NUCLEAR COOPERATION

Operation fission

There are ample opportunities for cooperation between India and France – and also a few issues

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Above: *Narora Atomic Power Station Unit - 1 & 2 (2x220) MWe, Bulandshahr Dist., Uttar Pradesh*

With the seventh largest land area (3.3 million sq km) and a population of 1.1 billion (expected to increase to 1.5 billion by 2050), fully half of which has an average age of 25 years, it is its human resource that many see as India's major accelerator of growth. Over the next two decades, the working age population is projected to grow at 1.9 per cent annually, and labour growth rate will contribute at the rate of 1.3 per cent per year. Combine this with an economy that has registered a growth rate of 9 per cent as a result of reforms initiated in the early 1990s, and projections of growing at over 5 per cent over the next thirty years and close to 5 per cent even by 2050, and you get the picture of an economic powerhouse.

But this could all collapse unless the energy to fuel this growth is in place. Even though India is the fifth largest producer of electricity in the world (at 662 billion units), the per capita electricity consumption is low – a fifth of world average. Even so, in 2006-07, the country faced a shortage 10-13 per cent. Currently, the country's installed capacity is 150,000 MWe (including captive power plants). Planners and policy makers, recognising the need to step up the faster capacity addition, have drawn up structured short- and long-term plans for the energy and electricity sector of India. The country pursues an integrated energy policy to reliably meet the growing energy needs of the people at competitive prices, while meeting the objectives of energy security, efficiency of use and addressing environmental concerns, by harnessing all sources of energy -- coal, hydro, wind and nuclear. Coal, though, remains the main source of electricity generation in India.

The Total Primary Energy Supply (TPES) is 542 million tonnes of oil equivalent (mtoe), of which 153 mtoe constitutes non-commercial energy, coming from fuelwood, animal dung cakes and other farm waste, resulting in about 390 mtoe of commercial energy (see figure 1).

Electricity demand projections have been made considering the energy shortages, expected growth in demand and the need for a spinning reserve. The GDP:electricity elasticises are expected to gradually fall as sectoral shifts take place in the economy, as under:

till 2012:	0.95
till 2022:	0.85
till 2032:	0.78

Forecasts for peak demand and installed capacity keeping a 9 per cent GDP growth rate for the year 2032 are 7333 and 960 GWe respectively, and about 1300 GWe by 2050.

Greenhouse gas emissions in India at about 1343 million tonnes of CO_2 equivalent (in 2004) constituted only about 4.8 per cent of global emissions (Source: UN statistics). The per capita emissions are among the lowest in the world at 1.02 tonnes of CO_2 equivalent per person. India is not a signatory of the Kyoto Protocol and does not have any limitations on CO_2 emissions.

It is pertinent to bring out here that there has been a concern worldwide about the projected releases of GHGs in view of growing economies and huge demand for power in India & China. The annual publication of the International Energy Agency (IEA) the "World Energy Outlook", an authoritative reference for energy decision makers worldwide, in its 2007 edition focuses on China and India, projected as major players in global energy markets. In conjunction with energy security implications, there is now more vociferous articulation of concerns regarding the share of emissions of GHGs emanating from China and India.

