ENERGY AND ENVIRONMENT: AN OVERVIEW

1

Introduction

India occupies 2.4% of the world's land and supports 16% of the world's population. India's economic growth has exceeded 7% a year for almost a decade. However, the high gross domestic product (GDP) growth has not come without a cost. Although India has brought many benefits through rapid economic growth in the past decade but the environment has suffered. It has led to a degraded environment with issues like air and water pollution.

One of the fundamental principles on which the notion of sustainable development rests is that human development will occur when all humans have fulfilling lives without degrading the planet (GFN 2011). On the other hand, environmental sustainability outcomes require that basic development needs of a nation are fulfilled; this in academic circles is discussed through Environment Kuznet's curve. It, thus, becomes important to simultaneously discuss human development and environmental sustainability (see Gandhi [1972]).

India's human development index (HDI) value for 2012 was 0.554, placing the country in the medium human development category, and positioning it at 136 out of 187 countries and territories. Between 1980 and 2012, India's HDI value increased from 0.345 to 0.554, which is an increase of 61% or an average annual increase of about 1.5%. When India's HDI is compared in the BRICS (Brazil, Russia, India, China, and South Africa) and its sub-group IBSA (India, Brazil, and South Africa), it is observed that the performance of India's HDI and HDI components is behind that of other countries (Table 1). GFN (2011) finds that most countries today do not meet the minimum requirements of having achieved a high HDI and a low ecological footprint.

There is a strong correlation presented between the UN HDI and per capita energy consumption where a strong relationship is observed between index values and energy consumption for the majority of the world (Martínez and Ebenhack 2008). The International Energy Agency (IEA) has developed energy development index (EDI) in order to better understand the role that energy plays in human development. EDI is an indicator that tracks progress in a country's or region's transition to the use of modern fuels and helps to measure energy poverty. It comprises indicators including per capita commercial energy consumption, per capita electricity consumption in the residential sector, share of modern fuels in the total residential sector energy use, and share of population with access to electricity, modern energy use for public

Table 1 India's HDI indicators for 2012 relative to countries from the BRICS and IBSA groups

	HDI value	HDI rank	Life expect-ancy at birth (years)	Expected years of schooling (years)	Mean years of schooling (years)	GNI per capita (2005 PPP, $)
Brazil	0.73	85	73.8	14.2	7.2	10 152
China	0.699	101	73.7	11.7	7.5	7 945
India	0.554	136	65.8	10.7	4.4	3 285
Russian Federation	0.788	55	69.1	14.3	11.7	14 461
South Africa	0.629	121	53.4	13.1	8.5	9 594
BRICS	0.655	–	69.8	11.5	6.6	6 476
IBSA	0.588	–	66.4	11.2	5	4 401

Source Details available at http://hdr.undp.org/sites/default/files/Country-Profiles/IND.pdf; last accessed on 12 February 2014

Table 2 Energy Development Index 2010 for India, China, Brazil and South Africa (normalized variables)

Country	Rank	EDI	Household-level energy access					Community-level energy access		
			Access to electricity indicator			Access to clean cooking facilities indicator	Household-level indicator	Public services	Productive use	Community-level indicator
			Electri-fication rate	Per-capita residential electricity consumption	Electricity access indicator	Share of modern fuels in residential total final consumption		Per-capita public services electricity consumption	Share of economic energy uses in total final consumption	
India	41	0.30	0.75	0.11	0.29	0.14	0.22	0.06	0.69	0.38
China	26	0.49	1.00	0.33	0.57	0.19	0.38	0.34	0.85	0.60
South Africa	14	0.65	0.76	0.72	0.74	0.04	0.39	0.97	0.84	0.91
Brazil	11	0.68	0.99	0.48	0.69	0.46	0.57	0.59	0.99	0.79

Source IEA (2012)

services (e.g. schools, hospitals and clinics, water and sanitation, street lighting), and energy for productive use, which deals with modern energy use as part of the economic activity (e.g. agriculture and manufacturing). EDI developed for 2010 for India, China, Brazil, and South Africa is discussed in Table 2. India is positioned at 41 among the 80 countries ranked by IEA in 2012.

