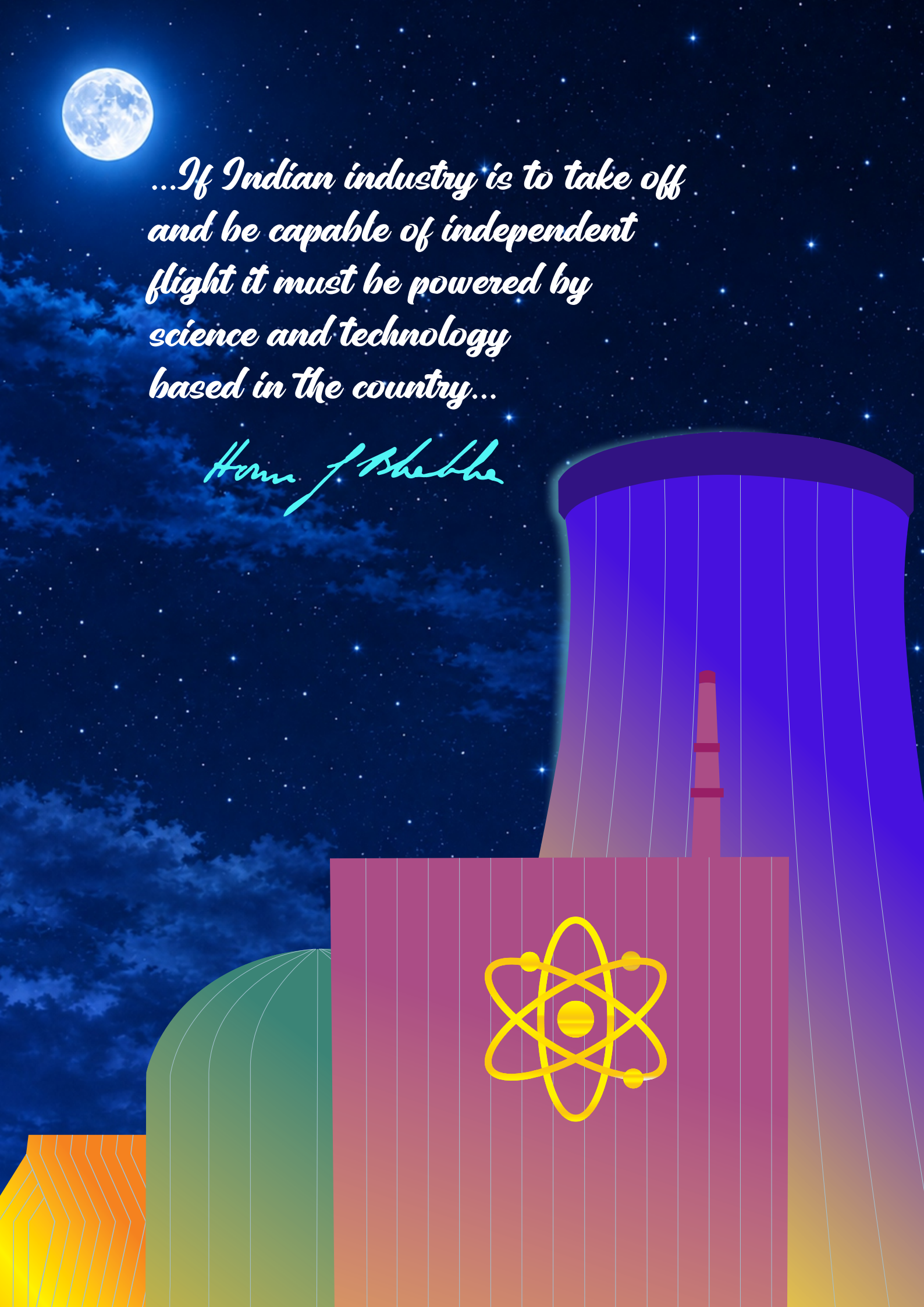

...If Indian industry is to take off
and be capable of independent
flight it must be powered by
science and technology
based in the country...

RESEARCH

Reactors

The Mainstay of Nuclear Programme enroute Viksit Bharat

अनुसंधान रिएक्टर: विकसित भारत की ओर अग्रसर नाभिकीय कार्यक्रम

High Flux Research Reactor Takes Shape in BARC Visakhapatnam: BARC has reached a significant milestone in its efforts to develop and establish advanced research reactor facilities in the country. The High Flux Research Reactor (HFRR), planned at the greenfield Visakhapatnam campus, has now moved to the construction stage with the successful breaking of ground for one of its key facilities.

The ceremonial 'Bhumi Pujan' (Ground Breaking) for the Reactor Common Services Building (RCSB) of the HFRR was held on 19 August 2026. Senior officials from BARC, particularly from the Reactor Projects Group (RPG) leading the project, along with NPCIL officials, were present on the occasion.

With a thermal power of 40 MW, the HFRR is being developed as a major facility to support advanced nuclear research and related activities. The reactor is expected to strengthen the country's capabilities in high-flux research and provide an important platform for future scientific and technological programmes.

