2.2 The forces and uncertainties shaping energy demand

Despite brisk economic growth in recent decades, India is still a lower-middle-income country. Even measured at PPP, its GDP per capita is almost 85% lower than that of advanced economies. Against this background, India's government wants to see substantial economic growth to raise living standards and reduce poverty. Over the projection period of this *Outlook*, 2019 to 2040, India's GDP is set to grow substantially. This will undoubtedly mean significant growth in demand for energy services. How this demand is met, which fuels and technologies are available and at what price, is a crucial issue for the aspirations and livelihoods of India's citizens. India's choices will in turn have a huge influence on global trends, against a backdrop of accelerating global action on climate change and commitments to reach net zero emissions. The objective of this section is to understand the macroscale drivers and uncertainties of demand growth in this new context. It starts with a brief review of historical energy demand growth before turning to the outlook period.

2.2.1 GDP and energy intensity

Between 1990 and 2019, India's GDP increased more than sixfold, while total final consumption increased only by a factor of 2.5. In other words, GDP grew more than twice as fast as energy consumption. Three main factors contributed to this rapid improvement in the final energy intensity of GDP.

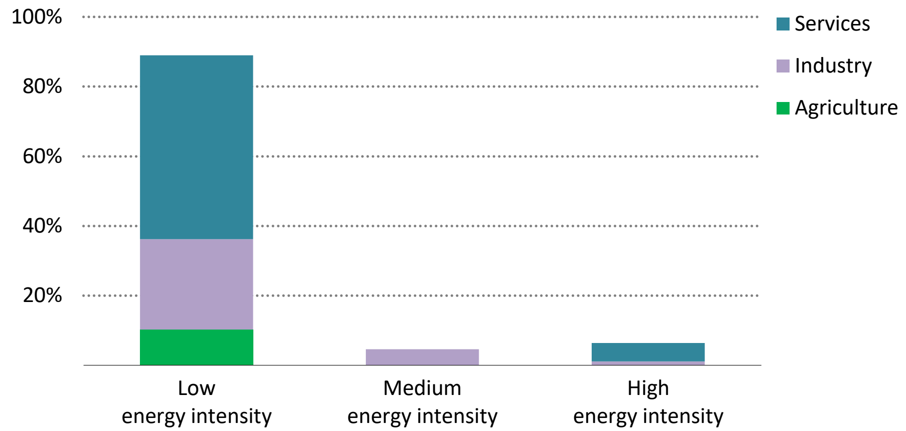
The first was the structural transition away from traditional biomass as a fuel in the residential sector. Although India still consumes a large amount of traditional biomass, the share of total final consumption accounted for by biomass fell from 42% in 1990 to 18% in 2019, as widespread electrification took place, oil consumption in transport grew and the buildings sector transitioned towards modern fuels. This transition in the buildings sector entailed a shift from traditional sources of biomass with very low conversion efficiencies (in the order of 5-10%) towards higher efficiency fuels such as LPG and electricity. The efficiency gains from fuel switching helped to enable substantial growth in economic activity without commensurate growth in energy consumption: the decline in traditional biomass was responsible for nearly 60% of the decline in energy intensity between 1990 and 2019.[2]

The second driver of this dramatic improvement in energy intensity was the structure of India's economic growth model. Unlike East Asian or some Southeast Asian countries, such as Korea, China and Viet Nam, India's economic growth has historically been driven by the services sectors, not the more energy-intensive industry sectors. This is illustrated in Figure 2.4, which shows that nearly 90% of total value-added growth in the period 1990-2017 came from sectors in the lowest energy intensity category. These include large retail service

[2] This may seem like a windfall that should not be recorded as an improvement in energy intensity per se. However, given the real economic costs of traditional biomass use, notably the time required to collect it and the health costs of indoor pollution, the transition away from traditional use of biomass is a driver of greater economic efficiency and thus rightfully recorded in indicators such as falling energy intensity of GDP.

sectors such as trade as well as very productive "low footprint" sectors such as business and financial services. India's service-oriented model of international trade has further embedded these less energy-intensive sectors in the domestic economy.

Figure 2.4 ▷ Share in value-added growth by sector and level of energy intensity, 1990-2017



The vast majority of value-added growth in the Indian GDP since 1990 has come from low-energy-intensity sectors.

Note: Energy intensity is calculated as the ratio of the value of energy inputs to the value of gross output in thousand rupees, with a range of 0-100 classified as low, 100-200 as medium, and >200 as high.

Source: IEA analysis based on RBI (2020).

The third driver of the improvement in energy intensity has been the technical efficiency of production and consumption processes. Low levels of energy use per unit of physical output have been driven by relatively high energy prices, price sensitivity among consumers, a young capital stock, and a robust policy framework in a number of sectors. For example, the average on-road fuel efficiency of a new passenger car purchased in India is around 5.7 litres/100 km, comparable with cars purchased in the European Union. The thermal energy intensity of clinker production in India is 20% lower than in the European Union.

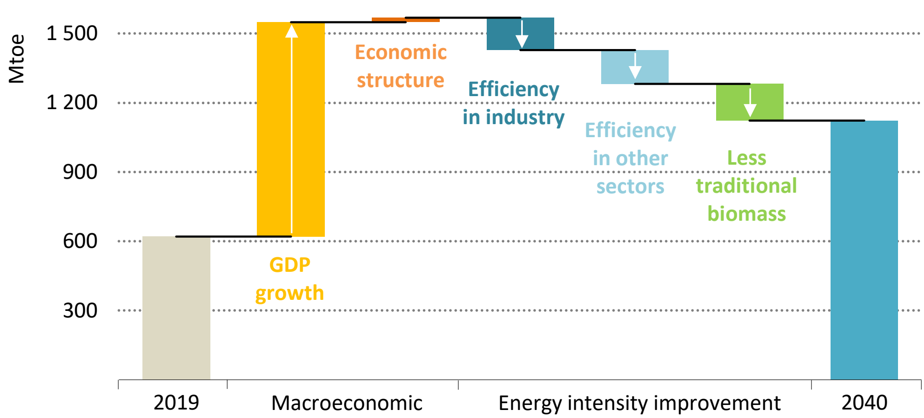
Looking at India's recent energy demand growth, the picture that emerges is one of a relatively frugal energy system. Rapid improvements in energy intensity have been driven by a transition to more efficient fuels, a structure of economic growth dominated by services, and high technical efficiencies in many sectors. The extent to which these trends continue will be crucial in determining the future growth of Indian energy demand.

2.2.2 Outlook for GDP growth and economic structure in the STEPS

Between 2019 and 2040, Indian GDP is projected in the STEPS to triple in size, growing 5.4% annually, while India's economic structure changes in ways broadly consistent with the historical trajectory charted by other countries. Agriculture continues to decrease as a share of GDP, albeit more slowly than in the past. By 2040, it accounts for about 11% of GDP. Consistent with India's services-driven development model, the share of industry in total GDP is projected to remain broadly stable over the outlook period, rising slightly from 30% in 2019 to 31% in 2040. The share of services in GDP continues to increase, rising from 54% in 2019 to 57% in 2040, with accompanying growth in service sector energy demand (see section 2.3).

The tripling in GDP in the STEPS is accompanied by less than a doubling of total final energy consumption, which rises from 620 Mtoe in 2019 to just over 1 100 Mtoe in 2040. As in the past, a reduction in energy intensity is anticipated to play a substantial role in reducing energy demand growth relative to GDP growth. This is evident from a decomposition of different factors affecting demand growth (Figure 2.5).

Figure 2.5 ▷ Drivers of total final energy consumption growth in India in the STEPS, 2019-40



The transition away from traditional biomass and an economy-wide improvement in energy efficiency reduce consumption growth by almost 50% over the period to 2040.

Notes: TFC = total final consumption. Economic structure represents the impacts of the change in the share of industry value-added in GDP. Energy intensity improvements include gains from energy efficiency as well as transitions to more conversion-efficient energy sources, such as electricity. Less traditional biomass represents the efficiency gains from switching away from traditional use of biomass towards modern fuels.

As Figure 2.5 shows, GDP growth without any improvement in energy intensity would increase final energy consumption in India to more than 1 500 Mtoe by 2040, and a slightly expanded share of industry in the economy would add a little to this. However, this increase is in practice moderated by improvements in industrial energy intensity, which avoid around 140 Mtoe (explored further in section 2.4). The transition away from traditional use of biomass continues, as its share in final consumption contracts from 18% in 2019 to 6% in 2040, thereby avoiding a further 160 Mtoe. Finally, energy intensity improvements in all other end-use sectors and fuels bring about an additional reduction of 150 Mtoe. Together, these three factors drive a cumulative reduction in the growth of total final consumption of over 440 Mtoe, an amount equivalent to Japan's total energy demand today.

