CHAPTER 6

INDIA COUNTRY REPORT[a,b]

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1. Country Brief

India, also called the Republic of India, is a country in South Asia and occupies an area of around 3.1 million square kilometres. It is the seventh-largest country by area, the second-most populous country (with over 1.2 billion people), and the most populous 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.

Its climate comprises a wide range of weather conditions across a vast geographic scale and varied topography, making generalisations difficult. Based on the Köppen system, India hosts six major climatic subtypes, ranging from 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.

According to the International Monetary Fund (IMF, 2018), India's economy in 2017 was nominally worth US$2.611 trillion. It is the sixth-largest economy by market exchange rate, and the third-largest by purchasing power parity (PPP) at US$9.459 trillion. With its average annual gross domestic product (GDP) growth rate of 5.8% over the past 2 decades and reaching 6.1% in 2011–2012, India is one of the world's fastest-growing economies. However, the country ranks 140th in the world in nominal GDP per capita and 129th in GDP per capita at PPP. Despite economic growth during recent decades, India continues to face socio-economic challenges, such as poverty and modern energy access.

[a] Based on model run and broad assumptions by The Institute of Energy Economics, Japan, with inputs provided by TERI School of Advanced Studies.

[b] Unless otherwise specified, the information in figures come from the results of the model run.

2. Energy Situation

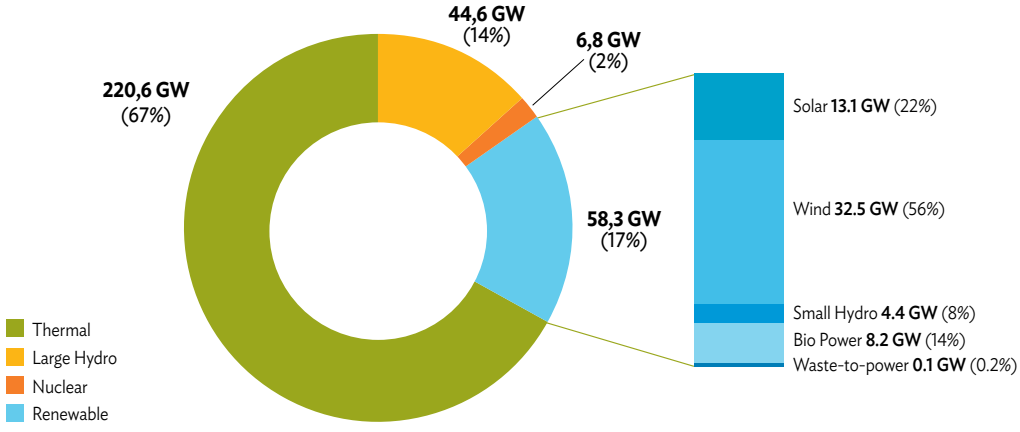
Energy systems in India have evolved over the last 6 decades along with the country's economic development, supporting the aspiration of 1.2 billion people within the framework of democratic polity, a globally integrated economy, and an environmentally sensitive regime. The ever-increasing demand of energy has posed tremendous pressure on its limited resources and has necessitated optimum use of its resources. India has pursued a reformed development agenda since 1991. Significant effort has gone into improving energy availability to support the country's development initiatives.

India is fuelled by primary (coal and lignite, natural gas), secondary (electricity and petroleum products), and renewable energy sources. India's energy mix is dominated by coal. Coal forms the largest source of primary energy in India, accounting for around 50% of the total primary energy supply (GoI, 2017). Coal production has witnessed an upward trend. It was about 430.83 million tons (MTs) in 2006–2007, and increased to 639.23 MTs in 2015–2016 with a compound annual growth rate (CAGR) of 4.02%. Production of crude petroleum increased from 33.99 MTs in 2006–2007 to 36.95 MTs in 2015–2016, a CAGR of about 0.84%.

Crude oil imports increased by 10 MT, although the value of imports fell for the second year in a row. The total share of imported crude oil in India's total supply was 84.3% in 2015/16. India's refining capacity increased to 230 MT per annum (MMTPA) owing to the commissioning of the Paradip refinery in Odisha, with a capacity of 15 MMTPA. The production of natural gas declined for the fifth year in a row to 32.2 billion cubic metres in 2015/16. Imports of liquefied natural gas grew to 19.95 MT in 2015/16. Import dependency of natural gas stands at 46%.

As of 31 January 2017, the total installed capacity of the power sector in India was 330 gigwatts (GW), with thermal power having the largest share of 67% in total installed capacity (Figure 6.1).

Figure 6.1: Grid Power Sources (GW) and their Percentage Shares up to June 2017



GW = gigawatt.

Sources: CEA (2017a), MNRE (2017).

