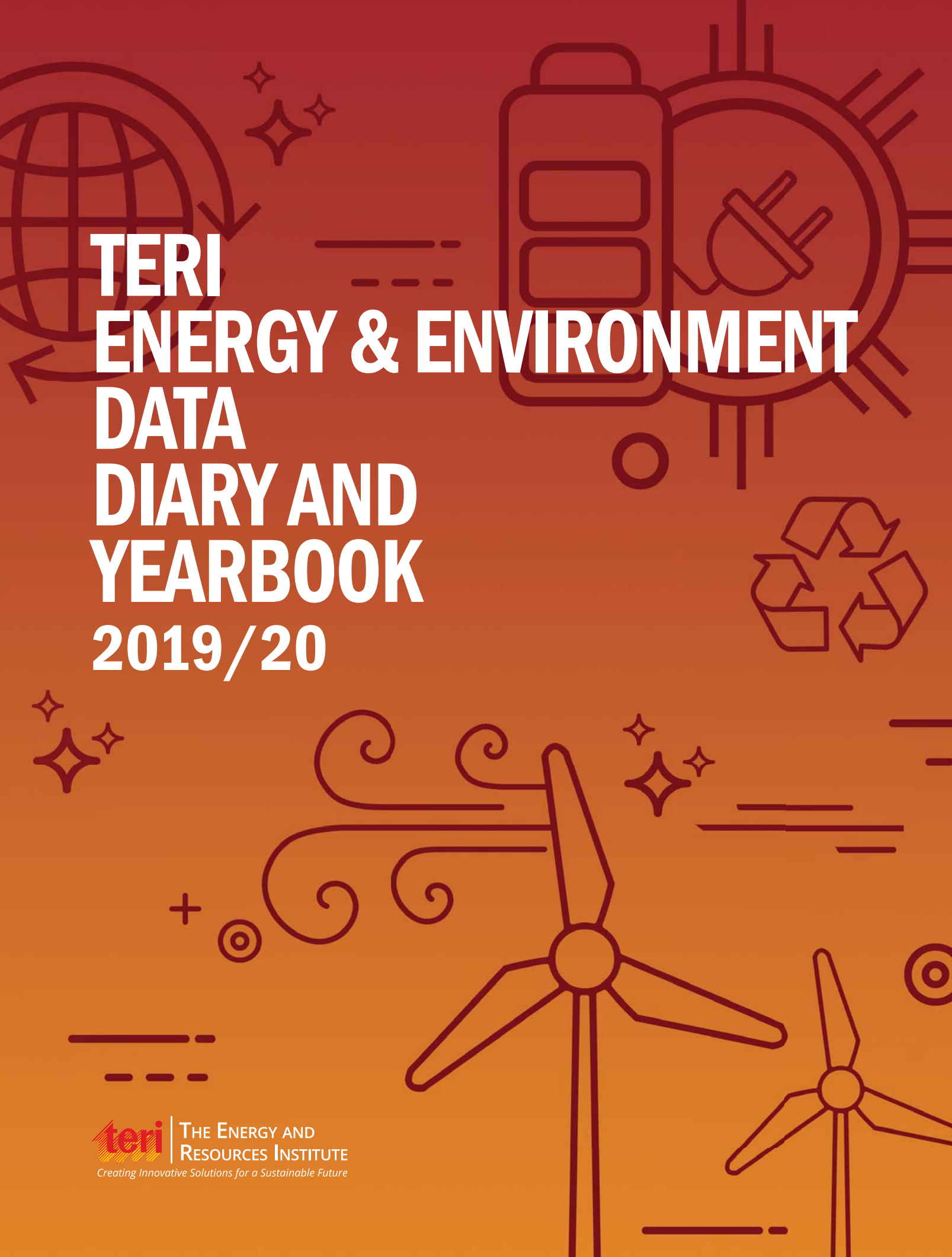
TERI ENERGY & ENVIRONMENT DATA DIARY AND YEARBOOK 2019/20



The Energy and Resources Institute
Creating Innovative Solutions for a Sustainable Future

TERI ENERGY & ENVIRONMENT DATA DIARY AND YEARBOOK 2019/20

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Preface

The world has changed. Apart from affecting countless lives, the novel coronavirus (2019-nCoV) has unleashed a shattering blow to the global economy by disrupting supply chains and choking off demand. The demand for electricity is down drastically in many regions and the transport fuel market has contracted significantly. According to the International Energy Agency (IEA) report, the overall global energy demand diminished by 4% in 2020 as compared to 2019 with massive economic shrinkage owing to the global pandemic outbreak. While the epidemic has not been kind to the energy sector, the numerous lockdowns throughout the world restricting the movement of people and goods has given the environment sector a much needed break, even if it has been temporary. Global CO_2 emissions decreased by 5.8% over 2020 or almost by 2 gigatonne of CO_2 equivalent. However, according to the IEA, the Energy Outlook for 2021 looks promising, especially for Indian economy which is likely to grow by 2% over 2019. There is a need to steer the economy towards a quick recovery path while making sure that the environment does not get negatively impacted.

The Energy and Resources Institute (TERI) takes pride in presenting the thirty-fifth edition of its flagship publication *TERI Energy & Environment Data Diary and Yearbook (TEDDY)*. It provides the latest information and statistics in the energy and environment sectors in India and serves as a ready-reckoner for energy- and environment-related information and statistics sourced from government bodies, policy documents, and other secondary sources.

In this latest publication, energy supply is discussed through chapters on coal and lignite, petroleum and natural gas, power, and renewable energy. The section on energy demand extensively covers the major energy-consuming sectors of the economy—agriculture, industry, transport, households, and buildings. The section on environment contains chapters on climate change along with air quality and pollution, solid waste management, water resource management, and land and forest resource management. The publication also provides a review of government policies with implications for the energy and environment sectors and contains data tables providing enhanced information on the sectors covered. An updated commercial energy flow in India with explanations prepared by TERI researchers is an important aspect of this publication. This predicts the flow of net available energy and its consumption by demand sectors in the future.

We strive to maintain the quality and comprehensiveness of the *TEDDY* as the go-to reference document for energy and environment data for India so that it continues to be a trusted citation in government policy documents, scholarly articles, journals, and other peer-reviewed books in India and abroad. Consequently, we bring constant refinements to *TEDDY* with a view to enhancing its value to policymakers, business organizations, academic institutions, and research scholars. Comments and suggestions from readers shall be appreciated as they would help us improve subsequent issues of this publication.

Dr Vibha Dhawan
Director General
The Energy and Resources
Institute (TERI)

About TEDDY 2019/20

TERI Energy & Environment Data Diary and Yearbook (TEDDY) is an annual publication brought out by The Energy and Resources Institute (TERI) since 1986. It provides updated information on energy supply sectors (coal and lignite, petroleum and natural gas, power, and renewable energy sources), energy-consuming sectors (agriculture, industry, transport, residential, and commercial), and environment (local and global). Recent changes in the energy sector and environment are depicted with the help of graphs, figures, maps, and tables. The publication also provides a review of the government policies that have implications for energy and environment.

The data in the yearbook provides the latest available information at the time of compilation of the chapters. The analytical narrative supporting the data has been well researched by sector experts at TERI. Care has been taken to ensure that continuity of information is maintained so that the readers can understand and analyse the trends and patterns of change in energy and environment over a period of time.

The overall structure of *TEDDY 2019/20* follows the trend of last year's edition. For the reference of our readers, the chapters of the publication are listed in the following table.

Chapter 1: Energy and environment: an overview
Energy supply
Chapter 2: Coal and lignite
Chapter 3: Petroleum and natural gas
Chapter 4: Power
Chapter 5: Renewable energy
Energy demand
Chapter 6: Agriculture
Chapter 7: Industry
Chapter 8: Transport
Chapter 9: Household energy
Chapter 10: Buildings
Local and global environment
Chapter 11: Air quality and pollution
Chapter 12: Solid waste management
Chapter 13: Water resource management
Chapter 14: Land and forest resource management
Chapter 15: Climate change

The thirty-fifth edition of the publication, *TEDDY 2019/20*, comes with some interesting changes. It continues to remain less prose intensive. Besides, the publication includes more data represented with the help of infographics, thus making it more interactive and user friendly. This year's publication also features a section on interlinkages of Sustainable Development Goals with energy and environment.

We are hopeful that like all the previous editions of the publication, *TEDDY 2019/20* would be of immense value to our readers, including policymakers, business organizations, academic institutions, research scholars, and development practitioners.

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The thirty-fifth edition of *TERI Energy & Environment Data Diary and Yearbook (TEDDY)* is a product of the collective effort of the research and publishing team at The Energy and Resources Institute (TERI). The publication provides the latest information and statistics on the energy and environment in India.

Throughout the preparation of the publication, the team gained guidance and support from Dr Vibha Dhawan, Director General, TERI; without her leadership, this publication would not have been possible. We especially thank Mr Ajay Shankar, Distinguished Fellow, TERI, for his leadership and guidance in restructuring this publication.

We extend our gratitude to all the authors and reviewers of the publication who have done due fact-checking and put together research narratives for the chapters. We greatly acknowledge the colleagues at TERI Press for their constant support in bringing out the publication. We would also like to thank Ms Lakshmi Subramanium for extending all possible executive support. Finally, we would like to thank Ms Diksha Gairola and Ms Aditi Goyal for their support in aiding the authors with the research required for compiling the chapters.

We are confident that *TEDDY 2019/20* meets the highest standards of scholarship and would be immensely useful to our readers, including policymakers, business organizations, academic institutions, and research scholars working in areas of energy and environment.

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1 ENERGY AND ENVIRONMENT: AN OVERVIEW

Overview of India's energy mix

India is fuelled by primary (coal, lignite, and natural gas), secondary (electricity and petroleum products), and renewable energy sources. Consumption of coal and lignite increased by 9.4% between 2017/18 and 2018/19, while natural gas consumption decreased by 15.5% during the same period. The rise in electricity consumption across sectors continued, indicating the increasing energy demand in the economy.

Figure 1 shows the fuel-wise energy consumption in India for 2018/19. Petroleum products occupied the largest share in India's fuel mix followed by coal and lignite. The industry sector continues to be the highest consumer of energy among all the sectors in the economy.[1] Petroleum products are majorly consumed by the transport sector, with high-speed diesel (HSD) accounting for 58% of the total fuel consumed in the sector. Electricity was majorly consumed by the industry sector (43%), which includes both utilities and non-utilities.[2] This is followed by the residential sector, accounting for 24% of the total power consumption.

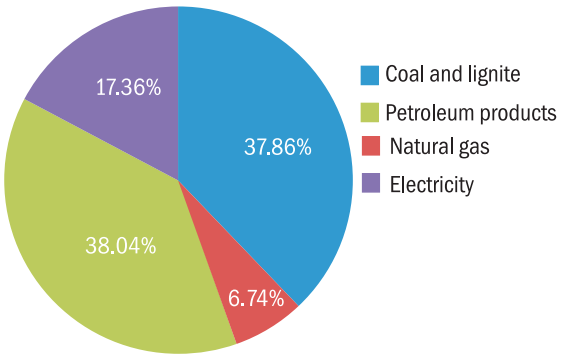

Figure 1 Energy mix in 2018/19

The overall energy supply and consumption pattern in the country is represented by the Sankey diagram (Figure 2). The Sankey diagram provides a visual representation of the country's energy balance and shows the contribution and flow of various energy commodities (for example, fuels and electricity) into different sectors of the economy (residential, industrial, transport, commercial, and agriculture) in million tonnes of oil equivalent (MTOE).

- Figure 2 shows the allocation of the net availability of fuels to different sectors of the economy for 2018/19. The energy flows are illustrated as bands. The width of the band is proportional to the extent of the energy flow.
- Electricity generation in 2018/19 was 243.90 MTOE, of which ~88% was contributed by coal, ~4.4% by natural gas, ~1.0% by renewables, and ~6% by nuclear and hydro. Energy loss from power generation was 59% of the total electricity

[1] The share of industrial sector is 57% in the total energy consumption for 2018/19, followed by transport (19%) and residential sectors (10%).

