2011 INDIA Energy Handbook

Demand Driven, Supply Chained

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India Energy Handbook

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India, home to 1.2 billion people and over 17% of the world's population, has a seemingly unquenchable thirst for energy. One harsh result of its meteoric growth is the widening gap between required energy and that which is produced. Herein lies the problem. India is unable to keep up with demand and faces growing pressure from the international community for climate change mitigation. A concerted effort by the central and state governments, and the growing importance of private sector access and investment, will drive India into the future.

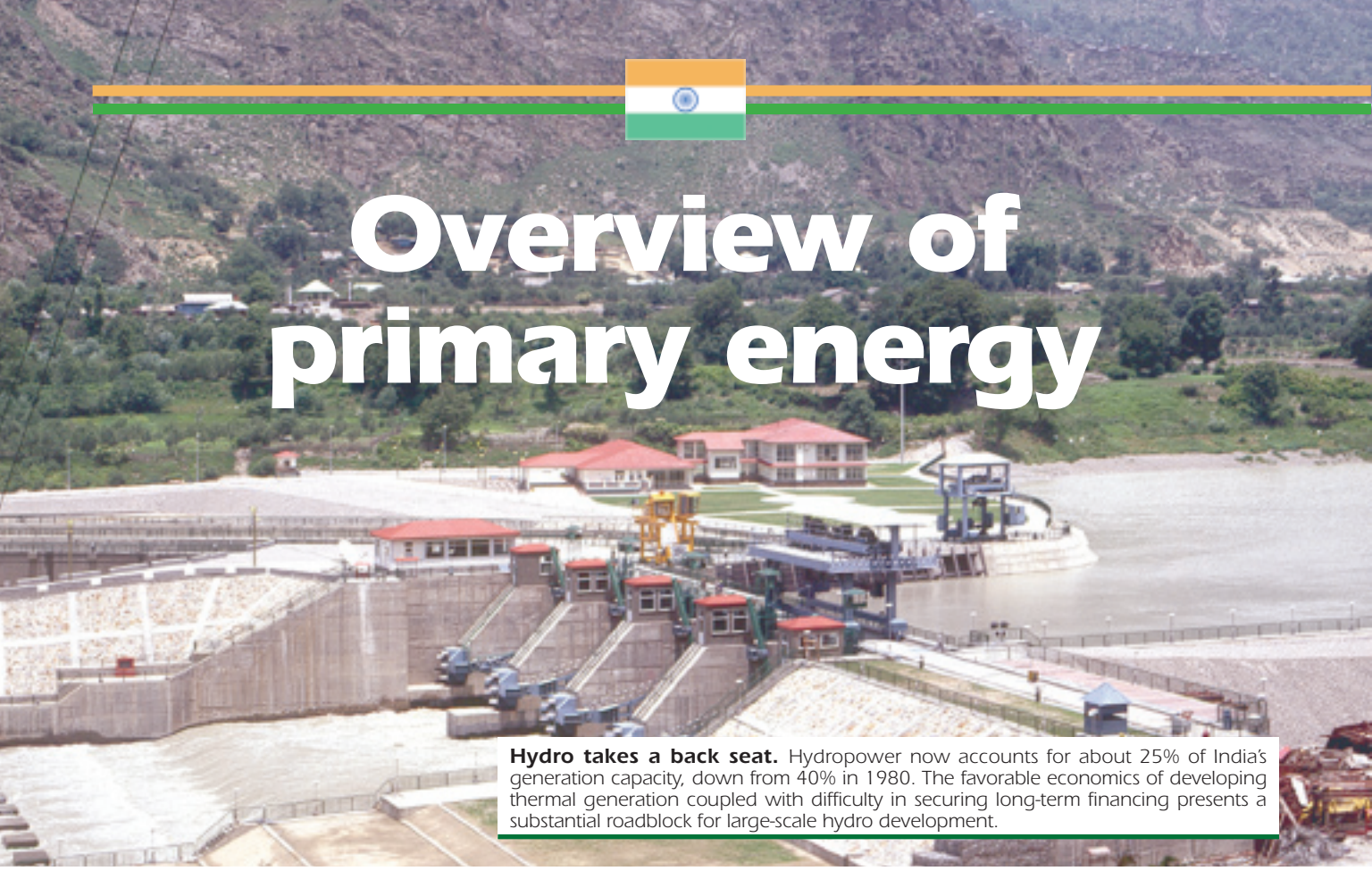
Foreign direct investment into India ranked third globally at over $35 billion for FY 2009. This number is expected to increase greatly in the coming years because of a policy roadmap by the Government of India that is increasing the liberalization of the nation's economy, especially in the energy sector. Initiatives include ambitious five-year plans for increasing installed electricity infrastructure, the New Exploration and Licensing Policy for increasing the production of oil and gas, and the nuclear sector's recent embrace of international companies to provide equipment and related services.

PSI Media, publisher of handbooks and technical journals for the energy industry, and International Energy Consultant Corp (IECC), specialists in providing solutions for energy companies, governments, and regulatory bodies in developing nations, collaborated on this project to provide the industry with an up-to-date overview of the structure and potential opportunities for investment in the Indian Energy sector. Headed by Sridhar Samudrala, IECC offers a great deal of insight into Indian affairs.


Samudrala

Regarding the current business climate in India, Samudrala says it best, "With the financial crisis almost over, India is the major energy user in the Indian sub-continent and requires energy investment from every angle. There is also a major initiative to bring in gas from the west through Pakistan to meet the energy requirements of India. With all these opportunities, India is one of the best places for energy investments."

Overview of primary energy



Hydro takes a back seat. Hydropower now accounts for about 25% of India's generation capacity, down from 40% in 1980. The favorable economics of developing thermal generation coupled with difficulty in securing long-term financing presents a substantial roadblock for large-scale hydro development.

Jaiprakash Associates

With 15% of the world's population and an economic growth rate that increases the aspiration of its people to better quality of life, India has a voracious appetite for energy. But the country lacks sufficient domestic energy resources, particularly of petroleum and natural gas, and must import much of its growing requirements. Currently, about 35% of India's commercial energy needs are imported. Table 1-1 indicates the primary commercial energy consumption in India.

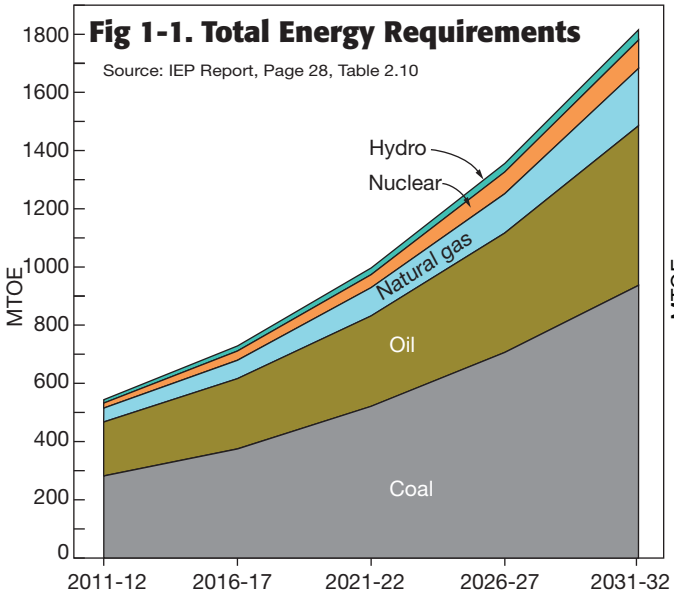
The Government of India's (GoI) Planning Commission predicts dramatic demand increases for coal and oil over the next 20 years. Fig 1-1 and Table 1-2 shows projections of India's energy requirements in its Integrated Energy Policy (IEP) report published in August 2006.

Nuclear energy now contributes more than 4,000 MW of power using a largely indigenous technology, but the nuclear industry's development has been hamstrung by India's refusal to sign the Nuclear Non-Proliferation Treaty, cutting the country off from cooperation and assistance in civil nuclear technology.

In 2008, India and the Nuclear Suppliers' Group agreed on a waiver to the embargo on trade in nuclear technology. The waiver has removed most of the obstacles, and India now is planning to have 63,000 MW of nuclear generating capacity by 2032.

India's long-range plans, however, foresee coal as the sector with the most growth potential, fueled mostly by demand for power generation (Fig 1-2).

Coal reserves are mainly in the eastern



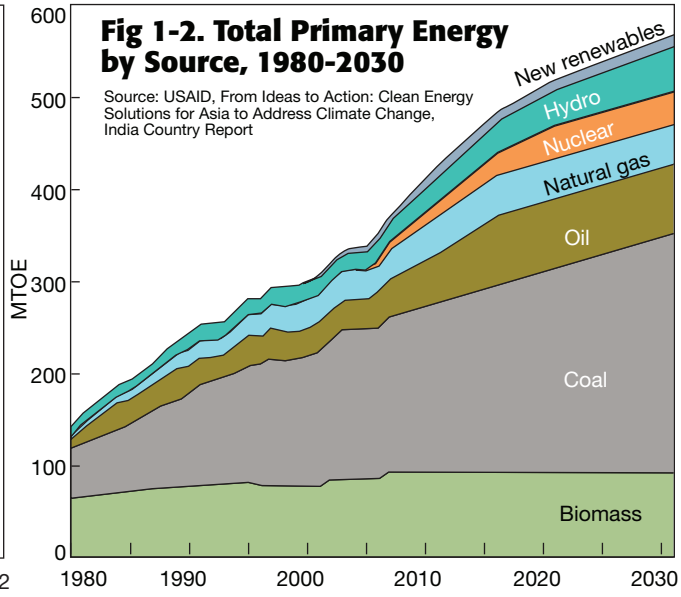


Fig 1-3. India Energy Resource Map

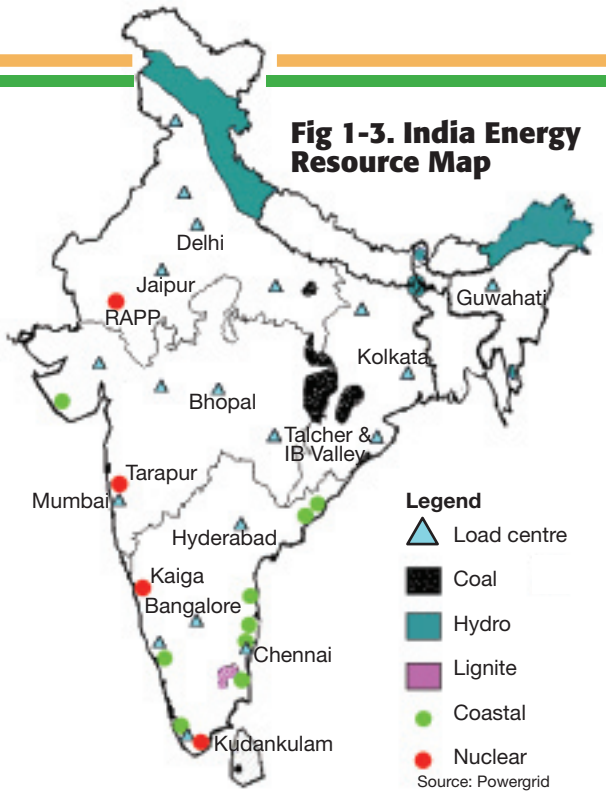
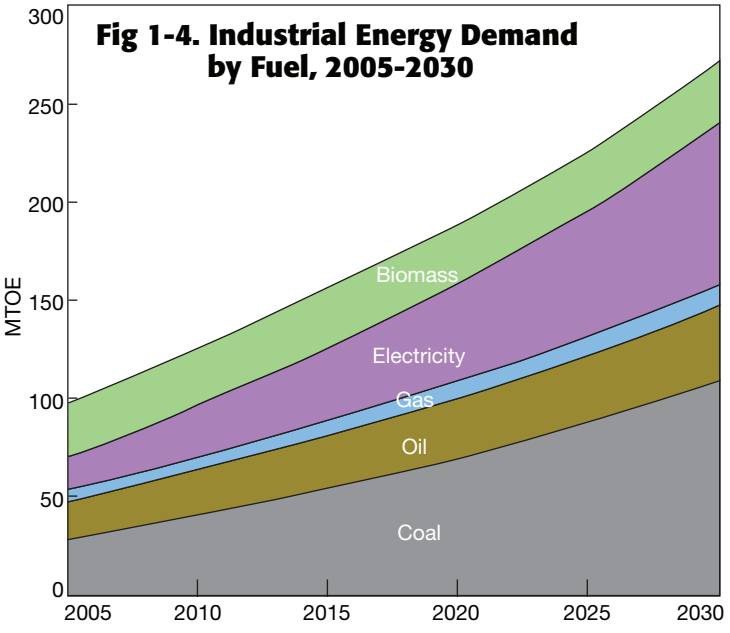


Fig 1-4. Industrial Energy Demand by Fuel, 2005-2030



Source: IEA, World Energy Outlook (2007)

region while the load centers are growing rapidly in the southern, western and northern part of the country. But coal's appeal lies in the facts that coal-fuelled power plants are less costly per installed megawatt than most other designs. Mining of India's large coal deposits can be expanded relatively cheaply, with the product shipped by rail to the power plant.

The bulk of India's hydro potential, in contrast, is in the northeastern region and the northern part of the country in the Himalayas. The distribution of energy resources and load centers is consequently much skewed. The medium and long-term plan is to promote pithead stations using domestic coal and coastal stations using imported coal and to strengthen the inter-regional transmission systems. Fig 1-3 illustrates the distributions of energy resources across India.

Coal is expected to continue to meet India's energy needs in a significant way for power generation and other industrial purposes. Fig 1-4 illustrates the industrial energy demand by fuel in India till 2030.

Impact of environmental regulations

Total carbon-dioxide emissions in the country have been gradually increasing and are expected to increase sharply in the next 20 years as India enters a period of sustained economic growth and higher consumption of energy.

Over 50% of the total CO_2 emissions are from the power sector. Cement, shipping, and iron and steel are other industries that have experienced annual growth rates above 4% between 1985 and 2005. In fact many industries have great potential for improving energy efficiency through use of combined heat and power (CHP). The primary driver for CHP is economic, but it is also an effective means of reducing CO_2 emissions.

Over the past two decades, the GoI has been very active in participating in international efforts for climate change mitigation:

- Vienna Convention – ratified in 1991
- Montreal Protocol – ratified in 1992
- UN Framework Convention on Climate Change – ratified in 1993
- Kyoto Protocol – ratified in 2002
- Establishment of National Clean Development Mechanism Authority (CDM) in 2003
- 337 CDM projects are currently registered with the UNFCCC with estimated annual emission reduction of 31.62 million tonnes of CO_2 per year

Still, India is facing enormous international pressure to reduce its greenhouse-gas emissions under a successor agreement to the Kyoto Protocol that is now in development. In June 2008, the National Action Plan on Climate Change (NAPCC) was announced as a major move toward reducing carbon intensity, but its real effect is still unclear (see p. 10).

What is obvious is that India will have to choose between increasing its fossil-fuel use and reducing its emissions; it cannot do both. Investors should keep this uncertainty in mind and closely watch developments in Indian climate-change policy to make the wisest use of their investment capital.

Table 1-1. Commercial Energy Consumption

Source	Unit	2007-08	2008-09*
Petroleum Products	MMT	140.7	145.3
Natural Gas (net)	BCM	31.5	31.8
Coal	MMT	457.1	493.3
Lignite	MMT	34.0	NA
Electricity	Billion kWh	813.1	842.8

Source: Basic Statistics on Indian Petroleum and Natural Gas, 2008-09, Ministry of Petroleum & Natural Gas, New Delhi
* Estimate

Table 1-2. Total Energy Requirements (MTOE)

Year	Hydro	Nuclear	Coal	Oil	Natural Gas	Total
2011-12	12	17	283	186	48	546
2016-17	18	31	375	241	64	729
2021-22	23	45	521	311	97	997
2026-27	29	71	706	410	135	1,351
2031-32	35	98	937	548	197	1,815

Source: IEP Report, Page 28, Table 2.10

Opportunities for foreign investment in India's energy infrastructure

In the first decade of the 21st century, cumulative foreign direct investment (FDI) in India totaled more than $160 billion. Beginning with a modest $4 billion between April 2000 and March 2001, FDI rose to $9 billion in 2005-2006, then shot up dramatically. For the 2009-2010 period, total FDI flow into India is expected to surpass $34 billion, roughly on a par with the two previous years.

The power sector ranked sixth among the leading sectors of the Indian economy, attracting $4.6 billion in FDI since 2000, according to the Ministry of Commerce and Industry's Department of Industrial Policy & Promotion. Adding in the electrical equipment sector, the total rises to $6.8 billion. FDI in petroleum and natural gas totaled $2.7 billion for the period, ranking that sector ninth in foreign investment. Restrictions on FDI in coal production caused that sector to rank 54th, with just $15.6 million for the decade.

