from renewable generators, as a way of meeting green purchasing goals and locking in low-cost power supply. Solar PV based on corporate PPAs have, however, reduced considerably in India in 2020 – despite considerable growth in previous years. Reforms could lead to greater utilisation of forward contracts to increase the options for hedging, which are currently not available in India.

Overall, scaling up investment for utility-scale renewable projects will require policy reforms, as well as an expansion of the availability of low-cost financing. Policy and regulatory certainty that allows investors and financiers to price risks effectively remains a key condition. Targeted financial measures, especially those aimed at debt structuring, credit enhancement and guarantees, could further help to address off-taker and finance-related risks. Madhya Pradesh has adopted a three-tier payment security mechanism to address purchase risks, for example, and this kind of mechanism could be adopted more widely. The ability to access loans for longer periods and on more flexible repayment terms that better match project cash flows will become more critical as tenders become more complex. In all these areas, development finance institutions have the potential to play a key financing role, but long lead times and stringent conditions can blunt their effectiveness. Expanding the suite of off-takers through better frameworks for corporate PPAs could also be helpful.

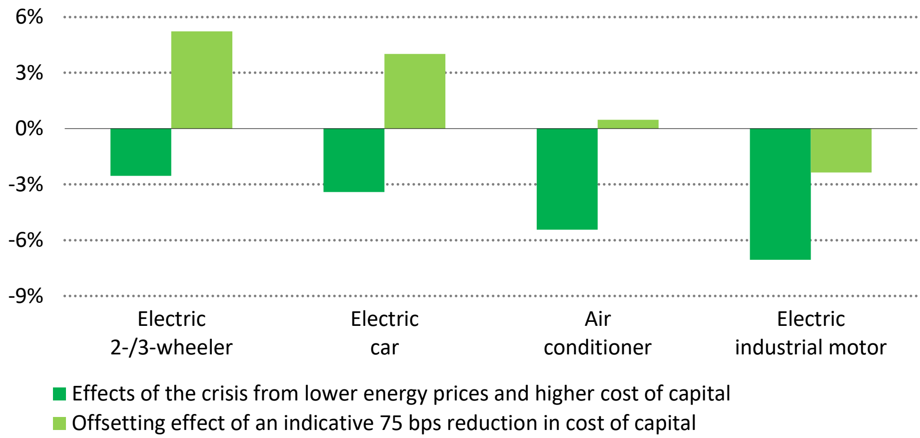
Financing energy efficiency, electrification of transport and small-scale clean energy

Over the next decade, the energy intensity of commercial buildings declines by over one-third in the SDS while the fuel economy of passenger cars improves by 40% compared with the previous five years. These goals are supported by investments in more efficient lighting, cooling and appliances, as well as uptake of EVs and in charging infrastructure. Investment in distributed renewables, including solar PV and solar thermal, tops $14 billion by 2030 compared with $2 billion in 2020.

Much of the investment in the SDS would be for smaller-scale resources, and investment models for such resources differ considerably from those for bulk power assets. They rely to some extent on the balance sheets of consumers, MSMEs, real estate developers and ESCOs, and are often not able to adopt long-term contracts. Remuneration frequently depends on energy savings against retail tariffs, which differ considerably among consumer classes. They also depend to a large extent on equity. Over half of buildings-related investment, and nearly 70% of transport investments, will be financed with equity over 2025-30; investments in utility-scale power and in more developed markets will make more use of debt. Mobilising investment depends on improving returns and financing costs, but changing energy prices and higher market risk premiums are currently extending payback periods and reducing profitability for key efficiency investments. Efforts to improve financing could help (Figure 4.20), but increasing the pipeline of bankable efficiency projects depends on stronger policy frameworks and greater standardisation of financial models with projections of energy savings and monitoring and verification protocols.

Investment in distributed generation, including rooftop solar PV and mini-grids, could help improve electricity services while taking some financial pressure off discoms. Integrating distributed applications with agriculture or other uses could similarly help to relieve subsidy burdens and lower technical losses. The current tariff system does not, however, provide sufficient incentive for utilities to adopt supportive frameworks, in part due to fear that providing such incentives would risk their losing revenues from more profitable industrial consumers. Industry sources point to consumer-owned installations as more common than those leased or made on a PPA basis with third parties, although some investment has been supported by auctions for government off-takers. Captive power users and MSMEs represent a large potential market, but often face credit constraints and lack suitable collateral. Domestic lending capacity has been reinforced by development financing, with preferential lines of credit earmarked by the World Bank and Asian Development Bank in collaboration with local banks, but an acceleration in investment has yet to be seen.

Figure 4.21 ▷ Changes in NPV for key efficiency improvements with changes in energy prices and cost of capital in 2020, compared with 2019



Changing energy prices and a higher cost of capital have reduced profit expectations for efficiency measures; better access to finance would improve the investment case.

Notes: NPV = net present value; bps = basis points. Changes in cost of capital in 2020 reflect movements in the economy-wide risk-free rate and equity- and debt-market risk premiums, weighted by capital structure. Equity share assumptions = air conditioner, 100%; industrial motor, 75%; electric car and two-/three-wheeler, 70%.

For buildings efficiency and distributed generation, bundling assets to achieve scale is one route to securing investment. Construction of green buildings has emerged as another fast-growing mechanism for obtaining investment: in 2020, nearly 1 billion m^2 was certified as green, which is equivalent to 5% of total residential floor space. Efficiency upgrades can increase building valuations, but the benefits are not easy to monetise without independent ratings systems to verify and communicate performance to stakeholders (including current and future owners and tenants). The capital structure of real estate developers mostly relies on relatively costly equity. Access to finance remains a constraint for these developers, particularly those at the smaller end of the scale, and no dedicated finance facility for the sector exists (World Bank, 2018). Incentives to integrate smart energy management systems, government procurement of efficient equipment and appliances, and reduced administrative hurdles for code-compliant investments would all help support the business case for efficiency.

Targeted financial solutions, such as credit enhancement, could better encourage investment in projects serving MSMEs. One study has assessed that the provision of credit guarantees to local banks to support lending to developers could increase private investment in rooftop solar PV by up to 14 times (CPI, 2018). In recent years, domestic lending capacity has been reinforced by development financing, including preferential lines of credit to encourage lower-risk on-lending to distributed sectors. The pooling of real estate assets into marketable securities – through REITs or INVITS – can also support reinvestment by developers and reduce reliance on banks, but action is needed to address regulatory and taxation uncertainties.

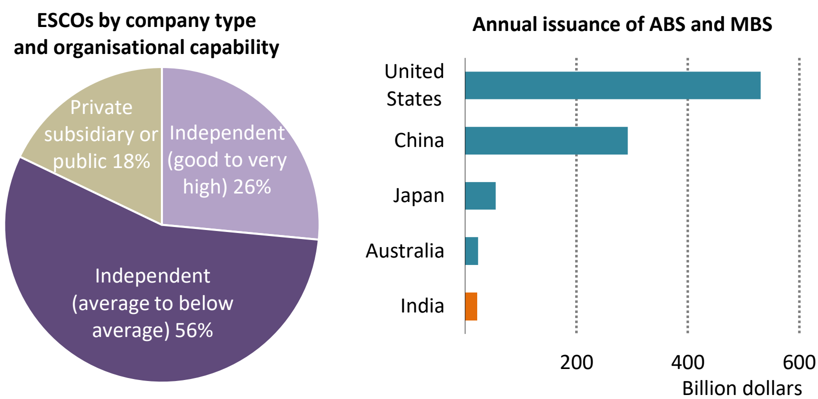
In transport, improving financial options for drivers will be critical. Two-thirds of the increase in EV sales in the SDS comes from two- and three-wheelers. Most three-wheeler (auto-rickshaw) operators lease their vehicle, paying the owners daily from their earnings. Owning an electric auto-rickshaw outright might well make more economic sense for such operators, but it is often hard for them to gain access to finance because of a track record of high default rates on loans for such rickshaws (in part due to the initially unreliable performance of lead-acid batteries), the small size of the loans that are sought and a lack of collateral on the part of the operators (EVreporter, 2020). Incomes for drivers have suffered during the pandemic, making lenders even more cautious about extending finance. Dedicated loan products and buy-back schemes for existing vehicles could help to support investment.

