

India's Fast-Growing Power Sector

From Regional Development
to the Growth of a National Grid

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INDIA IS ONE OF THE LARGEST COUNTRIES IN THE WORLD, WITH A GEOGRAPHICAL area covering 3 million km² and teeming with a population of over 1 billion. The economic growth of a nation calls for a matching rate of growth in infrastructural facilities. The growth rate of the demand for power in developing countries is generally higher than that of the gross domestic product (GDP). The elasticity ratio for the growth rate in demand of power over that of GDP is about 1.5 for India. In order to support a reasonable rate of growth of GDP, around 7% per annum, the growth rate of power supply needs to be more than 10% annually. The government of India (GOI) has emphasized infrastructure development, with top priority given to the power sector. Being a developing country, the per capita consumption of electricity in India is on the order of 582 kWh (and projected to be 1,000 kWh by the year 2012) as compared to more than 5,000 kWh in developed countries. However, it has taken rapid strides in power development despite high poverty levels.

During the 1960s and 1970s, the growth rates of electricity consumption were 11.6% and 12.2%, whereas in the 1980s and 1990s, the growth rates were 6.5–7.4%. The estimated future



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growth rate is around 6.75%. The large growth rate for electricity consumption has been mainly in the agriculture sector as well as the domestic and commercial sectors. The installed generating capacity has increased from 1.362 GW in 1947 to about 115.52 GW at present. By 2012, the peak demand of the entire country will be 157.107 GW, with an energy requirement of 975 billion units. The phenomenal growth in demand has always outstripped supply. The development of the Indian power sector is done on a regional basis. Currently, the region-wise peak demand and energy

and environmental considerations. It also coordinates the activities of various planning agencies for the optimal utilization of resources. The functions of various central sector institutions under the overall supervision of MoP are depicted in Table 3.

The power development in the states is mainly handled by the vertically integrated state electricity boards (SEBs) or, recently, by the unbundled entities of SEBs in many of the states. In some states, private sector utilities (like Tata Power Company, Reliance Energy, etc.) have been given licenses for

power generation, transmission, and distribution. Power trading is a licensed activity and the Central Electricity Regulatory Commission (CERC) has issued licenses to nine traders for the interstate trading of power.

table 1. Peak demand (MW) and energy shortages (MU) as of 31 January 2005.

Region	MW			MU		
	Peak Demand	Peak Met	Deficit	Requirement	Availability	Deficit
NR	25,095	22,316	2,779	14,938	13,010	1,928
WR	30,084	23,096	6,988	18,724	15,882	2,842
SR	21,506	20,954	552	13,279	12,897	382
ER	8,489	8,371	118	4,768	4,561	207
NER	1,272	995	277	596	558	38
All India	86,446	75,732	10,714	52,305	46,908	5,397

shortages are 12.39% and 10.32%, as shown in Table 1. Forecasted demand is shown in Table 2.

The power development is supported by both central as well as state governments through five-year plans. Currently, the tenth five-year plan (2002–2007) is in progress. For the 11th plan (starting from April 2007), the generation capacity is planned so that reliability indices in terms of loss-of-load probability (LOLP) and energy not served (ENS) would be 1.07% and 0.0342%, respectively.

Institutional Framework in the Indian Power Sector

With power development on the concurrent list of the constitution of India, both GOI and the state governments have been vested with powers to make laws and regulations on various issues. The Ministry of Power (MoP) under the GOI formulates the national power policy for the entire country. The Central Electricity Authority frames a national electricity plan (NEP) every five years and revises the same from time to time in accordance with the NEP. The NEP suggests locations for capacity additions in generation, transmission, and load center requirements. The plan deals with grid standards, security of supply, quality of power,

table 2. Long-term demand forecast in megawatts.

Region	2006–2007	2011–2012
NR	35,540	49,674
WR	35,223	46,825
SR	31,017	42,064
ER	11,990	15,664
NER	1,875	2,789
Islands	60	94
All India	115,705	157,107

Electricity Act 2003

The Electricity Act 2003 (EA2003) aims to enhance the scope of power sector reforms. This act consolidates and supersedes the earlier acts of the years 1910, 1948, and 1998 and introduces provisions with respect to new developments in the sector. It also focuses on protecting consumer interests and rationalizing tariffs. All the necessary powers (including issuance of licenses) are given to the regulators and made independent from the government.