The RCSB will form a vital part of the reactor's support infrastructure. It will house critical reactor services, including six 315 kW secondary coolant water system pumps and six 11 MW induced-draft cooling towers, along with the reactor heat-sink systems. These facilities will play a crucial role in ensuring reliable heat removal and supporting the safe and efficient operation of the reactor.



HFRR Core Team and the ceremonial Ground Breaking for the Reactor Common Services Building of the HFRR held on 19 August 2026 (Inset Photo).

Construction of the RCSB is being taken up in parallel with other major activities associated with the establishment of the HFRR. The building is targeted for completion within 24 months, marking another important step towards bringing the new research reactor facility to fruition.

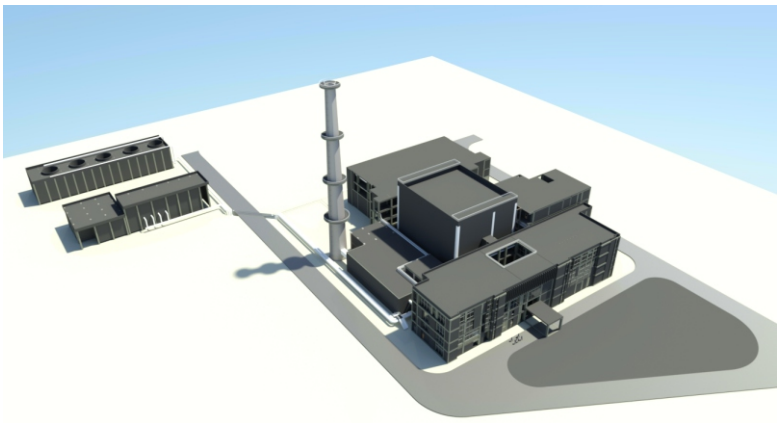
Isotope Production Reactor: Advancing India's capacity in vital radioisotopes for healthcare and others: The 40 MW Isotope Production Reactor (IPR), an open-pool-type, high-flux research reactor, is being developed at BARC, Visakhapatnam, to support large-scale production of critical radioisotopes for nuclear medicine and other strategic applications, including ^{177}Lu, ^{131}I, ^{192}Ir, ^{60}Co, ^{99}Mo, ^{153}Sm, ^{166}Ho and ^{188}W.

The Detailed Project Report (DPR) has been prepared, and administrative and financial sanction has been obtained from DAE. The Notice Inviting Tender (NIT) for engineering and construction has been floated. Award of the EPC contract and commencement of major project activities are targeted by the end-2026, with First Approach to Criticality (FAC) targeted for 2031.

Basic design and engineering of major reactor and plant systems, core mechanical design and associated analyses, and basic civil, structural and architectural designs have been completed. Detailed technical specifications required for construction and commissioning have also been prepared.

The Radiological Impact Assessment (RIA) has been completed, and siting clearance has been obtained from the BARC Safety Council. The Preliminary Safety Analysis Report (PSAR) required for excavation clearance have been prepared and independently reviewed. For environmental clearance, requisite documents have been submitted to MoEFCC, resulting in issuance of the Terms of Reference (ToR) for EIA studies. An EIA consultant has been appointed to support Environmental Clearance and Consent-to-Establish. Geo-technical investigations at the identified site locations have also been completed.

The IPR has therefore made substantial progress across design, safety, regulatory, environmental and site-preparation stages. The project is now poised for EPC award and construction, followed by commissioning and FAC by 2031- strengthening India's capacity to produce vital radioisotopes for healthcare.

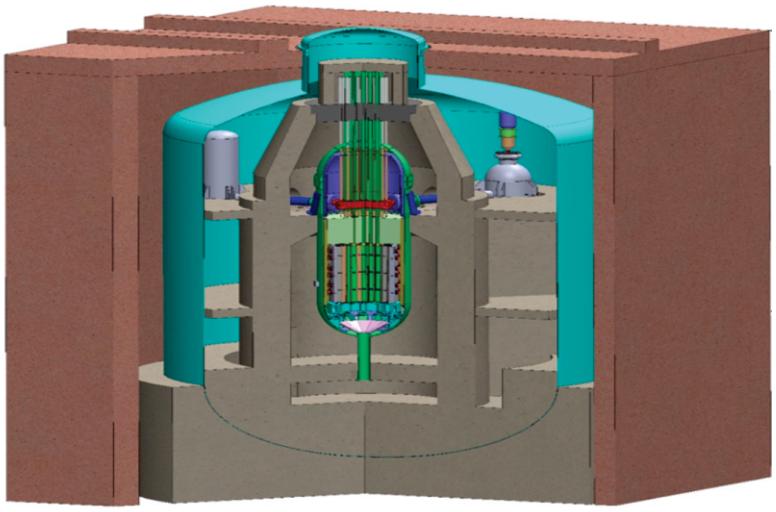


3D (architectural) view of the proposed IPR facility.

High Temperature Gas Cooled Reactor - Design & Development: BARC is committed to the design and development of advanced nuclear reactors to support India's vision of energy security, global industrial competitiveness, and long-term environmental sustainability. A targeted technology push towards High Temperature Reactors (HTRs) aims to integrate nuclear energy with the green hydrogen economy.