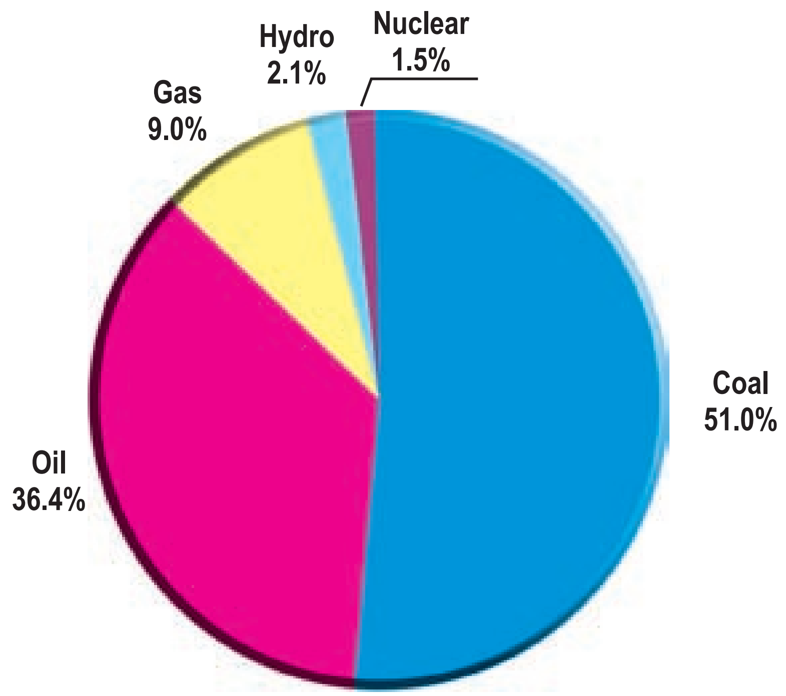

Fig. 1 -- Total Primary Commercial Energy Supply

Economic growth and, therefore increasing energy consumption will see a rapid increase resulting in huge increases in greenhouse gas emissions. As per projections made by the Planning Commission, Government of India in its Integrated Energy Policy report, India's CO_2 emissions in 2031-32 will range from 3.9 billion tonnes to 5.5 billion tonnes in various scenarios. There is therefore no place for complacency when it comes to initiating immediate measures to control the emissions of greenhouse gasses. As a responsible country, India is making endeavours proactively through a multi-pronged approach to reduce GHG emissions. The country is a signatory to the United Nations Framework Convention on Climate Change (UNFCC) and all its policies are directed at sustainable development.

India has modest uranium reserves to support a capacity of 10,000 MWe. The thorium reserves, on the other hand, are huge, at about 30 per cent of total world reserves. With a view to judiciously utilising the nuclear resources, a three-stage sequential nuclear power programme consisting of PHWRs in the first stage, FBRs using spent fuel from the first stage reactors in the second stage, and thorium reactors in the third stage, has been envisaged from the very beginning of nuclear power programme in the country. The Indian nuclear power generation programme is based on a closed-cycle approach that involves reprocessing of spent fuel and recycling of Plutonium-239 and Uranium-233 for power generation. The first stage has reached a state of maturity, the second stage has been launched and the third stage is under development. While the indigenous programme is robust and on course, imported light water reactors, as additionalities to the indigenous programme, have also been set up to enable faster nuclear capacity addition to meet the growing demand.

India has developed comprehensive capabilities is all aspects of nuclear fuel cycle. Apart from comprehensive, multi-dimensional R&D centres, front-end and back-end fuel cycle facilities have been set up. All other facilities of the supply chain, such as heavy water, zirconium components and other special products, have been set up. The Indian industry is sufficiently developed to manufacture critical nuclear components and equipment and take up execution of large

Kakrapar Atomic Power Station Unit - 1 & 2 (2x220) MWe, Surat Dist., Gujarat

Tarapur Atomic Power Project Unit - 3 & 4 (2x540) MWe, Thane Dist., Maharashtra

Kudankulam Atomic Power Project Unit - 1 & 2 (2x1000) MWe, Tirunelveli Dist., Tamil Nadu

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nuclear package contracts.

There are 17 reactors with a capacity of 4120 MWe in operation and 3160 MWe under construction (see figure 2). The current plans envisage reaching a capacity of about 20000 MWe by the year 2020 through indigenous programmes (14,000 MWe) and through imported LWRs (6000 MWe). A much larger capacity can be achieved with additionalities, subject to developments in international cooperation.

The first ever bilateral cooperation India entered into was interestingly enough with France in the area of nuclear energy. The cooperation has been very meaningful enough, covering areas such as R&D, fast breeder reactors, safety and, now, fusion energy. France is an excellent example of how energy security can be realised through the nuclear route in an environmentally benign way. Currently, France reprocesses and recycles almost the entire spent fuel that arises from its fleet of PWRs. France has been a forerunner in FBR technology and the host of the ITER project. The success of the ITER will pave the way in augmenting global energy supply through almost unlimited fusion energy. India is also a partner in this global effort.

Discussions have been held between nuclear industries in India and France on industrial cooperation in manufacturing of PWR components in India. This is an important element in the competitiveness of French PWRs in India. This will also help in enhancing competitiveness of French PWRs worldwide. The Indian industry manufactures and supplies equipment for its PHWRs and FBRs, and is also qualified for PWRs.

Indian and nuclear French industries have been in regular interaction through structured forums and have visited each others' industries to explore possibilities for business cooperation in manufacturing and supply of equipment for nuclear power.

As an example, over 300 senior management and practicing engineers from nuclear industries of India and France participated in a recent Indo-French nuclear industry business meet in Mumbai. The most influential French and Indian companies were a part of this important meet. And French financial institutions appeared keen to finance such projects in India.

International cooperation in commercial nuclear power in India took off with the Tarapur units 1 and 2 (then 2X210 MWe BWRs (currently 2X160 MWe) as early as 1965, followed by the finalisation of 2X1000 MWe, LWRs with the Russian Federation. These international cooperation agreements were initiated prior to the formation of the Nuclear Suppliers Group.