The all-India gross electricity generation from utilities, excluding that from captive generating plants, was 670,654 gigawatt-hours (GWh) in 2006–2007. It rose to 1,116,850 GWh in 2014–2015 (CSO, 2017). During 2015–2016, the production of electricity from utilities has further increased to 1,167,584 GWh, registering an annual growth rate of about 4.54%. Total electricity generation in the country from utilities and non-utilities in 2015–2016 was 1,335,956 GWh. Out of the total electricity generated through utilities, 943,013 GWh was generated from thermal, 121,377 GWh was from hydro, and 37,414 GWh was generated from nuclear sources. Total output from non-utilities was 168,372 GWh.

As of June 2017, the cumulative installed capacity from renewable sources was 58.3 GW in India, which was 17% of the total installed capacity of 330 GW. Currently, India ranks sixth worldwide in renewable energy capacity (REN21, 2017). The current installed nuclear power capacity of the country is 5,780 MW, and it is expected to increase to 10,080 MW by 2019. India is ranked 12th in terms of power generation from nuclear sources as per data published in May 2015 by the Power Reactor Information System of the International Atomic Energy Agency (IAEA). India has signed nuclear agreements with the United States (US), France, Russia, Namibia, Mongolia, Republic of Korea, Argentine Republic, United Kingdom, Republic of Kazakhstan, Canada, Sri Lanka, and Australia (PIB, 2015). India's installed capacity of hydro was 44,189.43 MW as of 31 January 2017 (CEA, 2017b). Of the all-India target of 10,897 MW under the Twelfth Five-Year Plan, 3,311.02 MW of hydro capacity has been achieved (as of August 2015).

India's final energy consumption has increased more than seven times since 1980, with the industry sector consuming the largest amount of energy. In 2015–2016, the industry sector accounted for about 52% of final energy consumption. This is followed by the transport sector (24%), and then the residential and commercial sectors (17%). The agriculture sector accounts for the least share of final commercial energy demand during the same period.

3. Modelling Assumptions

India's GDP is assumed to grow from US$ 2.29 trillion of 2010 in 2015 to around US$ 11.49 trillion of 2010 in 2040, equivalent to 6.5% and 6.7% average annual growth rates in 2015 and 2040, respectively. The population is assumed to grow at an average annual rate of 0.9% from 1.31 billion persons in 2015 to around 1.61 billion persons in 2040. Regarding future electricity supply, coal share in electricity generation will continue to be the largest. Meanwhile, nuclear power plants and others, especially wind and solar, are projected to increase to 2040. On the other hand, the shares of oil and hydro are expected to decrease.

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

4. Outlook Results

4.1. Business-As-Usual (BAU) Scenario

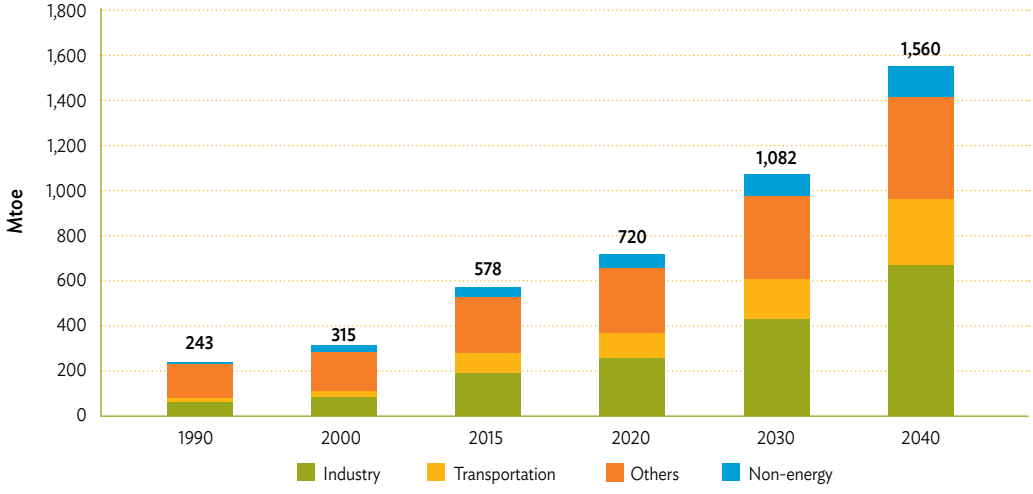
This section describes the current trend of energy production and utilisation in the country, without any policy intervention, aimed at reducing energy demand or CO_2 emissions.

4.1.1. Total final energy consumption

Under the BAU scenario, with assumed strong economic growth and a rising population, India's final energy demand is projected to increase at an average rate of 4.1% per year, from 578 million tons of oil equivalent (Mtoe) in 2015 to 1,560 Mtoe in 2040 (Figure 6.2). The strong growth is projected to occur in the transport and the industry sectors, increasing at 5.1% a year between 2015 and 2040. Strong growth is also expected in non-energy consumption (4.8% a year). Due to the large share of non-commercial energy in the final energy consumption, the growth rate of the 'others' sector that includes residential and commercial sectors is projected to be modest at 2.3% per year. However, in the residential and commercial sectors, the consumption of commercial energy, especially electricity, will increase rapidly.

