

GOVERNMENT OF INDIA
DEPARTMENT OF ATOMIC ENERGY
RAJYASABHA
UNSTARRED QUESTION NO. 1605
ANSWERED ON 13/03/2025

DAE'S CONTRIBUTIONS BEYOND NUCLEAR POWER

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Will the PRIME MINISTER be pleased to state :-

- (a) whether it is a fact that the Department of Atomic Energy (DAE) units contribute to areas beyond nuclear power production and cater to other societal sectors;
- (b) if so, details thereof; and
- (c) whether DAE technologies have been transferred to industrial and rural enterprises and if so, the details of such technology transfers?

ANSWER

THE MINISTER OF STATE FOR PERSONNEL, PUBLIC GRIEVANCES & PENSIONS
AND PRIME MINISTER'S OFFICE (DR. JITENDRA SINGH)

- (a) & (b) Yes, Department of Atomic Energy (DAE) is a multi-disciplinary Nuclear Research Centre of India having excellent infrastructure for advanced Research and Development with expertise covering the entire spectrum of usages of atomic energy. DAE plays a crucial role in various societal sectors such as nuclear agriculture & food preservation, health care, water treatment, waste management, and hydrogen production through its extensive research and technological advancements. Various technologies pertaining to societal applications developed by DAE are mentioned below :

Nuclear Agriculture & Food Preservation:

1. To ensure food security in years to come, DAE has well laid programmes for crop improvement, food preservation using radiation technology. Using radiation induced mutagenesis along with cross breeding, Bhabha Atomic

Research Centre (BARC) a constituent unit, has developed varieties in oilseeds (groundnut, mustard, soybean and sunflower), pulses (urdbean, mungbean, pigeonpea and cowpea), rice and jute, wheat etc. Total of 70 (seventy) improved crop varieties have been developed, Gazette notified and released for commercial cultivation across the country. These crop varieties have desirable traits such as high yield, disease resistance, early maturity, climate resilience, biotic and abiotic stress tolerance etc.

2. Preservation of food forms another important area for National Food Security. Feasibility of food irradiation for preservation has been studied for a number of agricultural and food commodities for several years. Food Safety and Standards Authority of India (FSSAI) notified “Food Safety and Standards (Food Product Standards and Food Additives) Sixth Amendment, 2016 and the Food Safety and Standards (Packaging and Labelling) Fourth Amendment, 2016” related to standards and labelling requirements for irradiated foods.

Radiation processing of food is very effective in treating the agricultural produce and flesh foods. Extension of shelf life of these produces is very much depended on the produce, variety and storage conditions.

BARC has developed radiation-based technology for setting up irradiation plants and protocols for gamma irradiation of several food items to extend their shelf life, provide safe foods and promote exports. A large number of food items for various objectives are being irradiated commercially. Till date 28 (twenty-eight) irradiation plants based on BARC developed technology have been set-up in the country.

Standard Operating Procedures (SOPs) involving gamma irradiation and subsequent storage in controlled environment have been developed for shelf-life extension of onion and potatoes up to 7.5 months and 8 months respectively while retaining the quality attributes. Large-scale trials have been carried out for the same. SOPs involving radiation technology has been successfully demonstrated to extend the shelf life of mangoes to facilitate export through sea route. SOPs for shelf-life extension of cereals, wheat, spices, mushroom, fruits & vegetables such as green tomato, broccoli, poultry, fish and fishery products have also been developed.

Some of the irradiation-based food preservation technologies developed and transferred to private entrepreneur for commercialisation are preservative free Shelf Stable Jamun product, Sprouts & Sweet Corn Kernels, intermediate moisture shrimp and ready-to-eat (RTE) intermediate moisture (IM) fruits cubes.

Litchi Treatment plant based upon BARC technology was set-up at National Research Centre on Litchi, ICAR located at Mushahari, Muzaffarpur, Bihar. An Indian patent has been awarded to this technology which increases the shelf-life of litchi up to 60 days.

