to efficiently capture and adsorb moisture.

Development of various components using conventional manufacturing

During the period, the laser workshop supported the development of many ongoing activities. 110 work requests were received during this quarter, 134 work requests were completed, &169 work requests are under process.

Development of High throughput Food Irradiation Facility and 9.5 MeV, 15 kW Industrial Linac

Detailed design of high throughput food irradiation facility including evaluation of material handling equipment and conveyor layout for product movement is near completion preparation of specifications and documentation for industrial

manufacturing of Linacs is in progress. Interactions done with ECIL for collaborative development of Industrial Linacs of 18 kW of higher beam power.

Installation of plasma Nitriding system to be operated in GOCO mode

IPR has installed a 3m height and 800mm diameter Plasma Nitriding system. This system will be intended to work in GOCO made for the first time in INDIA. In this model, the Plasma nitriding system and the capital infrastructure owned by IPR will remain a property of IPR. The said capital equipment shall be run, operated and maintained by a company which will utilize the technology & system to its best capacity – thereby facilitating commercializing using home grown technology. The scope of the company will be to market the process so that more jobs are obtained and the PN system works with maximum capacity, arrange for human resources for operating and maintain the plasma nitriding system and ensure safety protocols during their presence in FCIPT, IPR. The company will have to make payments to IPR as per the GOCO agreement.

Linear Induction Motors (LIMs)

Linear Induction Motors (LIMs) (10 Nos.) for Electro-Magnetic Launcher (EML) are manufactured. Stage wise inspections are conducted at vendor's site. Final Factory Acceptance Tests (FAT) and delivery is pending. Support structure for Linear Induction Motors (LIMs) are manufactured and delivered at IPR. FAT and SAT are completed.

Data Acquisition & Control (DAC) system for 8 kN Linear Induction Motor (LIM)

Data Acquisition & Control (DAC) system for 8 kN Linear Induction Motor (LIM) based Electro-Magnetic Launcher (EML) is delivered at IPR. Installtion is in progress. RTDs for temperature monitoring and Optical sensors for velocity measurements are integrated with CAC and tested successfully. Software development for various modes of EML is in progress.

Pulse Forming Network (PFN) based pulsed power supply

A Pulse Forming Network (PFN) based pulsed power supply has been developed and microwave absorption experiment has been conducted successfully by producing high density pulsed plasma.

Augmentation and Upgradation of Scientific and Technical infrastructure at RRCAT

Material has been received and Installation is in progress for Perimeter level Video Surveillance Setup. Switches and servers have been procured and commissioned for extension of RRCATNet.

Video surveillance setup has been installed along the perimeter of RRCAT technical area and Guard House. It consists of 124 nos. of IP video Surveillance cameras, 6 no of Embedded Network Video Recorders (NVRs), 1 no of Video Management Server, 1 no of Network Attached Storage, 2 nos. of 5 kVA Uninterrupted Power Supplies (UPS), Control room and dedicated network.

Enhancement of Infrastructure facilities for Superconducting Cavity Development and Testing

Testing of 325 MHz/100 kW tetrode-based pulsed RF power amplifier for 3 MeV proton accelerator Radio Frequency Quadruple (RFQ).

Optimization of operating parameters of Low Energy Beam Transport (LEBT) and ion source was carried out and 2.5 mA negative hydrogen ion beam was transported up to the end of the LEBT.

Toward development of Front-End Test Stand (FETS) for proton accelerator, successful brazing for first segment of RFQ structure was carried out in vacuum brazing furnace at RRCAT, Indore. Hydraulic and vacuum testing of first tank of 325 MHz DTL structure was carried out.

The indigenous technology for 30 Kelvin class cryocooler with a helium compressor, capable of generating ultra-low temperatures, has been transferred to industry.

The project target of preparing the "Detailed Physics Design Report for the ISNS Accelerator System" has been completed, by including the details on beam collimators for the 1 GeV Accumulator Ring in the earlier draft version.

A dressed five-cell 650 MHz cavity was high pressure rinsed and tested at 2 K in VTS facility. The cavity achieved the required accelerating gradient of 21 MV/m with quality factor of 2.8 x 1010. There was no signature of field emission or multipactoring.

Latest drawings of HB 650 MHz Cryomodule have been reviewed. Procurement specifications, QC documents including manufacturing inspection plan have been prepared. Indian vendors have been appraised of critical fabrication requirements and realistic cost estimation and time schedule through regular technical web meetings.

Under Hi Temperature Superconducting (HTS) transportation the design of restraining fixtures approved by FermiLab has been completed. Order for Shipment of HTS cryostat and Feedcan unit to Fermilab has been awarded.

650 MHz superconducting RF (SRF) cavity testing was repeated for evaluating performance at 2 K temperature in vertical test stand (VTS) facility.

Horizontal Test Stand (HTS-2) Cryostat and feedcan units (along with accessories) are being shipped to Fermilab USA as R&D phase PIP-II deliverable to Fermilab USA. The unit is expected to get despatched from RRCAT by the first week of Jan, 2025.

Development of High throughput Food Irradiation Facility and 9.5 MeV, 15 kW Industrial Linacs

Design of high throughput food irradiation facility is in progress including evaluation of material handling equipment and conveyor layout for product movement.

For manufacturing of 9.5 MeV, 15 kW Industrial Linacs with participation of Indian industry, a theme meeting was arranged at RRCAT on 14th Oct 2024 where about 10 Indian industries participated. Tender design drawings, bill of material and technical specifications are under preparation.

Health physics and environmental Research

Environmental and radiological surveillance was carried out at BARC Trombay, Vizag and NPP sites for checking compliance of the regulatory requirements. The annual dose imparted to the members of public from the various facilities was evaluated and found to be well below the stipulated regulatory limits.

HYDROGEN RESEARCH

At BARC, integrated pilot-scale Cu-Cl facility was commissioned and H2 production was demonstrated at 50 NL/h for 45 hours. Detailed engineering of full capacity 500 kW stack with balance of the plant has been completed. Fabrication of prototype 1MW electrolyser cell stack is in progress. Cold commissioning of tank-type compact unipolar cell configuration AWE system completed with 1m3/h hydrogen generation capacity. Set up for the preparation of MgH2 in 500 gm for hydrogen storage is established.

Operation of pilot-scale Cu-Cl cycle facility continued. H2 production was gradually ramped up. Facility operated at design capacity (150 NL/h) for 12 hrs.

A 1 MW prototype alkaline water electrolyser stack (~ 1.25 m diameter) was fabricated, assembled, integrated with electrolyser plant. Trial operations of stack were successfully done for ~ 50 hr

After successful demonstration of 0.5MW prototype alkaline electrolyser stack at BARC, design, fabrication and assembly of indigenous actual 0.5MW cell module stack (~ 1 meter diameter and 2.5 meter long) was completed under MoU with BPCL for green Hydrogen production for transport sector.

Moderate pressure lab scale hydrogen generator, using indigenous PEM based pure water electrolyser cell, was developed and tested. Hydrogen production of 18 NLPH at 5 bar pressure was achieved.

2.5 litre foam type chromium doped iron oxide catalyst was produced for its use in I-S process for decomposition of sulphuric acid.

HWB is establishing a cutting-edge hydrogen gas generation facility utilizing the I-S thermochemical process, based on the advanced design provided by BARC. The technical specifications have been finalized, and financial sanction has been secured from the Department. EPC tendering is currently underway for the execution of the facility at HWBF-Mumbai.

CHAPTER 5

HUMAN RESOURCES, PUBLIC AWARENESS, INTERNATIONAL RELATIONS, TECHNOLOGY TRANSFER

Honourable PM Shri Narendra Modi is being briefed by Chairman & Managing Director, NPCIL during his visit to KAPP in Gujarat

Dr. Mohanty and Dr. Likhachev signed the amendment to the Inter-Governmental Agreement of 2008

HUMAN RESOURCE MANAGEMENT

Homi Bhabha National Institute (HBNI)

Homi Bhabha National Institute (HBNI), a Deemed to be University, is a Grant-in-aid institute of the Department of Atomic Energy (DAE) has successfully completed 19 years. It has established itself as one of the best research Universities in the country, encouraging research in various facets of Nuclear Science and Technology including Mathematics. HBNI secured 6th rank in the Research Institution Category, 16th rank in the University category and 27th rank in the overall category in the National Institute Ranking Framework (NIRF) exercise conducted by the Ministry of Education (MoE) in 2024. Based on high-quality publications the Nature Index 2024 has placed HBNI in the third position, among all academic institutions in India, and first position among all academic institutions regarding publications in the discipline of physical sciences as on 31-08-2024.

The academic programs of HBNI are leading to Human resource development not only in core areas of Nuclear Sciences and Engineering but also in several other areas of societal importance such as Medical and Health Sciences. HBNI awarded 145 PhD degrees during April 1, 2024 to December 31, 2024 in various disciplines and the total number of PhD degrees awarded by HBNI till December 2024 stands at 2773. During the year, HBNI has set up HBNI R&D Cell, Institution Innovation Council and Placement & Alumni Cell for the benefit of its students.

During the year HBNI organized several value-added courses, viz., Advanced Materials Chemistry, Advanced NMR Spectroscopy, Research Methodology, Research & Publication Ethics, Disaster Management-Challenges in Chemical, Biological, Radiological and Nuclear (CBRN) Emergencies for the benefit of students/faculty members. In addition, a unique course on "Structural Integrity Assessment of Mechanical Components: Concepts & Procedures" was organized by HBNI in association with INSTN, CEA, France.

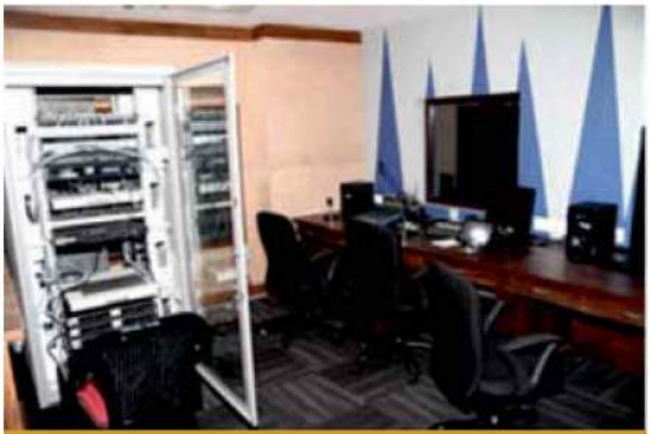
During the period under report, with a view to enhance academic collaborations, HBNI signed MoUs with IIT Delhi, IIT Jammu, Indian Institute of Management, Ahmedabad, Confederation of Indian Industry, and renewed MoU with TIFR. Ministry of Education has accorded approval for recognizing Homi Bhabha Cancer Hospital and Mahamana Pandit Madan Mohan Malaviya Cancer Centre (HBCH & MPMMCC), Varanasi, as second Off-Campus Centre of HBNI on May 20, 2024. This is an important milestone for HBNI, as with these twelve institutions of DAE are affiliated to HBNI for their academic programmes.

Training

BARC conducted the training programs on 'Preparedness and Response to Radiological Emergencies' for CISF personnel; for Navy personnel; for Thane Disaster Response Force and Thane Fire Brigade and for State Disaster Response Force. Awareness Programme on Radiation was conducted for Divyanjan Employees of DAE. BARC conducted the training of First Responders of State Disaster Response Force (SDRF), Rajasthan in May 2024. It also conducted the training of First Responders of 2nd BN NDRF (Nadia, WB) at VECC, Kolkata on 14 June 2024.

OCES program for 67th Batch of BARC Training School was concluded The foundation course for the 177 TSOs, 6 IPR TSOs, 4 NTPC Executives and 7 TDOs from 12 disciplines was conducted.

Advertisements for OCES/DGFS-2025 and DDFS-2025 were released for wider publicity in Newspaper and website. Course work for 3rd Batch of



Control Room Digital Studio

JRFs were completed and they joined various Divisions in BARC for pursuing their Research. BARC Digital Studio and Six ICT lecture halls were commissioned and inaugurated.

Training programmes on 'Preparedness and Response to Radiation Emergency' have been conducted for Fire Services & Security Staff of Mumbai International Airport Limited, Mumbai Police and National Disaster Response Force (NDRF).

TIFR awarded a total of 54 Ph.D. Degrees and a total of 36 M.Sc. Degrees to students during the period of first quarter.

Administrative Training Institute (ATI)

The mandate of the Administrative Training Institute (ATI) is to conduct Department specific induction training programmes for the new recruits in the Administrative, Auxiliary and Security cadre of Constituent Units of DAE and orientation courses to the middle level and senior employees of Constituent Units, Public Sector Undertakings and Aided Institutions. The topics covered are on service, legal, financial, vigilance, soft skills & Management (ethics & values, team building, organization behaviour), computer and development skill. ATI also conducts special programmes for the Scientific, Technical, Medical and Para-medical staff members of DAE on various job-related matters like Intellectual Property Rights, Contract Management, tender and work procedure etc. Over more than a decade, ATI has developed a robust training system to meet the unique requirements of the DAE and has been successfully imparting series of training programmes on behavioural and soft skills, cadre plan, capacity building, faculty development, induction, refresher/orientation courses etc.

ATI continued to witness new initiatives during the year 2024-2025. A summary of the notable features of the ATI towards Human Resources Development are listed below:

Contributed in the field of Training and Development by conducting 71 training programs on functional & behavioural skills covering a training population of 2596 with 362 training days.

Witnessing the huge response and need of the time, two training programs on Government e-Market place (GeM) were conducted in coordination with expert faculty of the subject. The number of employees participated is 174.

With the aim of developing in-house faculties for imparting training to the DAE employees, ATI conducted two faculty development programmes.

Keeping the tempo and implementation of guidelines /instructions of the Government of India, ATI has conducted training programmes on Preventive Vigilance, Role of Inquiry Officer/Presenting Officer (IO/PO), Reservation in Services, MACP, Handling of Court case, Drafting of Charge sheet etc. Further, ATI conducted series of programme on Soft Skills covering topics, like Stress Management, Conflict management, Time Management etc.

Focusing on the mandate of ATI to conduct Department specific induction training programme to the new recruits in the Administrative, Auxiliary and Security cadre of Constituent Units of DAE, ATI conducted five (5) Mandatory Induction Trainings benefitting new entrants from Admin, Auxiliary & Security Cadre. 2 of the 5 Trainings were residential trainings for Security Guards.

Management Development Programmes (MDP) exclusively for Senior Scientific Officers conducted at Global Centre for Nuclear Energy Partnership, Bahadurgarh and Orientation Training Programme for Assistants on Service Matters at National Centre for Biological Sciences, a constituent centre of the Tata Institute of Fundamental Research (TIFR). Both the programmes were well received and appreciated.

Management Development Programme for Scientific Officers of the Department conducted at GCNEP, Bahadurgarh

ATI conducted special programs like 3 days Soft Skills for Trainee Scientific Officer, Awareness generation for Divyangjan, Orientation program for Drivers, training on Proactive disclosure of Information under the RTI Act, training for healthcare professionals etc. A unique program on 'Awareness of Cyber frauds' for homemakers was conducted at ATI, Mumbai, for the benefit of the spouses of employees of Mumbai based DAE Units. The programme was a great success.

The ATI is recognized by Central Information Commission (CIC) as Third-Party Agency to carry out Transparency Audit for the Constituent Units of DAE, Public Sector Undertakings and Aided Institutions under the Right to Information Act, 2005. Accordingly, for the year 2023-2024, ATI with its Task Force has conducted third party audit of 28 DAE Units, PSUs & AIs within the stipulated time given by CIC, New Delhi.

For revamping of ATI Website and development of Dynamic Website for ATI, Memorandum of Understanding (MoU) with CDAC was signed on 13.12.2024. With this arrangement, ATI will be having dynamic website and same will be operational soon.

Mission Karmayogi and iGoT portal: Government of India has set up the Capacity Building Commission (CBC) with an aim to transform the training ecosystem and make it more focused and create shared knowledge resource under Mission Karmayogi. As a part of the Government initiative of Mission Karmayogi, ATI function as the Nodal Agency of the Department to co-ordinate between the Capacity Building Commission (CBC) and Constituent Units in promoting on-boarding of DAE employees on the iGot portal. Training Calendar of ATI is aligned with the Annual Capacity Building Plan (ACBP) launched in the Department under the Mission Karmayogi program. About 16571 employees of DAE have been On-boarded on the iGot portal of the Mission Karmayogi. ATI is actively involved in the Capacity Building for all employees of DAE.

As a part of Mission Karmayogi, Know Your Ministry (KYM) Module of the Department is under development for uploading on iGoT portal. KYM will serve as an induction material and an informative document to showcase the activities and achievements of the Department.

Launching of DAE Training Policy by Secretary, DAE

For the first time since its inception, a formal 'Training Policy' for the cadres of Administrative / Accounts, Stenographer, Official Language, Drivers, Purchase and Stores and Work Assistants / Canteen Attendants of the Constituent Units has been launched by the Secretary, DAE on 27th February 2025. The comprehensive Training Policy aims to equip the multi-disciplinary cadre of DAE employees with the tools and knowledge necessary to excel in their roles and contribute meaningfully to the broader goals of the Department.

The Capacity Building Commission (CBC) has initiated a Large-Scale Jan Seva Programme "Serving the Karmayogi Way", an initiative aligned with the Hon'ble Prime Minister's vision of "Jan Seva", aiming to instill "Seva Bhav" among public servants across the Ministries / Departments/Organizations (MDO). ATI being nodal agency is coordinating and regularly taking actions for implementation and success of the said initiative by way of conducting training of Jan Seva and other related actions.

ATI continues to carry out Training Need Analysis for the Department. It has been the endeavour of ATI to innovate and adopt the best practices in training with an aim to make it a robust Institute thereby creating a strong, informed and skilled human capital.