The share of 'others' which is the largest at 43% in 2015, will drop to 28.3% in 2040. Meanwhile, the share of industry will increase to 43.1% in 2040 from 33.7% in 2015, and that of transport will reach 19% in 2040, from 14.9% in 2015.

Figure 6.2: Final Energy Consumption by Sector, BAU (1990–2040)

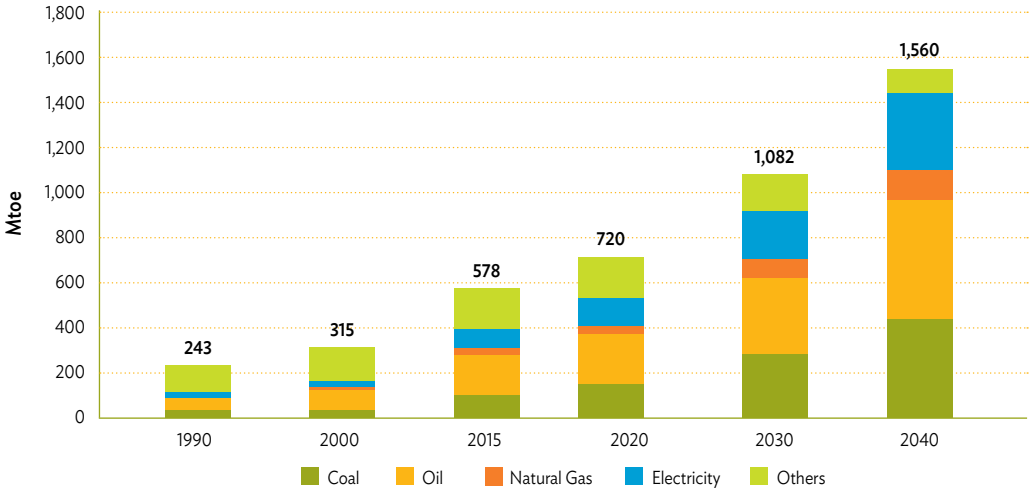


BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

In the final energy consumption by source, natural gas will have the fastest growth, increasing by 6.1% per year over the period 2015–2040 (Figure 6.3). Coal demand will have the second highest increase of 5.8% a year, followed by electricity (5.4% per year) and then oil (4.7% per year).

Figure 6.3: Final Energy Consumption by Fuel Type (1990–2040)



Mtoe = million tons of oil equivalent.

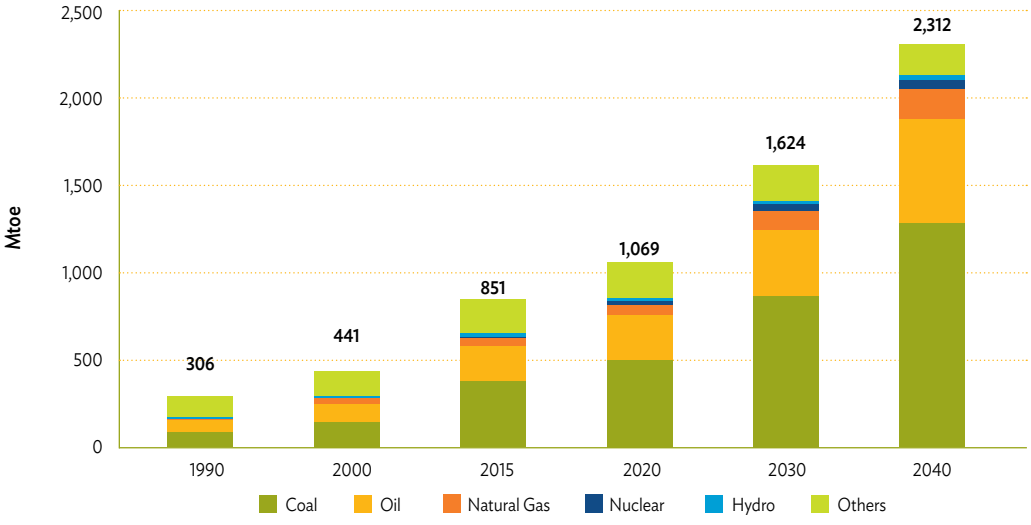
Source: Model results.

4.1.2. Primary energy supply

Under the BAU scenario, India's primary energy supply will increase at an average annual rate of 4.1% to 2,312 Mtoe in 2040 from 851 Mtoe in 2015. Coal demand, driven by the demand of power generation, will grow at 5% per year and reach 1,290 Mtoe in 2040, from 379 Mtoe in 2015, maintaining the largest share at 56% in 2040 (45% in 2015). Due to rapid motorisation, oil will increase to 592 Mtoe and will have the second-largest share at 26% in 2040. The average annual growth rate for oil demand in 2015–2040 would be 4.3%. Natural gas consumption is expected to increase by 5.8% per year between 2015 and 2040. Its share will be 7.6% in 2040, 2.5 percentage points up from 5.1% in 2015. Figure 6.4 shows the projected primary energy supply in India from 1990 to 2040 under the BAU scenario.

