the lowest-consuming and highest-consuming states varies by a factor of five (Figure 1.6 and Table 1.1). Average citizens in Delhi consume about half of the global average, while their counterparts in Bihar consume less than 20% of the global average. In states with lower per capita incomes, traditional fuels for cooking dominate. In states with higher per capita incomes, the share of electricity and oil products – which include transport fuel and also LPG – is higher, and it rises with increasing energy use.

Table 1.1 ▷ Energy and economic indicators in selected states in India, 2018

	Urban population (million)	Rural population (million)	GDP per capita (PPP) ($)	Total final consumption per capita (toe)	Electricity demand per capita (kWh)
Higher income	192.7	233.8	12 159	0.6	1 615
Delhi	16.4	0.4	19 970	0.6	1 548
Haryana	8.8	16.5	12 900	0.8	2 082
Telangana	13.6	21.4	11 170	0.5	1 896
Karnataka	23.6	37.5	11 520	0.6	1 396
Kerala	15.9	17.5	11 150	0.5	757
Gujarat	25.7	34.7	10 790	1.1	2 378
Uttarakhand	3.0	7.0	10 860	0.5	1 467
Maharashtra	50.8	61.6	10 480	0.5	1 424
Tamil Nadu	34.9	37.2	10 590	0.5	1 866
Middle income	84	220.6	6 540	0.5	1 129
Punjab	10.4	17.3	8 470	0.6	2 046
Andhra Pradesh	14.6	35	8 260	0.5	1 480
Rajasthan	17	51.5	6 040	0.5	1 282
West Bengal	29.1	62.2	5 980	0.4	703
Chhattisgarh	5.9	19.6	5 290	1.0	1 961
Odisha	7	35	5 200	1.0	1 628
Lower income	88.7	352.1	3 930	0.3	647
Madhya Pradesh	20.1	52.6	4 970	0.4	1 084
Assam	4.4	26.8	4 490	0.3	341
Jharkhand	7.9	25.1	4 150	0.6	938
Uttar Pradesh	44.5	155.3	3 640	0.3	606
Bihar	11.8	92.3	2 400	0.2	311

Notes: kWh = kilowatt-hours. Delhi is a union territory rather than a state but is included here as the capital of India.

Source: IEA analysis, MoSPI (2020)

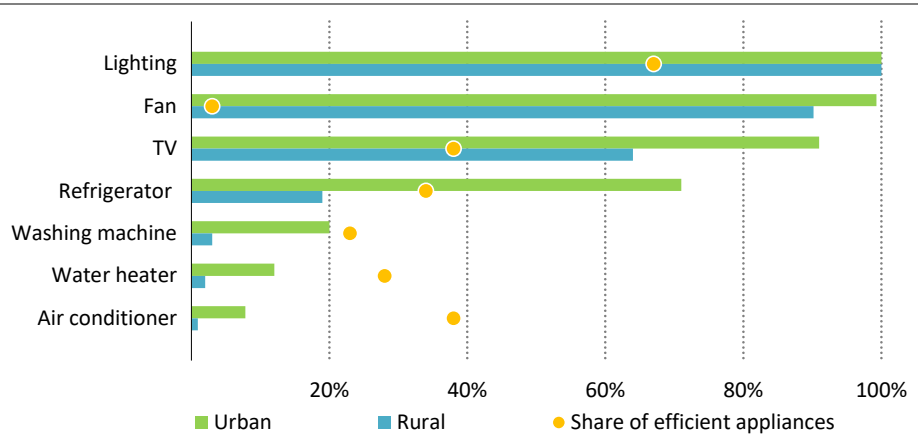
1.2.1 Key issues for energy demand

Electricity and modern life

In 2019, India achieved a historic landmark of reaching near-universal household connectivity to electricity, meaning that over 900 million citizens have gained an electric connection to their households since 2000 – a remarkable achievement. There are still challenges in providing reliable, affordable and sustainable access to all potential consumers, but electricity consumption in buildings has nearly doubled over the past decade, outpacing electricity consumption in the wider economy. This has been driven by growing appliance use, even though electricity use in Indian households is largely limited to powering light-emitting diode (LED) bulbs, ceiling fans and televisions.

Appliance use in Indian households differs starkly between urban and rural areas, with the exception of lighting and ceiling fans, which are very widely owned (Figure 1.7), and of televisions (TVs) and smartphones, which have ownership levels of over 60% in rural areas. Rural areas have relatively low adoption rates of other energy-consuming appliances, with fewer than one in five households owning a refrigerator, electric water heater or washing machine. Urban households are nearly four times as likely as rural households to own a refrigerator, seven times as likely to own a washing machine, and nearly nine times as likely to own an air-conditioning unit (AC) (Agarwal, et al., 2020).

Figure 1.7 ▷ Percentage of households using appliances, 2019



Most Indian homes own lighting, ceiling fans and TVs, while the ownership of other appliances is concentrated in urban areas.

Source: IEA based on Agarwal et al (2020)

Note: Efficient appliances are those with 4 or 5 stars on India's standards and labelling programme, except for lighting where it refers to LEDs.

India has seen a strong emphasis in recent years on the deployment of energy-efficient appliances, a policy push that has led to considerable energy savings. With the exception of

three Indian states, LEDs are now used in over 80% of households thanks to a major effort to move away from more inefficient bulbs. The government's flagship Unnat Jyoti by Affordable LEDs for All (UJALA) scheme, launched in 2015, has led to the deployment of 366 million LEDs (Ministry of Power, 2020), while the LED Street Lighting National Programme has led to the installation of over 10 million LED smart streetlights by the Energy Efficiency Services Limited, a government-owned energy services company. The government estimates that energy savings of about 54 terawatt-hours (TWh) per year have been achieved through these measures (PIB, 2020).

India's standards and labelling programme is meanwhile influencing consumer choices and the deployment of efficient appliances. This programme, introduced in 2006, is operated and managed by the Bureau of Energy Efficiency. As of 2020, over one-third of TVs, refrigerators and air conditioners and over one-quarter of washing machines and water heaters in use were classed as efficient, with 4 or 5 stars on India's standards and labelling programme.

While the number of air conditioners in India is still low, sales are expected to grow sharply in the coming years. In anticipation, the government launched the India Cooling Action Plan in 2019. This aims to reduce cooling energy demand through a range of energy efficiency measures targeted at appliances and at building design and construction, while acknowledging the principle of "thermal comfort for all".

Access to clean cooking

Having electrified nearly every household in the country, one of the next big energy sector challenges for India is to achieve a full transition to clean cooking. Some 660 million Indians remain without access[1] to modern, clean cooking fuels or technologies. Access to clean cooking goes beyond technical availability: it also extends to issues of adequacy, reliability, convenience, safety and affordability.

While the government has broadened availability to LPG through different schemes to reach most Indian dwellings, nearly half of all households in 2019 continued to rely on traditional uses of biomass for cooking, mostly in rural areas. The premature deaths of around 800 000 Indians every year are attributable to household air pollution, much of which is caused by the traditional use of biomass for cooking (Health Effects Institute, 2020). The damaging health effects are felt disproportionately by women and children, and the time and effort involved in collecting biomass impose an additional cost that is again overwhelmingly borne by women.

Affordability is the key factor that has made biomass hard to dislodge as a cooking fuel. In rural India, biomass and other traditional fuels are practically free or are available at a very low cost, compared with a significantly more expensive cylinder of LPG. To overcome this affordability barrier, the government has put in place two subsidy schemes to increase the uptake and regular use of LPG in rural areas: Pradhan Mantri Ujjwala Yojana (PMUY) and Pratyaksh Hanstantrit Labh (PAHAL). As a result of the push towards clean cooking over the

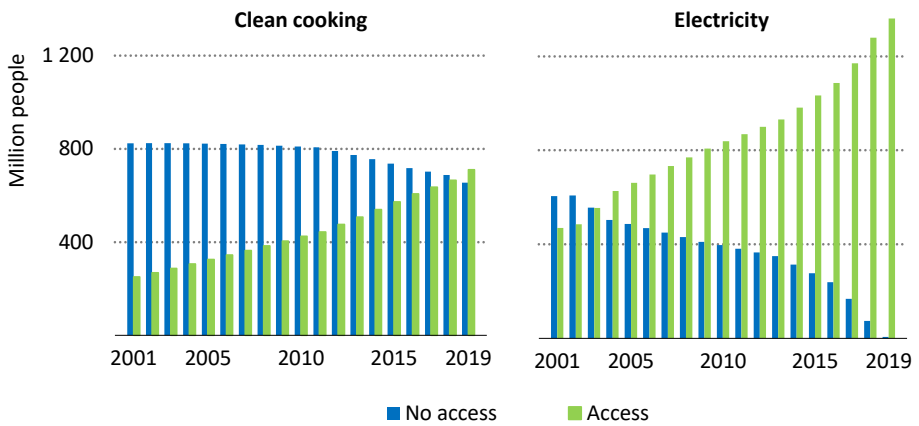
[1] A full description of the *World Energy Outlook* energy access methodology can be found at www.iea.org/articles/defining-energy-access-2020-methodology.

past decade, more than 200 000 premature deaths are estimated to have been prevented between 2010 and 2019 (Health Effects Institute, 2020).