For now, nuclear energy can at best play a complementary role in power generation as the domestic uranium available can support only

Figure 2: India's Energy Resource Base

	Amount	Thermal Energy			Electricity Potential
		EJ	TWh	GW-yr	GWe-yr
Fossil					
Coal	38-BT	667	185.279	21.151	7.614
Hydrocarbon	12-BT	511	141.946	16.204	5.833
Non-Fossil					
Nuclear					
Uranium -	61.000 -				
In PHWR		28.9	7.992	913	328
In Fast		3.699	1.027.616	117.308	42.231
Thorium -	2.25.000				
In Breeders		13.622	3.783.886	431.950	155.502
Renewable					
Hydro	150 -	6.0	1.679	192	69
Non-conv.	100 -	2.9	803	92	33

Source: A Strategy for Growth of Electrical Energy in India - DAE, Government of India 2004

10,000 MWe capacity (5000 MWe realised and another 5000 to be added). It is also critically linked to the establishment of fuel linkages – the success of starting mines at new locations. It can play a role of a larger contributor only when FBR technology reaches a maturity level, which may take 15-20 years.

As such, for meeting the immediate requirement of power through a nuclear route, the country has no choice but to have global access to nuclear power plants and uranium. India cannot afford to remain isolated from the nuclear club.

In the first phase, even to achieve 20,000 MWe by 2020, the contribution of imported light water reactors is envisaged to be 8,000 MWe. Two LWRs (VVER type) of 1000 MWe each are in advanced stages of construction at Kudankulam in Tamil Nadu. These are being set up in technical cooperation with the Russian Federation. Among countries, France is a competent player in commercial nuclear technology and has a strong potential for supplying nuclear power plants to India. Historically, India and France, ever since the late eighties/early nineties, have been deliberating mutual cooperation in nuclear power. Several rounds of discussions between their nuclear power experts have been held. Of late, in view of India's strong and competent industrial infrastructure, good human resource availability, conducive environment for business and several opportunities, attention has been drawn in the global markets. India's impeccable non-proliferation record has been one key factor in addition to its core strengths and business opportunities, attracting other countries to enter in business relationships/ cooperation in nuclear power.

The Indian nuclear industry, over a period of time, has developed to meet any challenge in design, manufacture and supply of equipment comparable to international standards.

Kaiga Atomic Power Station Unit - 1 & 2 (2x220) MWe, Uttar Kanada Dist., Karnataka

Recognising the imperative of increasing international cooperation for boosting nuclear power capacity, the Indian government has taken unprecedented initiatives. However, the following issues need to be resolved to facilitate the initiation of international cooperation in nuclear power. Efforts are being made at government level to resolve these issues at the earliest:

a) Conclusion of international agreements
b) IAEA safeguards agreement
c) Concurrence/ approval by the Nuclear Supplier group

For the success and longevity of mutual cooperation, it is important to understand, appreciate and address all concerns. For this, the following issues need deliberation and appropriate solutions:

a) **Compliance to national statutory and regulatory requirements:** The statutory and regulatory requirements of India need to be understood and addressed appropriately in all phases of NPP by participating countries in mutual cooperation. The supplier country's national regulatory, qualification and licencing aspects also need to be brought in consonance with Indian regulatory requirements.

b) **Competitiveness of electricity tariff:** To procure electricity for the future via the competitive tariff bidding route, the tariff will play a key role and will depend on the overnight cost, funding pattern and mechanism, cost of capital, mode of implementation and a host of other factors.

c) **Modalities of implementation/indigenous content:** India would prefer that projects through international cooperation be

Rajasthan Atomic Power Project - Unit 5 & 6 (2x220) MWe, Chittorgarh Dist., Rajasthan

implemented on a technical cooperation basis, with as high an indigenous content as possible. This is essentially to achieve further growth, development and technology absorption by Indian industry. The indigenous content envisaged in the first few reactors is about 50 per cent, which needs to increase in later reactors.

d) **Modalities of Implementation:** The modalities for Indian participation in design, engineering and procurement, apart from execution of projects, commissioning and operation, needs to be worked out through

Figure 3: Installed Capacity MWe - Regional Break up (as on 30.09.2007)

