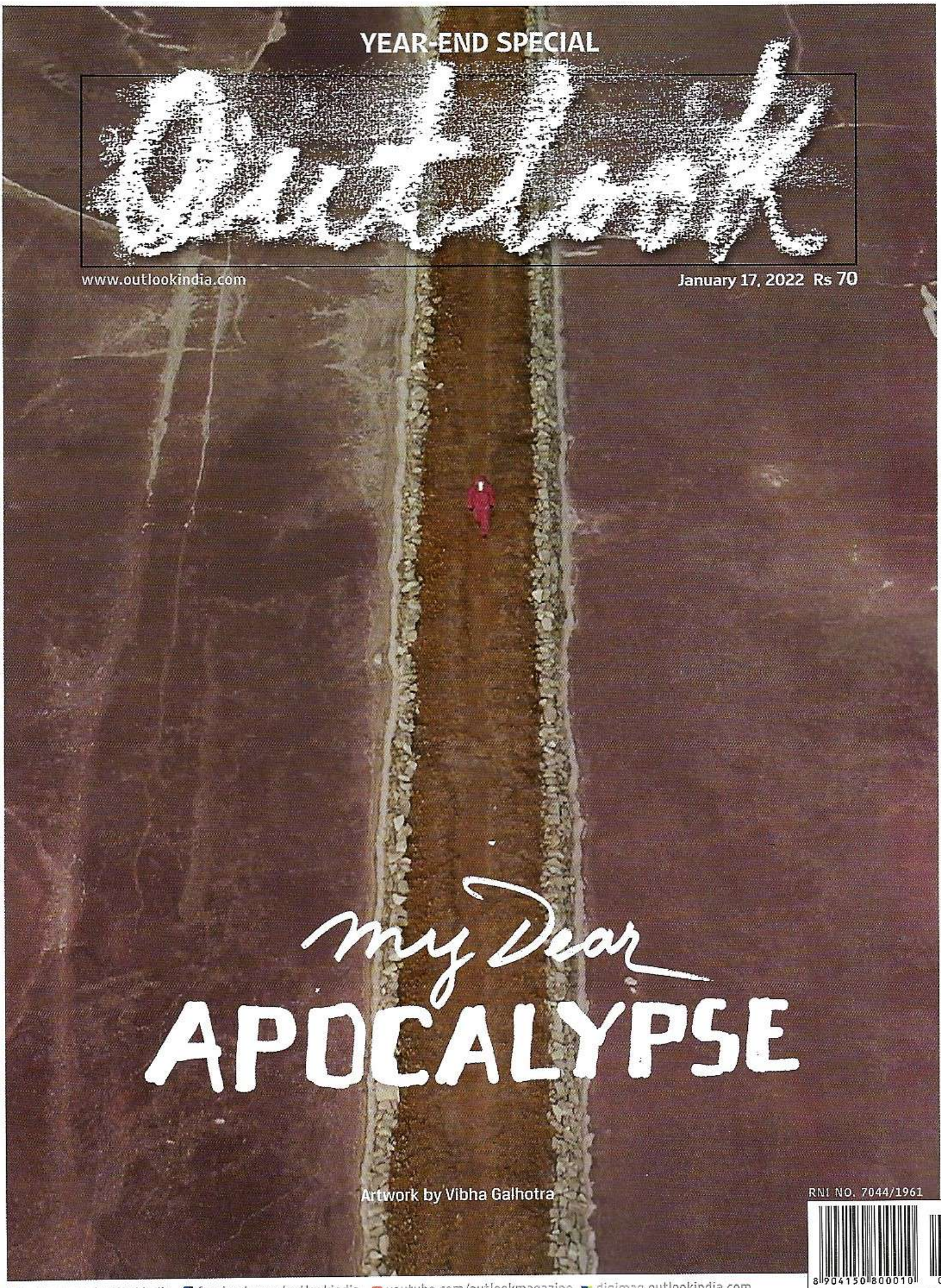
YEAR-END SPECIAL

Outlook

www.outlookindia.com

January 17, 2022 Rs 70



my Dear APOCALYPSE

Artwork by Vibha Galhotra

RNI NO. 7044/1961

DEPARTMENT OF ATOMIC ENERGY:
A technology powerhouse

TECHNOLOGIES FOR NEW INDIA@75
आज़ादी का अमृत महोत्सव

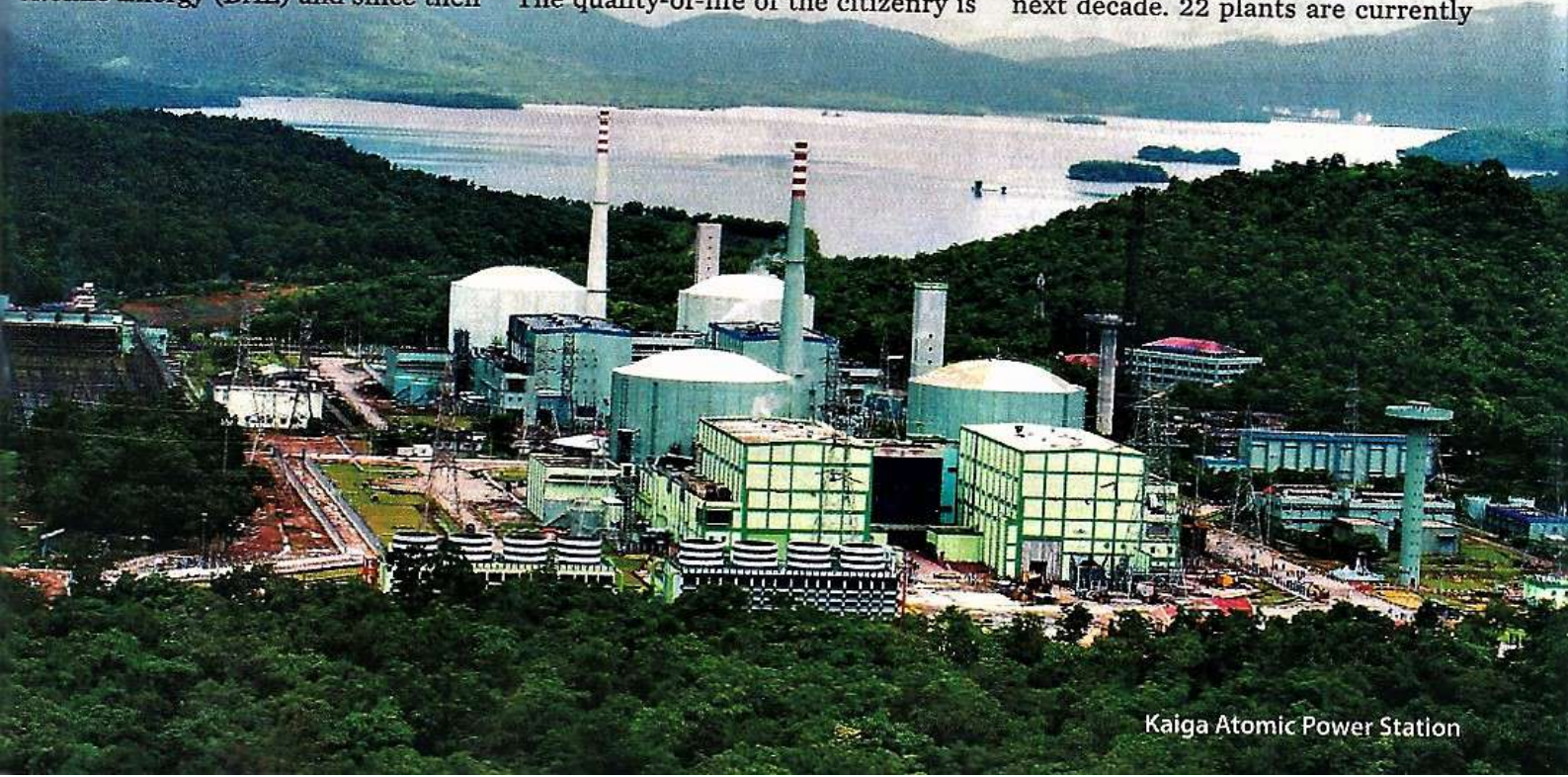
On the 75th anniversary of Indian Independence, the nation has taken a collective pledge to embark upon a phase of rapid development, in order to uplift the quality and standard of living of all its citizens. This objective can be achieved by implementing measures to alleviate poverty and malnutrition and launch developmental projects to meet the demands for energy, health care, housing, education, and many other basic requirements of its populace. The nation also pledges to achieve this goal in a self-sufficient, viable and equitable manner. AatmaNirbhar Bharat is the clarion call of the Government of India. As responsible global citizens, it is equally important that this progress is achieved in a sustainable and environmentally friendly manner.