Box 4.4 ▻ Mobilising investment through service models and securitisation

The provision of energy as a service is growing, and this is helping to boost investment in distributed resources and efficiency in India. Some 150 private ESCOs are now accredited by the Bureau of Energy Efficiency, and their numbers have tripled over the past decade. They play particularly important roles in industrial sectors, where their use of performance contracting helps to attract credit from banks. Around 90% of the arrangements made by private ESCOs in industry involve energy performance contracts (EPC) based on shared savings; the remainder take the form of EPCs with guaranteed savings (IEA, 2018). These contracts are reinforced by a Partial Risk Guarantee Fund established by the Bureau of Energy Efficiency, which has mobilised private capital at a rate of over three times the level of public commitment.

The government is also trying to cultivate a market for energy services supported by the state-owned "super ESCO", Energy Efficiency Services Limited (EESL), which has used its balance sheet and development bank funding to become the largest developer of small-scale clean energy, investing nearly $0.2 billion annually over 2017 and 2018 in areas such as lighting, smart meters and buildings. It seeks to increase its spending to over $0.8 billion annually, partly in support of setting up EV charging stations. EESL also aims to bolster bulk procurement programmes, such as the successful UJALA LED initiative, to support lower-cost appliance purchases by consumers.

Figure 4.22 ⊳ India registered ESCOs by type and organisational capability (left) and size of total securitisation market by country (right)



Despite rapid growth, India's energy service market faces organisational and financial constraints, while progress on asset aggregation and securitisation remains limited.

Notes: ABS = asset-backed securities; MBS = mortgage-backed securities. Organisational capability corresponds to ESCO grades assessed by the Bureau of Energy Efficiency.

Sources: IEA analysis based on Bureau of Energy Efficiency (2020) and VKC (2019).

Despite rapid growth, only 5% of the Bureau of Energy Efficiency assessed efficiency market has been tapped by ESCOs. This is due in part to insufficient policy signals and lack of standardisation around savings and contractual frameworks, and in part to constraints in balance sheets, which have deteriorated during the economic crisis. While some ESCOs are part of larger private companies or public entities, most are independent players with limited organisational capability and access to finance (Figure 4.22). Credit-worthy clients have been reluctant to engage, and large industries have yet to show strong interest in performance contracting and energy service models. Banks have nonetheless been willing to lend to projects that are viable, even without the support of guarantee funds (BEE, 2018).

Infusions of both equity and debt are needed in the sector. New business models focused on providing system and end-user services beyond efficiency could help attract risk capital (AEEE, 2017). The promotion of warehousing and securitisation, which aggregate loans, receivables or projects and issue them as listed securities, could support lower-cost refinancing and free up balance sheets for reinvestment. This practice has accelerated globally with the issuance of green MBS and Property Assessed Clean Energy loans in the United States, but the securitisation market has yet to take off properly in India. Better certification, more credit enhancement options for projects and the establishment of a state-backed pooling intermediary could help enhance such a market.

The emissions reductions seen in the SDS compared with the STEPS in industry – including in steel, cement, chemical and manufacturing – require a reduction in energy intensity by around a quarter over the next decade. The investments that would be necessary to make this happen mostly focus on efficiency, but they also include funding for the direct use of renewables, such as bioenergy and solar thermal (the market for which has rapidly expanded to around $1 billion in 2019), as well as for gas and electricity to substitute for coal. These goals come at a time when the government is prioritising domestic manufacturing. Three-quarters of industry investment depends on equity, and there is potential to diversify funding sources and attract more debt to reduce the cost of capital.

The PAT scheme – a market-based mechanism with efficiency targets and tradeable energy savings certificates – provides the main incentive to invest. PAT Cycle 1 resulted in investments of around $4 billion, mostly from large companies, and its targets were met in all sectors except for thermal power. Incentives remain volatile, however, with energy savings certificate pricing varying considerably in recent years, in part owing to an excess of supply. Moreover, the PAT scheme to date has largely excluded the MSME sector. The Atmanirbhar Bharat Scheme is now making available collateral-free debt ($42 billion) and subordinated debt ($6 billion) to businesses and stressed MSMEs. Improving funding options could be enhanced through better domestic corporate bond markets, as well as performance-based financing instruments for use by energy-intensive companies.

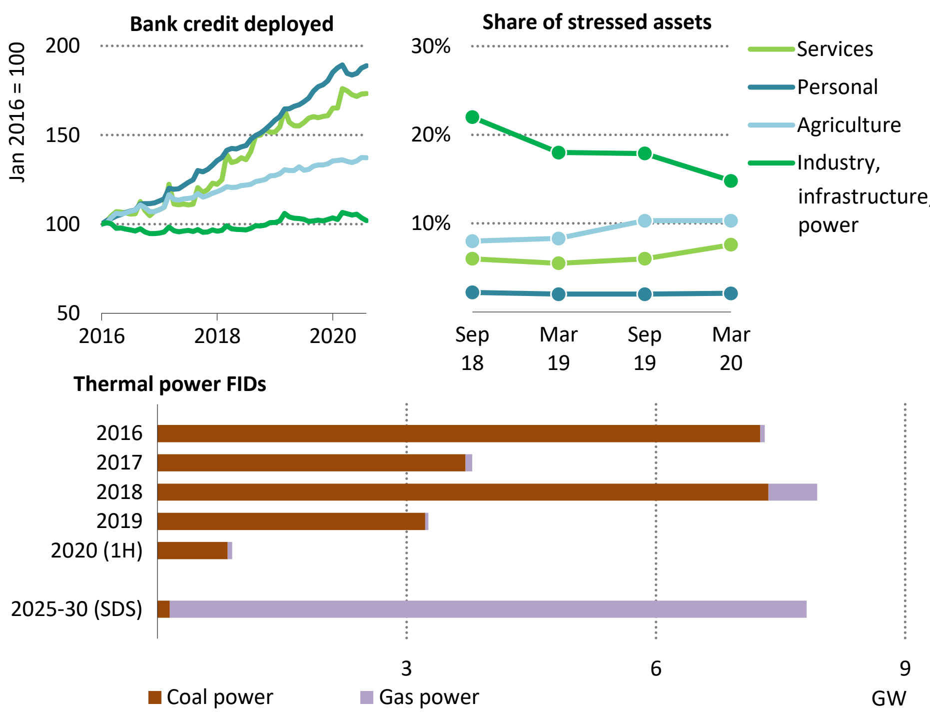
Links with the financial performance of other parts of the energy sector

The financial health of other parts of the energy and industrial sectors has an impact on financing conditions for clean energy investments because there are limits to the capacity of banks to mobilise debt for investments. Industry, infrastructure and power remain the largest recipients of bank credit in absolute terms, but lending has stagnated over the past five years, with most growth occurring in the personal and services sectors. Moreover, while overall bank credit has grown by 40% since the start of 2016, it has stalled with the start of the pandemic.

One reason for the stagnation in recent years is that the RBI has prescribed sector limits to guard against concentration of credit risks, and these limit bank loan portfolios for infrastructure, including power, to 20-25%. Another reason is the high level of stressed assets now in the financial system, which is creating headwinds for overall lending. Nearly 15% of bank portfolios in industry and power remain stressed, and the stressed assets include over 50 GW of existing coal power plants due to a lack of availability of PPAs and coal supply contracts, as well as declining fleet utilisation rates. Exposure to gross non-performing assets in the electricity sector alone stood at over $10 billion in early 2020, with a further $8 billion in metals, $4 billion in construction and $1 billion in mining.

The high level of stressed assets represents an important risk for India’s energy transition because it dampens liquidity in the economy and crowds out funds for utility-scale renewables and large-scale investments. While a decline in final investment decisions for thermal power plants in recent years stems from the shifting role of coal and the rise of renewables in India's energy system, it also reflects increased risk aversion by banks. This risk aversion also affects the financing of gas power capacity, which would need to step up in the SDS, and of retrofits and refurbishments of power and industrial plants. For example, banks appear reluctant to fund investment in emissions control equipment of $7 billion for 120 GW of coal power seeking to comply with more stringent environmental rules.

Figure 4.23 ▷ Growth in bank credit deployed by sector (left), share of stressed assets in bank portfolios (middle) and thermal power FIDs (right)



After easing conditions in the past two years, the pandemic and a high level of energy-related stressed assets in the financial system are creating new headwinds for lending.

