# CHAPTER 6

# India Country Report

Patul Kumar, Michael O. Dioha and Seiya Endo

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## CHAPTER 6

# India Country Report [1]

Atul Kumar,[2] Michael O. Dioha,[2] and Seiya Endo[3]

## 1. Country Brief

Located in South Asia, India has an area of about 3.1 million square kilometres. It is the seventh-largest country by area, the second–most populous (with over 1.35 billion people), and the biggest democracy in the world. It is bounded by the Indian Ocean in the south, the Arabian Sea in the southwest, and the Bay of Bengal in the southeast. It shares land borders with Pakistan to the west; China, Nepal, and Bhutan to the northeast; and Bangladesh and Myanmar to the east.

The climate comprises a wide range of weather conditions across a vast and varied topography. Based on the Köppen system, India has six climatic subtypes, including arid desert in the west, alpine tundra and glaciers in the north, and humid tropical regions supporting rainforests in the southwest and the island territories. Many regions have starkly different microclimates.

The economy was nominally worth US$2.9 trillion in 2019; it is the fifth largest by market exchange rate and the third largest by purchasing power parity (PPP), at US$11 trillion (International Monetary Fund, 2020). With its average annual gross domestic product (GDP) growth rate of 5.8% over the past 2 decades, India is one of the fastest-growing economies. However, it ranks 139th for world nominal GDP per capita and 118th for GDP per capita at PPP. Despite economic growth in recent decades, India continues to face socio-economic challenges such as poverty and access to modern energy.

[1] Based on the Institute of Energy Economics, Japan (IEEJ) model and assumptions, with inputs from TERI School of Advanced Studies, New Delhi, India.

[2] Department of Energy and Environment, TERI School of Advanced Studies.

[3] Energy Data and Modelling Center, IEEJ.

## 2. Energy Situation

Energy systems have evolved over the last 6 decades, along with economic development, within the framework of democratic policy, a globally integrated economy, and an environmentally sensitive regime. The ever-increasing demand for energy has put tremendous pressure on limited resources and necessitated their optimum use. India has pursued a reformed development agenda since 1991. Significant effort has gone into making energy more available to support development.

Total final energy consumption (TFEC) has steadily increased across all sectors, including agriculture, industry, commercial, and residential, and is expected to continue to grow. Per-capita energy consumption, however, stands at 30% of the world's average (0.44 tonnes of oil equivalent [toe] per capita versus the global average of 1.29 toe and the International Energy Agency average of 2.9) (IEA, 2020). The rapid growth in TFEC and in power generation to supply rising electricity demand has led to the rapid increase in total primary energy supply (TPES). From 2007 to 2017, TPES increased by 55%, largely fossil fuel (IEA, 2020).

India is fuelled by primary (coal and natural gas), secondary (electricity and petroleum products), and renewable energy sources. The energy mix is dominated by coal. Coal production was 728.72 million tonnes (MT) in 2018–2019. Coal has had a compound annual growth rate (CAGR) of 3.2% since 2009–2010, when production amounted to 532.04 MT. Production of crude oil in 2018–2019 was 34.2 MT, declining by a CAGR of 4.2% from 35.7 MT in 2017–2018. The CAGRs for natural gas and electricity were –3.61% and 6.49%, respectively, from 2009–2010 to 2018–2019. Electricity had the highest CAGR amongst all commercial sources of energy during the period (National Statistical Office, 2020).

In 2018–2019, the country produced 262.36 MT of petroleum products as against 254.4 MT in 2017–2018, an increase of 3.13%. In 2018–2019, high-speed diesel oil accounted for the biggest share (42.13%), followed by motor gasoline (14.50%). Net production of natural gas for consumption increased from 31.58 billion cubic metres (BCM) in 2017–2018 to 31.96 BCM in 2018–2019, registering growth of 1.18% (National Statistical Office, 2020).

The average quality of coal is not high, necessitating the import of high-quality coal for steel plants. Imported coal increased from 73.26 MT in 2009–2010 to 235.24 MT in 2018–2019, and exported coal decreased from 2.45 MT to 1.31 MT.

India is highly dependent on imported crude oil. It increased from 159.26 MT in 2009–2010 to 220.43 MT in 2017–2018 and by 2.75% to 226.50 MT in 2018–2019. The CAGR of imported crude oil was 3.6% from 2009–2010 to 2018–2019 (National Statistical Office, 2020).

Exported petroleum products increased by a CAGR of 1.8%, from 51.15 MT in 2009–2010 to 61.10 MT in 2018–2019. Exports in 2018–2019, however, declined by 8.58% from 2017–2018. Imported petroleum products declined by 5.96% in 2018–2019 compared with 2017–2018. They increased by a CAGR of 8.6%, however, from 14.67 MT in 2009–2010 to 33.35 MT in 2018–2019. Imported natural gas increased by a CAGR of 8.3%, from 12.92 BCM in 2009–2010 to 28.69 BCM in 2018–2019.