The atomic energy programme of the nation was started in 1954 with the establishment of the Department of Atomic Energy (DAE) and since then DAE has evolved into a technology powerhouse providing solutions across a spectrum of domains such as energy, healthcare, agriculture, food preservation, water purification, environmental sustainability, and many others. Some of the major and more recent contributions of DAE are highlighted in the following paragraphs, to showcase the scope and breadth of its activities and contributions.

Nuclear Energy

The spectre of global warming and the ensuing disruptions due to climate change, such as rise in ocean levels, change in weather patterns, frequent occurrences of natural disasters such as floods and cyclones etc., looms large upon the globe, and is a clear and an existing danger. Most of these changes are attributable to the carbon emissions arising out of the use of fossil fuels for energy production and electricity generation. The quality-of-life of the citizenry is directly correlated to the per capita consumption of electricity, and it is therefore inevitable that, as we move towards development and prosperity, the per capita electricity and energy consumption of India would be steadily increasing. As responsible global citizens, it is important that the increase in energy consumption be achieved in a manner that it is environmentally sustainable. A pronounced shift towards carbon free energy sources is therefore a national imperative.

Solar, wind and hydro are important sources of carbon free green energy. However, all of these sources are intermittent in nature and cannot provide uninterrupted 24x7 power requirements of an electricity grid. The only uninterrupted source of carbon free energy is nuclear energy. India has realised this requirement early enough to ramp up the construction and commissioning of nuclear power plants over the next decade. 22 plants are currently



Kaiga Atomic Power Station

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operational, 4 are in advanced stages of construction and at least 10 more plants are in the pipeline. The most recent addition has been a state-of-the-art 700MW reactor at Kakrapar in Gujarat. India is fully AatmaNirbhar in the construction, commissioning and operation of these plants and the safety and operational track records are amongst the best in the world, with many plants running continuously for more than 2 years, emphatically bringing to fore the uninterrupted nature of nuclear power generation.

Recent Developments

Some common and well-known examples of the applications of gamma radiation are radiation Sterilization of medical equipment, food irradiation for preservation by elimination of pathogens, sludge irradiation for killing micro-organisms and pathogens in dry sludge and converting it into organic manure, radiation therapy for treatment of cancerous tumors etc. In addition to these applications, several high technology spin off benefits have also been delivered by DAE in multiple domains. Some of these contributions are detailed in the following paragraphs.

Ru-106 Eye Plaque for Treatment of Ocular Cancer

Radiation has the property of killing cancerous cells. Radiation therapy can be administered externally for treatment of tumors which are approachable from outside without collateral damage to healthy tissues. For the treatment of deep seated tumors as well as tumors of sensitive organs, radiation sources in sealed condition are placed close to the location of the tumor. A recent contribution of DAE in this direction has been the development of an eye plaque for treatment of ocular cancer. Ru-106, a radioisotope (recovered after nuclear fission from the spent fuel) is integrated into circular plaques for use in the treatment of eye cancer. The handling of the BARC plaque during the treatment procedure was found to be surgeon-friendly and at par with international standards in all respects.

Oncodiagnoscope for Real-Time Screening and Diagnosis of Oral Cavity Cancer

A tablet computer based, compact and portable health-care instrument for non-invasive, real-time screening/ diagnosis of oral cavity cancer called OncoDiagnoScope has been developed and tested. The device is based upon the principle of the change in the optical properties of the mucosa lining the oral cavity in the case of patients afflicted with oral cavity cancer. These optical changes can be measured with this USB powered machine using a pencil size stainless steel fiber optic probe. The device has been validated on patients with oral neoplasia in various hospitals and cancer screening camps and has been found to detect cancer with an accuracy of over 90%.