The PMUY scheme provides LPG connections to households living below the poverty line. It was originally launched in 2016 with the objective of providing 50 million LPG connections by 2019. This target was later increased to 80 million connections by 2020, and was achieved ahead of schedule. Under the PMUY scheme, the beneficiaries have access to an interest-free loan facility for the cost of stove and first refill.

Once a household has an LPG connection, it continues to receive a subsidy through the Direct Benefit Transfer of LPG scheme, also known as PAHAL. Every residential consumer in India is eligible for this subsidy. PAHAL was launched in stages in 2013 and was scaled up to a nationwide scheme in 2015. Under PAHAL, a customer purchases an LPG cylinder at market price, and the subsidy is subsequently transferred to their bank account. In parallel, the government launched the "Give It Up" campaign to persuade high-income households to opt out, which led to at least 10 million households forgoing this subsidy.

Figure 1.8 ▷ Access to electricity and clean cooking in India



India connected almost half a billion people to the electricity grid during the last decade; attaining universal access to clean cooking is the next big challenge.

Note: A full description of the *World Energy Outlook* energy access methodology can be found at www.iea.org/articles/defining-energy-access-2020-methodology.

Despite these schemes, household surveys reveal continued reliance on biomass for cooking, due in part to the burden of upfront payments. Even with the LPG subsidy, biomass is abundantly available at no or very little monetary cost for a significant number of households, particularly in rural India. Households may also choose to use biomass alongside LPG depending on their cooking preferences. This practice of using multiple fuels for similar purposes as the household income level increases is known as fuel stacking. Survey data indicate that fuel stacking appears to be common among users of the PMUY, who often

procure LPG well below their allocations (CAG, 2019). Barriers to access, including the long distances sometimes involved in LPG supply, further contribute to continued reliance on biomass.

Additional measures to promote LPG uptake such as the provision of cheaper 5 kilogramme (kg) cylinders (compared with standard cylinders that weigh 14.2 kg) have so far not been very successful. These cylinders accounted for only 0.2% of the cylinders sold by the end of 2019, and significant increases in sales are likely to require active promotion and awareness building. The Covid-19 crisis added another dimension to the access challenge, with reverse flows of migrant labour back to rural areas and unemployment further reducing the affordability of LPG cylinders. To address this, the government announced that it will arrange for the distribution of three free full-sized cylinders to all 80 million PMUY beneficiaries.

The total cost to the government of subsidising LPG depends on oil prices and rates of uptake. In 2019, it amounted to 23 000 crore Indian rupees (INR) ($3 billion).

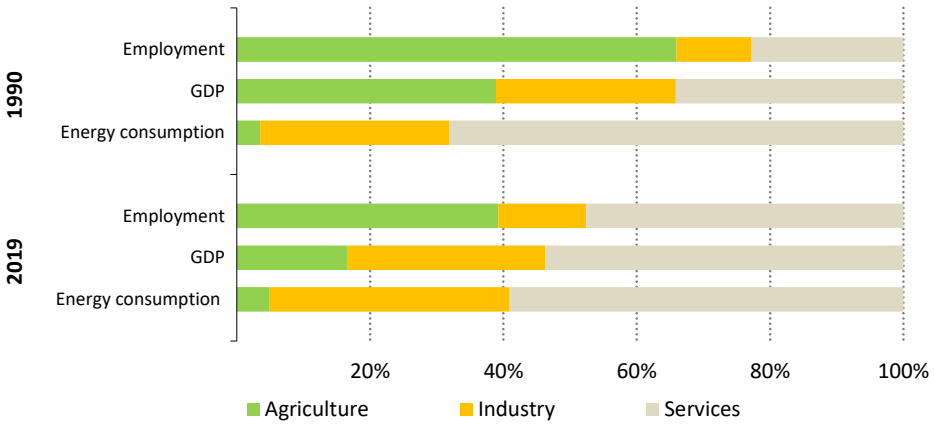
Alongside the increasing use of LPG in rural areas, there has also been growth in the use of pipeline natural gas (PNG) in urban areas. In April 2019, there were 5 million domestic PNG connections, over 90% of which were concentrated in four Indian states. The government now has plans to expand this city gas distribution network to cover 70% of all households by 2030. There is also potential for an accelerated uptake of induction and other electric cooking appliances, especially in urban areas, even though they accounted for less than 1% of cooking energy demand in 2019.

Employment

India has a large and diverse workforce employed in activities that can be broadly grouped into three sectors: industry, including manufacturing; services, including transport, utilities, information technology and retail; and agriculture. The share of the labour force in the agricultural sector has declined from about 70% in 1990 to less than about 40% today (meaning that the headcount of workers in agriculture declined by around 58 million even as India's overall labour force increased by over 110 million). There has been a corresponding rise in labour demand from the industry and services sectors, in which employment has more than doubled in the past three decades (MoSPI, 2019). This has gone hand in hand with growing urbanisation, with the share of the urban population increasing from 26% in 1990 to 34% in 2019, and many cities experiencing rapid growth.

The resulting construction activity has led to rising demand for steel, cement, aluminium, plastics and chemicals. India has also emerged as a manufacturing hub for vehicles, electronics and pharmaceuticals. The Perform, Achieve and Trade (PAT) scheme has set energy saving targets for each industrial subsector and enables the trading of energy efficiency certificates, and this has helped to improve technical efficiencies. As energy demand from industry has tripled over the past three decades, its share in final consumption has risen to 36% today, higher than industry's nearly 30% share of GDP. The services sector's share of final consumption is also higher than its share of GDP: it accounts for 54% of GDP and 59% of energy use. By contrast, agriculture makes up 17% of GDP but only 5% of final energy consumption.

Figure 1.9 ▷ India's sectoral shares in employment, GDP and energy consumption



The sectoral composition of employment and GDP has shifted away from agriculture over recent decades, but agriculture remains a big source of employment in rural areas.

Source: IEA analysis based on MoSPI (2019); NSSO (2018).

India has long pursued a structural economic shift towards manufacturing, and the government announced the landmark Make in India initiative in 2014 with the intention of turning India into a global manufacturing hub. This programme had a stated goal of raising the share of manufacturing in GDP to 25% by 2022 and creating 100 million jobs. However, despite reform measures attracting some foreign direct investment, the total number of manufacturing jobs – around 65 million – has remained broadly static since 2014, and the share of GDP attributable to manufacturing has remained around 17%. The sector has seen an annual average growth rate of 7%, outpacing agriculture but growing more slowly than the services sector (RBI, 2020). A higher share of industries in GDP and the material intensity of future economic growth would have profound implications on the outlook for the energy sector.

Mobility and transport

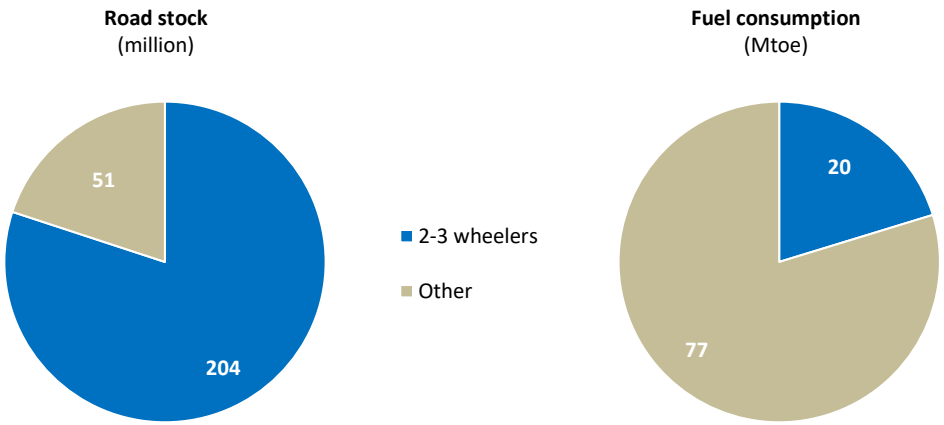
With a growing economy, Indians are now travelling farther than ever before. On average, Indians travel nearly 5 000 kilometres (km) each year, a threefold increase since 2000.