3. Eco-friendly and biodegradable BARC-hydrogel, which can absorb water up to 550 times of its weight has been developed and deployed for agriculture in arid regions.
4. Gamma Chamber Facility at Indira Gandhi Centre for Atomic Research (IGCAR) a constituent unit of DAE, has been used for irradiation of seeds and plants by various universities for research purposes.
5. Raja Ramanna Centre for Advanced Technology (RRCAT), Indore a constituent unit of DAE has indigenously developed 10 MeV industrial electron linacs, process technology and electron beam radiation processing facility for terminal sterilization of medical device. This, first of its kind facility in the country, is operating in commercial mode at Indore with Atomic Energy Regulatory Board (AERB) and Food & Drugs Administration (FDA) licenses and is regularly providing electron beam processing services for terminal sterilization of regulated medical devices as per ISO 11137. Since starting operations, the facility has provided electron beam services for sterilization of more than 75 Lakh medical devices for various medical devices industries. RRCAT has also developed 10 MeV, 10 kW food irradiation linac which is useful for setting up food irradiation facilities within the country. Technology of the food irradiation linac is available on “technology transfer basis” to the Indian industries and institutes which are interested in manufacturing the linacs and/or are interested in setting up food irradiation facilities. The facility is also used for colour modification of precious gem stones by the industry.

6. RRCAT has developed a Liquid Nitrogen cooling based technology named “SHIVAY”- Sheetal Vahak Yantra for transportation of perishable fruits & vegetables under combination of controlled temperature, humidity and inert atmosphere for freshness of fruits and vegetables for a long duration during transportation. The system is successfully tested for about 4000 km of road trials. Farmers can access far off markets even 1000 km away with same freshness at a very low refrigeration cost of Rs.1/kg.

Health Care:

1. **Radioisotopes:**

Nuclear Medicine uses radioactive isotopes (radio-isotopes) for the non-invasive diagnosis of several human diseases, including cardiology, oncology (cancer), neurology, psychiatry and infectious diseases and for the treatment of thyrotoxicosis, thyroid cancer, neuroendocrine tumours, neural crest tumours, bone-pain palliation etc. BARC regularly produces radio-isotopes and radiopharmaceuticals and supply through Board of Radiation and Isotope Technology (BRIT) an industrial unit of DAE, to various nuclear medicine centres across India for diagnostics and therapeutic application for treatment of various types of cancers.

BARC has developed and demonstrated partition technology for recovery of Caesium-137, Strontium-90 and Ruthenium-106 from high level waste for medical applications. Non-dispersible glass pencils containing Caesium-137 is being used in blood irradiators. Strontium-90 are used for milking of Yttrium-90 for cancer treatment. Cost effective $^{106}\text{RuBy}$ (Ruthenium Brachytherapy) plaques (round, notched, pediatric) developed for Eye Cancer Treatment and supplied to various hospitals in the country.

2. Chlorophyllin tablet has been developed and launched as regenerative nutraceutical and antioxidant with a commercial name of Aktocyte. The tablets are approved by Food Safety and Standards Authority of India (FSSAI) as nutraceutical.

3. BARC is significantly contributing in the field of Nuclear Medicine and for diagnostic and therapeutic services for cancer treatment through its clinical patient services units at Radiation Medicine Centre (RMC), Mumbai & Radiation Medicine Research Centre (RMRC), Kolkata.
4. NO_x releasing dressing for the treatment of Diabetic foot ulcer and other chronic wounds has been developed. The technology has been transferred to a private firm and Drugs Controller General of India (DCGI) approval has been obtained for manufacturing & commercialisation.
5. Thermal Imaging for Early Detection of Breast Cancer - Technique has been applied for early detection of breast cancer successfully as an adjunct imaging modality in rural area and is now proposed on a larger scale.
6. Hyperthermia based cancer treatment using magnetic nanoparticles - Magnetic fluid hyperthermia is being developed as an alternate cancer therapy, where super paramagnetic nanoparticles are to be injected into cancerous tissues and subsequently exposed to high frequency alternating magnetic field.
7. **Radio-isotope Production:** The indigenous production of Sr-89 is an important societal need and a valuable import substitution; it is a pure beta emitter with a half-life of 50.5 days and used for palliative care of bone metastatic cancer. Production of Sr-89 with high specific activity at Fast Breeder Test Reactor (FBTR), Kalpakkam was successfully demonstrated. The product satisfied all the Quality Control Parameters as per the US, European and International Pharmacopeia. Bio-distribution study in progress. This technology ensures increased availability and complete import substitution.
8. The proton beams from 30 MeV Medical Cyclotron Facility (MCF) at Chakgaria campus, Variable Energy Cyclotron Centre (VECC), Kolkata a constituent unit of DAE, is producing radioisotopes/radiopharmaceuticals, which are used for cancer diagnostics and are being delivered on regular basis to various hospitals/Nuclear Medicine Centres.

