1 ENERGY AND ENVIRONMENT: AN OVERVIEW

Introduction

According to the Union Budget 2015/16, India is projected to be the fastest growing large economy globally with an expected real GDP growth rate of 7.4% (New Series) (MoF 2015). This economic growth and rising population have strained the limited ability of resources to generate consumptive outputs and sustain life-supporting functions. Another implication of this economic growth is the increasing use of energy in the country (TERI 2009). Coal continues to remain the dominant fuel in the total energy production with a share of 65% (BP 2014). The situation of energy access in India needs much attention. India's electrification rate is reported to be at 75%, which indicates that one-fourth of the population still lacks access to electricity. Also about 815 million people rely on traditional biomass[1] for cooking, which is approximately 66% of India's total population (IEA 2014).

Human development is considered the principal reason as well as the result of sustainable development. India's human development index (HDI) for 2013 was 0.586, which placed the country in the medium human development category and at the 135th position out of 187 countries and territories (UNDP 2014). Strong correlation has been observed between the HDI and per capita energy consumption for the majority of the world (Martínez and Ebenhack 2008). The energy development index (EDI)[2] ranked India at 41 among the 80 countries for 2010. Occupying 2.4% of the world's land area, India is home to one-sixth of the total plant species of the world, and out of the 34 biodiversity hotspots of the world, four are in India (MoEF 2014).

Figure 1 shows the environment performance index (EPI)[3] and the gross state domestic product (GSDP) index for 35 states and union territories of India.

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) indicates water stress and food shortage in South Asian countries in the future (IPCC 2014). In the backdrop of depleting natural resources and increasing energy demand and consumption, this would hold serious implications for India. This stresses upon the need to take appropriate action to address climate change and related issues.

India participated at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties at Lima (COP-20), where it reiterated the need for collective action along the principles of equity and common but differentiated responsibilities to form the basis of continued action of climate change (MoEFCC 2014). Ahead of the COP-21 meeting in Paris in 2015, India has been carrying out consultations on the Intended Nationally Determined Contributions (INDCs).[4]

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[1] Biomass consists of wood, agricultural residues, and dung for the purpose of cooking.

[2] The International Energy Agency (IEA) develops EDI to better understand the role that energy plays in human development. EDI accounts for indicators such as per capita commercial energy consumption, per capita electricity consumption in the residential sector, share of modern fuels in the total energy use of the residential sector, and share of population with access to electricity, modern energy use for public.

[3] EPI is based on the composite index developed by the Planning Commission, which combines data on 16 indicators based on criteria such as air pollution, water quality, forests, waste management, and climate change. Details available at < http://pib.nic.in/newsite/erelease.aspx?relid=95839>

[4] INDCs are country commitments aimed at reducing global emissions to limit the average global temperature rise to 2°C; these are to be decided in context of their national priorities, circumstances, and capabilities. Details available at <http://unfccc.int/resource/docs/2014/adp2/eng/7drafttext.pdf>

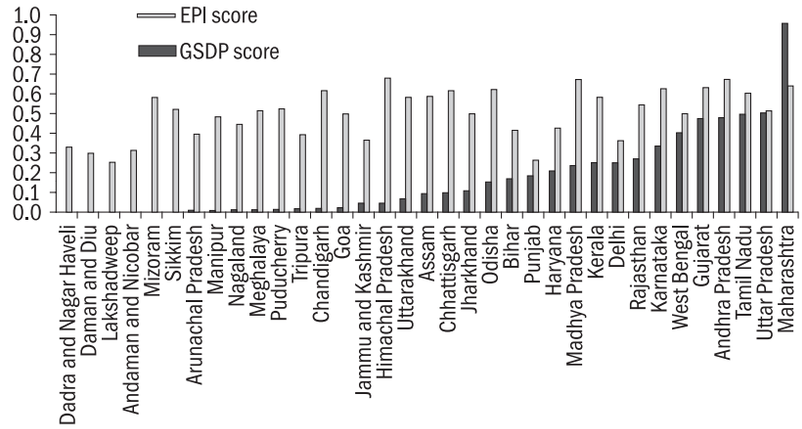

Figure 1 State environment performance index and gross state domestic product index

Source PSCST–TERI (2014), based on Chandrasekharan, Kumar, Raghunathan, *et al.* (2013)

The Government of India has announced building up of 100 smart cities, which would have smaller carbon footprint on the environment and have sustainable energy systems.[5] Also the launch of the "Swachh Bharat Abhiyan" or the "Clean India Campaign" by the Government of India emphasizes on cleaning and maintaining the local environment, with an emphasis on sanitation and waste disposal (PMO 2015a). The Prime Minister Council on Climate Change, in January 2015, held its first meeting with the council of ministers of the newly elected government in India. The council laid emphasis on addressing the issues of climate change, which presents a great opportunity to India for working towards bringing improvement in the quality of life of its citizens and thus making a positive social impact (PMO 2015b).