Vehicle ownership per capita has grown five-fold since 2000, with particularly significant growth in the fleet of two- and three-wheelers (Figure 1.10). Today, with a stock of just over 200 million, there are five times more of these vehicles than passenger cars. Three-wheelers in India are widely used in shared mobility and public transport, complementing a relatively low stock of 2 million buses that serve mass and public transport needs. Freight activity also quadrupled between 2000 and 2019, alongside a fivefold increase in the stock of light commercial vehicles, and a thirteen-fold increase in the stock of heavy freight trucks.

The rapid growth of mobility has been enabled by the expanding road network in India, which increased from 3.3 million km in 2000 to 5.9 million km in 2016 (MoRTH, 2019). India's total road network is now the second-largest in the world, behind the United States.

Indians are also travelling on rail twice the distance they did in 2000. India's per capita distance travelled on rail increased from 430 km in 2000 to nearly 860 km in 2019 (Figure 1.11). With over 8 billion trips annually, rail continues to be one of India's most preferred ways to travel (Ministry of Railways, 2019). Freight activity similarly more than doubled on India's vast railway network, reaching 740 billion tonne kilometres (tkm) in 2018, although the share of freight that moves on railways has been falling.

Figure 1.10 ▷ Two- and three-wheelers in Indian road transport, 2019



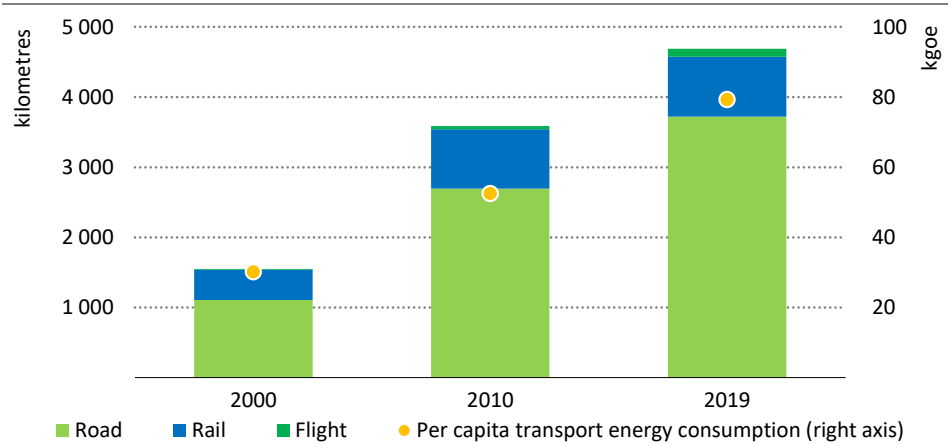
Two- and three-wheelers dominate India's road transport fleet, but account for a relatively small proportion of total energy demand in the transport sector.

While air travel remains out of reach for most Indians, there has been a steady growth in India's aviation industry over the past decade. The per capita distance flown in India was 110 km in 2019, which is three times as much as 10 years ago. Domestic passenger numbers, too, have nearly tripled in the last decade to over 140 million, up from around 50 million in 2010 (DGCA, 2019). There has been an increase in short-distance flights in recent years, enabled by policies that have supported the development of small airports and made flying more affordable. India has added 50 domestic airports in the past five years, taking the total to about 150 airports with commercial operations.

As Indians travel more and transport freight in larger volumes, the transport sector has become the fastest-growing energy end-use sector in the country. Energy use in India's transport sector has increased fivefold over the past three decades, reaching more than 100 Mtoe in 2019. While other sectors are fuelled by relatively diverse sources of energy, transport is heavily reliant on oil, with 95% of demand being met by petroleum products. Just under half of India's oil demand is accounted for by transport.

The Covid-19-related lockdowns and economic recession had a significant impact on transport demand in 2020. Overall road transport activity fell by 12% compared with 2019. While energy demand fell across all transport modes, it was most pronounced in domestic aviation and rail, falling about 20% in both these sectors. In time, however, the trends that have led to growing demand for transport are set to return, together with a range of challenges arising from this growth. Key among these challenges are road congestion, urban air pollution and growing dependence on imported oil. In India, about 75 000 vehicles of all types are sold daily, and there are now at least 42 cities and towns in India that have over a million vehicles each (MORTH, 2019). This large stock of vehicles has in turn contributed to an air quality crisis in urban areas.

Figure 1.11 ▷ Annual distance travelled per capita



Indians have been travelling farther every year, resulting in growing energy demand from transport.

Note: kgoe = kilogrammes of oil equivalent.

Sources: IEA based on DGCA (2019); Indian Railways (2019).

India has responded to these challenges by instituting a range of policies to improve fuel quality and energy efficiency and to diversify the energy use of the sector. In April 2017, India put in place corporate average fuel consumption (CAFE) fuel efficiency norms for passenger cars, and these will become more stringent from 2022. The government mandated the leapfrogging of vehicle fuel standards from Bharat Stage-IV to Bharat Stage-VI for all new vehicles sold starting April 2020. This standard is in line with Euro-6. The Ethanol Blended Petrol (EBP) programme was launched in 2003 with an ambition to blend an average of 5% ethanol into petrol, but it eventually fell short of this target owing to supply chain and procurement difficulties and a lack of attractive pricing. A more comprehensive National Policy on Biofuels (NBP) was approved in 2018 that envisages a target of 20% blending of ethanol in petrol and 5% blending of biodiesel in diesel by 2030 (MoPNG, 2018).

India's push for compressed natural gas (CNG) in transport over the past decade has resulted in the doubling of CNG use in transport since 2010. There are now over 3 million CNG-fuelled vehicles registered in the country, 92% of which are concentrated in four Indian states. These vehicles are largely three-wheelers, buses and cars, most of which are used for shared mobility, for example as taxis, or for public transport.

While India has a range of policies that support the increased adoption of a wide variety of electric vehicles (EVs) (section 2.3.2), electrification in road transport so far has largely come from two-and three-wheelers. The number of electrified two-and three-wheelers has grown by more than 60% each year on average since 2015, and there were 1.8 million such vehicles in 2019. Despite this rapid rise, they still constituted only 3% of overall two-and three-wheeler sales that year. The electrification of transport has accelerated in other modes of transport too. India's railway network now has a target of 100% electrification of its tracks by 2022, up from 51% of the railway network (in route kilometres) in 2019. There has also been a rapid increase in urban light rail in cities. In 2020, over 650 km of metro rail was operational in 18 cities (MOHUA, 2020).

1.2.2 Key issues for energy production and trade

Coal

Coal remains the bedrock of India's energy economy, commanding a 44% share of the primary energy mix, the third-highest among Group of 20 (G20) countries. India is the world's second-largest coal market, with plentiful domestic reserves. Indian mines produce over 700 million tonnes (Mt) of coal per year, mostly in the eastern part of the country in Odisha, Chhattisgarh, Jharkhand and Madhya Pradesh. The vast majority of production comes from open pit mining. Since the 1970s, government-owned Coal India Limited (CIL) has been the dominant coal producer and today it is the world's largest coal mining company, supplying over 80% of the country's domestically produced coal.

Since the 1990s, the government has also made provision for "captive mining", which enables end users to mine their own coal, as CIL could not keep up with growing coal demand. At the outset it simply allocated captive mining rights, but since 2015 it has auctioned them through a competitive bidding process. However, this has not translated into meaningful growth in production from captive mining. To encourage further private investment, the government permitted commercial mining of coal in March 2020 and opened the sector to foreign investment.