Notes: FID = final investment decision; 1H = first half. Stressed assets are defined by the RBI as those with delays in the payment of their interest and/or principal by the stipulated date in the loan repayment schedule.

Source: IEA analysis based on Reserve Bank of India (2020) and McCoy Power Reports (2020).

Improving the situation requires a multifaceted approach. In addition to efforts to improve the performance of the distribution sector, and coal supply, enhancements to market design and interconnection to facilitate the more flexible use of the thermal generation fleet could unlock additional value in financially stressed assets and the power system, while the expedited retirement of the oldest, lowest-efficiency and least system-relevant coal power plants could help ease financial strain on newer plants. From a financial standpoint, greater flexibility in the rules and regulations around stressed assets would help matters, as would separate treatment of renewables and other clean energy projects within sectoral lending limits. Greater use of new financial mechanisms, such as off-balance-sheet refinancing through the capital markets, could also help with the management of economic burdens caused by unprofitable assets (IEA, 2020d).

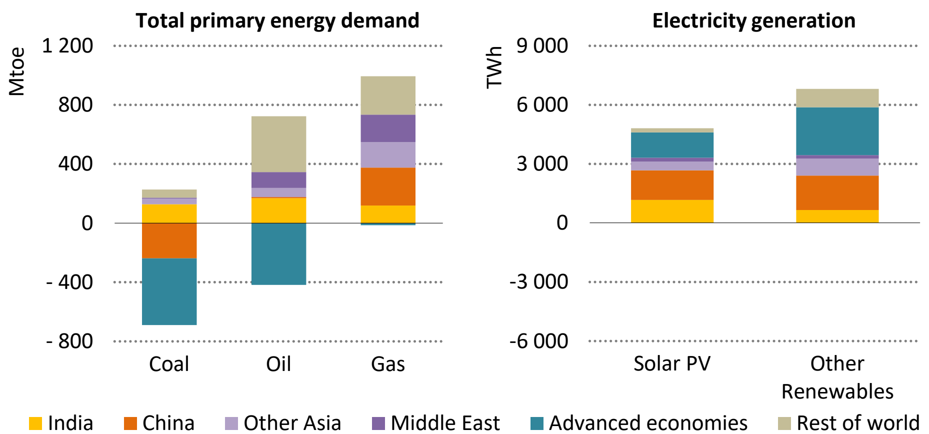
4.4 India in global energy

India already has a seat at the top table of international energy affairs, and its role is set to increase in importance in the years ahead. In this section, we consider different aspects of the interactions between India and the global energy economy, ranging from the impacts of Covid-19, market balances and energy security through to clean technology development and emissions.

4.4.1 India in global energy markets, trade and security

India is the fourth-largest global energy consumer today, after China, the United States and the European Union, and in the STEPS it overtakes the European Union by 2030 to move up to third position. This is underpinned by a rate of GDP growth that adds the equivalent of another Japan to the world economy by 2040.

Figure 4.24 ▷ Change in total primary energy demand and electricity generation in selected regions in the STEPS, 2019-2040



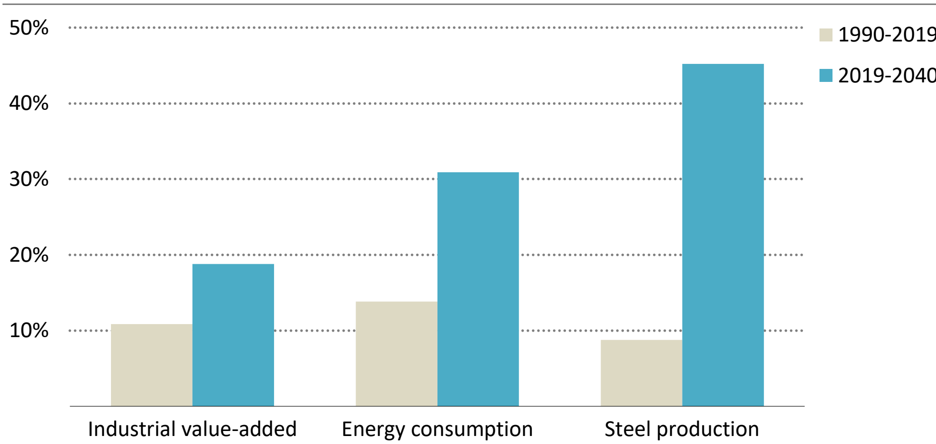
India sees demand grow across the energy sector through to 2040, and its increasing requirements for coal and oil partially offset reductions in advanced economies.

India accounts for nearly one-quarter of global energy demand growth from 2019-40 in the STEPS, the largest of any country. As such, its influence in global energy affairs is felt across all fuels and technologies (Figure 4.24). India's share in the growth in renewable energy in the STEPS is the second-largest in the world, after China. Already a heavyweight in solar PV, India takes on a similar role in battery storage, attracting more than a third of global investment between 2019 and 2040. By 2040, India's power system is bigger than that of the European Union, and is the world's third-largest in terms of electricity generation; it also has 30% more installed renewables capacity than the United States.

India likewise plays an extremely important role in global fuel markets. It leads oil demand growth, which rises over the period on the back of a fivefold increase in per capita car ownership. The country also becomes the fastest-growing market for natural gas, with demand more than tripling to 2040. India is one of the very few growth markets for coal in the STEPS, offsetting just over a quarter of the decrease in coal consumption in advanced economies.

India's continued industrialisation becomes a major driving force for the global energy economy. Over the last three decades, India accounted for about 10% of world growth in industrial value-added (in PPP terms). In the STEPS to 2040, India is set to account for almost 20% of global growth in industrial value-added, and to lead global growth in industrial final energy consumption, especially in steelmaking; India accounts for nearly one-third of global industrial energy demand growth to 2040 (Figure 4.25). This pivot in the global industrial economy towards India has important implications for world energy markets, for example for coking coal and natural gas, but also for global efforts to mitigate CO_2 in the industry sector.

Figure 4.25 ▷ India's share in the growth of global industrial output and energy consumption by time period in the STEPS, 1990-2040



In the STEPS, India becomes a global industrial heavyweight, and by 2040 it is producing almost 15% of the world's steel.

The picture is similar in the IVC, although India's development model is based more heavily on renewables, efficiency and natural gas. India remains the largest source of global energy demand growth in the DRS as well, although an extended pandemic would be extremely damaging to India's development prospects (see Chapter 2).

There is a sharp distinction to be made in the STEPS in terms of India's position in global energy trade between oil and gas, where the volumes and share of imported fuels rise steadily, and coal, where demand for imports is tempered by stagnant demand and relatively strong domestic output. India currently sources around 40% of its primary energy from abroad (360 Mtoe of imports out of a total of 935 Mtoe in 2019), a share that remains roughly constant in the STEPS.

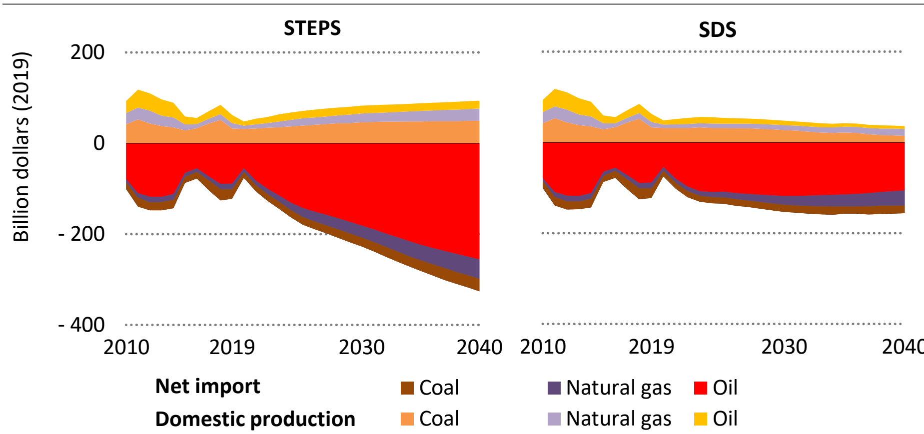
India's net dependence on oil imports – taking into account both the import of crude oil and the export of oil products – is around 75% today; this increases to more than 90% by 2040 in the STEPS, as domestic consumption rises much more than production. Natural gas import dependency increased from 20% in 2010 to almost 50% in 2019, and is set to grow further to more than 60% in 2040 in STEPS. The dynamics look quite different for coal, where India's demand for imported coal barely gets back to pre-crisis levels over the next decade in the STEPS, and this has outsize implications for global trade. India currently accounts for 16% of global coal trade, and many global coal suppliers were counting on growth in India to underpin planned export-oriented mining investments. These expectations are now running up against India's determination to boost domestic production (see section 3.4), leaving relative certainty only over India's requirement to import coking coal for its rising steel production, together with steam coal for those coastal power generation plants that have been designed to receive imported grades.