Energy sector

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 depicted in Table 3.

Table 3 Final commercial energy consumption (in MTOE) in India by sector

Sector	1980/81	1985/86	1990/91	1995/96	2000/01	2005/06	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%)
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%)
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%)
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%)
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)
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%)
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%)

Note Figures in parentheses indicate the percentage share of each sector
Sources TERI (Various years); CEA (2011); MoPNG (2011); MoP (2012)

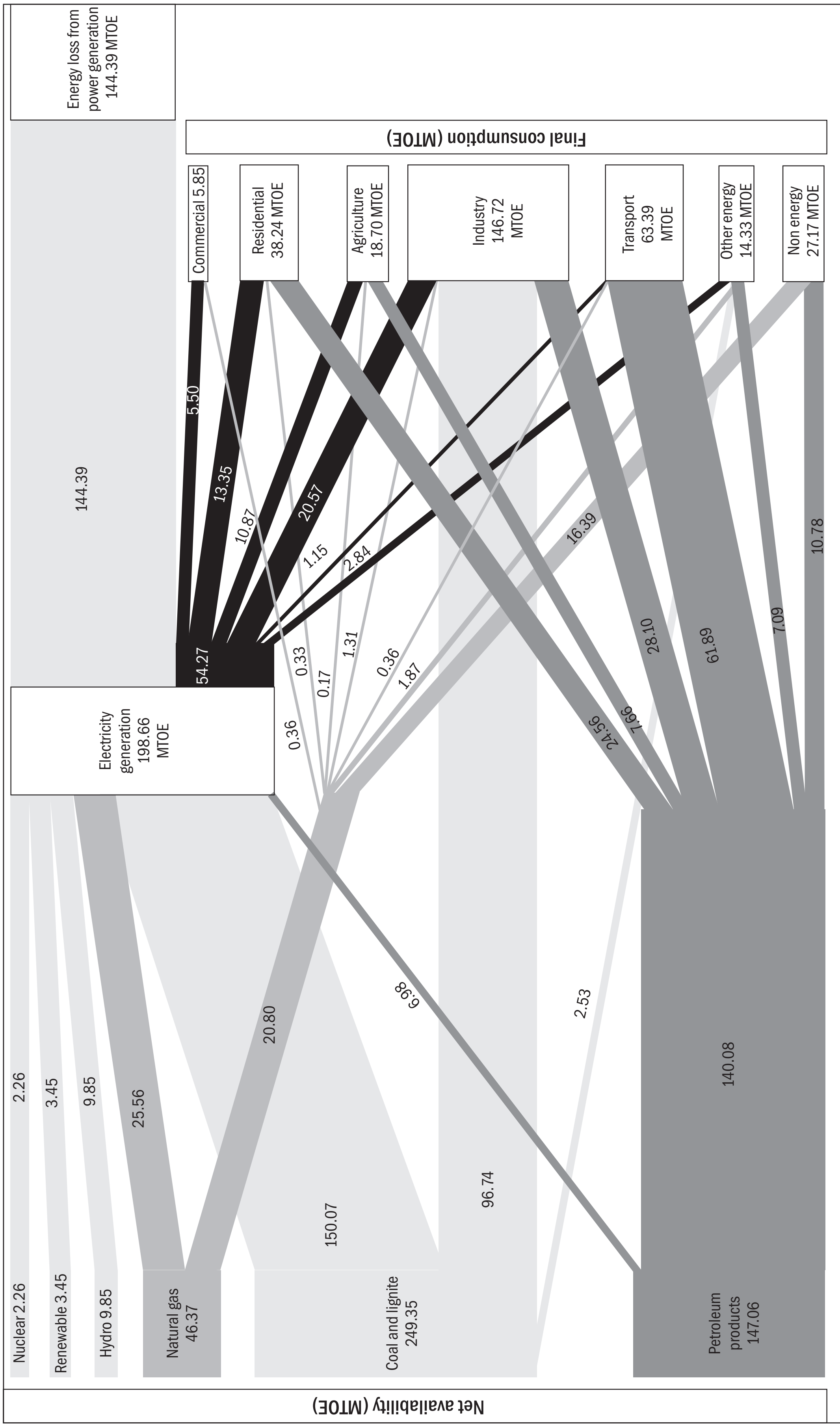


Figure 1 Commercial energy flow in India for 2010/11

Source Compiled from data given in Chapter 3

Commercial energy flow in India: explanation for the Sankey diagram (Figure 1)