SPONSORED RESEARCH

Board of Research in Nuclear Sciences (BRNS)

The Board of Research in Nuclear Sciences (BRNS), established in 1945 as the Atomic Energy Committee, continues to serve as the Department of Atomic Energy's (DAE) principal extramural funding

agency for advancing nuclear science and technology in India. Over the decades, BRNS has fostered a vibrant research ecosystem by supporting fundamental and applied research, promoting science education, and facilitating collaborations across institutions. BRNS is operating under the guidance of distinguished panel of scientists and experts, functioning through nine specialized Committees on DAE Programmes (CDPs) that assess and recommend proposals of DAE's mandate.

In the FY 2024–25, BRNS sanctioned 64 new research projects, reaffirming its commitment to fostering innovation and R&D in nuclear science domain. Maximum number of research projects were sanctioned by the Basic Research and Science Education (BRE) Committee, followed by the Nuclear Power Programme (NPP) Committee. A total of ₹24.45 crore was disbursed to universities and research institutions across the country, enabling them to undertake high-quality research aligned with the mandate of DAE. All the projects submitted under Co-ordinated Research Project (CRP-2023) scheme have been reviewed by appropriate committees. Based on the recommendation by the committees, BRNS has sanctioned these projects. During this period, BRNS has also closed (scientifically and financially) 67 completed projects as per recommendation of the BRNS committees.

In parallel, BRNS continued to support scientific events through the funding of 136 symposia and 11 theme meetings. These events provided platforms for knowledge exchange and fostered greater collaboration among India's scientific community. The International Science Olympiad programme, a flagship initiative supported by BRNS, continued to bring laurels to the country. Indian students achieved remarkable success by securing 5 gold, 12 silver and 1 bronze medals in global competitions, underlining the importance of sustained investment in nurturing young scientific talent.

Efforts to expand outreach and public engagement were equally notable. A total of 43 Technical Programme Discussion Meetings were organized to facilitate review and monitoring of research projects. Public awareness initiatives, including the screening of DAE-produced films during symposia, were undertaken to demonstrate the societal relevance and peaceful applications of nuclear science and technology. These outreach efforts reflect BRNS's broader vision of demystifying nuclear science and strengthening public trust in its contributions.

National Board of Higher Mathematics (NBHM)

The National Board of Higher Mathematics (NBHM) was set up in 1983 to promote development of higher mathematics in the country, to formulate policies for development of mathematics, help in establishment and development of mathematical centres and give financial assistance to research projects and to doctoral and postdoctoral scholars, by the Government of India under the Department of Atomic Energy (DAE).

To execute its responsibility to support various schemes diligently, NBHM Board has set up several committees to consider proposals received for various mathematical activities, from institutions and individuals throughout the year. Based on the recommendations of these committees, NBHM provides financial supports to various schemes through R&D-2, DAE. To carry out NBHM activities under NBHM Schemes in various geographical regions within our country, various regional sub-committees are constituted with/existing member along with some new members. These committees are working tirelessly towards proliferation of higher mathematics through various training courses and examination for selection of applicants for various schemes.

All new proposals from Institutes, Fellowship applications, Research Project, etc. for financial support were thoroughly scrutinised by respective committees and based on the recommendations for support, funding is provided.

All the continuing proposals for financial support to various schemes were processed following all administrative procedures, along with review of yearly progress, certification of financial utilisation and other requisite documents, and subsequent activity renewal is granted on compliance with all required inputs/documents.

DAE allocated ₹ 34.00 Crores for various NBHM schemes for the Financial Year 2024-25. Allocation of funds to various activities were re-worked according to the proportion of actual expenditures in previous years to match the sanctioned amount of ₹ 34.00 Crores.

NBHM has sent the recommendations and sanctions of ₹ 28.43 Crores has been disbursed in various schemes by December 31, 2024.

The various schemes/activities of NBHM to realise its objectives includes Undergraduate Scholarship for BA/BSc and Postgraduate Scholarship for MA/MSc; MA/MSc & Ph. D. Scholarship Examination; PhD Scholarship; Post-Doctoral Fellowship; Visiting Professorship; Library Support & Book Distribution Scheme; Research Project Grant-in-aid; Travel Grant; Conference Support; Mathematical Olympiad & Madhava Mathematics Competition; Indian Women in Mathematics (IWM); Mathematics Training and Talent Search (MTTS), Hyderabad and Support to various Centres of Mathematics such as Chennai Mathematical Institute (CMI), Chennai; Kerala School of Mathematics (KSoM), Kozhikode; Bhaskaracharya Pratishthan (BP), Pune; Institute of Mathematics & Applications (IM&A), Bhubaneswar and National Centre for Mathematics (NCM), IIT-Bombay Campus, Mumbai.

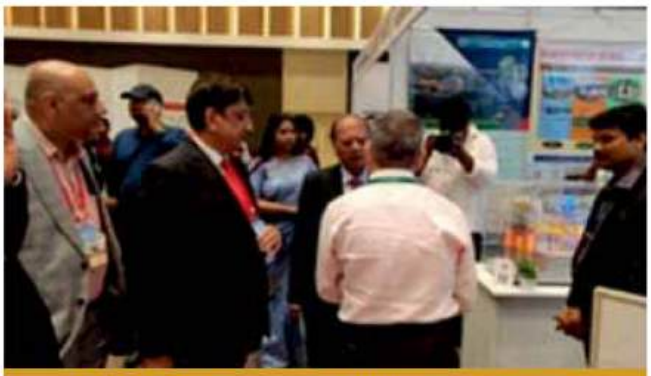
PUBLIC AWARENESS & OUTREACH ACTIVITIES

The Department of Atomic Energy (DAE) carried out a gamut of Public Awareness programmes in order to alleviate unwarranted fears, misconceptions and apprehensions harboured against nuclear energy. To keep the public abreast of the latest developments and contributions of atomic energy towards societal welfare, DAE organized a spectrum of events comprising exhibitions, seminars, workshops, essay and quiz contests in different parts of the country which were well received by the targeted audience.

Some of the major events in which DAE and its units participated are mentioned below:

DAE Participated in the "Government Achievements & Schemes Expo- 2024" on 20th - 22nd July, 2024 at Pragati Maidan, New Delhi. The main objective of the Expo 2024 was to bring the government departments, boards, government agencies, financial institutions, autonomous bodies, PSUs, private sector etc. on one platform and provide them the opportunity to showcase their achievements, welfare policies, plans and activities. The expo also provides an interactive platform for various boards, autonomous bodies, corporations and PSUs.

DAE along with IGCAR, AMD and IREL participated in the International Conference on "Heavy Minerals & Lithium" for Energy Security (REES Series-2024) held on 29th-30th August, 2024 at Kochi, Kerala. The objective of REES 2024 was to serve as an apt platform for exchanging ideas, networking and furthering academic and applied knowledge of Heavy Minerals and Lithium base on interdisciplinary knowledge/experience for the development of value chain of heavy Minerals and Lithium in the Country and globally.



CMD, IREL, interacting with the delegates at the conference

A mega exhibition was organized at Udaipur, Rajasthan from 26th to 28th September, 2024 in which DAE participated along with BRIT. This "Mega Exhibition" provided a platform which focused on promoting and creating awareness about the advancements in radiation therapy equipment and techniques, radiopharmaceuticals, and initiatives towards Viksit Bharat. It also showcased the advancements in nuclear medicine, including diagnostic imaging techniques such as PET and SPECT to showcase the development of new radiotracers for specific medical conditions and highlight their applications in clinical practice.

School students being briefed at the mega exhibition held at Udaipur, Rajasthan

DAE participated in the 2nd Shinning Uttarpradesh - 24 from 27th to 29th September, 2024 at Varanasi, Uttarpradesh. DAE showcased it's technologies by setting up a DAE pavilion which was witnessed by large no. of audience.

World Food India (WFI) was organized by the Ministry of Food Processing Industries (MoFPI), Government of India from 19th to 22nd September 2024 at Pragati Maidan, New Delhi. DAE participated in the event by setting up a stall showcasing research and development efforts in the area of food and agriculture. The exhibits from Food Technology Division (FTD), BARC provided an overview about radiation processing of food, including its role in ensuring food security, safety and promotion of international trade. The exhibits from Nuclear Agriculture & Biotechnology Division (NABTD), BARC were pertaining to the improved crop varieties developed in BARC, productivity enhancement, waste management and newer technologies for agriculture.

Director, RRCAT explaining the nuclear power technologies to the NUJ journalists during the NUJ workshop conducted at RRCAT, Indore

DAE organized a three-day Journalists Workshop, at RRCAT, Indore during October 3-5, 2024 in collaboration with the NUJ (I) School of Journalism & Communication, Delhi. The objective of this workshop was to reach out to the general public in the right perspective through media. DAE had put up an exhibition on technologies for better quality of life. DAE, along with BARC, IGCAR, BRIT & RRCAT showcased its technologies.

30th Convention of Food Scientists & Technologists (CFoST) was held at Navi Mumbai from 19th -21st December, 2024. DAE participated in the convention along with BARC. BARC technologies were showcased to the visitors at the DAE pavilion.

"Rise in India 2025, Ghaziabad", exhibition event was organized from 20th to 22nd February 2025 at HRIT Group of Institutions, Ghaziabad, Uttar Pradesh to make people aware about the schemes, policies & initiatives of the Government in different fields. Shri Anil Agrawal, M.P., Rajya Sabha, Uttar Pradesh inaugurated the 3-day event and visited the DAE exhibition stall. The stall showcased plethora of technologies created by DAE & GCNEP for societal benefits in various fields. DAE exhibition stall displayed and disseminated the societal benefits of the DAE technologies.

Aligned with the vision of Aatmanirbar Bharat Abhiyan, "Visual Myths", a mega exhibition 'Radiant Jharkhand' was organized at Hotel Ramada, Jamshedpur. The exhibition was held from 20th to 22nd February, 2025.The exhibition was inaugurated by Honourable Member of Parliament Shri Bidyut Baran Mahato. DAE participated in the exhibition along with UCIL to spread awareness regarding the nuclear energy sector, achievements and initiatives in the nuclear sector. Awareness about nuclear energy, ongoing activities of DAE, upcoming projects, CSR activities, employment opportunities were provided to the visitors at the DAE pavilion.

DAE along with BARC participated in the "Pragatishil Chattishgarh - Unnati ki aur Ek Pahal" exhibition organized from 22nd-25th March, 2025. More than 1000 visitors including progressive farmers, students and young entrepreneurs visited DAE stall and appreciated the significant contributions made by DAE

Visitors being briefed about DAE technologies at the exhibition

for societal benefits. BARC representatives interacted with the guests and educated them about the various technologies, which included the flagship crop improvement programme and the Nisarguna-Biogas plant. DAE activities were well-appreciated by the dignitaries and farmers who attended the event. Notably, the DAE stall also received the Best Stall Award.

DAE along with Atomic Minerals Directorate for Exploration and Research (AMD), Northeastern Region, Shillong and Dr Bhubaneswar Borooah Cancer Institute (BBCI), Guwahati participated in the Government Development Schemes Expo-2025 organised by Bharat Events Pvt. Ltd. at Maniram Dewan Trade Center, Guwahati during March 17-19, 2025. At the Expo, DAE's activities were explained to the visitors which included non-power applications such as agriculture, healthcare, food irradiation, etc. Shri Atul Bora, Minister of Agriculture, Horticulture, Excise, BP&D, IAA, Government of Assam and Shri Urkhao Gwra Brahma, Minister of Handloom, Textiles & Sericulture, Soil conservation, Welfare of Bodoland, Government of Assam visited the DAE stall. Around 200 visitors per day from different Schools, Colleges, Villages visited the DAE stall.

BRIT in association with Assam Medical College Hospital (AMCH), Dibrugarh organized "Awareness Programme on Non-Power applications of Nuclear Energy (APNANE-2024)" at Oil Lecture Hall Complex, Dibrugarh, Assam on 22.11.2024. The program was attended by more than 120 delegates including medical practitioners and university teachers. The programme was inaugurated by Mr Arijit Mahajan, IAS, SDO, Dibrugarh in presence of Shri Pradip Mukherjee, Chief

Awareness Programme on Non-Nuclear Applications of Nuclear Energy (APNANE-2024) Organized by BRIT and Assam Medical College Hospital, Dibrugarh

Executive, BRIT and Prof Reema Nath, Vice Principal, AMCH.

A National Conference on Industrial Safety & Hygiene –Zero Incident Vision (IndSHIV-2024) was organized by BARC from 18-20 Jan, 2024 at DAE Convention Centre, Mumbai. HWB officials participated in conference by putting an exhibition stall and showcased its products & activities to various communities and demonstrated the achievements and accomplishments of HWB. Visitors have evinced keen interest in our diversified activities especially about O-18 water, DDW and NMR solvents. A talk on Case studies: "Let's learn from other's mistakes" was delivered. It covered various unusual occurrences at different HWPs. The lecture was well-received by the delegates.

Visit of the Chief Guest CMD, UCIL along with CE, HWB and other dignitaries to HWB Stall

The 5th International Conference on Reliability, Safety and Hazard -2024 (ICRESH-2024) was organized by BARC, Mumbai and Society for Reliability and Safety, Mumbai jointly at DAE convention Centre, Mumbai. HWB officials participated in conference by putting an exhibition stall and showcased its products

manufactured across 7 plants / facilities. Students from educational institutions and delegates and professionals from all over India belonging to different units of DAE and other Governmental organizations like ISRO, DRDO, Indian Navy visited the stall to learn more about activities of HWB and DAE.

On October 2024, DAE hosted its inaugural Conclave at NISER, Bhubaneswar as part of its Platinum Jubilee Celebrations, commemorating decades of scientific excellence and unveiling its vision for the future. The event showcased a wide range of DAE technologies designed to benefit society, young researchers, industries, and healthcare professionals. The Heavy Water Board (HWB) actively participated in the exhibition, presenting its cutting-edge products and innovative technologies utilized in the production of Heavy Water and specialized materials essential for both the front-end and back-end processes of the closed Nuclear Fuel Cycle. This participation highlighted HWB's pivotal role in advancing India's nuclear energy program and its commitment to technological innovation for societal advancement.

HWB presence at DAE Conclave – 2024

The talk titled 'Heavy Water Technologies and Diversified Activities' delivered at the DAE Conclave illuminated HWB's extraordinary journey toward making India self-reliant in Heavy Water production. It traced the evolution from dependence on imports to becoming a global exporter and highlighted HWB's strategic foray into diverse activities beyond its core mandate.

The presentation underscored HWB's remarkable achievements in developing and producing advanced materials and technologies, including organo-phosphorus solvents, enriched boron carbide pellets, and nuclear-grade sodium, to meet DAE's stringent requirements. Additionally, it showcased HWB's pioneering work in non-nuclear applications such as Heavy Water, deuterium gas, Oxygen-18, deuterium-labeled compounds, and Deuterium Depleted Water, among others.

In recent years, HWB has expanded its horizons, spearheading cutting-edge technology development and demonstration projects for recovering critical materials like gallium, cobalt, nickel, and helium, as well as advancing hydrogen production on various bench and pilot scales. This talk not only celebrated HWB's legacy of innovation but also highlighted its pivotal role in driving India's technology.

The Public Awareness Cell at VECC conducted lecture on Career Opportunities in DAE for students. Students from different schools of Kolkata, visited VECC. VECC also celebrated the National Science day which was organized on 28th Feb, 2024. National Environment Day was celebrated on June 05, 2024, involving 60 students of various schools and colleges in and around Kolkata and trainee students of VECC.

TIFR celebrated National Science Day on Feb. 25, 2024, allowing students and general public to visit the institute. More than 1000 persons comprising school/college/university students and the general public attended the event. The day-long programme consisted of popular talks on some of the advanced topics in scientific research being pursued at the institute (such as quantum computing, advances in chemotherapy, green chemistry, stellar formation, cell biology etc.), exciting science demonstrations, visits to the state-of-the-art laboratories and a new 'DIY arcade' in TIFR lawns with easy-to-perform experiments by the participants.

TIFR strived to share the research done at TIFR with the public at large, especially students. Several programs were organized for the public to convey the overall importance of science, and the joy of discovery and research. 'Chai and Why?' sessions were held regularly at Prithvi Theatre, Juhu and Ruparel College, Matunga. Six Chai and Why? sessions were organized during the period reaching out to 3000 participants.

'Neuroscience Summer Camp', a collaborative event with the Centre for Brain and Mind, was organized

from 15 to 17 May, 2024 at NCBS, Bengaluru. The camp was aimed at the children of non-scientific staff at NCBS. The camp covered various areas of neuroscience, including the neuroscience behind illusions, model organisms and mental disorders. Fifteen students from the 8th, 9th, and 10th grades participated in the summer camp.

Gender in/of Science podcast (a joint initiative with Archives@NCBS) was released on 21 May, 2024. It is a video podcast series conceptualized and hosted by Prof. Gita Chadha, Sociologist and Obaid Siddiqi Chair (2023-24) at NCBS, Bengaluru.

NCBS-TIFR Communications Team participated in the event 'Dengue Warriors Education Series: Bengaluru's Awareness Program' on 24th July 2024. The event was organized by the Rockefeller Foundation-Alliance for Pathogen Surveillance Innovations-India in collaboration with the Bruhat Bengaluru Mahanagara Palike (BBMP)'s Dengue Warrior Program, along with the BeST cluster, to offer education and awareness to school children for long-term impacts.

'5th Instalment of Tinkle Comic Series featuring NCBS faculties' featuring Dr. Anjana Badrinarayanan was released on October 04, 2024.

TIFR Centre for Applicable Mathematics, Bengaluru conducted a summer research program for undergraduate students from across the country. A few faculty members were involved in the summer students program called SWIM (Summer Workout in Mathematics) which was organized jointly with Bengaluru Planetarium. The primary purpose of SWIM is to emphasize the importance of learning mathematics by solving problems, understanding examples, and discovering proofs and counter examples.

IPR has completed Bhojpuri and Filipino translation of the comic book titled "The wonderful world of Plasma". Currently the comic is available in English, 14 Indian languages and 5 foreign languages.

At IPR, the National Science Day was celebrated during 10-11 Feb, 2024. A total of 445 participants from 44 schools participated in this event.

IPR conducted various academic visits and off-campus exhibitions wherein students and teachers from eminent educational establishments participated in the academic visits. A popular talk on 'Introduction to Plasma' was organized at Gujarat Vidhyapeeth on National Space Day.