Space is lacking for a detailed breakdown of all the energy sectors eligible for FDI, but a sampling of data for the largest sector in that group–power–suggests the scope of opportunities that are available. Up to 100% foreign direct investment, with amounts unlimited, is allowed for most projects relating to electricity generation, transmission, and distribution, but not for nuclear power plants. In the renewable-energy sector, too, 100% FDI is allowed and a generation-based incentive scheme has been put in place for wind power projects especially for the foreign investors who cannot take advantage of the benefits of accelerated depreciation, as domestic investors can.

Some financial institutions owned by the Government exist specifically to meet the needs of the energy sector. For example, the Power Finance Corporation (PFC) and the Rural Electrification Corporation (REC) serve the financing needs of the power sector across the electricity value chain.

Electric generation. Plans now are being developed for the augmentation of the power sector's capacity required in the XII Plan period, 2012-2017. The goal is to add a total of 100,000 MW of capacity--76.5% powered by coal and lignite; 20% by hydroelectric resources. Required investment needed to develop this generation infrastructure is estimated at nearly $100 billion.

A presentation in August 2009 by the Central Electricity Authority at the "International Conclave on Key Inputs for Accelerated Development of the Indian Power Sector for the XII Plan and Beyond" suggested that the aggregate capacity of supercritical generating units would total 43,600 MW of the coal/lignite component. More specifically, 27 projects would be built with a total of 64 units in the 660-800 MW range. Another 18 projects having 34 subcritical units in the 500-600-MW range also would burn coal or lignite. Smaller subcritical units would make up the balance of the 76,500 MW.

With coal playing a very significant role in India's energy future substantial investments will be required to boost annual production of the fuel to the 900 million tonnes required. Current thinking is that domestic sources would supply 845 million tonnes, imports the balance.

Electric distribution. Required investment in the distribution sector is estimated at $86.4 billion for the XII Plan. The infrastructure that must be installed to meet the five-year plan is staggering: 2.5 million poles for 33-kV overhead lines, another 9.4 million poles for other lines rated above 11 kV, and 20 million poles for low-tension lines. More than 50 million service connections would be added.

The 33-kV lines planned total 180,000 circuit kilometers, 11-kV lines 750,000 ckm, and low-tension lines 800,000 ckm. To put these numbers in perspective, India is planning to install in only 60 months an amount of distribution cable that if placed end to end would circle the equator more than 40 times.

The 250,000 circuit breakers required (50,000 annually) nearly consumes India's current production capability of 59,000 breakers, the 14 million meters required annually is well above the 12.5 million that the country could produce in 2009 (according to the Indian Electrical & Electronics Manufacturers Assn.), and the total requirement of 190,000 MVA in distribution-transformer capacity exceeds current annual production capacity by more than 3,000 MVA.

Gas value chain. Investments in LNG terminals and gas transmission and distribution pipelines, although significant, pale in comparison to those required by the electric sector. While data for the XII Plan were not readily available at press time, a look at spending to achieve the XI Plan offers some insights.

In round numbers, $2 billion for LNG terminals, $4.5 billion for transmission pipelines, and nearly $2 billion for distribution infrastructure in cities.

Of course, upstream activities in the gas sector (exploration and production) are in addition to the investments required for terminals and pipelines. Planned upstream outlay to achieve the XI Plan was more than $30 billion, but internal resources fell short by about 30%–thereby creating opportunities for foreign investment.

Looking ahead, supply options to meet growing demand include the following:

- New domestic sources. Attention currently focuses on the East Coast, offshore.
- Transnational pipeline imports. Routes include Iran-Pakistan-India; Turkmenistan-Afghanistan-Pakistan-India; Myanmar-India.
- New LNG imports on the West Coast via Dabhol, Kochi, Dahej (expansion), and Mangalore.

Major trade organizations

Indian Electrical and Electronics Manufacturing Association (IEEMA)
Founded in 1948, IEEMA represents the entire Indian electrical and industrial electronics industry. IEEMA promotes and protects interests of the Indian companies active in the industry and is invited to represent the sector on many councils and committees constituted by the governments. http://www.ieema.org

Confederation of Indian Industry (CII)
CII is India's premier industrial association, with a direct membership of over 7,800 organizations from the private as well as public sectors and an indirect membership of over 90,000 companies from around 396 national and regional sectoral associations. CII has a strong energy sector presence and advocates the industry viewpoint with government and policy makers. http://www.cii.in

Federation of Indian Chambers of Commerce and Industry (FICCI)
Established in 1927, FICCI is one of the largest and oldest business associations in India and the voice of India's business and industry. Through its 400 professionals, FICCI is active in 39 sectors of the economy. FICCI's stand on policy issues is sought out by think tanks, governments and academia. Its publications are widely read for their in-depth research and policy prescriptions. FICCI has joint business councils with 79 countries around the world. A non-government, not-for-profit organization, FICCI has direct membership from the private as well as public sectors and an indirect membership of over 83,000 companies from regional chambers of commerce. http://www.ficci.com

Energy policy

Planning and policy

India's four-decade-long experiment with a state-owned economy has evolved since a 1991 crisis forced the country to liberalize its economy. It now allows greater individual initiative and, importantly, foreign direct investment. Federal- and state-owned companies still dominate the energy industry, but the private sector is actively capturing market share and even investing in the state-owned companies.

Energy policy and planning are largely controlled by the central government in India's federal political setup. While the central government alone controls planning and policy related to fossil fuels such as coal, natural gas, and petroleum, the constitution outlines both the state and central government's responsibility for electricity policy and planning. The Planning Commission of the GoI is responsible for planning for power, energy, energy policy, and rural energy within the framework of a succession of national five-year plans. States take responsibility for power delivery.

The August 2006 *Report of the Expert Committee on Integrated Energy Policy* (IEP) for the first time analyzed the resource options for India's energy needs. It comprehensively examined all sources of energy, including renewables. The IEP forecasted energy demand up to 2031-32 and made broad recommendations to optimally meet the surging demand.

It concluded that coal, particularly domestic coal, would continue to fuel the power sector in the country. Since then, the possibilities of exploring nuclear energy as well as the discoveries of natural gas have somewhat tilted the balance. The energy sector is overseen by the following GoI ministries:

- Ministry of Power (http://powermin.nic.in/)
- Ministry of Petroleum and Natural Gas (http://petroleum.nic.in/)
- Ministry of New and Renewable Energy (http://mnre.gov.in/)
- Ministry of Coal (http://coal.nic.in/welcome.html)
- Department of Atomic Energy (http://www.dae.gov.in/)

The Planning Commission is in overall charge of developing India's five-year plans across the ministries and sectors. Since the public sector continues to play a dominant role in the energy sector in India, the ministries wield enormous power and influence in the way the sector develops and is managed.

The framework for independent regulation has been established for the electricity and downstream petroleum and natural-gas sectors. The Central Electricity Regulatory Commission (CERC) regulates interstate transactions and business, and each state has a State Electricity Regulatory Commission (SERC) for intrastate transactions. Much of the regulation covering electricity generation and transmission stems from the CERC (and is by and large followed by the SERCs), while SERCs have exclusive jurisdiction on electricity distribution in the respective states.

The Petroleum and Natural Gas Regulatory Board (PNGRB) regulates downstream activities in the petroleum and natural gas sectors. The upstream activities continue to be regulated by the central government through the Directorate General of Hydrocarbons.

Power sector

India's power sector continues to be a stumbling block for its infrastructure growth and overall development. Energy and peak shortages abound and transmission and distribution losses continue to be unreasonably high.

The Government of India began liberalizing the power sector in India in 1991 by opening up the sector to private investments in generation. The key legislative and policy interventions in India have been:

- The Electricity Act 2003 (http://www.cea.nic.in/home_page_links/ElectricityAct2003.pdf)

Jindal Steel and Power

OP Jindal coal plant. Already the largest coal-fired IPP in India (1000 MW), a brownfield expansion consisting of 4 x 600-MW units supplied by BHEL is underway. The site is also home to the largest private coal mine, coal washery, and covered coal conveyor belt in India.

- National Action Plan on Climate Change (http://pmindia.nic.in/Pg01-52.pdf)
- National Electricity Policy 2005 (http://www.cea.nic.in/planning/national_Electricity_policy.htm)
- National Tariff Policy 2006 (http://www.powermin.nic.in/whats_new/pdf/Tariff_Policy.pdf)
- Rural Electrification Policy 2006 (http://www.powermin.nic.in/whats_new/pdf/RE%20Policy.pdf)

The basic aim of the Electricity Act 2003, which consolidated the provisions of all previous legislation, was to take measures conducive to the growth of the electricity sector in the country, to promote competition, to protect consumers' interest, to rationalize tariffs, and to promote efficient and environment-friendly policies. Its main features are:

- Delicensing electricity generation
- Mandating restructuring of state electricity boards to separate transmission (wires business) and trade
- Allowing for open access on transmission and distribution networks
- Facilitating electricity trading
- Mandating the establishment of SERCs in each state.
- Liberalizing captive or self-generation
- Setting up the Appellate Tribunal for Electricity (ATE)

In addition, the focus was widened to upgrade and improve the financial and operational efficiency of the distribution companies. A massive funding scheme of the GoI called the Accelerated Power Development and Reform Program (APDRP) was initiated to provide funds to State Electricity Boards and distribution companies to improve system efficiency and provide incentives for better performance.

The National Electricity Policy 2005, which introduced the concept of universal service, mandated that all villages should be electrified by 2007-2008 and all households by 2011-2012. Table 2-1 outlines the structure of the Power sector in India.

The GoI's Ministry of Power (MoP) is responsible for planning, formulating policies, processing of projects for investment decision, and monitoring of the implementation of power projects. The Central Electricity Authority (CEA) is a statutory body constituted by the central government that functions under the Electricity Act 2003. The CEA is responsible for formulating the National Electricity Plan in accordance with the National Electricity Policy, once in five years.

The CEA is the main technical adviser to the government and regulatory commissions. It is also required to specify technical standards and safety requirements for the construction, operation, and maintenance of electrical lines and setting up of electrical standards. Any generating company intending to set

KSK Energy Ventures

Sai Regency combined-cycle plant. This 58-MW CHP plant in Tamil Nadu supplies steam and electricity to multiple industrial customers. The addition of 2000 MW of CHP generation is included in the XII Plan to increase the reliability of steam and electricity supply for industry and hospitals.

Table 2-1. Structure of the Indian Power Sector

Policy Making	Central Government State Governments
Planning	Central Electricity Authority (Planning Commission under Central Government) State Planning Departments
Regulation	Central Electricity Regulatory Commission (Appellate Tribunal for Electricity) State Electricity Regulatory Commissions (Ombudsman in each SERC)
System Operators	National Load Despatch Centre Five Regional Load Despatch Centres State Load Despatch Centres
Generation	Central Generating Stations (e.g. NTPC, NHPC) Joint Ventures – Centre & State (NEEPCO, THDC, DVC) State Generating Stations (e.g. APGENCO, Mahagenco) Independent Private Producers (e.g. GVK, Spectrum, etc)
Transmission	Central Transmission Utility (PGCIL) State Transmission Utilities (e.g. APTransco, KPTCL) Private entities (e.g Lanco, Reliance, Tata)
Traders	Traders designated to trade across borders (PTC) Inter-state traders (e.g. LANCO, NTPC etc.) Intra-state traders
Distribution	Distribution arm of State Electricity Boards (e.g. TNEB, PSEB etc.) Distribution Companies (e.g. Reliance, Tata, Bescom, etc.) Private Companies (e.g. Reliance Infra, NDPL, CESC, etc.) Franchises (e.g. Torrent)
Financial Institutions	Power Finance Corporation (PFC) Rural Electrification Corporation (REC)
Energy Conservation	Bureau of Energy Efficiency (BEE)

Cairn

The Mangala Development Pipeline is the world's longest continuously heated and insulated pipeline and has an access to 75% of India's refining capacity. It originates from Mangala Processing Terminal and runs 670 km through Rajasthan and Gujarat before it reaches its end near Jamnagar on the western coast line of India.

Nuclear Power Corp of India

Big plans for nuclear. While there is currently a prohibition on FDI for nuclear power plants, installed capacity is expected to increase tenfold by 2020 to 44,000 MW. By 2050, the GoI expects nuclear energy to supply 25% of the country's power.

up a hydropower generating station also requires the concurrence of the CEA.

The Electricity Act 2003 and the subsequent policies of the government, especially the Ultra Mega Power Projects (UMPPs) under the competitive bidding route, are expected to add substantial thermal capacity. In 2008, the GoI promulgated the Hydro Power Policy to encourage private investments, improve resettlement and rehabilitation and enhance the financial viability of hydropower development. Earlier in 2007, the MoP had issued the approach and guidelines for the development of merchant power plants (MPPs).

Two main programs of the GoI are aimed at improving electricity distribution. The APDRP provides loans and grants to augment investments in distribution system upgrades. The Rajiv Gandhi Grameen Vidyutikiran Yojana (RGGVY), launched in 2005, aims at electrifying all villages and providing access to electricity to all rural households over a period of four years.

Petroleum and natural gas

India's petroleum and natural-gas sector relies heavily on government-run oil companies as seen in Table 2-2.

India conducted nine rounds of exploration bidding between 1979 and 1995, but they were not successful. The New Exploration and Licensing Policy (NELP) introduced by the government in 1997-98 brought about major changes in the structure of the Indian oil industry as well as increased the rate of exploration of the sedimentary basin area of the country from 11% to more than 44%.

The NELP opened India's oil and gas sector to private-sector participation through international competitive bidding for blocks under a production-sharing contract with the GoI. National Oil Companies (NOCs) continue to account for a major share of crude oil and natural gas production, but there has been a significant increase in private participation.

All 10 oil discoveries in 2007-08 were made by private oil companies like Reliance Industries Ltd. (RIL), Cairn and Essar Oil Ltd. (EOL). The GoI is examining the possibility of introducing the Open Acreage Licensing Policy (OALP) to allow year-round bidding for blocks to explore rather than waiting for the government to identify blocks for exploration. Recently, there has been a thrust towards NOCs acquiring hydrocarbon assets abroad to meet the country's need for energy security and accelerating demand.

Table 2-2. Structure of the Indian Petroleum and Natural Gas Sector

Policy Making	Ministry of Petroleum and Natural Gas	
Planning	Ministry of Petroleum and Natural Gas Planning Commission Petroleum Planning and Analysis Cell (PPAC) ATE with a separate bench to hear petroleum and natural gas cases	
Regulation	Directorate of Hydrocarbons under the GoI (upstream) Petroleum and Natural Gas Regulatory Board (downstream)	
	Public Sector	**Private Sector**
Upstream (Exploration & Production)	ONGC OIL OVL GSPC (State Sector)	Cairn Hardy
Refineries	CPCL BRPL NRL MRPL	RPL Essar
Marketing Companies	GAIL IGL MGL	
Integrated Oil Companies	IOCL HPCL BPCL	RIL EOL Shell
Financial Institution	OIDB	

Source: IECC

With the increasing presence of private players and the move towards increasing the extent of gas distribution in the country, the Petroleum and Natural Gas Regulatory Board (PNGRB) was set up under the PNGRB Act 2006. The PNGRB regulates the refining, processing, storage, transportation, distribution, marketing, and sale of crude oil, petroleum products, and natural gas. It also protects the interests of consumers and entities engaged in specified activities in these areas and is responsible to ensure uninterrupted and adequate supply of crude oil, petroleum products, and natural gas to all parts of the country and to promote competitive markets.

The PNGRB issued guidelines relating to city gas distribution network and natural gas pipelines in 2007-08 and 2008-09. However the upstream oil and gas business continues to be regulated by the Directorate of Hydrocarbons (DGH). The DGH operates under the Ministry of Petroleum & Natural Gas (MOP&NG) as a regulator

Table 2-3. Structure of Renewable Energy in India

Policy Making	Central Government, Ministry of New and Renewable Energy	
Planning	Planning Commission, Ministry of New and Renewable Energy	
Regulation	CERC at the Centre SERCs at the State ATE Orders where applicable	
	Public Sector	**Private Sector**
Equipment Manufacturing and Generation Companies		Suzlon Enercon Tata BP Solar NEG-Micon Vestas-RRB
Financial Institution	IREDA	

Table 2-4. Structure of the Indian Coal Sector

Policy Making	Central Government State Governments
Planning	Office of the Coal Controller under the Central Government
Regulation	Office of the Coal Controller under the Ministry of Coal
Mining Companies	Coal India Ltd. and its Subsidiaries (94% market share) Neyveli Lignite Ltd. (CPSUs) Singareni Collieries Ltd.; captive mining for state government companies Private coal blocks for captive mining
Mining Equipment	Bharat Earth Moving Equipment Ltd. (CPSU)

Source: IECC

Table 2-5. Structure of the Nuclear Sector in India

Policy Making & Planning	Central Government / Department of Atomic Energy
Regulation	Atomic Energy Regulatory Board / Atomic Energy Commission
Generation Companies	Nuclear Power Corporation of India Ltd. (NPCIL) BHAVINI
Input Providers	Heavy Water Board (HWB) Nuclear Fuel Complex (NFC) Indian Rare Earth Ltd (IREL) Uranium Corporation of India Ltd. (UCIL)
Financial Institution	Board of Research in Nuclear Sciences (BRNS)

Source: IECC

to advise the MOP&NG on exploration strategies and production policies.