Some of the major provisions of the EA2003 are the following:

- ✓ Generation has been delicensed and captive generation is being freely encouraged and permitted. For hydro projects, approval of the state government and clearance from the CEA are needed to check the safety aspects and optimum utilization of water resources.
- ✓ There will be government-owned transmission utilities at the central as well as state level with the responsibility of ensuring that the transmission network is developed in a planned and coordinated manner to meet the requirements of the sector. The load dispatch function can be integrated with or separated from the transmission utility, and in either case it will remain under government control.
- ✓ A provision for private transmission licensees has also been made.
- ✓ Open access in transmission with provision of surcharge for cross-subsidy and the surcharge to be gradually phased out. However, captive power plants (CPPs) are exempted from surcharge payment if power is wheeled for self-use.
- ✓ Distribution licensees are free to undertake generation and generating companies are free to take up distribution licensees.

- ✓ For rural and remote areas, stand-alone systems for generation and distribution would be permitted. This provision seems to be aimed at promoting CPPs and distributed generation (DG). However, independent power producers (IPPs) may try converting themselves to CPPs to gain advantages.
- ✓ For rural areas, the decentralized management of distribution system through Panchayats, cooperatives, etc., would be permitted.

commercial principles and should gradually be cost-reflective in order to reduce cross-subsidies.

Generation Development

The installed power generation capacity as it is today is shown in Table 4.

GOI, in coordination with the states, had made an ambitious plan to bridge the gap between demand growth and capacity addition during the eleventh five-year plan. Even

table 3. Central sector institutions.

Ministry of Power(MoP)	
Agency	Functionality
Central Administrative Tribunal (CAT)	To adjust/arbitrate in any matter of dispute
Central Electric Authority (CEA)	National power planning
✓ Regional Electricity Board (REB)	Coordination, planning, and security studies of SEBs
Central Electricity Regulatory Commission (CERC)	Tariff, legal and regulatory issues
Power Grid Corporation of India Ltd. (PGCIL)	Central transmission utility and grid operator
✓ National Load Dispatch Center (NLDC)	Operation of all regional links
✓ Regional Load Dispatch Center (RLDC)	Regional grid operation
Power Finance Corporation Ltd. (PFCL)	Funding
Rural Electrification Corporation (REC)	To finance and promote rural electrification
Power Trading Corporation (PTC)	Power trading
National Thermal Power Corporation (NTPC)	Thermal generation
National Hydro Power Corporation (NHPC)	Hydro generation
Neyveli Lignite Corporation Ltd. (NLCL)	Lignite generation
Nuclear Power Corporation of India Ltd. (NPC)	Nuclear generation
Bureau of Energy Efficiency (BEE)	Estimate energy conservation and DSM potential
Central Power Research Institute (CPRI)	Training and research
National Power Training Institute (NPTI)	Training and research
Ministry of Non-conventional Energy Sources (MNES)	Renewable energy development

- ✓ Regulatory commissions are authorized to issue licenses for power trading, and they will fix the upper limit on power trading margins higher.
- ✓ State governments to convert SEBs into corporate bodies in the field of generation, transmission, and distribution.
- ✓ A central administrative tribunal (CAT) has been created for the speedy disposal of appeals against the decision of CERC and state electricity regulatory commissions (SERCs).
- ✓ In accordance with EA2003, CERC has issued new generation tariff regulations for the period 2004–2009 that would follow a light-handed cost-plus approach based on normative parameters. The tariff principles should encourage utilities to run their business on

though current demand growth is 6.75%, capacity addition is planned to meet demand growth of 8%. Capacity addition by central sector public utilities is expected to be as per the envisaged programs. However, in the state sector, financial shortages are a major problem in capacity addition. The NEP aims at achieving financial turnaround and commercial viability of the electricity sector. Some of the new projects conceived are planned to be taken up under joint ventures between state-owned generating companies (GENCOs) and industrial consumers. This would facilitate the joint venture

table 4. Installed power generation capacity in MW as of 31 January 2005.

Region	Hydro	Coal	Thermal			Nuclear	Total
			Gas	Diesel	Wind		
NR	10,579	16,915	3,213	15	179	1,180	32,080
WR	5,502	20,792	5,036	17	632	760	32,739
SR	10,438	13,893	2,650	939	1672	780	30,372
ER	2,460	15,237	190	17	5	0	17,909
NER	1,134	330	751	143	0	0	2,357
Island	5	0	0	64	0	0	69
All India	30,118	67,166	11,840	1,196	2,488	2,720	115,527

There is significant potential in India for the generation of power from renewable energy sources, such as wind, small hydro, biomass, and solar energy.

companies to provide adequate equity so that loans can be tied up with financial institutions. For ensuring payment security to the generators, the SEB can open an escrow account in favor of generators (with first right to receive) over selected collection area. Capacity can be added in the states by allocating some projects to the private sector as well as IPPs.