2.2.3 Similar destinations, different pathways: Exploring the IVC and DRS

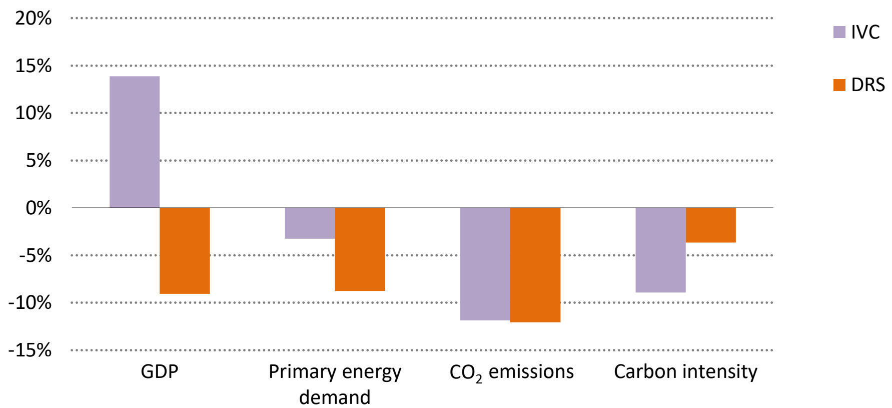
The disruption from Covid-19 has caused an unprecedented level of uncertainty about the future of the global economy. India has suffered a significant economic contraction as a result of the pandemic and the ensuing lockdowns, and its economic output is expected to have fallen by around 8% in 2020 (IMF, 2021). In the STEPS, India's GDP returns to an annual average growth rate of around 5.4% per year between 2019 and 2040. However, substantial uncertainty remains about the depth and duration of the downturn induced by Covid-19, and the speed of the subsequent recovery in GDP growth rates. For this reason, two alternative scenarios have been used in this report alongside the STEPS and the SDS, namely the DRS and the IVC.

In the IVC, GDP growth is higher across the outlook period, reflecting a scenario in which substantial structural reforms boost the long-term growth potential of the economy, despite the short-term shock of Covid-19. This scenario also assumes the achievement of ambitious government policy objectives related to energy efficiency, deployment of renewable energy, and the provision of modern fuels to households. The DRS, on the other hand, reflects a scenario in which the shock of Covid-19 continues to weigh on the subsequent economic recovery: precautionary household saving, high corporate debt levels and a strained fiscal deficit result in a slower rate of economic growth. Consequently, the structural transition in the energy system is also delayed, with fewer improvements in energy efficiency, slower deployment of renewables and natural gas, and a slower transition away from traditional biomass.

The IVC sees an annual average GDP growth rate of 6% in the period 2019-40, compared with an annual average growth of 5% in the DRS. As a result, the size of the economy in 2040 is 14% bigger in the IVC than in the STEPS, whereas it is 9% smaller in the DRS. On the face of it, one would expect that these differences in 2040 would drive substantial differences in energy demand and CO_2 emissions. However, this is not the case. In the IVC, total final consumption of energy is actually lower than in the STEPS, and similar to that in the DRS. Stronger improvements in energy efficiency and faster moves towards more efficient fuels, notably electricity and gas, reduce the rate of final consumption growth in the IVC, notwithstanding its higher GDP. The similarly low level of demand in the DRS, by contrast, is a result of slower GDP growth and more prolonged economic challenges, which reduce the rate of improvement in energy efficiency and delay the transition towards more efficient fuels.

Overall, energy-related CO_2 emissions are around 12% lower in both the IVC and the DRS relative to the STEPS in 2040, but the reasons for these similar-sized reductions are very different (Figure 2.6). In the IVC, emissions growth is lower as a result of faster energy efficiency improvements compensating for rapid economic growth; modern renewables partially compensating for the accelerated transition away from the traditional use of biomass; and the shift within the fossil mix towards natural gas. In the DRS, by contrast, emissions reductions come from low GDP growth, and from the persistence of traditional biomass in the energy mix, which reduces the carbon intensity of total primary energy demand relative to the STEPS but also means higher levels of air pollution and a greater number of premature deaths. Given the imperative of achieving economic growth, poverty reduction and the transition to welfare-enhancing modern fuels, these CO_2 reductions are achieved at a very high social and economic cost.

Figure 2.6 ▷ Relative differences in key energy system indicators in the IVC and DRS, compared with the STEPS, 2040



Similar changes in energy demand and CO_2 emissions are seen in the IVC and DRS relative to the STEPS, but for very different reasons.

2.2.4 Urbanisation

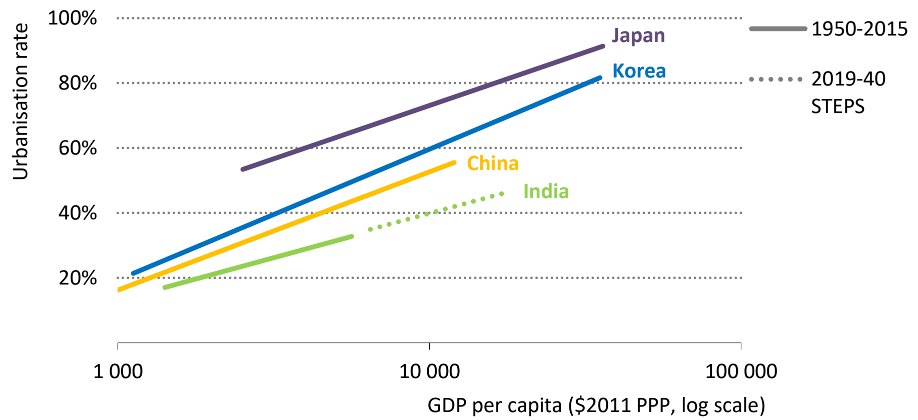
Throughout history, the urban share of the population has increased as countries have become richer. Urbanisation is one of the most consequential elements of the process of economic development. It facilitates larger markets for goods, services and labour, allowing the economy to increase its productivity. It also enables the growth of the more productive service and industry sectors that drive high incomes.

At the same time, the process of urbanisation is energy- and material-intensive. It generates much of the global demand for steel, cement and plastics, and hence is closely linked to energy demand. Because urbanisation facilitates higher average household incomes, it also drives higher average household energy consumption, as city dwellers spend a share of extra income on purchasing more energy services. Finally, a country's urbanisation model locks in very long-lived patterns of energy demand; for example, sprawling urbanisation with little public transport demand can lock in higher transport energy consumption.

How fast India urbanises, and with what urbanisation model, is therefore of material significance for its energy future. Exploring the long-term relationship between GDP per capita and the urbanisation rate offers some clues, comparing India with the East Asian late-industrialising countries, Japan, Korea and China (Figure 2.7). Across the historical period assessed, the speed of India's urbanisation process, as its GDP per capita has grown, has been slower than in these other countries. India is projected to continue this historical trend and remain a relatively rural country in our scenarios, even as its GDP per capita grows. By 2040, India's urbanisation rate is projected to be just 46%, which is some 15-30 percentage points lower than in the comparison countries at similar levels of GDP per capita.

Despite this relatively low urbanisation rate, India's huge population means that there is still a massive absolute growth in the total urban population, from about 470 million in 2019 to nearly 740 million in 2040. This increase in urban population is the equivalent of adding 13 cities the size of Mumbai to India by 2040. By contrast, India's rural population is expected to fall by 40 million in this period.

Figure 2.7 ▷ Relationship between GDP per capita and the urbanisation rate in selected economies



India has not so far urbanised as fast as other countries have done historically.

Sources: IEA analysis based on data from UN DESA (2018); Maddison Project Database (2018).

India thus looks set to buck the global trend between GDP per capita and urbanisation. This raises a number of important questions for India's energy future. First, given the strong relationship between development and urbanisation seen in economic history, will India be able to sustain a high level of GDP growth while retaining a high rural share of the population? Second, if India does retain a high share of rural population in the coming decades, what are the implications for India's energy future, given the observed differences between rural and urban households in terms of energy services demand and ownership of energy-consuming equipment?

There is some uncertainty about whether the rather stringent definition of urbanisation that India applies belies the country's actual level of urbanisation. Indeed, India's definition of urbanisation has long been subject to debate. Indian states have an incentive to label areas as rural because this enables them to receive subsidies and exemptions that they would not otherwise be entitled to. Alternative definitions exist, based on population density per square kilometre, or the percentage of the population employed outside of agriculture. Other metrics, increasingly based on remote sensing, continue to provide mixed signals about India's "true" level of urbanisation.

However, while there is debate about the stringency of India's definition of urban areas, it is clear that the definition is meaningfully reflected in energy indicators such as household appliance ownership. Persistent divergences have been evident in rural versus urban household appliance ownership for a long time, particularly for large, expensive energy-intensive equipment such as cars or air conditioners. The extent to which there will be convergence in the pattern of energy service demand between rural and urban households is a question of great importance for India's future energy demand, given the large projected rural population share in 2040. The extent and physical model of India's urbanisation process – compact versus sprawling, high-rise versus low-rise, formal versus informal – will likewise be crucial in determining demand for energy-intensive materials such as steel and cement, as well as transport demand.