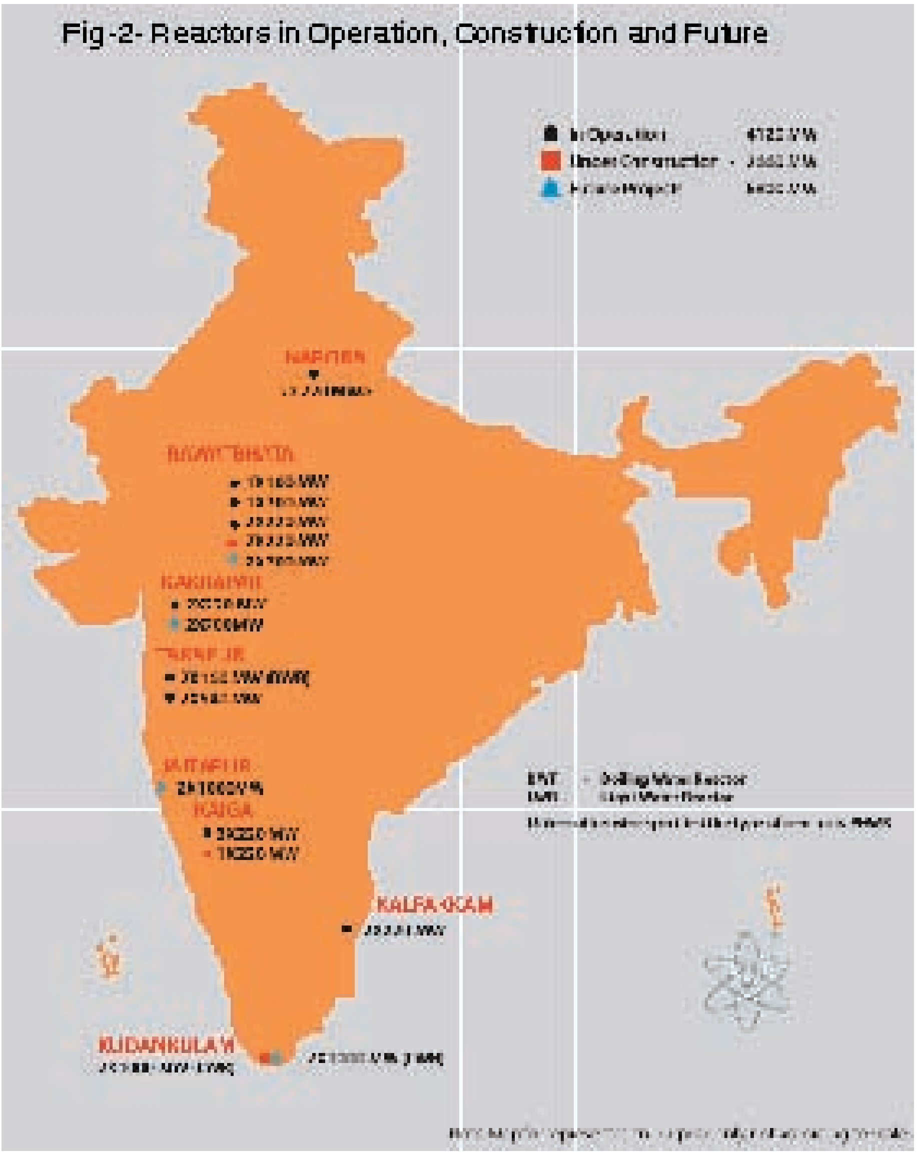
S.No.	Region	Hydro	Thermal				Nuclear	R.E.S.	Total
			Coal	Gas	Diesel	Total			
1.	Northern	1267	1	3433	15	215	1180	1220	36547
2.	Western	7004	2	5861	17	293	1840	2670	40895
3.	Southern	1064	1	3586	939	204	1100	5899	38144
4.	Eastern	2824	1	190	17	145	0	228	17609
5.	N.	1116	3	772	143	124	0	146	2506
6.	Islands	0	0	0	70	70	0	11	81
7.	Total	3426	7	13842	1202	872	4120	1017	13578

In addition, a captive generating capacity of 14636 MW is available.
Renewable Energy Sources (RES) include Wing, Small Hydro Projects, Biomass Gas, Biomass Power, Urban & Industrial Waste Power.
Totals may not exactly add up due to rounding off.
Ref.: Central Electricity Authority, Ministry of Power, Government of India.

Figure 4: Projections for 8% GDP Growth Rates

Year	Energy Requirement (BUs)	Peak Demand (GWe)	Installed Capacity (GWe)
2007	761	107	153
2012	1097	158	220
2017	1524	226	306
2022	2118	323	425
2027	2866	437	575
2032	3880	532	778

Reference: Integrated Energy Policy, Planning Commission, Government of India



mutual consensus. Training modules and an evaluation methodology, simulator training and maintenance training aspects need to be evolved to train Indian manpower in the technology.

e) **Guarantees and warranties:** Guarantees of technical support for equipment and systems, including supplies of spares during the entire life of the plant, protection against obsolescence and experience sharing need to be built into the agreements.

f) Fuel supplies: Linkages have to be established for uninterrupted supply of fuel over the entire life of the plant.

Recent initiatives of the Indian government have opened up opportunities for cooperation between India and France in nuclear power. With the experience gained by India in its Tarapur 1 and 2 and Kudankulam 1 and 2 reactors, any techno-commercial issues can be resolved amicably, in a manner acceptable to both countries.

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