For meeting the per capita electricity consumption target of 1,000 kWh by 2012, India needs to add capacity of over 100 GW. Out of this, it is proposed that 52 GW must come from central sector utilities and the remaining 48 GW from state and private sectors. It is expected that energy conservation measures would result in a savings of 14 GW, while peak demand management would result in a savings of 10 GW. Interregional diversity would further contribute to savings of 7.5 GW. However, there may be demand growth due to the Accelerated Rural Electrification Program (AREP), adding 12.5 GW, and household modernization, adding 8.3 GW.

The demand estimates of the 16th Electric Power Survey (EPS) report are shown in Table 2. These estimates have been taken as the basis for planning sector-wise capacity additions as shown in Table 5.

The utmost emphasis is given to the development of hydro potential. A 50 GW hydro initiative has already been launched in the NER states with large hydro power potential. The execution of the projects will be supported by the National Hydro Power Corporation (NHPC). It is proposed to adopt a basin-wise policy to expedite expansion. Also, ranking studies and the preparation of prefeasibility reports (PFRs) are carried out. Less than one fourth of the total potential of 150 GW has been tapped so far.

For thermal generation planning, coal will be the major fuel for meeting future demand; accordingly, large pit head stations with large size units would be preferred. The annual requirement of the indigenous coal during 2012 will be about 411 million t and for that of lignite, it will be about 28.8 million t. The annual requirement of hydrocarbons—natural gas, liquid natural gas (LNG), and liquid fuel—will be about 16.4 billion m³, 8.5 billion m³, and 1.4 million t, respectively. Significant lignite resources in the country are located in the

states of Tamil Nadu, Gujarat, and Rajasthan. Imported coal-based power stations at coastal locations would be encouraged. Concerns about pollution are being addressed through strategies to promote environmentally sustainable power development and the disposal of the large amount of ashes. All central utilities have been advised to adopt ISO 14001 standards. Under the modernization programs, the options of blending coal with imported coal, super critical technology, etc., are encouraged. The higher unit size of 800 MW to 1,000 MW, using clean coal technology with improved efficiency, would lead to enhanced performance with reduced production costs.

table 5. Capacity addition in megawatts.

Sector	10th Plan				11th Plan			
	Hydro	Thermal	Nuclear	Total	Hydro	Thermal	Nuclear	Total
Central	6,002	11,570	2,520	20,092	15,828	11,740	4,940	32,508
State	4,213	9,101	0	13,314	4,328	12,523	0	16,851
Private	700	5,814	0	6,514	2,264	9,273	0	11,537
All India	10,915	26,485	2,520	39,920	22,420	33,536	4,940	60,896

As of today, the total nuclear capacity of the country is 2.72 GW with 14 units. About 4.46 GW of capacity will be added in the future. By April 2005, one of two 540 MW units at Tarapur, Mumbai, is expected to be commissioned using indigenous technology. The nuclear program for the future includes pressurized heavy water reactors (PHWRs) using natural uranium in the first stage followed by fast breeder reactors (FBRs) using plutonium-based fuel in the second stage. In the third stage of the nuclear power program, light water reactors (LWRs) using thorium as a fuel, which is available in large quantities in India, would take precedence over other technologies. It is expected that by the year 2020, the cumulative nuclear power capacity will be 20 GW.

Renewable Energy Development

There is significant potential in India for the generation of power from renewable energy sources, such as wind, small hydro, biomass, solar energy etc. The Ministry of Non-Conventional Energy Sources (MNES) has issued guidelines to all the states on policies for power generation from renewable energy sources with a view to encourage commercial developments.

It is mandatory for all the power utilities to procure 5% of their supplies from renewable energy sources. India is the

fifth largest wind power producer in the world (after Germany, the United States, Denmark, and Spain) with a generation capacity of 1,870 MW, out of which 1,805 MW has come through commercial projects. The gross wind energy potential in India is about 45 GW. The GOI policy on non-conventional energy sources is also expected to facilitate sizable capacity addition. In Maharashtra state alone, more than

2,000 MW of wind power generation is expected during the tenth plan's period. The focus of the small hydro power (SHP) program is to promote commercialization and active private sector participation. There exists an estimated potential of about 15 GW for SHP in India. The MNES has a database of 4,233 potential sites with an aggregate capacity of 10.3 GW for projects up to 25 MW. Power of about 19.5