Oil and natural gas exploration and production, refining, and distribution, as well as the marketing, import, export, and conservation of petroleum products and liquefied natural gas fall under the responsibility of the MOP&NG.

The government continues to regulate prices for both petroleum and natural gas through the Petroleum Planning & Analysis Cell (PPAC), attached to the MOP&NG.

Renewable energy

The renewable-energy sector is administered by a separate line ministry, but it is regulated by the CERC and SERCs along with the power sector. The Ministry of New and Renewable Energy (MNRE) plans and promotes the development of all sources of renewable energy. By far the largest renewable-energy source is hydropower, which in 2008 generated 113.85 billion kWh. Wind energy was a distant second, with 14.8 billion kWh. Comparatively, energy from other renewable sources was negligible or non-existent. Table 2-3 summarizes the structure of the renewable sector in India.

The Electricity Act 2003 provides the legislative impetus for the development of renewable energy in part by directing the CERC and SERCs to fix renewable power purchase obligations (RPPOs) for all distribution companies under their jurisdiction. The regulatory commissions can also determine preferential tariffs for renewable power to make it more competitive with conventional sources on cost of electricity.

Foreign direct investment up to 100% is allowed under the automatic route and can set up a wholly-owned subsidiary. Foreign investors are allowed to set up renewable-energy-based power projects on a Build-Own-Operate (BOO) or a Build-Own-Transfer (BOT) basis. Investors are allowed to bring in funds directly, incorporate an Indian company, or allot shares to foreign investors.

With the announcement of the National Action Plan on Climate Change (NAPCC), there is a marked shift in policy to diversifying the energy mix to lower carbon intensity. The NAPCC calls for boosting renewable energy's share of the national generation from 2% to 5%, with specific emphasis on significantly increasing solar energy's share of the total energy mix. It envisions increased use of distributed solar photovoltaic cells, but also, as technology permits, commercial-scale solar-reflector generating stations.

Coal

The Ministry of Coal is the apex organization responsible for the development of coal and lignite in the country. It has the overall responsibility for determining policies and strategies for exploring and developing coal and lignite reserves, sanctioning important projects of high value and deciding all related issues. The coal sector continues to be dominated by government-owned companies with no significant private-sector presence, and foreign direct investment is restricted (see p. 6). Table 2-4 outlines the framework of India's coal industry.

In December 2000, the GoI loosened the restrictions on state government companies to allow them to mine coal and lignite reserves anywhere in the country, subject to certain conditions. Since 2004, the GoI has engaged in allocating large areas/blocks to government companies (both central and state). Preference is being given to government power utilities.

Nuclear energy

The Department of Atomic Energy is mandated to increase the share of nuclear power using both indigenous and other proven technologies, and also developing fast breeder reactors and thorium reactors with associated fuel-cycle facilities. Table 2-5 illustrates the central government's influence over the nuclear sector.

The signing of the Indo-U.S. nuclear deal in October 2008 has opened up opportunities for the growth of nuclear power in the country. The Nuclear Power Corporation of India Ltd.(NPCIL), the only nuclear power generating company in the country, aims to increase its installed capacity from 4,120 MW to 21,000 MW in the next five years, but GoI policy prohibits foreign direct investment in nuclear power plants (see p. 6) .

In summary, India's power, petroleum, and natural gas sectors have mostly opened

Private power growth. Lanco Amarkantak Power Ltd. is adding 2 × 660-MW units to its coal-based generating station in Chhattisgarh to increase plant output to 1920 MW. Project financing was secured through the state-run Project Finance Corp. under XI Plan.

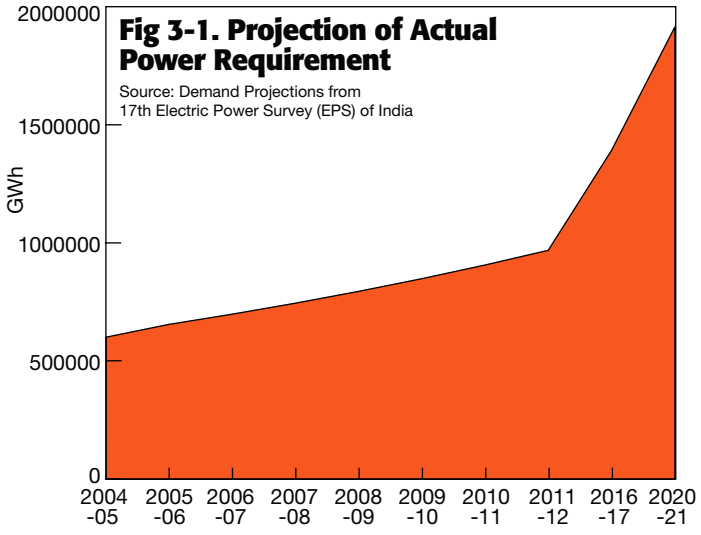
V A Chakrarthy

Electricity sector

up to the private sector and market-based interventions even while government-owned entities continue to dominate the sectors. Private-sector participation is much more limited in the coal sector, with captive mining for industries as well as state government-owned organizations being the main exception. The nuclear sector has only recently been opened to other government-owned entities and most likely will proceed in the form of joint ventures with the incumbent corporation NPCIL.

Pell-mell load growth driven by the fast-expanding economy has left India scrambling to catch up with electricity demand as power outages bedevil the country. The *Electric Power Survey 17* forecasts a peak demand growth of 9% for the period up to the end of the XI Plan (2011-12) against actual achievement of 5.3% (Fig 3-1). In 2009, CRISIL research estimated that roughly $160 billion would likely be invested in the power sector by 2014. About $100 billion would be in generation, with nearly half of that from private investors.

Spikes in power demand from the agricultural sector are forcing state governments to increase load shedding in the summer months. For example, the power deficit in state of Punjab is so severe that it has mandated a one-day-per-week power cut for the steel manufacturing industry, which could be extended to two days if the situation remains unchanged. Plans for increased capacity and power management initiatives are being explored to reduce the cost and increase the reliability of electricity to customers.



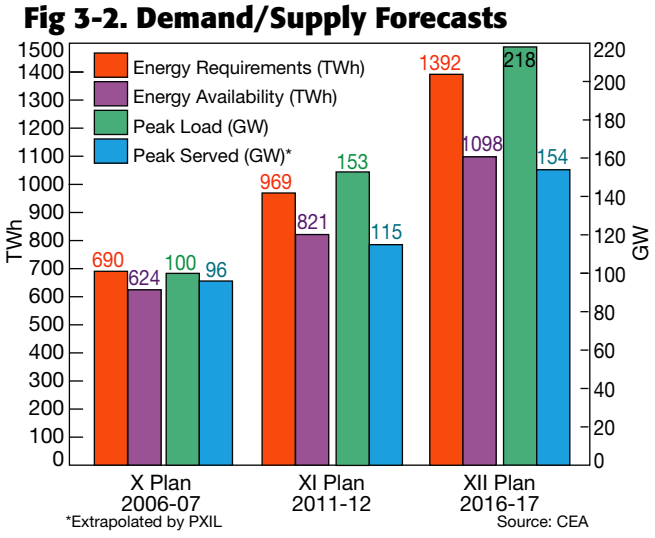


Table 3-1. Status of Awarded UMPPs

UMPP	Project Developer	State	Fuel Linkage	EPC	Schedule
Mundra	TPC	Gujarat	26% stake in Indonesia's Bumi Resources' two coal mines	Doosan Heavy Industries . & Construction Co.	Two 800 MW units
Sasan	RPL	Madhya Pradesh	Moher, Moher-Amlohri Extension coal blocks at Singrauli Coalfields	Reliance Infrastructure Limited	Two units by Dec 2011, all six units by Apr 2013
Krishnapatnam	RPL	Andhra Pradesh	Acquisition of three Indonesian coal mines	RPL in talks with Doosan Heavy Industries & Construction Co., Toshiba Corp., and L&T	September 2013—October 2015
Tilaiya	RPL	Jharkhand	Kirandhari B and C blocks of North Karanpura Coalfields	Reliance Infrastructure Limited	2015

Source: India Infrastructure

A variety of initiatives are in the works to boost additional capacity from public and private players, including UMPPs, MPPs, and group captive generation. Despite these ambitious targets, power demand will likely outstrip supply well into the XII Plan period (Fig 3-2).

In January 2010, KPMG released a report that offers insightful perspectives on the future of the power generation, entitled *Power Sector in India: White Paper on Implementation Challenges and Opportunities*. With such large-scale development taking place in the power sector and the associated challenges, the importance of comprehensive project management organization is paramount to ensure that projects are completed in a thorough and timely manner.

Power trading

The Electricity Act 2003 laid the legal foundation for the development of a national power market by mandating the unbundling of the wires business from electricity trading and permitting open access on transmission and distribution networks.

However, a single-buyer model prevails in most of the states and the pace of restructuring is slow largely because there is no transparency on transmission capacity and because of restrictive conditions of cross-subsidy surcharge. In fact, the only open-access activity is by captive generators to transmit power to their load center. Most of the power in the country continues to be procured through long-term power-purchase agreements (PPAs).

Since January 2004, the CERC has granted 43 trading licenses, of which the Power Trading Corporation (PTC) has the largest share. PTC is the designated trader for international electricity transactions, particularly from Bhutan and Nepal. Capacities of MPPs, UMPPs, and captive plants are expected to increase the share of power traded in the country either through bilateral, short-term trades or the power exchanges.

Traders can use either of two power exchanges, the Indian Energy Exchange (IEX) or the Power Exchange India Ltd. (PXIL). They were initially given permission for day-ahead trading, but the CERC is considering whether to allow longer-term contracts, including week-ahead, month-ahead, and year-ahead as well as seasonal contracts.

The national Power Grid Corp. of India (POWERGRID) has always been a wires company and is unaffected by the separation of the trading and transmission sectors. But at the state level, vertically integrated state electricity boards and transmission companies (which also traded under the single-buyer model in operation) in restructured states had to further separate the wires business from the trading business. Implementation of the mandated separation differs among the states.

Andhra Pradesh and Karnataka chose to allocate the long-term PPAs to the

Fig 3-4. Fuel Breakdown of Thermal Generation

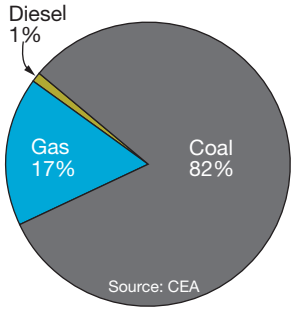


Fig 3-3. Electricity Generation Growth by Type, 1985-2008

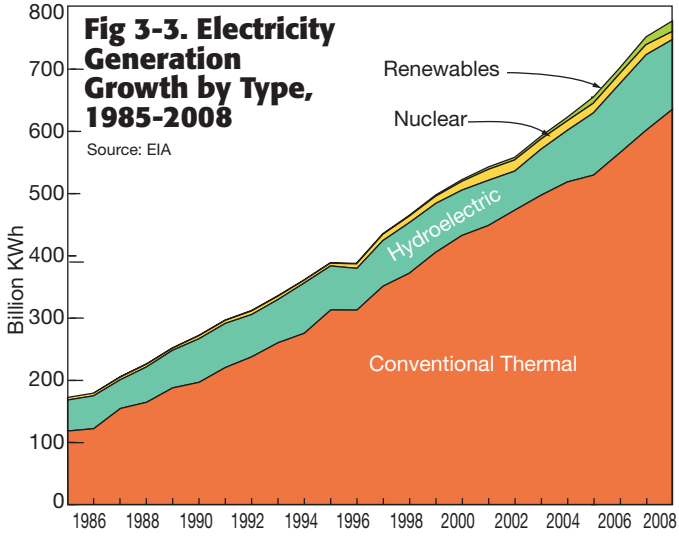
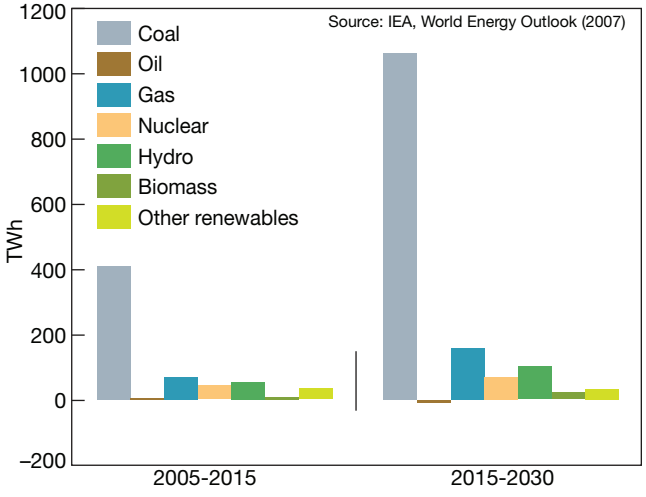


Fig 3-5. Electricity Generation Mix, 2005-2030



distribution companies of their states. Orissa retained Gridco as a trading company and formed a separate transmission company. Still other states, like Gujarat, entrusted the holding company in the state with the responsibility of power purchase and trading.

Domestic customers make up about 75% of total customers in India, but they consume less than 65% of the power. Industrial customers account for more than 35% of total electricity sales despite substantial captive generation, which is conservatively estimated at about 25,000 MW.

Generation

The Indian power generation market is the fourth-largest in Asia and the sixth-largest in the world. Coal fuels about 55% of India's power generation, and if current projections are accurate, that proportion will grow substantially in the next 20 years. To this point, India has met its burgeoning demand for electricity primarily with the development of conventional thermal power generation with coal representing the lion's share of generating fuel (Fig 3-3, 3-4).

The central and state governments control 83% of India's generation capacity of 153,694 MW; the National Thermal Power Corporation Ltd. (NTPC), owned by the central government, has almost 20% of the country's capacity, and the private sector accounts for only 17%. But the figures for total generation capacity exclude self- or captive generation, which is estimated to be 19,500 MW. The per capita consumption was 704.2 kWh in 2007-08 against the world average of 2595.7 kWh.

Energy availability is 689 TWh but the requirement is 774 TWh, so shortages are chronic. India s peak deficit is 12.1%, and its energy deficit 9.4%. A July 2009 pan-Indian study commissioned by Wärtsilä India, entitled *The Real Cost of Power,* estimates that Indians spend about $6.2 billion every year to fuel and maintain power back-up equipment to secure themselves against frequent outages.

The XI Plan (2007-2012) aims to address this problem by adding 78,700 MW of generation. Of that, 76% is expected to be coal-based and 20% from hydroelectric sources. India's increasing dependence on coal generation to meet electricity needs will continue well into the future, with some projections increasing to over 70% of electricity generation by 2030 (Fig 3-5).

Nine UMPPs of 4,000 MW each have been identified for development under the international competitive bidding route. The Ministry of Power defines a UMPP as a coal-fueled, supercritical power plant of about 4,000 MW each involving an investment of about $3.5 billion. Table 3-1 outlines four UMPPs that have already been awarded.

One 660-MW unit at Sasan and two 800-MW units at Mundra each are expected to be commissioned in the current Eleventh Five-Year Plan. The status of the other UMPPs is as follows:

- UMPP at Sarguja District, Chhattisgarh: All the pre-Request for Qualification (RfQ) activities have been completed.
- UMPP at Sundergarh District, Orissa: Most of the requisites for issuing the RfQ are in place except the Section 4 notification regarding land acqusition.
- UMPP in Tamil Nadu: Site has been finalized at Cheyyur along with the captive port, which is under finalization.
- UMPP in Andhra Pradesh (second one): Site has been identified at Nayunipalli, Prakasam District, and finalized by CEA/PFC in consultation with the state government.

The requisite inputs regarding land availability and water linkage are being examined for the UMPPs to be located in Maharashtra, the second UMPP in Gujarat, and two additional UMPPs in Orissa.

Hydropower

Hydropower's share of the country's generation capacity is expected to remain around 25% in the long run. Even if the potential of 150,000 MW is fully exploited by 2030-31, the share of hydro would in fact be less than 25%. However, the XI Plan has seen slippages of 5,200 MW of hydro projects, including 1,100 MW by NTPC and 2,000 MW by NHPC. Land-acquisition, resettlement and rehabilitation issues have caused significant delays in hydro projects.