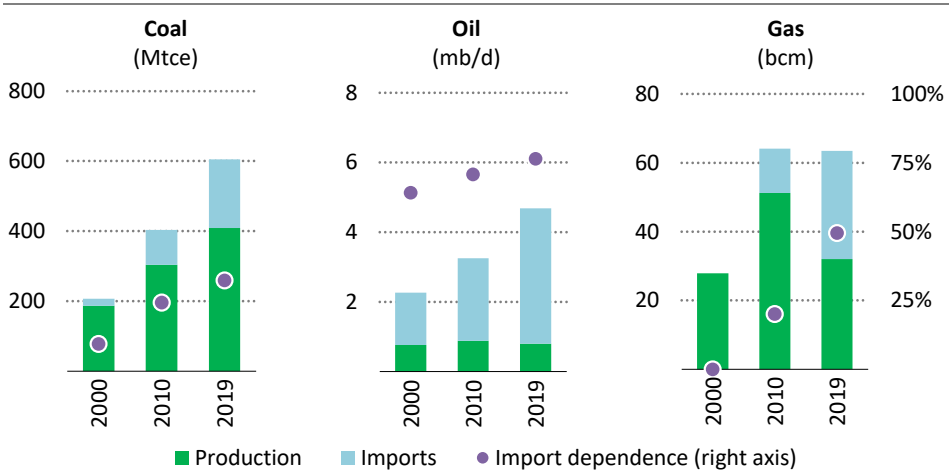
India has the world's fifth-largest proven coal reserves, but domestic production has been unable to keep pace with demand. This has resulted in a steady rise in imports in recent years (Figure 1.12), although the growth of import dependence on thermal coal has slowed since the mid-2010s as a result of increased domestic production and lower demand growth. Part of the import requirement arises from the steel industry's need for coking coal, which is far less abundant domestically than thermal coal. In addition, around 18 GW of coal-fired power plants (8% of the total fleet) are located in coastal areas and are designed to use imported

coal rather than lower-quality domestic grades. Domestically produced coal also has high ash content and a low calorific value, raising operational, transport and maintenance costs. Despite these challenges, the government has a target to eliminate imports by 2025 by encouraging domestic coal production.

The supply of coal is regulated by the government to ensure that coal reaches priority sectors while keeping transport and logistics costs down. Most domestically mined coal in the east ends up having to travel considerable distances by rail to reach consumption centres in the north and west. As a result, coal uses up almost half of all railway capacity for bulk commodity transport, and freight costs make up a considerable amount of the delivered cost of coal, particularly as they are used to cross-subsidise passenger rail fares.

Coal is largely supplied at prices notified in fuel supply agreements (FSAs) by public-sector companies. These prices are set at a level intended to maintain average profitability across supplier companies rather than being dynamically linked to production costs or market forces. Notified coal prices are lower for "priority" customers such as power plants. Additionally, there are e-auctions where flexible quantities of coal can be supplied at a premium price, although only a small proportion of coal is traded this way. Coal mining also attracts a lower GST rate than other mining, but on the other hand it is subject to an added coal levy of INR 400/tonne (about $5.5/tonne) which acts as a de facto green tax. When this levy was first introduced in 2010, the revenues collected were directed to a National Clean Energy and Environment Fund (NCEEF). Upon the introduction of the GST in 2017, however, the original levy (the "coal cess") and NCEEF were abolished and replaced with a GST Compensation Cess on coal to make up for the shortfall in overall tax revenues.

Figure 1.12 ▷ India production and trade of coal, crude oil and natural gas



India's domestic production of fossil fuels has not been able to keep pace with demand, leading to a rapid rise in import dependence over the past two decades.

Note: Mtce = million tones of coal equivalent; mb/d = million barrels per day; bcm = billion cubic metres.

Oil

Unlike coal, India has limited domestic resources of oil, largely relying on imported crude to meet its needs. India has become the second-largest net oil importer after China. Crude oil is brought in by tanker from the Middle East, Latin America and Africa to Indian refineries along the western coast. India's dependence on imported crude oil has been rising, and currently stands at around 75%.

To address the risks that could arise from growing import dependence, the government has expanded its strategic petroleum reserve (SPR). As of mid-2020, India held around 40 million barrels of oil in its SPR, equivalent to about 10 days of the country's net oil imports. India has a long-standing ambition to reduce oil import dependence, and the government announced in 2015 an ambition to reduce this dependence by 10 percentage points by 2022. This was to be achieved through a variety of policies, including policies to expand the use of alternative transport fuels such as bioethanol, biodiesel and CNG, and through the expansion of domestic oil production. To encourage domestic exploration and production, the government adopted the Hydrocarbon Exploration and Licensing Policy (HELP) in 2016 to provide a level playing field for the exploration of all types of hydrocarbons under a revenue sharing model.

These policies have not so far succeeded in reducing India's oil import dependence, which has continued to rise, broadly tracking the increase in demand, while domestic oil production has remained broadly flat since 2015, as it has for the past three decades. Over these decades, however, India has proactively expanded its refining capacity, making it a net exporter of refined products. India's refining capacity stands at 250 Mt per year, making it the fourth-largest in the world. While production is largely in the hands of publicly owned companies, India's largest refineries are privately owned, notably the Reliance-owned Jamnagar refinery on the western coast of Gujarat, which is the world's largest.

The prices of transport fuels, gasoline and diesel are determined by fuel retailers based on prevailing market conditions. The government has removed regulated prices and subsidies, and has progressively increased excise duties on these fuels during periods of lower crude oil prices.

Natural gas

While the share of natural gas in India's primary energy mix has largely remained flat in recent years at around 6%, overall energy demand has risen rapidly, and there have been significant shifts in demand for natural gas in specific sectors of the economy. The use of natural gas as a fuel in industry has increased about tenfold since 2010, against the background of an overall 50% increase in energy use in the sector. This has increased the share of natural gas in industry from less than 2% to nearly 10%. Similarly, natural gas use in buildings has tripled over the past decade, albeit from a low base. These increases have, however, been partly offset by a fall in the use of natural gas for power generation. The pressures that have led to this fall remain: nearly 60% India's natural gas-based power generation capacity is facing extreme financial pressure and operating on very low capacities on account of lack of affordable gas.

India has a stated ambition to increase the share of natural gas in its primary energy mix to 15% by 2030, up from 6% in 2019. The government has been taking a range of measures in support of this ambition in order to expand domestic production, facilitate imports and encourage demand. To expand production, HELP allows for pricing and marketing freedom for gas produced from deepwater, ultra-deepwater and other complex reservoirs. The gas price from all other fields is determined on a half-yearly basis by a formula linked to hub prices in other countries, including the United States, Canada, the United Kingdom and the Russian Federation. In 2020 the government also launched the Indian Gas Exchange (IGX), a trading platform for natural gas. The relatively low level of gas prices over the past few years has, however, acted as a disincentive for significant investments in domestic production.

Growth in India's gas demand has outpaced domestic production, leading to rising dependence on imported LNG. Imports of natural gas have risen from 20% of India's total gas demand in 2010 to 50% today. To facilitate these imports, India has six LNG terminals. Although there are some infrastructure bottlenecks, India already has a 17 000 km network of pipelines to transport gas to centres of consumption, and it has ambitions to expand this grid significantly. India's downstream regulator, the Petroleum and Natural Gas Regulatory Board, is in charge of overseeing this expansion as well as of regulating tariffs for users of this infrastructure. In addition to this long-distance pipeline network, India has ambitious plans for city gas distribution (CGD) networks to cater to households, commercial establishments and factories within cities. There are currently 18 states with CGD networks, and successive bid rounds have awarded CGD licences with the aim of reaching 70% of all households by 2030.

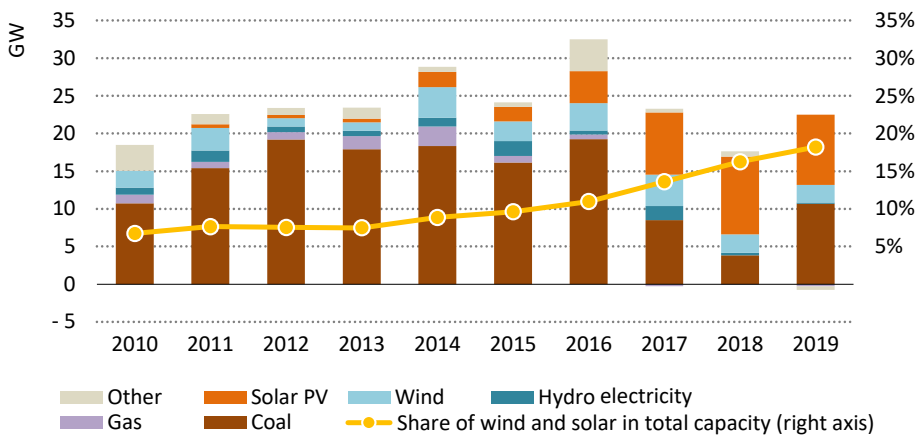
Solar and wind

The most remarkable story in India's power sector in recent years has been the growth of solar PV and wind**,** which have rapidly increased their share of the overall energy mix in recent years as coal and hydropower capacity growth has slowed (Figure 1.13). Over the past five years, solar PV capacity has grown at an average growth rate of around 60% and wind capacity of around 10%, outpacing the 7% growth in overall installed capacity. This rapid growth reflects government policy support and falling equipment costs.