Energy supply and demand

The energy sector in India is closely linked to the economic activity of the country. The past and current patterns of energy generation and consumption are bound to determine the economic future and well-being of the country. The final commercial energy consumption in India over the last three decades is shown in Table 1.

Sources of energy supply in India

Coal and lignite

In terms of the total commercial energy supplied as well as the installed power generation capacity, coal forms the largest source of energy in India. During 2004–14, coal production witnessed an upward trend. In 2013/14, the total production of raw coal in India increased by 1.7% from that in 2012/13. According to provisional estimates by the Coal Controller Organization, the overall coal consumption for India increased by about 11% from 696.03 million tonnes (MT) in 2011/12 to 772.84 MT in 2012/13; this is further expected to reach 980 MT by 2016/17. Until April 2014, the estimated gross geological resources of coal were 301 564 MT. Out of this, 42% constitutes proved reserves, and the rest 58% is in the category of indicated and inferred resources.

With more demand from the power, steel, and cement sectors, the demand and supply gap for coal is getting widened and has led to a rise in the import of coal. With the assumption of total projected coal demand of 980.50 MT and projected domestic coal supply of 795 MT, coal imports are projected to increase to 185.50 MT by the end of the Twelfth Five-year Plan, as against the figure of 137 MT by

[5] Details available at <http://indiansmartcities.in/site/index.aspx>

Table 1 Final commercial energy consumption (in Mtoe) in India by sector

Sector	1980/81	1985/86	1990/91	1995/96	2000/01	2005/06	2009/10	2010/11	2011/12
Agriculture	1.6 (2.3%)	2.4 (2.6%)	4.9 (3.9%)	8.4 (5.3%)	15.2 (7.9%)	15.1 (6.9%)	23.14 (7.32%)	18.70 (5.9%)	21.79 (6.17)
Industry	36.9 (53.7%)	49.2 (53.0%)	62.9 (50.4%)	77.5 (48.6%)	77.4 (40.4%)	96.2 (44.4%)	137.98 (46.62%)	146.72 (46.7%)	160.09 (45.35)
Transport	17.4 (25.3%)	21.7 (23.4%)	28 (22.4%)	37.2 (23.4%)	33.5 (17.5%)	36.5 (16.8%)	55.34 (17.5%)	63.39 (20.2%)	76.46 (21.66)
Residential and commercial	5.6 (8.1%)	8.9 (9.6%)	12.6 (10.1%)	15.3 (9.6%)	24.1 (12.6%)	32.6 (15.1%)	43.43 (13.73%)	44.09 (14%)	48.7 (13.79)
Other energy uses*	1.9 (2.8%)	2.7 (2.9%)	3.9 (3.1%)	6.8 (4.3%)	13.4 (7.0%)	18.7 (8.6%)	30.25 (9.56%)	14.33 (4.6)	15.07 (4.27)
Non-energy uses**	5.3 (7.7%)	7.9 (8.5%)	12.6 (10.9%)	14.1 (8.8%)	28 (14.6%)	17.5 (8.1%)	26.15 (8.27%)	27.17 (8.6%)	30.9 (8.75)
Total	68.7 (100%)	92.8 (100%)	124.9 (100%)	159.3 (100%)	191.6 (100%)	216.6 (100%)	316.29 (100%)	314.4 (100%)	353.01 (100%)

* This comprises energy spent in miscellaneous uses and mining.

** Non-energy uses exist only for naphtha and natural gas sectors, since both these fuels are consumed as feed stock in fertilizers and petrochemicals

Mtoe – million tonnes of oil equivalent.

Note Figures in parentheses indicate the percentage share of each sector

Sources TERI (various years); CEA (2012); MoPNG (2012a); MoC (2014)

Commercial energy flow in India: explanation for the Sankey diagram (Figure 2)

1. The net availability of natural gas refers to that availability of gas net of flaring and LPG extraction. The formula for estimating the net availability of natural gas in Mtoe is explained in Table A.

Table A Formula for estimating net availability of natural gas

Production	42.80
+ Imports	11.96
– LPG extraction from natural gas	2.50
– Flaring of natural gas	0.97
– Petroleum refining	5.08
– Own use	3.26
Net availability of natural gas	42.95

Source MoPNG (2012b)

2. The net availability of coal and lignite refers to the total availability of coal and lignite net of own use and washery rejects. The formula for the net availability of coal and lignite in Mtoe is explained in Table B.