The northeastern region holds the greatest potential for hydropower. The North Eastern Electric Power Corporation Ltd. (NEEPCO) estimates of potential hydropower in the region at about 60,000 MW. Because of the stagnation in hydro development, NEEPCO advocates a uniform power policy for the region to exploit its power potential.

Natural gas

Natural gas fuels about 10% of the total installed generation capacity. The XI Plan calls for 7,313 MW of gas-based capacity addition, of which 2,984 MW was commissioned by the end of June 2009. The capacity addition for the XII Plan will depend on the availability of gas, which is also used for fertilizer and transportation. In recent years the shortage of gas led to substantial loss of generation and stranded gas-based capacity.

The natural gas now being produced in India's Krishna-Godavari Basin (KG Basin) is expected to boost gas-based generation, particularly the plants that have stranded capacity because of the previous nonavailability of gas. But under the government's gas-allocation policy, new power projects would get the lowest priority. Thus, planners are being cautious about increasing the capacities of gas-based generation. All the UMPPs are fueled by coal.

Gas availability improved in 2009-10 with allocation of 18 million standard cubic meters per day (MMSCMD) to existing power plants from Reliance Industries production in the KG Basin. But the need to reduce the power sector's CO_2 emissions and to compensate for threatened coal shortages is making construction of gas-based capacity more urgent.

Plans for the XII Plan call for a target of 12,000 MW of gas-based capacity, 2,000 MW of combined heating and power units (CHP) at large hospitals, malls,

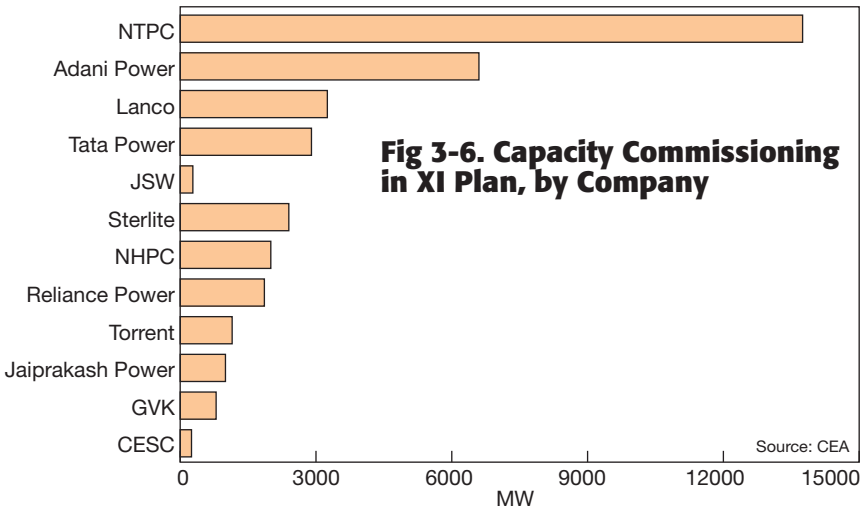


Fig 3-6. Capacity Commissioning in XI Plan, by Company

Table 3-2. Nuclear Power Generation by Central Sector during 2008-09

Power Station	Monitored Capacity (MW)	Generation Target	Actual Generation	Generation in 2007-08	Achievement in 2007-08 (% of Target)	Generation in 2007-08 (% of Target)	Plant Load Factor (%)
Kaiga	660	3,964	2,688	2,495	68	108	NA
Kakrapara	440	1,013	1,213	2,036	120	60	31
MAPP	440	2,026	1,518	1,752	75	87	39
NAPS	440	1,013	740	674	73	110	19
RAPS	740	3,731	2,255	2,480	60	91	35
Tarapur	1,400	7,253	6,298	7,339	87	86	51
Total Nuclear	4,120	19,000	14,713	16,777	77	88	41

Source: Central Electricity Authority

venture with NPCIL to enter the nuclear sector (Table 3-2). Several private players have also shown interest in the sector. Mumbai-based Larsen and Toubro, for example, have entered into agreements with international companies like Westinghouse, Atomic Energy of Canada Ltd., and AtomStroyExport for nuclear equipment and other related services. But no foreign direct investment in nuclear power plants is permitted.

Table 3-3. Renewable Power Purchase Obligations (RPPO) Fixed by SERCs in Different States

State	Annual RPPO
Andhra Pradesh	5%
Gujarat	2%
Haryana	3-10%
Karnataka	Min 10%
Kerala	5%
Madhya Pradesh	10%
Maharashtra	3% (annual increase of 1% point)
Orissa	450 MU
Rajasthan	7.5%
Tamil Nadu	10%
Uttar Pradesh	7.5%
West Bengal	3.8%

Source: http://mnes.nic.in/press-releases/press-release-28042008-2.pdf

Suzlon

Suzlon in Rajahstan. India's largest manufacturer of wind turbines received an order from Hindustan Petroleum Corporation Limited (HPCL) for a 25.5 MW wind turbine project with 17 units of Suzlon's S82 1.5 MW wind turbines. When the project is commissioned in Q3 FY 2010-11, HPCL will have a wind turbine portfolio exceeding 50 MW.

IT parks, and commercial buildings and 2,000 MW more through reciprocating engines located near large cities where gas pipelines are available for peaking and emergency generation. The gas requirement for this capacity is estimated at 50 MMSCMD.

Key Electric Power Producers

The XI Plan has seen a remarkable turnaround for private power producers (Fig 3-6). Of the planned capacity addition of 26,000 MW, Adani Power is likely to add 6,600 MW, followed by Lanco Infratech (3,200 MW), Tata Power (2,900 MW) and JSW Energy (2,900 MW).

This growth in private power has been attributed to better project management. The capacity addition mix is slowly changing in favor of the private sector.

Nuclear

The signing of the Indo-U.S. nuclear deal in October 2006, following a waiver from the Nuclear Suppliers Group, has opened up opportunities for India in the field of civilian nuclear trade. The Indian nuclear market is estimated to be worth $100 billion, and planners hope to build 40,000 MW of nuclear capacity by 2020. The GoI wants the share of nuclear in the overall fuel mix to increase from around 3% to 25% by 2050.

The Nuclear Power Corporation of India Ltd. (NPCIL) is the country's only nuclear generator. It has set itself a target of increasing its installed capacity from the current 4,120 MW to 20,000 in the next five years. NPCIL has entered into agreements with various international companies to import fuel and equipment.

The leading thermal generator in the country, the state-owned NTPC, is in joint

Table 3-4. Wind Power Installed Capacity In India by State (MW)

State	Gross Potential	Installed Capacity
Andhra Pradesh	8,968	123
Gujarat	10,645	1,567
Karnataka	11,531	1,327
Kerala	1,171	27
Madhya Pradesh	1,019	213
Maharashtra	4,584	1,939
Orissa	255	—
Rajasthan	4,858	738
Tamil Nadu	5,530	4,305
West Bengal		1
Others		3
Total	48,561	10,242

Source: Indian Wind Energy Association 2009 report (as of 3/31/09)

Renewables

India is promoting renewable energy to augment the total power supply and to meet rural needs either by augmenting grid supply or by off-grid supply. Its contribution to the total electricity matrix is only about 8% currently, but it is making the case for renewable energy as a necessary component of sustainable development. Over 15% of the incremental capacity addition in the current XI Plan is expected to be from renewable sources.

The primary vehicles for development, RPPOs, are regulatory mechanisms designed to increase the proportion of renewables in the power market, where fossil energy now dominates. An RPPO specifies the minimum quantity of renewable energy required in each state. Under the Electricity Act 2003, the National Power Policy 2005, and the Tariff Policy 2006, each SERC must set a distribution licensee's obligation for power purchases from renewable energy resources. Regulators in several states have issued orders for RPPOs varying from 1 % to 10% (Table 3-3).

The Electricity Act 2003, the policies framed under the Act, and the National Action Plan of Climate Change (NAPCC) together provide a roadmap for increasing the share of renewables in the total generation mix.

However, renewable-energy resources are not evenly spread across the country and the high cost of RE generation discourages local distribution companies from purchasing more than their obligatory amount of renewable generation. To address the imbalances and encourage RE-capacity addition in states with untapped RE potential, the CERC promulgated a regulation creating renewable-energy certificates in January 2010.

Fig 3-7. Regional Load Despatch Centres

Source: Powergrid

RE generators who register with CERC will have the option either to sell power at a preferential tariff set by their SERC or to sell the power and its associated environmental benefits in the form of renewable-energy certificates. The certificates can be sold in CERC-approved exchanges to entities needing them to meet their RPPO, thus creating a national market for such generators to recover their costs.

As of March 31, 2010, 16,817 MW of grid-connected renewable power was in place, according to the MNRE. Of that, 11,807 MW was from wind energy. Small hydropower, up to 25 MW, supplied 2,735 MW, and bagasse-fueled cogeneration 1,334 MW. Just 10.28 MW of solar energy generation capacity was installed. Off-grid and distributed renewable-energy generation supplied an additional 404.56 MW electricity equivalent, boosting the total to 17,221.86 MW.

In terms of installed capacity of wind-based generation, India ranks 5th in the world. Indian wind-turbine manufacturing giant Suzlon is the largest in Asia in terms of market share and has installed more than half of India's capacity. Great potential exists to develop wind energy and can be sustained for decades to come. Table 3-4 offers a glimpse at potential and installed capacity by state.

In December 2009, the GoI unveiled

Continued on page18

Making waste gas a business opportunity

Background

Gas turbine technology has enabled natural-gas- and fuel-oil-fired combined-cycle plants to achieve efficiencies up to 56-57%. Only in the last 15 years has a different requirement become important to the gas turbine market. A new business area is quickly growing requiring gas turbines to be able to offer good performance also by using low-Btu fuels.

This new requirement is strictly related to the commercial success of IGCC technology, which allows production of electric power from low-quality/low-cost fuels (as refinery residual oils or low rank coals) with an efficiency higher than boiler-based power plants.

Furthermore, gasification technology is coupled to very effective gas cleaning technologies which, in addition to the good performance of the gas turbine concerning the emissions problem, overcomes all the environmental problems related to the combustion of such fuels.

This requirement is also met when dealing with recovery gases from steel-mill processes that also can be burned in a gas turbine instead of a traditional boiler with higher performance and efficiency. All the fuels coming from these processes are mainly constituted by a mixture of carbon monoxide, hydrogen, methane, and nitrogen.

An example of the fuel opportunities mentioned above is given by the experiences in this business area gained by Ansaldo Energia (Table 1). All plants listed are equipped with AE94.2K gas turbines manufactured and directly supplied by Ansaldo Energia.

All the AE94.2K machines are equipped with silo-type combustors and with a proper low-Btu burner to accommodate fuel features and plant requirements. Thus, for each application it has been necessary to introduce some optimization of the burner design.

Table 2 provides an overview of the fuel characteristics in order to highlight the wide range of compositions of these mixtures, depending on the different feedstock to be gasified or the available by-product gas, the chosen gasification technology, and the available added diluents (nitrogen and/or steam).

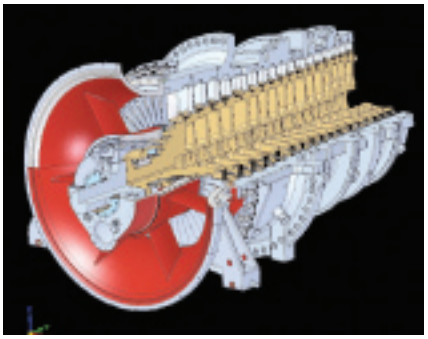


Fig 1: New AE94.2K2 compressor

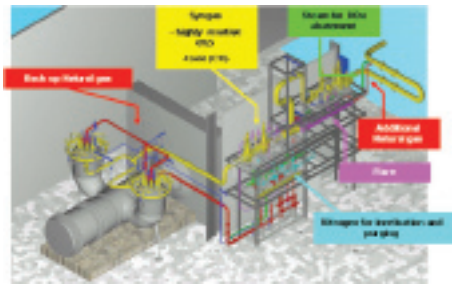


Fig 2: Fuel feed system

Looking at the table, note that the typical low-Btu fuel range is covered by Ansaldo Energia technology. In order to maintain the leadership position in this niche market, a continuous development process has been implemented to allow the existing fleet to burn fuel with a lower heating value (LHV) below 5.0 MJ/kg.

In this fuel range, the standard AE94.2K cannot be profitably employed due to the excessive partialization which would be necessary to operate on compressor inlet guide vanes. To maintain the proven design of the K series, Ansaldo Energia has released the AE94.2K2, featuring reduced air compressor capability. This model accommodates the much more stringent requirements of users of steel-mill by-product fuel.

The new gas turbine features the following:

- New compressor vane-carrier casings with minor changes on compressor vanes.
- Compressor bearing casing changed in the interface towards the compressor vane-carrier casing.
- Rotor unchanged, except for the removal of the first stage, but with the addition of two final stages with the same total length.
- No modification of hot components--that is, the turbine and combustors remain unchanged.
- External casings are unchanged.
- Burners with flow channels for gas of low heating value are designed in relation to Wobbe index and optimized in relation to the fuel used.
- Plant layout and foundations remain unchanged.

Compressor redesign

Depending on the LHV of low-Btu gas, and therefore the fuel flow rate input, a suitable version of the V94.2 can be adopted in order to optimize fuel consumption and energy production.

As mentioned above, the key factor to cover the lower fuel range is compressor redesign to reduce air flow capability. Main changes have been performed to the compressor stages, by removing the first compressor stage and by redesigning the compressor inlet duct to take into account the reduced IGV cross-sectional area.

The compressor inlet duct performance also in the new design condition has been checked by accurate 3D study. In addition to the modification to the compressor first stage, to ensure proper operation in all working conditions, two additional compression stages were also added at the delivery side, in order to restore the previous surge margins.

This simple design concept allowed to limit the number of components involved in the change as much as possible and to use components of proven geometry (the last stages added are identical to the

Table 1: Ansaldo Energia's low-Btu fuel project

Table 2: Fuel properties

Table 3: Typical low-Btu

in the power generation industry

www.ansaldoenergia.com

previous ones). Due to this solution, the external machine layout is unchanged (Fig 1).

Combustion system

The two combustion chambers are arranged vertically on either side of the turbine and connected to lateral flanges on the turbine casing. This design allows concentric gas and air paths form the compressor to the combustion chambers and from the combustion chambers to the turbine, involving relatively low flow velocities and thus minimum pressure drop.

The combustion chamber is provided with a refractory lining. Each combustion chamber has eight separate burners equipped for burning low-Btu fuel as main fuel and natural gas as a backup fuel. The burner design is based on Ansaldo Energia's previous experience on other low-Btu fuel projects (Isab Energy Priolo, Elettra Servola, Enipower), redesigned, and tested in two different test campaigns at Ansaldo Caldaie Combustion Centre and ENEL laboratories in Italy in order to take into account the different boundary conditions which occur for very low-Btu gases.

Table 3 presents several compositions of low-Btu gases as blends of blast furnace gas, coke oven gas, and oxygen. All are suitable for use in the AE94.2K2.

For some blends, natural-gas integration is necessary to reach a suitable LHV. Basically the engine is expected to be ignited and loaded at 40% of base load fueled by natural gas; after the change over to syngas, the engine can run on syngas with the natural-gas integration necessary to get to base load.

The critical point for the burner design process is facing different fuel compositions as the gas turbine is loaded. Therefore a detailed analysis has been performed taking into account the different cases shown in the mentioned table.

This means that for each kind of fuel, optimization of the standard low-Btu burner must be performed, including a numerical analysis (CFD with chemical routines) and a experimental test campaign in order to finalize the proper burner design. As already mentioned, the fuel system for the low-Btu engine has to supply much higher flow rates to the burners than for the standard engine.

The fuel system (Fig 2) consists of large-diameter pipe and control and stop valves, and must include additional mixing in order to get the final blend of recovery gas, natural gas, and, occasionally, steam. The presence of toxic and explosive components demands that the fuel system meet very high safety standards. Thus all flanges and joints between the burners and the connection point to the skids are welded.

According to the gas turbine working conditions, engine loading is performed by using the back-up fuel, mainly for safety reasons. Thus, a procedure for switch over from back-up fuel to the main fuel is accomplished under full automatic control.

The procedure is performed so that before the low-Btu fuel enters the combustor at the change over, its characteristics are monitored and analyzed online. The fuel is flared until the its properties and the design specifications match. Once that happens, the changeover procedure can start.

Finally, a purging procedure before any syngas partial or full-load working condition must be done with nitrogen or steam in order to avoid possible risks of explosion due to the reactivity of the fuel when exposed to mixing with air.