The combined import bill for fossil fuels triples in India over the next two decades in the STEPS, with oil making up by far the largest component of the total (Figure 4.26). As of 2019, energy accounts for almost one-third of India's total imports by value, and this exposure to global energy prices and market volatility increases in the STEPS. This implies significant vulnerabilities for India, both in terms of import bills and the potential for disruption to supplies.

The first of these vulnerabilities, while significant, has been mitigated to a degree by lower price trajectories in this year's outlook, which have reduced India's cumulative import bill to 2040 by 20% compared with the *WEO 2019*. Lower prices and import bills have already provided a boost to India in 2020, providing much-needed economic relief (and allowing the Indian government to raise duties on transport fuels at the same time). Lower oil and gas prices could also help to accelerate fuel switching from coal to natural gas or from traditional biomass to LPG, although equally they could undermine investment in domestic resources and reduce incentives to improve efficiency, or to switch away from fossil fuels altogether.

However, the shock of lower prices for major hydrocarbon exporters arguably increases the second of these vulnerabilities, the risks of disruptions to supply and market volatility. We estimate that net income from oil and gas in the Middle East, for example, fell by more than half in 2020, and year-on-year declines in net income for African producers on average are likely to be closer to 75%. These have exacerbated the fiscal strains facing many of these producer economies, leaving them with difficult choices on how to allocate scarce financial resources. Investment in new oil and gas supply around the world is expected to fall by around one-third in 2020, much more than the expected 9% drop in global oil demand and 3% fall in gas consumption, and this raises the possibility of new price cycles in the future. Given that India relies heavily on Middle Eastern and African producers to meet its crude oil and natural gas requirements, possible disruption to supplies in these regions could be felt much more in India than in other economies. The risk of a shortfall in investment appears to be higher for oil than for natural gas, which saw record approvals of new LNG export facilities in 2019. This vulnerability is mitigated by a large stock-holding capacity at publicly owned refineries, as well as by the continued build-up of the Indian Strategic Petroleum Reserve, which currently has a capacity of 40 million barrels, roughly equivalent to 10 days' oil consumption.

Figure 4.26 ▷ Value of domestic production and import bills for fossil fuels in India by scenario



The growing import bill for fossil fuels in India implies significant vulnerability to global energy prices and market volatility.

There is a much more profound change in the SDS, in which efficiency and fuel switching reduce the 2040 import bill by more than 50% compared with the STEPS. However, there would still be a need for continued vigilance on traditional aspects of fuel security in this scenario as well, not least because most imports would come from a handful of major low-cost producers whose hydrocarbon-dependent economies would come under immense strain as the global energy economy shifted away from fossil fuels.

Changing global energy dynamics and pathways for India point strongly towards the need for a broader concept of energy security that encompasses new and evolving risks to energy supply. To take one example, changes in India's electricity sector are dramatically increasing the need for flexibility in power system operation, as described in detail in Chapter 3: hour-to-hour ramping requirements are set to more than double in India over the next decade in the STEPS, and the pace of transformation would be even more rapid in the SDS. Like other countries, India needs to ensure that institutional and regulatory changes in the power sector keep pace with the speed of technological change if it is to safeguard the security of its electricity supply.

Another example concerns clean energy technologies. As described in more detail in the next section, India is set to become a major market for these technologies, and the government aims to capture a greater share of this demand through local production, using the leverage that India has as a leader in the deployment of battery storage and other clean energy technologies and as a country with a large and growing domestic market (Box 4.5). But this ambition raises questions about the adequacy of supplies of critical minerals. Managing the risks and geopolitical hazards associated with these increasingly important value chains will be an important task for India's policy makers and one where – as with other aspects of energy security – international collaboration can play a vitally important role.

Box 4.5 ▷ India's oil refining sector: leveraging the large domestic market

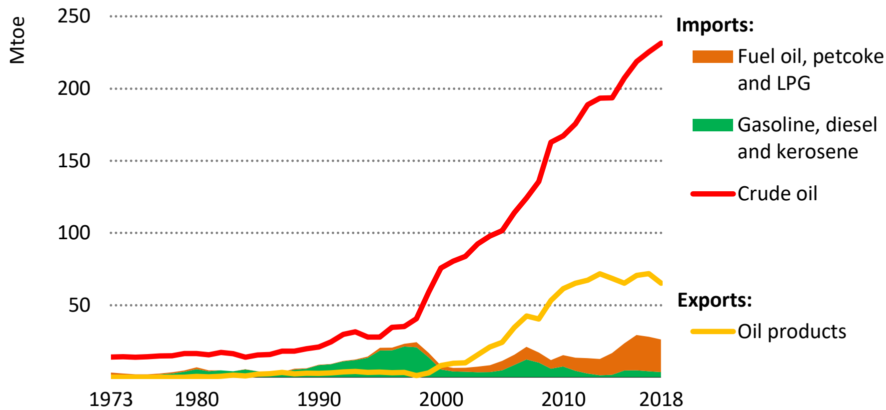
India's natural capital is as diverse as it is vast, but it still relies on imports for some key elements of the energy system. At present, its imports include oil products for transport and industrial applications, and natural gas.

However, limited raw materials do not necessarily lead to a reliance on imports for final product, a point that is exemplified by India's refining industry. With the exception of one refinery processing Assam crude, India's oil product demand was met by imports until the 1950s (Tang, 1994). India then chose to develop a national refining sector and to import crude oil rather than refined oil products, encouraging partnerships between Indian and foreign companies to establish coastal refineries (initially designed to process Iranian crude). In the 25 years to 1982, refining capacity in India grew from around 80 kb/d to more than 750 kb/d.

An initial consequence of this policy was the capture of more value in the supply chain by Indian companies (mostly PSUs). Following the opening of the Jamnagar refinery in 1999 by the private Indian company Reliance Industries, India then became an exporter of oil products and almost eliminated imports of gasoline, diesel and kerosene (Figure 4.27). By 2019, India's oil product exports generated around $3 billion dollars (UN, 2020). In recent years, Indian refineries have been expanding further down the value chain towards petrochemicals to capture additional value. India's ethylene production has almost doubled to 6.6 Mt since 2015 and is set to grow further by two-thirds through to 2030 in the STEPS.

Even without large crude oil resources, India has today developed a mature refining and downstream petroleum industry. In the STEPS, it overtakes Russia in the early 2030s to become the world's third-largest refining centre. The example of oil refining indicates how countries can move up the value chain where there is a strong strategic and economic rationale, especially where – as in this case – it is underpinned by a large and growing domestic market.

Figure 4.27 ▷ India's trade in crude oil and oil products, 1973-2018



Investments in refining have increased imports of crude oil, reduced imports of oil products and moved India up the oil value chain, leading to exports of oil products.