"Science at the Sabha" is a set of four public talks on different aspects of science and is part of the Institute of Mathematical Sciences, ongoing program of outreach to the general public. IMSc conducted the 7th edition of this flagship event in February. The event was attended by 500-700 people. The talks were aimed at anyone with an interest in science, irrespective of age or background.

Events

On 26th Feb, 2024, HWB organized a Theme meeting on "Amrit Kaal Roadmap of Heavy Water Board" at DAE Convention Centre, Mumbai to discuss and solicit suggestions from experienced technocrats to carry forward the mandate given by DAE in an effective way. Chief Guest of the programme, Dr. A. K. Mohanty, Secretary DAE & Chairman AEC inaugurated the theme meeting in presence of Guest of Honour, Shri B. C. Pathak, CMD, NPCIL and Shri S. Satyakumar, Chairman & Chief Executive, HWB. Former Chief Executives of HWB and other senior officers of various DAE units have also participated. Dr. Mohanty, in his speech appreciated the accomplishments of HWB in production of Heavy Water and specialty materials. He specifically mentioned HWB's achievement in producing medical grade Oxygen-18 enriched water first time in India.

The second session of the theme meeting included presentations by HWB officials on topics like "Reactor Input Material and Offshoots", "Developmental Activities of HWB", and "Non-Nuclear Applications of Heavy Water and Deuterium Depleted Water" followed by panel discussion. On this occasion, Heavy Water Board also commemorated its 36th Foundation Day. A good number of employees and their family members enthusiastically participated in cultural programme, which followed the theme meeting.

On 26th January 2024 Dr. A.K. Mohanty Secretary, DAE & Chairman, AEC launched the "DAE

Dr. A.K. Mohanty Secretary, DAE & Chairman, AEC launched the "DAE Digital Library" on 26th January 2024 at DAE Headquarters, Mumbai

Digital Library" which has the diverse collection of books authored and published by DAE experts. Dr. Mohanty highlighted the transformative nature of the initiative as a crucial step in digitizing the extensive knowledge resources of DAE and use of latest technology to provide its access for continuous learning. During the event, Hindi version of the book "Unreasoned Fear of Radiation" and Hindi version of the picture book "Enrico Fermi: a complete Physicist" were also unveiled, enriching the library's offerings.

The Indian team of four students secured 1 Gold and 3 Silver medals in the 35th International Biology Olympiad (IBO), held in Astana, Kazakhstan from July 7-13, 2024. In the 54th International Physics Olympiad (IPhO) 2024, held in Isfahan, Iran, from July 21-29, 2024, the Indian Team of 5 students won 2 Gold and 3Silver medals. In the 56th International Chemistry Olympiad (IChO) 2024, held in Riyadh, Saudi Arabia, from July 21-30, 2024, the Indian Team of 4 students won 1 Gold, 2 Silver and 1 Bronze medals. Indian students excelled with 4 Gold, 1 Silver, and 1 Hon Mention at the International Mathematics Olympiad (IMO) 2024 held in Bath, UK, in July 2024. This was India's best performance to date at the IMO, and the team ranked 4th in 108 participating countries. The Indian team of five students secured one gold medal and four silver medals at the 17th International Olympiad on Astronomy and Astrophysics (IOAA) held in Rio de Janeiro, Vassouras, Brazil, from August 17 to 26, 2024. The team also secured the eighth position among 52 participating countries.

Press Releases

Square Kilometre Array

The Government of India has accorded its approval for India's participation in the international mega science project, Square Kilometre Array (SKA), at an estimated cost of 1250 Cr. This approval covers funding support for the construction phase of the international SKA Observatory (SKAO) spread over the next 7 years. The project will be jointly funded by the Department of Atomic Energy (DAE) and Department of Science and Technology (DST), with DAE as the lead agency. The Indian participation in SKA is a nationwide, inclusive project led by a consortium of more than 20 academic and research institutes (with NCRA-TIFR as the nodal institute).

Deployment of 10 numbers of Water Purification Units in Railway Platform, Mumbai Division, Central railway

As a part of technology demonstration, while providing safe drinking water to the common masses, BARC has conceived a Project on deployment of water technologies in several parts of India. Under this project, 10 nos. of 75/500 LPH capacity BARC technology-based water purification units are installed & commissioned by M/s. Osmotech Membranes Pvt. Ltd. Rajkot (BARC technology licensee) – 3 units of 750 LPH capacity at CSMT, Mumbai; 4 units of 500 LPH capacity at LTT, Mumbai; 2 units of 500 LPH capacity at Dadar Station, Mumbai & 1 unit of 750 LPH capacity at Dockyard Road Station, Mumbai, as a polit project.

Bilateral meeting between India & Russia was held to review the progress of the construction of KKNPP units – 3 & 4.

Dr. A.K. Mohanty, Chairman, AEC and Secretary, DAE and Dr. A.E. Likhachev, Director General, ROSATOM visited Kudankulam Nuclear Power Projects (KKNPP) on 7th and 8th February 2024. They expressed satisfaction on the operating performance of KKNPP Units – 1 & 2 and discussed ways and means to expedite the ongoing construction of KKNPP Units-3 to 6. The delegations also discussed strengthening of ties in other areas of Civil Nuclear Cooperation. On 8th February, 2024, Dr. Mohanty and Dr. Likhachev signed the amendment to the Inter-Governmental Agreement of 2008.

Dr. Mohanty and Dr. Likhachev signed the amendment to the Inter-Governmental Agreement of 2008

The Honourable PM visits Kakrapar Atomic Power Project in Gujarat, dedicates to the nation two 700 MWe indigenous nuclear reactors, KAPP-3 and KAPP-4

Honourable PM Shri Narendra Modi visited Kakrapar Atomic Power Project (KAPP) of the Nuclear Power Corporation of India Limited (NPCIL), Department of Atomic Energy (DAE), on February 22, 2024, and dedicated KAPP-3 and KAPP-4, the two largest frontrunning nuclear reactors among the fleet of 700 MWe indigenous Pressurised Heavy Water Reactors of NPCIL, to the nation. Speaking on the occasion, the honourable Prime Minister said that the role of nuclear power in electricity generation is going to increase in 21st century India, and it is a matter of pride that India is AtmaNirbhar in this advanced technology.

PM witnessed the historic "Commencement of Core Loading" at India's first indigenous Fast Breeder Reactor (500 MWe) at Kalpakkam, Tamil Nadu

Honourable PM Shri Narendra Modi is being briefed by CMD, NPCIL during his visit to KAPP in Gujarat

In a historic milestone marking entry into the vital second stage of India's three stage nuclear program, Prime Minister, Shri Narendra Modi witnessed the commencement of "Core Loading" at India's first indigenous Fast Breeder Reactor (500 MWe) at Kalpakkam, Tamil Nadu. The honourable Prime Minister took a tour of the Reactor Vault and the Control Room of the Reactor. He was briefed about the salient features of this reactor.

Breakthrough Nutraceutical AKTOCYTE by the Department of Atomic Energy Set to Transform Cancer Care

In a breakthrough towards enhancing the quality of life for cancer patients undergoing radiotherapy, scientists from Department of Atomic Energy and M/s. IDRS Labs Pvt. Ltd. Bengaluru have joined hands to develop AKTOCYTE tablets. Experts from Bhabha Atomic Research Centre, Mumbai; Tata Memorial Hospital, Mumbai; Advanced Centre for Training Research and Education in Cancer, Navi Mumbai collaborated with the IDRS Labs with a primary aim of minimizing the side effects of radiotherapy. The AKTOCYTE tablets have shown remarkable results, particularly in pelvic cancer patients suffering from radiotherapy-induced Cystitis (Blood in urine). Patients treated with AKTOCYTE tablets demonstrated an extraordinary recovery, eliminating the need for surgical removal of the urinary bladder. The tablets, designed as an adjuvant to cancer radiotherapy, regenerative nutraceutical, immunomodulator, and antioxidant, mark a significant advancement in cancer care.

Department of Atomic Energy Celebrated the Birth Centenary of Dr. Homi N. Sethna

DAE and its constituent units had joined hands to celebrate the birth centenary of one of India's atomic energy pioneers, Dr. Homi N. Sethna. Dr. Homi N. Sethna (1923-2010), played multiple roles during his illustrious career. Starting as a General Manager of Indian Rare Earths in 1949, he led the Chemical Engineering programmes in the Atomic Energy Establishment Trombay (now BARC) as well as the

concerned public sector units in DAE. He oversaw the building of major facilities in Trombay, including Thorium Plant and Uranium Metal Plant during the period 1950-1960. Dr. Homi N. Sethna initiated and led the nuclear fuel cycle and heavy water segment of India's atomic energy programme with great success. DAE organized a one-day program in Anushaktinagar, Mumbai on December 07, 2023 to mark the birth centenary of Dr. Homi N. Sethna. The event comprised technical talks by experts and reminiscences from eminent persons from DAE, followed by a cultural programme.

India Celebrates Breakthrough Prize in Fundamental Physics Awarded to LHC Experiments

The 2025 Breakthrough Prize in Fundamental Physics is awarded to co-authors of publications based on CERN's Large Hadron Collider Run-2 data released between 2015 and July 15, 2024, at the experimental collaborations ATLAS, CMS, ALICE and LHCb. The $3 million prize is allocated to these four experiments at CERN and will be used by the collaborations to offer grants for doctoral students from member institutes to spend research time at CERN, giving the students experience working at the forefront of science and new expertise to bring back to their home countries and regions. The Breakthrough Science Award 2025 is a shared honour—celebrating not just the ALICE and CMS collaboration but the spirit of international science, powered by dedicated individuals and visionary support systems. As ALICE and CMS enters a new era, India stands proudly as both a contributor and a beneficiary—fueling discoveries that may forever reshape our understanding of the universe.

Dr. Rajagopala Chidambaram, Renowned Scientist and Former Principal Scientific Adviser and Secretary, Department of Atomic Energy, and Chairman, Atomic Energy Commission, Passes Away

Dr. Rajagopala Chidambaram, an eminent physicist and one of India's most distinguished scientists passed away on 4 January 2025 at 3:20 AM. Dr. Chidambaram's unparalleled contributions to India's scientific and strategic capabilities and his visionary leadership in science and technology will forever be remembered. Dr. Chidambaram held numerous prestigious roles throughout his illustrious career, including Principal Scientific Adviser to the Government of India (2001–2018), Director of the Bhabha Atomic Research Centre (1990-1993), Chairman of the Atomic Energy Commission & Secretary to the Government of India, Department of Atomic Energy (1993-2000). He was the Chairman of the Board of Governors of the International Atomic Energy Agency and (1994–1995). He also served as a member of the IAEA's Commission of Eminent Persons, contributing to the organization's vision for 2020 and beyond. Dr. Chidambaram played a pivotal role in shaping India's nuclear capabilities. He played an integral role in the nation's first nuclear test in 1974, and led the Department of Atomic Energy team during the Pokhran-II nuclear tests in 1998. His contributions established India as a nuclear power on the global stage. The nation mourns the loss of a true visionary. Our heartfelt condolences go out to his family and loved ones during this time of grief.

INTERNATIONAL RELATIONS

India, a founding member of the Board of Governors (BoG) of the International Atomic Energy Agency (IAEA), continued to take active part in policy management and programmes of the IAEA. India was represented on a number of IAEA Committees, including those on safety, safeguards, nuclear radiation, nuclear engineering and application, nuclear law etc. India hosted several IAEA Workshops, Technical Meetings etc., and offered the services of its experts under the IAEA Technical Cooperation programme in a number of fields. India made contributions towards Innovative Nuclear Reactors and Fuel Cycles (INPRO), Technical Cooperation Fund (TCF) and Regular Budget of the IAEA.

India's participation in the 68th Annual session of the IAEA General Conference, Vienna during 16-20 September 2024

Considering the primacy of the IAEA General Conference in India's international engagement in the field of Civil Nuclear Energy, Chairman, AEC and Secretary, DAE led the Indian delegation comprising of Director, BARC, Chairman, AERB to the IAEA 68th General Conference which was held at Vienna, Austria

from 16-20 September, 2024. In addition to this, the Ambassador and officials from Indian Permanent Mission in Vienna, participated in the event.

Bilateral meetings with our international partners

(a) On the sidelines of the 68th General Conference, Chairman, AEC had bilateral meetings with DG, IAEA, DG, ITER and delegations from Argentina, Australia, EURATOM, France, IAEA, Russia, U.A.E, U.K., USA and Vietnam.

(b) A Joint Working Group Meeting on GCNEP between India and United States was held on 12-13 June, 2024. Both the parties discussed on holding meetings coordinate events, agendas and exchange proposals. A notional annual schedule of all agreed upon events/meetings were agreed upon by both sides to move forward.

(c) An Indo-US Civil Nuclear Energy Working Group (CNEWG) and Technical Task Group meeting was held during 25-27 June, 2024 at DAE. The mail objectives of the meeting were to discuss and identify opportunities for bilateral cooperation between US and India in civil nuclear energy sector.

(d) A meeting was held between H.E. Mr. Mariano Causino, Ambassador of Argentina to India along with his delegation and Indian side headed by Head, NCPW on 26.07.2024, at OYC, DAE, Mumbai. The mail objectives of the meeting was to discuss and identify opportunities for bilateral cooperation between Argentina and India in civil nuclear energy sector.

(e) A meeting was held between India and Russia on 12.08.2024, at NCPW Conference Room, OYC, DAE, Mumbai. Indian side was headed by Head, NCPW, DAE and Director of Projects in South East and South Asia, ROSATOM Energy Projects (REP) from Russian side. The main objectives of the meeting were to discuss and identify opportunities for bilateral cooperation between Russia and India in civil nuclear energy sector on Small Modular Reactor (SMR).

(f) A meeting was held between India and Russia on 25.09.2024 at New Delhi. Indian side was headed by Head, NCPW, DAE and Deputy Director of International Cooperation Department, Rosatom State Corporation from Russian side. The main objectives of the meeting were for discussion on the text of the draft MoU between India and Russia on deepening the cooperation in the field of peaceful uses of Atomic Power and related high technologies.

(g) IAEA has established the World Fusion Energy Group (WFEG) to drive the discussion on fusion energy development forward by bringing together public and private sectors, industry, research organizations, academia and civil society in a holistic and collaborative setting to accelerate the fusion energy journey from research and development to demonstration and ultimately deployment. In this regard, the Government of Italy and the IAEA jointly hosted the Inaugural Ministerial Meeting of the World Fusion Energy Group (WFEG) on 06.11.2024 in Rome wherein Chairman AEC and Secretary, DAE has delivered a national statement on behalf of India.

(h) A meeting between Indian side and El Salvador side was held virtually on 07.11.2024 wherein the discussions were held on cooperation on civil nuclear energy and technology.

The following Agreement/ MoU were signed

(a) On the sidelines of the 68th General Conference held during September 16-20, 2024, an Amendment to renew the Memorandum of Understanding between Department of Atomic Energy (DAE) and Commissariat A L'Energie Atomique et Aux Energies Alternatives (CEA), France has been signed by Dr. Ajit Kumar Mohanty Secretary, DAE and from the France side by Mr. Francois Jacq, General Administrator of the CEA, France on 17th September, 2024. This MoU is concerning cooperation with Global Centre for Nuclear Energy Partnership (GCNEP) in the Fields of Peaceful Use of Nuclear Energy.

(b) A bilateral arrangement between the Atomic Energy Regulatory Board of India (AERB) and The United States Nuclear Regulatory Commission (USNRC) for the Exchange of Technical Information and Cooperation in Nuclear Safety and Nuclear Radiation Protection Matters, was signed by Mr Christopher T. Hanson, Chair, USNRC on 31.10.2024 and by Mr Dinesh Kumar Shukla, Chairman, AERB on 18.11.2024 through postal exchanges.

Visit organized by External Relation Division

A visit of 34 Foreign Diplomats from 32 different countries was organized from 21-22 January 2025 to Tata Institute of Fundamental Research (TIFR) and Bhabha Atomic Research Centre (BARC), Mumbai as part of the 5th Annual Disarmament & International Security Affairs (D&ISA) Fellowship Programme at the Sushma Swaraj Institute of Foreign Service (SSIFS) Campus New Delhi. The above diplomats visited TIFR and various facilities in BARC. This programme was organized for familiarizing the Foreign Diplomats with DAE's organization, functioning, objectives, capabilities, achievements etc.

Global Centre for Nuclear Energy Partnership (GCNEP) is being established as the sixth R&D unit, under the aegis of the Department of Atomic Energy (DAE) at Kheri-Jasaur, Bahadurgarh, Haryana. Phase-I of the Centre has been operational since April 2017.

GCNEP successfully conducted several programs during the period from April to December 2024. These included IAEA International Training Course on the Security of Non-Nuclear Radioactive Material in Transport (April 2024), Indo-US Joint Working Group (9th JWG) Meeting (June 2024), Indo-US Technical Meeting on Advances in Material Characterization and their Applications in Radiological Events (June 2024), Indo-US Technical Exchange on AC&D Central Alarm Station Software Simulation (July 2024) and Indo-UK Technical exchange meeting on Nuclear Security for A/SMR (December 2024). In addition, GCNEP has participated in various exhibitions promoting the applications of radio-isotopes and radiation technologies for the societal benefits such as 'Mega Science Exhibition' at Pragati Maidan, New Delhi (July 2024). Additionally, it is planned to participate in the upcoming exhibition 'Rise in India 2025', scheduled to be held in Ghaziabad, Uttar Pradesh, in February 2025.

At campus site, the development work including internal road network, construction of warehouse, maintenance office building and other support facilities are in progress. At Township site, construction of pre-school cum crèche facility building is in progress. Additionally, Guest House Block-B along with dining and recreation facilities and the dispensary, has been furnished in the township. To augment the laboratories under the five schools of GCNEP, various systems, equipment and instruments have been procured and are now operational. The field Facility for Nuclear Agriculture under SARRT is in advanced stage. Infrastructure work is in progress to equip the Campus and Township buildings with essential facilities such as the auditorium, IT/AV systems, e-surveillance, conference rooms, e-classrooms, laboratory equipment, etc.