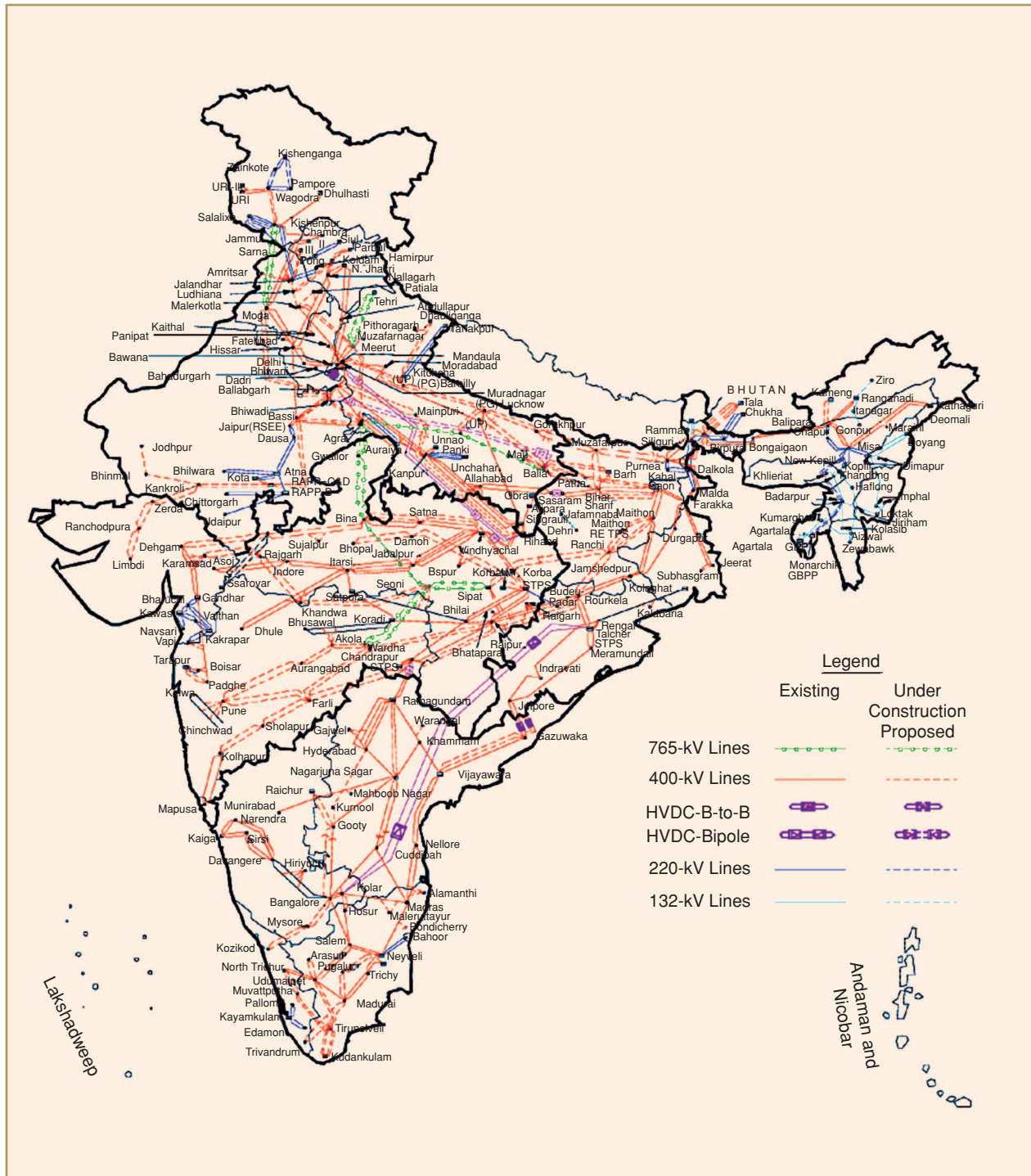


figure 1. A power map of India.