[2] Utilities – power derived from the grid; non-utilities – captive power

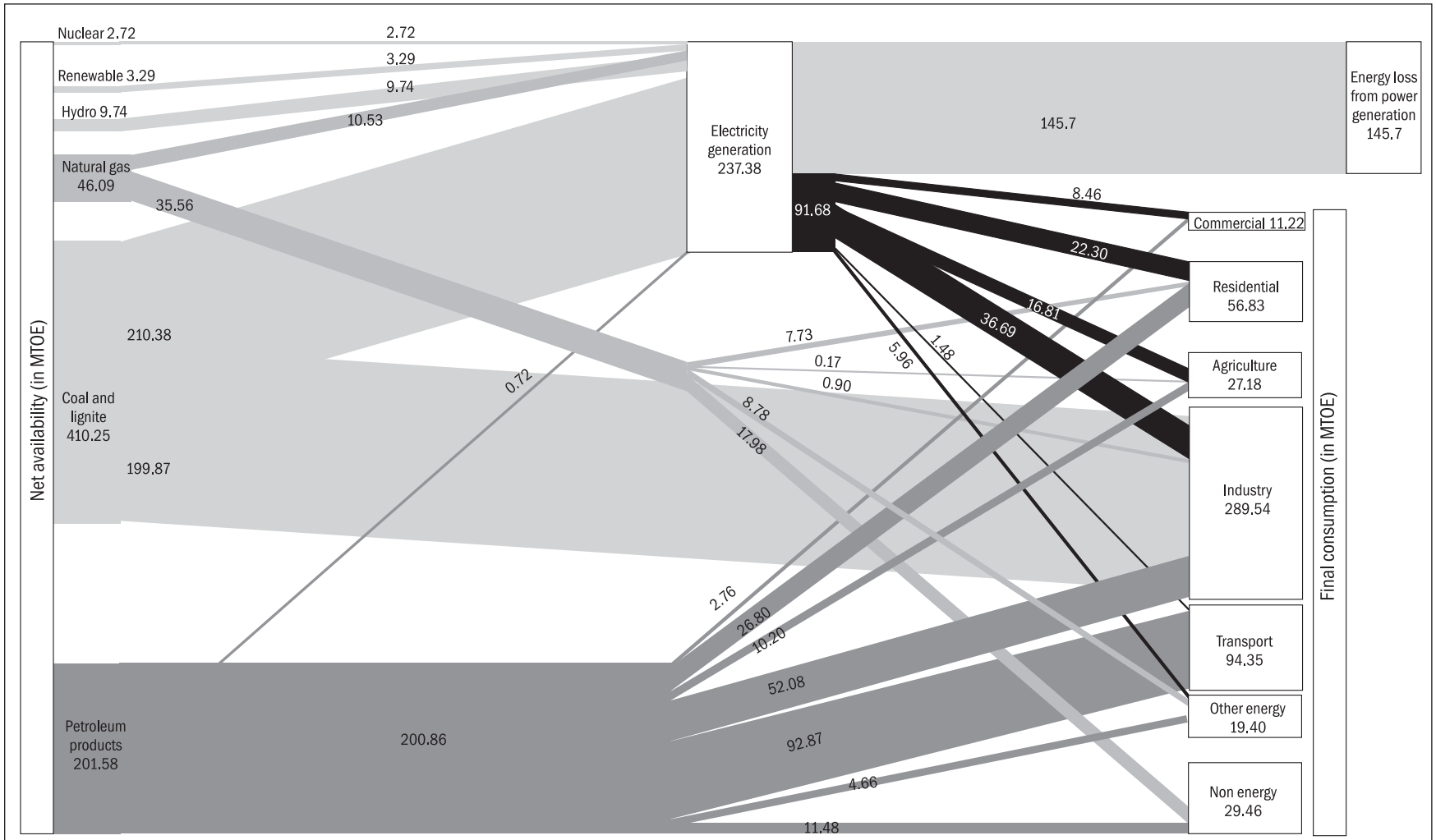

Figure 2 Sankey diagram for 2017/18 (P)

MTOE - million tonnes of oil equivalent; P - provisional

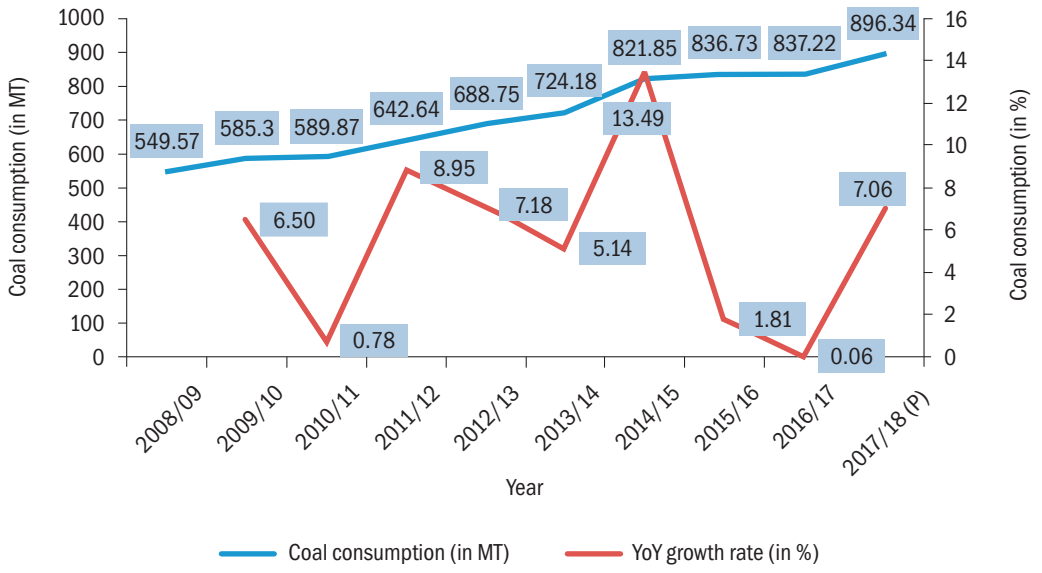

Figure 3 Trend in coal consumption
MT – million tonnes; P – provisional; YoY – year-on-year
Source CCO (2018)

generation. Of the remaining 41%, 43% was consumed by the industry sector and 32% was consumed by the residential and commercial sectors.

- Natural gas-fired power plants used 36% of the available natural gas to generate electricity. The remaining 64% was used for consumption across various sectors, of which ~58% was used for non-energy purposes (for example, feedstock in fertilizer industry, sponge iron, and petrochemicals).
- In 2018/19, the industry sector and the power sector consumed 34% and 66% of the total stock of coal and lignite, respectively, with iron, steel, and cement being the major players in the industry sector.
- Since only a negligible fraction of the total available petroleum products was used for power generation, almost all of it was consumed across various sectors of the economy. The transport sector was the major consumer of petroleum products as it accounted for ~47% of the total consumption.

Energy supply

Coal

- In 2019, coal constituted 54.7% of the total primary energy consumption (BP 2019a).
- India has the fifth largest coal reserves in the world after the USA, Russia, China, and Australia. In 2018/19, India's overall coal production was 728.718 million tonnes (MT) while that of lignite was 44.283 MT (MoC 2019).
- The estimated total consumption of raw coal by industry has increased from 587.81 MT during 2009/10 to 968.25 MT during 2018/19, with a compound annual growth rate (CAGR) of 5.12%. The annual growth rate from 2017/18 to 2018/19 was 7.76% (Figure 3) (MoC 2019).
- Industry-wise estimates of consumption of coal show that during 2018/19, electricity-generating units consumed 637.95 MT of coal, followed by steel and washery industries (69.50 MT), sponge iron industries (12.23 MT), and cement industries (8.82 MT) (MoC 2019). Industry-wise consumption is indicated in Figure 4.

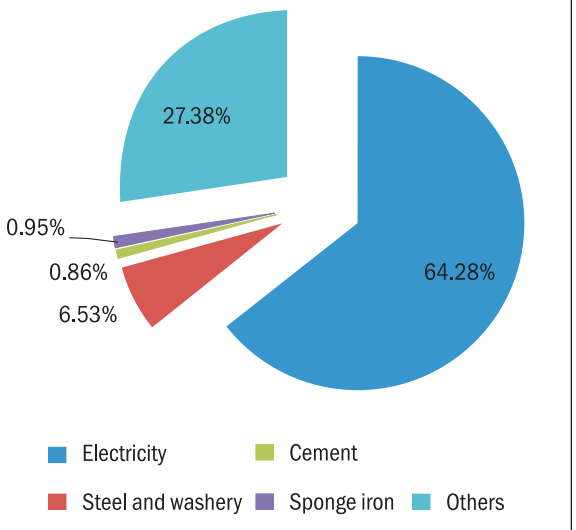

Figure 4 Industry-wise consumption of raw coal

Note Others include colliery consumption, jute, paper, textile, bricks, coal for soft coke, fertilizers and chemicals, and other industries consumption.

Source CCO (2018)

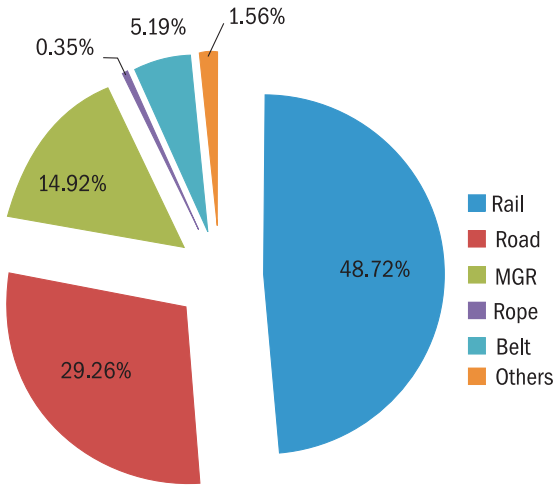

Figure 5 Coal transportation by various modes for 2017/18

MGR - merry-go-round

Source CCO (2018)

- The Indian Railways accounted for almost half (46.27%) of the total share of raw coal dispatched from pitheads to the centres of consumption (MoC 2019). Roads accounted for one-third of coal transportation in 2018/19 followed by merry-go-rounds (MGRs) at 14.65%. Rope and belt together transported close to 5% of raw coal in 2018/19 (Figure 5).
- Coal and coke imports during 2018/19 increased by 12.9% to 235.24 MT, in comparison to 208.27 MT imported in 2017/18 (MoC 2019).
- In 2018/19, the amount of non-coking coal imported was 183.402 MT, against 161.269 MT imported in the previous year (MoC 2019). Traders say coal imports grew largely due to restrictions on consumption of petroleum coke, a dirtier alternative to coal. Coking coal imported in 2018/19 amounted to 51.838 MT which was an increase of 10.3%, compared to 47.003 MT in the previous year.

Petroleum and natural gas

- As on 31 March 2018, the balance recoverable hydrocarbon reserves estimated for crude oil stood at 594 MT (Figure 6), in which Oil and Natural Gas Corporation Limited (ONGC) (under nomination regime) held more than 70% of the total recoverable reserves. In the case of natural gas, the balance recoverable reserves estimated were around 1339 billion cubic metres (BCM) (Figure 6) of which ONGC (under nomination block) and production sharing contract/ coal bed methane (PSC/CBM) regimes together held around 90% of the total.
- The crude oil imports rose marginally by 0.2%, from 226.64 MT in 2018/19 to 226.955 MT in 2019/20 (Figure 8). This is attributed to slow down of economic growth and impact of Covid on demand for petroleum products.
- On the other hand, natural gas imports have increased by 18%, from 28.69 BCM in 2018/19 to 33.87 BCM in 2019/20, contributing to more than 50% of the total natural gas supply (Figure 9).
- During 2019/20, the crude oil production in the country came down by 6%, from 32.5 MT in 2018/19 to 30.5 MT in 2019/20. On the other hand, natural gas production declined by 5%, from 32.87 BCM in 2018/19 to 31.18 BCM in 2019/20 (excluding condensates) (Figure 7).
- During 2019/20, the total petroleum subsidies reduced by 39.5%, from ₹43 687 crore in 2018/19 to ₹26 464 crore in 2019/20, wherein liquefied