Several programs are scheduled during the last quarter of FY2024-25 including Management Development Programme for Scientific Officers (January 2025), Indo-UK Technical Meeting on Nuclear Security for Decommissioning (February 2025) and Indo-US Workshop on SMR (March 2025). The inauguration of 'S N Bose Building' at GCNEP by 'Director General' of the International Atomic Energy Agency (IAEA), Mr. Rafael Mariano Grossi, is also scheduled for March 2025. As part of this event, the launch of a Six-Month Certificate Course on Nuclear Engineering is also scheduled. This course is aimed to provide an in-depth understanding of nuclear science, reactor physics, nuclear power plants, radiation safety, nuclear security and modern applications of nuclear technology.

International Co-Operation

IREL UKTMP JV

Joint Venture (JV) Agreement was signed on 04.11.2024 between M/s IREL (India) Limited and M/s Ust-Kamenogorsk Titanium and Magnesium Plant JSC, Kazakhstan (UKTMP) for production of Titanium Slag in India and incorporation of company by the name 'IREUK Titanium Limited' is in process.

REE (Rare Earth Element) Exploration at Khour Grama Village in OMAN

IREL has entered into MoU with Sultanate of Oman for Co-operation on Rare Earths. Further prospecting planned at Khour grama deposit, the potential REE prospect. Site activities were undertaken in month of October 2024. Lab analysis of geological samples collected during field work is underway.

IREL TAMIN JV

Joint Venture (JV) Agreement entered with Tamil Nadu Minerals Limited (TAMIN) on 29.11.2023 for harnessing the mineral sand deposits viz. the Santakullam and Kudiraimozhi deposits in the state of Tamil Nadu. The JV Company 'IREL TAMIN Limited' has been incorporated on 28.06.2024.

IREL IDCOL JV

IREL-IDCOL Limited, a JV between IREL and IDCOL Ltd. has obtained Letter of Intent (LoI) for the Hrushikulya Bajrakot Brahmapur Deposit in June-2022. Terms of Reference (ToR) towards grant of Environmental Clearance (EC) received on 13.04.2024. EIA/EMP report preparation is under way.

BRIT embarked upon a new domain by exporting its commercial training services on ISO 11137 to an Australian conglomerate at Colombo, Sri Lanka.

CRISIS MANAGEMENT

The Crisis Management Plan of the Government of India, which was first issued by Cabinet Secretariat in 1987 and latest in 2019 (CMP-2019), has designated the 'Department of Atomic Energy' along with MHA as the Central Nodal Ministry/Department responsible for handling any nuclear or radiological emergencies (NRE) in public domain in the country. As a result, a "Crisis Management Group" (CMG) was constituted in the DAE in 1987. The National Disaster Management Plan-2019 of NDMA also identifies DAE as the lead department to provide technical support and expert guidance to deal with any NRE in the country. CMG-DAE has been entrusted the role of all the facets of preparedness, planning, capacity building and response to any NRE situation in the country. A network of 25 Radiation Emergency Response Centers (RERCs) has presently been established at 25 locations across the country to deal with any radiation emergency in public domain. The responsibilities of the RERCs are to provide field response comprising of radiation monitoring, radiological assessment, provide the technical inputs to CMG-DAE for decision making and provide technical advice to the first responders and the local authorities.

CMG-DAE also acts as National Contact Point under International Atomic Energy Agency's conventions of 'Early Notification' and 'Assistance' to which India is a signatory. CMG-DAE assumes the role of Disaster Management Cell (DMC) for DAE in any disaster like situations (due to natural or man-made cause) arising in any of the DAE units. DAE-DMC provides necessary support to the Disaster Management Cell of the affected DAE unit when a requirement arises for coordinating response / mitigation actions with the state/central agencies.

Availability of the Emergency Control Rooms (ECRs) located in Mumbai at two different places in Mumbai, which are backing-up one another, was ensured throughout the year. These control rooms, manned on round-the-clock basis and equipped with diverse means of communication; remained in contact with the various nuclear facilities in the country, the Ministry of Home Affairs (MHA) as well as with the International Atomic Energy Agency (IAEA) in Vienna. The Emergency Control Rooms of DAE are the National Contact Point for nuclear and radiological emergency.

India, through the Crisis Management Group (CMG), participated in five International Convention Exercises (ConvEx) conducted by the IAEA which are designed to assess and enhance the international Emergency Preparedness and Response (EPR) framework. CMG coordinated India's active and satisfactory participation in these exercises and provided exposure to personnel from NPCIL, BARC, and AERB through these exercises.

To maintain a high state of readiness of emergency plans, major nuclear facilities (nuclear power stations and heavy water plants) conducted various emergency exercises. CMG-DAE monitored/participated in the following exercises during 2024-25: Communication Exercises – 437; Fire Emergency Exercises – 88; Plant Emergency Exercises – 56; Site Emergency Exercises – 18; Off-Site Emergency Exercises – 06; and Other Radiation Emergency Exercises – 34.

SOPs for managing fire, flood, and security events at the DAE secretariat (part of DAE DMP part-2) were reviewed and finalized. The Sectoral Crisis Management Plan of the Ministry of Home Affairs (MHA),

titled as 'Response to NRE,' was reviewed by CMG-DAE and forwarded to MHA. During the review, it was advised to include an appendix on 'Guidance on Medical Management of NRE' in the SOP. Communication SOPs for DAE Emergency Control Room (SOP-1: Responding to any emergency message received by the DAE emergency control room from DAE facility, SOP-2: Movement of special shipment/spent fuel, SOP-3: Handling of other types of Emergency messages received by control room & SOP-4: Periodic testing of various testing links) were revised by CMG-DAE and approved by competent authority in the Department.

The IMPACT-NRE capacity-building program was conducted at Mahakumbh Mela Kshetra on January 2-3, 2025, in coordination with UPSDMA. More than 500 participants, including decision-makers, responders, and medical personnel, received training and awareness for handling radiological incidents. The program included table-top exercises and a joint mock exercise with NDRF and other stakeholders, simulating a hypothetical RDD scenario.

CMG-DAE deployed the required manpower and resources to provide coverage for response to any radiological incident during Mahakumbh Mela-2025.

Medical Professionals with Faculty and UPSDMA officilas during of IMPACT-NRE Program

Hands On Training of Radiation Detection Euipment during IMPACT-NRE Prog

Actions taken include: Preparation of a specific SOP for Mahakumbh-2025, outlining stakeholder roles and responsibilities; Preliminary radiation survey by DAE-RERT around the Mela Kshetra to establish baseline data; Deployment of an MRAL vehicle for continuous radiological surveillance; Deployment of radiation detectors/monitors and other necessary equipment; Deployment of 30 officers and staff from various DAE-RERCs, including the nodal RERC at BARC, on a rotational basis for the 45-day event; Deputation of Radiation Emergency Response Officers (REROs) to the Integrated Command Control Centre (ICCC); and Establishment of a temporary control centre at the HRI Guest House, Prayagraj, U.P.

CMG-DAE provided response and technical advice for 11 cases involving suspected/actual presence of radioactive material in the public domain.

VIGILANCE

The overall responsibility for vigilance in any unit of the Department of Atomic Energy rests with the Chief Vigilance Officer (CVO). To ensure effective functioning of the vigilance machinery, a senior level officer in each of the Constituent Units and Aided Institutions of the Department has been designated as part time Vigilance Officer/ Chief Vigilance Officer. In the case of Public Sector Undertakings of the Department, full-time Chief Vigilance Officer discharges these responsibilities.

Activities of the Vigilance section during the year-2024 included the followings:

a. Submission of 25 monthly/quarterly/annual returns to various authorities such as Central Vigilance Commission (CVC), Department of Personnel and Training (DoPT), and Central Bureau of Investigation (CBI).

b. Processing of 12 new Disciplinary cases.

c. Processing of complaints: 71 complaints were received from CVC (Including complaints received under PIDPI resolution) and 189 complaints have been received directly in the Department.

d. Detailed status of complaints handled during the year are as follows:

- Complaints forwarded to CVO/VO of respective Units for investigation and report : 53

- Signed complaints filed being non-specific /vague/general allegations : 67

- Signed complaints not confirmed by sender-Filed as Anonymous/Pseudonymous : 66

- Passed to CVO/VOs for appropriative action having no vigilance angle: 50

e. Vigilance clearances request received for various purposes were issued in respect of 10603 Group 'A' officers of various Units, Aided Institutions and PSUs as well as staff in the Secretariat.

f. Appointment of Vigilance Officer/ Chief Vigilance Officer of Constituent Units/ Aided Institutes in the Department.

g. Scrutiny of Annual Immovable Property Returns in respect of Officers and staff of DAE Secretariat.

h. Co-ordination between CVC and Units for conducting of CTE (Chief Technical Examiner) examination.

I. Work orders issued by DAE Secretariat were verified as a part of preventive vigilance activities.

As per the directives of Central Vigilance Commission, "Vigilance Awareness Week" is observed every year. Accordingly, "Vigilance Awareness Week 2024" was observed in Department of Atomic Energy and its Constituent Units/PSUs/Aided Institutions from 28th October, 2024 to 03rd November, 2024 on the theme of "सत्यनिष्ठा की संस्कृति से राष्ट्र की समृद्धि / Culture of Integrity for Nations Prosperity".

The week commenced with administering integrity pledge by Director, Vigilance, DAE to the all employees of DAE Secretariat on 28.10.2024. A few of the important activities held during the week in which officers and staff of DAE actively participated were Quiz Competition, Poster Painting competition & Slogan competition. Prizes for the winners of the respective competitions were also distributed during the valedictory function held on 30.10.2024. Vigilance Awareness Week was also observed in the Constituent Units, Public Sector Undertakings and Aided Institutions of DAE.

As a prelude to VAW-2024, all Units under the administrative control of the Department had undertaken a three-month campaign from 16th August, 2024 to 15th November, 2024. As a part of the aforesaid campaign, the Department had organized "DAE 2nd Annual Vigilance Conclave on 21st and 22nd October, 2024 at DAE Convention Centre, Anushaktinagar, Mumbai.

OFFICIAL LANGUAGE IMPLEMENTATION

DAE and its constituent units are committed to effectively implement the Official Language Policy of the Government of India. This year, the Department undertook various activities to promote the use of Hindi, the official language, in the fields of nuclear energy and technology. Key achievements include the followings:

DAE honoured with Rajbhasha Kirti Pratham Puraskar

The Department of Official Language, Government of India, annually confers the First Prize of 'Rajbhasha Kirti Puraskar' to recognize outstanding implementation of the Official Language Policy. This national award is presented to Ministries, Departments, Public Sector Undertakings, and Institutions, categorized by those with fewer than 300 employees and those with more than 300 employees, based on their efforts to promote Hindi in official work.

DAE has been honoured with the Rajbhasha Kirti Pratham Puraskar for the year 2023-24. This award was presented on the occasion of Hindi Diwas, 14 September 2024, during a ceremony held at Bharat Mandapam, New Delhi, by Hon'ble Union Home Minister Shri Amit Shah. On behalf of the Chairman, the shield was received by Dr. Deep Prakash, Officer on special duty, DAE Branch Secretariat & Project Director, GCNEP. Other senior officials from various units of the Department also participated in the award ceremony. It is a matter of pride that this is the first time DAE has

In recognition of outstanding implementation of the Official Language Policy for the year 2023-24, the Department of Atomic Energy was awarded the First Prize in the Rajbhasha Kirti Puruskar. This prestigious award was presented by Hon'ble Union Home and Cooperation Minister Mr. Amit Shah to OSD, DAE, the representative of the Department of Atomic Energy, during the Fourth All India Official Language Conference held at Bharat Mandapam, New Delhi.

received the first-place award for Official Language Implementation. Notably, in the year 2021-22, the Department had received the second-place award in the same category, but this year the Department has established a new identity at the national level.

Platinum Jubilee Year of the DAE: Public Awareness Program Organized in Odisha

DAE is celebrating its Platinum Jubilee Year from August 2024 to August 2025, marking 70 years of excellence. As part of this milestone, the Department organized nationwide events. A notable public awareness programme was held in Odisha to educate the public about the importance and applications of nuclear energy.

These important public awareness programs were successfully organized in various educational and government institutions across Odisha from 27 January to 5 February 2025, in collaboration with National Institute of Science Education and Research (NISER), Institute of Physics (IOP) and IREL.

The main objective of these programs was to create awareness among the youth about atomic energy, its uses, and associated career opportunities, along with the Department's social contributions.

These programs were organized specifically for students and staff of the following reputed institutions such as Atomic Energy Central School, Chattrapur (Class IX students); Kendriya Vidyalaya, Chattrapur (Class IX students); Kalinga Institute of Social Sciences (KISS), Bhubaneswar (Class XI & XII students); Kalinga Institute of Social Sciences (KISS), Bhubaneswar (B.Sc. Honours students); Government Science College, Talcher (B.Sc. students); Sai International School, Bhubaneswar (Class XI to XII students) and Employees from 25 government departments located in TOLIC Bhubaneswar.

A 10-minute film on DAE highlighting its history and achievements was screened. Power Point presentation on the various activities and societal contributions of DAE was presented. Hindi competition was organized to evaluate the general knowledge and understanding of the students. Winners of the Hindi competition were felicitated with mementos and shields. The awareness campaign, supported by IOP, NISER, and IREL witnessed an active participation and cooperation from students and teachers, making it a great success.

Inspections and Achievements

Twelve constituent units DAE were inspected during this period. Additionally, eight offices of the Department were inspected by the Hon'ble Parliamentary Committee on Official Language.

The Committee reviewed the status of Official Language implementation and interacted with the officers. Reports based on these inspections were submitted to the Committee Secretariat.

As per the Official Language Act, 1963 and Official Language Rules, 1976 Rule 10(4), the use of Hindi in offices in Hindi-speaking states has been reviewed.

During the inspection, house magazines / newsletters published by units were reviewed for Hindi/bilingual content and reports were prepared with evaluation and suggestions.

Training programmes

A large number of seminars and lectures on various topics related to nuclear science and technology were organized. Souvenirs were also published in Hindi for some of these seminars.

Total 270 Hindi workshops were organized to provide training in "Noting and Drafting in Hindi" and other related topics. Approximately 5,700 officers and employees were trained through these programs.

Quarterly meetings of the Official Language Implementation Committee (OLIC) were held regularly at DAE Secretariat, and the progress of official language implementation was continuously monitored.

Quarterly progress reports and minutes of OLIC meetings from all units, public sector undertakings, and aided institutions were regularly reviewed.

Hindi Week/Fortnight/Month was celebrated in all the offices of the Department, during which various Hindi competitions were organized.

Training Programs Organized by the Administrative Training Institute (ATI) for the Official Language Cadre

ATI, Mumbai organized a two-day training program on "Parliamentary Official Language Inspection and Inspection Questionnaire" was organized on 29 and 30 August 2024 for Deputy Directors (Rajbhasha), Assistant Directors (Rajbhasha) and equivalent officers from various units of the Department.

An Orientation Program was conducted from 14th to 19th October 2024 for Junior and Senior Translation Officers and officers of equivalent ranks of different DAE units

Publications and Digital Presentation

The websites of DAE and its constituent units are in bilingual and they are being updated regularly. Digital versions of house journals/newsletters of various units of DAE were published in Hindi or bilingual.

Awards

Several units and offices of DAE across the country received 10 awards for excellent official language implementation from the Town Official Language Implementation Committee (TOLIC) and the Regional Official Language Implementation Office.

TECHNOLOGY TRANSFER

Technology Transfer & Collaboration Division (TT&CD), DAE is responsible for evaluation, advertising on website and transfer of spin-off technologies to Industry developed in all units of DAE located all over India. The major activities of TT&CD can be segmented into four broad domains: (a) Technology publishing and transfer, (b) Consultancy services, collaboration and patent, (c) Atal Incubation Centres (AIC) and (d) Advanced Knowledge and RUrban Technology Implementation Initiative (AKRUTI). The four subsequent sections below are to pronounce briefly the notable activities and achievements during the year 2024.

Technology publishing and transfer

Technology transfer is the process by which knowledge, intellectual property and capabilities developed at its centres/units and elsewhere, utilising DAE's resources are licensed to external entities including industries in the public and private sector, academia and State and Central Government organisations for commercialising the same during the licensing period. It is our mandate to actively pursue technology transfer so that benefits of the DAE programme are transferred to Indian industries, in both public and private sector. Technology Transfer &

Collaboration Division is the nodal agency in DAE through which state-of-the-art/import substitute technologies developed by Department of Atomic Energy (DAE) are made available to the end-users on non-exclusive basis with complete hand-holding support for commercialization. It interacts with all the Units of DAE, Government Institutions, Industries, and Educational Institutions for collaboration and technology commercialization. It offers an opportunity for employment generation and source of income for needy people. A total of 60 Agreements signed for Transferring 43 Technologies to 53 companies. The technologies are transferred after assessing the prospective transferees' current capabilities and interest in the commercialization. The table below is for ready reference about category-wise distribution of the technologies processed:

Technology category	Technologies (no.)	Transfer agreements (no.)	Companies (no.)
Advanced instrumentation	5	5	5
Agriculture & bioscience	9	19	14
Chemical	7	7	6
Engineering	10	11	7
Environment	4	7	11
Medical equipment	1	1	1
Radiation	2	2	2
Water	5	7	7

Total 9 new technologies have been assessed and released in public domain for advertisement in the year 2024. These are: 1. Low Dose Dosimeter (ANUDOSE) for food irradiation application, 2. AuRo Clean-Autonomous Robot for cleaning, 3. Indigenous Cold Atmospheric Pressure Plasma System: 10 MHz (ICAPPS-10), 4. Leakage Arresting Gripper for Piping, 5. Atmospheric pressure portable catalytic air plasma system for fast synthesis of aqueous Nitrate & Nitrite fertilizers, 6. A Kit for Detection of Intracellular Iron (Fe2+) in live cells, 7. Environmental Radiation Monitor (ERM), 8. Arsenic detection Kit and 9. Emergency in-situ advanced leakage arresting devices for piping technologies.