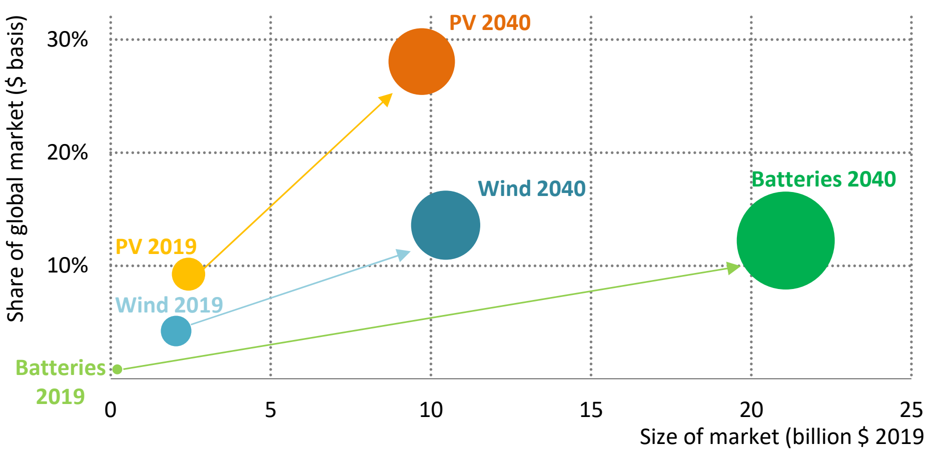
4.4.2 India in global clean energy transitions

India will soon become one of the world's largest markets for a range of clean energy technologies, making it a major target for technology developers looking for sales growth. In the STEPS, the Indian markets for solar PV modules, wind turbines, lithium-ion batteries and water electrolysers together grow to around $40 billion per year by 2040. Lithium-ion batteries alone account for nearly a third of this total, with annual demand in 2040 equal to the output of more than 20 times the capacity of today's largest gigafactory. For each product, India represents a sizeable share of the global market – around 10% for lithium-ion batteries, 15% for wind turbines, and 30% for solar PV (Figure 4.28). In the STEPS, 1 in every 7 dollars spent on these three types of equipment in 2040 is in India, compared with 1 in 20 today.

These trends are accelerated in the SDS, with the combined size of the markets in India almost doubling to around $80 billion in 2040 compared with the STEPS. However, as the faster deployment yields faster cost declines that stem from economies of scale, manufacturing improvements and other innovations, the growth in installed capacity is even larger. This is particularly notable in the case of solar PV: 12% more capacity is added from 2020 to 2040 in the SDS than in the STEPS, but the cost of this is just 6% higher. Faster deployment triggers a virtuous circle of investment, innovation, cost reductions and market growth that lowers the costs of energy transitions based on mass-produced technologies as they proceed.

Currently, India is a net importer of products such as solar PV and batteries, with around $3 billion of trade per year. India's manufacturing facilities for solar PV cells and modules have so far struggled to operate with high-capacity factors and compete with imports, especially those from China. Local production could potentially meet a greater share of demand in line with the government's policy goal of expanding domestic manufacturing. Some action has already been taken in pursuit of this goal. For example, contracts for 8 GW of solar PV were signed in 2020 under manufacturing-linked tenders that require the winner to undertake both project development and the setting up of new PV manufacturing facilities. In addition, India's first plant producing lithium-ion battery anodes was commissioned in Karnataka in mid-2020, while NITI Aayog's Advanced Chemistry Cell and Battery Gigafactory plan proposes incentives for developers of battery cell factories.

Figure 4.28 ⊳ India's market size and global share in clean energy technologies today and in the STEPS, 2040



India's markets for clean energy technologies grow rapidly in the STEPS, led by lithium-ion batteries. India's solar PV market accounts for around 25% of the global total in 2040.

Note: Includes PV modules, wind turbines and battery packs only. Batteries includes both stationary and vehicle markets.

Capturing value in these supply chains will be challenging. The most efficient manufacturers from around the world are likely to increase their focus on India as it takes a higher share of global markets. In addition, clean energy technology markets can be expected to remain highly dynamic and reliant on thin margins. PV cell and module production has been an extremely competitive business in recent years, for example, with many companies going bankrupt after failing to continually innovate or upgrade their assets.

Innovation offers a way to increase the added value of clean technology markets. With 15-30% of the global markets for some of these products, India could position itself as a hub for research expertise and a home for the associated intellectual property. Investments in research and development (R&D) and licensing of technologies could not only contribute to economic growth but also ensure that technologies are adapted to local contexts, taking account of climate, geography, grid requirements and the built environment.

The value of innovation increases dramatically for countries and companies that target net-zero GHG emissions, regardless of the time horizon. IEA analysis shows that around 35% of the cumulative CO_2 emissions reductions needed to shift to a sustainable path come from technologies currently at the prototype or demonstration phase (IEA, 2020e). In addition, many clean energy technologies that are already established in parts of the marketplace need further adaptations to keep reducing costs and expand into new end uses. As a result, there is a great deal of scope for enhanced innovation efforts in areas that are expected to grow rapidly, such as solar PV and battery systems; areas that tap into India's skills, such as digital know-how; and areas critical to tackling future emissions challenges that currently lack solutions (Spotlight). For each area there are opportunities in different parts of the value chain from raw materials processing to component design and installation. Hydrogen is a good example of a technology area where a wide variety of skills will be needed beyond manufacturing, including some that share characteristics with petrochemicals production.

S P O T L I G H T

India's net-zero challenge: addressing emissions, old and new

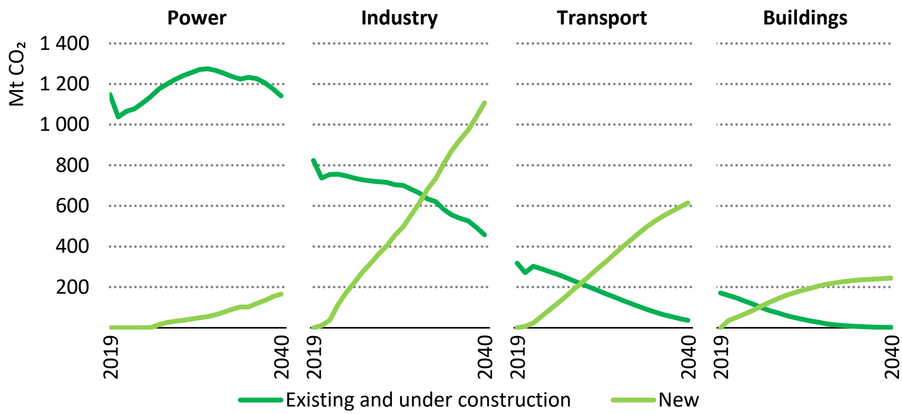
In the SDS, India is on course to reach net-zero emissions in the mid-2060s. In order to do so, India, like other emerging market and developing economies, faces the twin challenge of avoiding emissions from its existing infrastructure, while limiting as much as possible the carbon footprint of new capital stock. These twin challenges call for the deployment of a wide range of different technologies and policy approaches.

Two-thirds of India's total emissions over the period to 2040 in the STEPS come from power plants, factories, vehicles and buildings that exist today. By far the largest share of this comes from India's young and relatively inefficient coal-fired power fleet (Figure 4.29). Emissions will also be strongly influenced in this scenario by industrial facilities commissioned as recently as the 2010s.

If these existing plants and factories operate as planned, then the SDS is out of reach. This highlights the vital role for technologies that can help existing assets run more flexibly and efficiently, switch fuel inputs or capture their emissions. In the SDS, for example, the existing coal-fired fleet is either repurposed to provide system flexibility, co-fired with low-carbon fuels (mainly biomass), retrofitted with carbon capture and storage technology, or retired early.

In the case of industrial facilities, adapting cement plants to enable CO_2 capture is one example of technological efforts to reduce emissions from existing infrastructure, and replacing fossil fuels in steel production and refining with low-carbon hydrogen is another. In both cases, there is huge scope to develop new technologies and skills that are fit for Indian plants, and this has inspired a proposal to install one of the world's largest CO_2 capture systems at a cement plant in Tamil Nadu.

Figure 4.29 ▷ CO_2 emissions from existing and new infrastructure in India in the STEPS, 2019-2040



India faces the need to invest in a range of technologies capable of addressing both existing and new sources of CO_2 emissions.

Source: IEA (2020) and IEA (2020e).

However, much more so than in advanced economies, India's future emissions profile depends heavily on infrastructure that has yet to be built or bought – especially in industry and transport. Because of India's dynamic growth and the twin forces of urbanisation and industrialisation discussed in Chapter 2, already by the late 2030s India's emissions in the STEPS from new factories, vehicles and other equipment overtake those from sources existing today. In the SDS, India keeps these emissions from new sources to a minimum, avoiding higher-carbon infrastructure via early action to prioritise investment in efficient, low-emissions technologies across all parts of the energy sector, alongside a strong focus on sustainable urban design and transport. In doing so, India pioneers a new, low-carbon model of development, with major co-benefits for air quality, reduced energy import bills and increased clean energy jobs and industrial opportunities.