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	42.75
+ Imports	8.86
– LPG extraction from natural gas	2.53
– Flaring of natural gas	0.87
– Petroleum refining	2.90
– Own use	1.63
Net availability of natural gas	46.37

The data has been sourced from Indian Petroleum and Natural Gas Statistics 2010–11 published by the Ministry of Petroleum and Natural Gas.

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 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	212.82
+ Imports of coal	44.79
– Exports of coal	2.64
+ Stock changes	–2.82
– Own use[1]	0.16
– Coal washery rejects	2.64
Net availability of coal and lignite	249.35

The data has been sourced from the Coal Directory of India 2010–11 published by the Ministry of Coal

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

Table C Formula for estimating net availability of crude oil

Crude throughput	206.15
– Refinery boiler fuel	15.87
+ Imports of petroleum products	18.14
– Exports of petroleum products	68.07
+ LPG extracted from natural gas	2.45
Net availability of petroleum products[2]	**142.80**

The data has been sourced from Indian Petroleum and Natural Gas Statistics 2010–11 published by the Ministry of Petroleum and Natural Gas.

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

[1] Own use refers to the amount of coal consumed in collieries for their own consumption
[2] The net availability of petroleum products comes to be 147.06 MTOE with reference with Sankey diagram in Figure 1. However, the availability of petroleum products here is calculated to be 142.80 MTOE. The difference in the two values is accrued to refinery losses.

Table D Calculation of energy loss from generation	
Conversion losses in power generation	123.19
+ Auxiliary consumption in power stations	4.47
+ Transmission and distribution losses	16.73
Total energy loss from power generation	144.39

Final consumption of electricity across commercial, residential, agriculture, industry, transport, other energy and non-energy sectors is equal to 54.27 MTOE. The data has been sourced from CEA General Review 2012.

5. Net availability of nuclear, renewable, and hydro power sources indicates the power generation that takes place using these. The generation of electricity through nuclear, renewable, and hydro sources of energy is 2.26, 3.45, and 9.85 MTOE, respectively. The data has been sourced from CEA General Review 2012.
6. Final consumption refers to the energy available for the final demand sectors—residential, commercial, agriculture, industry, transport, other energy and non-energy sectors. Table 1 shows the calculation for the estimation of final energy consumption for each of these six sectors. Final energy consumption is the sum of consumption of coal and lignite, natural gas, petroleum products and electricity consumption. The data has been sourced from CEA General Review 2012, Coal Directory 2010–11 Coal Directory of India 2010/11 and Indian Petroleum and Natural Gas Statistics 2010–11.
   The final energy consumption across various sectors in India for the year 2009/10 has been explained in Table E.

Table E Final energy consumption across various sectors in India

Sector	Coal and lignite	Natural gas	Petroleum products	Electricity/power	Final consumption
Agriculture	–	0.17	7.66	10.87	18.70
Industry	96.74	1.31	28.10	20.57	146.72
Transport	–	0.36	61.89	1.15	63.39
Residential	–	0.33	24.56	13.35	38.24
Commercial	–	0.36	0.00	5.50	5.85
Other energy uses	2.53	1.87	7.09	2.84	14.33
Non-energy uses	–	16.39	10.78	–	27.17

Sources of energy supply in India

Coal and lignite

Coal has been the dominant source of primary energy in India, accounting for more than 50% of the total energy consumed in the country; and it is projected to further increase to 57% in 2021–22 (Planning Commission 2014). According to provisional estimates by 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. As on April 2013, the gross geological resources of coal are estimated at 298914 MT. Out of this, 41% constitute proved reserves, and the rest 59% are in the category of indicated and inferred resources.