Performance

Table 4 shows the performance that can be expected on V94.2 models when operating on singular fuels, in particular the different types of low-Btu gases.

Conclusions

The growing demand to supply gas turbines with very-low-Btu gases derived from steel-mill processes has driven the introduction of Ansaldo Energia's AE94.2K2, an engine developed for this specific niche market based on the relevant experience achieved on AE94.2 (Table 5). Thus the AE94.2 has proved to be the leading technology for a wide fuel flexibility in power generation.

This model will benefit by all the experience gained in low-Btu fuel market by Ansaldo Energia with the V94.2K. The model was officially released in 2008. Ansaldo Energia is in negotiation with a few customers for a new project relevant to the utilization of different blends of blast furnace gas, coke oven gas, and oxygen.

Ansaldo Thomassen Gulf: A new high-tech repair center in the Middle East

With a major new investment, Ansaldo Energia has significantly increased its service sector dedicated to all customers in the Middle East, one of the fastest developing areas in the world. Through its subsidiary Ansaldo Thomassen Gulf, Ansaldo Energia has built a futuristic new operations facility which was officially opened at the end of April 2010. The inauguration ceremony was organized with the backing of sheik Hamad bin Zayed Al Nayan. Guests included Ansaldo Energia CEO Giuseppe Zampini, Ansaldo Thomassen Gulf CEO Fausto Nepote, ZonesCorp CEO Mohammed Hassan Al Qamzi, and Paolo Dionisi, the Italian ambassador to the Arab Emirates.

The new facility, which has 3,200 sq m of workshop floor and 880 sq m of offices, will play a fundamental role in satisfying the needs of the local market in terms of quality and time.

Ansaldo Thomassen Gulf draws on the latest technology and the best human resources to provide an international centre of excellence in gas turbine repair and maintenance, while eliminating high costs of international transport for its customers. This represents a decisive step towards Ansaldo Thomassen Gulf's goal of becoming a point of reference in the service and repair market for all technologies of turbine, offering an innovative service for the first time in this area, with a structure that is rapid, professional, highly efficient, and easily accessible.

fuel composition

Table 4: AE94.2 family performance

Model		AE94.2	AE94.2K	AE94.2K2
Fuel		Natural Gas	Syn Gas medium LHV	Syn Gas Low LHV
[illegible]	[MW]	166	170	170
Grid frequency	[Hz]	50	50	50
[illegible]	-	17.6	17	16.7
[illegible]	[rpm]	50	50	50
Exhaust temperature	[°C]	544	544	544
[illegible] efficiency	[%]	36.8	36	36
Fuel LHV	[MJ/kg]	50	6	3.6

Table 5: AE94.2 family features

Engine Model	AE94.2	AE94.2K	AE94.2K2
LHV	35 ÷ 50 MJ/ kg	7 ÷ 35 MJ/ kg	3.5 ÷ 7 MJ/ kg
Compressor	Standard	K model	K2 model
Combustor	Standard	Standard	Standard
Burner	Standard	K model	K model, enhanced
Turbine	Standard	Standard	Standard
Fuel System	Standard	K model	K model, enhanced
Control System	Standard	K model	K model, enhanced
Lay out	Standard	Standard	Standard

Central Power Research Institute (CPRI)

CPRI was established in Bangalore by the Government of India to serve as a national laboratory for applied research in electric power engineering while functioning as an independent national testing and certification authority for electrical equipment and components. CPRI also offers expert consultancy services in the areas of transmission and distribution, power quality, energy auditing, conductor vibration, power system instrumentation, transformer oil reclamation, power system application, high and extra-high voltage, and related fields.
http://www.cpri.in/

National Hydroelectric Power Corporation (NHPC)

NHPC is wholly owned by the Government of India. It plans, promotes, and organizes integrated development of hydroelectric power in the country. With its present capabilities, NHPC can undertake all activities of hydroelectric projects, from conception to commissioning. The company has executed 13 projects with an installed capacity of 5,175 MW on ownership basis. It has also executed five projects on turnkey basis, with an installed capacity of 89.35 MW. Two of these projects have been commissioned in Nepal and Bhutan. NHPC also exploits other sources of renewable energy, including geothermal, tidal, and wind.
http://www.nhpcindia.com/index.aspx

National Thermal Power Corporation Ltd. (NTPC)

A wholly-owned company of the Government of India, NTPC is the largest thermal-power generating company in India. NTPC's core business is concerned with engineering, construction, and operation of power-generating plants. It also provides consultancy services to power utilities in India and abroad. NTPC's installed capacity is 29,394 MW, including 15 coal-based power stations (23,395 MW), seven gas-based power stations (3,955 MW), and four joint-venture power stations (1,794 MW) among others.
https://www.ntpc.co.in/

North Eastern Electric Power Corporation Ltd. (NEEPCO)

NEEPCO was incorporated to develop the power generation capability of India's North East, which possesses about 40% of the country's hydroelectric potential as well as a high potential for power from natural gas and coal. The Central Electricity Authority estimates this region's hydropower potential at approximately 58,971 MW. The region also has natural-gas reserves of about 152 billion cubic meters, which can generate about 7,500 MW of power for 10 years. Its 865 million tonnes of coal reserves could produce 240 MW power per day for 100 years. NEEPCO's installed capacity of 1,130 MW includes both hydroelectric and thermal projects.
http://www.neepco.gov.in/

Power Grid Corporation of India Ltd. (POWERGRID)

One of the largest transmission utilities in the world, POWERGRID operates the regional and national electrical power grids. Its areas of operation include (1) the development of interstate transmission systems, including planning and design, construction, quality assurance and inspection, and operations and maintenance; and (2) grid management, including establishment of modern load dispatch centers, real-time grid operation, scheduling and dispatch, and energy accounting, together with financial/commercial settlements. POWERGRID has also diversified into the areas of broadband telecom services, sub-transmission, distribution, and rural electrification. Each state has its transmission network; some of the larger ones are Andhra Pradesh Transco, Karnataka Power Transmission Corporation Ltd., and MAHA Transco.
http://www.powergridindia.com/PGCIL_NEW/home.aspx

Continued from page15

plans to achieve 20,000 MW of installed solar power capacity by 2022 under the Jawarharlal Nehru National Solar Mission. The plan aims to electrify thousands of villages, create jobs, help combat climate change and also achieve grid parity pricing by 2022. The target is set to be achieved in three phases:

- Phase I: A three-year phase from 2009-2012 to primarily focus on solar heating systems, which use proven technology and are commercially viable. The capacity additions are mainly going to be off-grid in the rural areas that do not have grid connections at present. The target is to add 1,000 MW of off-grid capacity by the end of Phase I.
- Phase II: Four years from 2013-2017 to use the experience gained in Phase I to ramp up off-grid capacity as well as grid-connected supply. The target is to add 3,000 MW of renewable capacity to the grid by 2017. The MNRE is planning to make solar water heaters mandatory through building bylaws and a new building code, effective mechanisms for certification and rating of manufacturers, measurement and promotion of these devices, and support for upgrading of technologies and manufacturing capacities through soft loans.

  The RPPOs, which would include a specific solar component for power utilities, would be a key component. The obligation for this is expected to gradually increase, while the tariff fixed for solar-power purchase is expected to decline over time.
- Phase III: Five years from 2017-2022.

The plan will also provide for the solar lighting systems in 10,000 villages under the on-going remote village electrification program and will also provide for setting up solar power plants in Lakshadweep, Andaman & Nicobar Islands and the Ladakh regions. However, there is no clear program for funding the project, which would require incentives and/or subsidies.

Combined heat and power

The policy foundation for combined heat and power (CHP) centers around bagasse-based cogeneration largely in the sugar industry and supported as a renewable-energy source. But CHP is conceptually much larger; it encompasses the idea of improving energy efficiency whether the primary fuel is renewable or not. Industrial CHP has been of interest in India for over a decade, both to augment industrial energy supplies in the face of endemic shortages and to use fuels of all kinds more effectively. The additional

benefits of carbon mitigation also are being gradually recognized.

Estimates of CHP in India have been scanty and based on differing definitions of CHP. The GoI estimate is restricted to bagasse-based cogeneration, whose current installed capacity of 719.83 MW is found predominantly in the states of Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, and Uttar Pradesh.

A study by The Energy and Resources Institute (TERI), covering 300 industrial units across 10 different sectors, estimates India's CHP potential at 7,574 MW. More than two-thirds of that, 5,131 MW, is in the sugar industry alone. The CHP estimates are based on the internal heat-to-power ratios, which would meet the plant's energy requirements, and on the existing production capacities of the various industry categories. The estimates do not cover the power-maximization options, which would significantly increase the CHP potential.

CHP potential is expected to grow with the country's expanding industrial base. The IEA estimates that CHP potential will reach 27,800 MW in 2015 and 84,800 MW in 2030.

Future prospects

India has abundant renewable resources in solar, hydro, biomass, and wind potential, and the legal, policy, and regulatory environment is becoming more hospitable to the increase of renewables in the energy sector. Along with SERC regulations on the RPPOs, the renewable energy certificates, and attractive rates for renewable power offered by CERC have moved renewables from the fringes of the energy basket to the mainstream.

The MNRE has set aggressive targets for renewable energy, with projections approaching 25,000 MW by 2012. This would require an estimated investment of about $257 million. The MNRE has also made provision for subsidies of up to $650 million.

The National Solar Mission, established under the NAPCC, has set a goal of generating at least 10% of India's power from solar energy. It envisages increasing the production of solar photovoltaic panels to 1,000 MW per year from the current 235 MW per year and generating 1,000 MW of grid-connected solar power, up from the current 10 MW, by 2017.

Electricity delivery

The Ministry of Power's ambitious goal of "Power for All by 2012" looks truly daunting in light of the power sector's current state. The KPMG white paper cites the MoP's own statistics that installed transmission capacity is only 13% of installed generation capacity, adding that the planned increase in generation in the coming decade will require corresponding investments in transmission.

Powergrid

Powergrid's Sipat-Seoni line. India's first of many planned 765-kV UHV lines runs over 350 km, connecting the states of Chhattisgarh and Madhya Pradesh, transmits 1500 MVA power from generation sources to load centres with greatly reduced transmission losses.

POWERGRID, owned by the government of India, is the Central Transmission Utility (CTU) with the mandate to plan, coordinate, supervise and control the interstate transmission network. As of July 2009, POWERGRID owned and operated about 71,500 circuit kilometers (ckm) of transmission lines at 800/765 kV, 400 kV, 220 kV, 132 kV AC, and ±500 kV high-voltage DC, plus 122 substations with transformer

Table 3-5. Transmission Sector

Transmission Lines (ckm)	Central Sector	State Sector	Inter-state Network	Total
765 kV	2,863	409	-	3,272
400 kV	61,491	27,970	3,243	92,704
220 kV	10,119	115,172	151	125,442
±500 kV HVDC Lines	5,848	1,504	—	7,352
Sub-Stations (MVA)				
765 kV	4,500	—	—	4,500
400 kV	57,965	56,072	—	114,037
220 kV	4,776	178,609	800	184,185
±500 kV BTB HVDC Converter Terminal	7,000	1,700	—	8,700

Source: CEA (as of Oct. 31, 2009)

Table 3-6. Distribution Line Length (km)

Region	33kV	22/20 kV	15/11 kV	6.6 kV	3.3/2.2 kV	Up to 500 v
Northern	71,381	5,579	598,408	—	46	917,056
Western	74,962	29,830	612,157	1,852	—	1,202,137
Southern	50,465	37,112	541,299	—	19	1,671,796
Eastern	32,668	50	223,362	4,452	62	3,616,731
North Eastern	8,486	—	67,332	—	—	85,795
Total (All India)	237,962	72,571	2,042,558	6,304	127	7,493,515

Source: CEA General Review 2008 (as on 31 March, 2007)

capacity of about 81,200 MVA. This grid is maintained at an availability of 99%, and about 45% of the total power generated in the country is wheeled through it.

Each state has a separate intrastate transmission grid that is connected to the interstate transmission network owned by POWERGRID. Table 3-5 provides the transmission infrastructure in the country.

Fig 3-7 illustrates the five interconnected electrical regions across the country.

More electricity sector entities

Power trading and exchange

Power Trading Corporation of India Ltd. (PTC)
PTC India was incorporated in 1999 to develop a full-fledged, efficient, and competitive power market, attract private investment in the Indian power sector, and encourage power trade with neighboring countries.
http://www.ptcindia.com

Indian Energy Exchange (IEX)
IEX is a nationwide, automated, and online electricity trading platform. It has been conceived to catalyze the modernization of electricity trade in the country by ushering in a transparent and neutral market through a technology-enabled electronic trading platform.
http://www.iexindia.com

Power Exchange India Ltd. (PXIL)
Operating since late October 2008, PXIL is the exchange for electricity contracts on a day-ahead basis with voluntary participation. Since then, PXIL has received further approval from the Central Energy Regulatory Commission to introduce longer-tenure physical delivery products in the form of weekly and day-ahead contingency products. PXIL is promoted by the National Stock Exchange of India Ltd. (NSE), and the National Commodity & Derivatives Exchange Ltd. (NCDEX).
http://www.powerexindia.com

Power generation

Reliance Energy Ltd. (REL)
REL generates 941 MW of electricity and has several gas-, coal-, wind-, and hydro-based power generation projects at various stages of development, with an aggregate capacity of over 13,510 MW. Reliance Energy is also engaged in the transmission and distribution of electricity.
http://www.rinfra.com

The Tata Power Company Ltd.
Tata Power has an installed thermal, hydroelectric and wind generation capacity of more than 2,300 MW. Tata Power has a joint venture with the Power Grid Corporation of India for its 1,200-km Tala Transmission Project.
http://www.tatapower.com

Torrent Power Ltd.
Torrent Power has an installed generation capacity of 500 MW in Ahmedabad. Another 1,145.75-MW combined-cycle power plant is under construction. Torrent Power is also engaged in the transmission and distribution of electricity.
http://www.torrentpower.com

Calcutta Electric Supply Corporation Ltd. (CESC)
CESC has a total generation capacity of 975 MW at four thermal power stations in West Bengal. CESC also has a presence in the fields of establishing transmission network and cable manufacturing, and provides consultancy services in the operation and maintenance of power plants.
http://www.cescltd.com/cesc/menu.html#

Jindal Power Ltd. (JPL)
JPL, a subsidiary of Jindal Steel and Power Ltd., has a coal-based 1,000-MW thermal power plant in Chhattisgarh and has signed memoranda of understanding with the governments of Jharkhand and Chhattisgarh to increase power generation capacity.
http://www.jindalpower.com

Damodar Valley Corporation (DVC)
Apart from being involved in the general social and economic upliftment of the Damodar Valley in northeastern India, DVC is engaged in the generation and transmission of electricity in the area. It generates 144 MW of hydroelectric power and 2,652.5 MW of thermal power. The DVC transmission system is spread across Jharkhand, West Bengal, and Orissa.
http://www.dvcindia.org/index.htm

Bhakra Beas Management Board (BBMB)
BBMB administers, operates and maintains irrigation and hydroelectric power projects with 2,906 MW total capacity. It is also currently constructing three hydropower projects with an aggregate capacity of 19 MW.
http://bbmb.gov.in/english/index.asp

Tehri Hydro Development Corporation Ltd. (THDC)
THDC is a joint venture between the Government of India and the Government of Uttar Pradesh to plan, promote and carry out integrated and efficient development of hydro resources of Bhagirathi River and its tributaries at Tehri, along with complementary downstream development for power generation and other services.
http://thdc.gov.in

Satluj Jal Vidyut Nigam Ltd. (SJVN)
This organization was incorporated as a joint venture between the Government of India and the Government of Himachal Pradesh to plan, promote, organize and execute hydroelectric power projects in the Satluj River Basin in Himachal Pradesh.
http://sjvn.nic.in

Narmada Hydroelectric Development Corporation Ltd. (NHDC)
A joint venture of the NHPC and the Government of Madhya Pradesh, NHDC has been entrusted with the construction of Indira Sagar Project (1,000 MW) and Omkareshwar Project (520 MW). It is the largest organization for hydropower development in the state of Madhya Pradesh.
http://www.nhdcindia.com

Nuclear sector entities

Nuclear Power Corporation of India Ltd. (NPCIL)
NPCIL has been set up to operate nuclear power stations and implement nuclear power projects for the generation of electricity. Its 17 nuclear power units have a combined capacity of 4,120 MW.
http://www.npcil.nic.in

Bharatiya Nabhikiya Vidyut Nigam Ltd. (BHAVINI)
BHAVINI has been incorporated to construct and commission the first 500-MW fast breeder reactor and to pursue construction, commissioning, operation, and maintenance of subsequent FBRs for power generation.
http://www.bhavini.nic.in/main.asp

Bhabha Atomic Research Centre (BARC)
BARC is a multidisciplinary nuclear research centre having infrastructure for advanced research and development, with expertise covering the entire spectrum of nuclear science and engineering and related areas.
http://www.barc.ernet.in

Indira Gandhi Centre for Atomic Research (IGCAR)
IGCAR has been set up with the main objective of conducting broad-based multidisciplinary programs on scientific research and advanced engineering, directed towards the development of sodium-cooled fast breeder reactor technology in India.
http://www.igcar.ernet.in

Atomic Minerals Directorate for Exploration and Research (AMD)
AMD is entrusted with the survey of atomic

These inter-regional connections are very important to India as power supply and power demand are not matched across the regions. Power-generation potential is greater in the east and northeast. As new plants are built, their power will need to flow to power-deficit states in the southern, northern, and western parts of the country. Future generation will necessarily be concentrated where coal resources are abundant in the states of Bihar, Jharkhand, West Bengal, and Chhattisgarh in the eastern region as well as the northeastern states where the hydropower potential exists.