A redoubled effort to promote clean energy innovation in India can play an important role in reaching SDS goals. India is currently drafting a new Science, Technology and Innovation Policy, which will be its first since 2013. Among the stated aims are to double the number of researchers and the level of public and private expenditure on R&D every five years, with energy as a priority topic (DST, 2020). A Science, Technology and Innovation Development Bank is proposed to direct strategic long-term investments, which could help catalyse progress in clean energy technology areas that reflect India's circumstances and needs.

Building on the insights in this report, several clean energy technology areas can be identified as pivotal for reaching net-zero emissions, all of which present opportunities in the near term:

- **Lithium-ion batteries**. India becomes the world's largest market for batteries in the STEPS, IVC and SDS. Supply chains for lithium and cobalt are concentrated outside India, but battery recycling and reuse could be a major opportunity in India, which updated its battery waste management rules in 2020 in recognition of this issue (IEA, 2020b).
- **CCUS**. India's CO_2 storage potential has not yet been properly mapped. Given the important role likely to be played by CCUS in a variety of sectors in India, if CO_2 can be securely stored, there is a strong case for defining the potential and understanding how its geographic distribution might influence future investments in industry and power.
- **Hydrogen**. India has the potential to close the cost gap between hydrogen from electrolysis and natural gas more quickly than many other countries due to its relatively high gas prices and low-cost solar PV potential, but flexible electrolysis and cost-effective hydrogen storage will be essential to integrate hydrogen with variable renewables. Electrolysers share technical attributes with batteries and fuel cells, creating opportunities to co-locate research hubs and exploit synergies.
- **Material efficiency**. Action to minimise the material demands of an expanding stock of vehicles and buildings, including through lightweighting and recycling, has the potential to make a major contribution to India's energy future if it is integrated into planning and design.
- **Digital innovation**. India's information and communications technologies sector is a significant global player and has impressive strengths in digital technologies, which could do much to improve efficiency in energy systems (for example through shaping logistics to reduce diesel demand for freight transport) and to make energy systems smarter, helping to lower bills and integrate variable renewables.
- **Bioenergy**. India's agricultural sector contributes 17% of GDP and around 40% of overall employment. Its biomass resource is large and includes a considerable amount of agricultural waste. There is scope for India to build on its existing leadership in biotechnologies and the demonstration of advanced biofuel technologies, and potential for low-cost biomethane to meet two-thirds of gas demand in India by 2040.

The size of the potential market and the scope for innovation means that what happens in India on clean energy technology will affect the world. India is not currently a major global player in energy R&D. Public spending on energy R&D has increased since India joined the Mission Innovation initiative, rising to around $670 million in 2019, but this remains low as a share of GDP compared with other major economies. Private sector R&D spending is also relatively low, with government funding often favouring public institutions and enterprises. India's innovation and market potential mean that it has nonetheless become a destination for inward investment by multinational energy companies in R&D facilities.

A strategic approach to clean energy innovation in India, aligned with energy and industry objectives, would increase the chances of successful innovation. Where India sits in the value chain for key technologies will determine its trading partners and influence its trade patterns, which will in turn affect the location of its industrial investments. Many governments sought to boost their energy innovation systems in 2020 through the use of economic pandemic recovery plans that seek to improve future competitiveness. India has a range of options available in this context (IEA, 2020c). To take one example, the National Hydrogen Energy Mission proposed by the prime minister in November 2020 represents a near-term opportunity to take a strategic approach to an emerging international technology.

An important step for India will be to review best practice in prioritising technologies and stimulating public and private innovation in the types of technologies needed for energy transitions.[7] Doing this in the context of emerging markets with limited budgets and without a long legacy of energy technology innovation will fill a critical knowledge gap. International co-operation through multilateral initiatives and partnerships with overseas expertise that build local competences are likely to be helpful, while creating new linkages between industry and higher education could improve the exchange of ideas. Finance will also be important, and there is scope to explore how international finance institutions might accommodate pre-commercial energy technology development.

Smaller companies can be more agile than large incumbents when it comes to exploiting emerging market opportunities. However, the level of risk capital required for new energy technologies is often out of the reach of start-ups in the absence of government support. The Clean Energy International Incubation Centre, co-founded by the government as part of its work within Mission Innovation, is relevant in this context: it builds on the existing networks of incubators and investors in India, and also encourages researchers and start-ups to partner with international researchers and incumbent companies to help access costly infrastructure and early-stage customers.

If India were to become more successful at moving clean energy technologies from lab to market, the payback would be economic as well as environmental. In the IVC, for example, more batteries are installed and the industry sector invests in more CO_2 capture because the economy is more dynamic and the technologies are cheaper. By 2040, the IVC is closer to the SDS than STEPS for deployment of these technologies.

[7] This builds on five key recommendations of the IEA *Special Report on Clean Energy Innovation* (IEA, 2020f).

Tables for scenario projections

General note to the tables

This annex includes historical and projected data for the Stated Policies and Sustainable Development scenarios and India Vision Case for energy demand, gross electricity generation and electrical capacity, and CO_2 emissions from fossil fuel combustion for India.

Both in the text of this book and in the tables, rounding may lead to minor differences between totals and the sum of their individual components. Growth rates are calculated on a compound average annual basis and are marked "n.a." when the base year is zero or the value exceeds 200%. Nil values are marked "-".

Data sources

The World Energy Model (WEM) is a very data-intensive model covering the whole global energy system. Detailed references on databases and publications used in the modelling and analysis may be found in Annex E of the World Energy Outlook 2020.

The formal base year for the projections is 2018, as this is the last year for which a complete picture of energy demand and production is in place. However, we have used more recent data wherever available, and we include our 2019 estimates in this annex. Estimates for the year 2019 are based on updates of the IEA's *Global Energy Review* reports which are derived from a number of sources, including the latest monthly data submissions to the IEA's Energy Data Centre, other statistical releases from national administrations, and recent market data from the IEA *Market Report Series* that cover coal, oil, natural gas, renewables and power. Investment estimates include the year 2019, based on the IEA's *World Energy Investment 2020* report.

Historical data for gross electrical capacity are drawn from the S&P Global Market Intelligence World Electric Power Plants Database (March 2020 version) and the International Atomic Energy Agency PRIS database.

Definitional note

Total primary energy demand (TPED) is equivalent to power generation plus "other energy sector" excluding electricity and heat, plus total final consumption (TFC) excluding electricity and heat. TPED does not include ambient heat from heat pumps or electricity trade. Other renewables in TPED include geothermal, solar photovoltaics (PV), concentrating solar power (CSP), wind and marine (tide and wave) energy for electricity and heat generation. Sectors comprising TFC include industry, transport, buildings (residential, services and non-specified other) and other (agriculture and non-energy use). While not itemised separately, hydrogen is included in total final consumption and "other energy sector". Projected gross electrical capacity is the sum of existing capacity and additions, less retirements. While not itemised separately, other sources are included in total electricity generation, and battery storage in total power generation capacity.

Total CO_2 includes carbon dioxide emissions from "other energy sector" in addition to the power and final consumption sectors shown in the tables. Total and power sector CO_2 emissions also account for captured emissions from bioenergy with carbon capture, utilisation and storage (BECCS). CO_2 emissions do not include emissions from industrial waste and non-renewable municipal waste.

Abbreviations used: Mtoe = million tonnes of oil equivalent; CAAGR = compound average annual growth rate; Petrochem. feedstock = petrochemical feedstock.