Table B Formula for estimating net availability of coal and lignite

Production of coal and lignite	217.01
+ Imports of coal	66.84
– Exports of coal	1.21
+ Stock changes	–0.76
– Own use[#]	0.16
– Coal washery rejects	2.49
Net availability of coal and lignite	279.23

[#] Own use refers to the amount of local consumed in collieries for their own consumption

Source MoC (2012)

3. The net availability of petroleum products refers to the crude oil converted to petroleum products and that available for final consumption. The formula for the net availability of crude oil in Mtoe is given in Table C.

Table C Formula for estimating net availability of crude oil

Crude throughput	211.42
– Refinery boiler fuel	15.42
+ Imports of petroleum products	15.68
– Exports of petroleum products	63.31
+ Stock changes	6.49
+ LPG extracted from natural gas	2.50
Net availability of petroleum products*	**157.36**

* The net availability of petroleum products comes to be 161.17 Mtoe with reference to Sankey Diagram in Figure 2. However, the net availability of petroleum products here is calculated to be 157.36 Mtoe. This difference in the values is accrued to refinery losses.

Source MoPNG (2012b)

4. Energy loss from generation is a sum of conversion losses in power generation (taking into account the thermal efficiency of different power plants), auxiliary consumption in power stations, and transmission and distribution losses (Table D).

Table D Calculation of energy loss from generation

Conversion losses in power generation	126.27
+ Auxiliary consumption in power stations	5.12
+ Transmission and distribution losses	17.92
Total energy loss from power generation	149.31

Source CEA (2012)

Final consumption of electricity across commercial, residential, agriculture, industry, transport, other energy and non-energy sectors is equal to 54.27 Mtoe.

5. The net availability of nuclear, renewable, and hydro energy is the total electricity generated from these sources. The quantities of electricity generated through nuclear, renewable, and hydro sources are 2.78, 4.51, and 11.23 Mtoe, respectively (CEA 2013a).
6. Final consumption refers to the energy available for the final demand sectors: residential, commercial, agricultural, industrial, transport, other energy and non-energy sectors. Table E shows the calculation for the estimation of final energy consumption for each of these six sectors during 2011/12. The final energy consumption is the sum of the consumption of coal and lignite, natural gas, petroleum products, and electricity.

Table E Final energy consumption across various sectors in India

Sector	Coal and lignite	Natural gas	Petroleum products	Electricity/power	Final consumption
Agriculture	–	0.16	9.51	12.12	21.79
Industry	111.80	1.90	25.42	20.97	160.09
Transport	–	1.25	73.99	1.22	76.46
Residential	–	2.61	23.46	14.71	40.78
Commercial	–	1.05	1.24	5.62	7.92
Other energy uses	4.33	0.84	6.35	3.55	15.07
Non-energy uses	–	11.24	19.66	–	30.90

Source CEA (2013a); MoC (2012); MoPNG (2012b)