A further strengthening of the national power grid is envisaged through high-capacity alternating-current extra-high-voltage lines, 765-kV AC lines, and high-voltage direct-current lines. This phase should be implemented by 2012 when inter-regional power transfer capacity will be enhanced to about 37,700 MW by the end of the XI Plan, depending on the growth of the generation capacity. But current inter-regional transfer capacity is just 20,750 MW, according to the MoP, making the goal an extraordinary challenge.

Grid management is carried out using Supervisory Control and Data Acquisition (SCADA) with the National Load Dispatch Center (NLDC) at Delhi and five Regional Load Dispatch Centers. Each state has a state load dispatch center (SLDC) which operates the grid.

minerals in India, with exclusive rights to explore for uranium and other minerals required for the nuclear industry. It also conducts geological/geotechnical studies related to site selection for nuclear power plants and repositories for the disposal of radioactive waste generated from nuclear power plants.
http://www.amd.gov.in

Renewable-energy sector Research and development

Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE)
SSS-NIRE is an autonomous institution that serves as a technical focal point for the development of bio-energy, including biofuels and synthetic fuels.
http://mnre.gov.in/nire-rdd.htm

Alternate Hydro Energy Centre (AHEC)
AHEC is an academic center of the Indian Institute of Technology, Roorkee, with the mission to promote power generation through the development of small hydropower projects in hilly as well as plain areas. It also promotes development of decentralized integrated energy systems in conjunction with other renewable-energy sources such as biomass, solar, and wind.
http://ahec.org.in

Centre for Wind Energy Technology (C-WET)
C-WET is an autonomous research and development institution working in the field of wind energy. C-WET's services include developing components and sub-systems for wind turbines, identifying resource-rich regions in the country, testing complete wind turbine generator systems according to international standards, preparing standards suitable for Indian conditions, and collecting, collating, and analyzing the related information to serve as an information center in the field of wind energy.
http://www.cwet.tn.nic.in

Solar Energy Centre (SEC)
SEC acts as a national test and standardization center for solar energy materials, components, and systems; collaborates with other research institutions and industry on research projects; provides advisory and consultancy services to the industry and users; and evaluates new technologies, products, and systems for their adaptability to Indian conditions.
http://mnre.gov.in/sec/sec-objective.htm

RE manufacturing

Suzlon
Suzlon is a leading India-based wind-turbine maker with over 14,000 people in 21 countries and operations across the Americas, Asia, Australia and Europe. It has a fully integrated supply chain with manufacturing facilities in three continents, sophisticated R&D capabilities in Denmark, Germany, India and The Netherlands and is the third-largest wind turbine manufacturer in the world.
http://www.suzlon.com

Tata BP Solar India Ltd.
Tata BP Solar is a Joint Venture between Tata Power Company and BP Solar, one of the largest solar companies in the world. Tata BP Solar has a fully integrated solar manufacturing plant in Bangalore, which in April 2010 completed a project to add 32 MW of photovoltaic-cell production to its existing 52-MW line. By early next year, the company plans to achieve 180 MW of cell capacity, and ultimately 300 MW by 2012. Tata BP Solar's talent pool comprises over 600 employees spread over four manufacturing units and eight offices.
http://www.tatabpsolar.com

Power distribution

Electricity distribution is in the public and private sector. In the public sector, electricity distribution is either an unbundled distribution business or part of the vertically integrated State Electricity Board.

Bangalore Electricity Supply Company Ltd. (Bescom)
BESCOM has responsibility for distribution of electricity in eight districts covering 41,092 sq km with a population of nearly 14 million and a consumer base of 6,363,764. Its system includes 112,745 distribution transformers, 62,941 circuit-km of high-tension lines, and 140,067 circuit-km of low-tension lines.

North Delhi Power Ltd. (NDPL)
NDPL is a joint venture between Tata Power Company and the Government of the National Capital Territory of Delhi, with the majority stake being held by Tata Power. It distributes electricity to 1 million customers in north and northwest parts of Delhi with a peak load of around 1,180 MW.
http://www.ndpl.com

Distribution

Electricity distribution is a state government responsibility in India. State Electricity Boards (SEBs) were set up as vertically integrated monopolies in each state after Independence, but some private-sector companies continued to exist. The Bombay Suburban Electricity Supply Co. (BSES) in Mumbai (taken over by Reliance Energy in 2003), Ahmedabad Electricity Company (AEC), and Surat Electricity Co. (SEC), taken over by the Torrent Group in 1998, and Calcutta Electricity Supply Company (CESC), which continues to be owned by the RPG group.

With power-sector reforms in the 1990s, several states unbundled and restructured their electricity sectors and created two to five small distribution companies. Table 3-6 is a summary of the distribution infrastructure in the country.

High distribution-line losses are among the most vexing problems in the Indian power sector. India's aggregate technical and commercial losses average about 32% of electricity. The Restructured Accelerated Power Development and Reform Program (R-APDRP) of the Ministry of Power aims to reduce these losses to below 15%. Many urban areas have shown a decline in losses, but the rural areas continue to be mismanaged. Latest estimates indicate that line losses average 27.2% and in some states exceed 60%. Table 3-7 indicates the distribution of line losses in India by state.

Losses average almost 30% in the

Powergrid

Smart Grid technology. The NRLDC instituted a pilot program in May 2010 to install four Phasor Measurement Units (PMUs) with GPS at substations near Delhi to assist grid operators with real-time data, visualization software for situational awareness, and data archiving for predictive analytics.

Table 3-7. T&D Losses by State (2007-08)

0-15%	15-25%	25-35%	35-45%	45-55%	Above 55%
Puduchery	Himachal Pradesh	Delhi	Uttarkhand	Bihar	Jammu & Kashmir
	Punjab	Haryana	Madhya Pradesh		Arunachal Pradesh
	Chandigarh	Rajasthan	Orissa		Manipur
	Goa	Uttar Pradesh	Sikkim		Nagaland
	Daman & Diu	Gujarat	Assam		
	Dadra & Nagar Haveli	Chhattishgarh	Meghalaya		
	Andhra Pradesh	Maharsthra	Mizoram		
	Karnataka	Andaman & Nicobar	Tripura		
	Kerala				
	Tamil Nadu				
	Lakshadweep				
	Jharkhand				
	West Bengal				

Source: Compiled from Data in General Review 2009, CEA

Eastern and Western Regions and even higher—43.4%—in the northeastern region. The southern region fares the best with T&D losses of 19.77%. The GoI's R-APDRP focuses on demonstrated, sustained loss reduction. The Central Power Research Institute (CPRI) is the epicenter of research and development for transmission and distribution systems in India. Under the XI Plan, their role as Information Technology consultants assists state utilities to develop baseline studies and to monitor T&D projects.

All urban areas with a population of more than 30,000 (10,000 in the case of special-category states) would be covered. In addition, rural areas with significant loads, works of separation of agricultural and domestic feeders and of high-voltage distribution system (11 kV) would also be taken up.

Funding for this project consists of a 100% loan for all projects selected. As the project nears completion and the required targets are met, the loan will be progressively converted to a grant. For utilities having Aggregate Technical and Commercial (AT&C) losses of above 30%, the expected reduction would be 3% per year. For utilities with AT&C losses below 30%, the expected reduction would be 1.5% per year.

Grid operators

The state transmission utilities, such as AP Transco, Delhi Transco, Karnataka Power Transmission Corporation Ltd., and the central transmission utility, POWERGRID, are responsible for the intrastate and interstate transmission networks.

The SLDCs under the state transmission utilities and the RLDCs and NLDC under POWERGRID are responsible for grid management. In the emerging scenario, policy makers have suggested that grid operation functions need to be "ring fenced" if not hived into a separate entity. This is yet to happen.

The NLDC is the apex body in the hierarchy of the national grid system. The launch of the NLDC in September 2009 has set the stage for synchronous operation of the national grid on a real-time basis and for smooth power transfers across regions.

Distribution operations

India's distribution network starts at the 33-kV substation and ends at the customer's meter, or doorstep in the case of unmetered rural domestic customers. Each state has its own distribution network, and the old vertically integrated SEBs have been unbundled into smaller distribution companies in many states.

In Delhi and Orissa, distribution companies have been privatized as joint ventures with entities owned by the state government. There are also several private distribution companies that have operated for several decades, as described above. Some states like Tamil Nadu and Punjab continue to have a single distribution entity for the entire state.

Recently, attempts have been made to franchise out segments of the distribution business to private entities to bring in improvements. Torrent Power, for example, took over the Bhiwandi area (near Mumbai) under an input-based franchisee model.

India's distribution system included more than 6.76 million ckm of lines and over 282,000 MVA of distribution transformer capacity as of March 2008. This is assumed to be growing at an annual average rate of around 3% and 7.5%, respectively.

The Rajiv Gandhi Grameen Vidyuthikaran Yojana (RGGVY), aimed at rural electrification, is an initiative to provide focus and funds to rural distribution. As of 15 February 2010, a total of 567 projects were sanctioned, at a cost of $5.5 billion, electrifying 418,499 un/de-electrified villages.

The estimated electricity customer base of 160 million is growing at an annual rate of about 4.5%. The average per-capita consumption of 704 kWh in 2007-08 is expected to surpass 1,000 kWh by 2011-12.

Oil & Gas sector

Cairn

Offshore exploration. NELP IX, expected to launch by the end of 2010, will offer up about 45 new oil and gas blocks for auction. After a disappointing NELP VIII where less than half of the blocks were awarded, the GoI remains optimistic for the upcoming auction as crude prices have stabilized at around $80 bbl.

Exploration and Recovery

Despite increased exploration and production activities in the country by both national oil companies and private players, India depends on imported crude to meet 75% of domestic demand. As shown in Table 4-1, as of April 1, 2009, India had total reserves of 775 million tonnes of crude oil and 1,074 billion cubic meters of natural gas.

Production of crude oil has stagnated, but there have been a number of natural-gas discoveries in India. With the discovery of gas in the Krishna-Godavari Basin (KG Basin), there has been a perceptible change in the estimates of natural-gas reserves in India's sedimentary basin. Most of the new gas discoveries have been made by private players who have bid for the exploration blocks under the GoI's New Exploration Licensing Policy (NELP).

Crude oil production during 2008-09 at 33.51 MMT was 1.79% lower than the previous year. However, gross production of natural gas in the country stood at 32.85 BCM in the same period and 1.33% higher than the previous year (Table 4-2).

During 2008-09, 381 exploratory and development wells totaling 888,000 meters were drilled in onshore and offshore areas. The onshore regions are predominantly in the states of Assam and Gujarat while the offshore regions are near Mumbai.

In 1999, the NELP took effect. Since then, the Ministry of Petroleum and Natural Gas has signed 203 production-sharing contracts under seven rounds of bidding. In the seventh round of bidding under NELP VII, 181 bids were received from 95 companies including 21 foreign companies (Table 4-3).

The NELP has facilitated 68 oil and gas discoveries made by private and joint-venture companies in 19 blocks, adding more than 600 MTOE hydrocarbon reserves. As of April 1, 2009, investment commitment on exploration under NELP was about $10 billion, against which

Table 4-1. Oil and Gas Reserves

Crude Oil (MMT)	2005	2009
Onshore	376	405
Offshore	410	369
Total	786	775
Natural Gas (BCM)		
Onshore	340	287
Offshore	761	787
Total	1,101	1,074

Sources: ONGC, OIL, DGH
Note: The oil and natural gas reserves (proved and indicated) data relate to 1st April of each year

Table 4-2. Petroleum Industry Production for 2008-09

Reserves (Balance Recoverable)	
Crude Oil (MT)	770
Natural Gas (BCM)	1,090
Production (MT)	
Crude Oil	33.51
Petroleum Products	152.68
Consumption (MT)	
Crude Oil	160.77
Petroleum Products	124.17

Source: Ministry of Petroleum and Naural Gas

Bechtel

Reliance Industries' Jamnagar Refinery. Already the largest greenfield refinery in the world, the expansion completed by Bechtel in 2008 nearly doubled the output of Jamnagar to 1.24 million barrels per day of nominal crude processing capacity, representing one-third of India's capacity.

Table 4-3. Progress Under the New Exploration License Policy

	NELP I	NELP II	NELP III	NELP IV	NELP V	NELP VI	NELP VII
Blocks awarded	25	23	23	21	20	52	44
PSCs signed	24	23	23	20	20	52	41
Signed in	2000	2001	2003	2004	2005	2007	2008
Area awarded (km^2)	194,735	263,050	204,588	192,810	115,180	306,200	121,000

Source: Ministry of Petroleum & Natural Gas

actual expenditure so far is about $4.7 billion. In addition, $5.2 billion has been invested on the development of discoveries.

The NELP effort opened up deepwater offshore areas of the country for exploration, and seven rounds of NELP increased the area under exploration to 48% of the Indian sedimentary basin area from 11% before the implementation of NELP. Hydrocarbon reserves accretion had been more than 600 million tonnes of oil

Oil & Gas sector entities

Integrated oil companies

Hindustan Petroleum Corporation Ltd. (HPCL)
HPCL is an integrated oil refining and marketing company with 16% of the market share and 10.3% of the nation's refining capacity. Its two coastal refineries in Mumbai and Visakhapatnam have a combined capacity of 13 MTPA. HPCL also owns and operates the country's largest lube refinery, which has a capacity of 335,000 tonnes.
http://www.hindustanpetroleum.com/En/UI/Home.aspx

Bharat Petroleum Corporation Ltd. (BPCL)
BPCL is engaged in both refining and retail business. It has refineries in Mumbai and Kochi, with a combined capacity of 19.5 MTPA for refining crude oil. BPCL is also engaged in the retailing of gasoline, diesel, kerosene, jet fuel, LPG, a range of oils and greases, and various non-fuel products.
http://www.bharatpetroleum.com

Reliance Industries Ltd. (RIL)
RIL has been realizing value across the entire energy chain. It has been involved in the exploration and production of oil and gas as well as refining and marketing of petroleum. The company has 34 domestic exploration blocks covering an area of about 331,000 km^2, one exploration block each in Yemen and Oman, and five coal-bed methane blocks. Reliance's 60-MTPA refinery at Jamnagar, Gujarat, is the world's largest.
http://www.ril.com

Essar Oil Ltd. (EOL)
An integrated oil and gas company, the EOL has E&P rights in several blocks in the country. Its 10.5-MTPA refinery at Vadinar, Gujarat, started production in 2008. It has been built with the state-of-the-art technology and has the capability to produce gasoline and diesel for India as well as advanced international markets.
http://www.essar.com

E&P companies

Oil India Ltd. (OIL)
OIL is engaged in the business of exploration, development, and production of crude oil and natural gas, and transportation of crude oil and production of LPG.
http://www.oil-india.com

Gujarat State Petroleum Corporation Ltd. (GSPC)
GSPC is India's only state-government-owned company in the oil and gas E&P business. From a small oil and gas producing company in Gujarat, it has become a vertically integrated large-scale energy organization in India, excelling in a wide gamut of hydrocarbon activities.
http://www.gspcgroup.com/gspc.html

Cairn India Ltd.
Cairn is engaged in the E&P of crude oil and natural gas. Cairn India operates offshore platforms, approximately 200 km of subsea pipelines, and two processing plants.
http://www.cairnindia.com

Refineries

Chennai Petroleum Corporation Ltd. (CPCL)
CPCL, a subsidiary of the Indian Oil Corporation Ltd., has two refineries with a combined refining capacity of 10.5 MTPA, mainly producing LPG, motor spirit, superior kerosene, aviation turbine fuel, high-speed diesel, naphtha, bitumen, lube base stocks, paraffin wax, fuel oil, hexane, and petrochemical feedstocks.
http://www.cpcl.co.in

Bongaigaon Refinery and Petrochemicals Ltd. (BRPL)
BRPL, also a subsidiary of the IOCL, is the first indigenous grass-roots refinery in the country, integrated with a petrochemical complex at a single location. BRPL has a total refining capacity of 2.35 MTPA and produces LPG, naphtha, kerosene, gas oil, and reduced crude oil.