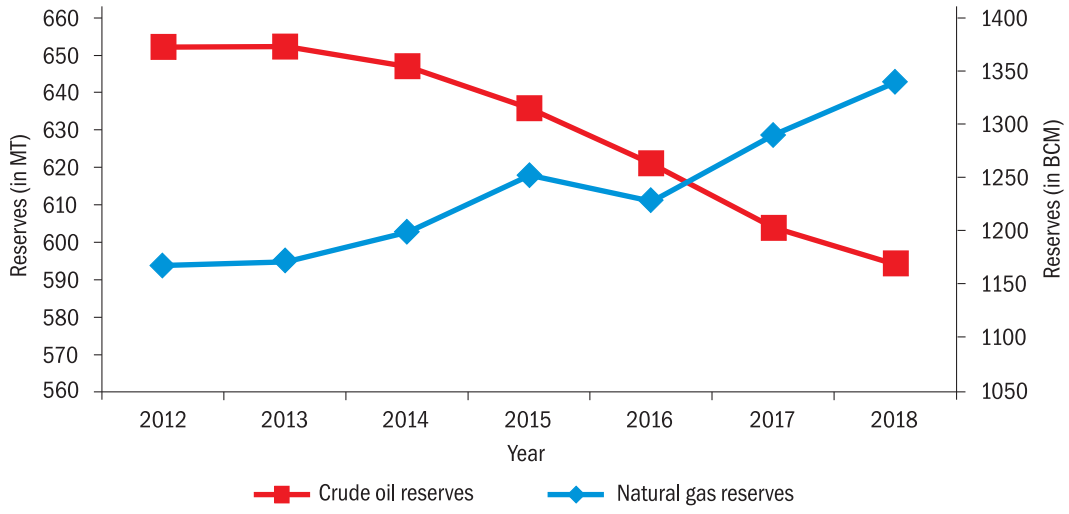

Figure 6 Total balance recoverable crude oil and natural gas reserves in India
BCM – billion cubic metres; MT – million tonnes
Source DGH (2018)

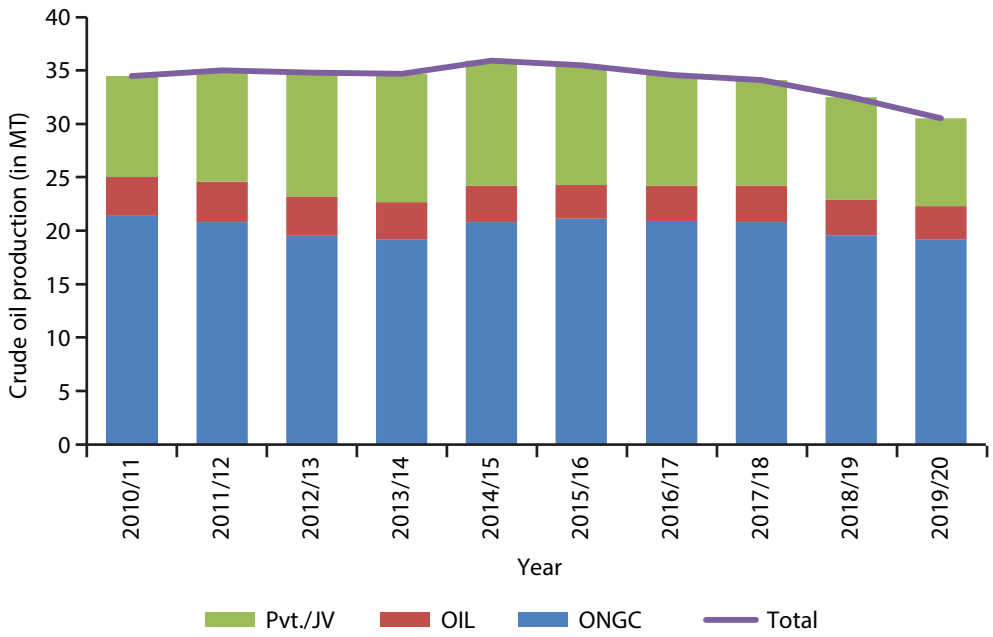

Figure 7 Trend in domestic crude oil production
JV – joint venture; MT – million tonnes; OIL – Oil India Limited; ONGC – Oil and Natural Gas Corporation Limited; P – provisional; Pvt. – private
Source PPAC (2020a)

petroleum gas (LPG) subsidies such as Direct Benefit Transfer for LPG (DBTL) and Pradhan Mantri Ujjwala Yojana (PMUY) for consumption and adoption. Public Distribution System (PDS) Kerosene and Direct Benefit Transfer for Kerosene (DBTK) subsidies had accounted for 91% and 7%, respectively, of the total petroleum subsidies (PPAC 2020a).

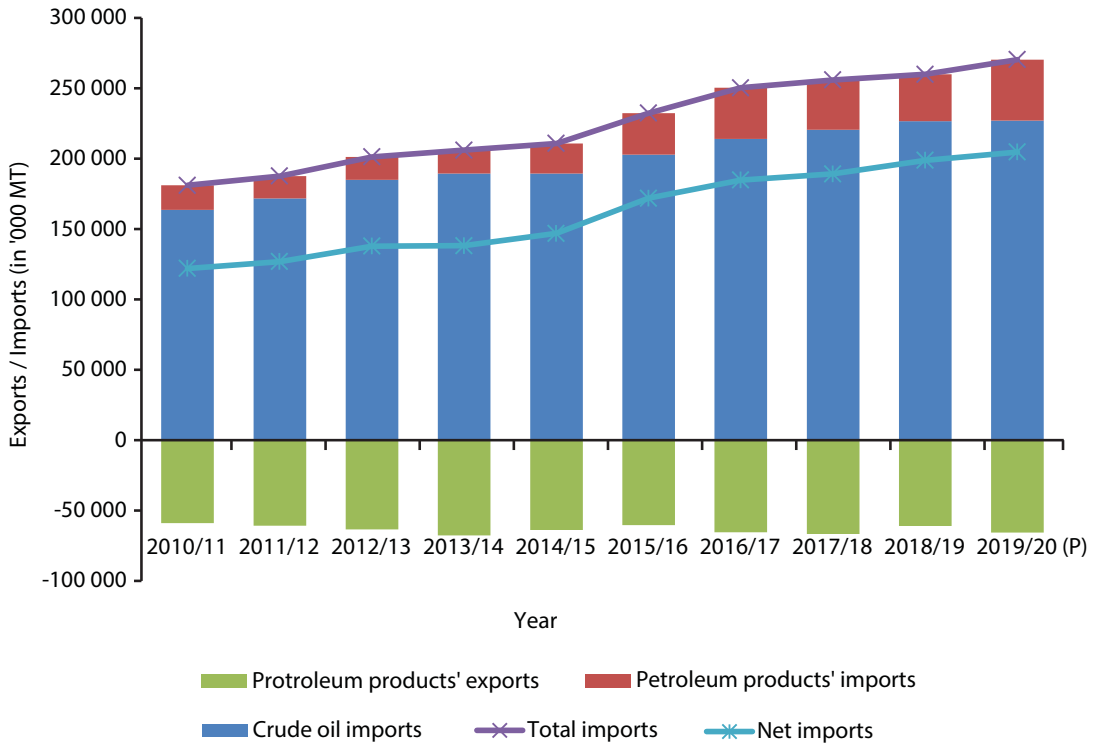

Figure 8 Crude import, product imports, and total imports (in '000 MT)

MT – million tonnes; P – provisional

Source PPAC (2020a)

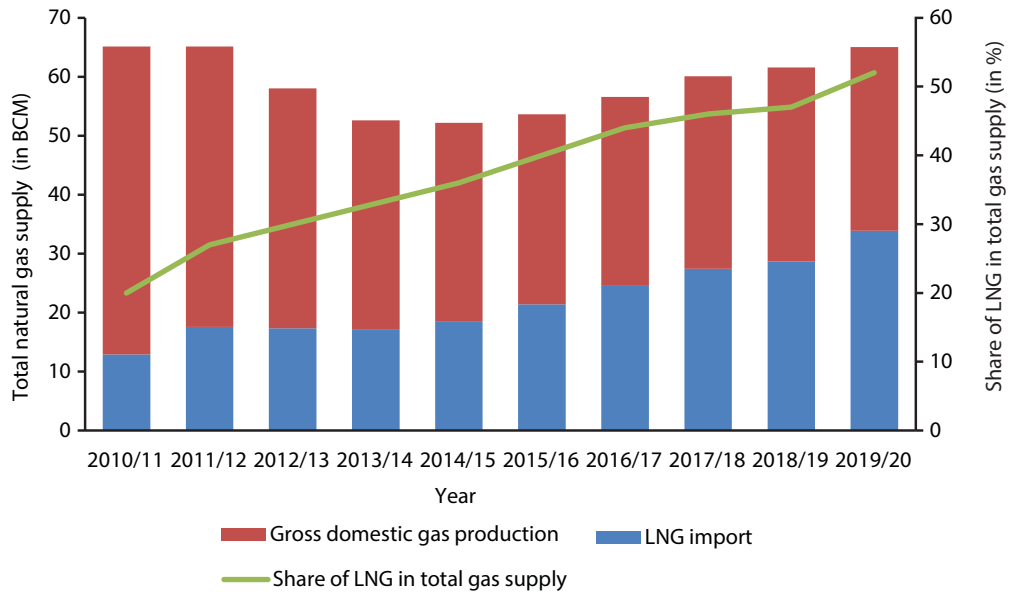

Figure 9 Trend in natural gas imports and the share of imported natural gas in overall supply

BCM – billion cubic metres; LNG - liquefied natural gas

Source PPAC (2020b)

Power

- Electricity generation from conventional sources was 1 252 610.90 million units (MU) till March 2020 against the target of 1 330 000 MU for the 2019/20 (CEA 2020a).
- The per capita electricity consumption of 2019/20 was 1208 (provisional) kilowatt hour or kWh (a growth of 2.3% from 2018/19) (CEA 2020b).
- Installed generation capacity in India (utilities) was 370 106 MW as on 31 March 2020 (CEA 2019c), with an increase of 3.9% compared to the previous year.
- As on 31 March 2020, the share of renewable energy in the total installed capacity was 23%*, the share of coal-based thermal plants was 54%, while the installed capacities of gas, nuclear, and hydropower were 7%, 2%, and 12%, respectively (Figure 10) (CEA 2020a).
- Figure 11 shows mode-wise gross electricity generation in India.

Renewable energy

- In India, the cumulative installed capacity of renewable sources was 86.76 gigawatt (GW) till February 2020, approximately 23% of the total installed capacity of 370 GW. Figure 12 shows the trends in India's installed capacity from renewable energy sources.

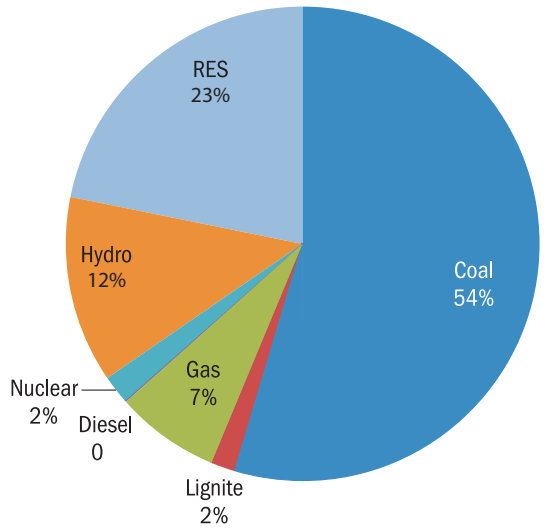

Figure 10 Installed generating capacity in India by mode (utilities)
RES - renewable energy sources
Source CEA (2020a)

- The installed capacity of India's solar power reached 34.6 GW by February 2020. As on 31 December 2019, solar rooftop systems of 34 627.82 MW capacity have been installed (CEA 2019).