Domestic production of coal and lignite accounted for two-third of the total production of commercial energy in 2000–01 and is projected to be around the same figure in 2021/22. The share of coal and lignite was 50% in the total consumption of commercial energy in 2000–01; this has been projected to increase to 57% in 2021–22. Much of this increase would come from the power sector. The state, central, and private power utilities are the biggest consumers of coal with 512 MT of estimated coal consumption in 2012–13 (CCO 2013). The growing coal shortages pose serious challenges with respect to sustainability and have hampered the sector's development.

The consumption and usage of coal continue to exert adverse impacts on the environment and ecology. There are also various socio-economic challenges like displacement and loss of livelihoods associated with coal mining. Other issues related to the coal sector include health and safety, and policy and regulatory issues; all of which have been discussed in detail in Chapter 4.

Petroleum and natural gas

Production of crude oil declined marginally by 0.7% from 38.08 MT in 2011/12 to 37.86 MT in 2012/13 (MoPNG 2013). Primarily, the reason for this shortfall was the steady decline in the production levels of the Oil and Natural Gas Corporation (ONGC) and the Oil India Limited (OIL). India's overall crude imports increased by 7.6% in 2012/13[3] and about two-thirds of the imports were from Middle East alone. Saudi Arabia and Iraq together accounted for a third of India's total oil imports.[4] The crude import bill for India was $144 billion during the fiscal year 2012/13; forming the largest part of its overall import costs. After depreciation of rupee, India faced an oil bill which was 50% higher than 2012–13; to resolve this issue the Ministry of Petroleum and Natural Gas (MoPNG) undertook several measures to cut the country's oil cost.

With a total refining capacity of 4.3 million barrels per day, India became the third largest refiner of crude oil in Asia at the end of 2012, only after China and Japan.[5] With the increase in refining capacity, the total production of petroleum products also went up in 2012/13 by almost 14 MT as compared to the previous year. In absolute terms, the largest increase in production of nearly 3 MT has been registered for the production of motor spirit. During 2012/13, the total consumption of petroleum products recorded an increase of 5% and most of this increase has been due to rise in diesel consumption by almost 5 MT. Consumption of petrol also increased from 14.99 MT to 15.74 MT as compared to the previous year. There has been a fall of 14% in the natural gas production and the production was estimated to be 40.68 BCM for 2012/13.[6] Even though share of Oil and Natural Gas Corporation (ONGC) and Oil India Limited (OIL) has been maintained at around 25 BCM every year; the decrease in production by private and joint venture companies is responsible for this decline. India ranks number six for its LNG imports and has about 5.3% share in the global imports.[7] The recommendations of the Rangarajan Committee on the subject of gas pricing has have been approved by the Cabinet Committee on Economic Affairs and shall be put in implementation in April 2014. Other topics including the potential of shale gas and a discussion on unconventional fuels in India have been discussed in detail in Chapter 5.

Power

As on 31 March 2013, the total installed capacity of the power sector in India was 223 344 megawatt (MW); representing an increase of 11.75% as compared to previous year. With thermal power having the largest share of 68% in the total installed capacity; nearly 85% of the total thermal installed capacity in the country is accrued to coal. The installed capacity of captive generation has increased over past few years. In the case of captive plants of 1 MW capacity, the installed capacity has risen from 31 517 MW in 2010/11 to 344 444 MW in 2009/10; registering a growth of 9.25% (CEA 2012b).

The electricity generated from captive generating units was 120 BU during 2010/11 as compared to 106 BU during 2009/10. Here again, coal accounts for a major share of 80% in the total electricity generation from captive plants; followed by gas, diesel, wind, and hydropower (CEA 2012c). India has an extensive network of transmission and distribution of power. About 3 506 730 circuit km of lines operate at different voltages and the length of distribution lines upto 500 volt (V) is 4 858 571 circuit km. The transmission and distribution lines have grown by 7.2% during 2010/11. The electricity lost in transformation, transmission, and distribution system, including unaccounted electricity, was around 194 BU, which was 23.97% of the total available electricity (CEA 2012d). For 2010/11, the all-India energy sales were 617 billion units (BU). The industrial sector has been the highest consumer, accounting for 36.5% of the total electricity sold by utilities; this is followed by domestic sector (25%) and agriculture (20.5%).