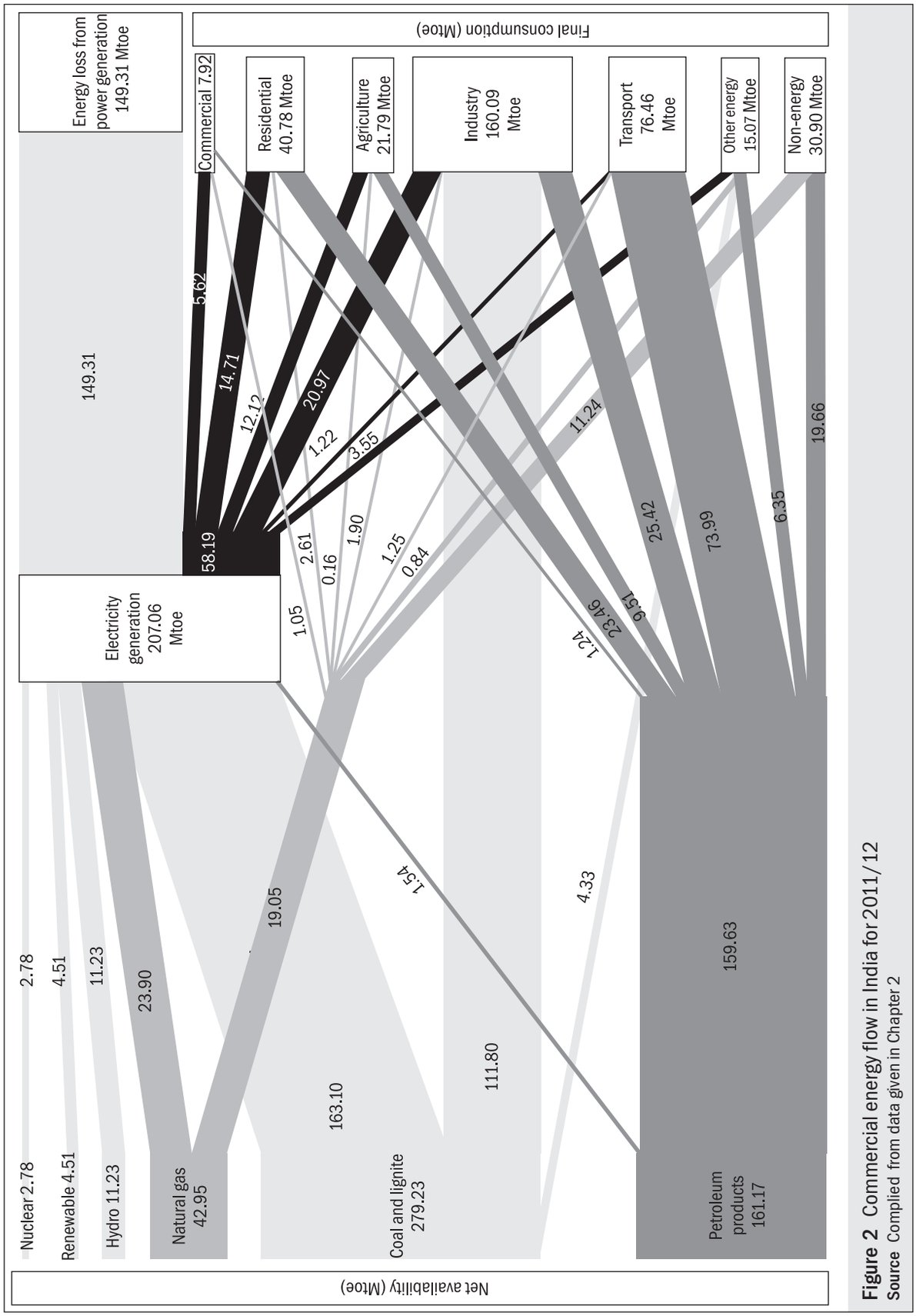

Figure 2 Commercial energy flow in India for 2011/12
Source Complied from data given in Chapter 2

the end of the Eleventh Five-year Plan (CCO 2014). Coal has been the dominant source of primary energy in India, and its share in the energy supply mix is expected to go up to 50% by 2031. Out of the total power generation capacity in India (projected to be at 821 GW in 2031), the share of coal is estimated to be 62% in 2031 (TERI 2015).

In an important development regarding coal pricing, the Cabinet Committee of Economic Affairs (CCEA) approved the proposed pass-through mechanism in June 2013, allowing the power producers to transfer the higher cost of imported coal to consumers contrary to the previous planned price-pooling mechanism. Other topics including pilferage and theft of coal, environmental and socio-economic challenges associated with coal mine exploration, and increase in clean energy cess have been discussed in Chapter 3.

Petroleum and natural gas

The production of crude oil witnessed a marginal decline of 0.26% from 38.8 MT in 2012/13 to 37.7 MT in 2013/14 (MoPNG 2014a). Production has also declined at the onshore and offshore fields of the Oil and Natural Gas Corporation (ONGC) and the Oil India Ltd (OIL), as well as private offshore fields. However, starting 2014/15, the ONGC has plans to increase its production by 23% until 2019/20. India imported 189.2 MT of crude oil in 2013/14, constituting 83% of its total domestic supply of crude oil for this year (MoPNG 2014b; TERI 2014).

While India is a net importer of crude oil, it is also one of the largest exporters of petroleum products in the world. Since 2001, India has been a net exporter of petroleum products (EIA 2014), and with a total capacity of 215.07 MT per annum in 2013/14, India continues to have the third largest refining capacity in Asia after China and Japan.

The production of petroleum products increased from 217.82 MT in 2012/13 to 220.19 MT in 2013/14. The total consumption of petroleum products rose only marginally from 157.1 MT in 2012/13 to 158.4 MT in 2013/14. Natural gas production in India declined for the fourth consecutive year, with production at 35.4 BCM (billion cubic metres) in 2013/14, as against 40.68 BCM in 2012/13. India was the fourth largest liquefied natural gas (LNG) importer in 2013, with a share of 6% in the global imports (EIA 2014).

Chapter 4 discusses topics on pricing of petroleum products, natural gas imports, natural gas pricing, and LNG terminals. The chapter also discusses unconventional fossil fuels and associated gas flaring.