Exported electricity increased from 105 gigawatt hours (GWh) in 2009–2010 to 8,494 GWh in 2018–2019, improving by 17.9% compared with 2017–2018. Gross imported electricity decreased by a CAGR of 1.39% from 2009–2010 (5,359 GWh) to 2018–2019 (4,657 GWh). Net imported electricity declined from 2009–2010 to 2018–2019. For 3 consecutive years, net imported electricity declined; in 2018–2019, it declined by 80.08% compared with 2017–2018 (National Statistical Office, 2020).

Total installed electricity generation capacity increased by a CAGR of 8.05%, from 190.9 GW at the end of March 2010 to 414.1 GW at the end of March 2019. Electricity generation capacity increased by 3.8% to 414.1 GW in 2018–2019 from 398.9 GW in 2017–2018. Other renewable sources registered the highest rate of annual growth in installed capacity (12.5%) from 2017–2018 to 2018–2019, followed by thermal power (1.5%). Amongst thermal sources, installed diesel capacity fell the most, by 24%. Total installed capacity of power utilities increased by a CAGR of 8.37%, from 159.398 GW at the end of March 2010 to 356.1 GW at the end of March 2019. At the end of March 2019, thermal power plants accounted for an overwhelming 68.2% of total installed capacity, with installed capacity of 282.35 GW, compared with 69.2% at the end of March 2018.

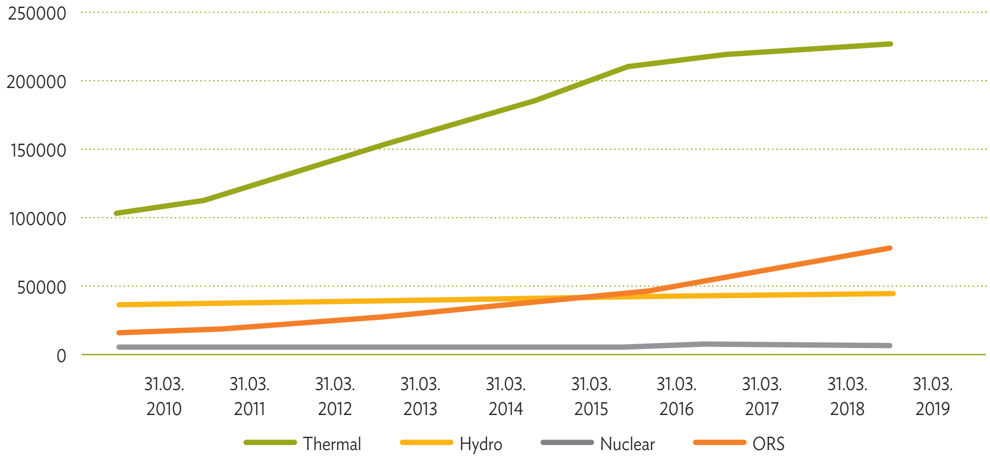
Other renewable sources (excluding hydro) had installed capacity of 79,522 GW in March 2019, accounting for 19.2% of total installed capacity, up from 17.7% as of March 2018. The shares of hydro and nuclear energy were only 10.97% and 1.64%, respectively, of total installed capacity as of March 2019. Non-utilities accounted for 14.01% (58.0 GW) of total installed electricity generation capacity (National Statistical Office, 2020).

Other renewable sources had the highest rate of annual growth in installed capacity, at 12.5%, from 2017–2018 to 2018–2019, followed by thermal power, at 1.5%. Amongst thermal sources, installed capacity of diesel power fell by 24%. Total installed capacity of power utilities increased by a CAGR of 8.37%, from 159.4 GW as of the end of March 2010 to 356.1 GW as of the end of March 2019. Thermal power plants accounted for 282.35 GW or 68.2% of total installed capacity as of the end of March 2019, compared with 69.2% as of the end of March 2018.

Other renewable sources (excluding hydro) had installed capacity of 79.5 GW or 19.2% of total installed capacity as of March 2019, higher than the 17.7% share as of the end of March 2018. The shares of hydro and nuclear energy were only 10.97% and 1.64%, respectively, of total installed capacity as of March 2019. Non-utilities accounted for 14.01% (58.0 GW) of total installed electricity generation capacity (National Statistical Office, 2020).

**Figure 6.1. Trends in Installed Electricity Generation Capacity from Utilities, 2009–2010 to 2018–2019**

(megawatts)




ORS = other renewable sources.

Source: National Statistical Office (2020).

Total installed capacity of grid-interactive renewable power was 69.78 GW as of the end of March 2018 and grew by 12.23% to 78.316 GW by the end of March 2019. Of total installed generation capacity of renewable power as of the end of October 2019, wind power accounted for about 45.5%, followed by solar power, including rooftop (36.0%), and biomass power (12.5%) (National Statistical Office, 2020).