Apart from that, nine technology licenses were renewed. The repository of technologies available for transfer is continuously updated and obsolete technologies are removed or upgraded. The scope and application of the technologies available for transfer is uploaded to the website with photographs and procedure for transfer of the technologies has also been detailed. Communication to industry and entrepreneurs about the benefits of the technologies available for transfer is essential for successful commercialization. TT&CD is participating in such events to inform the industry as well as the end-users regarding the products and the technologies developed by DAE. The licensees were contacted for the commercialization status and active licensees list is displayed on BARC website with their contact details.

Consultancy services, collaboration and patent

BARC offers a wide range of services and consultancy to different DAE units and also to outside companies. TT&CD evaluates the costing of such services and consultancy offered by BARC. Usually agencies/ institutes in need of the service/ consultancy applies directly to TT&CD or to the concerned division offering the service/ consultancy who in turn would contact TT&CD for the costing of the same. TT&CD performs the calculation for costing of the services/ consultancy and the proposal is forwarded to TTSC for approval. Based on the approved costing, MBS raises the bill to the companies and institutes for payment. Altogether there are five different consultancy services provided by various divisions of BARC within DAE units & outside companies in 2024.

Memorandum of Understanding is another mechanism through which collaboration work is carried out by BARC along with national institutes and other government/non-government agencies. MoU committee has been constituted) for scrutinizing all such agreements between BARC and academia/industry. Head, TT&CD is the member secretary of the committee. TT&CD through this MoU committee looks after the execution of new MoUs, their extension, and finally closure of the MoUs after their completion. Altogether two MOUs have been signed in 2024.

As Innovations needs to be protected for ensuring its intellectual property rights, TT&CD coordinates the meetings for evaluation of the merit of the Patent proposals forwarded to DAE. The inventor division submits a patent proposal to TT&CD in a prescribed format with adequate evidences supporting the invention and thorough patent search for discarding its obviousness and establishing its novelty. TT&CD constitutes a patent sub-committee of experts in the field of the proposal with Head, TT&CD as the convenor of the committee. The committee reviews the proposals and often suggests corrections and changes to it. The revised draft of the proposal is again circulated amongst the committee members for their agreement to the final draft. The proposal is then sent to TTSC for forwarding it to DAE-IPR cell for further processing. Suitability of its filing and the countries in which the know-how is to be protected is decided at DAE IPR Cell. Nine patent proposals have been processed and forwarded to DAE IPR cell for further dealing out in 2024. TT&CD also plays a crucial role in ensuring returns from patent has been filed by inventors. It is also ensured that non-working patents are not renewed.

Atal Incubation Centres (AIC)

Atal Innovation Mission (AIM) NITI Aayog, is GOI's flagship initiative to create and promote a culture of innovation and entrepreneurship across the length and breadth of our country. AIC's have been started in four DAE units at BARC, RRCAT, IGCAR and IPR to take deep tech innovations to the industry for the benefit of society. This helps in Linking India's robust start-up eco-system to nuclear sector - setting-up of Technology Development cum Incubation centres.

AIC-BARC is BARC's arm for technology translation by which existing technologies at BARC are incubated for development in collaboration with industrial partners.

AIC-BARC has now released eight more technologies for incubation and many more are currently in pipeline. At present six technologies are undergoing incubation under the in-house category and three technologies are progressing in the collaborative incubation mode, three startup entrepreneurs are incubating BARC technologies. Two companies have already graduated from AIC-BARC.

Third Start-up Entrepreneurship workshop was organized by Atal Incubation Centre (AIC) – BARC, at DAE Convention Centre, Anushaktinagar, Mumbai on May 02, 2024. Technologies like Banana Health Drink, Debittered Karela Juice, Jamun /Strawberry /Chikkoo /IM Cube and Sea-food processing technologies, were introduced. From this workshop, we got one in-house technology incubation and one startup entrepreneur.

A brainstorming session on pathways of translating DAE Technologies via the start-up ecosystem was organized by Atal Innovation Mission and BARC together on May 26, 2024. Top delegates from academia, industry, incubator, government, finance institutions, prominent technology supporting social groups in presence of Secretary DAE, Director BARC, AIC governing board members, AIM officials and Incubation heads of DAE units attended.

First cohort of a 6-week start-up pre-incubation program (S-Prep) was started on May 29. 2024 to aspiring individuals and teams. Eight sessions have been completed and a total of 6 teams participated and at the end of the program, they pitched before BARC jury panel for deciding on the possible incubation opportunities and technical mentoring support. AIC-BARC and HBNI, Mumbai organized a productive Co-founder Pairing session for the second cohort of its Start-up Preincubation Program on Sunday, November 10, 2024 at HBNI Council Hall, Anushaktinagar.

To align with our Nation's key missions of Atmanirbhar Bharat and Viksit Bharat-2047, the DAE Incubation Centre of IGCAR functioning since October, 2020 has been registered as an Atal Incubation Centre with the name "AIC-IGCAR-FAST Foundation" on October 08, 2024 and as a 'Section-8 Company' under Companies Act, 2013.

At RRCAT, three technologies are at various stages under incubations and they are Liquid Nitrogen Based Transportable Refrigeration System- Sheetal Vahak Yantra (SHIVAY-V) with Tata Motors Ltd. Pune; Antimicrobial Photodynamic Therapy Device with Organ/ Application Specific Attachments with Dr. Cure and Care, New Delhi and Directed Energy Deposition based Laser Additive Manufacturing with three industrial entities – (1) Lokesh Machines Ltd., Hyderabad; (2) Vfuse Metal 4 Manufacturing Private Ltd., Bhopal and (3) Unnati 5D Manufacturing Systems Pvt. Ltd., Mumbai

Eight incubation agreements were signed during the period under report at RRCAT and they are High voltage DC Power Supply for Glass-based CO2 laser with Suwa Tech Photonics, Noida; Refurbishing of Commercial Sealed-Off CO2 Laser and Development of New Commercial Sealed-Off CO2 Laser Tube with Suwa Tech Photonics, Noida; Dynamic Argon Pressure System (DAPS) with Godrej & Boyce Manufacturing Company Limited, Mumbai; Special Type Adapter (STA) with Godrej & Boyce Manufacturing Company Limited, Mumbai; Gas Mixer with Electronics Devices Worldwide Pvt. Ltd., Mumbai; Build Preparation Software for Laser Powder Bed Fusion (LPBF) based Metal Additive Manufacturing with Samisan Tech Pvt. Ltd. Mumbai; Co-Axial Wire Feed Based Laser Additive Manufacturing Head with Advance Mechanical Services Pvt. Ltd. (ASM), Bengaluru and Fiber Grating Based Optical Sensors and Interrogation System with Lab To Market Innovations Private Limited, Bengaluru.

The following products developed jointly by AIC-π-Hub Indore and respective companies have been launched:

1. A 2 kW LAM DED metal 3-D printer by M/s VFuse Metals, Bhopal.

2. A special purpose welding machine capable of joining solid and porous pipes by M/s Metal and Membrane Pvt Ltd, Indore.

AIC π-Hub, Indore has signed MoU with Liquid Propulsion System Centre (LPSC) ISRO for the exploration of the development rocket engine technology using Laser Additive Manufacturing process for future reusable launch vehicle for Indian Space program.

At RRCAT, using 'SHIVAY' technology, a chassis mounted 32' reefer prototype has been developed by Tata Motors under technology incubation. The reefer, equipped with a 585 litre capacity Liquid Nitrogen (LN2) tank, was able to maintain the chamber temperature for ~ 35 hr.

AIC π-Hub organized one-day workshops titled "Spandan – nurturing young minds"

The workshop "Spandan – nurturing young minds" is designed to raise awareness about DAE activities and to foster innovation and entrepreneurship this workshop was carried out at RRCAT and also at 3 schools and institutes.

AIC π-Hub demonstrates RRCAT technologies during AMTECH-2024 at KPTO Bengaluru

At AMTECH Expo 2024, held in Bangalore on December 11 & 12, 2024, RRCAT showcased its cutting-edge research and development in metal additive manufacturing technologies, including 500 Watt Laser Powder Bed Fusion and 2 kW wire-fed Laser Directed Energy Deposition.

Exhibition stall arranged at various activities organized at RRCAT

AIC π-Hub put a stall to create awareness about RRCAT technology translation activities during 6th DAE National Union Journalists workshop during October 3-5, 2024, 40th DAE Safety & Occupational Health Professional Meet (DAE-SOHPM) during October 17-19, 2024, and 2-days workshop on Electron Beam Welding for Particle Accelerator and associated technologies during November 8 -9, 2024. More than 500 participants including academia, national labs, and industry visited the stalls and interacted about the technology translation opportunities through AIC π-Hub.

Advanced Knowledge and RUrban Technology Implementation initiative (AKRUTI)

DAE has launched Societal Initiative for utilisation of Non-Power Applications (NPAs) and Spin-off technologies in all the areas in the field of Science & Technology for improvement of rural and urban sector for promotion of Entrepreneurship. Under Vision 10 for social outreach and awareness, strengthening of AKRUTI Programme, which primarily provides access to BARC developed technologies to all sections at no cost for deployment in rural sector through AKRUTI Kendra. For Establishment of AKRUTI Kendra in this year 2024 eight agreements have been signed with Academic Institutes for deployment of BARC technologies in rural and urban areas. Under sustainability plan of AKRUTI Kendra, three licenses for eight technologies were disbursed and revenue of Rs. 2.5 Lacs was generated.

AKRUTI Kendra- MGU Agreement was signed between BARC and Mahatma Gandhi University, Kottayam

DAE has been putting constant endeavours for expanding AKRUTI programme at its various units all over India. On 14th Jan 2024, Kite Festival was organized by Welfare Club, NPCIL, Tarapur, during this KRUTIK Team from AKRUTI Kendra-Tarapur displayed various DAE-BARC Technologies and sell dried products manufactured by using Foldable solar Dryer (FSD) technology, revenue was generated through this activity. Under New AKRUTI policy and the awareness initiatives of AKRUTI Kendra - Tarapur and SVERI College, Pandharpur set up AKRUTI and RHRDF stall during the Shri Vitthal Wari in Pandharpur. The stall was operational from 15th to 19th July 2024. More than 30,000 people visited the stall and got awareness regarding BARC technologies useful for rural region. As part of awareness camp to school children, AKRUTI Kendra – Tarapur demonstrated the various BARC technologies to students of Homi Bhabha School, Tarapur.

Apart from the above major undertakings, DAE technology awareness & transfer meets, lectures on Technology transfer mechanism in DAE, outreach programmes and technology exhibitions have been organized by TT&CD throughout the year 2024. 'The Technology Powerhouse Books' for Agriculture, bio-sciences & food preservation, Environment & water technology, Advanced instrumentation & engineering, Chemical sciences & engineering, and Medical equipment & radiation technology, have been uploaded at DAE website.

List of AKRUTI Kendra

KRUTI Kendra	Name of AKRUTI Kendra	Place and State
1	Shri Vitthal Education and Research Institute (SVERI)	Pandharpur, Maharashtra
2	Brahmdevdada Mane Institute OF Technology (BMIT)	Solapur, Maharashtra
3	Raipur Institute of Technology (RITEE)	Raipur, Chattisgarh
4	Pt. Ravishankar Shukla University (PRSU)	Raipur, Chattisgarh
5	Uttar Banga Krishi Vishwavidyalaya (UBKV)	Cooch Behar, West Bengal
6	DR. D. Y. Patil Arts, Commerce and Science College	Pune, Maharashtra
7	Mahatma Gandhi University (MGU)	Kottayam, Kerala
8	Punyashlok Ahilyadevi Holkar Solapur University	Solapur, Maharashtra

INTELLECTUAL PROPERTY

DAE-IPR Cell constituted by the Department, works as a nodal agency for all Intellectual Property Rights (IPR) related matters including filing of patents within India and abroad for all the Units including Public Sector Undertakings and Autonomous Institutions under DAE. During this period, six DAE-IPR cell meetings were held, where twenty-two new patent proposals were reviewed along with one Patent Cooperation Treaty (PCT) international applications for filing the national phase applications.

The following table gives unit wise summary of patents filed, published, granted and the associated countries during the period:

No.	DAE Unit	Patent Applications			Countries
		Filed	Published	Granted*	
1	BARC	5	4	13	India, PCT, France, UK, Australia
2	IGCAR	1	1	3	India, Europe, Japan
3	RRCAT	2	1	2	India, PCT, USA
4	IPR	4	5	4	India
5	TIFR	3	2	2	India
6	SINP	0	0	1	India
7	AMDER	1	1	0	India
8	BRNS	1	1	2	India
	Total	17	15	27	

I. Patent Applications Filed

Seventeen patent applications were filed during this period. This includes fifteen in India and two PCT applications.

II. Patent Applications Published

Fifteen patent applications were published during the year. All the applications were published in India.

III. Patents Granted

During this period, twenty-seven of the previously filed patents were granted to the Department. These include twenty-one in India and one each in Australia, France, UK, Japan and USA.

IV. Patent Applications Referred to DAE u/s 4 and 39 of The Patents Act, 1970

During the year CY 2024, 105 Indian patent applications were referred to the Department by the Controller General of Patent, Designs & Trademarks (Department for Promotion of Industry and Internal Trade, Ministry of Commerce & Industry), under section 4 and section 39 of The Patents Act, 1970. These applications are referred to the department to assess whether the application is related to or useful for atomic energy, under section 20 of Atomic Energy Act, 1962.

INFRASTRUCTURE

Directorate of Purchase & Stores (DPS)

The Directorate of Purchase & Stores (DPS), a service organization of DAE, is the Centralized Agency entrusted with the responsibility of procurement of raw materials, plant and machinery, instruments, components, spares and other allied responsibilities for various Research & Development units as well as Industrial units of DAE. The requirement of DAE projects is of highly specialized in nature with stringent quality requirement. DPS played a key role in procuring the vital requirements of DAE units in a timely manner, resulting in meeting the larger end of Department i.e. attaining self-sufficiency in Nuclear Energy and in the field of Nuclear Technology. DPS is responsible for effectively implementing and executing the procurement activities in-line with the Public Procurement Policy of Government of India. DPS has promptly adapted to the changes and functions to best suit the dynamic material management requirements, such as procurement through Government e-Market, Central Public Procurement Portal, Preferential Purchase Policy, Implementing the Policy of Make in India & Global Tender Enquiry etc., in a uniform, transparent, systematic, efficient and cost-effective manner.

In addition to above, DPS provided services such as logistical support, receipt, accounting, transportation of material to various units, custom clearance of import, arranging insurance, export of goods, proper storage and issue of material as and when required by the units. Inventory management and the other allied activities are also rendered by this Directorate. DPS has also set its goals for Viksit Bharat@2047 and the same has been showcased in the DAE Conclave held at NISER, Bhubaneshwar. DPS strictly follow the Global Tender Enquiry norms by processing all the tenders of value less than 200 crores indigenously.

DPS has been successful in achieving 77.04% of its procurement through GEM. DPS has effectively processed 15981 indents and issued 20760 purchase contracts worth Rs. 2357.56 crore. Stores Unit of DPS has floated 169 sales tenders and released 159 e-sales orders. Under Swachhata Pakhwada, this Directorate disposed 7126 MT of scrap generating revenue of ₹ 12.25 Crore. Stores Unit have codified 37319 items this year thereby improving its inventory management.

For Capacity Building of Indigenous Suppliers and for anticipating more competitive and economic bids, also in compliance with Public Procurement Policy, DPS conducted vendor meets to enhance the participation of the MSE vendors in the Government tenders.

DPS being as a procurement agency, has received a large number of requests for imparting information and Grievances. DPS could reply all the RTI queries and grievances received through RTI & CPGRAMS portals respectively are within the time line.

General Services Organization (GSO)

The General Services Organization (GSO), a Service Unit of DAE, is providing the essential services of housing, health services, water supply, power supply,

solid waste management etc. to the employees of IGCAR, MAPS, BARCF, CISF situated at Kalpakkam and their families. There are two residential Townships, one at Kalpakkam and the other at Anupuram. About 4800 families reside at Kalpakkam Township and 2400 families reside at Anupuram Township. The townships are located 10 km apart from each other and approximately 12 kilometres from the DAE Plant Site. There are three Atomic Energy Central Schools, two Kendriya Vidyalayas, three Kindergarten Schools and a school for the mentally challenged (MEHATVA). Sports and Cultural Facilities are provided through the Nuclear Employees Sports and Cultural Organization (NESCO).

The primary mandate of GSO is to provide residential quarters & related infrastructure, health services, transport and civil, electrical and mechanical maintenance services. The Engineering Services Group and the Medical Group are the two Groups in the Unit.

The Engineering Services Group comprises of Security and Resource Management Group, Civil Engineering Division, Mechanical Services Division and Electrical Services Division. The Civil Engineering Division is involved in construction of residential and public buildings. It also takes care of civil maintenance, solid waste management and upkeep of gardens and greenery. Mechanical Services Division manages water and sewage treatment plants, air conditioning and refrigeration systems, ventilation, water-based fixed firefighting systems, as well as industrial, road, and fire safety operations across both townships. The Electrical Services Division takes care of complete electrical systems from design to O & M. Security & Resource Management Group comprising of Resource Management Division and Autoshop Division takes care of computer networking, e-surveillance, audio-visual system integration, computerization and providing telecommunication services. The Autoshop Division takes care of maintenance of department transport of IGCAR, BARC Facilities and GSO. In addition to providing the basic essential services to the residents, the Engineering Services Group supports the five schools in the Townships in terms of Augmentation of Infrastructure, maintenance and e-surveillance. Along with the endeavour to augment the technical capabilities, the spirit of service has also continued, and a number of steps have been taken to enhance the services and increase the satisfaction level of the residents.