Power

Until 31 March 2013, the total installed capacity of the power sector in India was 243 GW, representing an increase of about 8.96% compared to the previous year. With thermal power having the largest share (82%) of the total installed capacity (excluding renewables), nearly 86% of the total thermal installed capacity in the country is accrued to coal. The installed capacity of captive generation has increased over the past few years. In the case of captive plants of 1 MW capacity, the installed capacity has risen from 34 444 MW in 2010/11 to 39 375 MW in 2011/12 (CEA 2014a, 2014b).

The electricity generated from captive generating units was 134 billion units (BU) during 2013/14 compared to 120 BU during 2010/11. Here again, coal accounts for the major share (78%) of the total electricity generation from captive plants, followed by gas, diesel, wind, and hydropower (CEA 2014c). India has an extensive network for the transmission and distribution of power. About 3 652 528 circuit km of lines operate at different voltages, and the length of distribution lines up to 500 V is 5 073 564 circuit km. The transmission and distribution lines have grown by 4% during 2011/12 (CEA 2013b). The electricity lost in transformation, transmission, and distribution system, including unaccounted electricity, was around 208 BU, which was 23.65% of the total available electricity (CEA 2013c). For 2011/12, the all-India energy sales were 785 BU. The industrial sector has been the highest consumer, accounting for 55% of the total electricity sold by utilities; this is followed by the domestic (22%) and agriculture (18%) sectors (CEA 2014d). While there has been improvement in power supply position, the Indian power sector continues to face energy and peak shortages. Other topics including policies, programmes and regulations, and the power sector reforms have been discussed in Chapter 5.

Renewable energy sources

Out of the total installed power generation capacity, the share of renewables is around 14%. For 2011/12, the total gross (on-grid) renewable energy generation was about 51 226 million units (MU) or around 5.52% of the total generation of 928 113 MU (CEA 2012). The

off-grid applications of renewable energy systems in India include biomass gasification, biogas technology, solar photovoltaic, solar cooking, solar industrial process heat and steam-generating systems, and solar air heating. The main grid-connected renewable energy technologies include biomass gasification, biomass cogeneration with and without bagasse, onshore wind energy, grid-connected solar photovoltaic, solar thermal and small hydropower plants.

So far the largest renewable energy system in India is that of wind power, reaching 21 996 MW of installation. Also India is ranked fourth in the world for its wind power installations (REN21 2014). During 2012/13, the installed capacity of solar power stood at 2765 MW, which was a significant increase from the previous year.[6] Government of India has announced plans for attracting investments worth $100 billion in the renewable energy sector over the next few years, along with the proposed revision of the National Solar Mission targets to 100 GW, compared to the previous target of 22 GW, by 2022.[7] The National Wind Energy Mission is expected to be launched soon, and the government has announced the target to double the installed wind power capacity to 40 GW by 2019.

India has seen a fairly good growth in renewable energy due to supportive government policies, rising costs of conventional energy, reduction in costs of renewable energy technology, and economies of scale in manufacturing. The status and potential of several renewable energy technologies in India are discussed in Chapter 6.

Nuclear power

India has a booming and largely indigenous nuclear power programme and is expected to have 14 600 MWe of nuclear capacity in place by 2020. The country aims to supply 25% of electricity from nuclear power by 2050.[8] In the past, India's capacity to generate atomic energy was limited due to the lack of domestic uranium and difficulty in obtaining international uranium fuel because of restrictions imposed by the Nuclear Suppliers Group (NSG). However, with the withdrawal of these restrictions, faster expansion in nuclear generation capacity is expected.[9] The availability of foreign technology and fuels is expected to benefit India's nuclear power expansion plans. With its expertise in fast reactors and thorium fuel cycle, India has a vision of becoming a world leader in nuclear technology.

During 2012/13, nuclear energy contributed 34 BU to the total power generation (CEA 2014c). About 40% of the nuclear capacity (until December 2014) is operated on imported uranium, and the remaining is met by indigenous uranium, which operates below capacity. The gross generation of nuclear power in India during 2014/15 stands at 24 160 MU, with an average capacity factor[10] of 82% and an availability factor[11] of 90%. With about 50 nuclear units across the various nuclear plants, the installed capacity of nuclear power in India was 4780 MW during 2013/14 (NPCIL 2014). This was 1.96% of the total installed capacity of 243 000 MW (CEA 2014a, 2014b). There have been recent developments in the operationalization of the nuclear deal between India and the USA. While the two countries are working towards developing a fine print of the deal set in the direction of commercial cooperation, India still has to ratify the International Atomic Energy Agency's Convention on Supplementary Compensation for Nuclear Damage (CSC) and stand by the principle that plant operators should bear primary liability in the event of a nuclear disaster.[12]