# 3. Modelling Assumptions

GDP is assumed to grow from US$2.65 trillion (2010 prices) in 2017 to about US$16.32 trillion (2010 prices) in 2050, equivalent to 5.7% average annual growth rate. The population is assumed to grow at an average annual rate of 0.6% from 1.34 billion people in 2017 to about 1.64 billion in 2050. Coal will continue to have the largest share in electricity generation. Nuclear power plants and others, especially wind and solar, are projected to increase by 2050. Shares of oil and hydro are expected to decrease.

The implementation of energy efficiency programmes in power generation and energy end-use sectors is expected to attain India's energy-saving goals. Improvements in highly energy-intensive industries and in inefficient small plants can ensure energy saving in industry. In the residential and commercial sectors, significant saving can be induced through efficient end-use technologies and energy management systems. In transport, improved vehicle fuel economy and more effective traffic management are important to increase efficiency.

# 4. Outlook Results

### 4.1. Business as Usual Scenario

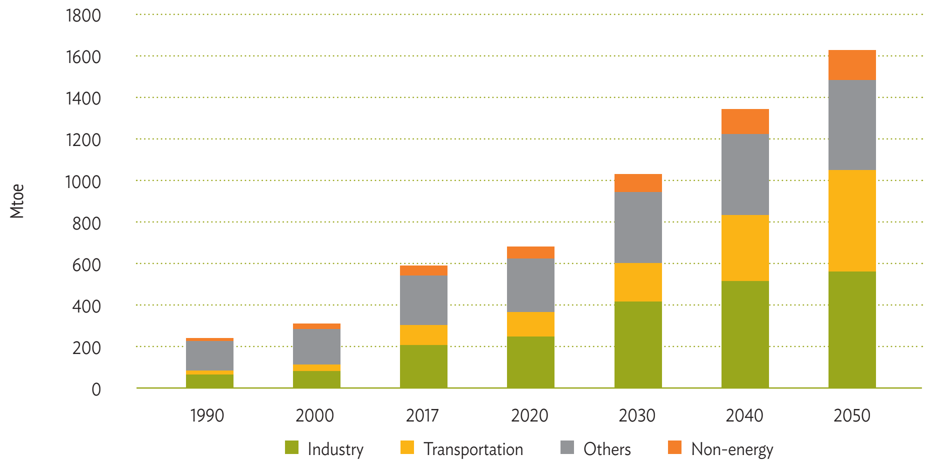
This section describes trends in energy production and utilisation, without any policy intervention, to reduce energy demand or carbon dioxide (CO2) emissions.

#### 4.1.1. Total Final Energy Consumption

Under the business as usual (BAU) scenario, with assumed strong economic growth and a rising population, TFEC is projected to increase at an average rate of 3.1% per year, from 591 million tons of oil equivalent (Mtoe) in 2017 to 1,631 Mtoe in 2050 (Figure 6.2). Strong growth is projected in transport and industry, at 5.0% and 3.1% per year, respectively, from 2017 to 2050. Strong growth is expected in non-energy consumption (3.6% per year). Due to the large share of non-commercial energy in final energy consumption, the growth rate of 'others', including the residential and commercial sectors, is projected to be modest, at 1.8% per year. However, residential and commercial consumption of energy, especially electricity, will increase rapidly.

The share of 'others', which was the largest, at 40.9% in 2017, will drop to 26.6% in 2050. The share of industry will remain at 34.7% in 2050, and that of transport will reach 29.8% in 2050 from 16.6% in 2017.

**Figure 6.2. Final Energy Consumption by Sector, Business as Usual**

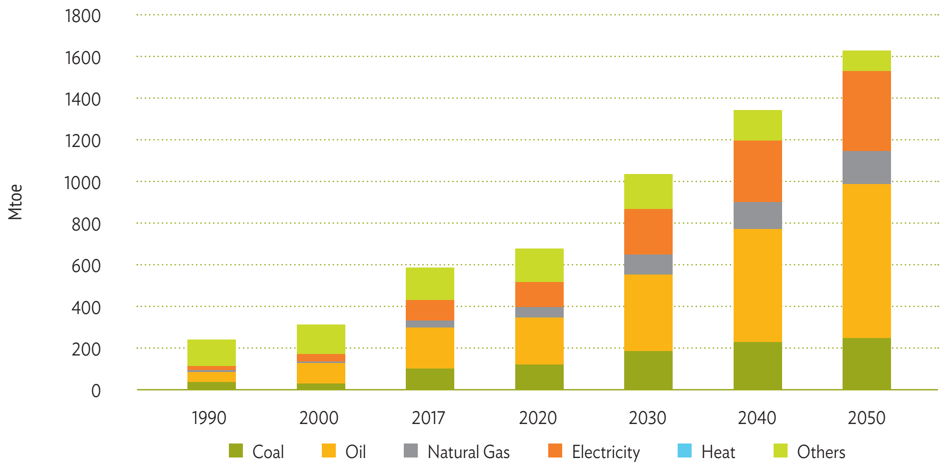



BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Authors.