Numaligarh Refinery Ltd. (NRL)
NRL, a subsidiary of the Bharat Petroleum Corporation Ltd, is a petroleum refining company designed to process 3 MTPA of indigenous crude oil with state-of-the-art technology. This refinery mainly produces high-speed diesel. It also produces LPG, naphtha, motor spirit, aviation turbine fuel, kerosene, raw as well as calcinated petroleum coke, and sulfur.
http://www.nrl.co.in
http://www.bharatpetroleum.com

Mangalore Refinery and Petrochemicals Ltd. (MRPL)
A subsidiary of the ONGC, the MRPL is a grass-roots refinery with a capacity of 9.69 MTPA. It has a versatile design, which gives high flexibility for processing crude oils of various API weights, providing a high degree of automation. This refinery's petroleum products include LPG, naphtha, motor gasoline, diesel, gas oil, kerosene, aviation fuel, furnace oil, low sulfur heavy stock, bitumen, reformate, feedstock, and sulfur.
http://www.mrpl.co.in
http://www.ongcindia.com/english.asp

Marketing Companies

Gas Authority of India Ltd. (GAIL)
GAIL is India's principal gas transmission and marketing company, and has expanded into gas processing, petrochemicals, LPG transmission, and telecommunications, as well as into power, LNG regasification, city gas distribution, exploration, and production through equity and joint venture participation.
http://www.gailonline.com/gailnewsite/index.html

Indraprastha Gas Ltd. (IGL)
A joint venture of GAIL, the BPCL, and the Government of NCT (National Capital Territory), Delhi, the IGL has established a network for the distribution of natural gas to consumers in the domestic, transport, and commercial sectors in the NCT of Delhi.
http://www.iglonline.net

Mahanagar Gas Ltd. (MGL)
A joint venture of GAIL, the BG Group (formerly British Gas), and the Government of Maharashtra, the MGL provides piped natural gas to households and compressed natural gas for transportation across Mumbai.
http://www.mahanagargas.com

Table 4-4. Existing and Proposed Liquefied Natural Gas Terminals

Project and Developer	Location (State)	Capacity (MTPA)	Supplier	Status
Dahej LNG Terminal (Petronet)	Dahej (Gujarat)	6.5 (to be expanded to 10)	Rasgas (Qatar-based LNG supply company) and spot cargoes	Commissioned in February 2004 and commercial sales began in April 2004
Hazira LNG (Shell and Total)	Hazira (Gujarat)	2.5 (phase I)	Spot cargoes	Commissioned in April 2005
Dabhol Terminal (owned by Ratnagiri Gas and Power Co)	Dabhol (Maharashtra)	5	Not finalized	75% complete (commissioning delayed due to no firm supply contracts)
Kochi LNG (Petronet LNG)	Kochi (Kerala)	2.5	Not finalized	Project expected to be completed by 2011
Ennore LNG (IOCL, CPCL)	Ennore (Tamil Nadu)	2.5	Not finalized	Planned
Mangalore (ONGC and MRPL)	Mangalore (Karnataka)	2.5	Not finalized	Planned

Source: TERI

equivalent. Under the NELP program, 68 oil and gas discoveries have been made in 19 exploration blocks. A total of 149 blocks are under operation under production-sharing contracts.

NELP VIII in 2009 offered 70 exploration blocks comprising 24 deepwater blocks, 28 shallow-water blocks, and 18 onshore blocks. These 70 blocks cover a sedimentary area of about 164,000 km^2, or about 5.2% of the Indian sedimentary basin area. The 18 onshore blocks fall in the states of Assam (2), Gujarat (8), Haryana (1), Madhya Pradesh (3), Manipur (2) and West Bengal (2). In the western, eastern, and Andaman Offshore regions, there are 28 shallow-water and 24 deepwater blocks.

Refining

The refining capacity in the country stood at 177.97 million tonnes per year on April 1, 2009, an increase of more than 19% over the previous year. Consequently, total refinery throughput in 2008-09 of 160.77 million tonnes was up 3% over the previous year, with a pro-rata capacity utilization of 107.9%.

Consequently, the country is a net importer of crude oil (128.155 million tonnes valued at $72.8 billion) while being a net exporter of petroleum products (18.647 million tonnes valued at $12 billion). India is emerging as a refinery hub as more capacity is added and Indian companies are venturing abroad to set up refineries.

Oil & Gas pipelines

As of March 31, 2009, the total length of crude oil pipelines crossing the country stood at 5,559 km owned by Oil India Ltd. (OIL) and Indian Oil Corporation Ltd. (IOCL). OIL owns the 1,405-km-long Duliajan-Digboi-Bongaigaon-Barauni pipeline, with 7.68 million tonnes per annum capacity. IOCL operates three crude oil pipelines:

- Salaya-Mathura-Panipat pipeline, 1,870 km, 21 MTPA capacity
- Paradip-Haldia-Barauni pipeline, 1,302 km, 7.50 MTPA capacity
- Mundra-Panipat pipeline, 1,174 km, 6 MTPA capacity

In 2008-09, product pipelines including for LPG totaled 12,017 km with a capacity of 68.19 MTPA. Capacity utilization was about 77%.

Natural-gas pipelines are currently limited but are expected to become more extensive with the increase in the availability of gas. All of India's principal gas pipelines move gas from the Gujarat coast northeastward to destinations in Uttar Pradesh and Haryana.

The most important pipeline in the country is the 2,800-km-long HBJ pipeline (Hazira-Bijapur-Jagdishpur), with a capacity of 60 million standard cubic meters per day. This pipeline supplies gas mainly to the power and fertilizer plants in northern and western India.

In addition to the HBJ pipeline, there are regional gas pipelines of varying sizes in the north Gujarat region (142 km), South Gujarat region (257 km), and Andhra Pradesh's KG Basin (728 km) among others. Many of these pipelines were initially built by the Oil and Natural Gas Corporation Ltd. and OIL, but were subsequently taken over by the Gas Authority of India Ltd. in 1992.

Liquefied natural gas (LNG)

Importing LNG is one of the ways India is bridging the demand-supply gap of energy sources. Two LNG terminals, both in Gujarat, currently are operating: the 6.5-MTPA Dahej terminal and the 2.5-MTPA Hazira terminal. Table 4-4 outlines four more terminals at various stages of development.

Indian Oil Corporation Ltd. (IOCL)

IOCL is currently India's largest integrated oil company. Along with its subsidiaries, it accounts for 49% of market share of petroleum products among public-sector oil companies, 40.4% of national refining capacity, and 69% of downstream product pipeline capacity. The Indian Oil Group of Companies owns and operates 10 of India's 19 refineries, with a combined refining capacity of 60.2 million tonnes per annum. These include two refineries of its subsidiary Chennai Petroleum Corporation Ltd. (CPCL) and one refinery of Bongaigaon Refinery and Petro Chemicals Ltd. (BRPL) The company has a crude-oil and product pipeline network spanning nearly 9,300 km across the country, with a capacity of 61.72 MTPA.
http://www.iocl.com/home.aspx
http://www.cpcl.co.in/

Oil and Natural Gas Corporation Ltd. (ONGC)

ONGC is the largest company engaged in the exploration and production of oil and natural gas in the country. It is the only fully integrated petroleum company in India, operating along the entire hydrocarbon value chain. ONGC Videsh Ltd. (OVL), a wholly owned subsidiary of the ONGC, manages the international E&P business for the acquisition of overseas reserves.
www.ongcindia.com/english.asp
www.ongcvidesh.com

Coal India

Coal sector

Coal is king. Growing demand for coal will eventually overburden the current railway system resulting in fuel shortages for power generation stations. Improvements to the current infrastructure and new means of coal transport, such as ferry and coal-slurry pipelines, are being explored to ensure energy security for India.

Coal provides more than one-quarter of the world's primary energy and is used to generate nearly 40% of its electricity. India's coal consumption ranks third in the world, and the country's demand for coal continues to grow much faster than the world average. Table 5-1 estimates its recoverable reserves at 101.9 billion tonnes, about 10% of the total world reserves of both lignite and coal.

Coal and lignite meet about 50% of India's commercial energy requirements. More than 75% of the coal and lignite is consumed by the country's power sector. Cement and steel (coking coal) are the other significant consumers. The Planning Commission's Integrated Energy Policy anticipates a steep rise in demand for coal, particularly to meet the country's power needs (Table 5-2).

The Ministry of Coal determines policies and strategies for exploration and development of coal and lignite reserves as well as all matters relating to coal production, supply, distribution, and pricing. Its public-sector undertakings include Coal India Ltd.(CIL), Neyveli Lignite Corporation Ltd., and the Singareni Collieries Company Ltd. (SCCL), which is a 51-49 joint sector undertaking between the Government of Andhra Pradesh and the GoI.

The public sector still dominates the mining and production of coal in India. CIL, along with its subsidiaries, has a market share of over 83%. The next-largest—the joint state and central government SCCL—has an 8.6% share. But opportunities for foreign and private investment can also be found.

In June 2010, South Africa-based Sasol Ltd. announced plans to spend $10 billion in a 50-50 joint venture with Tata Group on a coal-to-fuel project in Orissa, with the goal of producing 80,000 barrels-per-day of motor fuel by 2018. And CIL scheduled a $2.8-billion initial public offering for late July 2010, although it was subsequently postponed to September.

Exploration and recovery

The Geological Survey of India, Central Mine Planning & Design Institute Ltd., and Mineral Exploration Corporation Ltd. have estimated total coal reserves at 267.21 billion tonnes as a result of exploration activities carried out at depths up to 1,200 meters. Table 5-3 breaks down these reserve estimates to the state level.

Many coal resources are available in sedimentary rocks of older Gondwana

Table 5-1. World Recoverable Coal Reserves (billion tonnes)

Region/Country	Coal	Lignite	Total
World Total	827.4	173.4	1,000.8
United States	234.7	36	270.7
Russia	161.6	11.5	173.1
China	89.1	20.5	109.6
India	99.3*	2.6	101.9

Source: Expert Committee on Coal Reforms
* Total proved "in place" reserves instead of recoverable reserves relevant for other countries

Table 5-2. Coal Demand Projections (million tonnes)

Plan	Period	Power	Non-Power	Total
XI	2011/12	436	164	627
XII	2016/17	603	221	824
XIII	2021/22	832	299	1,131
XIV	2026/27	1,109	408	1,517
XV	2031/32	1,475	562	2,037

Source: Integrated Energy Policy, Planning Commission

Table 5-3. Distribution of Coal Resources (million tonnes)

State	Proved	Indicated	Inferred	Total
Andhra Pradesh	9,194	6,748	2,985	18,927
Arunachal Pradesh	31	40	19	90
Assam	348	36	3	387
Bihar	—	—	160	160
Chhattisgarh	10,910	29,192	4,381	44,483
Jharkhand	39,480	30,894	6,338	76,712
Madhya Pradesh	8,041	10,295	2,645	20,981
Maharashtra	5,255	2,907	1,992	10,154
Meghalaya	89	17	471	577
Nagaland	9	—	13	22
Orissa	19,944	31,484	13,799	65,227
Sikkim	—	58	43	101
Uttar Pradesh	866	196	—	1,062
West Bengal	11,653	11,603	5,071	28,327
Total	105,820	123,470	37,920	267,210

Source: Ministry of Coal (as of April 1, 2009)

Table 5-4. Coal Resources in Sedimentary Rock (million tonnes)

Formation	Proved	Indicated	Inferred	Total
Gondwana Coals	105,343	123,380	37,414	266,137
Tertiary Coals	477	90	506 *	1,073
Total	105,820	123,470	37,920 *	267,210

*Includes 456 million tonnes of Inferred resources established through mapping in Northeastern region.

Table 5-5. Allocation of Coal Blocks to Private Companies

Sector/End Use	Blocks	Geological Reserves (MT)
Power	20	2,702
Iron and Steel	47	6,703
Small and Isolated	2	9
Cement	3	232
Ultra Mega Power Project	7	2,607
Total	79	12,254

Source: Annual Report 2007-08, Ministry of Coal, GoI

Table 5-6. Coal Letters of Assurance (LOA)

Name of Sector	Number Approved	Quantity Approved (MTPA)
Power Utilities	15	57
Captive Power Plants including Cement CPPs	224	42
Independent Power Producers	12	24
Cement Plants	72	21
Sponge Iron Units	236	17
Total	559	161

Source: Annual Report 2007-08, Ministry of Coal, GoI

formations of peninsular India and younger Tertiary formations of northeastern/ northern hilly region. Based on the results of regional/promotional exploration, where the boreholes are normally placed 1-2 km apart, the resources are classified as "indicated" or "inferred." Subsequent detailed exploration in selected blocks, where boreholes are less than 400m apart, upgrades the resources into the more-reliable "proved" category. Table 5-4 reports the results as of April 1, 2009.

Thus, of the estimated reserves of 267 billion tonnes, 105 billion tonnes are Proved. Even on the conservative assumption of 60% recoverability for the Proved resources, about 64 billion tonnes could be recovered. This could sustain a production level of over 1,800 million tonnes per year for the next 30 years.

Up to December 2007, the Ministry of Coal had allocated 172 Coal Blocks with reserves of coal of 38.05 billion tonnes to eligible companies. The private sector was allocated 79 blocks with geological reserves of 12,254 MT (Table 5-5).

Private-sector participation in the coal sector is restricted to joint ventures and companies that can use coal for captive purposes. If the production is greater than what is required for internal use, the balance must be sold to Coal India Ltd. As of 31 March 2009, 201 coal blocks with reserves of 45.89 billion tonnes had been allocated to eligible companies.

Of the 201 blocks, 97 have been allocated to Public Sector Undertakings. Private companies have been allocated 100 blocks with geographical reserves of 17.93 billion tonnes and production has begun in 23 blocks.

During 2007-08, 45 coal blocks with total geological reserves of 11.386 billion tonnes were allocated to public and private companies, of which 21 blocks with total geological reserves of 8.64 billion tonnes were allocated to public and private companies in the power sector. Table 5-6 shows the commitment of coal supply through the letter of assurance (LOA) recommended by the Standing Linkage Committee.

Table 5-7. Status of CBM Blocks

Blocks Awarded	3
Under Round I	5
Under Round II	8
Under Round III	10
Total	26
Area Awarded (sq km)	13,600
Total CBM Resources (BCM)	1,374
CBM Wells drilled	210
Expected Production Potential (MMSCMD)	38
Approved Gas Sale Price ($/MMBTU)	6.79

Source: India - Petroleum Exploration and Production Activities, 2007-08

Coal-bed methane

Investor response was lukewarm in 2001 to the first round of bidding for blocks to develop coal-bed methane. But by 2006, both national and international players were seeing a change in the commercial viability of CBM, and the third round that year was marked by a perceptible rush to grab a share of the action. Now, after three rounds of CBM bidding, 26 blocks have been offered and 23 CBM exploration blocks have been signed.

More than 6 trillion cubic feet (TCF) of reserves have already been established in four CBM blocks. First commercial production of CBM commenced in the country in July 2007 at the rate of about 72,000 cubic meters per day. Table 5-7 displays the details of the CBM blocks awarded so far.

The fourth round of CBM Policy offers 10 blocks covering an area of about 5,000 km^2 falling in the states of Assam (1), part Chhattisgarh and part Madhya Pradesh (1), Jharkhand (2), Madhya Pradesh (2), Maharashtra (2), Orissa (2) and Tamil Nadu (1). The total exploration period has been reduced from eight years to five.

Shale oil

A preliminary assessment of the sedimentary rocks in India suggests that there could be around 137 billion tonnes of oil available in shale in Assam and Arunachal Pradesh alone. The Cambay basin, off the Gujarat Coast, also has shale gas deposits. Of this, around 10% is estimated to be recoverable reserves.

The Directorate General of Hydrocarbons (DGH) plans to come up with an exploration and licensing policy, on the lines of the New Exploration and Licensing Policy (NELP), for shale oil and gas in India once the initial studies are done and deposits are established.

The DGH has formed a consortium with state-run Indian Oil Corporation (Indian Oil), Mineral Exploration Corporation Ltd. (MECL) and the French Institution of Research in Earth Sciences, BRGM, to establish the potential of shale-oil exploration in India.

Planned coal projects

At March 31, 2009, out of a total of 701 mining projects costing more than $450,000, 411 projects stood completed (including projects which are merged, completed and merged, and where coal reserves have since been exhausted) and 160 projects were in various stages of

implementation. Out of 160 ongoing projects, 125 were on schedule and 35 were delayed. Reasons include delay in environmental and forestry clearances, delay in acquisition of land and associated problems of rehabilitation, adverse geo-mining conditions and problems with law and order. Some areas of India have experienced extended periods of rebellion or insurgency.