Hydropower

In India, hydropower projects are usually categorized into two segments: small hydro and large hydro. Hydro projects up to 25 MW capacity are categorized as small hydropower (SHP) projects. The Ministry of Power is responsible for large hydro projects (above the station capacity of 25 MW), and the mandate for the subject of small hydropower (up to 25 MW) lies with the Ministry of New and Renewable Energy. Power generated from large hydro is expected to play an important role in supplementing conventional power

[6] Details available at <http://mnre.gov.in/> http://www.cea.nic.in/>
[7] Details available at <http://www.pv-tech.org/news/india_to_boost_national_target_to_100gw_by_2022>
[8] World Nuclear Association, details available at <http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/India/>
[9] Planning Commission, details available at <http://planningcommission.nic.in/plans/mta/11th_mta/chapterwise/chap15_energy.pdf>
[10] Ratio of a plant's actual output over a period of time to its potential output
[11] Ratio of the amount of time a plant produces electricity over a certain period to the amount of the time in the period
[12] Details available at <http://timesofindia.indiatimes.com/india/US-India-nuclear-breakthrough-could-be-finalised-within-a-year/articleshow/46104733.cms>

generation and meeting energy needs, especially for regions with good hydro potential.

Hydropower[13] constitutes 40 531 MW or 16.67% of the total installed capacity of utilities in India (CEA 2013a). During 2012/13, hydropower contributed 134 BU of electricity to the total power generation (CEA 2014c). The share of hydro in the captive generation declined from 57 MW to 48 MW (CEA 2012). As against the all-India target of 10 897 MW under the Twelfth Five-year Plan, 1559 MW of hydro capacity was achieved (until March 2014).

Sources of energy demand in India

Agriculture

Agriculture in India occupies a significant position in the country, as it provides livelihood and employment to over 54% of the population (Census of India 2011) and constitutes around 14% of the GDP. The agriculture sector has major implications for the overall demand and supply of energy in India. The share of total electricity consumption by the agriculture sector increased from 81 673 GWh in 2001/02 to 153 116 GWh in 2012/13 (CEA 2014e). Energy use in agriculture at the farm level can be categorized as direct or indirect. Direct energy use in agriculture is in the form of diesel and electricity to operate mobile and stationary equipment/machinery to prepare fields, plant and harvest crops and transport inputs and outputs to and from markets. Indirect energy is consumed off the farm for the manufacture of inputs such as fertilizers and pesticides.

There has been an increase in the consumption of high-speed diesel (HSD) in the agriculture sector in India since the sale of tractors and agricultural machinery and implements has increased with the joint effort of the government and the private sector. The sector is a major consumer of diesel in India; it accounted for 13% of the total consumption in 2012/13. Other topics such as water efficiency in agriculture and agriculture planning are discussed in Chapter 7.

Industry

The Index of Industrial Production (IIP) has been fluctuating over the last few years. Industrial growth peaked at 15.5% in 2007/08 (manufacturing growth rate was 18.4%) and then declined to 2.5% in 2008/09; however, it recovered and further improved to 8.2% in 2010/11. The industrial growth decelerated to 1.1% in 2012/13, and during April–March 2013/14, it again moderated and recorded a negative growth of −0.1% in comparison to the corresponding period of the previous year. The specific energy consumption (SEC) in 2013 for primary aluminium production for the Asia region, excluding China, was 14 749 KWh alternating current per tonne, as compared to the world average of 14 555 KWh. There is a large scope for improving energy efficiency in aluminium production.

The steel sector constitutes nearly 2% of India's GDP; India is the fourth largest producer of crude steel and the largest producer of direct reduced iron or sponge iron in the world. The crude steel production grew at a compound annual growth rate (CAGR) of 7% during the last five years ending 2013/14. The SEC of Indian steel-making units is more than that of Japan (between 4.3 and 6.0 GJ per tonne of crude steel) and Korea (between 4.5 and 4.7 GJ per tonne of crude steel).

Fertilizer production consumes approximately 1.2% of the world's total energy on an annual basis. The Indian fertilizer industry is comparable to the best in the world in terms of efficiency, capacity utilization, energy consumption, and utilities such as power and water. The new fertilizer plants are comparable to the best in the world and have been able to bring down the energy consumption in urea production from about 9% in 1987/88 to 6.24% in 2010/11 (MoCF 2011). The textile industry is also energy intensive, where the wet processing or dyeing operation consumes almost 50% of the energy. Boilers and spinning plants consume most of the energy in the textiles industry. With effective energy conservation measures, there is a large scope for saving energy in the textile mills.