In 2015, the Indian government announced a target of 175 GW of renewables by 2022 (excluding large hydro), which included 100 GW of solar and 60 GW of wind capacity. Published a year after India had set these aggressive targets, the 2015 *India Energy Outlook* projected that India's solar capacity would reach 28 GW in 2020 under the prevailing policy framework in the New Policies Scenario (the forerunner of today's Stated Policies Scenario [STEPS]), but that it could reach 48 GW under a more aggressive Indian Vision Case. The *Outlook* identified several challenges that would need to be overcome to scale up renewables in India, including difficulties in acquiring land, the financial difficulties faced by distribution companies, and the long-term nature of existing contracts with conventional producers. Partly owing to the effective management of these risks, India's solar capacity reached 38 GW by 2019 (mostly utility scale), with wind adding a further 38 GW of capacity.

Together, they now constitute nearly 20% of India's installed capacity. In 2019, India announced a new target of 450 GW of renewable electricity capacity by 2030.

Figure 1.13 ▷ Annual power sector capacity additions



With coal capacity growth slowing down and solar PV and wind ramping up, the share of variable renewables in installed capacity has doubled since 2014.

The policy actions that have facilitated the growth of grid-connected renewables include reverse auctions resulting in progressively falling prices, lower corporate tax rates for developers, renewable purchase obligations mandating utilities to procure a certain minimum purchase of renewable power (in 2019-20, the guideline set by the central government was 17.5%, although state regulators have their own targets), investment in transmission infrastructure, and support for solar parks that help reduce project development and land acquisition risks.

The rise of renewables in India's power sector has been a major success story; wind and solar PV now account for 7% of total generation, twice their share in 2014. In renewable-rich Indian states, wind and solar contribute as much as 15% of power generation. In some states, they contribute nearly 50% of power generation during those parts of the year when wind speeds are at their strongest. Solar PV and wind have been relatively resilient during the crisis in 2020; even though overall electricity demand was down sharply in the second quarter, coal accounted for most of the reductions in generation.

However, there are still important structural, regulatory and institutional challenges that could hamper further growth, and progress has been uneven across different renewable technologies. The challenges include the poor financial position of many state distribution companies, difficulties in obtaining access to finance and in acquiring land, grid congestion, and uncertainties over grid infrastructure development. The expansion of rooftop solar has lagged behind the growth in utility-scale projects, constrained by higher costs and the lack of attractive financial models for consumers. Rooftop solar had a share of 40 GW in the 100 GW

solar target for 2022, but deployment remains at well under 10 GW. This sector is now a focus area for the government as 2022 gets closer.[2] Similarly, despite an identified potential of 10 GW to 20 GW, offshore wind has not yet taken off in India owing to the high cost of capital and to supply chain and infrastructure bottlenecks.

Other technologies and fuels

Growth in the share of wind and solar PV in the Indian power system needs to be accompanied by a strengthening of **grid infrastructure**. To address this, the government has been focusing on flexibility in operations, technologies and infrastructure. The Green Energy Corridors initiative is one attempt to boost flexibility; it aims to expand and improve transmission infrastructure, facilitate the integration of renewable energy management centres and energy storage options, and enhance the flexibility offered by India's thermal power fleet.

Storage technologies are also set to be vital to India's electricity security. Of the country's 4.8 GW of installed pumped storage hydro capacity, 3.3 GW is operational; total pumped storage hydro potential has been estimated at 90 GW (CEA, 2019). Battery storage will also have an important part to play. The government estimates that India will require 27 GW of grid-connected battery storage by 2030 (CEA, 2019), and has established a National Mission on Transformative Mobility and Battery Storage in 2019 with the aim of becoming a competitive battery manufacturer. In May 2020, the government also announced the result of the first ever "round the clock" renewable energy auction, which will lead to the development of 400 MW of generation capacity that will supply power through the day through a combination of solar and other generation and storage technologies. India also announced in November 2020 a production-linked incentive (PLI) scheme for the domestic production of high-efficiency solar PV modules and advanced chemistry cell storage batteries.

India has significant potential to expand its modern **bioenergy** sector, which can be done using the vast quantities of organic waste generated by the agricultural sector as well as a growing amount of municipal solid waste, used cooking oil and wastewater. There are a number of supporting policies, some of which have been strengthened in recent years, notably new biofuel blending targets and plans to expand India's bio-compressed natural gas infrastructure.

India has also made initial steps towards exploring the potential of **hydrogen** as a source of energy. The first roadmap for the fuel was produced in 2006 by the Ministry of New and Renewable Energy, and the government has since been investing in research and development via various public sector institutions.

[2] Solar PV has also grown in off-grid applications, notably to power street lighting and water pumps in rural areas. With policy support, over 3 million solar-powered streetlights had been installed by the start of 2019. There is also a government programme in place for solar-powered irrigation pumps and decentralised ground-mounted grid-connected renewable power plants with a combined target of 31 GW by 2022.

1.3 Energy and India's development path

India's energy choices are inextricably linked to wider socio-economic developmental goals. The use of energy, development of energy markets and deployment of technologies are not ends in themselves, but means for the country to reach wider objectives including economic growth and improvements in the quality of life and the environment. This section explores the linkages between the energy sector and wider economic, social and environmental issues.

1.3.1 Energy and the economy

The year 1991 was a seminal one in India's economic history. India took important steps in that year to liberalise its economy, initiating a change towards a more market- and services-based economy. This altered the trajectory of its development, expanding per capita incomes, attracting higher levels of private and foreign investment, stimulating competition, and leading to new manufacturing capacity, new service-sector firms, productivity gains and a falling poverty rate. Along with greater economic activity came increasing competition for land resources and growing levels of emissions and pollutants, presenting new challenges for society at large.

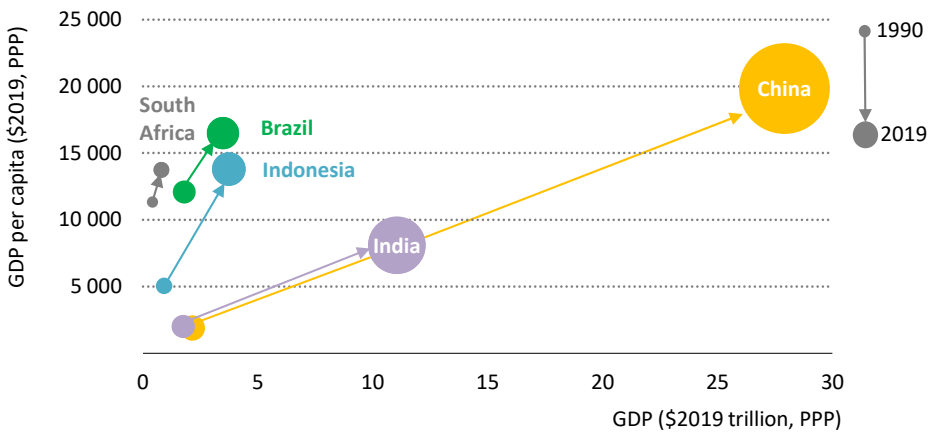
In the period between 1991 and 2019, India's GDP grew at an annual average rate of 6.8%, outpacing the average annual growth of 4.2% in the two decades before that. India was one of the world's fastest-growing large economies in this period, second only to China (Figure 1.14). With GDP having nearly doubled over the past 10 years, India has become the world's third-largest economy in PPP terms and the fifth-largest in nominal terms.

India's per capita annual income has quadrupled since 1991 and reached $8 100 (PPP) in 2019. Although this remains well below the world average of $18 500 (PPP), the rapid rise in per capita incomes has led to a significant fall in India's poverty rate. India's Poverty Headcount Ratio[3] fell from 48% in 1993 to 13% in 2015 (World Bank, 2020). This has been accompanied by a rise in standards of living and development indicators. India's Human Development Index value has increased from 0.43 in 1990 to 0.65 in 2018, representing a growth in life expectancy, education access and incomes (UNDP, 2019).

Growth in the economy has fuelled the demand for energy, and the growing supply of energy has fuelled India's economic growth. Indians on an average now use nearly twice as much energy as they did three decades ago, as a result of rising vehicle ownership, demand for construction material and a rise in appliance ownership. However, India's energy intensity of GDP has improved at an average rate of 3% per year during these three decades, meaning it has required less energy over time to produce an additional unit of economic output. This has happened as a result of the growth in the Indian services sector, energy efficiency improvements and a transition away from inefficient biomass towards modern fuels.