While there has been improvement in power supply position, the Indian power sector continues

[3] Details available at <www.ppac.org.in>
[4] US Energy Information Administration—India Energy Report (March 2013)
[5] US Energy Information Administration—India Energy Report (March 2013)
[6] Details available at <www.ppac.org.in>
[7] Energy Information Administration—India Analysis (18 March 2013)

to face energy and peak shortages. Further, the requirement for electrical energy is projected to increase by 8.5% during the Twelfth Five-Year Plan period (MoP 2012). Other topics including policies, programmes, and regulations in power sector and power sector reforms are discussed in detail in Chapter 6.

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 or around 5.52% of the total generation of 928 113 million units (TERI compilation). 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 renewable energy technologies that are grid connected include biomass gasification, bagasse-based biomass cogeneration, non-bagasse-based biomass cogeneration, 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 19 565 MW of installation. Also, globally India is ranked fifth for its wind installations. During 2012, 980 MW of solar capacity was installed, which was a significant increase from the previous year. It is estimated that during 2012–17, India's renewable energy would require an investment of around $50 billion. Phase II of Jawaharlal Nehru National Solar Mission for 2013–17 commenced in April 2013 and it targets 10 gigawatt (GW) utility-scale and 1 GW off-grid solar power projects (MNRE 2013). India has seen a fairly good growth in renewable energy due to supportive government policies, rising costs of conventional energy, reductions in renewable energy technology costs, and economies of scale in manufacturing. The status and potential of various several renewable energy technologies in the context of India are discussed in detail in Chapter 7.

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, the expansion in capacity of atomic energy in India has been limited due to the lack of availability of domestic uranium and difficulty in obtaining international supply of uranium fuel because of restrictions imposed by the Nuclear Suppliers Group (NSG). However, now these restrictions have been lifted and faster expansion in nuclear generation capacity is expected.[9] Availability of foreign technology and fuels are expected to benefit India's nuclear power expansion plans majorly. With its expertise in fast reactors and thorium fuel cycle, India has a vision of becoming a world leader in nuclear technology.

The installed capacity of nuclear power in India is 4780 MW, which is 2.1% of the total installed capacity (CEA 2013a). During 2012/13, nuclear contributed 32 BU in the total power generation (CEA 2013b). The total target for capacity addition for the Twelfth Five-Year plan for nuclear power is set at 5300 MW—all of this is planned for power generation in the central sector only (Planning Commission 2012).

Hydro power

In India, hydro power projects are usually categorized in two segments, that is, small and large. The hydro projects up to 25 MW station capacities have been categorized as small hydro power (SHP) projects. It is the Ministry of Power which is responsible for large hydro projects (above the station capacities of 25 MW); and the mandate for the subject small hydro power (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 generation and meeting energy needs especially for regions with good hydro potential.

Hydro power[10] constitutes 39 491 MW or 17.7% of the total installed capacity of utilities

[8] Details available at <http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/India/>
[9] Details available at <http://planningcommission.nic.in/plans/mta/11th_mta/chapterwise/chap15_energy.pdf>
[10] In this context, hydro power means power generated from large hydro projects.

in India (CEA 2013a). Hydro power contributed 113 BU of electricity in the total power generation for 2012/13 (CEA 2013b). The share of hydro in the captive generation is a miniscule of 0.12% (CEA 2012c). Planned capacity addition for hydro in the Twelfth Five-Year Plan is a total of 10 897 MW with 6004 MW for the central sector, 1608 MW for the state sector, and 3285 MW for the private sector. Till June 2013, four projects under the state sector with total installed capacity of 990.60 MW have been completed with an expenditure of 625.7 million—these were planned under the Twelfth Five-Year Plan (CEA 2013c).

Sources of energy demand in India

Agriculture

The share of total electricity consumption in the agriculture sector increased from 81 673 GWh in 2001/02 (which was nearly 25% of the total electricity consumption in that year) to 133 660 GWh in 2011/12—which was 17.3% of the total consumption of electricity during that year (CEA 2013d). It is important to understand the linkages of energy to the agriculture sector. The use of energy in agriculture at the farm level can be categorized as either direct or indirect. Direct energy usage in agriculture is in the form of diesel and electricity which are used for operating stationary and mobile equipment for preparing fields, planting and harvesting of crops, and transportation of inputs and outputs to and from markets. Indirect energy is consumed off the farm for manufacturing of fertilizers and pesticides.