Within 'others', solar and wind will increase significantly. However, due to the negative growth of non-commercial biomass, which has the largest portion, 'others' is projected to decrease by 0.5% a year through to 2040. Its share will drop to 7.7% from 23.4% in 2015.

Figure 6.4: Primary Energy Supply by Source, BAU (1990–2040)



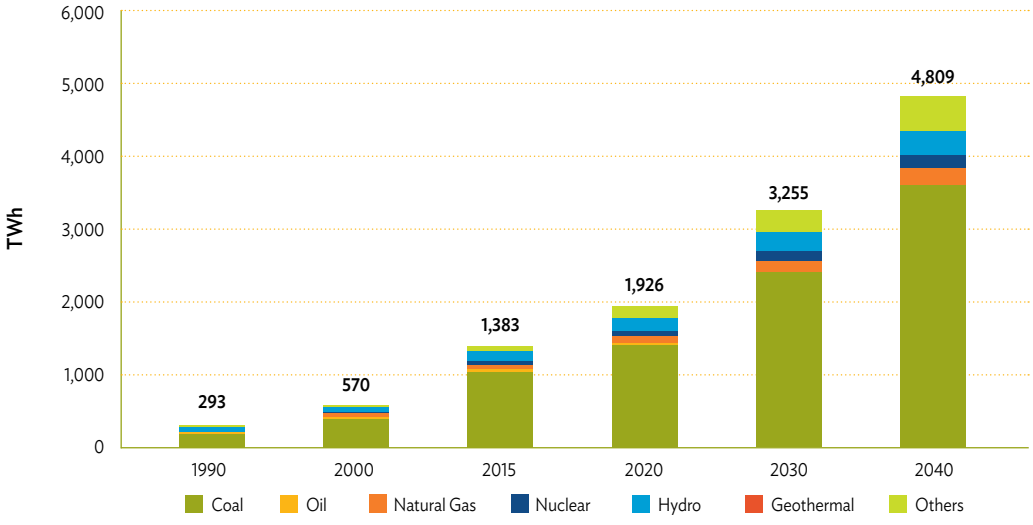
BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

4.1.3. Power generation

In 2015, power generation in India was 1,383 terawatt-hours (TWh). Under the BAU scenario, it will be increasing at the rate of 5.1% per year to 4,809 TWh in 2040. Coal will continue to dominate India's power generation mix; however, the share will slightly drop from 75.3% in 2015 to 74.8% in 2040. Hydro's share in India's power generation mix will decline from 10% in 2015 to 6.7% in 2040, and oil's share will decline from 1.7% in 2015 to 0% in 2040. In contrast, the share of nuclear power will increase from 2.7% to 3.9%, and 'others', including wind and solar power, will increase from 5.4% to 9.8%. The share of natural gas will be 4.7% in 2040, and the average growth rate during 2015–2040 will be 5% per year. Figure 6.5 shows the projected power generation in India from 1990 to 2040 under the BAU scenario.

Figure 6.5: Electricity Generation, BAU (1990–2040)



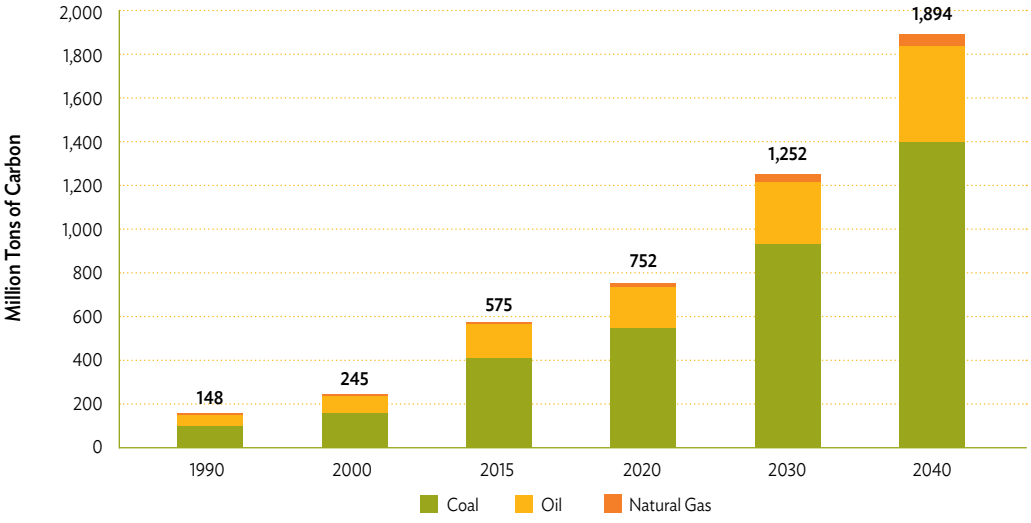
BAU = Business-As-Usual, TWH = terawatt-hour.