Energy demand: India

	Stated Policies Scenario Energy demand (Mtoe)						Shares (%)			CAAGR (%)	
	2010	2019	2025	2030	2035	2040	2019	2030	2040	2019-30	2019-40
Total primary demand	**700**	**929**	**1 057**	**1 237**	**1 412**	**1 573**	**100**	**100**	**100**	**2.6**	**2.5**
Coal	279	413	441	498	522	541	44	40	34	1.7	1.3
Oil	162	242	288	335	381	411	26	27	26	3.0	2.5
Natural gas	54	55	86	113	143	173	6	9	11	6.8	5.6
Nuclear	7	10	17	28	44	58	1	2	4	9.6	8.5
Hydro	11	15	15	19	23	26	2	2	2	2.3	2.7
Bioenergy	185	182	183	188	197	204	20	15	13	0.3	0.5
Other renewables	2	11	26	54	102	160	1	4	10	15.6	13.6
Power sector	**237**	**355**	**395**	**475**	**548**	**621**	**100**	**100**	**100**	**2.7**	**2.7**
Coal	177	278	285	317	315	311	78	67	50	1.2	0.5
Oil	7	3	4	3	3	2	1	1	0	2.8	-0.2
Natural gas	25	15	19	22	27	28	4	5	5	3.4	3.1
Nuclear	7	10	17	28	44	58	3	6	9	9.6	8.5
Hydro	11	15	15	19	23	26	4	4	4	2.3	2.7
Bioenergy	8	24	31	34	38	42	7	7	7	3.3	2.8
Other renewables	2	10	24	51	98	154	3	11	25	16.2	14.0
Other energy sector	**69**	**89**	**101**	**120**	**141**	**162**	**100**	**100**	**100**	**2.8**	**2.9**
Electricity	22	32	36	44	53	64	36	36	40	2.7	3.3
Total final consumption	**478**	**621**	**723**	**853**	**992**	**1 123**	**100**	**100**	**100**	**2.9**	**2.9**
Coal	87	111	129	148	168	185	18	17	16	2.6	2.4
Oil	138	216	260	306	349	379	35	36	34	3.2	2.7
Natural gas	19	35	57	78	99	125	6	9	11	7.5	6.3
Electricity	62	103	127	168	216	270	17	20	24	4.5	4.7
Heat	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Bioenergy	172	154	148	150	155	157	25	18	14	-0.2	0.1
Other renewables	0	1	2	3	5	6	0	0	1	9.3	8.1
Industry	**151**	**224**	**277**	**337**	**401**	**465**	**100**	**100**	**100**	**3.8**	**3.5**
Coal	75	99	119	139	159	178	44	41	38	3.2	2.9
Oil	17	31	34	37	39	40	14	11	9	1.6	1.3
Natural gas	2	21	37	53	71	92	9	16	20	8.8	7.3
Electricity	28	41	48	61	77	92	18	18	20	3.6	3.9
Heat	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Bioenergy	29	33	40	47	54	60	15	14	13	3.4	2.9
Other renewables	0	0	0	1	2	2	0	0	0	23.6	16.7
Transport	**65**	**108**	**139**	**177**	**217**	**248**	**100**	**100**	**100**	**4.5**	**4.0**
Oil	62	102	127	157	187	206	94	89	83	4.0	3.4
Electricity	1	2	2	5	9	13	1	3	5	11.1	10.6
Bioenergy	0	1	3	7	12	17	1	4	7	15.4	12.5
Other fuels	1	4	6	8	9	11	3	5	4	7.8	5.5
Buildings	**209**	**218**	**218**	**234**	**257**	**283**	**100**	**100**	**100**	**0.7**	**1.3**
Coal	12	13	10	9	8	7	6	4	2	-3.1	-3.0
Oil	30	38	42	47	51	54	17	20	19	2.0	1.7
Natural gas	1	3	5	6	8	10	2	3	3	5.8	5.1
Electricity	22	42	54	74	99	130	19	31	46	5.2	5.5
Heat	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Bioenergy	143	120	105	95	87	79	55	41	28	-2.1	-2.0
Traditional biomass	136	113	96	85	74	63	52	36	22	-2.6	-2.7
Other renewables	0	1	2	2	3	4	1	1	1	6.7	6.1
Other	**54**	**71**	**89**	**105**	**118**	**128**	**100**	**100**	**100**	**3.6**	**2.9**
Petrochem. Feedstock	24	22	33	41	48	55	31	39	43	5.8	4.5

Energy demand: India

	Sustainable Development Scenario				India Vision Case			
	Energy demand (Mtoe)		Shares (%)	CAAGR (%)	Energy demand (Mtoe)		Shares (%)	CAAGR (%)
	2030	2040	2040	2019-40	2030	2040	2040	2019-40
Total primary demand	**994**	**1 147**	**100**	**1.0**	**1 152**	**1 522**	**100**	**2.4**
Coal	318	209	18	-3.2	463	497	33	0.9
Oil	292	268	23	0.5	325	379	25	2.2
Natural gas	124	181	16	5.9	129	215	14	6.7
Nuclear	28	64	6	9.1	28	58	4	8.5
Hydro	22	31	3	3.5	19	26	2	2.7
Bioenergy	120	169	15	-0.4	116	158	10	-0.7
Other renewables	90	225	20	15.4	72	188	12	14.5
Power sector	**385**	**475**	**100**	**1.4**	**466**	**641**	**100**	**2.9**
Coal	162	42	9	-8.6	261	252	39	-0.5
Oil	3	2	0	-0.5	3	2	0	-0.2
Natural gas	42	52	11	6.2	53	82	13	8.5
Nuclear	28	64	14	9.1	28	58	9	8.5
Hydro	22	31	7	3.5	19	26	4	2.7
Bioenergy	43	72	15	5.4	34	42	7	2.8
Other renewables	84	212	45	15.7	67	177	28	14.7
Other energy sector	**109**	**138**	**100**	**2.1**	**128**	**176**	**100**	**3.3**
Electricity	39	56	40	2.6	45	70	40	3.7
Total final consumption	**703**	**843**	**100**	**1.5**	**782**	**1 071**	**100**	**2.6**
Coal	125	130	15	0.8	154	186	17	2.5
Oil	266	246	29	0.6	297	350	33	2.3
Natural gas	67	103	12	5.3	69	116	11	5.9
Electricity	164	254	30	4.4	179	296	28	5.1
Heat	0	0	0	n.a.	-	-	-	n.a.
Bioenergy	73	93	11	-2.4	77	112	10	-1.5
Other renewables	6	13	2	12.2	5	11	1	11.1
Industry	**290**	**361**	**100**	**2.3**	**328**	**450**	**100**	**3.4**
Coal	118	130	36	1.3	135	168	37	2.6
Oil	28	24	7	-1.1	34	35	8	0.6
Natural gas	43	72	20	6.1	51	92	20	7.3
Electricity	59	85	24	3.5	59	87	19	3.6
Heat	-	-	-	n.a.	-	-	-	n.a.
Bioenergy	39	43	12	1.3	47	62	14	3.1
Other renewables	3	7	2	22.9	3	7	1	22.9
Transport	**161**	**183**	**100**	**2.5**	**179**	**250**	**100**	**4.1**
Oil	129	115	63	0.6	151	192	77	3.1
Electricity	8	26	14	14.3	8	22	9	13.3
Bioenergy	15	26	14	14.8	12	27	11	14.9
Other fuels	10	15	8	7.2	8	10	4	5.0
Buildings	**155**	**190**	**100**	**-0.6**	**170**	**244**	**100**	**0.6**
Coal	7	1	1	-11.6	9	6	3	-3.3
Oil	50	42	22	0.5	54	55	23	1.8
Natural gas	5	6	3	2.8	8	13	5	6.5
Electricity	73	116	61	4.9	79	145	59	6.1
Heat	0	0	0	n.a.	-	-	-	n.a.
Bioenergy	17	19	10	-8.4	18	21	8	-8.0
Traditional biomass	-	-	-	n.a.	-	-	-	n.a.
Other renewables	4	6	3	8.6	3	4	2	6.6
Other	**96**	**110**	**100**	**2.1**	**104**	**126**	**100**	**2.8**
Petrochem. Feedstock	39	49	45	3.9	41	57	45	4.6

Electricity and CO_2 emissions: India

Stated Policies Scenario	Electricity generation (TWh)						Shares (%)			CAAGR (%)	
	2010	2019	2025	2030	2035	2040	2019	2030	2040	2019-30	2019-40
Total generation	**975**	**1 583**	**1 896**	**2 461**	**3 139**	**3 887**	**100**	**100**	**100**	**4.1**	**4.4**
Coal	658	1 135	1 206	1 343	1 344	1 334	72	55	34	1.5	0.8
Oil	18	5	7	7	6	6	0	0	0	4.0	0.6
Natural gas	113	71	94	108	143	157	4	4	4	3.9	3.8
Nuclear	26	40	66	109	168	222	3	4	6	9.6	8.5
Renewables	160	332	523	893	1 477	2 169	21	36	56	9.4	9.3
Hydro	125	175	177	226	268	307	11	9	8	2.3	2.7
Bioenergy	15	42	67	77	91	106	3	3	3	5.7	4.5
Wind	20	66	105	195	374	520	4	8	13	10.3	10.3
Geothermal	-	-	-	0	1	1	-	0	0	n.a.	n.a.
Solar PV	0	48	174	392	736	1 221	3	16	31	20.9	16.6
CSP	-	-	1	3	7	13	-	0	0	n.a.	n.a.
Marine	-	-	-	0	0	1	-	0	0	n.a.	n.a.