9. Commercial production and supply of Radiopharmaceuticals, ¹⁸F-Sodium Fluoride (for bone scanning), and Gallium-68-PSMA (for diagnostics of Prostate cancer) have been started.
10. Production and successful human application of Thallium-201-Chloride Radiopharmaceuticals (for conducting Cardiac studies, diagnosis of brain tumour) successfully carried out first time in India.
11. VECC is also engaged in the development of first indigenous 18 MeV Medical Cyclotron (MC18) in India in collaboration with BARC.
12. Pilot scale production of radio isotopes (Y-90 & P-32) for the benefits of society was initiated during April, 2024.
13. “Mobile Health – Wellness Program for the Rural Population” is being implemented in the rural areas in and around Chengalpattu region with DAE developed Technologies.

Water Treatment:

1. Several membrane assisted technologies have been developed at BARC for desalination of brackish & seawater and purification of contaminated water for drinking purposes at domestic and/or community levels. Desalination and water purification includes purification with respect to microbiological decontamination, arsenic removal, iron removal, de-fluoridation, salinity and hardness removal. The technologies have been transferred to several private entrepreneurs on non-exclusive basis for commercialisation and field deployment. BARC has installed BARC developed water purification technologies in 200 equivalent villages in India including BSF border posts at Kutch & Barmer posts, Central Railway platforms in Mumbai and Indian Railway’s Deen Dayalu coaches.
2. BARC has developed Hybrid granular Sequencing Batch Reactor (hgSBR) technology for treatment of sewage waste water. The technology has been successfully transferred to private entrepreneurs for commercialisation. The

technology was successfully deployed in the Kumbh 2021 and Maha Kumbh 2025.

3. A technology for removal of dye from effluent from textile industry has been developed and successfully demonstrated in a textile plant at Jodhpur.

Waste Management :

Sludge Hygienisation : BARC has developed radiation hygienisation technology for treating dry sewage sludge & converting into organic manure. 100 tons/day dry sludge hygienisation plants have been set up and operationalised by Ahmedabad and Indore Municipal Cooperation with technological support from BARC.

Shesha, a technology that works on bio-methanation, has been developed for managing bio-degradable kitchen and garden waste from small housing society. The bio-gas produced during the process can be used as fuel & remaining process waste can be used as manure.

Hydrogen production :

BARC has developed and successfully demonstrated hydrogen production technologies based on thermochemical processes namely; integrated process of Iodine-Sulphur (I-S) and Copper Chlorine (Cu-Cl) and electrochemical such as Alkaline water electrolyser (AWE) for contributing towards achieving the target of net zero.

Other significant such contributions in various fields:

1. An Online Chemical Emergency Response System (CERS) with chemical sensors, dispersion models and GIS based impact assessment modules is developed for Chemical Disaster Management at industrial sites. The first version of CERS is implemented for Ammonia storage facilities of The Fertilisers And Chemicals Travancore Limited (FACT) Cochin, Kerala.
2. Development and deployment of compact Ion Mobility Spectrometer (IMS) at important security posts as an import substitute, for trace level detection of explosives and narcotics, by taking swab samples.