Source: Model results.

4.1.4. CO_2 emissions

In 2015, CO_2 emissions from India's energy sector were 575 million tons of carbon (Mt-C). Under the BAU scenario, CO_2 emissions will be increasing at an annual rate of 4.9% to 1,894 Mt-C in 2040. Coal is the main source of CO_2 emissions in India. CO_2 emissions from coal will rise at an annual rate of 5% from 409 Mt-C in 2015 to about 1,393 Mt-C in 2040. CO_2 emissions from oil will increase by 4.4% annually, from 151 Mt-C in 2015 to 441 Mt-C in 2040, while emissions from natural gas will increase at a rate of 5.6% from 15 Mt-C to 59 Mt-C during the same period. In 2040, coal will account for around 73.5% of total energy CO_2 emissions, followed by oil with a share of 23.3%; the remaining 3.2% comes from natural gas. Figure 6.6 shows the projected energy-related CO_2 emissions in India from 1990 to 2040 under the BAU scenario.

Figure 6.6: CO_2 Emissions under BAU (1990–2040)



BAU = Business-As-Usual.

Source: Model results.

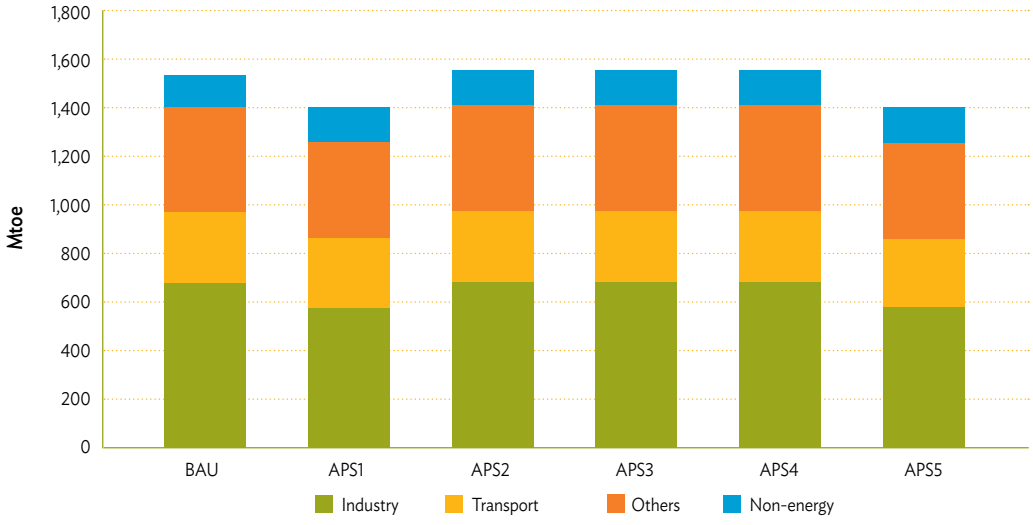
4.2. Energy Saving and CO_2 Reduction Potential

This section describes the energy saving and CO_2 mitigation potential of different energy policies. Five alternative policy scenarios (APS) are considered and have been tagged as APS1, APS2, APS3, APS4, and APS5. APS1 is a scenario of improved efficiency in final energy demand. APS2 deals with more efficient thermal power generation. APS3 assumes a high contribution of renewable energy to total supply. APS4 involves the use of nuclear energy in the total supply, and APS5 is a combined effect of APS1, APS2, APS3, and APS4.

4.2.1 Final energy demand

Total final energy consumption by 2040 in APS1, APS2, APS3, APS4, and APS5 will be 1400, 1560, 1560, 3121, and 1400 Mtoe, respectively. This implies that only APS1 and APS5 can potentially reduce energy demand. (Figure 6.7). It may be observed that the final energy demand of APS2 and APS3 are the same with the BAU scenario.