2.3 The built environment and mobility

Two-thirds of the buildings that exist in 2040 in the STEPS have not yet been constructed. India is also facing a huge expansion of transportation networks – from highways, railways, and metro lines to airports and ports – to move an ever-increasing number of people and goods across the country. In the STEPS, around 300 million vehicles are added to India's roads by 2040, and there is a threefold increase in freight activity. How the built environment and India's transport systems interact is a crucial question for India's energy future.

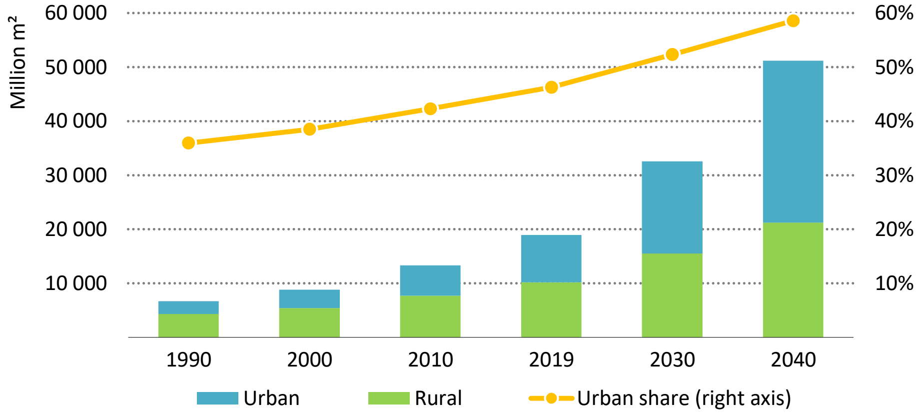
2.3.1 The built environment

There are three trends that underpin buildings energy demand in India. First, new construction activity is increasingly being concentrated in urban areas, making urbanisation a key driver for material demand; second, informal settlements and traditional built structures are being replaced by new buildings that use modern and energy-intensive materials such as bricks, cement and steel; third, there has been a steady growth in appliance use, with air conditioners emerging as the single most significant source of electricity demand in the buildings sector.

Material demand in the buildings sector

In the STEPS, urban floor space more than triples by 2040; this far outpaces projected growth of floor space in rural areas (Figure 2.8). This predominance of urban growth is a result of continued migration towards urban areas, rising incomes in urban areas that drive home ownership and investments in real estate, and a reduction in the number of people per household which reflects falling fertility rates and the splitting of larger families into multiple households.

Figure 2.8 ▷ Residential floor space in India in the STEPS



Historically, most built spaces in India were in rural areas, but urban demand for floor spaces is set to outpace rural demand over the next 20 years.

Note: m^2 = square metres.

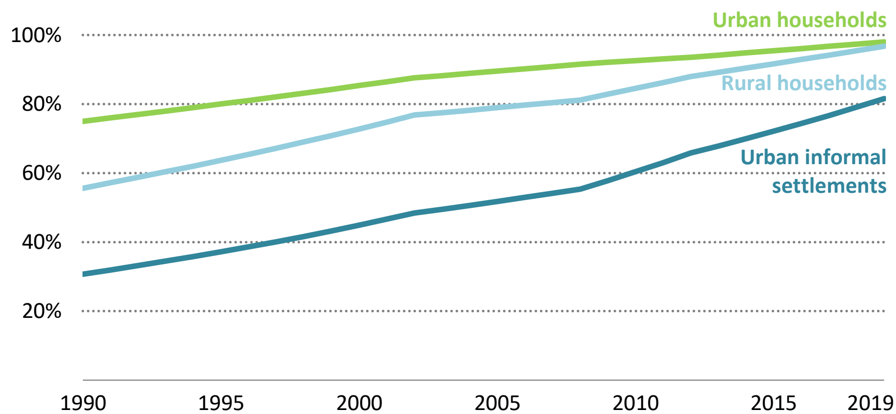
Source: IEA analysis based on NSSO (2018).

Indian cities have emerged as hubs for construction activity. India now has over 53 cities with more than a million residents, and a further 8 000 urban agglomerations, defined as areas with over 5 000 residents with a majority share of non-agricultural employment. The prevalence of multi-dwelling and multi-storey apartment buildings has steadily increased, with over half of all households in India's eight largest cities (each with a population of over 5 million) located in buildings of this kind in 2018, up from a third in 2002 (Sai, 2020).

India's construction boom has also been fuelled by a renewed focus on public housing. More than 150 million Indians live in unorganised informal settlements that lack basic infrastructure and services, and are often built as non-permanent structures on land that does not belong to the residents. These settlements have been targeted for replacement through public housing programmes that stretch back several decades. The government's various efforts in this direction were merged into the Pradhan Mantri Awaas Yojana (PMAY) scheme in 2015 with the overarching goal of "housing for all" by 2022. This public housing scheme aims to provide a house built with modern building materials for all those who are homeless and all those living in dwellings made using traditional building materials.

This focus on public housing has had significant impacts on building energy demand: in the six years leading to March 2020, more than 15 million houses were constructed, and a further 7 million are now under construction in urban areas. The government reported that 60 Mt of cement and 14 Mt of steel were used for the urban component of the construction (MOHUA, 2020). Moreover, as a part of PMAY, some informal settlements have been transformed into high-rise neighbourhoods, contributing to the growth in urban India's per capita floor space.

Figure 2.9 ▷ Share of households in India using modern building materials



There has been a steady increase in the share of new buildings constructed using modern, energy-intensive building materials such as cement, bricks and steel.

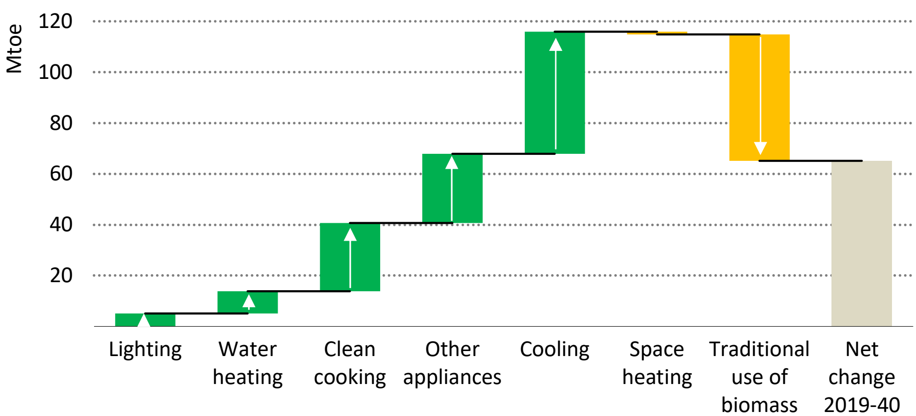
Source: IEA analysis based on NSSO (2018).

In the past, there were clear differences in the way in which rural and urban houses were built. In 1990, only 30% of rural homes were built using modern building materials, compared with 75% homes in urban areas. The rest were built using traditional materials such as unburnt mud, cow dung and other organic materials. That has been changing rapidly. By 2018, 80% of rural and 97% of urban houses were being constructed using modern materials (Figure 2.9). Overall, steel and cement production in India in the STEPS nearly triples by 2040 as a result of growth in the stock of housing and of a further closing of the gap between urban and rural areas in terms of their use of modern building materials.

Cooking and appliance ownership

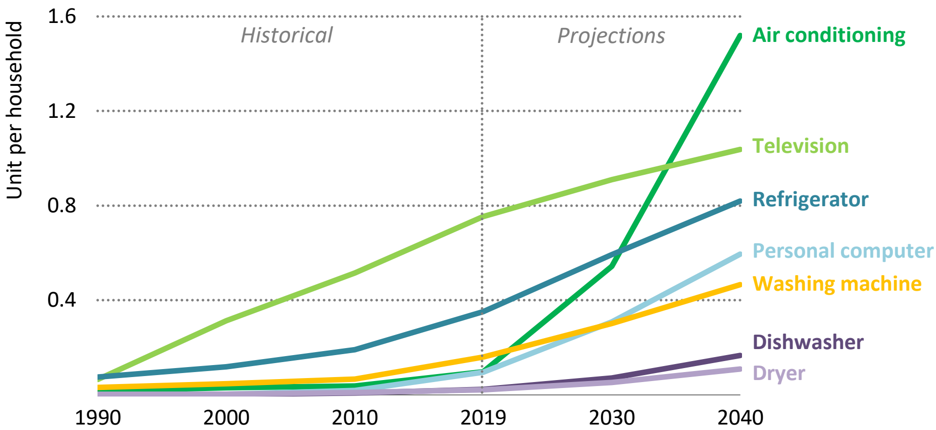
Cooking, heating, cooling and appliances are the four pillars of energy demand in buildings. In the STEPS, clean cooking (cooking that uses LPG, electricity, natural gas), appliances and cooling are responsible for the overwhelming majority of energy demand growth until 2040. The use of traditional cooking fuels and heating using biomass halves by 2040, and is replaced by cleaner alternatives including LPG and electric space heaters (Figure 2.10). The share of buildings in final energy consumption falls on account of falling biomass use, but the widespread uptake of cooling and appliances means the share of buildings in total electricity consumption rises from 41% in 2019 to 48% in 2040. Under the IVC, households move away completely from traditional bioenergy by 2030 as they adopt clean cooking technologies.