Natural gas will grow the fastest, increasing by 4.7% per year in 2017–2050 (Figure 6.3). Oil and electricity demand will each grow at an average of 4.1% per year, whilst coal demand will increase by 2.8% per year. 'Others' with grow by –1.4%.

**Figure 6.3. Final Energy Consumption by Fuel, Business as Usual**




Mtoe = million tons of oil equivalent.

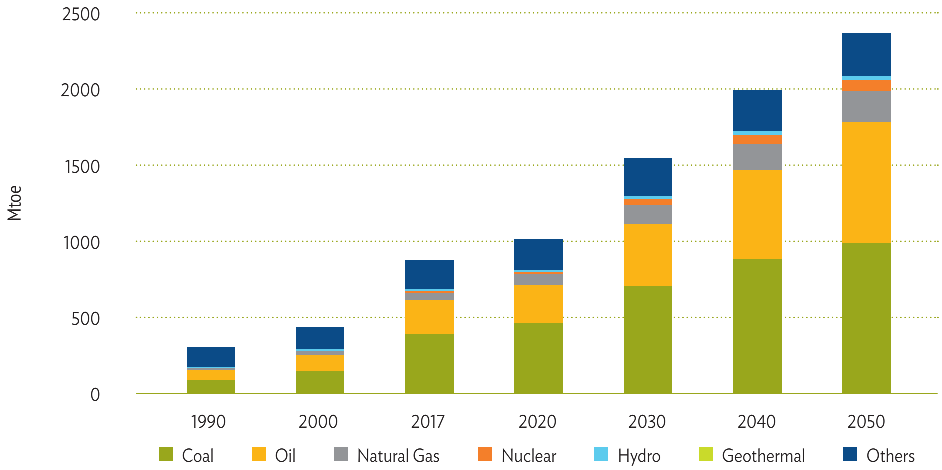
Source: Authors.

### 4.1.2. Primary Energy Supply

Under BAU, primary energy demand will increase by an average annual rate of 3.0%, to 2,368 Mtoe in 2050 from 882 Mtoe in 2017. Coal demand, driven by demand for power generation, will grow by 2.9% per year and reach 990 Mtoe in 2050, from 391 Mtoe in 2017, maintaining the largest share at 41.8% in 2050 (44.3% in 2017). Due to rapid motorisation, oil demand will increase to 792 Mtoe and will have the second-largest share at 33.5% in 2050. The average annual growth rate for oil demand in 2017–2050 will be 3.9%. Natural gas consumption is expected to increase by 4.4% per year in 2017–2050. Its share will be 8.9% in 2050, up from 5.8% in 2017.

Of 'others', solar and wind will increase significantly due to negative growth of non-commercial biomass, which has the largest portion, projected at –0.3% a year through to 2050. Its share will drop to 7.1% in 2050 from 21.2% in 2017. Figure 6.4 shows projected primary energy demand from 1990 to 2050 under BAU.

**Figure 6.4. Primary Energy Supply by Source, Business as Usual**



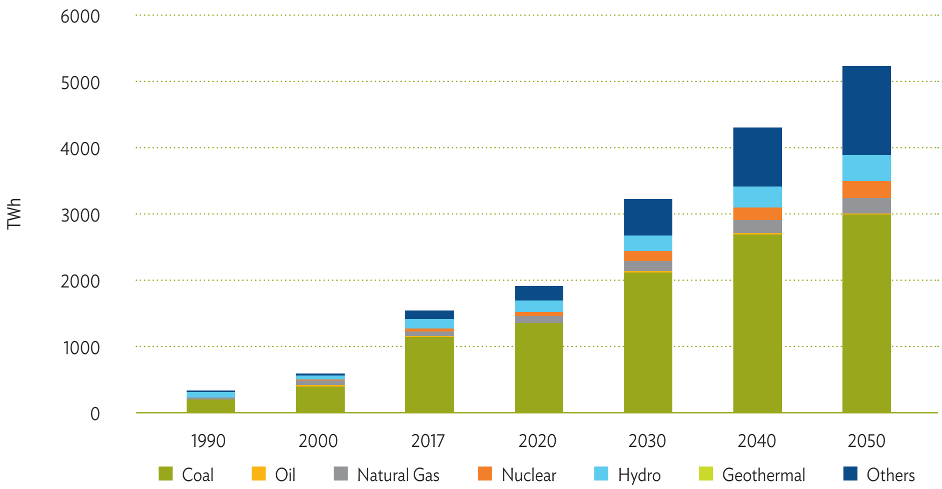

BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Authors.