Figure 6.7: Final Energy Consumption under APSs



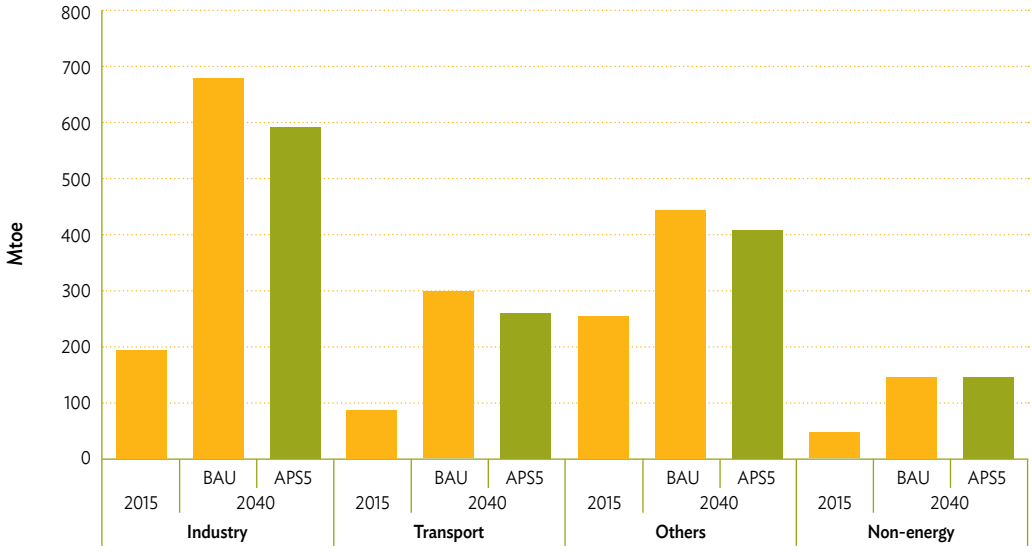
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

Under APS5, final energy demand is projected to decrease by 10.3% in 2040 compared to the BAU scenario. The reduction in energy demand is expected to occur across all end-use sectors, reflecting improvements in end-use technologies and the introduction of energy management systems (Figure 6.8).

In 2040, under APS5 relative to the BAU scenario, are estimated savings of 82 Mtoe (12.2%) in the industry sector, 40 Mtoe (13.4%) in the transport sector, and 38 Mtoe (8.5%) in the 'others' sector.

Figure 6.8: Final Energy Consumption, BAU vs APS5 (2015 and 2040)



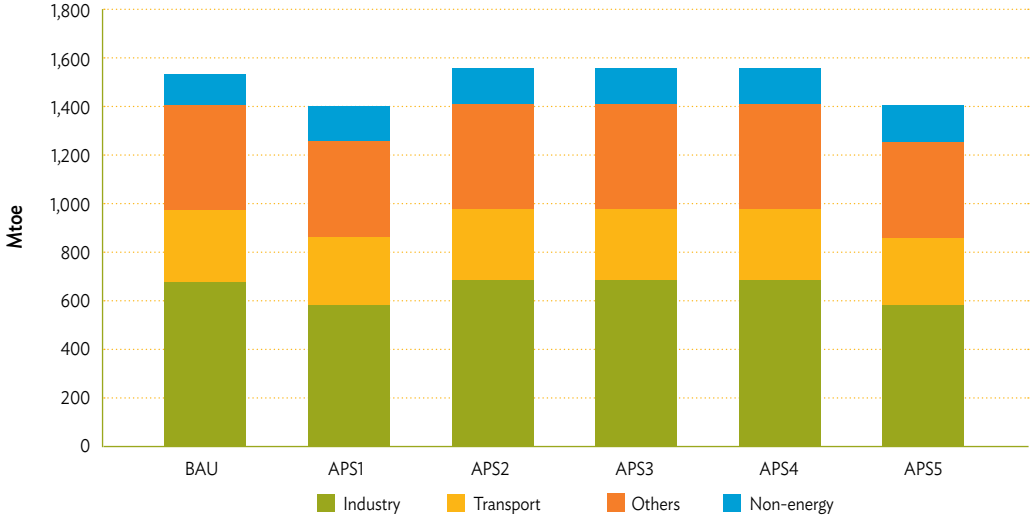
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

4.2.2 Primary energy demand

By 2040, primary energy demand in APS1, APS2, APS3, APS4, and APS5 will be 2057, 2245, 2276, 2115, and 1973 Mtoe, respectively (Figure 6.9). The results indicate that primary energy supply in 2040 will reduce in APS1, APS2, APS3, and APS5 compared to the BAU scenario. Analysis shows that primary energy demand in APS4 will be higher than the BAU scenario.

Figure 6.9: Primary Energy Supply by Sectors, BAU vs APS5

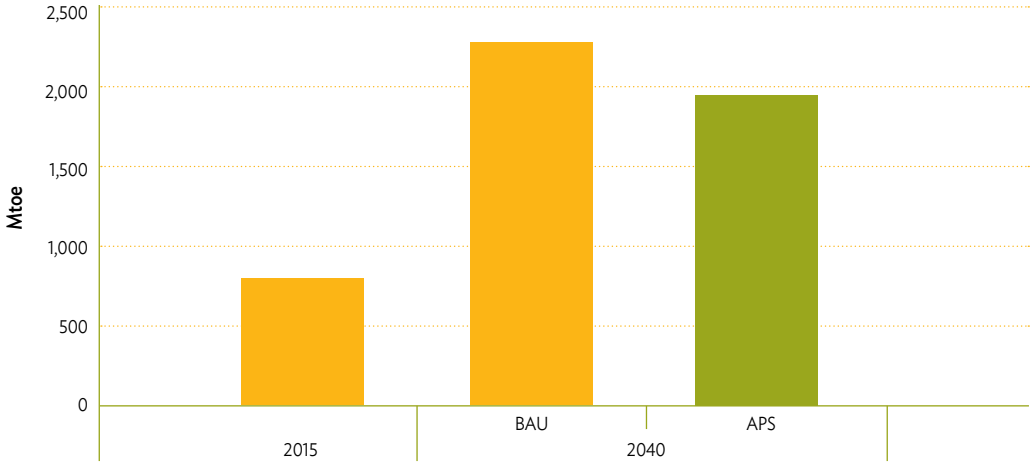


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

Under APS5 relative to the BAU scenario, India's primary energy demand is projected to decrease by 339 Mtoe or 14.7% (Figure 6.10).