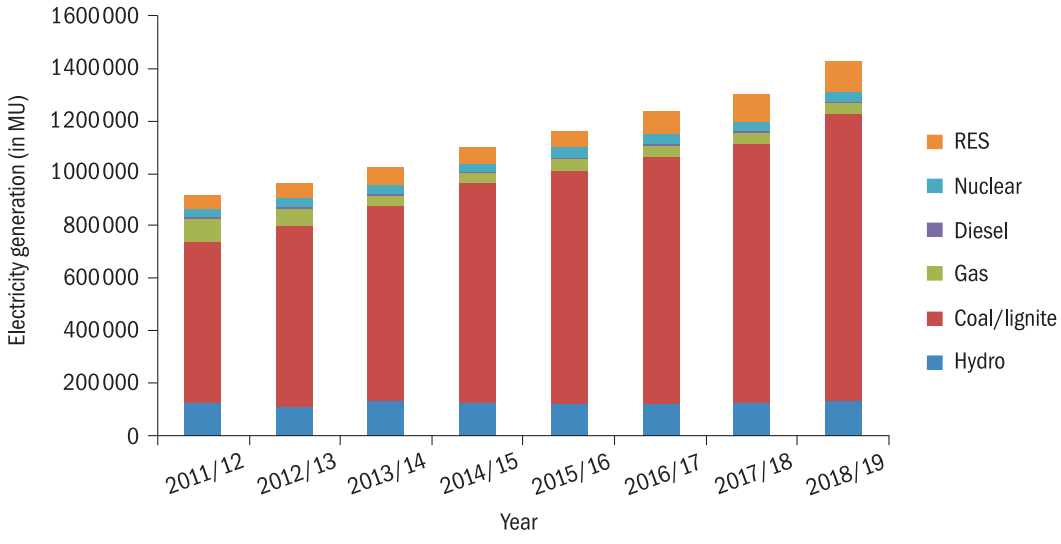

Figure 11 Growth of gross electricity generation in India by mode
MU – million units; RES – renewable energy sources
Source CEA (2019b)

* Data till 29 February 2020

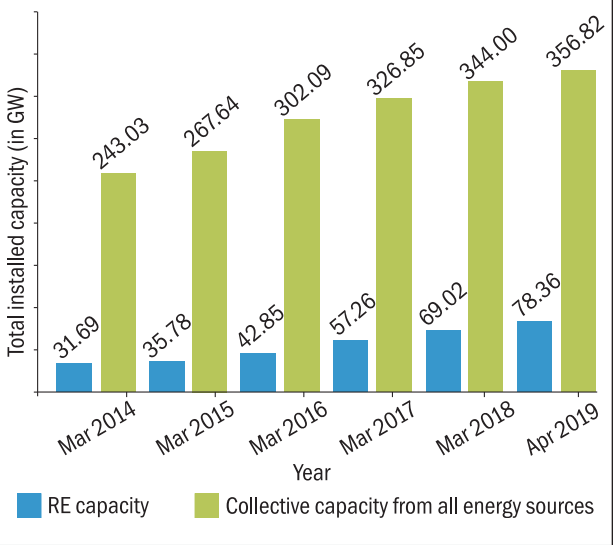

Figure 12 Growth of renewable energy sources (till April 2019)
GW – gigawatt; RE – renewable energy
Source CEA (2019)

- India ranks fourth in the world in terms of installed capacity of wind, with installed wind capacity as on July 2019 being 36.69 GW.[3] Wind energy accounts for 49% of the renewable energy capacity in India.
- Cumulatively, 9945 MW of biopower projects, including biomass power (bagasse and non-bagasse cogeneration) and waste-to-power, were installed in India till June 2019 (Figure 13).

Energy consumption

The total energy consumption in India has almost tripled since 2002/03 (Figure 14).

Agriculture

- The total electricity consumption by the agriculture sector increased from 84 729 gigawatt hour (GWh) in 2000/01 (accounting for nearly 26.76% of the total electricity consumption in that year) to 207 791 GWh in 2018/19 (17.94% of the total consumption of electricity during that year) (Figure 3) (MoSPI 2020). This increase was primarily driven by higher irrigation demand for new crop varieties and the huge levels of subsidies extended to this sector.
- HSD, which is used in tractors and tube wells, was estimated at 0.639 MT in 2018/19 (Figure 16). This represents around 0.76% of the total HSD consumption in India during 2018/19. In comparison, the other major sectors such as transport, industry, mining and quarrying, and power generation used 6.210 MT (7.4%), 1.264 MT (1.5%), 1.465 MT (1.7%), and 0.222 MT (0.3%) of HSD, respectively. Resellers/retail sector with an HSD consumption of 71.697 MT accounts for the largest share (85.8%) of the total HSD consumption.
- India is one of the few countries that produces light diesel oil (LDO), which is a distillate fuel with a small proportion of residual fuel. It is used

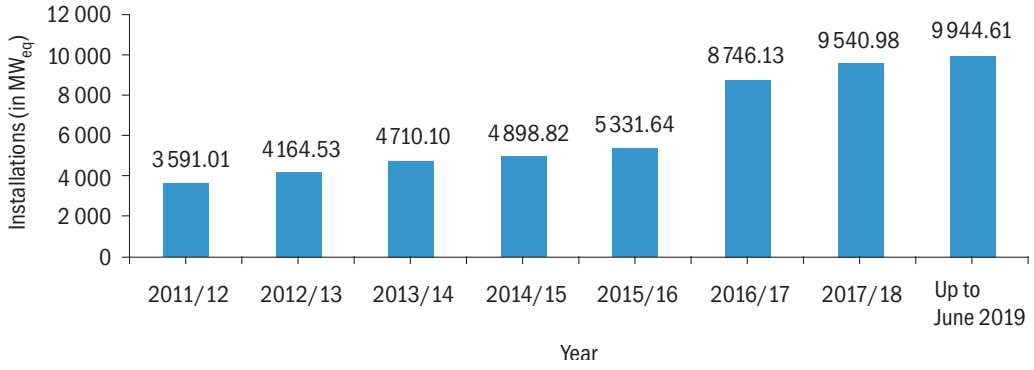

Figure 13 Cumulative biomass power, gasification, and bagasse cogeneration projects
MW_{eq} – megawatt equivalent
Source MNRE (2019)

[3] Details available at http://www.cea.nic.in/reports/monthly/installedcapacity/2019/installed_capacity-07.pdf

Figure 14 Final energy consumption in India by sector

P – provisional

Sources CEA (2018); MoPNG (2018); CCO (2019)

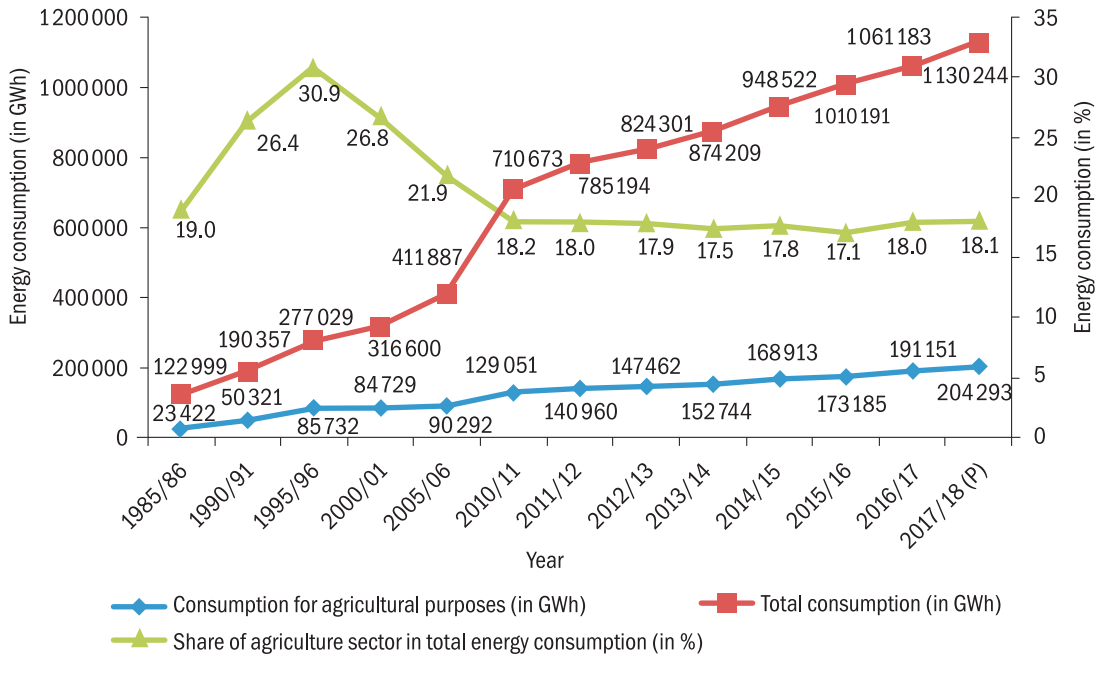

Figure 15 Electricity consumption in the agriculture sector

GWh – gigawatt hour; P – provisional

Source MoSPI (2019)

in agricultural pump sets by small industries and as start-up fuel in power generators. The consumption of LDO in the agriculture sector has reduced significantly over the years from 13 000 tonnes in 2006/07 to 2000 tonnes in 2016/17 (MoSPI 2019). However, LDO consumption in agriculture increased to 9000 tonnes in 2017/18 and is estimated to increase to 16 000 tonnes in

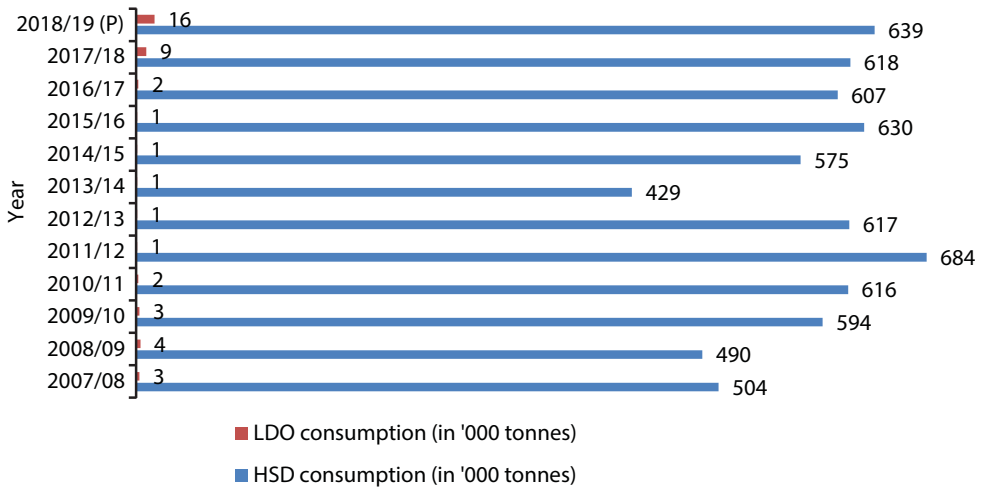

Figure 16 HSD and LDO consumption in the agriculture sector

HSD – high-speed diesel; LDO – light diesel oil; P – provisional

Source MoSPI (2020)

2018/19 (MoSPI 2020). The ban of furnace oil in some regions has led to an increase in LDO consumption.

- Sustainable use of land (food), water, energy, and other natural resources underpins several Sustainable Development Goals (SDGs) and their sub-targets (SDG 1, SDG 2, SDG 6, SDG 7, SDG 8, SDG 12, SDG 14, and SDG 15). Integrating policies and strategies in the agriculture, water, and energy sectors and progressing from a sectoral to a holistic approach would enable sustainable use of resources and the long-term sustainability of food, water, and energy security.

Industry

- Industry accounted for 56% of the total energy consumption in 2017/18. Of the total electricity consumption in 2017/18, industry accounted for the largest share (41.48%) (IEA 2019). The electricity consumption in the industry sector has increased at a much faster pace compared to other sectors between 2008/09 and 2017/18 (with a CAGR of 8.39%).
- The consumption of electricity in the industrial sector registered an increase from 347 671 GWh in 2011/12 to 468 825 in 2017/18 (Figure 17).
- In 2017/18, among all the sectors consuming electricity, the industry sector accounted for the highest share (41.48%), followed by domestic (24.20%), agriculture (18.08%), and commercial sectors (8.51%) (MoSPI 2019).
- Consumption of petroleum products registered a CAGR of 1.78% between 2008/09 and 2017/18 (provisional) (Figure 18). Naphtha (64%)

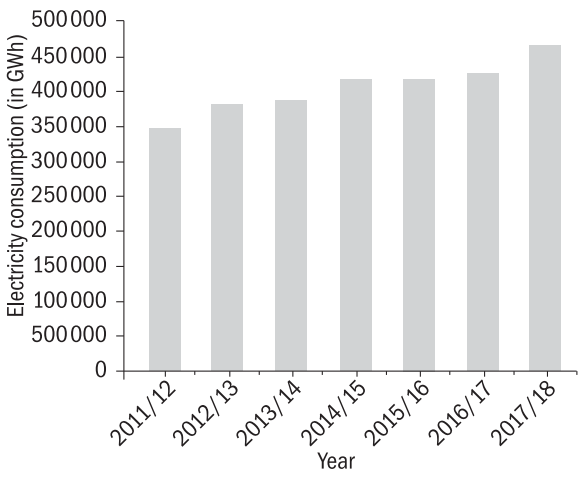

Figure 17 Trends in electricity consumption in the industry sector

GWh – gigawatt hour

Source MoSPI (2013, 2014, 2015, 2016, 2017, 2018a, 2019)

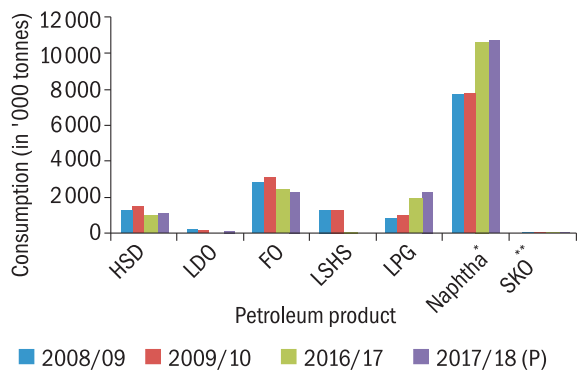

Figure 18 Consumption of selected petroleum products

FO - furnace oil; HSD - high-speed diesel; LDO - light diesel oil; LPG - liquefied petroleum gas; LSHS - low-sulphur heavy stock; P - provisional; SKO - superior kerosene oil

*Includes fertilizer sector, petrochemicals, and steel sector.