Tele-ECG Machine

Rural and remote areas of the country often have poor access to well-equipped hospitals, leading to grievous consequences in the case of cardiac episodes and emergencies. A simple Tele-ECG machine has been devised by DAE to cater to the emergency needs of patients at such locations. Tele-ECG is a portable, lightweight and low cost 12-channel device and is powered by a rechargeable battery which can be charged with any mobile phone charger. A mobile based app facilitates taking the ECG and sharing the ECG in real time through any file sharing app such as WhatsApp. The device is ideally suited for deployment at rural health care centres where it can be handled by local health care workers with minimal training. The device can also be used in hospitals at urban centres as a centralized facility connected to the LAN for transmission to the experts seated at a different location in the hospital. An interface for printing an ECG report on A4 size paper is also built into the device.

EC-Vikram-An IoT Based Health Monitoring System

An IoT based innovative solution called EC-VIKRAM for Remote Health Monitoring and tracking of patients and quarantined persons

has been developed by DAE. The device monitors the vital parameters of patients such as heartbeat, SpO2, respiration rate, body temperature, ECG & Non-Invasive Blood Pressure (NIBP) and forwards the report to healthcare professionals by means of mobile or web-based apps using Bluetooth, Wifi or GSM connectivity. The device also has built in location tracking as well as a system to issue alerts in case any parameter crosses the prescribed limits. A simple and user friendly interface makes it easy to set up and operate the device.

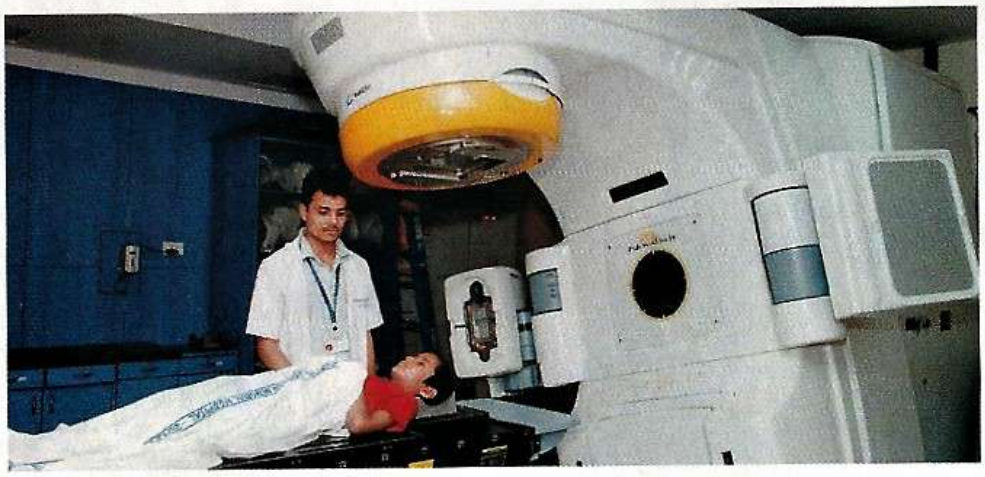
Several other medical instruments such as Covid-Beep 20, Monal 2020, Ventilators, Thermal Scanners, Oxygen Concentrators etc. have also been recently developed for the use in Covid wards as well as for the benefit of regular patients.

Sewage Sludge Hygenisation

Radiation Hygensiation Technology is a technology developed for the treatment of dried sewage sludge with gamma radiation from a Cobalt-60 source and making it free of pathogens. The pathogen free sludge is subsequently enriched with micronutrients by inoculation with Bio-NPK and used as an organic fertilizer. It is a simple, effective, economical, reproducible and scalable technology for dealing with sewage sludge. A 100 ton/day capacity, first of its kind facility has been constructed and commissioned at Shahwadi, Ahmedabad and is being used by the Ahmedabad Municipal Corporation.