3. Wireless Sensor Network Technology for assessment of slope stability of avalanche site and Pollution monitoring.
4. Cadmium Zinc Telluride (CZT) single crystals for Gamma Radiation Detection and Lead Zinc Niobate - Lead Titanate (PZN-PT) single crystals for transducer applications have been developed.
5. A-TIG welding technology for welding of 304 L SS spiral pipes used in LIGO-India project has been developed in collaboration with RRCAT, Indore. The ease of implementation of A-TIG for making spirally welded precision beam pipe for LIGO-India has demonstrated significant cost reductions over other competing welding technologies.
6. The Remote Internal and Orbital Welding Technology was developed in collaboration between private industry. This achievement highlights the advancement in welding techniques, enabling precise and efficient welding in challenging and confined spaces, opening new possibilities for various industries.
7. U-233 fuelled Kalpakkam Mini Reactor (KAMINI) is continuing its successful operation for neutron radiography of critical components for the nuclear and strategic sectors, neutron shielding and neutron activation of materials. This facility is also utilized for conducting neutron beam experiments. The pyro devices used in the space programme were routinely tested in KAMINI.
8. Development of a variety of sensors, for carbon, hydrogen, NO_x, Piezo electric etc. that find applications in many industries.
9. The technologies developed at IGCAR have found wide societal applications and a 'DAE Incubation Centre' is in place for incubation of technology to the industry meeting the Atma Nirbhar Bharat goals of the Government of India. Many technologies have been transferred to the industry and many more are in the pipeline.

10. RRCAT houses indigenously built Synchrotron Radiation Sources (SRS), 450 MeV Indus-1 and 2.5 GeV Indus-2 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. More than 1000 user experiments have been carried out with more than 200 research publications every year. Users from more than 140 different universities, national labs, and institutes and Researchers from more than 20 industries have been regularly using the Indus beamlines for their research activities. 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.
11. 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, materials processing, R&D in materials and laser additive manufacturing.
12. DAE in association with DST and in collaboration with Caltech & MIT, USA is building Laser Interferometer Gravitational-wave Observatory (LIGO) in India. As part of the pre-project activities, an off-site facility for testing and training has been established at RRCAT.
13. Homi Bhabha National Institute (HBNI) at RRCAT is providing quality education using the facilities, knowhow, and expertise available at RRCAT.
14. AIC π -Hub Foundation, a Section-8 company with 100% equity holding by DAE and hosted at RRCAT with a mandate to translate the technology, know-how and expertise into products/processes with the partnership of Indian industries/startups is facilitating transfer and incubation of RRCAT technologies to the industry and startups. AIC π -Hub Foundation, RRCAT has launched three incubated products and signed two incubation agreements with industrial partners.

15. Various technologies, indigenously developed at VECC, are transferred to industries, such as, RFID based Hand Held Reader for attendance recording, RFID Reader/Writer for Library Management System, Pico Ampere Meter, Digital Nano Amp. Meter etc.

(c) Till date DAE has developed and published around 250 spin-off technologies for transfer to private entrepreneur for commercialization on non-exclusive basis and nearly 850 licenses have been issued to various industrial and rural enterprises for these technologies.

Statistics on DAE technologies that have been transferred to industrial and rural enterprises in recent years is mentioned below:

Year	No. of technologies transferred	No. of enterprises where technologies transferred		
		Industrial	Rural	Total
2022	88	98	36	134
2023	91	91	31	122
2024	40	17	14	41

List of few important technologies transferred are mentioned below:

Sl. No.	Details of technology
1.	Emergency in-situ advanced leakage arresting devices for piping.
2.	Tungsten filament-based Scanning Electron Microscope (SEM) with imaging resolution of 20nm.
3.	On-Line Domestic Water Purifier Based On Ultrafiltration Polysulfone Membrane.
4.	Radiation Assisted Adsorbent Technology For Textile Effluent Decolouration.
5.	Alkaline Water Electrolyser Plant.
6.	Multi Effect Distillation with Thermo Vapour Compression (MED-TVC) Desalination.