**Includes commercial and industry.

Source MoSPI (2019)

occupied the highest share, followed by liquefied petroleum gas (LPG) and furnace oil (each with a share of 14%).

- Different processes within the industrial sector consume different amounts of energy. However, there has been a transition towards adoption of energy-efficient techniques in production processes. For example, the cement industry in India is already one of the most energy efficient in the world, with relatively large production units using latest technologies.

Table 1 SEC Indian industries

Industry		Unit	Value
Aluminium		kWh/tonne	14 400–18 000
Cement*		kWh/tonne	30
Chlor-alkali		kWh/tonne	3 062.71
Fertilizer	Urea	Gcal/MT	5.93
	Ammonia	Gcal/MT	8.33
Iron and steel		GJ/tonne	6.5
Pulp and paper		GJ/tonne	23–37

Gcal – gigacalories; GJ – gigajoules; kWh – kilowatt hour; MT – million tonnes; SEC – specific energy consumption

*Represents specific energy consumption of cement mill.

Sources IAI (2019); LBNL (2005); NPC (2017); DoF (2018); BEE (2019)

- Specific energy consumption (SEC) in different industries in India is listed in Table 1.

Transport

- As per MoSPI (2020), in 2018/19, the transport sector accounted for 9.99% of the total final energy consumption; it was the second-largest energy-consuming sector in the country (after the industry sector).
- The transport sector accounted for more than 70% of the total diesel sales in India in 2018/19, and was the third-largest user of natural gas with a share of 17.10% in 2018/19 (MoSPI 2020).
- The trend in consumption of selected petroleum products in the transport sector is listed in Table 2.
- Over the period of 2013–18, diesel and electricity consumption by the railways grew at CAGR of 0.6% and 3.7%, respectively (Figure 19).

Table 2 Trend in consumption of select petroleum products in India (in MT)

	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19 (P)
High-speed diesel	69.1	68.4	69.4	74.6	76.0	81.1	83.5
Transport[a]	48.4	47.9	48.6	52.3	53.2	56.8	58.5
Motor spirit	15.7	17.1	19.1	21.8	23.8	26.2	28.3
Aviation turbine fuel	5.3	5.5	5.7	6.3	7.0	7.6	8.3

MT – million tonnes; P – provisional

[a]Estimated as 70% of total for each year.

Source Petroleum Planning and Analysis Cell (2019a)

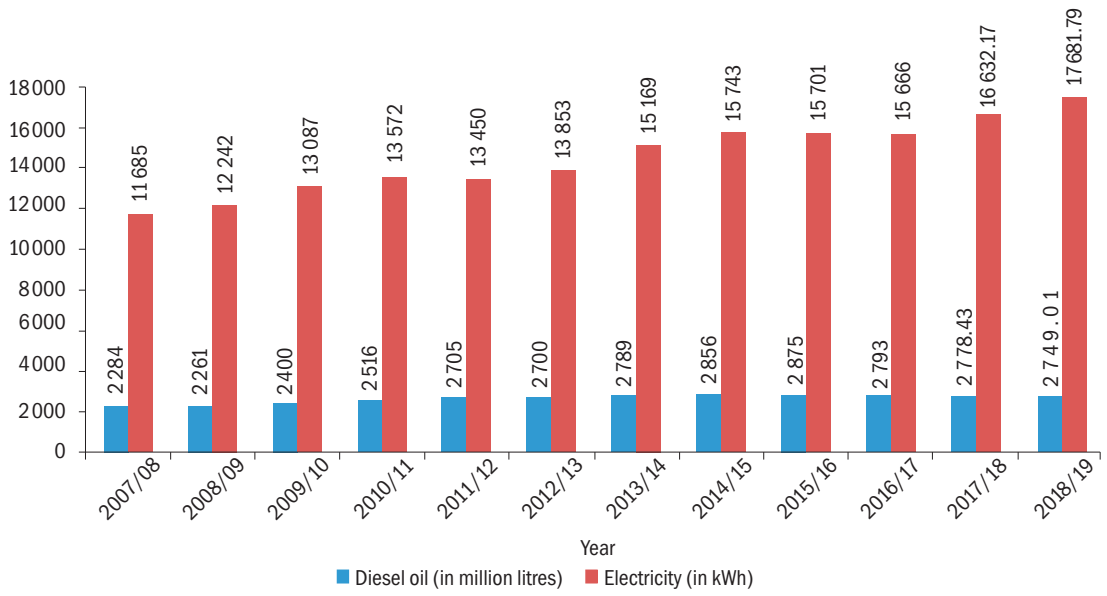

Figure 19 Trend in diesel and electricity consumption by railways

kWh – kilowatt hour

Source MoR (2019)

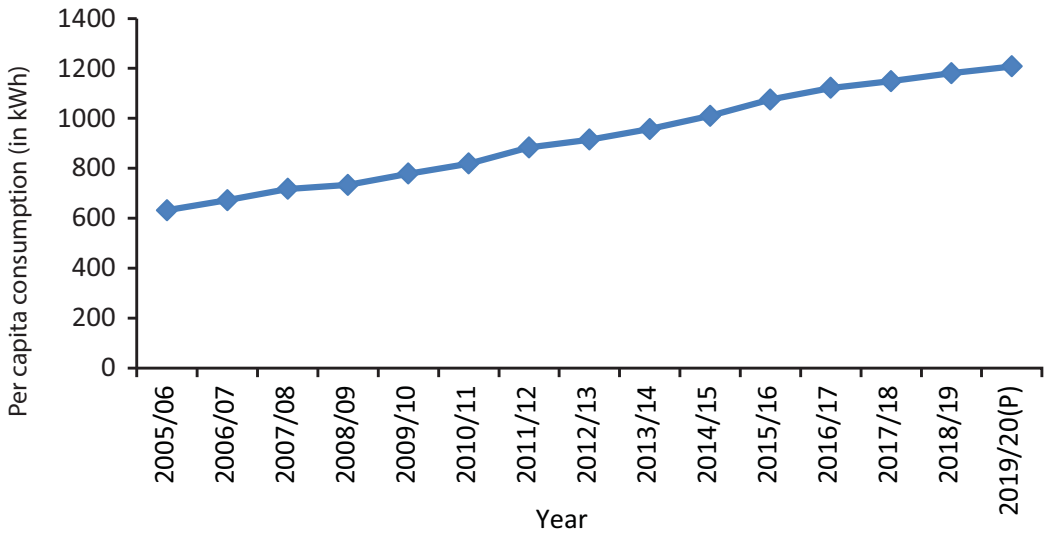

Figure 20 All India annual per capita consumption of electricity since 2006

kWh – kilowatt hour; P – provisional

Source CEA 2020b

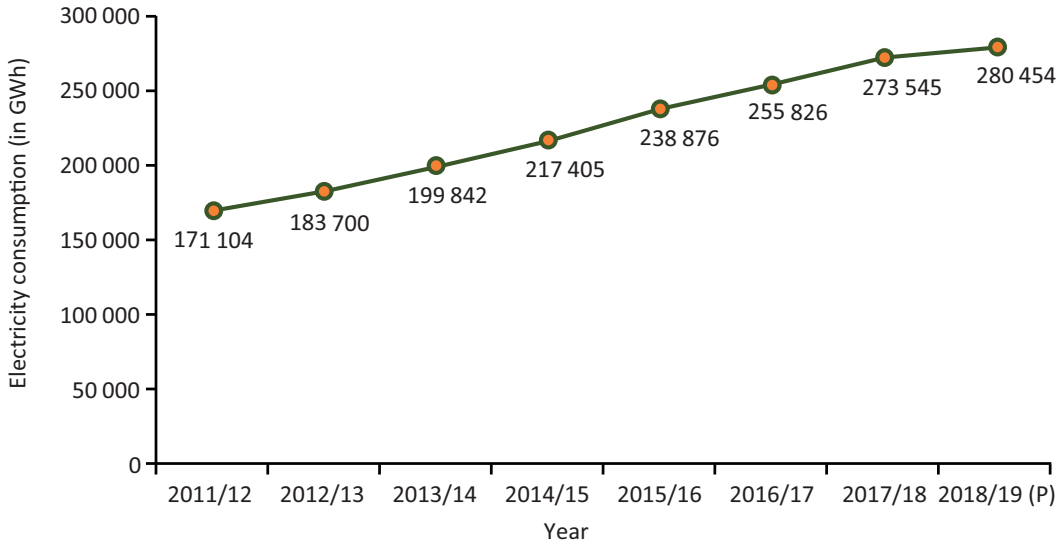

Figure 21 Consumption of electricity by the domestic sector from 2011/12 to 2018/19 (P)
GWh – gigawatt hour; P – provisional
Source MoSPI (2020)

Household energy

- During 2017/18, the estimated electricity consumption in the residential sector stood at 1130.244 terawatt hour. This sector accounted for 24.20% of the total power consumption in the country.
- There has been a rise in the residential consumption of electricity, along with a growth in the total number of consumers of electricity. Between 2015/16 and 2016/17, residential consumers grew at a rate of approximately 42.27%, whereas the growth in total consumers of electricity was only 6.68% (CEA various issues). There has been a sight increase in the per capita electricity consumption in the same time period (Figure 20).
- During 2018/19, the residential sector consumed 87.2% and 93.4% of the total LPG and kerosene in the country, respectively, across all consumer categories.
- Between 2019 and 2020, there has been an 5% growth in the number of residential consumers with access to LPG across urban and rural areas. Between 2017 and 2020, the number of beneficiaries of the Pradhan Mantri Ujjwala Yojana in terms of access to residential LPG connection and LPG stove had more than doubled.
- Figure 21 shows the consumption of electricity by the domestic sector.
- The primary sources of cooking for residential households have been coke, coal, charcoal, firewood and chips, LPG, dung cake, and kerosene. The change in distribution of fuel sources in households in rural and urban areas is depicted in Figure 22, which shows a decline in the use of firewood and chips, and an increase in the use of LPG as a cooking fuel.

Buildings

- Commercial buildings account for about 8% of the total energy consumed in India (MoSPI 2020).
- Residential buildings account for 24% of the total energy consumed in India (MoSPI 2020).
- Electricity consumption projected for the next 10 years and 20 years for the commercial building sector is about 134 billion units (BU) and 227 BU, respectively (Figure 23).
- Electricity consumption by end use for commercial and residential sectors is shown in Figure 24.

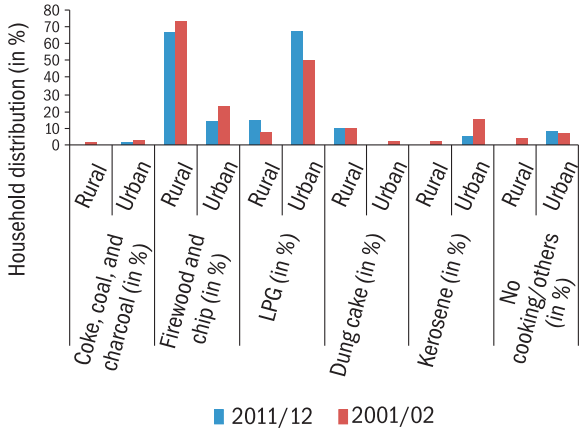

Figure 22 Percentage distribution of households by primary energy source for cooking (2001/02 and 2011/12)

LPG - liquefied petroleum gas

Note For 2011/12, the category 'coke, coal, and charcoal' does not include charcoal and the category 'no cooking/others' includes gobar gas, charcoal, electricity, and others.

Sources MoSPI (2001–02); MoSPI (2011–12); NSS rounds 57 and 68

- The share of space cooling in peak electricity load is projected to rise sharply in many countries, with the biggest increase occurring in hot countries such as India, where the share is expected to rise from 10% in 2016 to 45% in 2050.