Energy cost accounts for 35%–45% of the production cost in a cement plant; this makes the

[13] In this context, hydropower means power generated from large hydro projects.

cement industry energy intensive. The average electrical energy consumption is about 80 kWh per tonne of cement. The best values for thermal and electrical energy consumption currently achieved by the Indian cement industry are about 667 kcal/kg clinker and 67 kWh/tonne cement, which are comparable to the best reported figures of 660 kcal/kg clinker and 65 kWh/tonne cement in a developed country such as Japan. For the chlor-alkali industry, the average operating SEC has declined from 3351 kWh/tonne in 1990/91 to 2350 kWh/tonne in 2009/10 (SSEF 2013).

The pulp and paper industry is also highly energy intensive, where energy cost accounts for about 16%–25% of the cost of production of paper. With the adoption of energy conservation measures such as delignification process in pulping and the use of pressure screens instead of centrifugal screens, the Indian pulp and paper industry can achieve better energy efficiency. The energy conservation measures for large industries (aluminium, iron and steel, fertilizer, textile, cement, chlor-alkali, and pulp and paper, as well as micro, small, and medium enterprises) and various policy measures have been discussed in Chapter 8.

Transport

India's transport system is one of the world's largest, serving the land area of 3.3 million km^2 and a population of over 1.21 billion (Census of India 2011). The transport sector's contribution to the country's GDP in 1999/2000 was 5.7%, which further increased to 6.6% in 2010/11.[14] The transport sector is also a key energy consuming sector; it consumed 34.24% of the total volume of petroleum products used in India during 2009/10 (MoPNG 2012a). Of all the products consumed within the sector, HSD consumption was the maximum. Out of the total consumption of 56.32 MT of HSD in India during 2009/10, the transport sector's consumption was 59.1% (33.74 MT) (MoPNG 2012a).

India's road network of 3.33 million km is the second largest in the world. The number of registered motor vehicles in India has grown with a CAGR of 10.5% from 2002 to 2012 (MoRTH 2014). Within the transport sector, the road sector is the largest consumer of energy from petroleum products. The sector now accounts for the largest share (72%) of HSD consumption in India (MoPNG 2012a). The Indian Railways is one of the largest rail networks in the world, with a network of 65 436 route km and a running track length of 89 236 km (MoR 2014). Rail transport is six times more energy efficient and four times more economical than road transport. The consumption of HSD on locomotive services decreased from 2705.1 million L in 2011/12 to 2699.6 million L in 2012/13 (MoR 2014). Direct consumption of coal by the railways is almost negligible after the phasing out of steam locomotives. The Indian Railways has been striving to bring environment-friendly initiatives and save fuel over the years.

Maritime transport handles over 90% of the volume and 70% by value of India's trade. During 2011/12, the shipping sector consumed 0.54 MT of HSD, 0.002 MT of light diesel oil (LDO), and 0.37 MT of furnace oil. Other topics such as energy consumption trends in the various transport sectors and the key legislations and regulations in the sector have been covered in detail in Chapter 9.

Household energy

Over 1200 million people worldwide lack access to affordable basic energy services, such as effective lighting and clean cooking. The challenge to energy access has received global attention, and a High-Level Group on Sustainable Energy for All (SE4ALL) has been formed to address the pressing issues and acts in support of the Decade of Sustainable Energy for All (2014–24). India is home to over 300 million people deprived of electricity, and more than 750 million people depend on solid biomass as fuel for cooking (IEA 2013a). The total residential consumption of energy in thousand tonnes of oil equivalent on a net calorific value basis during 2012 was 182 020 (IEA 2013b). The two major uses of energy at the household level in India are lighting and cooking. In 2001 more than 55.6% of rural households used kerosene as the primary energy source for lighting, which declined to 43.2% in 2011. In urban India also, households using kerosene show a declining trend in percentage terms. While 92.7% of urban households depended on electricity as the primary energy source for lighting during 2011, electrification for rural households was 55.3% in 2011 as against 43.6% in 2001. These are

[14] Details available at < http://indiabudget.nic.in/es2011-12/echap-10.pdf>

the houses using electricity as their primary energy source for lighting (Census of India 2011). At an all-India level, Bihar has the highest percentage (82.4%) of households dependent on kerosene as the primary energy source for lighting.

In India, 67.4% of households depend on solid biomass (firewood, crop residue, cow dung cake, coal, lignite, and charcoal) as the fuel for cooking (Census of India 2011). More than 31% of households lack the access to proper kitchen and cook inside the house; this exposes women and children to health risks. The domestic sector accounted for 22% of the total electricity from utilities during 2012/13 (MoSPI 2013). Other topics such as household level monthly consumption of energy, household energy consumption pattern across monthly per capita expenditure (MPCE) classes, and policies, programmes, and regulations for modern energy access in households are discussed in Chapter 10.