Figure 2.10 ▻ Change in energy demand in residential buildings in India in the STEPS, 2019-2040



Clean cooking, cooling and appliances are responsible for the overwhelming majority of energy demand growth in buildings to 2040, while there is a fall in traditional biomass use.

Figure 2.11 ▻ Appliance ownership in Indian households in the STEPS



AC units see faster growth than any other household appliance over the period to 2040 in the STEPS.

Appliance ownership in India has been growing and diversifying. In 1990, the only appliance that most households had was a ceiling fan. By 2019, televisions had also become quite commonplace, and the number of refrigerators was steadily increasing. By 2040, air conditioners, personal computers and washing machines are expected in the STEPS to become much more common, particularly in urban areas. Air-conditioning (AC) units see faster growth than any other household appliance over the period to 2040, and become the largest single driver of energy demand growth in buildings (Figure 2.11).

Focus on cooling

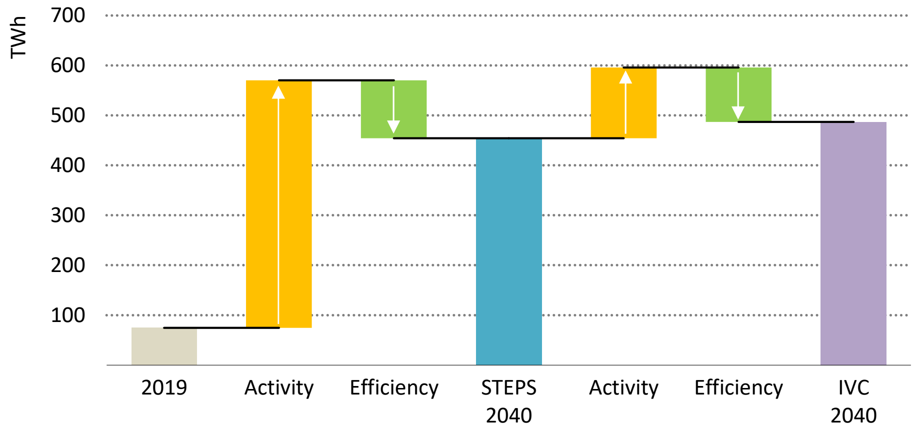
AC ownership is driven by the frequently hot and humid weather conditions in large parts of India. These conditions are being made more acute by rising temperatures stemming from global climate change and the "heat island effect" that affects urban areas in particular: as vegetation on land surfaces and water bodies have been replaced with impermeable and high-emissivity surfaces as part of the built environment, there has been an increase in temperatures in urban areas. With rising urban temperatures and per capita incomes, the growth in ownership of ACs is likely to become more broad-based, and it is expected to be led over the coming decades by mid- and low-income households in urban India (Kachhawa, Kumar, & Singh, 2019).

In the STEPS, air conditioner stock reaches 670 million in 2040, up from 30 million today. As a result, India's consumption of electricity for cooling grows sixfold to reach 650 TWh by 2040, which is more than the total electricity consumption of Germany today, and accounts for around half of all electricity consumption in buildings. Around two-thirds of this demand comes from the residential sector, with the remainder stemming from a steady rise in office buildings, retail, education, hotels and hospitals. Given that cooling demand peaks at certain times of the day and year for both residential and commercial buildings, this could put a considerable strain on India's ability to balance its grid and maintain reliable supply (see Section 3.2).

The growth in cooling demand could be mitigated by energy efficiency improvements in ACs, as well as thermally efficient building design, cool roofs and the adoption of other more efficient cooling appliances including desert air coolers. Government action has the potential to underpin mitigation efforts, and the India Cooling Action Plan (ICAP), which was launched in 2019, sets the scene for the future: it adopts the principle of "thermal comfort for all" including low-income groups, alongside a target to reduce cooling energy requirements by 25-40% by 2037-38, although the precise nature of this commitment is not clearly defined.

A range of policies and measures that could lower cooling demand and the resulting energy use is already in place. The Energy Conservation Building Codes for commercial buildings and the Eco-Niwas Samhita for residential buildings already set energy performance standards for new buildings that have a minimum energy consumption threshold or floor area, while the standards and labelling programme covers 10 appliance categories including air conditioners. Under the STEPS, nearly a quarter of electricity demand growth for residential space cooling is avoided by efficiency measures by 2040, broadly in line with the target set out under ICAP. In the IVC, a more robust implementation of energy efficiency policies means that the electricity demand arising from an additional 130 million air conditioners is almost entirely offset by efficiency gains (Figure 2.12).

Figure 2.12 ▷ The impact of efficiency measures on electricity demand from residential space cooling, 2019-2040



Electricity demand in 2040 from cooling alone will be more than the total electricity consumption in Germany today; energy efficiency measures can moderate this growth.

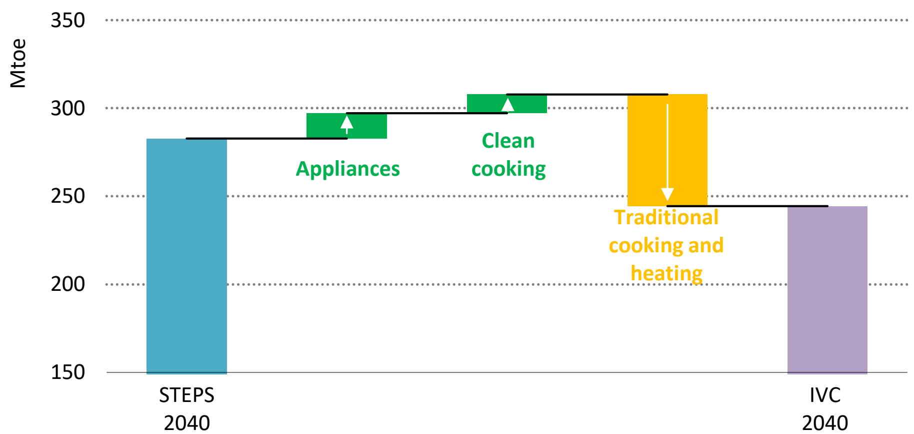
Building energy demand in the India Vision Case

In the STEPS, India's energy demand from buildings in 2040 is 30% higher than in 2019. This net growth figure would be much higher still without the drop in energy demand that comes from the displacement of inefficient biomass by efficient clean cooking fuels such as LPG and PNG. If cooking energy demand were excluded, energy demand from buildings would double in the STEPS in this period, due to increased uptake of electric appliances including water heaters, refrigerators, ACs, TVs and lights.

In the IVC, higher GDP growth means that ownership of appliances rises at a faster rate than in the STEPS, while greater disposable incomes means higher per capita consumption of energy services. These factors serve to push up energy demand, but there are countervailing forces that moderate the overall growth in consumption. First, there is an accelerated move away from traditional biomass towards modern fuels, as well as a parallel increase in appliance ownership, which raises the share of electricity in total energy use in buildings; both factors are instrumental in increasing the overall efficiency of energy use by India's building stock. Second, there are additional efforts to enhance India's efficiency policies, for example through more robust labelling and performance standards, as well as through stricter implementation of building codes covering insulation, shading and glazing, and other passive cooling solutions. As a result of these countervailing forces, energy demand from buildings grows in the IVC by only 12% over 2019 levels by 2040, less than half the level of growth seen in the STEPS.

The stronger push on policy and implementation in the IVC results in important co-benefits for India's built environment. To take one important example, indoor air quality improves drastically on the back of a rapid fall in traditional biomass use, resulting in fewer premature deaths in the IVC than in the STEPS. These gains far outlast the clean cooking transition (which is complete before 2030), with energy demand in 2040 remaining 14% lower in the IVC than in the STEPS (Figure 2.13).

Figure 2.13 ▷ Energy demand in buildings in the STEPS and the IVC, 2040



In the IVC, energy demand from buildings in 2040 is lower than in the STEPS because policies in the IVC bring to an end the traditional use of biomass for cooking and heating.

Note: Appliances includes cooling, lighting and all other electrical appliances.