### 4.1.3. Power Generation

In 2017, power generation was 1,532 TWh. Under BAU, power generation will increase by an annual rate of 3.8% to 5,240 TWh in 2050. Coal will continue to dominate the power generation mix, but its share will gradually drop from 74.0% in 2017 to 57.1% in 2050. Hydro's share in the power generation mix will decline from 9.3% in 2017 to 7.3% in 2050, and oil's share will decline from 1.6% in 2017 to 0.2% in 2050. The share of nuclear power will increase from 2.5% to 4.7%, and 'others', including wind and solar power, will increase from 8.0% to 26.0%. The share of natural gas will grow by an average of 3.9% per year in 2017–2050 to 4.7% in 2050. Figure 6.5 shows projected power generation from 1990 to 2050 under BAU.

**Figure 6.5. Electricity Generation, Business as Usual**




BAU = business as usual, TWh = terawatt-hour.

Source: Authors.

### 4.1.4. Carbon Dioxide Emissions

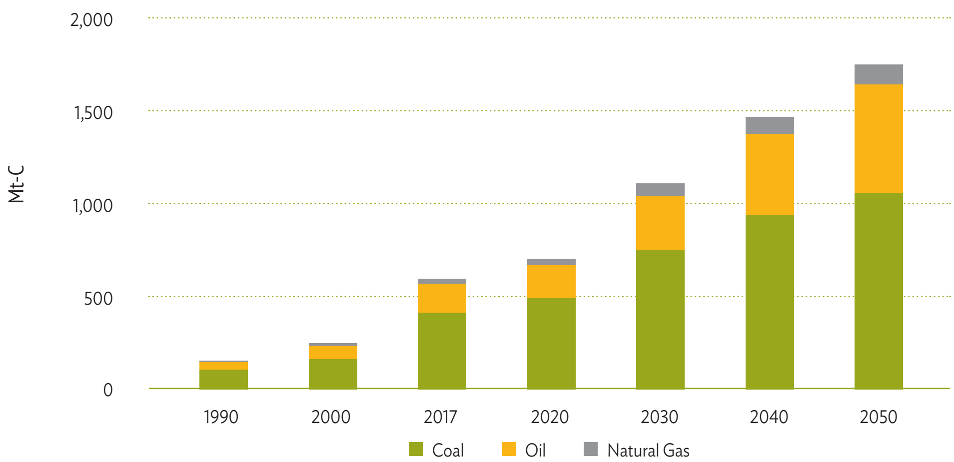
In 2017, CO2 emissions from the energy sector were 589 million tons of carbon (Mt-C). Under BAU, CO2 emissions will increase by 3.4% per year to 1,750 Mt-C in 2050. Coal is the main source of CO2 emissions, which will rise by 2.9% per year, from 412 Mt-C in 2017 to about 1,055 Mt-C in 2050. CO2 emissions from oil will increase by 4.1% annually, from 157 Mt-C in 2017 to 590 Mt-C in 2050, whilst emissions from natural gas will increase by 5.1% per year, from 20 Mt-C to 105 Mt-C. In 2050, coal will account for about 60.3% of total energy CO2 emissions, followed by oil, with a share of 33.7%. The remaining 6.0% will come from natural gas.

Figure 6.6 shows the projected energy-related CO2 emissions from 1990 to 2050 under BAU.

### 4.2. Energy-Saving and Carbon Dioxide Reduction Potential

This section describes the energy-saving and CO2 mitigation potential of five alternative policies: APS1 – improved efficiency in final energy demand, APS2 – more efficient thermal power generation, APS3 – high contribution of renewable energy to total supply, APS4 – use of nuclear energy, and APS5 – a combination of APS1 to APS4.

**Figure 6.6. Carbon Dioxide Emissions, Business as Usual**



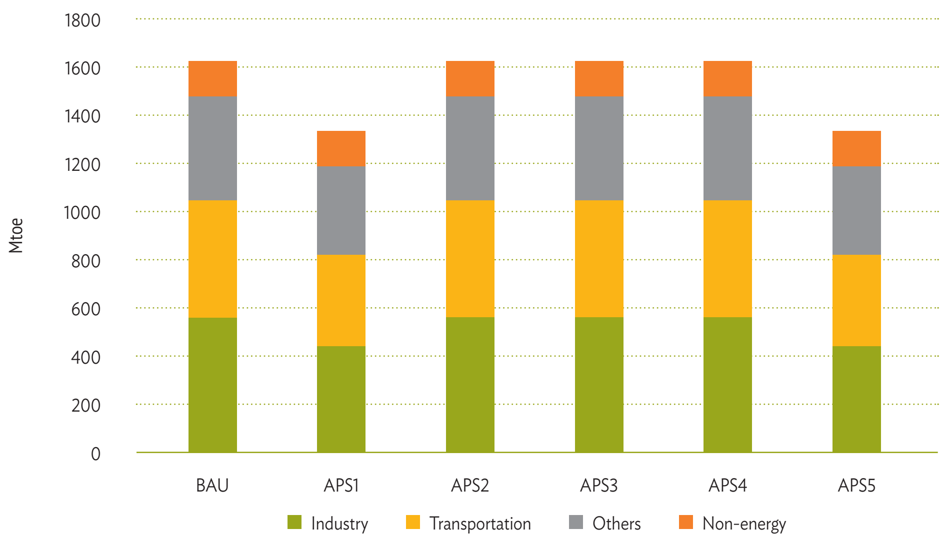

BAU = business as usual, Mt-C = million tons of carbon.