Commercial sector

Energy consumption by commercial sector in India witnessed growth from 11 Mtoe in 2006/07 to 16 Mtoe in 2011/12 with the electricity consumption in the building sector increasing at an average growth rate of 9% from 2001 to 2011 (TERI 2015). India doubled its floor area of building from 2001 to 2005 and would have added about 35 billion m^2 of new building floor area by 2050. The total commercial floor space in India, as on 2010, was approximately 659 million m^2 (International Resource Group 2010). Moreover, with increase in income and possible changes in living standards, there are possibilities that electricity and energy consumptions in households will also increase.

Energy consumption across commercial sector in India for 2009/10 was 7.92 Mtoe. Energy Conservation Building Code (ECBC) was launched in May 2007 and is in vogue on voluntary basis. Energy audits indicate energy saving potential from 23% to 46% in end-uses in buildings (BEE n.d.).

Environment

Economic development in India has been accompanied by degradation of natural resources; also the growing urbanization is exerting incredible pressure on the local environment. As India grows, finding a solution to local and global environmental issues becomes a priority. In India, ambient air pollution has been identified as the fifth biggest cause of mortality (Atkinson, Cohen, Mehta, *et al.* 2011). Respirable particulate matter (RSPM) is of prime concern as it exceeds the ambient air quality standards at many locations in India. The data collected on air quality in India show that particulate matter is a pollutant of major concern at the national level. The Lancet's Global Health Burden 2013 report termed air pollution the sixth biggest human killer in India.

Groundwater is becoming a crucial issue since it meets 50% of the water requirements for urban and industrial activities. Under the National Water Quality Monitoring Programme, there are 2500 water quality monitoring stations spread across the country. Considering the fact that almost 70% of India's surface water resources are contaminated by biological, toxic, organic, and inorganic pollutants (MoEF 2009), water management is emerging as a key area the government should look into.

With the urban population increasing from 27.81% in 2001 to 31.16% in 2011 (Census of India 2001, 2011), the amount of solid waste generated has also increased. "Management of municipal solid waste (MSW) is a major challenge being faced by cities and towns. According to report released by Ministry of Urban Development (MoUD) in May 2000, the quantity of MSW generated in India stands at 100 000 MT per day (CPCB 2012)."

Moreover, as of February 2009, there were about 36 165 hazardous waste generating industries, producing about 6.2 MT of hazardous wastes every year. India is among the few countries that have developed a biogeographic classification for conservation planning and mapped biodiversity-rich areas in the country. Forest cover of India has increased by 5871 km^2 since 2011 (FSI 2014). For further details on the state of environment and various interventions that are in practice in India, see Chapter 11.

Climate change is believed to be unequivocal and essentially driven by anthropogenic factors, as has been indicated in the Fifth Assessment Report of the IPCC. Both minimum and maximum temperatures have been steadily rising over large parts of India, and

rate of rise in minimum temperatures has exceeded that of the maximum temperatures (IMD 2012). All-India maximum and minimum temperatures have shown an increase by, respectively, 0.71°C and 0.27°C per 100 years for the analysis period of 1901 to 2007 (INCCA 2010). All-India monsoon rainfall series based on 1871–2009 indicates that the mean rainfall is 848 mm with a standard deviation of 83 mm. India's CO_2 emissions have increased over last year mainly due to emissions from the energy sector.

In India, the National Action Plan on Climate Change and the State Action Plan on Climate Change are policy frameworks aimed at enhancing the current and planned programmes and translating policy into action. On 5 November 2014, the government reconstituted the Prime Minister's Council on Climate Change; this council will formulate and coordinate the National Action Plan for Assessment, Adaptation and Mitigation of Climate Change. Other topics such as observed climate trends, greenhouse gas emission trends, and the government's responses to address climate change are discussed in Chapter 12.

Energy and environment goals

The United Nations Open Working Group (OWG)[15] for Sustainable Development Goals (SDGs) submitted its proposal for the SDGs for consideration at the 68th session of the General Assembly of the United Nations. The General Assembly recognized the OWG proposal as a key basis for integrating the SDGs into the future development agenda. The OWG proposed 17 goals, including energy and environment-related goals. Chapter 13 discusses the progress achieved towards the sustainable development goals in key thematic areas.

Chapter 14 discusses methods for developing a tracking framework for energy goals based on the proposed SDGs by the OWG–Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all. Regarding the three energy sub-goals, data from various agencies at the global, national (India), and state levels (in India) are reported and analysed.

The current status on sustainable development reflects the need for concerted efforts as well as the need to track the progress of outcomes at the global, national, and sub-national levels.

[15] In January 2013, the United Nations General Assembly established the Open Working Group to steer the formulation of the proposal on SDGs. With its co-chairs elected, the group has adopted methods and programme and conducted several sessions on the various themes identified in the Rio+20 outcome document.

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