2.3.2 Mobility

The last three decades have transformed mobility in India. The economic reforms of the early 1990s laid the groundwork for a huge expansion in transport and communication activities. The rapid growth in almost all types of transport infrastructure since then has fuelled economic growth, which in turn has led to a continual increase in demand for mobility for both passengers and goods. These changes have led to both energy use and emissions in the transport sector increasing fivefold over the last three decades.

Outlook for passenger mobility

Around 270 million people are expected to be added to India's urban population in the next two decades. Unless carefully planned, urban transport infrastructure could become a potential bottleneck to India's growth and development. The Indian cities with more than 1 million inhabitants already account for nearly 30% of total registered vehicles in India (MoRTH, 2019), and the level of vehicle ownership in urban households is higher than in rural households: in 2019, the motorcycle ownership rate was 1.4 times higher in urban areas and the passenger car ownership rate was twice as high. With growing disposable incomes and rapidly increasing motorised vehicle ownership, cities across India face the dual challenges of traffic congestion and poor air quality; Indian cities are consistently ranked high on the list of the most congested and the most polluted cities globally.

Following the National Urban Transport Policy (NUTP) of 2006, the last decade has seen the launch of programmes such as the Jawaharlal Nehru National Urban Renewal Mission, 100 Smart Cities Mission, and the Atal Mission for Rejuvenation and Urban Transformation to build and upgrade urban transport infrastructure, with a focus on public transport. These initiatives underpin a planned expansion of metro railways, rapid transit systems and bus services across dozens of cities.

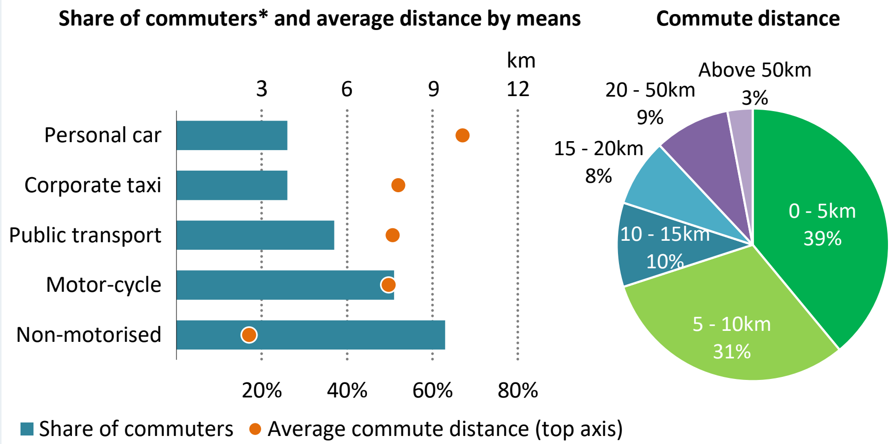
While the focus of transport policies has been on passenger vehicles and mass transit, a significant share of mobility needs in India continue to be met by three-wheeled auto rickshaws, private motorised two-wheelers and non-motorised modes of transport such as cycle rickshaws and bicycles, as well as by walking (Box 2.1).

Box 2.1 ▷ The role of non-motorised transport in urban India

Non-motorised transport plays a major role in mobility in India (Figure 2.14). In urban areas, nearly 40% of trips are 5 km or less. People usually walk or cycle in these cases. In a typical week, over 60% of urban Indians walk or cycle on trips that average 2.5 km. As the average length of journey increases, however, they become more likely to switch to two-/three-wheelers, public transport and personal cars (CEEW, 2019). People using non-motorised transport generally do so because they cannot afford motorised transport. Without an appropriate focus on non-motorised transport infrastructure, these individuals could transition to two-/three-wheelers or passenger cars as their per capita incomes increase.

There is a significant opportunity to avoid energy use in transport by ensuring adequate and safe pedestrian and cycling infrastructure in cities. Currently, Indian cities and towns rarely have extensive networks of walkable sidewalks or dedicated cycle lanes, and this forces non-motorised commuters to use roads meant for vehicular traffic instead, leading to a high number of fatalities from accidents. While the NUTP, launched in 2006, has an objective of “moving people and not vehicles”, this has not yet led to sustained investment in safe infrastructure for non-motorised commuters.

Figure 2.14 ⊳ How urban Indians travel, 2019



Most commutes in urban areas in India are short, and most short trips are non-motorised.

Notes: *Share of commuters using a particular mode of transport in any given week. Public transport includes bus, metro, taxi and 3-wheelers.

Source: IEA analysis based on CEEW (2019).

In the STEPS, the fleet of buses in India doubles by 2040 to reach a stock of 4.4 million. Efforts are being made to ensure that new bus fleets operate on fuels such as natural gas and electricity to reduce their impacts on local air quality. With about 6 200 buses, Delhi is home to one of the largest fleets of natural gas-powered buses in the world. However, public buses represent only 8% of India's total bus fleet (MoRTH, 2020). Efforts to transform bus operations therefore also require appropriate regulations and incentives to help private bus fleets move towards more efficient and cleaner fuel types.

While efforts are under way to develop more organised forms of public transport, the growth in the motorisation of mobility in India is largely being driven by increases in numbers of two-/three-wheelers. More than 80% of vehicles in India are two-/three-wheelers, and this vehicle category has grown faster than any other in the last decade (MoRTH, 2019). Three-wheeled auto-rickshaws help meet last and first mile mobility demands and, like buses, act as shared modes of transport operating on specific routes in both urban and rural settings. In some cities, they also operate as a metered service, like taxis. They operate on a wide range of fuels, including gasoline, diesel, LPG, natural gas and, in some recent cases, electricity. In the STEPS, the number of two-/three-wheelers on the road increases by over 55% by 2040.

Passenger cars are the third-fastest-growing vehicle category in India, with annual average growth of around 10% over the last decade. Increasing disposable incomes and a growing range of available models mean that demand for cars is set to rise over the coming decades.

Passenger cars are now subject to a CAFE energy efficiency standard with an upper limit of 5.49 litres/100 km, and this standard will become more stringent from 2022. Together with the Bharat Stage VI fuel quality standards and incentives for purchase of EVs, this should help to reduce the level of energy demand growth. At the same time the increasing use of shared app-based ride-hailing passenger services has the potential to make more efficient use of the stock of passenger cars and to reduce road congestion and local air pollution. In the STEPS, the stock of passenger cars nevertheless still grows fivefold between 2019 and 2040 to reach 200 million, outpacing the growth of all other vehicle categories.

In the SDS, there is a concerted effort to move towards more efficient forms of transportation. As a consequence, the stock of buses and two-/three-wheelers is about 7% higher in 2040 than in the STEPS, while the stock of passenger cars is about 6% lower. In the IVC, buses and two-/three-wheelers grow at much the same rate as in the STEPS, but there are nearly 10% more passenger cars in 2040 than in the STEPS owing to the greater purchasing power of Indians.

The electrification of road transport

Road transport has historically been dominated by gasoline and diesel vehicles, but this is starting to change as a result of a range of policy initiatives and technology trends. India's vision for vehicle electrification was first outlined in the National Electric Mobility Mission Plan launched in 2012, which foresaw rapid growth in both the manufacturing and use of EVs in India.

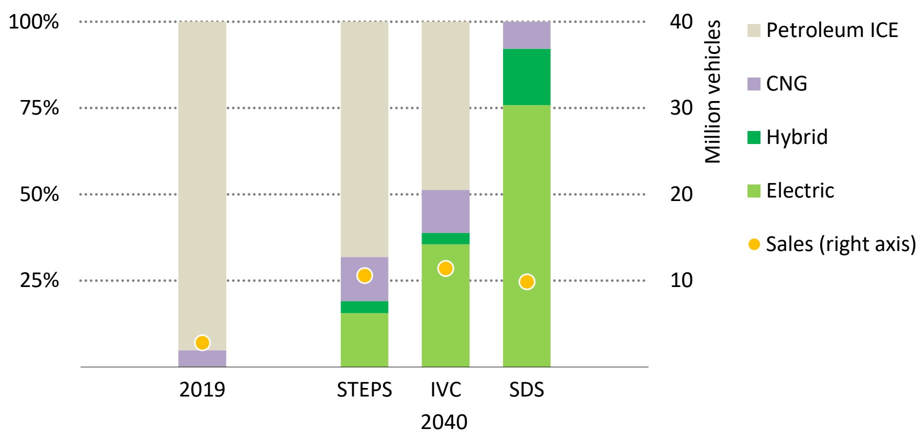
To increase the uptake of EVs, a subsidy programme called the Faster Adoption and Manufacturing of Electric Vehicles (FAME) was introduced in 2015. The second phase of the policy, FAME-II, was approved in 2019 with a budget of $1.4 billion for a three-year period. This includes policy incentives for the purchase of electric and hybrid vehicles as well as for the deployment of charging stations. FAME-II aims to increase the number of electric buses, two-/three-wheelers and cars. Subsidies are available only for vehicles with advanced battery chemistries, rather than lead-acid variants that make up the majority of electric two-/three-wheelers sold today. In addition to these policies, Energy Efficiency Services Limited, India's largest energy services company, has a bulk procurement programme in place to acquire 10 000 EVs for government use, although to date around 15-20% have been acquired. State and city governments have also introduced policies to incentivise the uptake of EVs.