Source: Authors.

### 4.2.1. Final Energy Consumption

TFEC under APS2, APS3, and APS4 will be the same as under BAU (1,631 Mtoe in 2050) since they have no energy saving targets. Under APS1 and APS5, where efficiency is improved in final energy demand, TFEC will be lower, at 1,338 Mtoe in 2050 (Figure 6.7).

**Figure 6.7. Final Energy Consumption, Alternative Policy Scenario**

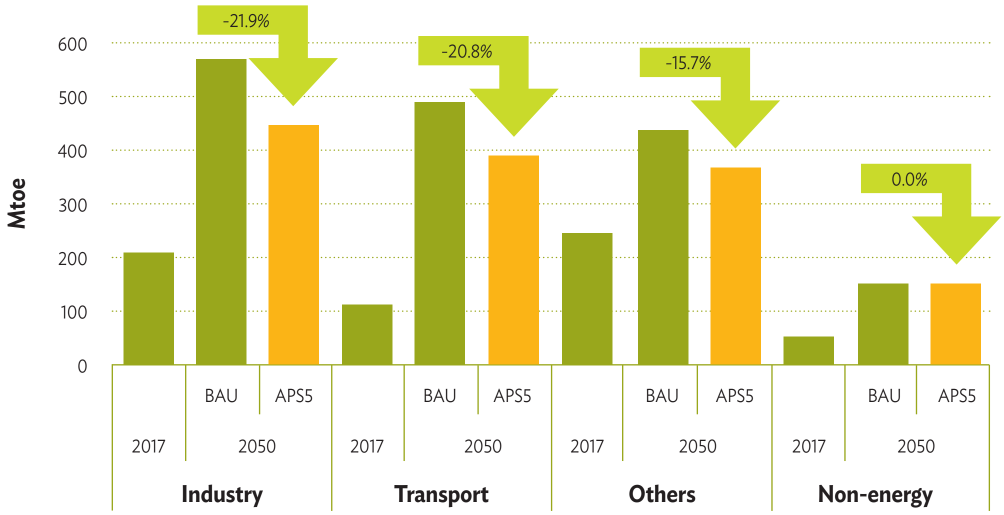



APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Authors.

Under APS1 and APS 5, TFEC will be 17.9% lower than under BAU in 2050. Final energy consumption is expected to decrease across all end-use sectors, reflecting improvements in end-use technologies and the introduction of energy management systems (Figure 6.8). In 2050, under APS5 relative to BAU, savings are estimated at 123 Mtoe (21.9%) in industry, 101 Mtoe (20.8%) in transport, and 68 Mtoe (15.7%) in 'others'.

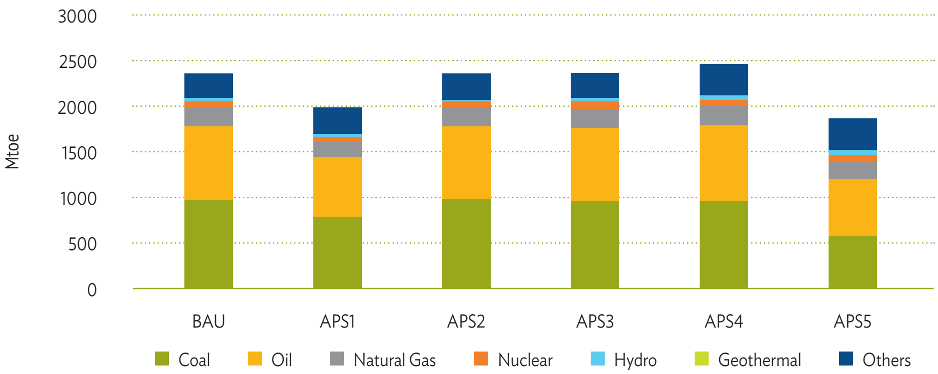
**Figure 6.8. Final Energy Consumption, Business as Usual and Alternative Policy Scenario 5**




APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.

Source: Authors.

**Figure 6.9. Primary Energy Supply by Source, Alternative Policy Scenario**




APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.