DAE Hospital at Kalpakkam & Anupuram is covered under Contributory Health Service Scheme, is catering to the health services requirement of DAE/NPC/BHAVINI/AECS/CISF employees and their dependent family members including retired employees and the total beneficiaries are about 28,000. The 100 – bed hospital has all the important departments such as General Medicine, Paediatrics, Gynecology, Surgery, Ophthalmology, ENT, Orthopedics, Anesthesia, Radiology, Pathology and Dental and is equipped with basic facilities like Laboratory, X-ray, USG, ECG, TMT, Pharmacy etc. The dispensary at Anupuram township has been enhanced to a hospital with few departments such as radiology and Casualty in the new constructed hospital building during 2024. OPD consultation for Ortho, Pediatric, General Medicine, Ophthalmology, ENT, Gynecology, Psychiatry, Dermatology and Cardiology are available on routine/periodic basis. Further expansion plan is under progress and expected to be completed within a period of 3 years. A Clinic continues to function at IMSc premises, Taramani, Chennai for the benefit of CHSS patients residing in Chennai and surrounding areas. Another new clinic has also started functioning at DAE Nodal Center, Pallavaram, Chennai to further extent the facility for the benefit of CHSS patients residing in nearby areas such as Kancheepuram, Chengalpattu and Tiruvallur Districts. An Occupational Health Centre at IGCAR site is also functioning for the benefit of employees working in IGCAR and BARC Facilities Units.

Some of the significant works carried out during the year 2024-25 are mentioned below:

Augmentation of infrastructure for essential services

Construction of CHSS Dispensary at Pallavaram for the benefit of the retired employees staying in and around Chennai. Construction of AECS-IV school (Phase-1) building to meet the additional demand.

Water conservation and related activities

Providing and laying effluent water lines for garden in VE bungalow type clusters, Construction and

repair of Storm water drain at Sadras area in DAE Township, Kalpakkam, Construction of Rain water harvesting cum waste water stabilization pond at Sadras area in Kalpakkam.

Township Security related activities

Restoration of damaged Southern side & Northern side compound wall (1600m) with new wall (Phase- II) at DAE Township Anupuram.

Energy Conservation related activities

Establishment of roof top solar power plant 80kWp over public buildings in DAE Township. The combined annual production now stands at 0.69 MU (394 kWp), covering approximately 56.56% of the annual energy consumption of streetlights in Kalpakkam Township (KTS). Conversion of conventional fluorescent discharge luminaires to energy efficient LED luminaires in Public Buildings of Kalpakkam Township resulted in an annual energy savings of 100000 kWh. Energy saving of 11.5% was achieved in street light energy consumption of Kalpakkam Township by conversion of conventional gas discharge luminaires to energy efficient LED luminaires.

Communication Infrastructure Enhancement

Six ground-based mobile towers, three each in Kalpakkam and Anupuram Townships, were established thereby significantly improving communication capabilities in the region.

Safety related activities

Automatic Fire Alarm System was provided at various office and public buildings in GSO townships.

Upgradation of Autoshop

Autoshop facilities were upgraded with Latest Garage Equipment Including Starter/Alternator Automatic Tester, Exhaust Gas Extractor and Mobile Pneumatic Barrel Grease Filler.

Retrofitting of aged civil structures

In order to strengthen the structures, retrofitting works to Residential buildings in DAE Township, Kalpakkam was carried out.

Refurbishment of old apartments

To provide better amenities in line with latest norms of DAE refurbishment of 230 residential apartments was completed.

Health Services

About 660 patients were treated in OPD daily (1,62,508 per year) at Kalpakkam Township. Major services performed during the period are 377 major surgeries and 2,540 minor procedures, 4,69,740 Pathology lab investigations, 35,639 Physiotherapy treatments, 1,275 USG scans, 16,142 X-rays, 6,465 ECG, 1891 vaccinations, Echo – 3450 cases,TMT – 103 cases. Cervical cancer screening has been done for 332 patients and glaucoma screening done for more than 400 patients. A Dialysis Unit is also functioning through outsourcing with the capacity of 12 patients per day. On an average 315 patients are getting treatment in the OPD daily (77,230 per year) in the hospital at Anupuram Township. It is also providing day care facility of 5 beds for patients who require immediate treatment. All the patient's records are being maintained in digitally through introduction of HIMS. The clinic functioning at IMSc premises at Taramani, Chennai handled about 425 OPD cases and the total number of cases treated were about 4634 cases. The clinic at DAE Nodal Center, Pallavaram, Chennai extended the facility to about 400 OPD cases and the total number of cases treated were about 4192 cases. As part of expansion plan of medical facilities at Anupuram Township, the construction of buildings under Phase-II got completed in 2024 which included Casualty, in-patient facilities and new consultation rooms. Registration, Pharmacy, Radiology & new Casualty started functioning in the new building. A new digital radiography system was installed and commissioned.

Directorate of Construction, Services and Estate Management (DCSEM)

The mission of DCSEM is to provide support to DAE in transforming its vision into reality. Scientists, Technicians and other supporting Staff members of DAE family working in various units who are striving hard towards achieving the vision of the Department deserve

to be provided conducive environment and proper housing facilities in order to achieve functional effectiveness in their respective fields. As a service organization, DCSEM provides above services to various units of Department of Atomic Energy (DAE) for constructing and maintaining necessary infrastructure. DCSEM is involved in Planning, Designing, Engineering, Execution, Testing and Commissioning of Civil, Public Health, Electrical, Mechanical, Air-conditioning and Ventilation etc. It also carries out works for Housing, Hostels, Schools, Hospitals, Laboratories and various Public Buildings in support of Science & Technology programme of DAE including its aided institutions and some Departments of Govt. of India such as Science/ Electronics, Bio-Technology, Human Resource Development etc.

DCSEM continued to render its services through its various groups such as Planning & Design Group, Centralized Quality Division, Construction Group, Maintenance Group, General Services Group and Estate Management Group.

The Planning & Design Group remained involved in planning, designing of Architectural, Structural, Public Health, Electrical & Mechanical works which includes Collection of user's requirement; Detailed planning and design including preparation of drawings; Detailed design of all services; Providing planning support to execution group during progress of works; Taking up approval of new materials, design etc. for planning and Obtaining necessary statutory approvals.

The Centralized Quantity Division was involved in Preparation of estimate, taking up tendering &finalization of work orders pertaining to all capital projects of DCSEM & users project; Tendering &finalization of work order pertaining to Engineering Services Group and Finalization of variation, deviation, extra item proposals, final extension proposals and technical checks etc. pertaining to all works.

This Construction Group remained busy in the execution including construction, procurement, installation, testing commissioning of various buildings, equipment etc. which includes works such as Handling contract for execution; Day to day supervision; Quality control at site including testing of materials, pre-inspection of materials; Recording measurement; Preparation of bills; Monitoring progress of works; Maintaining site records/ registers; Testing, Commissioning of equipment; Use of new tools, equipment for speed up progress and Handing over buildings/ equipment to maintenance group/ Users.

This Maintenance Group comprising of Engineering Services Divisions and Horticulture and Cosmetic Maintenance Section was involved in civil maintenance of 9980 flats, VS Bhavan, AERB, AEES buildings common services at different areas of Mumbai like Anushaktinagar, Chembur, Bandra, Shivaji Park, Ghatkopar, Mulund, Worli, Peddar Road, Malabar Hills, Colaba, OYC, Guest House at New Delhi etc.

The General Services Group continued to look after operation and maintenance of external services pertaining to electrical, mechanical, public health works of residential buildings, public buildings etc. It also looks after the services & maintenance of lifts, air-conditioning systems for office complex, guest houses etc.

The Estate Management Group continued to provide the services such as allotment of departmental accommodation, monitoring of recovery of license fee & allied charges through Pay & Accounts Officers of various Units of Department of Atomic Energy, enforcing rules and regulations of allotment of premises. Presently there are 9980 flats of different categories in Anushaktinagar Township and other locations at Mumbai. It continued to maintain allotment & recovery of shopping facilities at various locations in the DAE Township at Anushaktinagar. Allotment of old community centre, lawns, stilts etc. for personal and community functions of the residents of the Township and employees of the Department staying outside. This activity will go a long way to promote communal harmony and cordial and healthier relationship among various sections of the people hailing from different states across the country. It also maintained the departmental canteen at V. S Bhavan and Guest houses Dhruva, at New Delhi and Zerlina, Anand Bhavan at Mumbai. The Estate Management Group also continued the management of Departmental Land and properties situated in the city of Mumbai, Navi Mumbai, Bhubaneswar, Delhi i.e., leasing of land and properties from and to outsiders, payment/receipt of lease

compensation, payment of service tax, maintenance of land records etc.

Salient achievements of DCSEM

During the report period the achievements made by DCSEM included the followings:

- Multi-Level Car Parking @ V.S. Bhavan is completed and is in use. This avoid parking in main road of V S Bhavan, improve the safety and security.
- Completed 312 flats of Type V-E.
- Extension of Cultural Centre is completed and allotted to various association, construction of crèche building is completed @ 80%.
- Construction of 4 Nos. firefighting underground tanks & pump houses near existing Surabhi, Malaygiri, Kedarnath pump houses and receiving tank near TIFR colony to improve storing capacity of domestic water is @ 95% completed. Fire Fighting works are 90% completed.
- Construction of Building and Ancillary Structures for Sewage Treatment Plant (STP) including civil, PHE works is @ 80% completed.
- Construction of additional two wings to existing HBNI building including Civil, PHE works, Electrical, HVAC, Fire Fighting works at Anushaktinagar is @ 35% completed.
- Construction of Roads, Footpaths, Water bodies, Ponds, Landscape Plaza, Percolation Pits, Sedimentation Tanks & Strom water drain at Campus & Township site, Construction of Pre-school & ware house for GCNEP is 70% completed.
- Construction of Bituminous Road, Storm Water Drain, External Sewer & Water Supply Line, External Electrical Works etc. for PEB-II at VECC, Rajarhat Campus, Kolkata. The work is @ 8% completed.

CHILDREN'S EDUCATION

Atomic Energy Education Society (AEES), an autonomous institution under the Department of Atomic Energy (DAE), Govt. of India, was established in the year 1969 with an aim to provide quality education to the children of the employees of the DAE units working at different centres/establishments across the country in an environment in which every student discovers and realizes his/her full potential. AEES currently administers 31 Schools/Junior colleges at 15 centres located all over India and provides education to over 27,000 students. AEES provides education to the economically backward children from the rural/tribal areas around its establishments through its Societal Enrichment and Education Programme (SEEP). This programme is meant for some children, who are identified only from those admitted under the Right to Education Act (RTE) category.

The total number of students benefitted under RTE (Class I to VIII) has reached 2,694.

Under the Societal Enrichment and Education Programme (SEEP) meant for rural and tribal area, 958 students were provided free education, textbooks, notebooks, uniform, scholarship and medical facilities.

Smt. S. Kanchana Devi, TGT (Selection Scale), Smt. Bharti Jain, TGT, Social Science and Shri S. Seshan, Vice-Principal, AECS-1, Kalpakkam have been awarded with appreciation certificate by Ministry of Parliamentary Affairs, Govt. of India under the National Youth Parliament Scheme (NYPS) on 29/05/2024.

Various school activities (co-curricular) such as All India Inter AECS Cultural (Music) Meet, Sports Meet etc. were held by AEES wherein students of all AEC Schools located all over India have actively participated in these events.

Representatives from AEES attended the 4th All India Rajbhasha Sammelan on 14th and 15th September, 2024 at Bharat Mandapam, Delhi.

About 50 teaching staff of AEES attended the Phase-VI Workshop on 'Leveraging Digital Technology in School Education for Master Trainers of Autonomous Organizations' for 50 hours in face-to-face mode from 23rd to 27th September, 2024 organized by the CIET, NCERT, New Delhi exclusively for AEES.

Induction programme was conducted by the AEES Training School for the 21 newly recruited Primary Teachers from 23rd to 29th May, 2024 in Mumbai in face-to-face mode.

Around 41 Science Teachers of AEES have enrolled in the Diploma in "Teaching of Science at Middle Stage (Classes 6-8)" conducted by NCERT commenced on November 2024 and will conclude in August 2025.

Various training programmes were attended by officials of AEES such as Atoms for Development, Gender Sensitization; Workshop on communication skills, yoga and meditation; Handling of recruitment procedures, conducting of DPC proceedings, reservation & MACP; Public procurement for Government officers; Training programme on Knowledge of Organisational Structure - (AEC, DAE Activities); Roster Maintenance; Training on Prevention, Prohibition and Redressal of Sexual Harassment of Women at workplace and Knowledge of Taxation-GST & Related Taxes, handling Parliamentary Matters etc.

Various events organised by AEES

- Junior Science Olympiad Orientation programme-2024 (for Classes VIII to X) was organized at AECS-2, Mumbai from 08th June to 13th June, 2024.

- All India Inter AECS Cultural (Dance) meet 2024-25 at AECS-4, Rawatbhata from 18th to 20th November, 2024.

- The Under -14 & Under-19 all India Inter AECS National level Basket Ball Tournament was organised at AECS, Jaduguda from 2nd to 5th December, 2024.

- All India Inter AECS/JC Rashtriya Bal Vaigyanik Pradarshini held at AECS, Kakrapar on 29th and 30th November 2024.

- The Under-14 all India National level Table Tennis, G K Quiz, English Debate held at AECS-2, Tarapur from 30/09/2024 to 01/10/2024.

- All India AECS Art Competition was held in all AEC Schools on 22/10/2024.

- Zonal level Basket Ball (U 14 and U-19 Boys, Girls) at following four zones in October 2024:

North Zone	: AECS, Narora
East Zone	: AECS, Oscom
West Zone	: AECS-1, Mumbai
South Zone	: AECS, Anupuram

- All India Inter AECS Table Tennis Tournament for U/19 (Boys & Girls)-2024 held at AECS, Indore from 12th to 15th November, 2024.

- All schools celebrated Swachhata Pakhwada from 16th to 28th February, 2024 and different activities like Art competition, Slogan writing, Essay writing competition etc. were conducted to create the awareness among the students.

In addition to Swachhata Pakhwada, other days such as Constitution Day, World Environment Day, Dr. Ambedkar Jayanti, Vigilance Awareness Week, Library Week, National Unity Day, International Yoga Day and Teacher's Day etc. were also celebrated by schools to enrich the learning experience and promote social awareness among students.

AWARDS & PRIZES

Indian students excelled at the international Olympiads in every subject as follows: 35th International Biology Olympiad (1 Gold and 3 Silver medals), 54th International Physics Olympiad (2 Gold and 3 Silver medals), 56th International Chemistry Olympiad (1 Gold, 2 Silver and 1 Bronze medals), International Mathematics Olympiad (4 Gold, 1 Silver, and 1 Hon Mention India's best performance to date at the International Mathematics Olympiad), 17th International Olympiad on Astronomy and Astrophysics (1 gold medal and 4 silver medals).

AMD has been conferred with Excellence Award in the category for 'Best Heavy Mineral Exploration of the Year' by Rare Earths Association of India (REAI) and Indian School of Mines Alumni Association (ISMAA), Kolkata Chapter in the forum of International Conference on Heavy Minerals and Lithium for Energy Security (REES – 2024) at Kochi, Kerala on 29th August 2024.

ECIL received prestigious Gold Trophy of SCOPE Meritorious Award for R&D, Technology Development & Innovation for the year 2023. Company's Corporate Office, has been awarded Rajbhasha Shield for 10th time in a row under big PSUs category by TOLIC (PSUs), Hyderabad, Secunderabad. ECIL team won the GOLD Award (State Level) and

qualified for participating in National Convention on Quality Concepts (NCQC) 2023 (National Level) and qualified to participate in ICQCC at Sri Lanka. ECIL received IETE Corporate Award for Performance in Electronic Instruments and Instrumentation-2024.

Tummalapalle Mine has won second prize in medium size metal-mine category and received Mines Safety Award 2024 on 28.07.2024 from Directorate General of Mines Safety, Ministry of Labour & Employment, GoI. Turamdih Mine also won the first prize in small size metal mine category and received Mines Safety Award 2024 from Directorate General of Mines Safety, Ministry of Labour & Employment, GoI. UCIL, Tummalapalle was awarded with Certificate of appreciation under the category of Manufacturing Sector (Group-B), by Director General, National Safety Council of India-2023 in recognition for appreciable achievement in Occupational Safety & Health during 2020-2022. Two Rescue Team of the UCIL, Group-A (Jharkhand region) & Group-B (Tummalapalle region) have won the "53rd All India Mines Rescue Competition 2024, organized by DGMS, Ministry of Labour & Employment, in Dhanbad, Jharkhand from 16th -20th December-2024. UCIL "A" Team- Second Prize in Statutory Competition and Second Prize in Theory (Computer Based) Competition. UCIL "B" Team- Third Prize in Rescue & Recovery Competition and Third Prize in Overall Team Performance Competition.

Scientists from TIFR won prestigious awards during this period. Prof. Vivek Polshettiwar has been awarded the Rashtriya Vigyan Puraskar: Vigyan Yuva - Shanti Swarup Bhatnagar award for the year 2024 in Chemistry. Prof. Adimurthy Adi, Prof. Jayant B. Udgaonkar (a former member of TIFR), and Prof. Naba Kumar Mondal (a former member of TIFR) were awarded the Rashtriya Vigyan Shri Award for 2024. Prof. Prahlad Chandra Agrawal (a former member of TIFR) received the prestigious COSPAR Harrie Massey Award 2024 for Space Research. Prof. Sunil K. Gupta (a former member of TIFR) has been elected as the President of the International Union of Pure and Applied Physics.

Department of Atomic energy has been awarded the Rajbhasha Kirti Puraskar (First Prize) for the year 2023-2024 on 14th September 2024 by the Department of Official Language, Government of India for the excellent implementation of the Official Language Policy.

CHAPTER 6

The Department of Atomic Energy has a mandate to develop peaceful uses of nuclear energy in areas like power generation and basic research in frontier areas of science and technology. In view of the nature of activities carried out by the Scientific and Technical persons in various Research Centres, Public Sector Undertakings, Industrial Units and Aided Institutions of the Department, this Department is not in a position to implement the provisions of reservation of posts fully as required under the "Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Act, 1995". Therefore, this Department has already sought exemption for the Units like Heavy Water Boards and Nuclear Power Corporation of India Ltd. From the provisions of the said Act. No specific scheme under plan projects for the benefit of persons with disabilities has been introduced in the Department. In-spite of the constraints, all the Units/PSUs/Aided Institutions have attempted to identify posts, where persons with disabilities could be employed without impairing the activities or causing inconvenience.