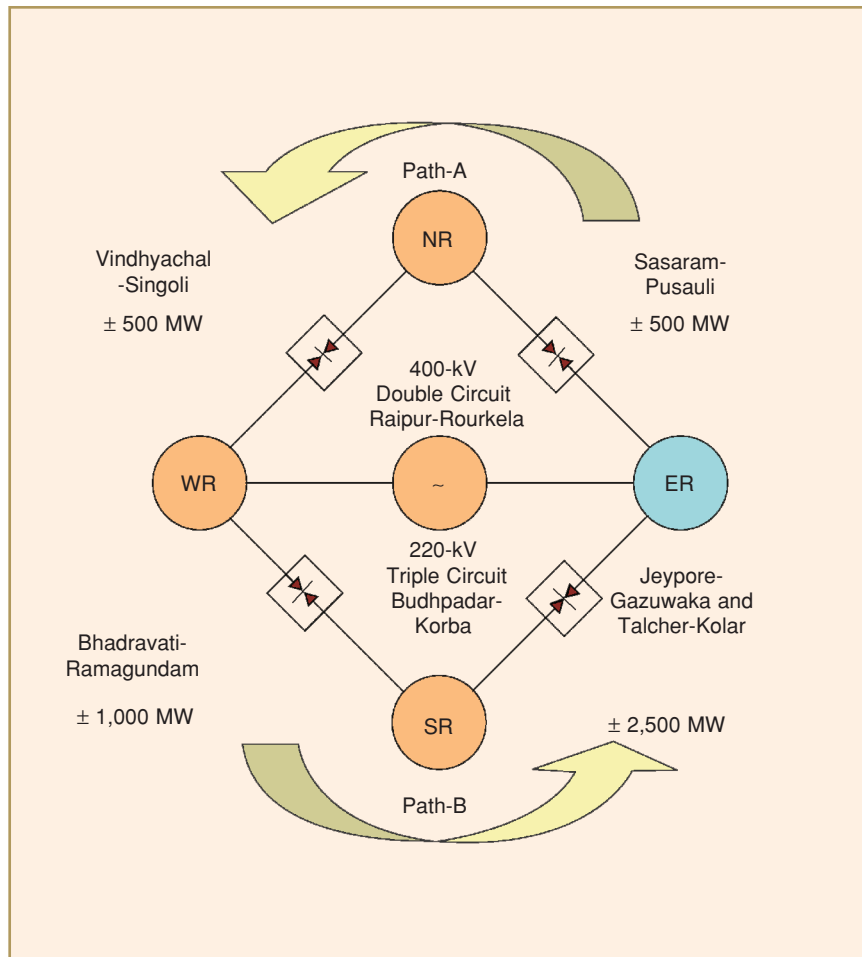


figure 2. Regional interconnections.

GW can be generated from fuel wood, crop residues, forest sources (about 500 million tons per annum), and bagasse in the sugar industry. About 43 bagasse-based cogeneration projects aggregating to 304 MW capacities have already been commissioned. There are about 300 clear sunny days a year in most parts of India, giving over 5,000 trillion kWh/year (more than the total energy consumption of the country in a year). About 66 MW of solar PV (photovoltaic) systems have been installed for various applications. One of India's first and among the largest in the world, the 140-MW integrated solar combined cycle (ISCC) project with a solar-thermal component of 35 MW is going to be installed at Jodhpur in Rajasthan state.

Transmission Development

In India, the transmission network has increased from 3,708 ckm (circuit kilometer) in 1950 to more than 265,000 ckm today. The present power map of India, highlighting important transmission lines, is shown in Figure 1. The transmission network, initially planned on a regional basis for the evacuation of generation, has grown over the years to form a national grid with power exchanges among neighboring

regions. The transmission network has evolved to fulfill transient stability requirements under N-1 contingency, without generation reduction or load shedding. In many transmission corridors, FACTS devices, e.g., thyristor-controlled series compensators (TCSCs) and static var compensators (SVCs), have been installed or are planned to facilitate strong interconnections, controllability of power flow, and savings in investments by increased capability.

Development of Regional Interconnections

In the 1980s, the GOI stepped into power development on a regional basis in order to provide SEBs with extra generation from the central sector generating stations. Each state in the region is allocated a share from central utilities having pit-head power stations. The GOI has also developed the transmission network for evacuating power from the central stations to the state grids as well as interstate/interregional networks. The development of central sector power stations and transmission networks led to the parallel operation of the state grids with each

other, thus forming a synchronous regional grid. Subsequently, the opportunity for exchanging seasonal surpluses as well as infirm power available during certain hours of the day (due to diverse peak demands) induced the need for development of regional interconnections. Due to weak inerties, continuous parallel operation was not conceived among the regions because tripping of weak ties may lead to disturbances in connected regions. Since regional grids were operating at different frequencies, high-voltage dc (HVDC) back-to-back links became the favored mode of regional interconnections.

The Indian power system is operated with five regional grids as follows: Northern Regional (NR) grid, Western Regional (WR) grid, Eastern Regional (ER) grid, Southern Regional (SR) grid, and North-Eastern Regional (NER) grid.

In the present scenario, NR, WR, and SR suffer from severe power deficits while ER has a surplus generation of about 2.5 GW, and NER is has a marginal surplus based on hydro reservoir levels. The regions are connected to each other, forming a national grid either through asynchronous links (HVDC back-to-back) or ac links to enable power exchange as shown in Figure 2. (NER is connected to ER by a synchronous link, which is not shown in the figure.)

The transmission expansion planning is based on the following factors.

- ✓ The national grid will be strengthened in order to provide adequate infrastructure for large-scale interstate/interregional power transmission. Central Transmission Utility (CTU) is entrusted with such development based on NEP.
- ✓ The State Transmission Utility (STU) has the responsibility of intrastate transmission development planning, commensurate with central plans. With open access transmission in operation, competition among the generating companies will be facilitated.