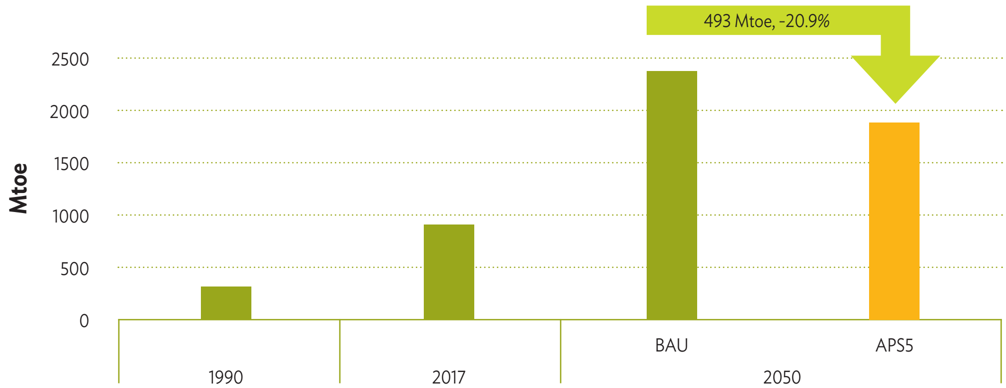
Source: Authors.

#### 4.2.2 Primary Energy Supply

By 2050, total primary energy supply under APS1, APS2, APS3, APS4, and APS5 will be 1,984, 2,364, 2,373, 2,471, and 1,875 Mtoe, respectively (Figure 6.9). TPES under APS1 and APS5 will be lower than under BAU because of improved efficiency measures in the final sector. Under APS2, TPES will be lower than under BAU due to improved thermal efficiency of thermal power generation. TPES under APS3 and APS4 will be higher than under BAU as more renewable and nuclear energy enter the power supply mix by 2050.

Under APS5, relative to BAU, primary energy supply is projected to decrease by 493 Mtoe or 20.9% (Figure 6.10).

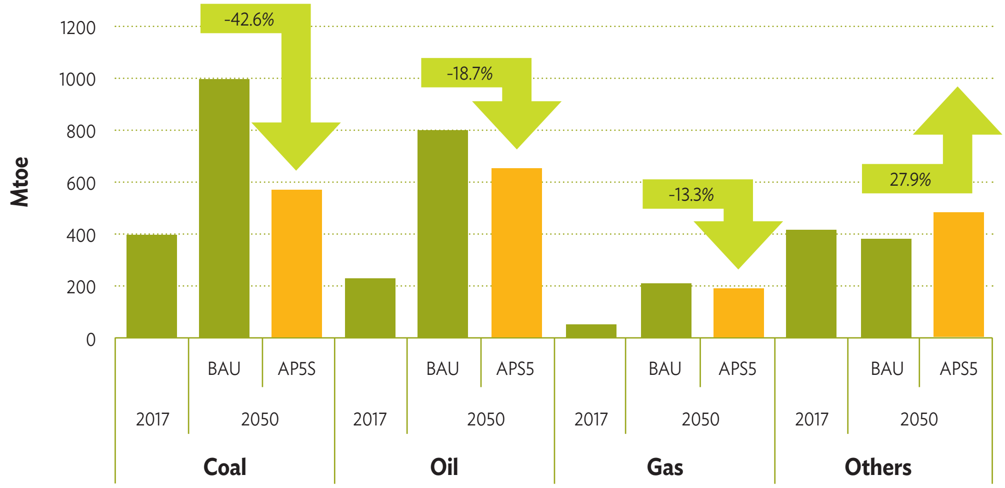
**Figure 6.10. Total Primary Energy Supply, Business as Usual and Alternative Policy Scenario 5**




APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.
Source: Authors.

Under APS5, compared with BAU, in 2050 (Figure 6.11), coal supply will decrease by 421.6 Mtoe or 42.6%, whilst oil supply will drop by 148.5 Mtoe or 18.7%. Natural gas supply will fall by 28.1 Mtoe or 13.38%. However, supply for 'others', driven by strong demand for renewables (wind and solar), will rise by 27.9% or 104.8 Mtoe.

**Figure 6.11.** **Total Primary Energy Supply by Fuel, Business as Usual and Alternative Policy Scenario 5**




APS = alternative policy scenario, BAU = business as usual, Mtoe = million tons of oil equivalent.

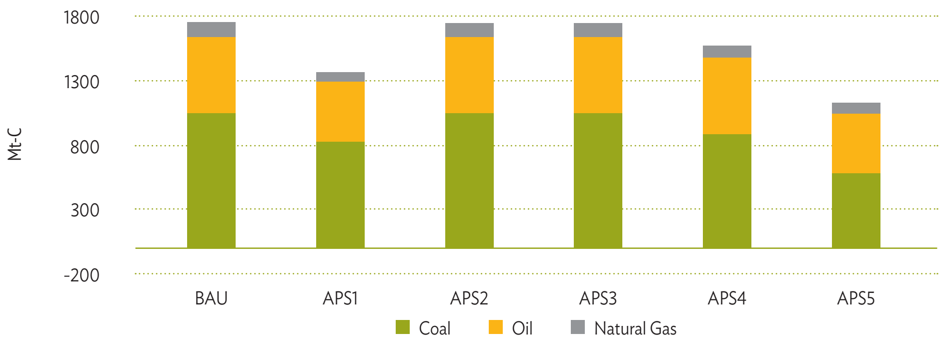
Source: Authors.