Hybrid Granular Sequencing Batch Reactor for Sewage Sludge Treatment

Wastewater contains fibrous impurities which are difficult to separate. DAE has developed a technology to cause the fibrous impurities to aggregate into large particles and settle to the bottom of the treatment vessel. The treatment effectively lowers organic carbon, nitrogen and phosphorous and other contaminants to acceptable level and eliminates foul odour. Pure water can be decanted and recirculated for industrial purposes and if subjected to tertiary treatment, could also be made potable. The footprint as well as the operation and maintenance costs of the hgSBR treatment plants are lower as compared to conventional sewage treatment plants.



Radiation therapy and radiopharmaceuticals are extensively used at TMC and other cancer centres of DAE. More than 5 lakh cancer patients receive treatment every year at economical costs.

Bone Scanning Applications

Flourine-18, a radioisotope of fluorine produced by DAE Medical Cyclotron at Kolkata, is used to synthesize labelled Sodium Fluoride (18F-NaF), which is a radiopharmaceutical used for the bone scanning applications. Bone scanning is carried out to initially diagnose benign and malignant diseases of the skeleton. A Positron Emission Tomography (PET) scan is subsequently carried out to obtain more detailed images for deciding the treatment protocols. This radiopharmaceutical has been supplied and is in use at the Indian Army Command Hospital.

Applications of Heavy Water and Deuterium

DAE is the largest producer of Heavy Water and Deuterium in the world. Heavy Water and Deuterium are finding wide ranging and novel applications in life sciences, medicinal chemistry, opto-electronic applications and cancer therapy. Some recent examples are their use in the thermostabilization of vaccines, preservation of biomaterials and use of deuterium depleted water for adjuvant therapy of cancer.