To ensure the development of EV charging infrastructure, the Bureau of Energy Efficiency has laid out targets for the installation of at least one publicly accessible charger within a grid of 3 km by 3 km in cities, and one charging station every 25 km on both sides of highways. There is an additional target of one fast-charging station every 100 km on highways. The government has also complemented its measures to promote the use of EVs and associated infrastructure by announcing a production-linked incentive for the manufacture of advanced chemistry batteries for EVs, renewable energy and other applications.

As many of these incentives are relatively recent, much of the growth in electric passenger car numbers lies ahead. Fewer than 4 000 electric cars were sold in India in 2019. However, supportive policies, a growing global market for EVs and falling battery costs should soon put more EVs within reach of India's increasingly affluent middle classes. In the STEPS, there are nearly 7 million electric cars on the road by 2030, and 27 million by 2040.

A more significant opportunity for electrification exists in the form of two-/three-wheelers. In 2019, India had a stock of 1.8 million electric two-/three-wheelers on the road, and battery-powered electric three-wheelers (also called e-rickshaws) are already serving the demands of over 60 million people per day, mostly in urban areas (Singh, 2019). Sales are modest in terms of the size of the overall market – around 740 000 electric two-/three-wheelers were sold in 2019, accounting for about 3% of total sales – but are set to rise rapidly in the future. In the STEPS, there are 55 million electric two-/three-wheelers on the road in 2030, and they make up 19% of the total stock. This increases to 160 million in 2040, by which time they account for over half the stock of such vehicles.

Figure 2.15 ▷ Passenger car sales by scenario, 2019 and 2040



Two- and three-wheelers see rapid electrification, but the speed at which the car fleet switches away from petroleum-based fuels varies widely by scenario.

Note: ICE = internal combustion engine.

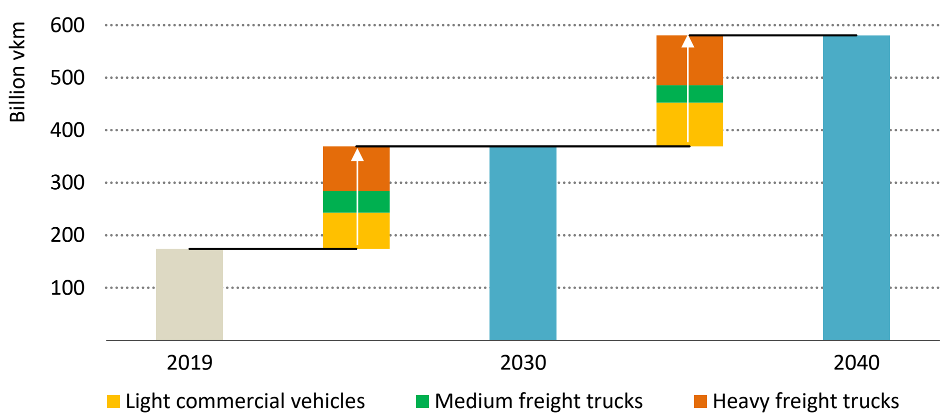
There were very few electric buses on the road in 2019, but there have been recent efforts by the central government jointly with states and municipal corporations to roll out 5 600 electric buses across 64 cities (for both urban and intercity movement) over the next few years (DHI, 2020). The number of electric buses grows to over 500 000 by 2040 under the STEPS, though they still account for only 12% of the stock. Overall, annual sales of EVs rise steadily in the STEPS (Figure 2.15). In all, the EV fleet – including two- and three-wheelers, cars, vans, buses, and trucks – represents 34% of the entire road stock by 2040, with two-/three-wheelers accounting for the vast majority of the total.

Things look different in other scenarios. In the IVC, more aggressive implementation of electrification targets results in 25% of the passenger cars sold and nearly half of the two-/three-wheelers sold being electric by 2030. By 2040, nearly 70% of all vehicles sold are electric. In the SDS, there is a much stronger policy push towards sustainable forms of mobility, together with a set of measures that support the domestic production of batteries, a rapid roll-out of charging infrastructure, and the implementation of building codes that encourage private charging. In the SDS, EVs constitute nearly half of all vehicle sales by 2030, and 86% by 2040. By 2040, 90% of the passenger cars sold are electric, up from 48% in 2030, and nearly 60% of the total vehicle stock is electric.

The future of road freight

India's steadily growing and more interconnected economy has led to a rapid rise in freight transport in recent years. Over 60% of goods transported in India travel by road (MoRTH, 2020). In the past decade, freight road activity and the number of commercial freight vehicles have both doubled, and they are projected to more than triple from current levels under the STEPS, with the stock of commercial freight vehicles reaching 35 million in 2040. Almost 45% of the growth in freight activity between 2019 and 2040 comes from heavy-duty freight trucks, which tend to serve long-distance routes, with a further 38% coming from the use of light commercial trucks, which largely serve urban centres within city limits (Figure 2.16). The growth in freight demand in the STEPS is mainly met by vehicles using diesel, with only small increases in the use of alternative fuels such as CNG. The increasing use of railways to transport freight does, however, avoid some growth in road freight activity (Box 2.2).

Figure 2.16 ▷ Growth of road freight activity in India in the STEPS, 2019-2040



Road freight activity in India more than triples by 2040 in the STEPS, with long-distance trucks and intra-city light commercial vehicles contributing most of the growth.

Note: vkm = vehicle kilometres.

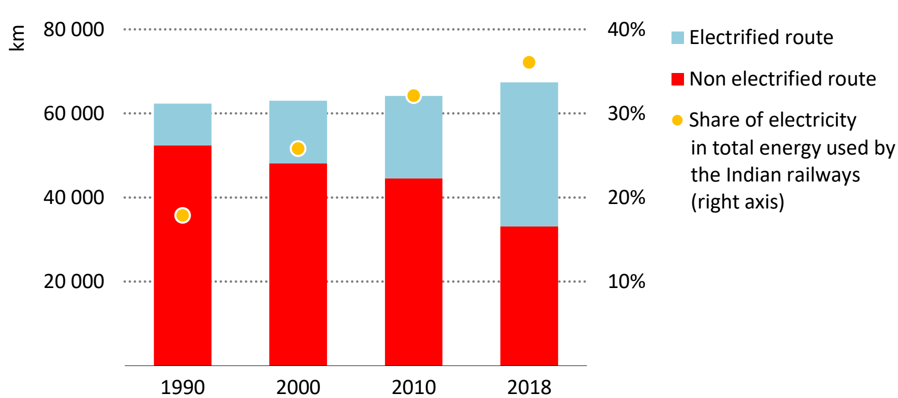
While the level of freight activity in the SDS is similar to that in the STEPS, much more of it is transported by hybrid, electric, hydrogen and natural gas freight vehicles, with around half of the 30 million trucks in 2040 in the SDS being powered by technologies other than diesel ICEs. In the STEPS, by contrast, these alternative technologies account for only 6% of energy demand from India's trucks.

Box 2.2 ▹ The transformation of India's railways

Railways in India have a long pedigree, dating back more than 160 years to the pre-independence era. By the time India gained independence in 1947, its railway network extended for more than 50 000 km. It has since grown to around 67 000 km, making it the fourth-largest railway network in the world. India's railway network was for a long time largely fuelled by coal and diesel. However, the share of electrified tracks has increased in recent decades, rising from 24% in 2000 to just over 50% in 2019. The share of electricity in total energy use by Indian railways has seen a corresponding increase, albeit at a more moderate pace (Figure 2.17).

In recent years, there has been a renewed focus on transforming railways to make them a desirable option for long-distance transport as well as urban public mobility. Indian Railways has an ambition to fully electrify its tracks by 2023, which will entail the electrification of over 30 000 km of track within four years. In parallel, there is an aspiration for rail transport to become "net zero" emissions by 2030 by drawing its entire electrical load from renewable energy.

Figure 2.17 ▹ Electrification of railway routes and operations



Indian railways are rapidly electrifying, with a goal of 100% electrification by 2023.

Source: Ministry of Railways (2019).

There is also an interest in developing high-speed rail in India, with the first line being developed between the cities of Mumbai and Ahmedabad. Further lines are also being explored which could run between Mumbai and Delhi, between Delhi and northern Indian cities such as Amritsar and Varanasi, and between Mumbai and cities in the south. Despite high capital costs, high-speed rail has the potential to displace air traffic, leading to energy savings and emissions reductions.