Stated Policies Scenario	Electrical capacity (GW)						Shares (%)			CAAGR (%)	
	2010	2019	2025	2030	2035	2040	2019	2030	2040	2019-30	2019-40
Total capacity	**197**	**414**	**573**	**792**	**1 132**	**1 552**	**100**	**100**	**100**	**6.1**	**6.5**
Coal	106	235	269	269	265	260	57	34	17	1.2	0.5
Oil	8	8	8	8	6	5	2	1	0	0.0	-1.6
Natural gas	22	28	30	30	39	46	7	4	3	0.5	2.3
Nuclear	5	7	9	16	25	31	2	2	2	8.2	7.6
Renewables	57	137	247	436	722	1 066	33	55	69	11.1	10.3
Hydro	40	49	60	76	89	101	12	10	6	4.0	3.4
Bioenergy	4	12	13	15	17	20	3	2	1	2.1	2.5
Wind	13	38	57	96	167	217	9	12	14	8.9	8.7
Geothermal	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Solar PV	0	38	117	248	447	724	9	31	47	18.7	15.1
CSP	-	0	0	1	2	4	0	0	0	13.8	15.1
Marine	-	-	-	0	0	0	-	0	0	n.a.	n.a.

Stated Policies Scenario	CO_2 emissions (Mt)						Shares (%)			CAAGR (%)	
	2010	2019	2025	2030	2035	2040	2019	2030	2040	2019-30	2019-40
Total CO_2	**1 572**	**2 319**	**2 576**	**2 948**	**3 188**	**3 359**	**100**	**100**	**100**	**2.2**	**1.8**
Coal	1 089	1 622	1 732	1 951	2 041	2 108	70	66	63	1.7	1.3
Oil	408	612	720	842	956	1 030	26	29	31	2.9	2.5
Natural gas	75	84	125	156	191	220	4	5	7	5.7	4.7
Power sector	**785**	**1 147**	**1 189**	**1 321**	**1 326**	**1 308**	**100**	**100**	**100**	**1.3**	**0.6**
Coal	704	1 104	1 133	1 259	1 253	1 234	96	95	94	1.2	0.5
Oil	23	8	11	11	9	8	1	1	1	2.8	-0.2
Natural gas	58	35	45	51	64	66	3	4	5	3.4	3.1
Final consumption	**752**	**1 110**	**1 316**	**1 544**	**1 768**	**1 949**	**100**	**100**	**100**	**3.0**	**2.7**
Coal	383	514	595	686	782	868	46	44	45	2.7	2.5
Oil	358	564	669	787	899	972	51	51	50	3.1	2.6
Transport	190	309	386	475	568	627	28	31	32	4.0	3.4
Natural gas	12	32	52	70	87	109	3	5	6	7.4	6.0

Electricity and CO_2 emissions: India

	Sustainable Development Scenario				India Vision Case			
	Electricity generation (TWh)		Shares (%)	CAAGR (%)	Electricity generation (TWh)		Shares (%)	CAAGR (%)
	2030	2040	2040	2019-40	2030	2040	2040	2019-40
Total generation	**2 365**	**3 601**	**100**	**4.0**	**2 603**	**4 254**	**100**	**4.8**
Coal	708	181	5	-8.4	1 104	1 073	25	-0.3
Oil	7	5	0	0.1	7	6	0	0.7
Natural gas	240	337	9	7.7	309	509	12	9.8
Nuclear	107	247	7	9.1	109	222	5	8.5
Renewables	1 302	2 832	79	10.7	1 074	2 445	57	10.0
Hydro	258	361	10	3.5	226	307	7	2.7
Bioenergy	105	210	6	7.9	77	106	2	4.5
Wind	343	782	22	12.5	251	695	16	11.8
Geothermal	2	5	0	n.a.	0	1	0	n.a.
Solar PV	584	1 368	38	17.2	517	1 322	31	17.0
CSP	11	104	3	n.a.	3	13	0	n.a.
Marine	0	1	0	n.a.	0	1	0	n.a.

	Sustainable Development Scenario				India Vision Case			
	Electrical capacity (GW)		Shares (%)	CAAGR (%)	Electrical capacity (GW)		Shares (%)	CAAGR (%)
	2030	2040	2040	2019-40	2030	2040	2040	2019-40
Total capacity	**997**	**1 835**	**100**	**7.3**	**931**	**1 764**	**100**	**7.1**
Coal	221	144	8	-2.3	252	231	13	-0.1
Oil	7	5	0	-1.9	8	5	0	-1.6
Natural gas	72	134	7	7.6	64	95	5	5.9
Nuclear	17	36	2	8.2	16	31	2	7.6
Renewables	641	1 334	73	11.5	542	1 206	68	10.9
Hydro	86	117	6	4.2	76	101	6	3.5
Bioenergy	20	39	2	5.8	15	20	1	2.5
Wind	163	334	18	11.0	121	289	16	10.2
Geothermal	0	1	0	n.a.	0	0	0	n.a.
Solar PV	367	806	44	15.7	330	792	45	15.6
CSP	4	36	2	27.1	1	4	0	15.1
Marine	0	0	0	n.a.	0	0	0	n.a.

	Sustainable Development Scenario				India Vision Case			
	CO_2 emissions (Mt)		Shares (%)	CAAGR (%)	CO_2 emissions (Mt)		Shares (%)	CAAGR (%)
	2030	2040	2040	2019-40	2030	2040	2040	2019-40
Total CO_2	**2 126**	**1 460**	**100**	**-2.2**	**2 733**	**2 960**	**100**	**1.2**
Coal	1 226	637	44	-4.4	1 698	1 710	58	0.3
Oil	706	594	41	-0.1	803	898	30	1.8
Natural gas	194	253	17	5.4	233	356	12	7.1
Power sector	**754**	**214**	**100**	**-7.7**	**1 172**	**1 202**	**100**	**0.2**
Coal	645	114	53	-10.3	1 036	1 001	83	-0.5
Oil	10	7	3	-0.5	11	8	1	-0.2
Natural gas	98	113	53	5.8	125	193	16	8.5
Final consumption	**1 298**	**1 173**	**100**	**0.3**	**1 481**	**1 670**	**100**	**2.0**
Coal	576	519	44	0.0	657	703	42	1.5
Oil	660	560	48	-0.0	751	853	51	2.0
Transport	391	350	30	0.6	459	582	35	3.1
Natural gas	63	94	8	5.2	73	114	7	6.2

Definitions

This annex provides general information on terminology used throughout the *WEO-2020* including: units and general conversion factors; definitions of fuels, processes and sectors; regional and country groupings; and abbreviations and acronyms.

Units

Area	m^2	square metre
Coal	Mtce	million tonnes of coal equivalent (equals 0.7 Mtoe)
Distance	km	kilometre
Emissions	g CO_2/kWh	grammes of carbon dioxide per kilowatt-hour
Energy	Mtoe	million tonnes of oil equivalent
	MBtu	million British thermal units
	kWh	kilowatt-hour
	MWh	megawatt-hour
	TWh	terawatt-hour
Gas	bcm	billion cubic metres
	tcm	trillion cubic metres
Mass	kg	kilogramme (1 000 kg = 1 tonne)
	Mt	million tonnes (1 tonne x 10^6)
	Gt	gigatonnes (1 tonne x 10^9)
Monetary	$ million	1 US dollar x 10^6
	$ billion	1 US dollar x 10^9
	$ trillion	1 US dollar x 10^{12}
Oil	kb/d	thousand barrels per day
	mb/d	million barrels per day
Power	GW	gigawatt (1 watt x 10^9)