7.	Nanocomposite ultrafiltration membrane device for domestic drinking water purification with respect to Arsenic Iron and Microbial contaminations.
8.	Process System for Clean-up of Dissolved Oil and Salt Contaminated Waste Water for Gainful Utilization.
9.	Fluoride Detection Kit for ground water.
10.	Membrane Assisted Defluoridation Process for Safe Drinking Water.
11.	UF Membrane Assisted Device for removal of Iron from contaminated water for drinking purposes.
12.	Hybrid Granular SBR For Waste Water Treatment.
13.	Nuclear Grade Half Face Mask.
14.	Production of abrasive grade Boron Carbide powder.
15.	Hydrogen Gas Sensor.
16.	A Process for Synthesis Of O-Tolylbenzotrile (OTBN).
17.	NISARGRUNA Biogas Plant For Processing Biodegradable Waste.
18.	Compact Helical Biodegradable Waste Converter SHESHA.
19.	A Purely Organic, Seed Dressing Bio-Fungicide Formulation.
20.	De-Bittered Bitter Gourd (Karela) Juice.
21.	A Rapid Bio Composting.
22.	Turmeric Tissue Culture.
23.	Ginger Tissue Culture.
24.	A Novel Universal Multi-Nutrient Soil Extractant for Assessing Bio-Availability of Nutrients in Soil.
25.	Biosensor Kit (BIOKIT) for Detection of Pesticides.
26.	Microfine Neem Biopesticide.
27.	Process for Long Lasting Ready-To-Eat (RTE) Intermediate Moisture (IM) Fruit Cube.

28.	Atmospheric Pressure Portable Catalytic Air Plasma System for Fast Synthesis of Aqueous Nitrate & Nitrite Fertilizers.
29.	Superabsorbent Barc-Hydrogel (MRIDAMRT).
30.	10 MeV LINAC for Radiation Processing Application.
31.	Air Plasma Incinerator.
32.	Air Plasma Torch.
33.	H2S Sensor with Monitor.
34.	AuRo Clean-Autonomous Robot for Cleaning.
35.	Radiation Monitoring Watch.
36.	Helium Leak Detector.
37.	High quality respiratory face mask.
38.	Large-scale Synthesis of Carbon Nanotube (CNT).
39.	Ultra Sensitive - Flexi Range Pulsating Sensor based Conductivity Meter.
40.	Portable High Volume Air Sampler.
41.	Autonomous Gamma Dose Logger.
42.	Penetration Enhancing Activated Flux for TIG Welding of Stainless Steels.
43.	High Efficiency Particulate Filter (HEPA) Test Rig.
44.	Leak Tight Flange and Gasket assembly for Instrumentation /Power Cables for Chemical and Radiochemical Facility.
45.	High Voltage DC Power Supply for Glass-based CO2 Lasers.
46.	Refurbishing of Commercial Sealed-Off CO2 Laser and Development of New Commercial Sealed-Off CO2 Laser Tube.
47.	Dynamic Argon Pressure System (DAPS).
48.	GAS MIXER (GMIX).
49.	Build Preparation Software for Laser Powder Bed Fusion (LPBF) based Metal Additive Manufacturing.

50.	Co-Axial Wire Feed Based Laser Additive Manufacturing Head (COAX-WIRE-LAM Head).
51.	Laser Additive Manufacturing System Using Powder Fed Direct Energy Deposition (LAM-PF-DED).
52.	Laser Additive Manufacturing System Using Powder Fed Directed Energy Deposition (TVESTHR-LML-XXXX).
53.	Special Welding Machine for porous material joining.
54.	Laser Additive Manufacturing System Using Powder Fed Direct Energy Deposition (LAM-PF-DED).
55.	SHIVAY Seetal Vahak Yantra.
56.	Development of Liquid Nitrogen Based Fire Extinguishing System Prototype and Evaluating Its Feasibility of Dousing Major Fires on board Seagoing Vessels.
57.	AGNI-RAKSHAK – Raman Optical Fibre Based Distributed Fire Sensor System.
58.	60kW RF Dual Directional Couplers and coaxial transitions, RF power amplifier module.
59.	High-stability, Current-controlled, Card-based, Unipolar, Switch-mode Power Converter for Electromagnets.
60.	High-stability, Current-controlled, Card-based, True-bipolar, Switch-mode Power Converter for Electromagnets.
61.	Neel Bhasmi, Oncodiagnoscope and Tubercloscope.
62.	RFID based Hand Held Reader for Attendance Recording.
63.	Digital Nano Amp. Meter.
64.	RFID Reader/ Writer for Library Management System.
65.	Pico Amp Meter.
66.	Digital Nano Amp. Meter.
67.	Digital Current Integrator.

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