Railway operators are seeking to double the average speed of freight trains by 2023, and to increase their share of freight movement from 30% in 2019 to 45% by 2032. The Dedicated Freight Corridor (DFC) between India's four largest cities of Delhi, Mumbai, Chennai and Kolkata aims to create over 10 000 km of railway track that would be used solely by freight traffic on a route that accounts for nearly 58% of the revenue-earning traffic on the railways. The DFC is currently under construction, with some sections of it opening to traffic in 2020, and further sections targeted to open in 2022. As well as improving freight rail transport, the DFC will free up other lines for passenger use, which should lead to an improvement in average speeds across the railways.

In addition, urban metro rail is expected to double in length: there are 650 km of lines in 18 cities today, and a further 900 km of lines are now under construction across 20 cities. The most extensive metro network is in New Delhi, but there are growing networks in other cities. More than 4.5 million passengers use the metro in Delhi every day, while the metros in Mumbai and Bangalore each have daily ridership of more than 450 000 people. As lines and stations expand, urban rail networks could potentially carry millions of additional daily commuters. This should reduce personal car travel and so prevent additional emissions and road congestion.

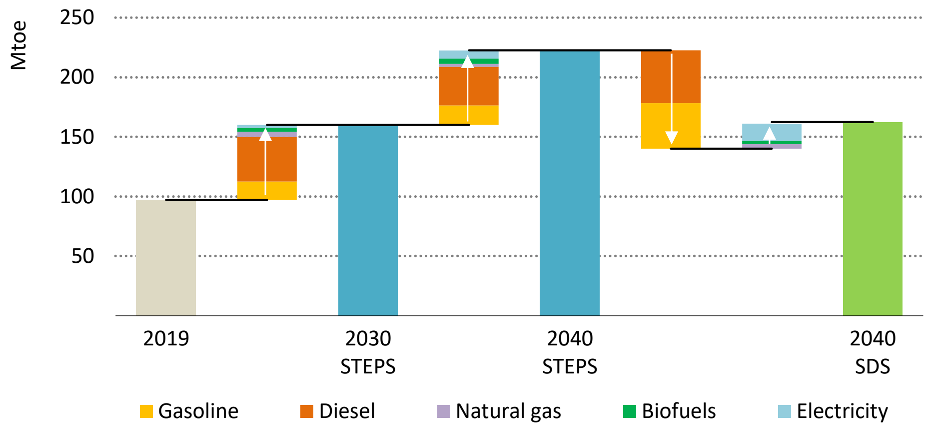
Together, these efforts could help shift some road and flight transport activity to rail, which is among the most efficient modes of transport. The energy used per passenger kilometre in rail is roughly one-tenth that of passenger cars and planes, and one-third that of buses (IEA, 2020).

The outlook for transport energy demand and emissions

Energy demand for road transport in the STEPS more than doubles by 2040 to reach 220 Mtoe (Figure 2.18). Freight transport constitutes half of the overall increase, most of which is fuelled by diesel: in 2019, around 80% of freight transport relied on the use of diesel, a share that remains largely unchanged to 2040. Energy use in passenger cars quadruples over the 2019-40 period. Despite rapid growth in EV sales, especially for two-/three-wheelers, electricity consumption growth constitutes only 7% of the overall growth in road transport energy demand to 2040 under the STEPS. Under the IVC, this rises to nearly 15% of the overall growth in transport energy demand.

Railway energy demand grows by over 80% through to 2040 in the STEPS, with electricity providing only half of the energy used by railways in India in 2040. In the IVC, however, the target of complete electrification is achieved. Energy demand from domestic aviation triples under both the STEPS and the IVC (although it is 10% higher in the IVC); it constitutes less than 1% of energy demand under both scenarios.

Figure 2.18 ▷ Changes in road transport energy demand by fuel/technology and scenario, 2019-2040

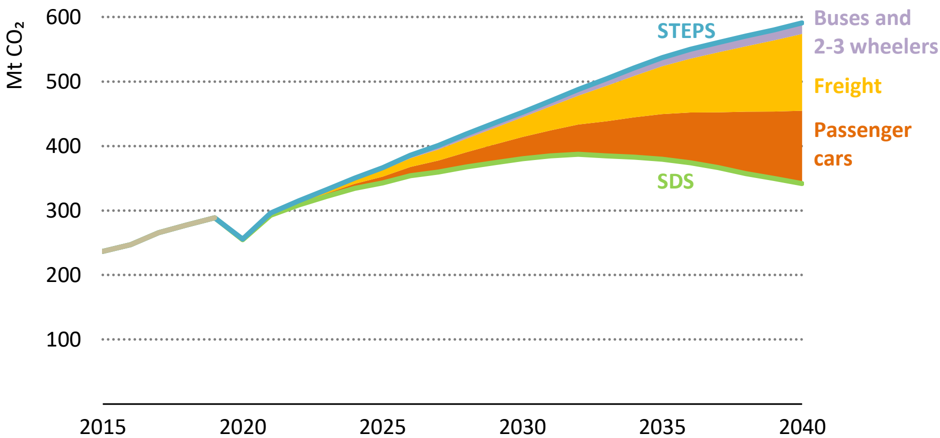


Diesel-based freight transport underpins demand growth in the STEPS to 2040. Greater efficiency and an uptake in electric mobility is key to avoiding demand growth in the SDS.

As a result of these demand increases, CO_2 emissions from road transport double between 2019 and 2040 in the STEPS, with around 65% of this increase coming from freight vehicles; road transport continues to account for nearly 90% of overall emissions in the transport sector. The scale of activity growth in the transport sector means that CO_2 emissions also grow in the SDS in the period to 2040, largely as a result of a doubling in emissions from heavy-duty trucks. However, a number of developments in the SDS help to improve the sustainability of transport. EVs account for a far larger share of new vehicle sales in the SDS than they do in the STEPS; this means that electricity (which is increasingly supplied from low-carbon sources) accounts for nearly one-third of the growth in road transport energy consumption to 2040. More robust efficiency targets also help to lower energy demand and emissions, while the use of biofuels helps to lower the emissions intensity of liquid fuel demand. Alternative fuels including biofuels, electricity and natural gas together meet 30% of road transport sector energy demand in 2040 in the SDS, which is over twice the share in the STEPS.

The result of these developments is that road transport emissions in the SDS begin to decline in the 2030s despite rising vehicle ownership and activity levels, and end up 42% below the level in the STEPS by 2040. This is primarily due to efficiency gains and an increasing share of passenger cars and road freight vehicles running on alternative fuels such as biofuels, CNG and electricity (Figure 2.19); two-/three-wheelers are already increasingly electrified in the STEPS.

Figure 2.19 ▷ CO_2 emissions reductions from road transport between the STEPS and the SDS

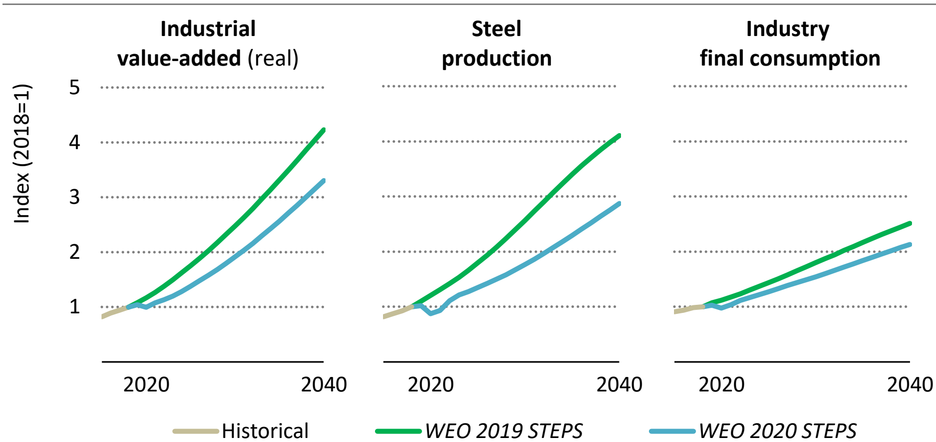


While two-/three-wheelers form a large majority of the stock of vehicles, the biggest opportunity to reduce CO_2 emissions comes from passenger cars and freight transport.

2.4 Industrial transformations

The share of the industry sector in total final energy consumption increased from 28% to 36% between 1990 and 2019, making it the largest end-use sector today, and a vitally important sector for India's energy future.