[3] The percentage of the population living on less than $1.90 a day at 2011 prices.

Figure 1.14 ▷ GDP and GDP per capita for selected countries, 1990 and 2019



While India is now the world's third-largest economy in PPP terms, it lags behind other emerging economies in terms of per capita incomes.

Note: Bubble size indicates GDP ($2019).

The Covid-19 pandemic has given India an abrupt economic shock, with April-June quarterly GDP falling by 23.9% and an estimated contraction of about 8% for the whole of 2020. This contraction, which has had a significant impact on energy demand across fuels and sectors, was caused by the disruption of the global economy due to the pandemic, and by the lockdown measures taken by India to address the spread of the virus. To counter its impact on the economy, the Indian government in May 2020 announced an economic recovery package with the overarching theme of Atmanirbhar Bharat ("Self-Reliant India"). This included welfare transfers to farmers, free LPG cylinders for the least well off, concessional loans for the medium and small industrial sector, the injection of liquidity into power distribution companies, and tax changes. The government also included measures to promote manufacturing in India and government procurement from domestic companies.

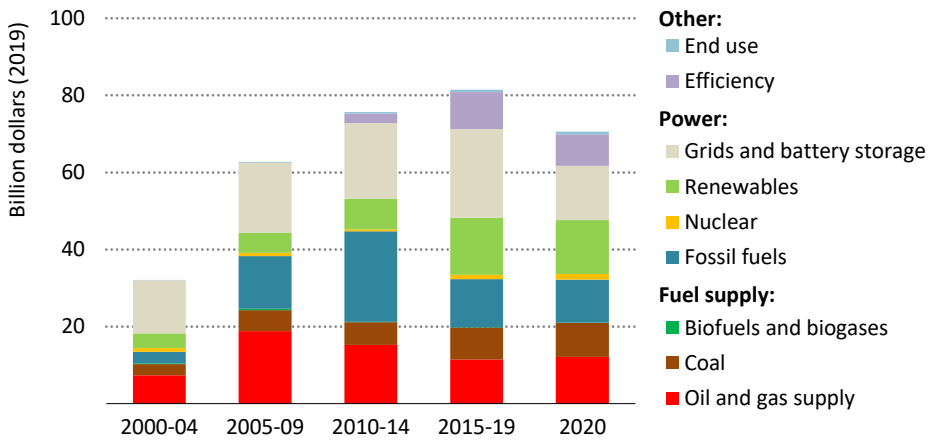
India's economy had been witnessing a slowdown even prior to the pandemic. Its annualised economic growth had fallen to 4.7% in the final quarter of 2019, the lowest in five years. Other economic indicators such as growth of private consumption, capital investments, exports and industrial activity also indicated a slowdown. In particular, capital investments, exports and the Index of Industrial Production registered negative growth in the second half of 2019. The year also saw a decline in vehicle sales and a slowdown in the growth of steel consumption and in sales of fast-moving consumer goods. The government had already introduced measures in 2018 aimed at simplifying and streamlining aspects of economic life, such as the GST. The post-pandemic recovery will not only have to address the disruption caused by Covid-19 but also to build on these measures and tackle structural obstacles to economic growth that existed prior to the crisis.

Investment and finance

Over the past decade, investment across the whole of India's economy has surged, with gross fixed capital formation doubling to $770 billion in 2019 from 2010 levels. Most of this has come from domestic sources: foreign direct investment inflows amounted to $50 billion in 2019. Public finances have also improved considerably in recent years. The fiscal deficit has stayed slightly above 3% (as a share of GDP) and the government debt-to-GDP ratio has declined since the early 2000s. In addition, foreign reserves held by the Reserve Bank of India (RBI) have increased by 1.5 times since the early 2010s, and tenfold since the early 2000s, providing an additional buffer during periods of financial stress.

Key economy-wide investment indicators weakened in 2020 due to the crisis. Rising debt and equity market risk premiums have more than offset a reduction in base lending rates by the RBI, increasing the economy-wide cost of capital by around 30 basis points, while bank credit growth across all sectors has stalled. Faced with economic uncertainty and strained balance sheets, corporations responded by reducing investments. In September, new non-financial capital projects declined to their lowest level since 2007, while the number of projects outstanding dipped to a four-year low. Fiscal pressures have pushed down central government capital expenditures by 12% through September for fiscal year 2020-21 compared to the same period in 2019-20. In the energy sector, we estimate that investment is set to decline by almost 15% to around $70 billion in 2020 compared to 2019 following five years of stable spending at around $80 billion, with larger falls in grid networks (Figure 1.15).

Figure 1.15 ▷ Investment trends in energy, 5-year annual averages (2000-19) and 2020



Investment in renewables exceeded fossil fuel power investment for the fifth year in a row in 2020, while investment in networks has been falling recently in absolute and relative terms.

Notes: Efficiency and other end use investment estimates are not available prior to 2014. Other end use includes carbon capture, utilisation and storage (CCUS) in industry, spending to meet the incremental cost of EVs, and investment in private EV charging infrastructure.

India's energy investment trends vary across different parts of its energy economy, reflecting differences in market conditions, policies, capital allocation and costs. Investment in oil and gas supply was hit hard by lower demand, prices and revenues in 2020, and fell by 20% to $12 billion compared to 2019. In recent years, reforms brought about through the HELP programme, putting all hydrocarbons under a single exploration and production policy, have underpinned stronger spending.

Coal supply investment reached an average of around $10 billion in 2017-19, although it is estimated to have fallen by nearly 15% in 2020. Ongoing reforms aim at increasing investment, in particular through the opening of the coal sector to commercial mining by domestic and international companies. However, challenges remain, including the pressure from international investors, which restricts financing options.

The power sector accounts for over half of energy investment in India. Capital investment amounted to almost $50 billion in 2019, a 4% decline from 2018, and a further drop of over 15% is expected in 2020. Investments in renewable power surpassed those in coal power plants for the fifth year in a row in 2020. Spending on coal power has moderated in recent years, though it remains above $10 billion a year, with up to 60 GW of coal-fired capacity designated as being under construction. However, a stark decline in final investment decisions for new plants since 2016, as well as more constrained bank lending, points to much lower investment levels in the years ahead.

Recent momentum in the power sector has been driven by investment in renewables, which grew by 60% over 2015-19 to $18 billion. Utility-scale solar PV and wind have led this growth, underpinned by supportive policies, competitive auctions, improved economics and a maturing industry. Although investment in these technologies is set to decline in 2020, interest has remained high, and the capacity awarded through auctions between January and June 2020 rose for the third consecutive year. The pandemic has nevertheless added uncertainty over India's ability to attract a diverse pool of private finance to meet ambitious deployment targets in the years ahead (see Chapter 4). Moreover, progress in other technologies such as distributed solar PV and bioenergy remains slow, with new financing challenges emerging. New hydropower investments have also been slow to materialise, although recently announced measures could help facilitate fresh investment. These include the creation of a hydro purchase obligation (HPO) to encourage hydropower purchases, and budgetary support for flood control and hydro energy storage projects.

The financial and operational performance of state distribution companies – key developers of grids, purchasers of power and integrators of new technologies – continues to constrain capital availability, despite efforts such as the Ujwal DISCOM Assurance Yojana (UDAY) initiative. This initiative involved writing off debt and restructuring loans against a commitment to improve performance. However, investors and developers continue to be concerned about the risks involved in power purchase projects. An $18 billion backlog of payments to generators emerged in 2020, and further reforms are required to enable distribution companies to return to profitability, including measures to achieve cost-reflective pricing.

Investment in grids has trended downwards in recent years from more than half of power investment in 2015 to around one-third in 2020, reflecting the challenging financial situation of distribution companies, while spending on battery storage is at an early stage and remains low. The government is, however, working to expand inter- and intra-state transmission capacity, which is key to the successful integration of a rising share of renewables. The first Green Energy Corridor project – a 1 800 km high-voltage transmission line – began construction in 2017, with the aim of transporting power from resource-rich states to other states more effectively than at present; the project will cost more than $5 billion (Ministry of Power, 2020). The government is also looking at new ways to procure flexible resources, for example by integrating batteries in utility-scale renewable tenders.