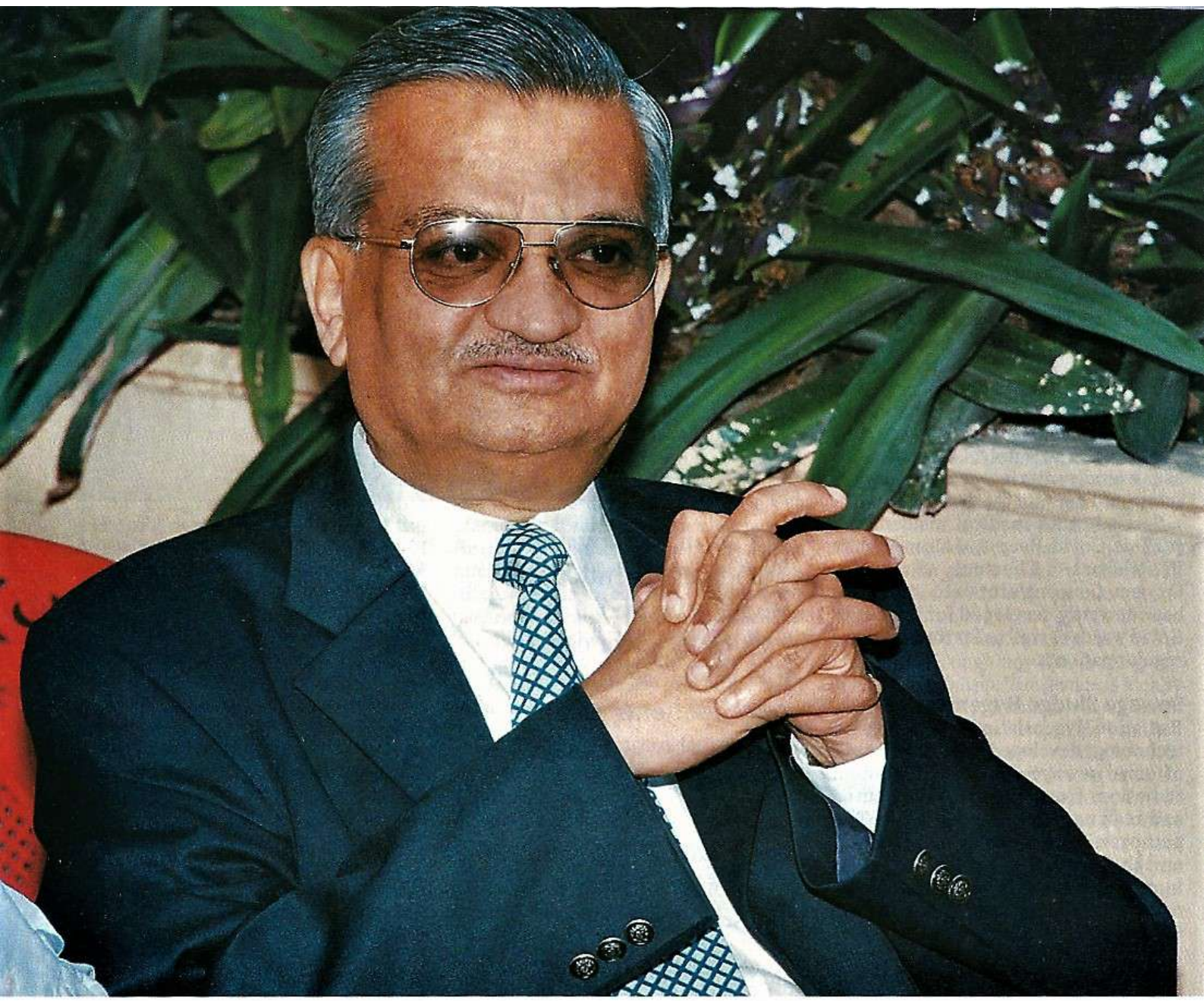
Cancer Care and Cure

No article on the contributions of DAE would be complete without mentioning the yeoman services being provided by Tata Memorial Centre (TMC) in carrying out the entire range of cancer care and cure services- from early diagnosis, treatment management, rehabilitation, pain relief and terminal care in a comprehensive manner. Radiation therapy and radiopharmaceuticals are extensively used at TMC and other cancer centres of DAE. More than 5 lakh cancer patients receive treatment every year at economical costs. Numerous hospitals all over the country have now been connected through a cancer care grid to share knowledge and expertise, leading to uniform and standardized treatment protocols to a large number of cancer patients around the country.

The technologies detailed above are by no means a comprehensive listing, but only provides glimpses of the more recent contributions of DAE. There are numerous other devices, techniques, instruments and processes which have been developed over the years. Many of these technologies have been transferred and many more are available for transfer at nominal rates to industries and entrepreneurs in a non-exclusive manner.

Compiled by Public Awareness Division,
Department of Atomic Energy
with inputs from respective unit.

For further details please visit the DAE Websites: https://dae.gov.in/, https://technologies.britatom.gov.in



ON A PATH TO BECOME VISHWAGURU

AtmaNirbhar India in Atomic Energy a major milestone

Atomic energy is critical for any nation. India has been continuously working on this critical energy for many decades. Giving insight into India's Department of Atomic Energy (DAE), one of India's senior and distinguished scientists, Dr Anil Kakodkar, former Chairman, Atomic Energy Commission, former Secretary, Department of Atomic Energy, *presents India's atomic journey in becoming AtmaNirbhar. In an engaging interview with M. Rajendran, he explains the potential areas India can achieve self-sufficiency using atomic energy through material and process applications research.*

The atomic energy programme of the nation has achieved many milestones. Which ones would you highlight as the most critical?
Dr Homi J Bhabha started the Indian atomic energy program, and it is perceived with the widest possible horizon. We call it a mission mode program in atomic energy. The application of atomic energy is the program's main thrust and is made in the broadest possible way. Basic research is done with an open-ended objective and covers all aspects of science and technology.

So, DAE does all this research?
It is done by centres of DAE like Bhabha Atomic Research Centre (BARC), Indira Gandhi Centre for Atomic Research (IGCAR), Raja

Ramanna Centre for Advanced Technology (RRCAT). These are the large laboratories working in the Government. There are also autonomous institutions like the Tata Institute of Fundamental Research (TIFR), Tata Memorial Centre, Institute for Plasma Research, Chennai Mathematical Institute. They do fundamental research, but technologies like the first computer in the country were made in TIFR. BARC does thermal reactors research and application of radioisotopes, RRCAT researches on laser and accelerator technologies, IGCAR second stage of our nuclear program. While they also go deep into basic research. That is the strength of the Indian atomic energy program.

Is it correct to say that India is AtmaNirbhar using atomic energy for energy requirements?