The phase-wise development of the national grid by interconnecting various regions through 765-kV ac and HVDC corridors has already begun. The first phase (September 2002) has already been completed; the regions are connected through asynchronous HVDC back-to-back interconnections. The first phase accomplished the transfer of 5 GW across the regions. The second phase, to be completed by 2007, will strengthen the regional interconnections through hybrid ac (400 kV/765 kV) and dc lines. At the end of the second phase, NR would be connected with a combination of ER, WR, and NER with a transfer capacity of 23 GW. The third phase (to be completed by the year 2012) aims at high-capacity 765-kV ring mains, which will have several corridors criss-crossing over all the regions with a transfer capacity of 30 GW.

National and Transnational Grids

The plan of regional interconnection led to the formation of a national grid. As a first step in this direction, the 400-kV Raipur-Rourkela double circuit line connecting ER and WR was commissioned. On 2 March 2003, ER-NER grids were synchronously connected with the WR grid forming a central grid. Presently, three synchronous grids, NR, SR, and WR-ER-NER (central grid), are operating in the country. NR and the central grid will be connected to form a single grid, and the SR grid will be separate. After this, the SR and remaining grids can form a single national grid through synchronous/asynchronous links. The national grid will help in tapping the least-cost energy resources, which are unevenly distributed over the various regions. In addition to this, the national grid will facilitate the use of regional peak diversity.

Currently, India and Nepal exchange power over a number of 33-kV and 132-kV lines connected to NR and ER in a radial manner. Plans are to develop hydro potential in Nepal in coordination with India and to export surplus power to India. Presently, the Chukka Power Project and Khirinchu Power Project in Bhutan are connected with ER for the evacuation of power. The 1,020-MW Tala Power Project in Bhutan is under construction, which will connect NR and the central grid with Bhutan by December 2005. Discussions are also under way for the formation of the South Asian Association for Regional Cooperation (SAARC) grid covering the power systems of India, Pakistan, Nepal, Bhutan,

Bangladesh, Sri Lanka, and Maldives. Plans are also under discussion for the transfer of gas by pipelines from Bangladesh to India and from Iran/Central Asian countries to India through Pakistan and Afghanistan.

Investments in Transmission

The approximate budget for the tenth and eleventh plans combined would require INR8 trillion (US\$1 = INR45) for generation and transmission development. Out of this, INR2 trillion would be spent for a transmission system, including INR700 billion for CTU lines. The Power Grid Corporation of India (PGCIL) is expected to mobilize nearly INR410 billion; remaining funds have to come from private investments, including those investors with 100% foreign direct investment (FDI).

Open Access

CERC has issued open access regulations as per EA2003. In May 2004, open access in transmission was introduced for the first time to promote competition among the generating companies. The open access provided nondiscriminatory use of the interstate and intrastate transmission system, facilitating the trading of power from one utility to other. Currently, the Indian transmission network is divided into a number of systems, covering CTU transmission networks in regions, interregional links, and the transmission networks of each state. Each state will act as a single control area, with postage-stamp transmission charges in INR/MW/day. Later, the tariff mechanism would be sensitive to distance, direction, and quantum of flow. The transmission losses are adjusted in kind. Long-term open access transactions (those more than 25 years) have priority over the short-term open access transactions during congestion. Therefore, in real-time operation under congestion, pro rata curtailment is done to all the short-term open access transactions. At present, the short-term open access is provided based on margins available in the existing network. The open access can yield desirable results if one can ensure adequate margins in the transmission system. After implementation of open access, the experience gained has been providing signals for identification of congested corridors and expansion planning. The open access enables competition in the procurement of cheaper power by utilities

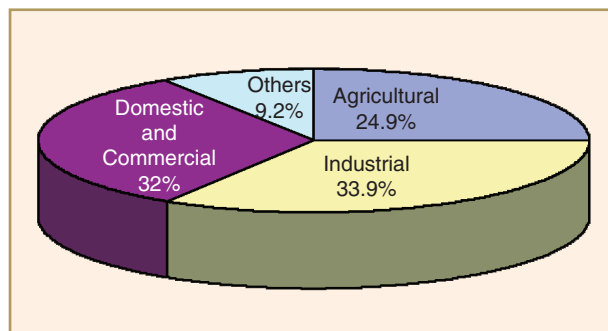


figure 3. Sector-wise energy consumption (2002–2003).

and promotes merit order dispatch. It also facilitates setting up of IPPs, CPPs, and merchant power plants. Open access at the state level will be facilitated by the intrastate availability-based tariff (ABT).

Distribution Development

The Indian power system has a peak demand of 85 GW. The typical sector-wise distribution of the demand for 2002–2003 is shown in Figure 3.