The sanctioned strength and number of persons with disabilities in various posts in Group A, B, C & D against 3% vacancies to be reserved for them under Section 33 of the said Act is indicated in the pages that follow.

IMPLEMENTATION OF PERSONS WITH DISABILITIES (EQUAL OPPORTUNITIES, PROTECTION OF RIGHTS & FULL PARTICIPATION) ACT, 1995

ANNUAL STATEMENT SHOWING THE REPRESENTATION OF **PERSONS WITH BENCHMARK DISABILITIES** AS ON 01.01.2025 AND NUMBER OF APPOINTMENTS MADE DURING THE PRECEDING CALENDAR YEAR 2024 IN RESPECT OF **CONSTITUENT UNITS**

Group	Number of Employees					Direct Recruitment									By Promotion							
						No. of vacancies reserved				No. of appointment made					No. of vacancies reserved				No. of appointment made			
	Total	Category (a)	Category (b)	Category (c)	Category (d&e)	Category (a)	Category (b)	Category (c)	Category (d&e)	Total	Category (a)	Category (b)	Category (c)	Category (d&e)	Category (a)	Category (b)	Category (c)	Total	Category (a)	Category (b)	Category (c)	
(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)		(9)	(10)	(11)	(12)		(13)	(14)	(15)	(16)	(17)	(18)	(19)	
Group A	9638	3	3	53	0	0	1	5	1	43	0	0	0	0	0	0	0	156	0	0	0	
Group B	9245	8	24	107	0	2	5	5	0	20	0	1	1	0	1	1	1	452	2	3	7	
Group C	7936	15	30	76	2	13	21	19	10	309	5	1	5	0	0	0	2	617	0	2	1	
TOTAL	**26819**	**26**	**57**	**236**	**2**	**15**	**27**	**29**	**11**	**372**	**5**	**2**	**6**	**0**	**1**	**1**	**3**	**1225**	**2**	**5**	**8**	

Respective categories:

(a) Blindness and low vision;
(b) Deaf and hard of hearing;
(c) Locomotor disability including cerebral palsy, leprosy cured, dwarfism, acid attack victims and muscular dystrophy;
(d) Autism, intellectual disability, specific learning disablility and mental illness;
(e) Multiple disabilities from amongst persons under clauses (a) to (d) including deaf-blindness;

ANNUAL STATEMENT SHOWING THE REPRESENTATION OF **PERSONS WITH BENCHMARK DISABILITIES** AS ON 01.01.2025 AND NUMBER OF APPOINTMENTS MADE DURING THE PRECEDING CALENDAR YEAR 2024 IN RESPECT OF **AIDED INSTITUTIONS**

Group	Number of Employees					Direct Recruitment									By Promotion							
						No. of vacancies reserved				No. of appointment made					No. of vacancies reserved				No. of appointment made			
	Total	Category (a)	Category (b)	Category (c)	Category (d&e)	Category (a)	Category (b)	Category (c)	Category (d&e)	Total	Category (a)	Category (b)	Category (c)	Category (d&e)	Category (a)	Category (b)	Category (c)	Total	Category (a)	Category (b)	Category (c)	
(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)		(9)	(10)	(11)	(12)		(13)	(14)	(15)	(16)	(17)	(18)	(19)	
Group A	2107	2	0	10	0	2	2	5	1	7	0	0	0	0	0	0	0	0	0	0	0	
Group B	3853	5	5	31	6	0	2	8	7	7	0	0	3	0	0	0	0	0	0	0	0	
Group C	2501	6	12	28	2	2	2	0	1	7	3	1	0	1	0	0	0	0	0	0	0	
TOTAL	**8461**	**13**	**17**	**69**	**8**	**4**	**6**	**13**	**9**	**21**	**3**	**1**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	

Respective categories:

(a) Blindness and low vision;
(b) Deaf and hard of hearing;
(c) Locomotor disability including cerebral palsy, leprosy cured, dwarfism, acid attack victims and muscular dystrophy;
(d) Autism, intellectual disability, specific learning disablility and mental illness;
(e) Multiple disabilities from amongst persons under clauses (a) to (d) including deaf-blindness;

ANNUAL STATEMENT SHOWING THE REPRESENTATION OF **PERSONS WITH BENCHMARK DISABILITIES** AS ON 01.01.2025 AND NUMBER OF APPOINTMENTS MADE DURING THE PRECEDING CALENDAR YEAR 2024 IN RESPECT OF **PUBLIC SECTOR UNDERTAKINGS**

Group	Number of Employees					Direct Recruitment									By Promotion							
						No. of vacancies reserved				No. of appointment made					No. of vacancies reserved				No. of appointment made			
	Total	Category (a)	Category (b)	Category (c)	Category (d&e)	Category (a)	Category (b)	Category (c)	Category (d&e)	Total	Category (a)	Category (b)	Category (c)	Category (d&e)	Category (a)	Category (b)	Category (c)	Total	Category (a)	Category (b)	Category (c)	
(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)		(9)	(10)	(11)	(12)		(13)	(14)	(15)	(16)	(17)	(18)	(19)	
Group A	7688	19	14	79	2	4	4	2	2	353	4	2	7	0	0	0	0	183	0	0	3	
Group B	4258	16	13	85	0	3	3	4	1	139	0	0	7	0	0	0	0	19	0	0	2	
Group C	3254	11	5	36	0	6	6	4	1	150	2	0	4	0	0	0	0	127	0	3	3	
TOTAL	**15200**	**46**	**32**	**200**	**2**	**13**	**13**	**10**	**4**	**642**	**6**	**2**	**18**	**0**	**0**	**0**	**0**	**329**	**0**	**3**	**8**	

Respective categories:

(a) Blindness and low vision;
(b) Deaf and hard of hearing;
(c) Locomotor disability including cerebral palsy, leprosy cured, dwarfism, acid attack victims and muscular dystrophy;
(d) Autism, intellectual disability, specific learning disablility and mental illness;
(e) Multiple disabilities from amongst persons under clauses (a) to (d) including deaf-blindness;

CHAPTER 7
CITIZEN's CHARTER

Government of India
Department of Atomic Energy

CITIZEN's CHARTER

I) OUR VISION

The vision of the Department of Atomic Energy is to empower India through technology, creation of more wealth and providing better quality of life to its citizen. This is to be achieved by making India energy independent, contributing to provision of sufficient, safe and nutritious food and better health care to our people through development and deployment of nuclear and radiation technologies and their applications.

II) MANDATE

The mandate of the Department, on which its programmes are based, covers :

- Increasing share of nuclear power through deployment of indigenous and other proven technologies, along with development of fast breeder reactors and thorium reactors with associated fuel cycle facilities ;
- Building and operation of research reactors for production of radioisotopes and carrying out radiation technology applications in the field of medicine, agriculture and industry, cancer care, water related technologies, waste management etc.;
- Developing advanced technologies such as accelerators, lasers, supercomputers, advanced materials and instrumentation, and encouraging transfer of technology to industry;
- Support to basic research in nuclear energy and related frontier areas of science; interaction with universities and academic institutions; Support to research and development projects having a bearing in DAE's programmes, and international cooperation in related advanced areas of research, and
- Contribution to national security.

III) OUR ACTIVITIES

- The Department is engaged in the design, construction and operation of nuclear power / research reactors and the supporting nuclear fuel cycle technologies covering exploration, mining and processing of nuclear minerals, production of heavy water, nuclear fuel fabrication, fuel reprocessing and nuclear waste management. It is also developing advanced technologies which contribute to the national prosperity. The human resource developed and technical services being rendered by the Department have been greatly helping the Indian industry.
- The Department is also developing better crop varieties, techniques for control/eradication of insects thus protecting the crops, radiation based post harvest technologies, radiation based techniques for diagnosis and therapy of disease particularly cancer, technologies for safe drinking water, better environment and robust industry.

IV) OUR CLIENTS

- User Ministries/Departments of Central Govt. and State Govt. dealing with energy, agriculture, food, health, education, oil and petroleum, industry, science and technology etc.

- Quasi Govt. Organisations, NGOs, industrial organizations, educational institutes.
- Electricity Boards, Hospitals, Research / Medical / Educational / Academic Institutions, agriculturists etc.

V) LINK TO RTI PORTAL

- Visit the link **www.rti.gov.in**

VI) WHOM TO CONTACT

I. Nodal Grievance Officer for CPGRAMS

Dr. Nitin Bhanudas Jawale,
Director(SCS) & Nodal Officer,
Department of Atomic Energy,
Anushakti Bhavan, C.S.M. Marg, Mumbai – 400 001.
Tel. No.022-22862742
Email I.D. – diradmn@dae.gov.in

II. Nodal Appellate Authority for CPGRAMS

Smt. Prajakta L. Verma,
Joint Secretary(A&A),
Nodal Appellate Authority,
Department of Atomic Energy,
Anushakti Bhavan, C.S.M. Marg, Mumbai – 400 001.
Tel No. 022-22022492
E-mail I.D. – jsaa@dae.gvov.in

II. Vigilance Complaints

Smt. Prajakta L. Verma,
Joint Secretary(A&A),
Chief Vigilance Officer,
Department of Atomic Energy,
Anushakti Bhavan, C.S.M. Marg, Mumbai – 400 001.
Tel No. 022-22022492
E-mail I.D.– jsaa@dae.gvov.in

III. Nodal Officer / Contact Officer for Citizen's Charter of DAE

Shri Daniel Babu P.,
Scientific Officer-H, Head, Public Awareness & Media Interaction Division (PA&MID),
Nodal Officer/Contact Officer for Citizen's Charter of DAE
Department of Atomic Energy,
Anushakti Bhavan, C.S.M. Marg, Mumbai – 400 001.
Tel. No.022-22862505
Email I.D. – daniel.babu@dae.gov.in

IV. Public Relations

Shri Daniel Babu P.,
Scientific Officer-H, Head, Public Awareness & Media Interaction Division (PA&MID),
Department of Atomic Energy,
Anushakti Bhavan, C.S.M. Marg, Mumbai – 400 001.
Tel. No.022-22862505
Email I.D. – daniel.babu@dae.gov.in

Government of India
Department of Atomic Energy
Anushakti Bhavan, C.S.M. Marg,
Mumbai - 400 001

NOTICE

We, the public servants of India do hereby solemnly pledge that we shall continuously strive to bring about integrity and transparency in all spheres of our activities. We also pledge that we shall work unstintingly for eradication of corruption in all spheres of life. We shall remain vigilant and work towards the growth and reputation of our Department. Through our collective efforts, we shall bring pride to our Department and provide value based service to our countrymen. We shall do our duty conscientiously and act without fear or favour.

This office is thus committed to maintaining the highest level of ethics in its working towards achieving the above objective, all are requested:

- Not to pay bribe
- If anybody in this department or its offices asks for bribe : or
- If you have any information on corruption: or if you are a victim of corruption in any of our offices.

YOU MAY COMPLAIN TO:-

Smt. Prajakta L. Verma,
Joint Secretary (A&A) &
Chief Vigilance Officer,
Department of Atomic Energy,
Anushakti Bhavan, C.S.M. Marg,
Mumbai – 400 001.
Tel. No.022-22022492
Email I.D. – jsaa@dae.gov.in

YOU CAN ALSO COMPLAIN TO THE :-

CENTRAL VIGILANCE COMMISSION,
Satarkta Bhavan, Block 'A',
GPO Complex, INA,
New Delhi – 110 023.
Tel. No. 011-24651084
Fax No. 011-24651010/24651186

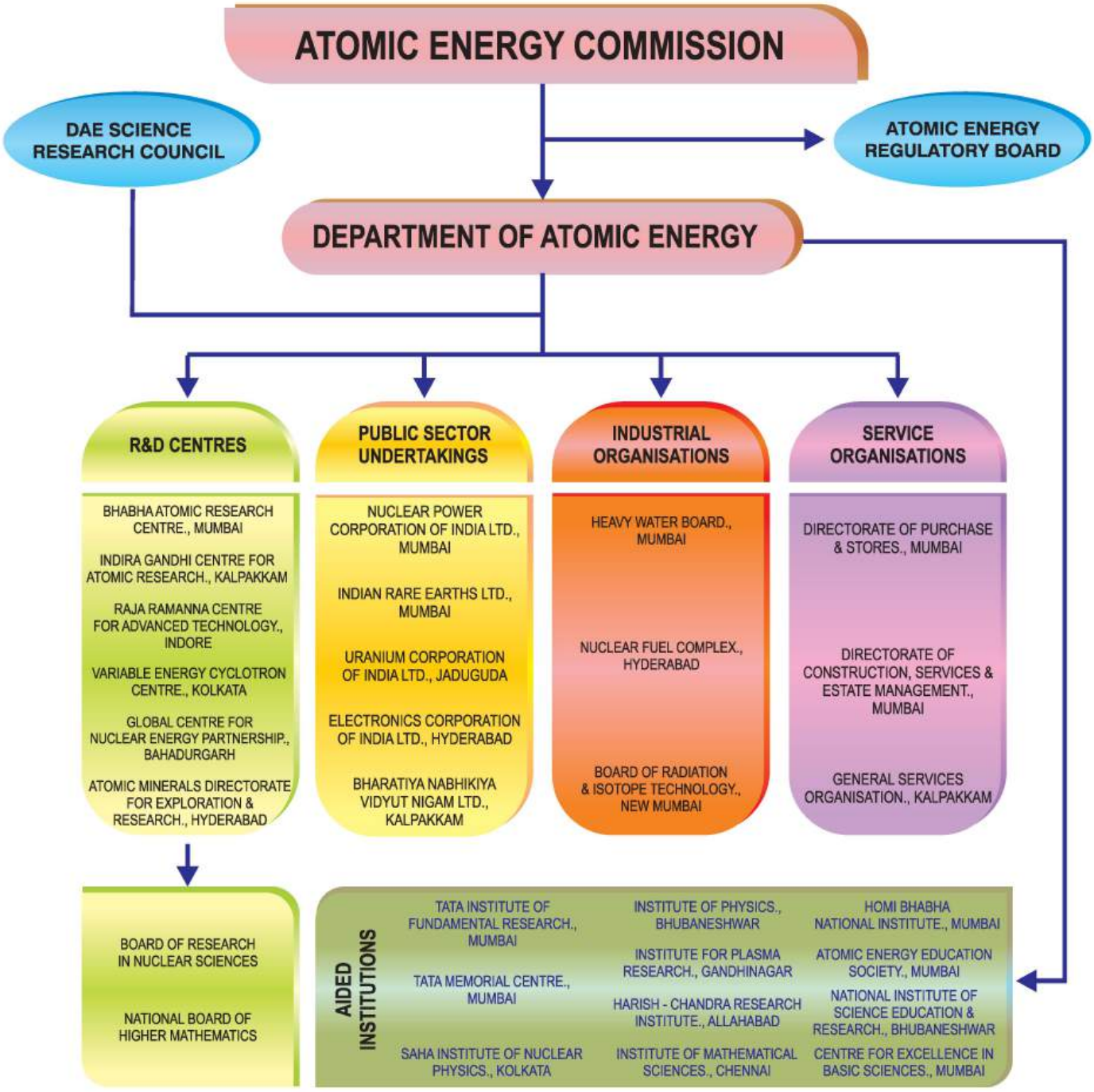
ANNEX-I

THE ORGANISATION

The Department of Atomic Energy (DAE), that came into being on August 3, 1954, has been engaged in the development of nuclear power technology, applications of radiation technologies in the fields of agriculture, medicine, industry, and basic research.

As integrated group of organizations, the Department comprises six Research Centres, three Industrial Organisations, five Public Sector Undertakings and three Service Organisations. It has under its aegis two Boards for promoting and funding extra-mural research in nuclear and allied fields, and mathematics.

It also supports eleven institutes of international repute engaged in research in basic sciences, astronomy, astrophysics, cancer research and education, etc., which includes a society that provides educational facilities to the children of DAE employees.


ATOMIC ENERGY COMMISSION
DAE SCIENCE RESEARCH COUNCIL
ATOMIC ENERGY REGULATORY BOARD
DEPARTMENT OF ATOMIC ENERGY
R&D CENTRES
BHABHA ATOMIC RESEARCH CENTRE., MUMBAI
INDIRA GANDHI CENTRE FOR ATOMIC RESEARCH., KALPAKKAM
RAJA RAMANNA CENTRE FOR ADVANCED TECHNOLOGY., INDORE
VARIABLE ENERGY CYCLOTRON CENTRE., KOLKATA
GLOBAL CENTRE FOR NUCLEAR ENERGY PARTNERSHIP., BAHADURGARH
ATOMIC MINERALS DIRECTORATE FOR EXPLORATION & RESEARCH., HYDERABAD
PUBLIC SECTOR UNDERTAKINGS
NUCLEAR POWER CORPORATION OF INDIA LTD., MUMBAI
INDIAN RARE EARTHS LTD., MUMBAI
URANIUM CORPORATION OF INDIA LTD., JADUGUDA
ELECTRONICS CORPORATION OF INDIA LTD., HYDERABAD
BHARATIYA NABHIKIYA VIDYUT NIGAM LTD., KALPAKKAM
INDUSTRIAL ORGANISATIONS
HEAVY WATER BOARD., MUMBAI
NUCLEAR FUEL COMPLEX., HYDERABAD
BOARD OF RADIATION & ISOTOPE TECHNOLOGY., NEW MUMBAI
SERVICE ORGANISATIONS
DIRECTORATE OF PURCHASE & STORES., MUMBAI
DIRECTORATE OF CONSTRUCTION, SERVICES & ESTATE MANAGEMENT., MUMBAI
GENERAL SERVICES ORGANISATION., KALPAKKAM
BOARD OF RESEARCH IN NUCLEAR SCIENCES
NATIONAL BOARD OF HIGHER MATHEMATICS
AIDED INSTITUTIONS
TATA INSTITUTE OF FUNDAMENTAL RESEARCH., MUMBAI
TATA MEMORIAL CENTRE., MUMBAI
SAHA INSTITUTE OF NUCLEAR PHYSICS., KOLKATA
INSTITUTE OF PHYSICS., BHUBANESHWAR
INSTITUTE FOR PLASMA RESEARCH., GANDHINAGAR
HARISH - CHANDRA RESEARCH INSTITUTE., ALLAHABAD
INSTITUTE OF MATHEMATICAL SCIENCES., CHENNAI
HOMI BHABHA NATIONAL INSTITUTE., MUMBAI
ATOMIC ENERGY EDUCATION SOCIETY., MUMBAI
NATIONAL INSTITUTE OF SCIENCE EDUCATION & RESEARCH., BHUBANESHWAR
CENTRE FOR EXCELLENCE IN BASIC SCIENCES., MUMBAI

ATOMIC ENERGY ESTABLISHMENTS IN INDIA

ANNEX-II

REPLIES TO AUDIT OBSERVATIONS

Report No. 2 of 2021 **Financial Audit, Union Government**

Para No. 3.2 – Short Realization of Lease Rent

Non revision of license fee in accordance with extant Government Orders and non-renewal of expired lease agreements by General Services Organization, Kalpakkam resulted in short realization of lease rent by Rs.3.75 Crore.