Figure 6.10: Total Primary Energy Supply, BAU vs APS5 (2015 and 2040)

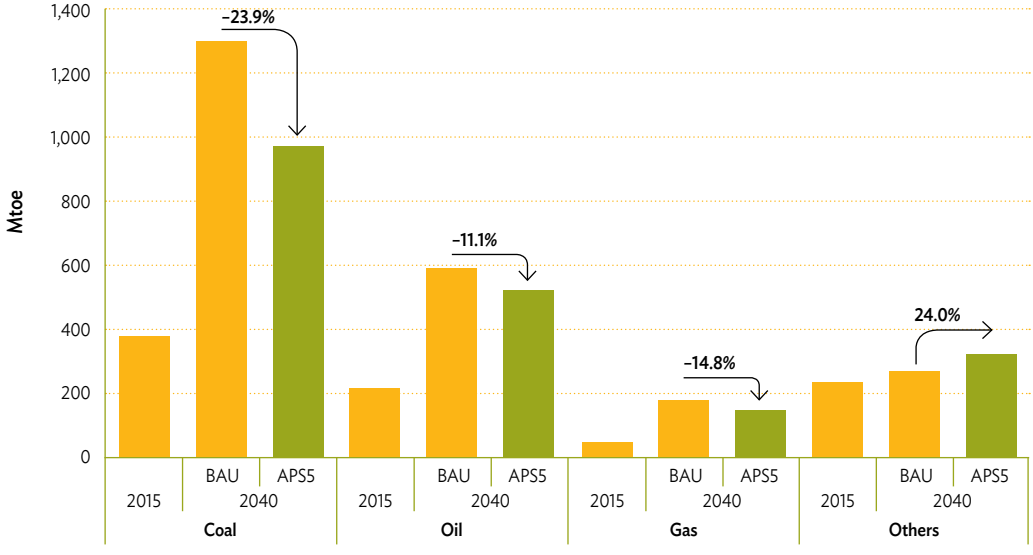


APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

In APS5 in 2040 (Figure 6.11), coal consumption will decrease by 308 Mtoe or 23.9% while oil demand will drop by 66 Mtoe or 11.1%. The demand for natural gas is seen to fall by 26 Mtoe (14.8%). However, the demand for 'others', driven by strong demand for renewables (wind and solar), is observed to rise by 59.4% or 61 Mtoe.

Figure 6.11: Total Primary Energy Supply by Fuel Type, BAU vs APS5 (2015 and 2040)



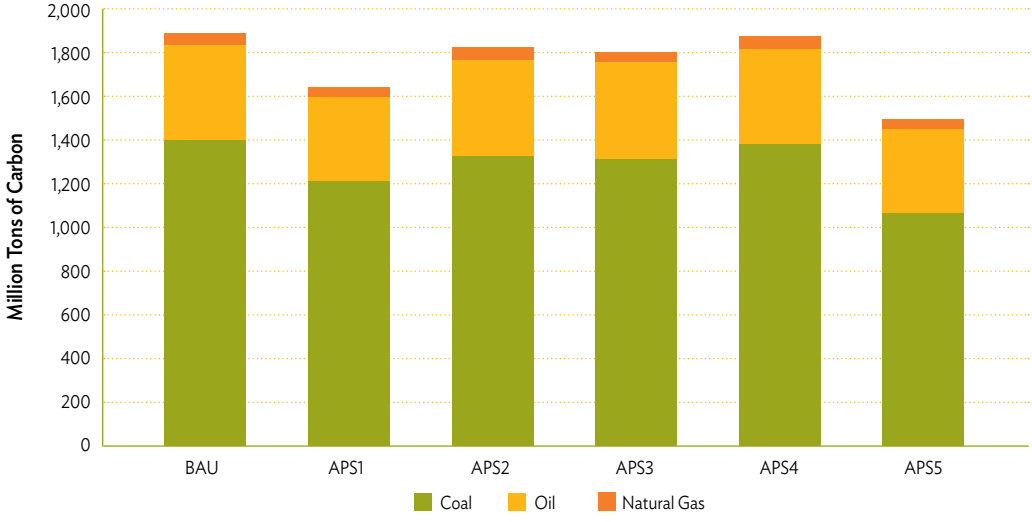
APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mtoe = million tons of oil equivalent.