To meet the growing food demand, higher growth in agricultural produce is required; this in turn results in greater energy and groundwater use. Groundwater scarcity is already severe in many parts of the country. Further, the substantial use of diesel and electricity for groundwater extraction, projected to increase in the forthcoming years, poses a problem given the pressure of limited availability of fossil fuel. The energy–water–food nexus has been resulting in groundwater depletion and wasteful use of scarce energy resources in the present agriculture system. The various direct and indirect energy uses in agriculture and water–energy–food nexus are discussed in detail in Chapter 8.

Industry

Index of industrial production, indicative of the industrial performance, has shown a fluctuating trend in the past few years. From 2.5% in 2008/09, it rose to 5.3% in 2009/10 and then to 8.2% in 2010/11. However, it again declined to 2.9% in 2011/12 and 0.7% in 2012/13. The industrial sector is also a major energy consuming sector. The specific energy consumption (SEC) in 2012 for primary aluminium production for the Asia region excluding China was 14 853 KWhAC/tonne, as compared to the world average of 14 637 KWhAC/tonne.[11] There is a large scope for improving energy efficiency in the aluminium production. For the large integrated steel plants in India, the average SEC ranges between 6.09 giga calories per tonne (Gcal/tonne) and 8.17 Gcal/tonne compared to about 4.3 Gcal/tonne in Japan and 4.54 Gcal/tonne in South Korea. 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 quite energy intensive with the wet processing or dyeing operation consuming almost 50% of the energy. Boilers and spinning plants consume major energy in the textiles industry. With effective energy conservation measures, there is a large scope to save energy in the textile mills.

For cement industry, the power consumption was in the range of 115–130 KWh/tonne of cement during 1950/60. Clinker production is the most energy-intensive stage of cement production. However, presently, the Indian cement industry has achieved the best thermal and electrical energy consumption patterns of 663 kcal/kg of clinker and 59 kWh/tonne of cement; these are comparable to the best reported figures of 660 kilo calories per kilogram (Kcal/kg) of clinker and 65 kWh/tonne of cement in Japan, a developed country. For the chlor-alkali industry, the average operating SEC has declined from 2350 kWh/tonne of caustic soda produced in 1990/91 to 2350 kWh/tonne of caustic soda produced in 2009/10 (SSEF 2013).

[11] Details available at <www.world-aluminium.org/statistics/primary-aluminiumsmelting-energy-intensity>

The pulp and paper industry is also highly energy intensive and unusually energy cost accounts for about 16%–25% of the cost of production of paper. With adoption of energy conservation measures like delignification process in pulping and use of pressure screens instead of centrifugal screens, the Indian pulp and paper industry can achieve better energy efficiency. The energy conservation measures for the large industries including aluminium, iron and steel, fertilizer, textile, cement, chlor-alkali and paper and pulp, micro, small, and medium enterprises; and the various policy measures have been discussed in detail in Chapter 9.

Transport

India has one of the largest transport systems in the world, serving a land area of 3.3 million km^2 and a population of over 1.21 billion. The transport sector is also a key energy consuming sector. The transport sector is heavily dependent on petroleum products. In 2009/10, the transport sector consumed 34.24% of the total volume of petroleum products in India (MoPNG 2012). Of all the products consumed within this sector, consumption of high speed diesel (HSD) is the highest. Out of the total consumption of 56.32 MT of HSD in India in 2009/10, the transport sector accounted for 33.74 MT or 59.1% of the total (MoPNG 2012).