If the power sector is required to grow at 10% per year, coal availability from domestic sources should also grow at 10%, and possibly even faster, since projections show coal supplying an increasingly large share of India's energy. Associated ports, railways and transportation infrastructure will need to be developed accordingly. In the current scenario (2009-10), 404 million tonnes of coal are required for the power sector. The government-owned companies CIL and SCCL are able to supply 343 mt and the captive mines 20 mt. This still leaves a shortfall of 41 mt and the power companies have been advised to import 28.7 mt of coal. This shortfall is expected to persevere into the XII Plan.

Though a number of coal blocks have been allocated by the Ministry of Coal for power projects, their development has been slow, resulting in the coal shortage. Among the obstacles to coal development have been coordinated development of the rail network and a lack of other models for coal exploration and mining, such as private-sector participation through a public-private partnership.

Coal India Ltd. (CIL)

Headquartered at Kolkata (formerly Calcutta), CIL is the apex body in the coal industry and is responsible for laying down policy guidelines and coordinating work of its nine subsidiaries. The eight subsidiaries responsible for coal mining activity are:

- Bharat Coking Coal Ltd., Dhanbad
- Central Coalfields Ltd., Ranchi
- Mahanadi Coalfields Ltd., Sambalpur
- Western Coalfields Ltd., Nagpur
- South Eastern Coalfields Ltd., Bilaspur
- Northern Coalfields Ltd., Singrauli
- Eastern Coalfields Ltd., Asansol
- North Eastern Coalfields, Guwahati

The ninth subsidiary, Central Mine Planning and Design Institute Ltd., Ranchi, supports the planning and design needs of new coal projects and is responsible for the reorganization of existing mines for optimal production of coal. CIL, on behalf of all its subsidiaries, is engaged in investment planning, manpower management, purchase of heavy machinery and financial budgeting.
http://www.coalindia.in

Coal sector entities

Neyveli Lignite Corporation (NLC)

NLC is engaged in the exploitation and excavation of lignite, generation of 2,490 MW of thermal power, and sale of raw lignite. It has the biggest open-cast mechanized lignite mines in India. It mined 21.58 million tonnes of lignite in 2007-08. NLC also provides consultancy in mine planning and renovation of power plants.
http://www.nlcindia.co.in

Singareni Collieries Company Ltd. (SCCL)

SCCL is a joint sector undertaking of the Government of Andhra Pradesh and the Government of India, with equity capital in the ratio of 51:49. Headquartered at Kothagudem in Andhra Pradesh, SCCL produced 41 million tonnes of coal in 2007-08.
http://scclmines.com

Appendix 1: Idiosyncratic India

Numeric system

This handbook presents numeric data and weights and measures in terms that are familiar to the Western tradition. But investors reading Indian business and government documents will be plunged into a language that requires some explanation.

The traditional Indian numeric system is still used in the subcontinent of India, Bangladesh, Nepal and Pakistan (Table A-1). It is based on a unique grouping of two decimal places instead of three as is common in the West. Thus, while Indians write 1,000 for "one thousand," their concession to the Western tradition ends there. Where a Westerner writes 100,000 and says "one hundred-thousand" for 10^5, Indian business English writes 1,00,000, and expresses it as "1 lakh" (or lac). The next step up in the Indian numeric system is 10^7, written 1,00,00,000 and expressed as "1 crore."

"Crores," "Lakhs," and the practice of grouping decimal places by twos instead of threes in numbers larger than 1,000 are widespread in Indian banking, stock exchanges, government data, journalism and business. The place value system is derived from Sanskrit, India's classical language, in which lakh, crore and a whole array of other terms serve as counterparts to the West's million, billion, trillion, etc. But instead of naming groups of 10^3, Sanskrit, and now Indian business English, names groups of 10^2.

Indians shift smoothly between their traditional numeric nomenclature and the Western standard. They speak in dollars in banking, for example, and a professional would never say "one lakh dollars." He would say "one hundred-thousand dollars," and would write $100,000. The same person, on the other hand, would refer to one crore rupees or INR 1 crore, not "a million rupees." One billion rupees would be "INR 1 arab."

A word of warning is in order here. If in Mumbai, India's commercial capital, you are doing business with someone who uses khokha instead of crore and peti instead of lakh, you've fallen in with bad company. These are slang terms used in the Mumbai underworld's parallel economy.

The Indian numeric system is very ingrained. Many expatriates in India recognize the need to speak in lakhs and crores. Although, as mentioned, there are many other terms for higher numbers, in practice it is more common to repeat lakh and crore or to combine them to designate those higher numbers. One lakh crore, for example, would refer to 10^{12}, or one trillion. However, with international companies now participating in government tenders, by and large the U.S. dollar is currency to be quoted.

Weights and measures

India was one of the first countries in the developing world to metricate its economy progressively. Metric weights have been compulsory in trade since 1962, although Imperial measures are still common in some other applications. Fuel efficiency is measured in kilometers per liter. Tire pressure is measured in kilograms per square centimeter (pounds per square inch only in some very old gauges) and tread sizes are in millimeters, while tire-rim diameters are still measured in inches, as is common throughout the world.

While road distances are in kilometers, road widths are popularly measured in feet, but official documents use meters. Almost all types of industry in India operate exclusively in metric units. A handful of industries, such as construction and real estate, still use both the metric and Imperial systems, probably because of their continued reliance on designs originating in the U.S. These will probably complete their conversion to metric when the U.S. does.

Temperature is almost always in degrees Celsius and rainfall is measured in centimeters and millimeters. However body temperature is still sometimes measured in degrees Fahrenheit.

While body weight is always measured in kilograms, body height is often measured in feet and inches, although many documents increasingly use centimeters.

Current status of Imperial units:

- Imperial units that are long forgotten: Ounces, gallons, miles, pounds, pints, and quarts (only metric equivalents are used, and it is likely that people born after 1980 might not even have heard of the old measures)
- Imperial units used along with metric equivalents: Inches, feet, yards (square yards for area), degrees Fahrenheit (Both metric and Imperial units are popular)
- Imperial units more popular: Acres (hectares are generally used only in government documents)

Indian abbreviations also may confuse the newcomer. "Cumec," for example, is a unit of volume flow rate equal to 1 cubic meter per second, common in the hydropower industry. We have included translations for some common abbreviations in the Acronyms pages, others in the text. The reader is advised to ask an Indian acquaintance when encountering unfamiliar terms.

Neelam Mathews

Table A-1. India's Unique Number System

Term	Figure	No. of Zeroes	In Words
lakh (lac)	1,00,000	5	Hundred thousand
crore	1,00,00,000	7	10 million
arab	1,00,00,00,000	9	1 billion
kharab	1,00,00,00,00,000	11	100 billion
neel	1,00,00,00,00,00,000	13	10 trillion
padam	1,00,00,00,00,00,00,000	15	1 quadrillion
shank	1,00,00,00,00,00,00,00,000	17	100 quadrillion

Appendix 2: Acronyms

AEC Atomic Energy Commission ..... www.aec.gov.in
AERB Atomic Energy Regulatory Board ..... www.aerb.gov.in
AHEC Alternate Hydro Energy Centre ..... ahec.org.in
AMD Atomic Minerals Directorate for Exploration and Research ..... www.amd.gov.in
ATE Appellate Tribunal for Electricity
BARC Bhabha Atomic Research Centre ..... www.barc.ernet.in
BBMB Bhakra Beas Management Board ..... bbmb.gov.in/english/index.asp
BCM Billion cubic meters
BEE Bureau of Energy Efficiency ..... www.bee-india.nic.in
BHAVINI Bharatiya Nabhikiya Vidyut Nigam Ltd. ..... www.bhavini.nic.in/main.asp
BPCL Bharat Petroleum Corporation Ltd. www.bharatpetroleum.com
BRNS Board of Research in Nuclear Sciences www.barc.ernet.in/webpages/brns/brns1.html
BRPL Bongaigaon Refinery and Petro Chemicals Ltd.
CBM Coal Bed Methane
CCO Office of the Coal Controller's Organization
CEA Central Electricity Authority ..... www.cea.nic.in
CERC Central Electricity Regulatory Commission ..... cercind.gov.in
CESC CESC Ltd. ..... www.cescltd.com/cesc/menu.html#
CHT Centre for High Technology ..... www.cht.in
CIL Coal India Ltd. ..... www.coalindia.in
CMPDI Central Mine Planning & Design Institute Ltd. ..... www.cmpdi.co.in
CPCL Chennai Petroleum Corporation Ltd. ..... www.cpcl.co.in
CPRI Central Power Research Institute ..... www.cpri.in
CPSU Central Public Sector Undertaking
CTU Central Transmission Utility
C-WET Centre for Wind Energy Technology ..... www.cwet.tn.nic.in
DAE Department of Atomic Energy ..... www.dae.gov.in/
DGH Directorate General of Hydrocarbons ..... www.dghindia.org
DISCOM Distribution company
DVC Damodar Valley Corporation .... www.dvcindia.org/index.htm
E&P Exploration and production
ECIL Electronics Corporation of India Ltd. ..... www.ecil.co.in
EIL Engineers India Ltd. ..... engineersindia.eil.co.in
EOL Essar Oil Ltd. ..... www.essar.com
GAIL GAIL (India) Ltd. ..... www.gailonline.com/gailnewsite/index.html
GoI Government of India ..... india.gov.in
GSI Geological Survey of India ..... www.portal.gsi.gov.in
GSPC Gujarat State Petroleum Corporation Ltd. ..... www.gspcgroup.com/gspc.html
HPCL Hindustan Petroleum Corporation Ltd. ..... www.hindustanpetroleum.com/En/UI/Home.aspx
HWB Heavy Water Board ..... www.heavywaterboard.org
IEEMA Indian Electrical and Electronics Manufacturers Association ..... www.ieema.org
IEX Indian Energy Exchange ..... www.iexindia.com
IGCAR Indira Gandhi Centre for Atomic Research ..... www.igcar.ernet.in
IGL Indraprastha Gas Ltd. ..... www.iglonline.net
IOCL Indian Oil Corporation Ltd. ..... www.iocl.com/home.aspx
IREDA Indian Renewable Energy Development Agency Ltd. ..... www.ireda.in
IREL Indian Rare Earths Ltd. ..... www.irel.gov.in
kW Kilowatts
MECL Mineral Exploration Corporation Ltd. ..... www.mecl.gov.in
MGL Mahanagar Gas Ltd. ..... www.mahanagargas.com
MMT Million tonnes
MMTOE (or MTOE) Million tonnes of oil equivalent
MNES Ministry of Non Conventional Energy Sources
MNRE Ministry of New and Renewable Energy ..... mnre.gov.in
MoC Ministry of Coal ..... coal.nic.in/welcome.html
MoP Ministry of Power ..... powermin.nic.in
MoPNG Ministry of Petroleum and Natural Gas ..... petroleum.nic.in
MPP Merchant power plant
MRPL Mangalore Refinery and Petrochemicals Ltd. ..... www.mrpl.co.in
MTPA Million tonnes per annum
MW Megawatts
MWeq Megawatt Equivalent
NEEPCO North Eastern Electric Power Corporation Ltd. ..... www.neepco.gov.in
NELP New Exploration Licensing Policy
NFC Nuclear Fuel Complex ..... www.nfc.gov.in/default.htm
NHDC Narmada Hydroelectric Development Corporation Ltd. ..... www.nhdcindia.com
NHPC National Hydroelectric Power Corporation Ltd. ..... www.nhpcindia.com/index.aspx
NLC Neyveli Lignite Corporation Ltd. ..... www.nlcindia.co.in
NLDC National Load Despatch Centre ..... www.nldc.in
NPCIL Nuclear Power Corporation of India Ltd. ..... www.npcil.nic.in
NPTI National Power Training Institute ..... www.powermin.nic.in/training/national_power_training.htm
NRL Numaligarh Refinery Ltd. ..... www.nrl.co.in
NTPC National Thermal Power Corporation Ltd. ..... https://www.ntpc.co.in
OIDB Oil Industry Development Board ..... www.oidb.gov.in
OIL Oil India Ltd. ..... www.oil-india.com
OISD Oil Industry Safety Directorate
ONGC Oil and Natural Gas Corporation Ltd. ..... www.ongcindia.com/english.asp
OVL ONGC Videsh Ltd. ..... www.ongcvidesh.com
PCRA Petroleum Conservation Research Association ..... www.pcra.org
PFC Power Finance Corporation Ltd. ..... www.pfcindia.com
POWERGRID Power Grid Corporation of India Ltd. ..... www.powergridindia.com/PGCIL_NEW/home.aspx
PPAC Petroleum Planning & Analysis Cell ..... www.ppac.org.in
PSU Public Sector Undertaking
PTC PTC India Ltd. ..... www.ptcindia.com
R-APDRP Restructured Accelerated Power Development and Reform Programme www.pfc.gov.in/apdrp/apdrp2.html
REC Rural Electrification Corporation Ltd. ..... recindia.nic.in
REL Reliance Energy Ltd. ..... www.rinfra.com
RGGVY Rajiv Gandhi Grameen Vidyutikaran Yojana ..... rggvy.gov.in/rggvy/rggvyportal/index.html
RIL Reliance Industries Ltd. ..... www.ril.com
RLDC Regional Load Despatch Center
RPPO Renewable Power Purchase Obligation
SCCL Singareni Collieries Company Ltd. ..... scclmines.com
SEB State Electricity Board
SEC Solar Energy Centre ..... mnre.gov.in/sec/sec-objective.htm
SERC State Electricity Regulatory Commission
SJVN SJVN ..... sjvn.nic.in
SLDC State Load Despatch Centre
SSS-NIRE Sardar Swaran Singh National Institute of Renewable Energy ..... mnre.gov.in/nire-rdd.htm
STU State Transmission Utility
TCF Trillion cubic feet
TERI The Energy and Resources Institute ..... teriin.org
THDC Tehri Hydro Development Corporation Ltd. ..... thdc.gov.in
TRANSCO Transmission company
UMPP Ultra Mega Power Plant

Appendix 3: Energy reports and planning and policy links

Atomic Energy Regulatory Board	www.aerb.gov.in/
Central Electricity Regulatory Commission	cercind.gov.in/
Directorate General of Hydrocarbons	www.dghindia.org/
EIA India Country Analysis Brief	www.eia.doe.gov/cabs/India/pdf.pdf
Electric Power Survey 17	www.cea.nic.in/planning/17TH%20EPSR-Highlights.pdf
The Electricity Act 2003	www.cea.nic.in/home_page_links/ElectricityAct2003.pdf
Expert Committee on Road Map for Coal Sector Reforms, Part I	coal.nic.in/expertreport.pdf
Expert Committee on Road Map for Coal Sector Reforms, Part II	www.indiaenvironmentportal.org.in/files/expertreport2.pdf
Integrated Energy Policy, Report of the Expert Committee, August 2006	planningcommission.nic.in/reports/genrep/rep_intengy.pdf
National Action Plan on Climate Change	pmindia.nic.in/Pg01-52.pdf
National Electricity Policy 2005	www.cea.nic.in/planning/national_Electricity_policy.htm
National Tariff Policy 2006	www.powermin.nic.in/whats_new/pdf/Tariff_Policy.pdf
Petroleum & Natural Gas Regulatory Board	www.pngrb.gov.in/
Planning Commission of the Government of India	planningcommission.nic.in/
Power Sector in India: White Paper on Implementation Challenges and Opportunities	www.kpmg.com/IN/en/IssuesAndInsights/ThoughtLeadership/PowerSector_2010.pdf
Renewable Energy Certificate Regulation 2010	cercind.gov.in/regulation/REC_2010.html
Report of the Expert Committee on Integrated Energy Policy	www.indiaenvironmentportal.org.in/files/energy.pdf
Rural Electrification Policy 2006	www.powermin.nic.in/whats_new/pdf/RE%20Policy.pdf
USAID India Country Report	usaid.eco-asia.org/programs/cdcp/reports/Ideas-to-Action/From%20Ideas%20to%20Action_Complete%20Report.pdf
World Energy Outlook 2007, IEA	www.iea.org/textbase/nppdf/free/2007/weo_2007.pdf

IPG—Industrial Project Group Srl

Principal Activities

- Feasibility studies for large fossil-fired, waste-to-energy, and nuclear power plants
- Retrofit of existing subcritical coal-fired boilers to ultrasupercritical operation
- Independent-engineer services for banks and other financial institutions, private investors, and power plant owners worldwide
- Help determine R&D needs of plant owner/operators and developers
- Feasibility studies of advanced carbon capture and storage systems and advanced gasification processes

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