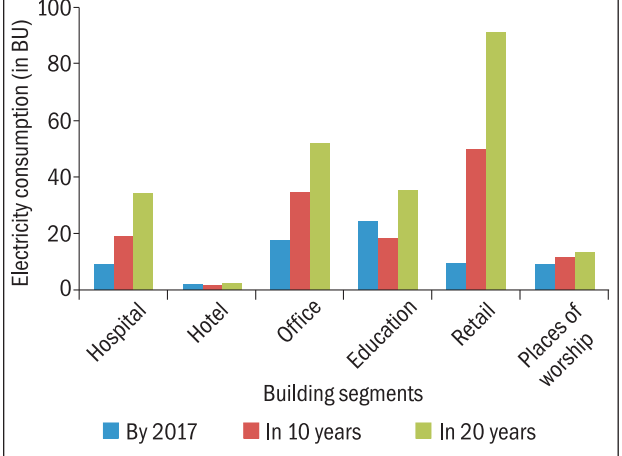

Figure 23 kWh in BU for commercial building segments in the next 10 and 20 years

BU - billion units

Source AEEE (2017)

Environment

Air

- Air pollution is reported as the second leading health risk factor in India and it reportedly costs 8.5% of the country's gross domestic product (GDP). Nearly 75% of deaths associated with air pollution in India are attributed to the emissions of pollutants during the burning of solid biomass fuels.

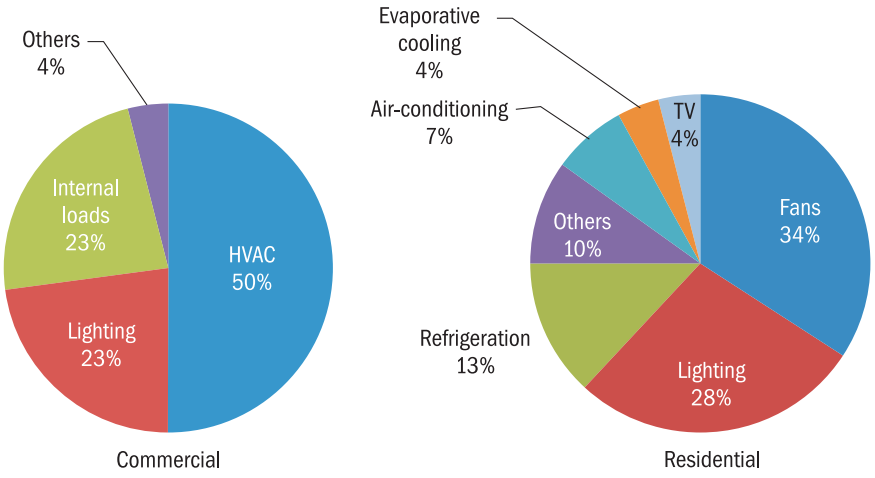

Figure 24 Commercial and residential energy consumption by use

HVAC – heating, ventilation, and air-conditioning

Source BEE (2011)

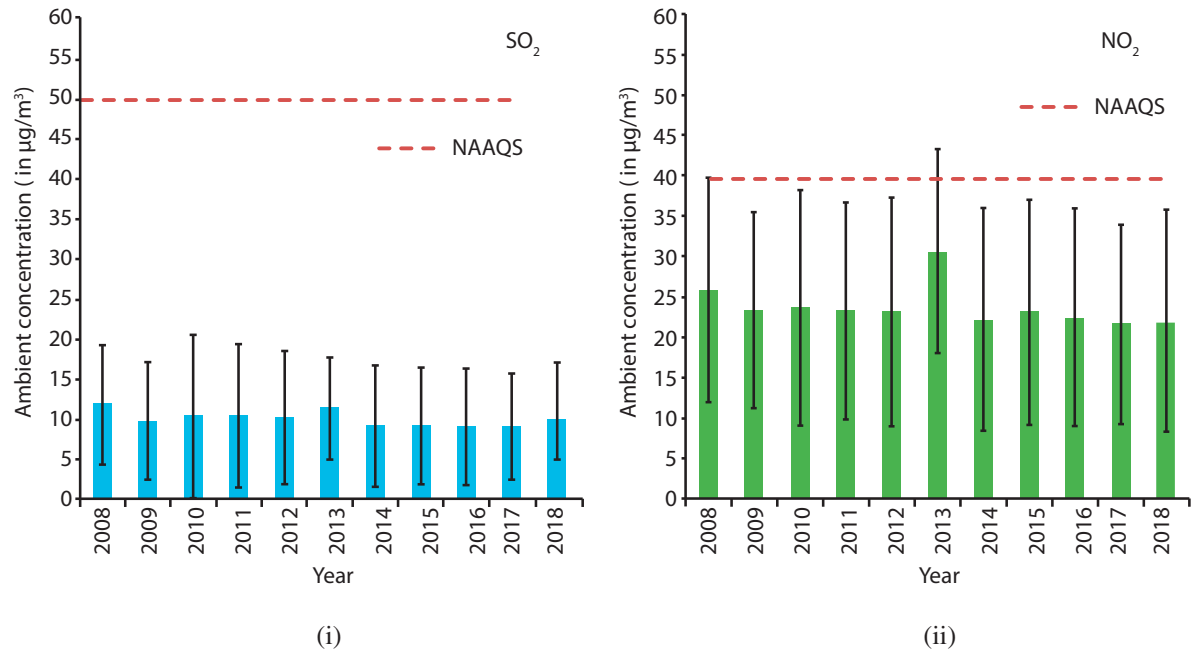

Figure 25 Annual ambient concentrations of (i) SO_2 and (ii) NO_2 pollutants across the country (2008–18)

µg/m^3 – micrograms per metre cube

Note Bars indicate the average annual concentration. Dashed line indicates the National Ambient Air Quality Standards.

Source Gazette of India (2009)

- In 2017, air pollution was recognized as the fifth highest mortality risk factor globally and was associated with about 4.9 million deaths and 147 million years of healthy life lost (SoGA 2019).
- The average annual ambient concentrations of SO_2 and NO_2 in India during 2008–18 remained within the National Ambient Air Quality Standards (NAAQS) (Figure 25). The state-wise average concentrations for the period 2008–17 show that all states complied with NAAQS for SO_2 and most of the states for NO_2 (except Delhi and West Bengal).
- The National Ambient Air Quality Monitoring Programme (NAMP) monitoring stations started to report the $PM_{2.5}$ concentration in 2014. The average annual concentration of $PM_{2.5}$ in 2017 at the national level was closer to the NAAQS (Figure 26). However, a majority of the states exceeded the NAAQS for $PM_{2.5}$, with the average being three to four times higher than the standard.
- The average annual concentration of PM_{10} at national level remained much higher than the NAAQS during the period 2008–18 (Figure 27).

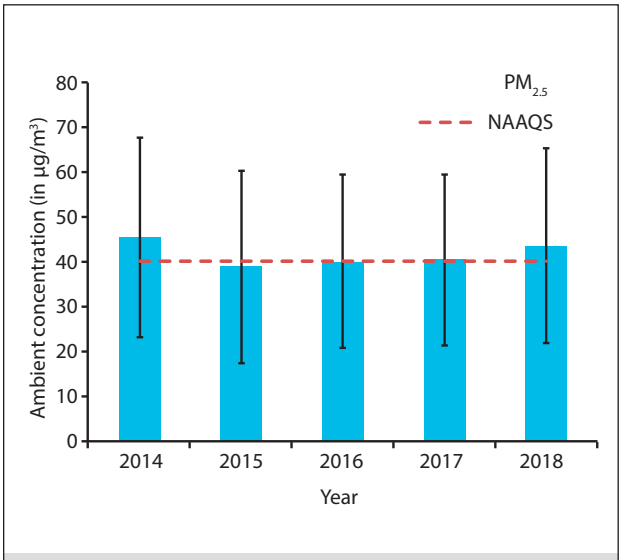

Figure 26 Annual ambient concentrations of $PM_{2.5}$ across the country (2014–18)

µg/m^3 – micrograms per metre cube

Note Bars indicate the average annual concentration. Dashed line indicates the National Ambient Air Quality Standards.

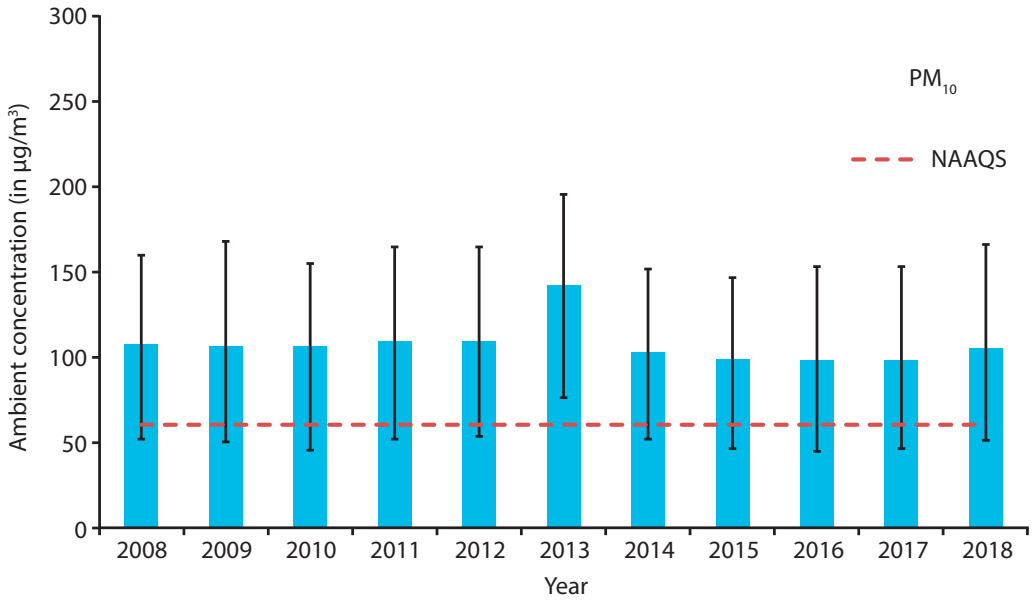

Figure 27 Annual ambient concentrations of PM_{10} across the country (2008–18)

µg/m^3 – micrograms per metre cube

Note Bars indicate the average annual concentration. Dashed line indicates the National Ambient Air Quality Standards.

- Development and implementation of policies towards addressing 170 targets of the 17 SDGs can improve air quality. Policies towards improvement of ambient air quality from its present conditions can also address some of the SDG targets.

Waste

- The municipal solid waste (MSW) generated by urban India was about 59.56 million tonnes per annum (MTPA) in 2019 (CPCP 2019). The average collection rate was reported to be around 92% and only about 37% of the collected waste was treated (Figure 28).
- India's plastic consumption is estimated to be 13.6 kg (virgin polymer)/capita/year (Plastindia Foundation 2019), with plastic waste ranging from 3% to 12.5% of MSW, varying from city to city. The plastic waste generation was reported to be about 9.468 MTPA in 2017 (CPCB 2017b). In early 2018, electronic waste (e-waste) generation in India was around 2 MTPA, and was expected to reach 3 MTPA by the end of 2018 (ASSOCHAM-NEC study 2018). Only 5% of the generated e-waste was recycled by the formal sector in India (Awasthi, Wang, Wang, *et al*. 2018). Construction and demolition waste rose to 530 MTPA in 2016 (PIB 2016).