Spending on energy efficiency, electric mobility and the direct use of renewables accounts for just over 10% of energy investment. Over 40% of efficiency investment has occurred in industrial sectors, supported by the PAT scheme, while investment in more efficient appliances and buildings accounts for another quarter. Sales of EVs and EV charging installations are low, but are set to grow rapidly. Investment in solar thermal heaters has expanded rapidly to nearly $1 billion in 2019, supported by government grants and rising interest among industrial users.

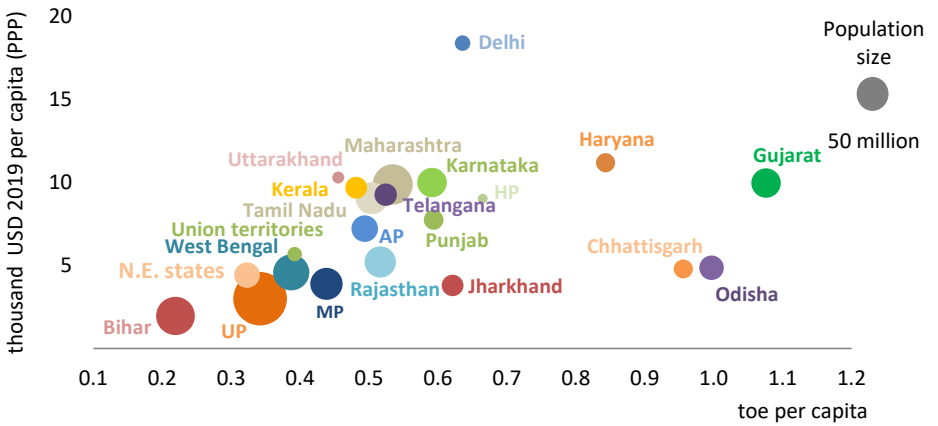
1.3.2 Energy and society

Growth in average per capita income and a fall in poverty means that increasing numbers of Indians are able to afford private modes of transport, clean cooking technologies, modern appliances and larger homes. However, income growth has been characterised by various kinds of inequities that are reflected in energy consumption levels, in particular in terms of interstate variances, poverty, the rural-urban divide, gender and caste. The provision of access to energy and opportunities to use it needs dedicated interventions that focus on gender, caste and class (Patnaik & Jha, 2020).

The 12 wealthiest states in India, including Goa, Haryana, Maharashtra, Kerala and Tamil Nadu, have an average per capita income that is at least twice as high as the bottom 8 states, including Bihar, Uttar Pradesh, Jharkhand and Madhya Pradesh. With an urban population of 44%, the wealthiest states are also twice as urbanised as the lower-income ones. These two groups of states have similar population sizes.

In terms of energy, the total final consumption of these higher income states is 40% higher than those with low per capita incomes. This trend holds true on a per capita energy use basis too (Figure 1.16). There are a few notable outliers, including Jharkhand, Chhattisgarh and Odisha, which combine relatively low per capita incomes with high energy use owing to the size of energy-intensive industries such as steel and cement in those states. Nearly 40% of Indians reside in states with both low per capita incomes and low per capita energy use.

Figure 1.16 ▷ Population size, GDP per capita and energy use per capita by state and union territories in India, 2018



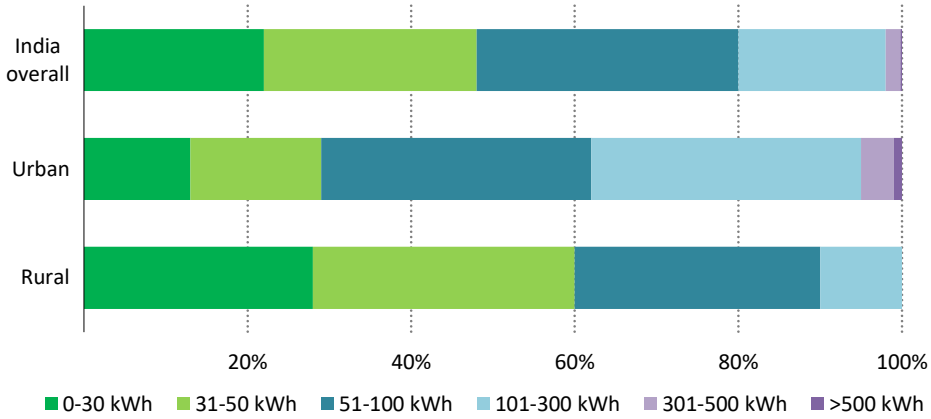
There is considerable variation in energy consumption across the states of India. The biggest coal-producing states challenge the normal relationship between economic output and energy use.

Notes: UP = Uttar Pradesh, AP = Andhra Pradesh, MP = Madhya Pradesh, HP = Himachal Pradesh. Delhi is shown separately from the remaining union territories, as the capital of India.

The state-by-state differences are overlaid by a pervasive rural-urban divide in energy use, as well as by major gender differences (see Spotlight). The rural-urban divide is linked to a range of factors, including income and appliance ownership levels, which feed through into electricity consumption (Figure 1.17). In 2014, the bottom 60% of households in rural India consumed less than 50 kWh of electricity per month, compared with an average of 100 kWh in urban areas. This rural-urban divide extends to access to clean cooking and the materials used in the construction of houses. In 1990, only 30% of rural homes were built using modern building materials, compared with 75% of homes in urban areas; the rest were built using traditional materials such as unburnt mud, cow dung and other organic materials. This gap in terms of housing is narrowing, however: by 2018, 79% of rural and 97% of urban houses were being constructed using modern materials.

Another dimension to inequity that is unique to India is the caste system. Historically, marginalised caste groups categorised as Scheduled Castes and Scheduled Tribes have had less access to electricity and clean cooking after controlling for factors such as income and education. These groups make up about 16% of India's population (Saxena & Bhattacharya, 2017).

Figure 1.17 ▷ Household electricity consumption per month in urban and rural India



Rural households consume considerably less electricity than urban households.

Source: Data from 2014, based on Prayas (2016).

S P O T L I G H T

A long way to go: Women's participation in India's energy sector

The issue of women's access to and participation in the energy sector is a key aspect of inequity in India. Economic progress in recent decades has not been matched by progress towards women's equal economic participation. The World Economic Forum's Global Gender Gap Index 2020 ranks India 112th out of 153 countries in offering equal opportunities to women and men, and women often lack the same access to health care and education as their male counterparts.

Between 1990 and 2019, the female participation rate in the workforce fell from 30% to 15% while the male participation rate remained largely constant at around 55%. India's declining female labour force participation has been particularly pronounced in rural India, with rural women leaving India's workforce at a faster rate than urban women (WEF, 2020). This low and falling participation rate among women has significant impacts on energy inequity in several ways: it leads to low workforce participation in the energy sector, lower demand for appliances, lower access to safe mobility, and lower clean cooking access and affordability.

Globally, women hold only around 22% of jobs in the energy sector as a whole, and 32% in renewables (IRENA, 2019). In India, the percentage of women with jobs in the energy sector is even lower, at less than 10%, and many of these jobs are non-technical (IEA-CEEW, 2019). In the rooftop solar sector, women account for an estimated 11% of the workforce.

India's low labour force participation rate for women is due in part to the gender wage gap, a lack of safety policies and flexible work arrangements, and cultural norms regarding women's work. Indian women are often required by their families to prioritise domestic work. A social stigma continues against women working outside the house, especially for those who can afford not to work. These trends risk being further aggravated by Covid-19, as the sectors most impacted by the pandemic are those with higher shares of female labour participation.

Poor access to safe and affordable transport for women imposes further constraints on their access to health care, education, and other social facilities and services, thereby effectively limiting their opportunities to participate in the country's workforce to the same extent as their male counterparts. Globally, it is estimated that safety concerns and limited access to transport reduce the probability of women participating in the labour market by 16.5% (ILO, 2018). Understanding and responding to women's mobility needs, which are different from those of men, is essential to enable more equitable participation in the energy sector and economy more widely.

Energy transitions can have important implications for gender gaps and equality in employment and remuneration. India has a high share of female graduates in engineering, and the renewable energy sector tends to attract a relatively high proportion of women. Accelerating the deployment of renewables could therefore mean an acceleration of employment in this sector for women. Codifying policies to provide a safe place for women to work, including accommodation, sanitation facilities and transport, would help to make this happen. Equal opportunities also implies protection from discrimination and access to maternity and parental leave allowances.