Within the transport sector, road sector is the largest consumer of energy from petroleum products. Of the different petroleum products consumed in the road transport sector, HSD accounts for the largest share of 72% (MoPNG 2011, 2012). Rail transportation is considered to be six times more energy efficient and four times more economical than road transportation. For 2011/12, electricity consumed for traction use in railways was 14 157.87 GWh in comparison to 13 571.53 GWh in the previous year. However, the consumption of HSD for locomotive services grew from 2516.0 million litres in 2010/11 to 2705.1 million litres in 2011/12 (MoR 2012). The shipping sector consumed 0.56 MT of HSD, 0.004 MT of light diesel oil (LDO), and 0.78 MT of furnace oil during 2010/11 (MoPNG 2012). Water transport is considered to be one of the most environment friendly and efficient modes of transportation. The aviation sector has experienced phenomenal growth in passenger traffic and has become a high energy consuming sector, with the use of aviation turbine fuel (ATF) in the sector going up from 3.3 MT in 2005/06 to 5.08 MT in 2010/11 (MoPNG 2011). Energy consumption trends in the various transport sectors and the key legislations and regulations in the sector have been covered in detail in Chapter 10.

Domestic

All over the world there are 1200 million people who do not have access to affordable basic energy services, such as effective lighting and clean cooking. India too is home to more than 300 million people who are deprived of electricity and more than 800 million people who are dependent on solid biomass as fuel for cooking (IEA 2013a). During 2011, the total residential consumption in India was about 178 453 thousand tonnes of oil equivalent (KTOE) on a net calorific value basis (IEA 2013b).

The two major uses of energy at the household level in India for basic access are lighting and cooking. In 2001, more than 55.6% of rural households used kerosene as primary energy source for lighting, this declined to 43% in 2011. In urban India also, households using kerosene showed a declining trend in percentage terms. While 92.7% of urban households depend on electricity as primary energy source for lighting during 2011, the electricity access for rural households was 55% in 2011 as against 43.6% in 2001—these are 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 of 82.4% of households dependent on kerosene as primary energy source for lighting.

More than 31% of households in India lack access to proper kitchen and undertake cooking inside the house; this exposes the women and accompanying children to health risks. Also 67.4% of households in the country depend on solid biomass (including firewood, crop residue, cowdung cake, coal, lignite, and charcoal) as fuel for cooking (Census of India 2011). The domestic sector utilized 22% of the total electricity from utilities during 2011–12 (MoSPI 2013). With respect to rural electrification, over 593 700 villages were electrified by end of first year of the Twelfth Five-Year Plan of the Government of India (CEA

2013). Other topics including household-level monthly consumption of energy, household energy consumption pattern across MPCE classes; and policies, programmes, and regulations for modern energy access in households are discussed in detail in Chapter 10.

Environment

In India, issues around local environment such as air pollution, water quality, and inadequate waste management continue to affect a large proportion of the country's population. The Environmental Performance Index (EPI), a metric developed for 132 countries, placed India in the category of "weakest performers" at the 126th position overall and last in the terms of air quality. According to the World Bank report, environmental degradation would cost India US$80 billion per year or 5.7% of its gross domestic product.

Ludhiana, Ghaziabad, Gwalior, Lucknow, Kanpur, Allahabad, and Raipur have respirable suspended particulate matter (RSPM) above 200 $\mu g/m^3$. Water quality also remains a cause of concern. In terms of surface water quality, for instance, with the exception of River Ganga in certain stretches, all the other rivers continue to be plagued by high levels of organic pollution, low level of oxygen availability for aquatic organisms and the presence of bacteria, protozoa and viruses, which have faecal origin and cause illness. According to estimates received by the State Pollution Control Boards (SPCBs), a total of 127 486 tonnes per day (TPD) of municipal solid waste (MSW) was generated in the country during 2011–12 out of which only 12.45% was processed or treated. The number of water quality monitoring has progressively grown over the last decade from 500 to 2500. In terms of forest and tree cover, India has added around 3 million hectares of forest and tree cover over the last decade. Local environment issues for India are discussed in Chapter 12.

Climate change has emerged as an issue of global importance. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, "warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased". IPCC (2013) finds that the globally averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of 0.85°C [0.65 to 1.06], over the period 1880 to 2012.