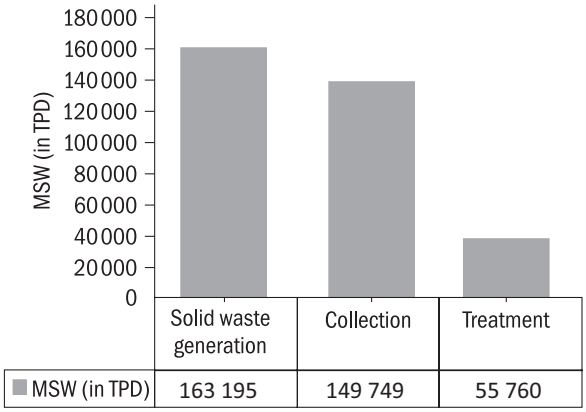

Figure 28 Municipal solid waste management status in India

MSW - municipal solid waste; TPD – tonnes per day

Source CPCB (2019)

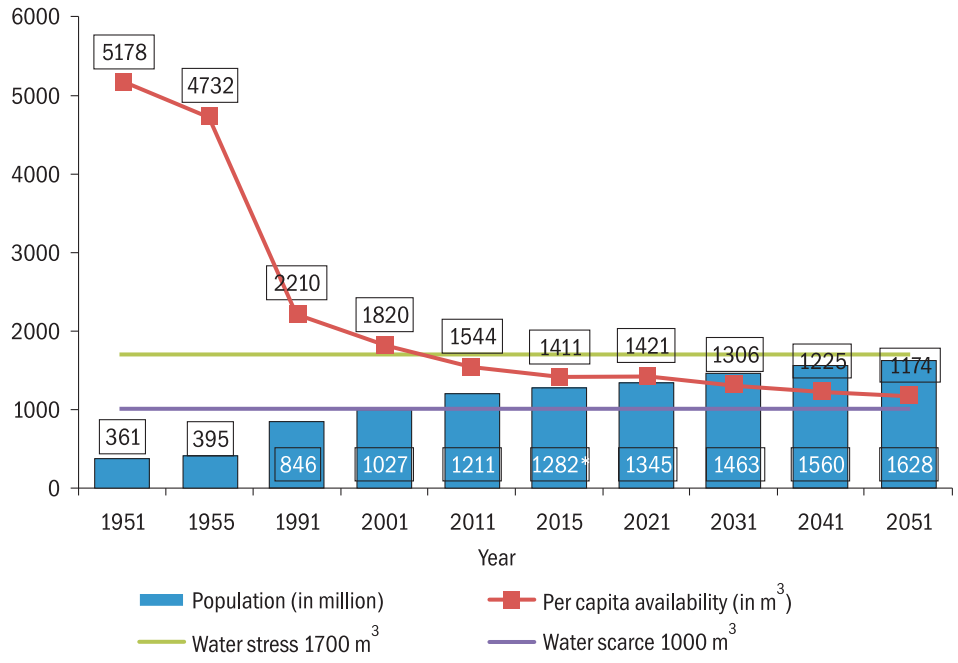

Figure 29 Per capita water availability in relation to population

Note The calculation of per capita availability from 2021 onwards is based on 2017 Water Resource Assessment tool estimates.

Source CWC (2017)

- In 2016, MSW disposal contributed about 20% of the total greenhouse gas (GHG) emissions from the waste sector, which in turn accounted for 3% of the total GHG emissions in India (TERI 2016).
- Solid waste management (SWM) is a cross-cutting issue that affects and impacts various areas of sustainable development in each of the three sustainability domains: ecology, economy, and society. Proper management of MSW would help in achieving SDGs 3 and 11, which are concerned with good health and well-being and the sustainability of cities, respectively. Decrease in waste generation by the practice of 3 'Rs' and cutting down of food losses along production and supply chains will help target SDGs 6, 12, and 15. Technological advancements could help derive energy from waste thus meeting SDG 7, which targets access to affordable and clean energy.

Water

- The per capita water availability has decreased from 1820 m^3 (as per Census 2001) to 1545 m^3 (as per Census 2011). The per capita availability of water registered a further decline to 1411 m^3 in 2015. It is projected to be 1174 m^3 by 2051, bringing the country ever closer to the 'water scarce' classification (CWC 2017) (Figure 29).
- A declining trend in the average water table across the country has also been observed (Figure 30).
- More than 82 lakh ha of inland water resources is available in the country (MoSPI 2020a).

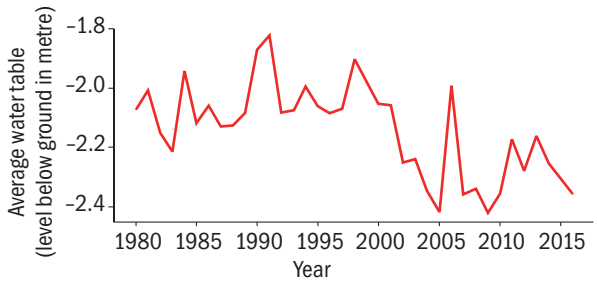

Figure 30 Trend of average water table in India from 1980 to 2015

Source MoSPI (2018b)

- In 2018, out of 6881 groundwater assessment units, 1186 were overexploited, 313 were critical, 972 were semi-critical, 100 were saline while 4310 were safe (CGWB 2019).
- In 2014, the Ministry of Jal Shakti (erstwhile Ministry of Water Resources, River Development and Ganga Rejuvenation) stated that industrial plants in India consume about 2–3.5 times more water per unit of production compared to similar plants operating in other countries. The National Water Mission strove to increase water-use efficiency in all the sectors of water use by 20% by 2017. However, the target has not yet been achieved.
- In order to improve water-use efficiency, the 'More Crop per Drop' scheme was launched under the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY). It aims at promoting the use of appropriate technological interventions such as drip and sprinkler irrigation technologies, and encourages farmers to use water saving and conservation technologies.
- The Government of India has been implementing a number of policies and programmes in the water and sanitation sector in order to achieve the SDG 6 target. The Swachh Bharat Mission with its ambitious goal of providing universal sanitation by 2019, is trying to address the gap in the sanitation sector.

Forest and biodiversity

- In India, the area covered by 'very dense forest' is 99 279 km^2, that with 'moderately dense forest' is 308 472 km^2, and by 'open forest' is 30 4499 km^2, corresponding to 3.02%, 9.38%, and 9.26%, respectively, of the total geographical area of the country (FSI 2019).
- There are 14 major forest types in India, of which almost 38.2% constitute the tropical dry deciduous forests and 30.3% are tropical moist deciduous forests (Champion and Seth 2019).
- India, with 2.4% of the world's land area, is home to 7%–8% of the recorded species of the world, which includes 47 485 species of plants (including fungi and lower plants) and 101 167 species of animals (MoEFCC 2019).
- There are 869 protected areas in India covering 165 158.54 km^2, which is 5.02% of the country's geographical area (WII 2019).

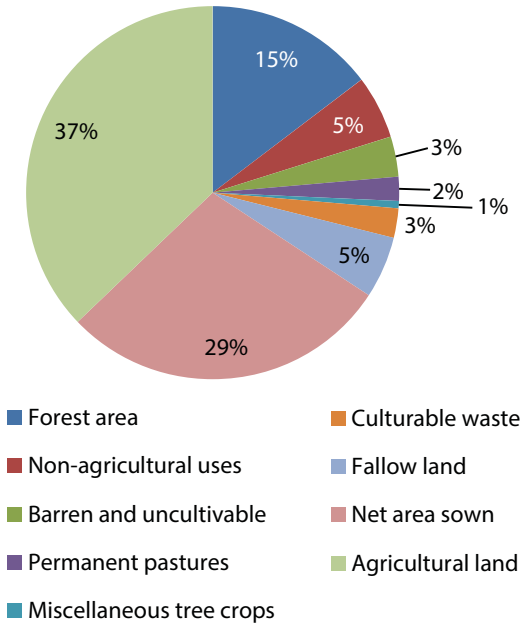

Figure 31 Percentage of land area under various uses in 2017

Source MoAFW (2017)

- In India, the total area under wetlands is 15.26 million hectares (Mha) out of which 4.14 Mha is under coastal wetlands, 10.56 Mha is under inland wetlands and 0.55 Mha of wetlands that are smaller than 2.25 ha (MoSPI 2020a).
- In the country, land use is classified into forest land, area under non-agricultural uses, barren and uncultivable land, permanent pastures and other grazing lands, land under miscellaneous tree crops, cultivable wasteland, fallow lands, current fallows, and net area sown. The percentage of different land use categories is shown in Figure 31 (MoAFW 2016).
- The net sown area has shown a decline of 1 MHa during 2010–15, in contrast to the other categories of land use which have shown an increase in the same time period (Figure 32).
- According to the National Remote Sensing Agency, about 16% of the geographical area of India is wasteland. This translates to 68.35 Mha of wasteland being present in India. Of this, approximately 50% is non-forest land, which can be made fertile again if it is treated properly (Balasubramanian 2015).

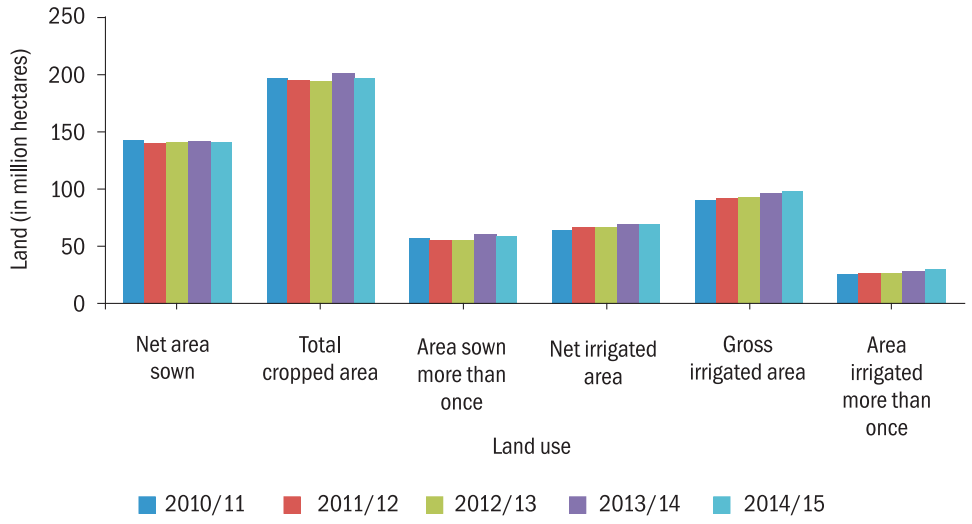

Figure 32 Land-use change from 2010/11 to 2014/15
Source MoAFW (2016)

- Drylands cover approximately 34.9% of the earth's terrestrial surface and are home to about 34% of the world population (Adeel, Safriel, Niemeijer, *et al*. 2005). According to Space Applications Centre drylands in India comprise arid areas covering 30.54 Mha (36.96%), semi-arid areas covering 35.4 Mha (42.84%), and dry sub-humid areas covering 16.7 Mha (20.21%) (SAC 2016). The area undergoing desertification from 2011 to 2013 was 82.64 Mha in these drylands, while it was 81.48 Mha between 2003 and 2005.

Climate change

- The annual mean temperature of India during 2019 was +0.36°C above the 1981–2010 average. The year 2019 was the seventh warmest year on record since 1901.
- Global mean temperature is projected to increase by 3–5.5°C (RCP 8.5) by 2100 relative to the 1986–2005 average (Hayhoe, Edmonds, Kopp, *et al*. 2017).
- India's per capita GHG emissions stood at 1.8 tonnes CO_2e for 2010 according to *Biennial Update Report II* (MoEFCC 2018). The report also highlighted a reduction in emission intensity of GDP by 21% between 2005 and 2014.
- CO_2 emissions trend in relation to GDP is shown in Figure 33.
- In terms of sectoral distribution, CO_2 emissions from the electricity and heat sectors for 2016 accounted for a little more than half of India's total CO_2 emissions (IEA 2018a). The transport sector emissions were dominated by road, followed by aviation and marine transportation (IEA 2017). The distributed share of emissions across different sub-sectors for India is highlighted in Figure 34.