Figure 2.20 ▷ Indices of industrial activity and energy consumption in the STEPS, compared with *WEO 2019*

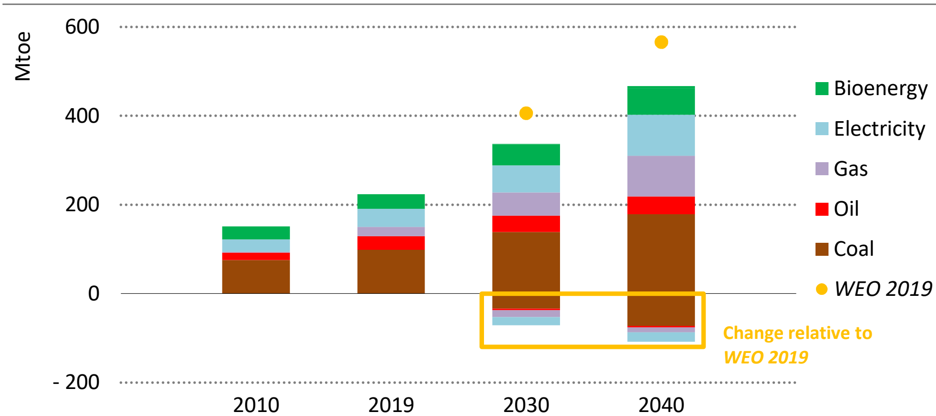


The pandemic leaves a lasting gap for key industrial indices that is not closed in the STEPS.

The Covid-19 pandemic and the nationwide lockdown sharply reduced India's industrial activity. On an annualised basis, in the months from January to August 2020, cumulative production of steel fell by around 20% (OEA DPIIT, 2020). Tentative signs of economic recovery were visible in the second half of 2020, with monthly production of heavy industrial commodities returning towards their pre-crisis levels. However, in the absence of a burst of industrial activity at higher rates than those prior to the crisis, there is likely to be a prolonged reduction in activity relative to pre-crisis projections. For example, compared with the *WEO 2019,* the growth in real industrial value in the period to 2030 in the STEPS has been adjusted down by around 20%, with steel production down by a similar rate. Despite a pickup of economic growth rates after 2020, these industrial indicators remain lower in the STEPS than in *WEO 2019* projections for the whole scenario period through to 2040 (Figure 2.20).

India's industrial energy consumption in 2040 in the STEPS is over 100 Mtoe (or 18%) lower than projected in the *WEO 2019*. This downward adjustment does not, however, affect all fuels equally. The downward revision falls hardest on coal, which is 34 Mtoe lower in 2030 and 73 Mtoe lower in 2040 than projected in the *WEO 2019*. Electricity consumption is down 21 Mtoe in 2040 and natural gas consumption is down 11 Mtoe (Figure 2.21).

Figure 2.21 ▷ Industrial final consumption by fuel in the STEPS, *WEO 2019* versus *WEO 2020*



Covid-19 has dampened the projected rise in industrial energy consumption in India; by 2040, demand is 18% lower than in pre-crisis projections.

2.4.1 Industrial energy demand in the STEPS

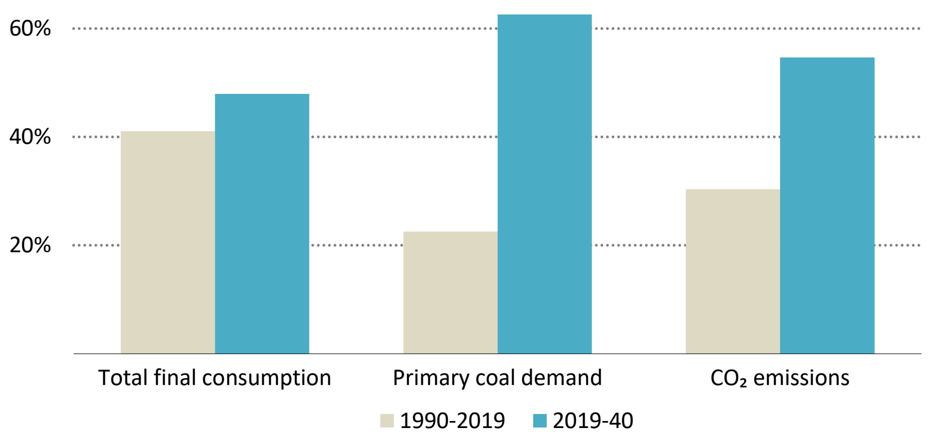
Despite the short-term revisions as a result of Covid-19, the long-term outlook for India's industrial energy consumption is one of substantial growth.

In the STEPS, industrial energy consumption doubles to reach 465 Mtoe by 2040. This represents almost half of the total growth in final energy consumption over this period.

Consequently, industry's share in total final consumption increases from 36% in 2019 to 41% by 2040. In addition to final consumption of energy, the industry sector is responsible for the non-energy use of fossil fuels as industrial feedstocks, for example in petrochemical and fertiliser production. Total feedstock consumption in the STEPS grows from 22 Mtoe in 2019 to 55 Mtoe by 2040, of which oil makes up 40 Mtoe and gas 13 Mtoe (the remainder being hydrogen and biomass feedstocks).

Over the past three decades, almost three-quarters of the growth in coal demand went to power generation. In the STEPS, this dwindles to one-quarter, and instead almost two-thirds of the growth in coal demand comes from industry. As a result, the industry sector accounts for the majority of CO_2 emissions as well as the majority of total demand growth in India between 2019 and 2040 (Figure 2.22).

Figure 2.22 ▷ Industry share in total final consumption, coal demand and CO_2 emissions growth in India in the STEPS

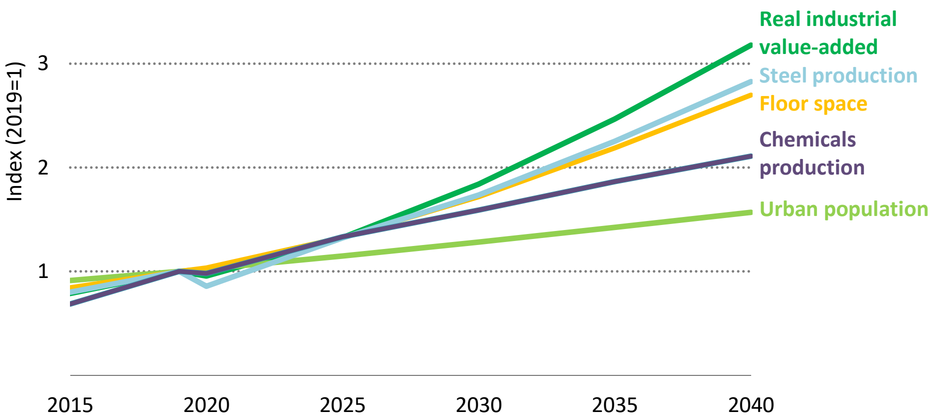


In the STEPS, the dominance of renewables in power means coal pivots from power to industry, making industry responsible for the majority of growth in CO_2 emissions to 2040.

In the STEPS, real industrial value-added grows more than threefold from 2019 to 2040, driven by materials-intensive investments in infrastructure, urban housing, factories and productive equipment. The urban population is projected to grow from 470 million in 2019 to 740 million by 2040, and total residential floor space from 19 billion m^2 to over 50 billion m^2. This massive urban transition underpins rapid growth in energy-intensive materials such as steel and cement. As a consequence of this robust growth in the industrial sector, India becomes increasingly central to global industrial energy demand (see Chapter 4).

Between 1990 and 2019, the energy intensity of India's industrial value-added (i.e. the amount of energy required to produce an additional unit of industrial output) decreased by more than 50%. This was due, in part, to the general wave of economic efficiency improvements that occurred after liberalisation in the early 1990s; it was also a consequence of relatively high energy prices, as well as specific policies such as the PAT scheme. The energy intensity of India's industrial value-added is now relatively low by international standards: in 2019, it was below the G20 average (measured at PPP).

Figure 2.23 ▷ Drivers of India's industrial energy consumption in the STEPS



Improvements in material efficiency and energy efficiency keep the rise in industrial energy consumption below the growth in industrial production and value-added.

India's economic growth and the increasingly industrialised structure of India's GDP are key drivers of the projected increase in industrial energy demand to 2040.[3] Over the period to 2040, industrial value-added increases faster than the production of physical outputs such as steel and cement (Figure 2.23). Total final energy consumption of the industry sector increases more slowly than either as a result of improvements in efficiency. These are partly the result of natural economic processes, as the economy becomes more efficient at extracting value from the factors of production, including materials and energy. They are also partly driven by policies aiming to improve material efficiency, for example through recycling and material reuse. In the STEPS, material efficiency avoids about 25 Mtoe of industrial energy demand growth over the period to 2040, while reductions in the energy intensity of the physical production of steel, chemicals, cement, paper, and aluminium avoid a further 150 Mtoe (Figure 2.24).

Within the heavy industrial sectors, the largest potential for material and energy intensity improvements lies in the steel sector, which contributes more than half of the total energy savings from these sectors. Although much smaller individually, substantial energy savings from energy intensity improvements also come from India's light industry base. Energy

[3] In the STEPS, the share of industrial value-added in overall GDP increases slightly, meaning there is a modest rise in industrial energy demand attributable to structural economic changes.