Source: Model results.

4.2.3. CO_2 emissions from energy consumption

By 2040, CO_2 emissions in APS1, APS2, APS3, APS4, and APS5 will be 1646, 1824, 1807, 1874, and 1489 Mt-C, respectively, compared to 1,984 Mt-C in the BAU scenario. The results indicate that CO2 emissions in 2040 will decrease by 405 Mt-C in APS5 compared to the BAU scenario (Figure 6.12).

Figure 6.12: CO_2 Emissions from Energy Combustion, BAU vs APSs

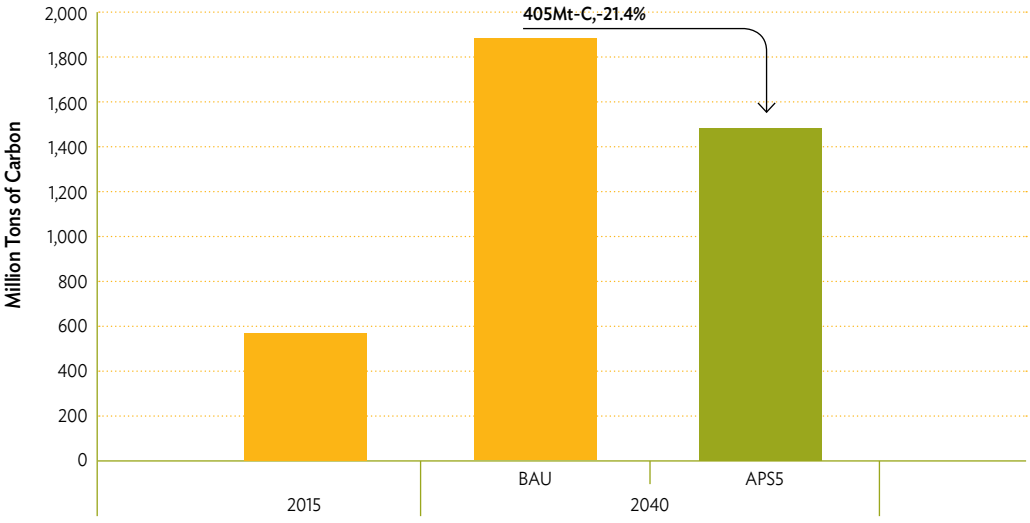


APS = Alternative Policy Scenario, BAU = Business-As-Usual.

Source: Model results.

In APS5, CO_2 emissions in 2040 will be 1,489 Mt-C, 21% lower than in the BAU scenario. Less demand of coal in final demand and in power generation and of oil in the transport sector will contribute most to reduced CO_2 emissions. Emissions from coal, oil, and natural gas in 2040 will decrease by 333 (24% reduction), 55.3 (13% reduction), and 16.7 (28% reduction) Mt-C compared to the BAU scenario. Figure 6.13 shows CO_2 emissions in 2040 under the BAU scenario versus APS5 in this energy outlook.

Figure 6.13: CO_2 Emissions from Energy Combustion, BAU and APS5 (2015 and 2040)



APS = Alternative Policy Scenario, BAU = Business-As-Usual, Mt-C = million tons of carbon.

Source: Model results.

4.2.4. Implications

- Energy security and access to energy are key challenges to India. Enhanced domestic production of energy is necessary to address these challenges.
- Hydrocarbons, particularly coal and oil, will continue to dominate the energy mix in both the BAU scenario and the APS. Use of domestic coal to secure supply as well as more efficient coal technologies such as ultra-supercritical, etc. would be necessary. In the long and medium terms, research and development on cleaner energy development will play a key role.
- Natural gas can play an important role in energy supply and environment issues. To fully utilise the increasing global natural gas production, the infrastructure for importation, domestic transportation, and utilisation needs to be enhanced.
- The Government of India announced ambitious targets for renewable energy, but the cost and infrastructure will be the bottlenecks. Developing domestic manufacturing capacity can play an important role.

- Energy efficiency and demand-side management are important. New power plants, new factories, new buildings, new appliances, and new cars should be more efficient. The Minimum Energy Performance Standard and mandatory energy labels should be expanded to more equipment.
  - The power sector has huge potential savings. Advance technologies for power generation should be used as much as possible.
  - Industry will account for 43% of the incremental energy use to 2040; energy efficiency programmes should be focused on this sector. Broadening the scope of the Perform, Achieve, Trade scheme will be an important way to achieve this.
  - Growth of energy consumption in the transport sector should be curtailed.
  - Losses in electricity distribution should be minimised by using better technologies.
- Rationalising energy prices across fuels and sectors is necessary.
- In its Nationally Determined Contributions (NDC), India pledged to reduce the emissions intensity of its GDP by 33% to 35% by 2030 from the 2005 level. This can be achieved between APS2 to APS5. This implies that India is on course to achieve its NDC and make more climate commitments in the future when significant progress has been made towards achieving the NDC.

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