Action Taken:

Revised Action Taken Note (ATN) is being furnished.

Report No. 2 of 2021 **Financial Audit, Union Government**

Para No. 3.3 – Payment of HRA at higher rates

Though Jatni belongs to the 'Z' category of city/town, the employees of NISER were granted HRA at the rate applicable for the 'Y' class cities. While replying to query raised by Audit, Director of Census Operational, Odisha, Ministry of Home Affairs, GOI, has clarified that NISER does not fall under Bhabaneshwar UA. Thus, the payment of HRA at higher rates by NISER was irregular, which resulted in the grant of additional benefits to its employees to the extent of Rs.2.80 Crore during the period from July 2015 to February 2020.

Action Taken:

Revised Final Action Taken Note (ATN) is being furnished.

Report No. 24 of 2023 **Financial Audit, Union Government**

Para No. 8.1 – Functioning of Institute for Plasma Research

IPR could not complete the projects in time and exceeded their planned completion period by 21 months to 54 months. It could not achieve the intended objectives of the projects though projects were declared as complete with many extensions and non-achieved objectives were migrated to new projects with further cost implications. Though 16 technologies were developed it could not transfer them even after one to eight years of development.

Action Taken:

Revised Action Taken Note (ATN) is being furnished.

Report No. 24 of 2023 **Financial Audit, Union Government**

Para No. 8.3 – Blockage of funds to the tune of Rs.7.86 Crore

Indigenous High Dose Rate Brachytherapy (IHDR), Treatment Planning Software (TPS) and Applicator with Coupling procured at a cost of Rs.7.86 Crore is yet to be transferred to desired hospitals even after nearly seven years since these were supplied.

Action Taken:

Revised Action Taken Note (ATN) is being furnished.

Report No. 24 of 2023 **Financial Audit, Union Government**

Para No. 8.4 – Absence of due process in engagement of legal counsel

Bhabha Atomic Research Centre (BARC) engaged legal Counsels in contravention of orders issued by Department of Legal Affairs, Ministry of Law & Justice.

Action Taken:

Revised Action Taken Note (ATN) is being furnished.

ANNEX-III

REPRESENTATION OF SCs, STs, AND OBCs

ANNUAL STATEMENT SHOWING THE REPRESENTATION OF **SCs, STs AND OBCs** AS ON 01.01.2025 AND NUMBER OF APPOINTMENTS MADE DURING THE PRECEDING CALENDAR YEAR 2024 IN RESPECT OF **CONSTITUENT UNITS**

Groups	Representation of ST/ST/OBC (as on 01.01.2025)				Number of appointments made during the calendar year 2024									
					By Direct Recruitment				By Promotion			By Deputation		
	Total Emp	SC	ST	OBC	Total	SC	ST	OBC	Total	SC	ST	Total	SC	ST
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Group A	9638	760	270	1583	163	12	4	57	516	45	16	8	1	0
Group B	9245	1736	947	3726	130	13	17	57	788	143	52	2	1	0
Group C	7936	1449	749	3271	461	68	21	172	777	120	69	0	0	0
TOTAL	**26819**	**3945**	**1966**	**8580**	**754**	**93**	**42**	**286**	**2081**	**308**	**137**	**10**	**2**	**0**

ANNUAL STATEMENT SHOWING THE REPRESENTATION OF **SCs, STs AND OBCs** AS ON 01.01.2025 AND NUMBER OF APPOINTMENTS MADE DURING THE PRECEDING CALENDAR YEAR 2024 IN RESPECT OF **AIDED INSTITUTIONS**

Groups	Representation of ST/ST/OBC (as on 01.01.2025)				Number of appointments made during the calendar year 2024									
					By Direct Recruitment				By Promotion			By Deputation		
	Total Emp	SC	ST	OBC	Total	SC	ST	OBC	Total	SC	ST	Total	SC	ST
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Group A	2107	110	13	144	82	6	2	13	18	2	0	0	0	0
Group B	3853	586	235	1066	348	51	10	97	23	6	2	0	0	0
Group C	2501	586	167	670	291	43	22	101	7	1	0	0	0	0
TOTAL	**8461**	**1282**	**415**	**1880**	**721**	**100**	**34**	**211**	**48**	**9**	**2**	**0**	**0**	**0**

ANNUAL STATEMENT SHOWING THE REPRESENTATION OF **SCs, STs AND OBCs** AS ON 01.01.2025 AND NUMBER OF APPOINTMENTS MADE DURING THE PRECEDING CALENDAR YEAR 2024 IN RESPECT OF **PUBLIC SECTOR UNDERTAKINGS**

Groups	Representation of ST/ST/OBC (as on 01.01.2025)				Number of appointments made during the calendar year 2024									
					By Direct Recruitment				By Promotion			By Deputation		
	Total Emp	SC	ST	OBC	Total	SC	ST	OBC	Total	SC	ST	Total	SC	ST
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Group A	7688	1028	425	1612	377	56	24	134	1263	174	72	2	0	0
Group B	4258	732	397	1615	184	29	8	86	681	117	51	0	0	0
Group C	3254	495	602	991	187	20	20	110	240	58	30	0	0	0
TOTAL	**15200**	**2255**	**1424**	**4218**	**748**	**105**	**52**	**330**	**2184**	**349**	**153**	**2**	**0**	**0**

ABT	Auto Bus Transfer
ACTREC	Advanced Centre for Treatment, Research and Education in Cancer
ADA	Aeronautical Development Agency
ADME	Absorption Distribution Metabolism & Excretion
AEC	Atomic Energy Commission
AECS	Atomic Energy Central School
AEES	Atomic Energy Educational Society
AERB	Atomic Energy Regulatory Board
AGN	Active Galactic Nuclei
AGVs	Automated Guided Vehicles
AHWR	Advanced Heavy Water Reactor
AKRUTI	Advanced Knowledge & RUral Technology Implementation
AMCH	Assam Medical College Hospital
AMD	Atomic Minerals Directorate for Exploration & Research
APBTS	Automated Pellet Boat Transfer System
ARMS	Automated Radiation Monitoring System
ASHVINI	Anushakti Vidhyut Nigam Ltd.
ATI	Administrative Training Institute
ATTPC	Active Target Time Projection Chamber
BARC	Bhabha Atomic Research Centre
BCD	Bleed Condenser
BEL	Bharat Electronics Ltd.
BHAVINI	Bhartiya Nabhikiya Vidyut Nigam Limited
BMS	Beetle Monitoring Systems
BoG	Board of Governors
BRIT	Board of Radiation & Isotope Technology
BRNS	Board of Research in Nuclear Sciences
BSA	Blanket subassembly
BSC	Biological Shield Cooling
BSM	Beyond Standard Model
BSM	Beach Sand Minerals
BSMR	Bharat Small Modular Reactor
BSR	Bharat Small Reactors
BWR	Boiling Water Reactor
CHSS	Contributory Health Service Scheme
CICC	Cable In Conduit Conductor
CISD	Computer and Information Systems Division
CLND	Civil Liability for Nuclear Damage
CMG	Crisis Management Group
CMI	Chennai Mathematical Institute
CMP	Condensed Matter Physics
CMPAPP	Chutka Madya Pradesh Atomic Power Project
CNEWG	Civil Nuclear Energy Working Group
COD	Chemical Oxygen Demand
CORAL	Compact Reprocessing facility for Advanced fuels of Lead cells
CSIR	Council of Scientific & Industrial Research
CSR	Corporate Social Responsibility
CRM	Certified Reference Material
CTAB	Cetryl Trimethyl Ammonium Bromide
CTC	Cryopumping Test Chamber
CTE	Consent to Establish
CVC	Central Vigilance Commission
CVO	Chief Vigilance Officer
CWS	Cooling Water System
CZT	Cadmium Zinc Telluride
DAC	Data Acquisition & Control
DAE	Department of Atomic Energy
DAE S&CC	DAE Sports and Cultural Council
DBR	Design Basis Report
DCSEM	Directorate of Construction Services & Estate Management
DDW	Deuterium Depleted Water
DEA	Dissociative Electron Attachment
DESI	Dark Energy Spectroscopic Instrument
DENV	Dengue Virus
DFRP	Demonstration Fast reactor fuel Reprocessing Plant
DFT	Density Functional Theory
DGFS	DAE Graduate Fellowship Scheme
DIR	Design Information Report
DNB	Diagnostic Neutral Beam
DoCA	Department of Consumer Affairs
DPR	Detailed Project Report
DPS	Directorate of Purchase & Stores
DRS	Disturbance Recording System
ECCS	Emergency Core Cooling System
ECIL	Electronic Corporation of India Limited
ECR	Emergency Control Room
EDF	Électricité de France
EIA	Environmental Impact Assessment
EMCCR	En-masse coolant channel Replacement
EMFR	En-masse Feder Replacement
EML	Electro-Magnetic Launcher
EMS	Environmental Management System
EOI	Expression of Interest
EPC	Engineering Procurement and Construction
ERM	Environmental Radiation Monitor
FAC	First Approach to Criticality
FAT	Factory Acceptance Test
FBTR	Fast Breeder Test Reactor
FBR	Fast Breeder Reactor
FCI	Food Corporation of India
FDG	Fluoro Deoxy Glucose
FETS	Front-End Test Stand
FMTF	Fuelling Machine Test Facility
FPNG	Fission Product Noble Gas
FPO	Farmer Producer Organization
FRBPS	Fast Response Bipolar Power Supply
FRENA	Facilities for Research in Experimental Nuclear Astrophysics
FRFCF	Fast Reactor Fuel Cycle Facility
FRT	Freight Ton
FSA	Fuel Subassembly

FSD	Foldable Solar Dryer
FVID	Fast Visible Imaging Diagnostic
GCR	Gas Cooled Reactor
GCNEP	Global Centre for Nuclear Energy Partnership
GDR	Giant Dipole Resonance
GHAVP	Gorakhpur Haryana Anu Vidyut Pariyojana
GMT	Geometric Mean Titre
GSO	General Services Organisation
HBCSE	Homi Bhabha Centre for Science Education
HBNI	Homi Bhabha National Institute
HELP	Heat Transfer Experimental Loop
HLLW	High-Level radioactive Liquid Waste
HPA	High-Power Amplifier
HSCMS	Hydrogen and Steam Concentration Monitoring System
HTA	Health Technology Assessment
HTBC	High Temperature Boron Counters
HTS	High Temperature Superconducting
HVPS	High Voltage Power Supply
HWB	Heavy Water Board
HWLS	Hot Water Layer System
HWP	Heavy Water Plant
HXRM	Hard X-Ray Monitor
IAEA	International Atomic Energy Agency
IBO	International Biology Olympiad
ICA	Ion Chamber Amplifier
ICCC	Integrated Command Control Centre
IGCAR	Indira Gandhi Centre for Atomic Research
IISF	India International Science Festival
ILLW	Intermediate Level Liquid Waste
IMSc	Institute of Mathematical Science
IMSBR	Indian Molten Salt Breeder Reactor
INGA	Indian National Gamma Array
IOP	Institute of Physics
IPPF	Isotope Production & Processing Facility
IPR	Intellectual Property Rights
IPR	Institute for Plasma Research
IPWR	Indian Pressurised Water Reactor
IRG	Inert Radioactive Gas
IREL	Indian Rare Earths Limited
ISI	In-service Inspection
ISMAA	Indian School of Mines Alumni Association
ITER	International Thermonuclear Experimental Reactor
IVV	Integrated Vacuum Vessel
IWM	Indian Women in Mathematics
KAMINI	KAlpakkam MINI Reactor
KAPP	Kakrapar Atomic Power Project
KAPS	Kakrapar Atomic Power Station
KARP	Kalpakkam Atomic Reprocessing Plant
KGS	Kaiga Generating Station
KHMDL	Karnataka Hybrid Micro Devices Ltd.
KKNPP	Kudankulam Nuclear Power Plant
KYM	Know Your Ministry
LAMBDA	Large Area Modular BaF2 Detector Array
LCP	Local Control Panels
LDEDS	Laser Directed Energy Deposition System
LEBT	Low Energy Beam Transport
LECCS	Loss of Emergency Core Cooling System
LHC	Large Hadron Collider
LHR	Linear Heating Rate
LIM	Linear Induction Motors
LOCA	Loss of Coolant Accident
LPBF	Laser Powder Bed Fusion
LPSC	Liquid Propulsion System Centre
LWR	Light Water Reactor
MACE	Major Atmospheric Cerenkov Experiment Telescope
MAPS	Madras Atomic Power Station
MCF	Medical Cyclotron Facility
MDP	Management Development Programmes
MHA	Ministry of Home Affairs
MoEFCC	Ministry of Environment, Forest and Climate Change
MPEDA	Marine Products Exports Development Authority
MSLB	Main Steam Line Break
MTTS	Mathematics Training and Talent Search
MTWP	Mid-Tropospheric Wind Profiler
MWPC	Multi-wire Proportional Counters
NAPS	Narora Atomic Power Station
NAFED	National Agricultural Cooperative Marketing Federation of India Limited
NBHM	National Board of Higher Mathematics
NCCF	National Co-operative Consumers' Federation of India Limited
NFC	Nuclear Fuel Complex
NGRI	National Geophysical Research Institute
NIRF	National Institute Ranking Framework
NIM	Nano Insulation Materials
NISER	National Institute of Science Education & Research
NPCIL	Nuclear Power Corporation of India Limited
NPP	Nuclear Power Plants
NUJ	National Union of Journalists
OESC	On-Site Emergency Support Centre
ONERS	Online Nuclear Emergency Response System
OPA	Optical Parametric Amplifiers
PBH	Primordial Black Holes
PCAR	Point Contact Andreev Reflection
PCB	Printed Circuit Board
PDHRS	Passive Decay Heat Removal System
PDMS	Polydimethylsiloxane
PEC	Pre-Engineering Contract
PET	Positron Emitting Tomography
PFBR	Prototype Fast Breeder Reactor
PFR	Pre-feasibility Report

PFN	Pulse Forming Network
PHT	Primary Heat Transport
PHWR	Pressurised Heavy Water Reactors
PIE	Post Irradiation Examination
PLF	Plant Load Factor
PMT	Photo Multiplier Tube
PNB	Positive ion Neutral Beam
PPS	Pulse Power System
PRZ	Pressurizer
PSAR	Preliminary Safety Analysis Report
QIC	Quantum Information and Computation
RAPP	Rajasthan Atomic Power Project
RAPS	Rajasthan Atomic Power Station
RCP	Reactor Coolant Pump
REBCO	Rare-Earth Barium Copper Oxide
REE	Rare Earths Elements
REM	Remote Emission Monitors
REMP	Rare Earth Permanent Magnet Plant
RETTP	Rare Earth & Titanium Theme Park
REO	Rare Earth Oxide
RFP	Request for Proposals
RFQ	Radio Frequency Quadrupole
RIA	Radioimmunoassay
RML	Radio Metallurgy Laboratory
RMC	Radiation Medicine Centre
RMRE	Rare Metal and Rare Earth
ROTEX	Remotely Operated Tungsten Shielded Exposure Device
RPES	Resonance Photoemission Spectroscopy
RPh	Radiopharmaceuticals
RPV	Reactor Pressure Vessel
RPP	Radiation Processing Plant
RRCAT	Raja Ramanna Centre for Advanced Technology
RRF	Raja Rammana Fellowship
RSW	Radiation Shielding Windows
RTC	Room Temperature Cyclotron
RTG	Radioisotope Thermoelectric Generator
RTI	Right to Information
SBC	Safe Bearing Capacity
SCC	Superconducting Cyclotron Centre
SCL	Semiconductor Laboratory
SCRF	Superconducting Radio Frequency
SDCS	Shutdown Cooling System
SDRF	State Disaster Response Force
SFSB	Spent Fuel Storage Building
SEAI	Seafood Exporters Association of India
SER	Site Evaluation Report
SGTF	Steam Generator Test Facility
SHIVAY	Sheetal Vahak Yantra
SINP	Saha Institute of Nuclear Physics
SIR	Site Information Report
SKA	Square Kilometre Array
SOP	Standard Operating Procedure
STC	Special Technical Committee
STFC	Science and Technology Facilities Counci
SQA	Software Quality Assurance
SSMC	Secondary Sodium Main Circuit
SVRC	State Varietal Release Committee
SWRO	Sea Water Reverse Osmosis
TAPS	Tarapur Atomic Power Station
TCPH	Torus Cryo-Pump Housing
TCF	Technical Cooperation Fund
TCS	Tata Consultancy Services
TEM	Transient electromagnetic
TIFR	Tata Institute of Fundamental Research
TJM	Trombay Jodhpur Mustard
TMC	Tata Memorial Centre
TMH	Tata Memorial Hospital
UCIL	Uranium Corporation of India Limited
URSC	U R Rao Satellite Centre
UHV	Ultra-high Vacuum
UKTMP	Ust-Kamenogorsk Titanium and Magnesium Plant

Edited & Published by Head, Public Awareness & Media Interaction Division,
DAE and Printed by him at M/s. Sundaram Art Printing Press