### 4.2.3. Carbon Dioxide Emissions from Energy Consumption

By 2050, CO2 emissions under APS1, APS2, APS3, APS4, and APS5 will be 1,361, 1,750, 1,750, 1577 and 1,129 Mt-C, respectively, compared with 1,750 Mt-C under BAU (Figure 6.12).

Under APS5, CO2 emissions in 2050 will be 1,129 Mt-C, 35.5% lower than under BAU. Less demand for coal in industry and power generation and for oil in transport contribute most to reduced CO2 emissions. Figure 6.13 shows CO2 emissions in 2050 under BAU versus APS5.

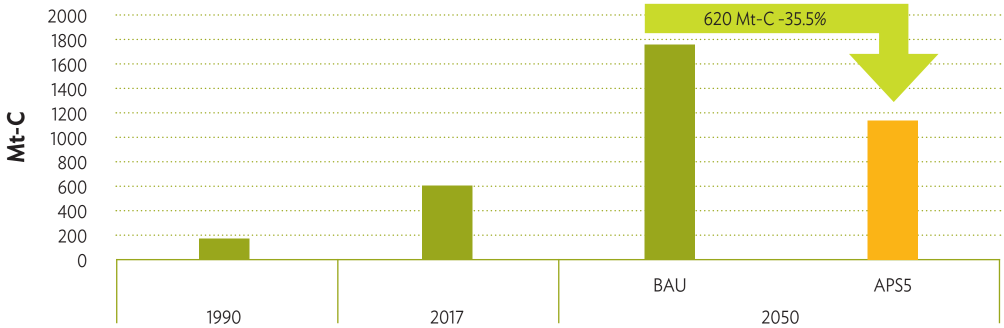
**Figure 6.12.** **Carbon Dioxide Emissions from Energy Combustion, Business as Usual and Alternative Policy Scenario**




APS = alternative policy scenario, BAU = business as usual, Mt-C = million tons of carbon.

Source: Authors.

Figure 6.13. Carbon Dioxide Emissions from Energy Combustion, Business as Usual and Alternative Policy Scenario 5




APS = alternative policy scenario, BAU = business as usual, Mt-C = million tons of carbon.

Source: Authors.

## 5. Implications

(i) Energy security and access to energy are key challenges. Enhanced domestic production of energy is necessary to meet them. The Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya), which aims to provide last-mile connectivity and electricity connections to all rural and urban households, must be improved and sustained. The Pradhan Mantri Ujjwala Yojana (PMUY) programme, which aims to provide free liquefied petroleum gas connections from oil marketing companies to women belonging to below-poverty-line households, must be strengthened.

(ii) Electric mobility will be key to decarbonising transport. Concerted efforts are needed to realise the National Electric Mobility Mission Plan 2020, the Scheme for Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles in India (FAME India), and the EV@30 campaign.

(iii) Hydrocarbons, particularly coal, will continue to dominate the energy mix under BAU and APS. Domestic coal for secure supply and more-efficient coal technologies such as ultra-supercritical coal power plants, amongst others, must be used. In the long and medium terms, cleaner energy research and development will play a key role.

(iv) Natural gas will play an important role in energy supply and CO2 mitigation. To fully utilise increasing global natural gas production, the infrastructure to import, domestically transport, and utilise natural gas must be upgraded.

(v) The government has announced ambitious targets for renewable energy, but the cost and infrastructure will be the bottleneck. Developing domestic manufacturing capacity can play an important role in this regard.. The variability of renewable energy supply remains a key challenge, but it can be tackled by quickly realising One Sun One World One Grid (OSOWOG), which encompasses the phased development of a single, globally connected solar electricity grid to leverage solar energy's multiple benefits (low cost, zero pollution). OSOWOG's underlying logic is that a grid spread across multiple time zones can balance intermittent renewables with other renewables: the setting sun in one part of the grid is made up for by solar, wind, or hydro energy produced elsewhere. Energy cooperation with East Asian countries will play a key role in this regard.

(vi) Energy efficiency and demand-side management are important. New power plants, new factories, new buildings, new appliances, and new cars should be more efficient. Minimum energy performance standards and mandatory energy labels should be expanded to cover more equipment.

a. Potential saving in the power sector is huge. Advanced technologies for power generation should be used as much as possible.

b. Industry has significant potential for energy saving. Energy efficiency programmes should, therefore, focus on this sector by, amongst others, broadening the scope of the perform, achieve, trade (PAT) scheme.

c. Growth of energy consumption in transport should be curtailed.

d. Losses in electricity distribution should be minimised by using better technologies.

(vii) Energy prices across fuels and sectors must be rationalised.

(viii) Through its nationally determined contribution (NDC), India pledges to reduce emissions intensity by 33%–35% by 2030 under APS5 from 2005 levels. India is on course to achieve its NDC and can make more climate commitments when significant progress has been made.

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