The major reasons for the financial sickness of SEBs are: the skewed tariff structure leading to unsustainable cross-subsidies, transmission and distribution (T&D) losses, and commercial losses. One hundred percent metering and effective management information system (MIS) for monitoring at the feeder level, backed up by a detailed energy audit to bring accountability into the system at all levels, is desirable. A multiyear tariff (MYT) framework can minimize the risks for utilities and consumers. It brings greater predictability to consumer tariff adjustments with known indicators such as power purchase prices and inflation indices. EA2003 has made a provision for multiple licensees in a single distribution area of supply through their independent distribution systems. The success of the reforms in the power sector heavily depends upon the efficient management of the distribution system. Following are the key policies to meet the objectives:

- ✓ safeguarding the interest of the consumer
- ✓ the promotion of efficiency and a reduction in T&D losses
- ✓ the recovery of cost of services
- ✓ a rational tariff as per the direction of the regulatory commission
- ✓ a reduction in the cross-subsidy in a phased manner
- ✓ the metering of all consumers within two years.

The MoP has initiated various measures for power management, including energy conservation, peak demand management, and exploitation of interregional diversity. In order to flatten the load curve by the shaving of morning and evening peak loads, the SEBs are planning for demand side management (DSM). The SEBs are not able to perform efficiently due to various government policies typical of a developing country. In order to meet a 100% electrification target, the distribution feeders of 11,000 V and 400 V are laid over long distances to hamlets and tribal areas, far away from the distribution transformer centers leading to very high losses. A high-voltage distribution system (HVDS) is an effective way to reduce losses, prevent theft, and improve the voltage profile. It has been successfully implemented in the state of Andhra Pradesh.

Currently, domestic and agricultural consumers in rural areas are fed through a common feeder, which makes it difficult to shed agricultural loads alone during peak hours. The SEBs are making investments to segregate single-phase and three-phase supplies. Thus, the onset of an agricultural load could be prevented during peak hours. The Accelerated Power Development and Reform Program

(APDRP)/Distribution Management Services (DMS) program initiated by GOI addresses the distribution infrastructure issues through the addition of distribution transformers for reducing loading of transformer and consequent failures, the addition of distribution feeders and replacing conductors of the existing feeders, the improvement of voltage using shunt capacitors, etc. Under this program, GOI provides funds to the SEBs and matching funds are to be provided by states. Under the energy conservation program, the use of energy-efficient pump sets is encouraged.

Rural Electrification Plan

The “Power to All” program plans to cover all nonelectrified households by the year 2012. Nearly 80,000 villages are yet to be electrified. Renewable energy sources and DGs are encouraged to achieve AARQA (accessibility, availability, reliability, quality, affordability), a goal set by the Draft of Rural Electrification issued by MoP. GOI has launched a new plan for electrification of all the villages and households that combines AREP, Kutir Jyoti and Grameen Yojana. The Rural Electricity Supply Technology (REST) mission by MoP involves MNES and others. The Akshay Prakash Yojana implemented in Maharashtra involves the cooperation of rural consumers to voluntarily desist from using agricultural pump sets during morning and evening peak hours, for which the rural consumers are rewarded with uninterrupted power supply to residential premises. This experiment has been found to be successful and plans are ready for execution to award associations of consumers in these villages distribution franchises so that bill collection efficiency can improve.

Grid Operational Issues

Generally, all developing countries have to face generation deficiency and large frequency fluctuations, and the system is susceptible to even small disturbances. Operating such systems is an onerous task and innovative solutions are needed to deal with such situations. The National Load Dispatch Center (NLDC) will be the nodal agency for coordination of all Regional Load Dispatch Centers (RLDCs) in the future. At present, the National Power System Desk (NPSD) set up in New Delhi is performing the job of NLDC. For the purpose of grid operation, the RLDCs are the apex bodies for regional grid operation, and State Load Dispatch Centers (SLDCs) are apex bodies at the state level. At present, the RLDCs are operated by CTU (i.e., PGCIL), while the SLDCs are operated by state-owned TRANSCOs designated as STUs. The legal framework for regulation of interstate power transfer is vested with CERC and the regulation of intrastate power supply is vested with the concerned SERC. Grid operation in the Indian context is based on the Indian Electricity Grid Code (IEGC) issued by CERC, which defines the roles and responsibilities of various utilities, the scheduling and dispatch code, the operational requirement and

The phase-wise development of the national grid by interconnecting various regions through 765-kV ac and HVDC corridors has already begun.

responsibilities in real-time operation, the planning code, and other allied issues. The state grid code issued by the SERCs deals with similar issues at the state level. The increased number of bilateral transactions under open access results in the loading of transmission lines close to the limit. To ensure the security from impending disturbances, defense plans are implemented. The plans include automatic underfrequency load shedding, undervoltage load shedding, islanding schemes, etc. These defense plans have successfully operated for many disturbances.