As a lead step, BARC is developing an indigenous 5 MW_{th} High Temperature Gas Cooled Reactor (HTGCR) to demonstrate clean hydrogen production using nuclear energy. Its high-grade heat, available at around 650°C, can also support clean ammonia production, hydrocarbon cracking, industrial heating, and other applications.

The Indian HTGCR employs slightly enriched Uranium dioxide (UO_2) fuel, CO_2 as the primary coolant, and graphite as the neutron moderator. Advanced physics and thermal-hydraulic analyses have led to an optimized fuel assembly comprising a 24-pin fuel cluster enclosed in double graphite sleeves. The physics design provides adequate excess reactivity for an extended core life of



Cross sectional view of major primary components & containment of HTGCR.

approximately 4 full power years with fresh fuel loading. The reactor core, comprising fuel assemblies, reactivity control devices, and graphite moderator and reflector, is housed within a reactor pressure vessel (RPV) fabricated from conventional 2¼Cr-1Mo steel widely used in chemical plants.

Key technological challenges include structural design of the graphite core, high-temperature and neutron-irradiated metallic components, and safe, robust coupling of the nuclear reactor with a chemical plant for hydrogen production. The heat transport system incorporates provisions for safe nuclear heat removal during normal operation and chemical-plant unavailability. The entire primary heat transport (PHT) system is enclosed in a nitrogen-inerted metallic containment.

Design-basis accidents, including loss of coolant accident (LOCA) and prolonged station blackout (SBO), along with anticipated operational occurrences (AOOs), are addressed through engineered safety systems (ESS). These advanced safety provisions, including protection against postulated reactivity-initiated accidents, ensure HTGCR safety comparable to modern Gen-IV nuclear reactors. Demonstration of clean H_2 production using HTGCR heat will advance decarbonisation of transport and process industries while reducing India's dependence on imported fossil fuels.

The Mainstay Operating Research Reactors: Research reactors Apsara-U and Dhruva operated safely and reliably, supporting medical, agricultural and industrial isotope production, fundamental research, materials testing and studies for future power reactor programmes. The Critical Facility (CF) met research community requirements.

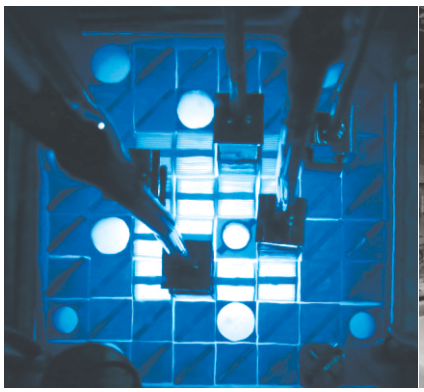
Apsara-U reactor achieved approximately 89% availability, supporting research and radioisotope production. Following shielding augmentation, successful operation at core position A enabled commissioning of the thermal column for irradiation and detector testing. Ten new B-10-lined Gamma Compensated Ion Chambers (GCICs) were tested.

The beam tube neutron imaging facility supported non-destructive investigations, including PGNAA experiments. A single-crystal alignment facility was commissioned in beam tube #6, while commissioning of a neutron detector test facility at beam tube #8 is underway. Twenty-five cans in tray rods were irradiated, and 109 samples were processed using Neutron Activation Analysis (NAA). Other activities included testing five IRM miniature fission counters for TAPS-1 and TAPS-2 after their long shutdown, and irradiation of neutron detector coaxial cables, SS 316L-glass fibre composite joints for cryogenic applications, and foils for neutron and gamma flux characterisation.

Dhruva reactor achieved approximately 85% of its maximum achievable availability. Production included 413 medical and industrial radioisotopes and 18 NAA samples. Fission molybdenum targets were irradiated as required, and 60 plates were delivered to the Fission Moly Processing Plant.

Major upgradation and life-management activities in Dhruva included replacement of Shut-Off Rod (SOR) position guide tube sealing O-rings for the first time since commissioning, and inspection of the SOR lattice and absorber guide tubes. Studies of O-rings removed after 40 years of radiation exposure informed future use. An additional canned-motor shutdown cooling pump was commissioned. A modified bearing-mounted SOR electromagnetic clutch assembly was qualified, tested and installed in one SOR. Replacement of rotameters with integral orifices, flow transmitters and current switches is underway. Underground HDPE effluent pipelines were inspected for ageing studies. TPLC software for alarm annunciation and start-up logic was upgraded, and Channel A setups of the bulk coolant gamma monitoring system were replaced.

On the other hand, the Critical Facility was operated on 71 occasions for detector testing and activation of large NAA samples. Twenty-seven nuclear detectors were tested, and 47 samples and five foils were activated. Special irradiation studies investigated organic dye stability and interactions with biological cells under neutron exposure. SNDs, GCICs and B-10-lined proportional counters for Nuclear Power Corporation of India Limited were tested. Hot commissioning trials of the iodine processing facility at CIRUS were completed.



Top view of Apsara-U Core.



Dhruva canned-motor shutdown cooling pump.