Achieving universal access to clean cooking options would also provide an important improvement in health for women together with major time savings and increased employment opportunities. Women are disproportionately exposed to household air pollution from the burning of traditional biomass, leading to a higher prevalence of asthma, pulmonary diseases and lung cancer among households that use biomass for cooking (Kankaria, Nongkynrih and Gupta, 2014). Women in these households also spend significant amounts of time collecting fuel. The PMUY scheme issues LPG connections specifically to women in poor households, and in some states women play a key decision-making role in processes that aim to accelerate the transition away from the traditional use of biomass.

Reliability and affordability

Reliability and affordability are key concerns for Indian consumers, and they are closely intertwined. Affordability is also a key consideration for clean cooking fuels (see section 1.2.1).

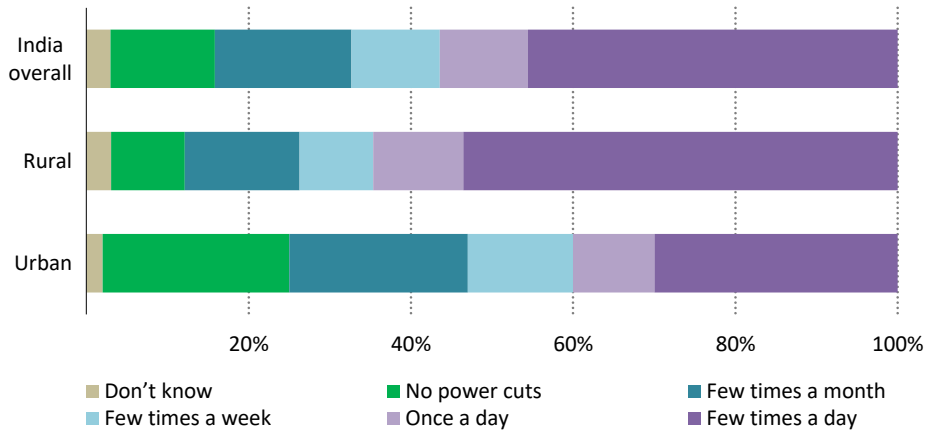
Satisfaction with electricity services is highly correlated with the hours of electricity that households enjoy (Alkin et al., 2016). Urban households receive about 22 hours of electricity

a day on average, and rural households receive about 20 hours. Lack of reliability is an important issue. In rural areas 53% of households experience multiple power cuts in a day compared with 30% of their urban counterparts.

Unreliable power is a major barrier to economic and social development, and imposes additional financial burdens on consumers, not least in terms of the expense of maintaining backup sources of power (Box 1.2). The use of such backups is widespread. In 2017, even as electricity access was improving, many rural households continued to use kerosene for lighting (Jain, 2018). In urban areas, diesel generators are common, especially in modern high-rises, while individual households often have rechargeable batteries to help them cope with power cuts. Similarly, about 35% of rural enterprises appear to be dependent on non-grid electricity sources such as solar home systems, rechargeable batteries, mini-grids, and diesel generators. These additional sources of power or lighting increase the financial burden on already low- and middle-income households (Smart Power India and ISEP, 2019).

Affordability is a key component of energy access, and tariffs for the Indian residential sector are much higher in PPP terms than in other developing countries (see Chapter 3). These relatively high tariffs, coupled with low per capita incomes, mean that energy costs account for a significant share of household expenditure. To address this issue of affordability, state governments have been cross-subsidising consumers by providing inexpensive electricity to households with low consumption. Electricity tariffs also tend to be fixed, and are often below cost price, leading to financial losses in distribution companies which in turn lead to frequent bailouts. The state governments in charge of such bailouts often struggle to make timely and complete payments, and this has prompted the central government to step in with loans and policy reforms (see Chapter 4.3).

Figure 1.18 ▷ Share of electrified households affected by power outages, 2019



Most Indian households report multiple daily power cuts.

Source: Agarwal et al. (2020).

In addition to subsidised prices, distribution companies suffer from high aggregate technical and commercial losses, and from difficulties in billing and revenue collection. Their consequent financial difficulties lead to a vicious circle of under-investment in infrastructure and poor quality of service (Figure 1.18). In line with its objective to provide reliable and continuous power, the government is deploying a range of policies to address these linked reliability and affordability barriers, while encouraging efforts by the utilities to improve the efficiency of their billing and revenue collection and to reduce aggregate technical and commercial losses.

One important government initiative is to replace 250 million analogue meters with smart meters across India over the next three years to improve metering and consumption transparency, and avoid the errors and costs that come with manual billing. Energy Efficiency Services Limited, a government-owned energy services company, has already installed 1 million smart meters in Uttar Pradesh, Haryana, Bihar and New Delhi (Economic Times, 2020). In 2020, the government also announced that it was considering a new tariff policy penalising unscheduled power cuts to incentivise investment in power infrastructure.

Box 1.2 ▷ Electricity security and the role of captive power

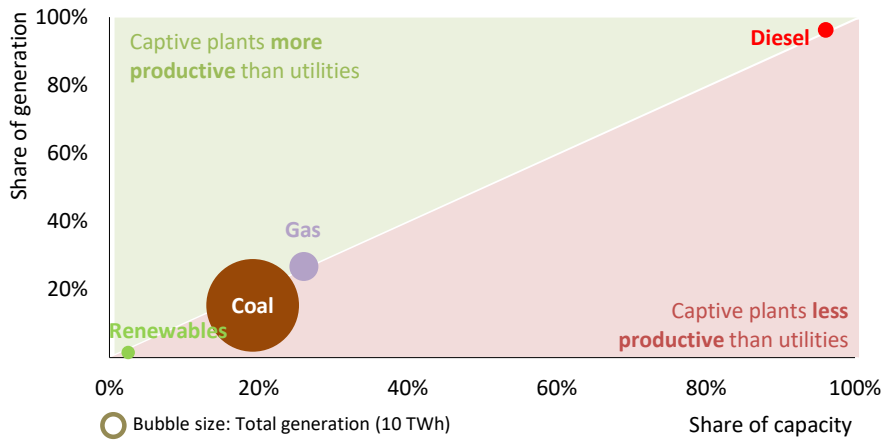
Captive power plants provide a localised source of power to an energy user. They play a crucial role in India's electricity generation, accounting for 75 GW of installed capacity and around 15% of total generation in 2018 (Figure 1.19). This is higher than the global average of around 7% and much higher than the advanced economies average of 4%. These facilities serve a wide variety of consumers from households and small businesses to large industrial plants, but the motivation is the same in all cases: to provide a hedge against unreliable supply from the grid, and – especially for large consumers – to benefit at times from cheaper power than that supplied by the grid.

As in the broader electricity mix, coal is the most common fuel source for captive plants, accounting for nearly 90% of captive generation (the bubble size in Figure 1.19 represents captive generation). Natural gas, with 10% of total captive generation, is the second-largest fuel source and is mainly used by petrochemical and fertiliser industries, which also use gas as feedstock for their production processes. The cost-effectiveness of these captive plants is helped by the structure of electricity tariffs, under which industrial and commercial users effectively cross-subsidise residential and agricultural customers (the price of grid electricity for industry is on average 70% higher than for residential users). Many of these industrial captive units are relatively old assets that have been fully depreciated.

The true extent of diesel generator use across India is unclear, as official data only include units of more than 1 MW; studies based on manufacturer data indicate that total capacity may be as much as 90 GW (The Indian Express, 2014). The many smaller units implied by

this data are relatively expensive to operate and are also a source of local pollution, even if used only sparingly.

Figure 1.19 ▷ Captive power as a share of total generation and capacity by fuel, and total captive generation by fuel, 2018



Almost all diesel-based generation in India takes the form of captive power for small businesses and households; coal-fired plants play a significant role for large industries.

Source: IEA analysis based on MoSPI (2020).

Rooftop solar is another potential source of captive power that is being increasingly taken up by both residential and commercial users, although adoption has fallen short of official targets. As rooftop solar schemes gain momentum and the cost of integrated solar-plus-battery offers falls further (and as government schemes make it easier for people to sell excess power back to grid), small-scale renewables are likely to go a long way towards replacing diesel backup. As gas networks expand within cities, gas-based generation could also become viable for larger users.

1.3.3 Energy and the environment

Air quality

Air pollution has emerged as one of India's gravest environmental problems in recent years, and energy use is at the heart of it. In 2019, there were well over one million premature deaths related to ambient and household air pollution; only China has a higher toll of premature deaths. The Central Pollution Control Board (CPCB) and National Green Tribunal has identified 124 cities across 24 of India's 36 states and union territories as "non-attainment cities" for exceeding pollutant levels set under the National Ambient Air Quality Standards (NAAQS) in 2009 (CEA, 2019). Although already a substantial number, the