The regional grid operation is based on the commercial mechanism ABT, Free Governing Mode Operation (FGMO), load management measures, system security measures, and restoration plans (based on stipulations in grid code). The IEGC and ABT facilitated setting up a loose power pool in which the participating utilities can inject (or draw) power into (or from) the pool based on an unscheduled interchanges (UI) pricing mechanism of ABT. Under ABT, the capacity charges payable to generators are linked to plant availability rather than PLF (plant load factor) to facilitate generators to vary their generations based on grid requirements. The energy charges payable to generators are linked to the cost of fuel and charged on the scheduled energy rather than actual energy drawn by a state. The scheme implemented for reactive energy charges aims to maintain the voltage profile within a band of 97–103% by penalizing reactive power injection above 103% and giving incentive to reactive power support below 97% of the nominal voltage.

Commercial Mechanism—ABT

The fluctuating frequency led to conceiving a UI mechanism with frequency-linked prices under ABT. The commercial mechanism ABT has been implemented in all the five regional grids of India according to CERC orders from 2002 onwards. Under ABT, each state and each central generating station is designated as a control area with schedules of demand and generation issued a day in advance. These schedules consider central allocations and open access scheduled transactions. Deviations from schedules are termed as UI and charged at frequency-linked prices. Under ABT, all UI power is injected into the regional UI power pool from which participant utilities can draw power.

Thus, the UI power pool of a region comprises all the states in the region with predetermined demand schedules, all central generators with predetermined injection schedules, and all other regions with predetermined tie-line schedules.

The introduction of ABT (referred to as “The Indian Medicine”) in all the regions of the country enabled the exchange of power through scheduled bilateral contracts or as unscheduled power without any commercial problems. In fact, a decision can be taken in real time itself to effect the transfer of power from one region to another, and there is no need to negotiate price because the price of such exchanges is determined by linking them to frequency, a universally available signal. The ABT mechanism can be visualized as a simple and transparent balancing market. The ABT has accomplished incredible, improved performance on commercial and operational fronts. It is encouraging to note that under ABT, even 8 h of power supply to agricultural consumers would suffice, as the same amount of water could be pumped without damage to motors.

Reforms and Restructuring

The EA2003 made it mandatory to restructure and segment the vertically integrated SEBs by 10 December 2004, and now the deadline has been extended to 10 June 2005. The management of these restructured entities is still under a single administrative control at the top, and the financial independence of these entities is yet to be made. In some of the states, many distribution companies were created, but the market model adopted was the single buyer model. All the supply from within the state, external supply from the central utility, and the power purchased through trading are pooled either by a residual SEB or state-owned TRADECO and distributed based on the requirements of distribution companies (DISCOs) in a pro rata manner. This model does not give autonomy to the DISCOs to explore sellers or buyers at competitive rates and maximize their earnings. In a multibuyer model, the distribution entities are totally autonomous in procuring and dispatching their supply. This model would lead to better operation and a lower cost to the end consumers. The objectives of a fully restructured system focus on core business activities, autonomy, financial independence, and accountability. However, the restructuring of the Indian system has a long way to go. The task force working on the model survey has recommended a transmission system operator (TSO) model for India.

Even though EA2003 made generation license free and promoted competition in generation and other supplies through open access, the distribution tariff is still regulated (cost plus scheme), and competition is not promoted in distribution. The DISCOs could engage only in the wire business

The Ministry of Power has initiated various measures for power management, including energy conservation, peak demand management, and exploitation of interregional diversity.

and metering, whereas franchises/private suppliers would be allowed to provide direct supply to consumers under a competitive environment. The competition in generation at one end and a regulated tariff at the distribution level at the other end would not reflect the variation in cost of procurement of supplies to the end consumers, and some of the distribution companies may suffer losses unless, and until, the regulators revise the tariff.

Conclusions

The Indian power system was not planned initially for regional interconnections. The growth was rather haphazard. Subsequently, a well-coordinated approach towards forming a national grid was felt necessary for development of the power sector. MoP has taken cognizance of this and has taken steps to achieve it. The unibus act (EA2003) unshackles the firm grip of public sector monopoly and throws open competition, private participation, and the path to reforms. EA2003 and open access have motivated SEBs and others to perform better. The implementation of ABT has been a success story which has contained frequency in a narrow band, improved system security, and has enforced grid discipline in a subtle way. The extension of ABT to the intrastate level will be a true test for its effectiveness. The distribution sector reforms, like the energy audit, proper metering, and MIS, are expected to improve recovery. Regulatory commissions have an important role to play in building confidence among all the stakeholders. In the vibrant economy of India, investment in the power sector is a key issue. The reforms and restructuring policies of GOI have assured an adequate rate of return to investors. The national electricity policy implementation is expected to fulfill the aim of meeting more demand at a higher security level.

For Further Reading

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