Yes, it was one of the objectives on the application side. Dr Bhabha conceived the three-stage nuclear program and began a comprehensive work. Tarapur Unit 1 and 2 was done under a turnkey agreement with the USA to assess how large nuclear power plants need to be set up, operated and maintained in Indian grids. Simultaneously he set up a group to define the reactor type, ideally suited for Indian requirements, particularly in achieving self-reliance or atmanirbhar. The group concluded, that in order to be AtmaNirbhar, the ideal technology would be a Pressurized Heavy Water Reactor (PHWR). It was visualized that it would be possible for India to develop this technology, manage and use it. It was done at a time when this technology was not mature. So, while we had a turnkey agreement with the USA, we set up collaborative arrangements with the Canadians.

India was participating in the technology, even while it was at the development stage of the reactor in Canada. That allowed India to start its self-reliant work step by step. So in 1974, when the Canadians left midway, we could carry on. No doubt, there was some delay, but India could achieve self-reliance in this technology. Unit-1 of Kaiga Generating Station (KGS-1) completed 962 days of continuous operation on December 31, 2018, setting the world record of long continuous operation among PHWR.

Moreover, since we made this technology 100 per cent in India, it was done at half the cost. India today has a platform to build a large scale power production.

What has been the contribution of atomic technology in developing the health sector in India?

Tata Memorial Centre is a cancer research hospital at Parel engaged in basic research. Later, the TMH research centre at Advanced Centre for Treatment, Research & Education in Cancer (ACTREC), Kharghar was set up and upgraded for treatment. One wing deals with basic cancer research, and another one deals with clinical research. It is a more focused activity; application and research go hand in hand.

Has there been any intervention in Agriculture?

Today if you see the contribution of atomic energy in oilseeds and pulses, a large variety of them have been developed in BARC. This is done along with agricultural universities, and it has been a successful program. A common saying is that if you eat an idli or dosa anywhere in Maharashtra, there is a 99% chance of being made out of urad dal of BARC variety called TAU1 In terms of pulses like black gram, oilseeds, particularly groundnut, BARC has contributed to a large share of national production.

Sewage management using atomic energy. What promise does it hold?

In collaboration with Amdavad Municipal Corporation (AMC), Ahmedabad, BARC has set up a Technology Demonstration Pilot Project, "Sewage Sludge Hygienisation Plant," at Shahwadi Ahmedabad. Another liquid sludge irradiator, Sludge Hygienisation Research Irradiator (SHRI), has been operating at Vadodara for radiation treatment of raw sludge containing 3-4% solids for the last 30 years. Some farmers have now formed a society and are managing a few of these plants, where they take the sludge, dry it and pack it as biofertilizer, taking the nutrition back to the soil. Now Indore is following up on this model. By Hygienisation, you kill the pathogens and derive value for safe conditioning of soil.

What has been the contribution to material development?

The comprehensive capability in BARC and other institutions allows India to develop products and processes. We do not depend on others and are atmanirbhar.

BARC has done reseach on carbon nanotubes on a large scale. It is a high-tech material with abilities to absorb a large amount of energy. So, it helped reduce the weight of bulletproof jackets. BARC developed Bhabha Kavach, an armour panel that gives personal protection against bullets of different threat levels. A special process developed in BARC is used to create panels offering Level III and Level III+ protection, and these are much lighter than currently available armours.

During Covid, EC-Vikram-An IoT Based Health Monitoring System was developed by Electronics Corporation of India Limited (ECIL), DAE. It helped monitor remotely a Covid patient and how much time they can spend in proximity with another non-covid person.

Luminescence based molecular imaging is another technique developed by BARC that helps in real-time visualization of biological processes and progression of tumour growth. It is a promising technology.

BARC has developed technology to transport vaccines in a van (called SHIVAY) cooled by liquid nitrogen to maintain a cold chain. This is in addition to the inbuilt refrigeration system in such vans.

Connecting research and industrial application remains a challenge.

Not anymore. The examples I just gave prove it, and the Homi Bhabha National Institute promotes research where there is also an academic drive and rigour, and it has become a vibrant and dynamic research environment. It has a full ecosystem, people with diverse disciplines, and capabilities to complement each other's knowledge to resolve a problem facing the country and global community.