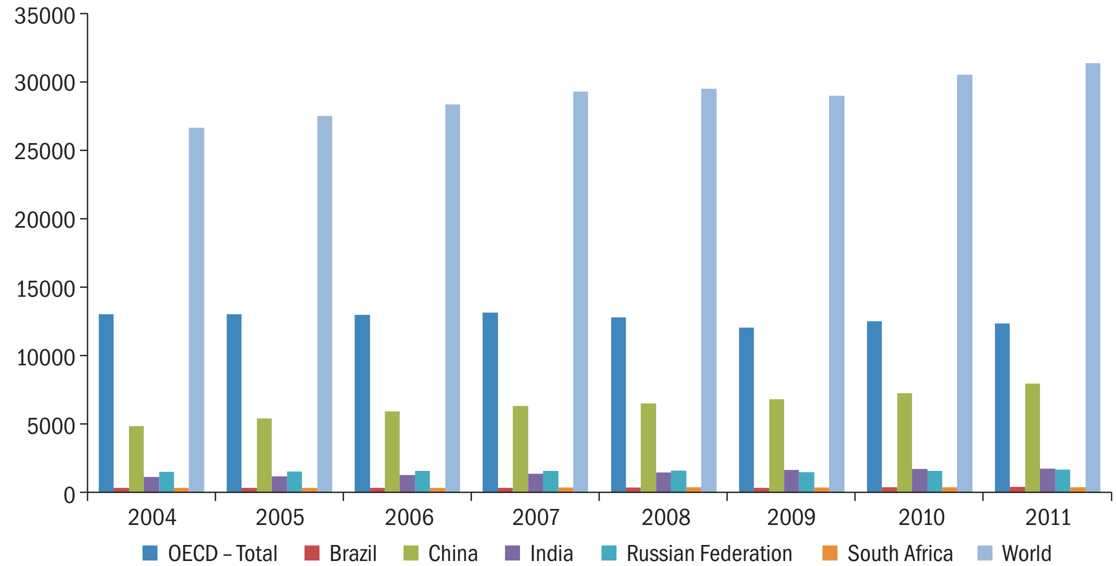
The all-India annual mean temperatures have shown a significant warming trend with an increase of 0.51°C per 100 years (Kothawale, Munot, and Krishna Kumar 2010). The all-India annual mean temperature anomalies for the period 1901–2009, based on the 1961–90 average, show that the annual mean temperatures have risen by 0.56°C (Attri and Tyagi 2010). This warming is mainly because of an increase in temperature during winter and post-monsoon seasons. While no significant trends in annual mean precipitation for the country as a whole can be seen, studies (Sen Roy and Balling 2004) have reported overall increase in extreme rainfall events and their intensities during 1910–2000 over the entire country. Climate change as an issue for India is discussed in Chapter 13.

The energy-related CO_2 emissions account for more than two-thirds of the total GHG emissions. According to estimates, emissions from electricity generation and fossil fuel burning in India have been increasing in the past few years. Figure 2 depicts fossil fuel-based CO_2 emissions for India. The latest emission trends by the IEA in emission indicates that India emits more than 5% of the global CO_2 emissions currently and shows a clear trend of rapid increase in the coming years.

In May 2013, the concentration[12] of CO_2 in the atmosphere reached 400 ppm and is projected to reach 450 ppm[13] by 2040. There is a general agreement in the international community that stabilizing the atmospheric concentration of GHGs below 450 parts per million (ppm) of carbon dioxide equivalent (CO_2-eq) is consistent with a near 50% chance of achieving the 2°C target. These point to the increasing need for low carbon transitions of energy systems globally and in India.

[12] Details available at http://climate.nasa.gov/climate_resource_center/7

[13] Details available at http://keelingcurve.ucsd.edu/what-does-this-number-mean/



	2004	2005	2006	2007	2008	2009	2010	2011
OECD – Total	13009	13024	12957	13120	12789	12021	12510	12341
Brazil	321	323	328	343	362	338	389	408
China	4837	5403	5914	6316	6490	6793	7253	7955
India	1118	1164	1258	1357	1452	1641	1710	1745
Russian Federation	1509	1512	1567	1566	1585	1478	1577	1653
South Africa	336	329	330	355	383	364	371	368
World	26628	27501	28333	29268	29478	28966	30509	31342

Figure 2 Fossil fuel-based CO_2 emissions in million tonnes (2004–11)
Source CO_2 emissions by product and flow, IEA CO_2 Emissions from Fuel Combustion Statistics (database); accessed from OECDstat

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