Moving ahead

TERI Energy & Environment Data Diary and Yearbook (TEDDY) is an annual publication, which presents the state-of-art information on energy supply, energy demand, and the environment. It seeks to support policy research and decision-making by providing policymakers and researchers with facts and data that can further be used to develop

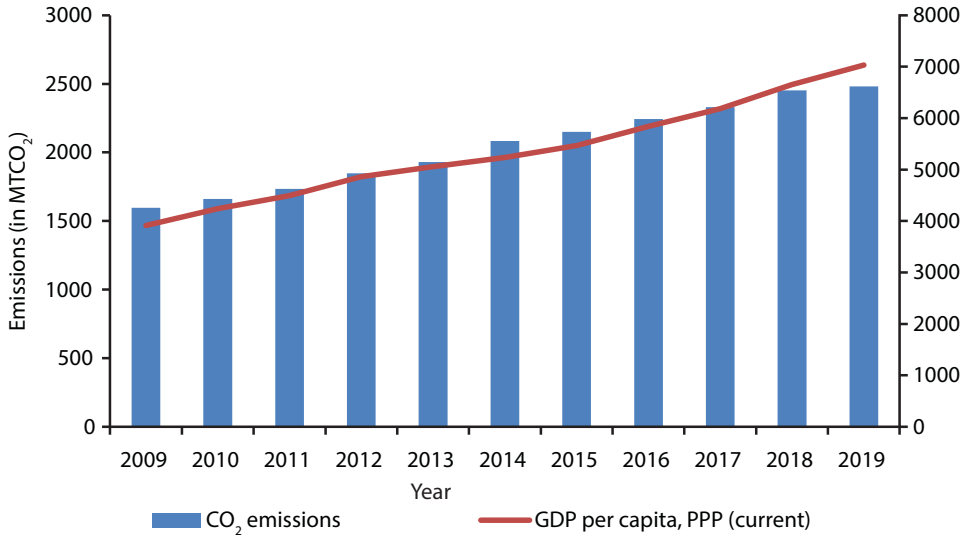

Figure 33 CO_2 emissions in India as compared to GDP (PPP)

GDP - gross domestic product; $MTCO_2$ - million tonnes of carbon dioxide; PPP - purchase power parity

Sources WEO (2020); BP (2020)

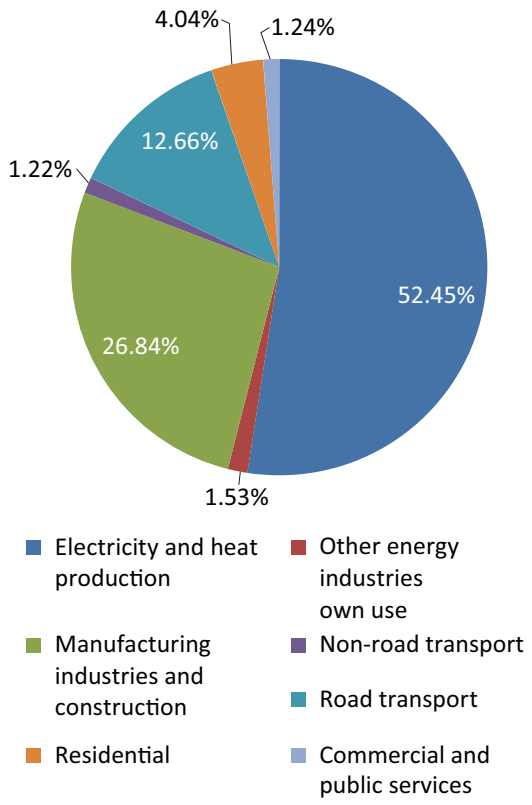

Figure 34 CO_2 emissions within subsectors in India

Source IEA (2019)

actionable solutions warranted by rigorous analysis. The data in *TEDDY* are compiled from various government sources, policy documents, and other secondary data. Each edition of *TEDDY* contains India's commercial energy balances that provide comprehensive information on energy flows within different sectors of the economy.

The data in the yearbook provide the latest available information at the time of compilation of the chapters, and is supported by well-researched analytical narratives. Energy supply is covered in chapters on coal and lignite, petroleum and natural gas, power, and renewable energy. Energy demand is explained in chapters on agriculture, industry, transport, household energy, and buildings. The section on local and global environment discusses the state of the environment in India, with chapters on air pollution, solid waste management, water resource management, land and forest resource management, and climate change. The publication also provides a review of government policies and analyses the latest policy discourse that has implications on the energy and environment sector of India. The interlinkages of various sectors with SDGs are also discussed.

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ANNEXURE

Annexure I

Availability of fuels

- Figure A1 shows the allocation of the net availability of fuels to different sectors of the economy for 2016/17. The energy flows are illustrated as bands. The width of the band is proportional to the size of the energy flow.
- The electricity generation in 2016/17 was 230.59 MTOE, of which ~86% was contributed by coal, ~4.5% by natural gas, ~3% by renewables, and ~6% by nuclear and hydro. Energy loss from power generation is 60% of the total electricity generation. Of the remaining 40%, 41.5% was consumed by the industry sector and 32.5% was consumed by the residential and the commercial sectors.
- A total of 24% of the available natural gas was used in natural gas-fired power plants to generate electricity. The remaining 76% was used for consumption across various sectors and of which 53% was used for non-energy purposes (for example, feedstock in fertilizer industry, sponge iron, and petrochemicals).
- The total stock of coal and lignite was consumed almost equally by the industry and power sectors in 2016/17, with iron and steel and the cement being the major players in the industry sector.
- As only a negligible fraction of the total available petroleum products was used for power generation, almost all of it was consumed across various sectors of the economy. The major consumer of petroleum products was the transport sector, which accounts for ~46% of the total consumption.

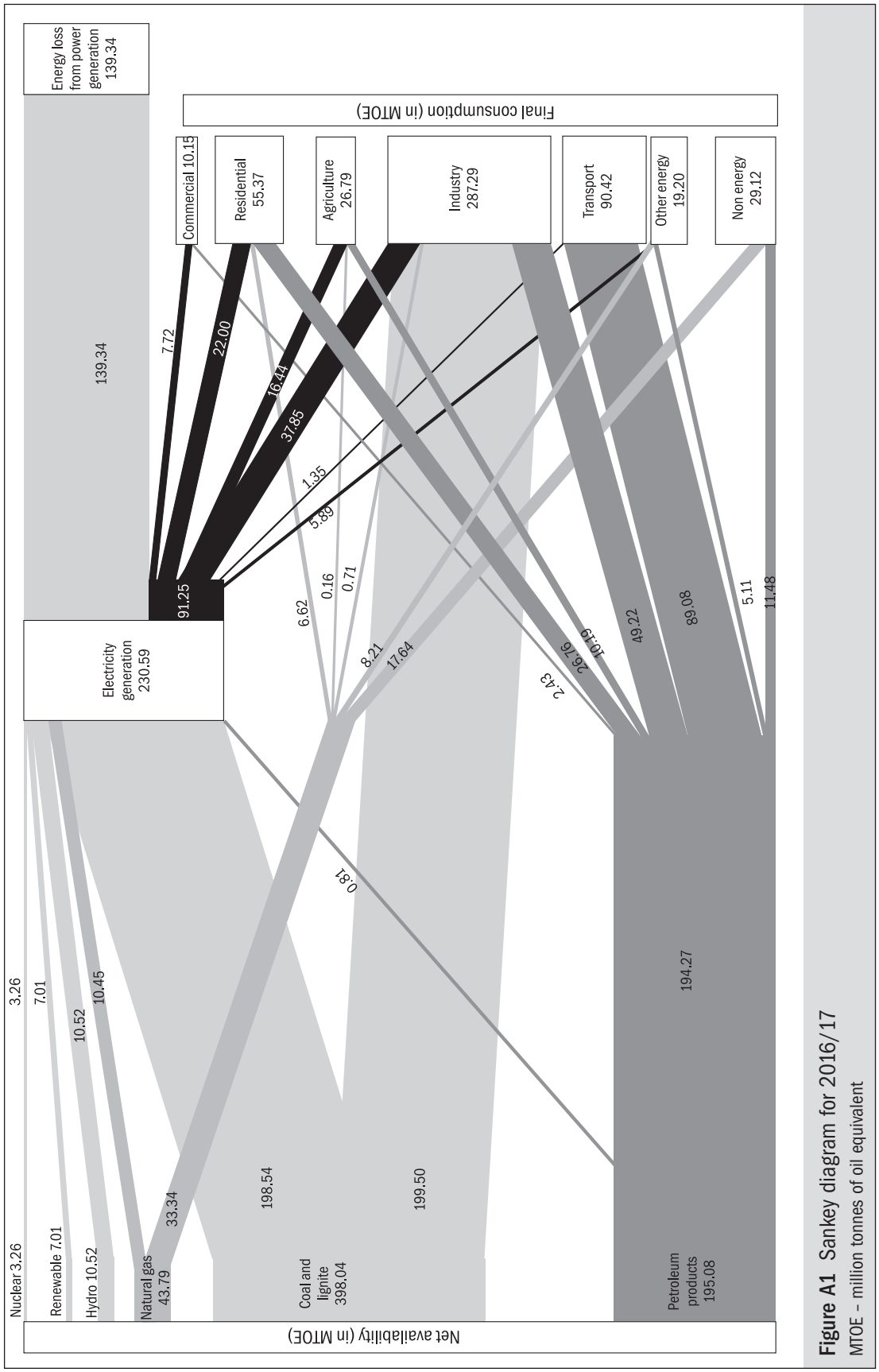

Figure A1 Sankey diagram for 2016/17

MTOE – million tonnes of oil equivalent

Table A1 Commercial energy balance																			
Commercial energy balance 2018/19 (P)	Unit: MTOE																		
							Sources of secondary energy												
	Coal and lignite	Hydro power	Nuclear power	Renewable energy sources	Natural gas	Crude oil	LPG	Naphtha	Motor gasoline	Aviation turbine fuel	Kerosene	High-speed diesel	Light-diesel oil	Fuel oil	Other petroleum products	Total petroleum products	Thermal power	Total power	Total energy
	Total																		
Supply																			
Production	323.40	11.61	3.24	2.14	29.58	34.20												46.58	404.18
Imports	152.96				25.65	226.50	14.96	2.24	0.72	0.28	0	0.57	0	1.36	14.52	34.65		0.40	439.75
Exports	0.81				0	0	0.47	7.49	13.79	7.87	0.02	28.91	0	2.11	3.16	63.81		0.73	64.62
Stock changes	-2.31				0	0	-0.79	-0.83	2.63	-0.05	-0.62	0.39	-0.10	-2.58	-18.55	-20.51			-22.82
Availability	473.23	11.61	3.24	2.14	55.23	260.70	28.14	15.19	30.26	8.84	3.62	86.23	0.30	5.97	41.71	220.25			756.49
Petroleum refining					6.34	257.21	14.09	20.75	39.70	16.08	4.15	111.59	0.67	9.63	48.89	265.56			265.56
Own use	0.09				5.44	21.45										26.89			
LPG extraction					0.79		0.35	0.52	1.00	0.41	0.10	2.81				5.20			
Power generation	215.26	11.61	3.24	2.14	10.80		0	0.01				0.23	0.27	0.33		0.84	226.91	243.90	243.90
Conversion loss in power feneration	137.73				6.31							0.17	0.20	0.25		0.61	144.65	144.65	144.65
Auxiliary consumption in power stations	16.45	0.13	0.38	0	0.40							0.01	0.01	0.01		0.03	16.88	17.39	17.39
Transmission and distribution losses																0		23.14	23.14
Flaring of natural gas					0.74											0			0.74

Contd...

Table A1 *Contd...*

Commercial energy balance 2018/19 (P)	Unit: MTOE																		
Coal washery rejects	4.85																4.85		4.85
Conversion	236.65				24.11	257.21	14.45	21.26	40.70	16.49	4.26	114.17	0.41	9.30	48.89	269.92	166.38	185.19	190.78
Net availability	236.58	11.48	2.86	2.14	31.13	3.50	28.14	15.19	30.26	8.84	3.62	86.23	0.31	5.97	41.71	220.25	65.37	104.96	592.92
Consumption	218.70				30.04		28.14	15.19	30.26	8.84	3.62	86.23	0.31	5.97	41.71	220.25		104.04	573.03
Agriculture					0.17		0.02	0			0	6.50	0.01	0.08		6.63		18.35	25.15
Industry	218.70				0.98		0.59				0.10	14.48	0.19	3.28	41.71	60.35		44.64	324.67
Transport					3.44		0.20	0	30.26	8.84	0	63.23	0.01	0.75		103.30		1.62	108.37
Residential					4.84		24.55	0			3.38	0	0	0		27.93		24.78	57.56
Commercial					0		2.67	0			0	0	0.03	0.33		3.04		8.45	11.48
Other energy uses					3.05		0.10	1.55			0.14	2.01	0.06	1.52		5.37		6.20	14.62
Non-energy uses					17.55		0	13.63			0	0	0	0		13.63			31.18

LPG - liquefied petroleum gas; MTOE - million tonnes of oil equivalent; P - provisional

TERI ENERGY & ENVIRONMENT DATA DIARY AND YEARBOOK 2019/20

TERI Energy & Environment Data Diary and Yearbook (TEDDY) is an annual publication brought out by TERI since 1986. It is the only comprehensive energy and environment yearbook in India that provides updated information on the energy supply sectors (coal and lignite, petroleum and natural gas, power, and renewable energy sources), energy demand sectors (agriculture, industry, transport, household, buildings), and environment (local and global). Recent changes in the energy sector and environment are depicted with the help of graphs, figures, maps, and tables. The publication also reviews government policies associated with energy and environment.

TEDDY 2019/20 gives an account of India's commercial energy balances, extensively covering energy flows within different sectors of the economy and how they have been changing over time. These energy balances and conversion factors are a valuable reference for researchers, scholars, and organizations engaged in energy and related sectors. Contents of the book are organized into three sections—Energy Supply, Energy Demand, and Local and Global Environment. Interlinkage of SDGs with energy and environment also forms the subject matter of *TEDDY 2019/20*. The thirty-fifth edition continues to remain less prose intensive with inclusion of more data, represented with the help of infographics, thus making the publication an authentic and interesting read.

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