# Towards nuclear self-reliance

The 50th year of the Indian nuclear fuel reprocessing programme underlines India's mastery in all aspects of the nuclear cycle. BY **T.S. SUBRAMANIAN**

THE spent fuel reprocessing programme of the Department of Atomic Energy (DAE) completed 50 years on August 18. The programme began on that date in 1964 with the commissioning of the plutonium plant at the Bhabha Atomic Research Centre (BARC) in Trombay.

The plant, the first in Asia, was inaugurated by Prime Minister Lal Bahadur Shastri in the presence of Homi J. Bhabha, the DAE Secretary and Chairman of the Atomic Energy Commission.

India's reserves of natural uranium are limited, but thorium is available aplenty. Hence, the DAE has formulated an interlinked three-stage nuclear electricity generation programme. The first stage comprises Pressurised Heavy Water Reactors (PHWRs), 18 at present, which use natural uranium as fuel. The spent fuel from these reactors is reprocessed to isolate plutonium and depleted uranium, which form the fuel for the Fast Breeder Reactors in the second stage. A 500 MWe Prototype Fast Breeder Reactor (PFBR) is set to reach criticality at Kalpakkam, Tamil Nadu, before the end of March 2015. In the third stage, the reactors will use a mixture of thorium, plutonium and uranium-233 as fuel. The DAE will soon build a 300 MWe Advanced Heavy Water Reactor (AHWR), which will use thorium as fuel.

Today, India has mastered every facet of the nuclear power generation programme. The Atomic Minerals Directorate (AMD) prospects for uranium all over the country. Uranium Corporation of India Limited, a public sector undertaking of the DAE, mines the uranium discovered by the AMD and processes it into yellow cake. The yellow cake is fabricated into fuel bundles at the Nuclear Fuel Complex (NFC) in Hyderabad to power the PHWRs. The NFC also makes the enriched uranium fuel assemblies for the two imported/American Boiling Water Reactors (BWRs) at Tarapur, Maharashtra.

Nuclear Power Corporation of India Limited (NPCIL) designs, builds, commissions and operates the PHWRs. The spent fuel from these reactors is reprocessed to obtain plutonium at the reprocessing facilities at BARC, Tarapur and Kalpakkam.The Advanced Fuel Fabrication Facility (AFFF) at Tarapur makes plutonium-based fuels for the BWRs, the PHWRs (for irradiation studies) and the PFBRs.

BARC has developed and mastered the difficult technology of making mixed oxide (MOX) fuel, containing oxides of uranium and plutonium. The AFFF, one of the few such facilities in the world, is an industrial scale MOX fuel fabrication plant and was designed and built for making alternative fuel for the two BWRs at Tarapur after the U.S. denied enriched uranium to them.

**Waste management**

India has also developed world-class expertise in radioactive waste management. The DAE has established waste management facilities at Tarapur and Kalpakkam to treat the waste coming from reprocessing plants, reactors and fuel fabrication plants. The radioactive wastes—solid, liquid and gas—are disposed of in rock-lined trenches or reinforced cement concrete tanks depending on their category. The high-level waste is vitrified into glass and stored underground in stainless steel canisters at the Solid Storage and Surveillance Facility at Tarapur. These canisters will be later stored in geological repositories such as abandoned mines.

## THE NUCLEAR CYCLE

### 1. URANIUM MINES AND MILLS

The AMD prospects for uranium, thorium, etc., in Andhra Pradesh, Jharkhand, Karnataka, Meghalaya and Rajasthan and other parts of the county.

Natural uranium ore at the uranium processing plant at Tummalapalle in Andhra Pradesh.

Uranium ore being processed into yellow cake at the mill at Jaduguda in Jharkhand.

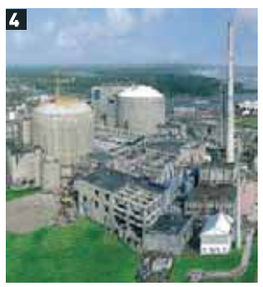
### 2. CONVERSION TO OXIDE

The UCIL mines natural uranium at Jaduguda, Bhatin, Narwapahar, Turamdih, Banduhurang and Bagjata, all in East Singhbhum district of Jharkhand, and at Tummalapalle in Andhra Pradesh. The UCIL has established mills at Jaduguda, Turamdih and Tummalapalle to convert natural uranium, through a series of chemical processes, into yellow cake. The Tummalapalle deposit has 79,000 tonnes of uranium oxide and exploration has revealed more reserves.

### 3. CONVERSION TO FUEL

The NFC converts yellow cake into fuel bundles for the reactors. Another NFC is coming up at Rawatbhatta in Rajasthan.

A nuclear fuel bundle being inspected before it is loaded at the Tarapur Atomic Power Station.



The PHWRs 3 and 4 at the Tarapur Atomic Power Station in Maharashtra.

### 4. REACTORS

The NPCIL operates 18 PHWRs at Tarapur, Kalpakkam, Kakrapara (Gujarat), Kaiga and Narora and two BWRs at Tarapur. It is also building 700 MWe reactors, two each at Rawatbhatta and Kakrapara. Bharatiya Nabhikiya Vidyut Nigam Limited, another public sector undertaking of the DAE, is building the PFBR at Kalpakkam.

### 5. REPROCESSING

There are two reprocessing facilities at Tarapur, called Power Reactor Fuel Reprocessing Plant (PREFRE), and a third one at Kalpakkam, called Kalpakkam Reprocessing Plant (KARP), to reprocess the spent uranium from the PHWRs into plutonium. KARP-II is coming up at Kalpakkam, which will be commissioned in 18 months. A Fast Reactor Fuel Cycle Facility is being built at Kalpakkam to reprocess spent fuel from the PFBR.

The DAE has built the Rare Materials Plant to enrich uranium at Ratnahalli near Mysore. The enriched uranium goes into powering India's nuclear-powered submarine Arihant. The DAE has plans for another uranium enrichment facility in Chitradurga district in Karnataka.

India's first Power Reactor Fuel Reprocessing plant (PREFRE) and Advanced Fuel Fabrication Facility (AFFF) at Tarapur.

The silos (right) in which steel canisters holding radioactive waste will be interred at the Solid Storage and Surveillance Facility at Tarapur.

### 6. WASTE MANAGEMENT

There are a series of waste management facilities at Tarapur to treat and store radioactive waste from the reactors.