

India Energy Outlook 2021

International
Energy Agency

iea

World Energy Outlook Special Report

INTERNATIONAL ENERGY AGENCY

The IEA examines the full spectrum of energy issues including oil, gas and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, demand side management and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability and sustainability of energy in its 30 member countries, 8 association countries and beyond.

Please note that this publication is subject to specific restrictions that limit its use and distribution. The terms and conditions are available online at www.iea.org/t&c/
This publication and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: IEA. All rights reserved.
International Energy Agency
Website: www.iea.org

IEA member countries:

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea
Luxembourg
Mexico
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

The European Commission also participates in the work of the IEA

IEA association countries:

Brazil
China
India
Indonesia
Morocco
Singapore
South Africa
Thailand



The International Energy Agency (IEA) last released a *World Energy Outlook* special report on India in 2015. Six years later, it is remarkable to consider the changes that have taken place.

The global energy sector has shifted a great deal over that period, particularly in terms of efforts to strengthen policies to tackle the threat of climate change. The growing number of net-zero emissions pledges by countries and companies reflects the increasing sense of urgency and accelerating momentum around clean energy transitions.

Most recently, the Covid-19 pandemic brought unprecedented disruptions to our societies and economies, with major consequences across the energy world. The damage to lives and livelihoods – and to many parts of the energy sector – will last for years to come.

Focusing on India's energy system in particular, I would like to highlight two extremely positive developments that stand out to me. The first is India's success in bringing electricity connections to hundreds of millions of its citizens in recent years. This is a monumental achievement that has improved the material well-being of a huge number of people, and I heartily congratulate the Government of India for it.

The second greatly encouraging development is the way in which India has grasped the transformative potential of renewables, and solar in particular. As this report shows, the growth of India's renewable energy sector has been highly impressive – and India is set to lead the world in areas like solar power and batteries in the coming decades.

This has also been an exciting period for India-IEA relations. Less than four years after joining the IEA family as an Association country, India recently agreed with IEA members to enter into a Strategic Partnership. Marked by a signing ceremony involving dignitaries from India and IEA members, this was a major milestone that could eventually lead to full membership for India, which would be a game-changing moment for global energy governance.

I hope that the depth and insight of the analysis in this new special report bears testament to the close working relationships and understanding that we have built over these years between India and the IEA.

As our new report makes clear, many challenges remain for India – in terms of energy security, access, affordability, emissions and more. But India's decision makers have shown on many occasions the value of well-designed policies. A compelling example is the roll-out of efficient LED lighting to millions of households all across the country, making electricity more affordable and sustainable at the same time.

What this report makes clear is the tremendous opportunity for India to develop and successfully meet the aspirations of its citizens without following the high-carbon pathway that other economies have pursued in the past. Seizing this opportunity is critically important for India, and critically important for the world.

In its endeavour to bring affordable, clean and reliable energy to all its citizens, the Government of India can count on the enduring support and partnership of the IEA. We sincerely hope this report will be of use to decision makers across the Indian energy sector as they seek to build a brighter future for a country that will remain at the heart of global energy trends for decades to come.

I would like to commend the dedicated team behind this report – from across the Agency – for their hard work under the excellent leadership of Tim Gould, with outstanding support from Peter Zeniewski in Paris and Siddharth Singh in Delhi. And I would like to thank the Government of India for its support – and all the experts and friends of the IEA in India and worldwide who contributed their time and insights.

Dr Fatih Birol
Executive Director
International Energy Agency

This study was prepared by the *World Energy Outlook* (WEO) team in the Directorate of Sustainability, Technology and Outlooks (STO) in co-operation with other directorates of the International Energy Agency (IEA). The study was designed and directed by **Tim Gould**, Head of Division for Energy Supply and Investment Outlooks. **Peter Zeniewski** and **Siddharth Singh** co-ordinated the work and were the lead authors.

Other principal authors of the report were **Simon Bennett** (innovation, clean energy); **Arthur Contejean** (access); **Davide D'Ambrosio** (power); **Szilvia Doczi** (flexibility); **Insa Handschuch** (air quality); **Zoe Hungerford** (flexibility); **Inchan Hwang** (investment and finance); **Christophe McGlade** (carbon emissions); **Sarbojit Pal** (transport); **Ryszard Pospiech** (supply); **Lucila Arboleya Sarazola** (investment and finance); **Michael Waldron** (lead on investment and finance); **Molly Walton** (water) and **Brent Wanner** (power). **Thomas Spencer** from The Energy and Resources Institute (TERI) was the lead on demand and industry. The report relied on the modelling and analysis of the entire WEO team and the guidance of **Laura Cozzi**, the IEA's Chief Energy Modeller.

Other key contributors were **Yasmine Arsalane** (macro-economy), **Aayushi Awasthy** (affordability, gender); **Stéphanie Bouckaert** (end-use modelling); **Amrita Dasgupta** (gender); **Tomás de Oliveira Bredariol** (water); **Timothy Goodson** (buildings and efficiency); **Astha Gupta** (bioenergy, affordability); **Paul Hugues** (bioenergy); **Peter Janoska** (air quality); **Tae-Yoon Kim** (fuels); **Toru Muta** (overview); **Pawel Olejarnik** (supply modelling); **Apostolos Petropoulos** (transport); **Sree Sanyal** (gender); **Andreas Schroeder** (industry); **Rebecca Schulz** (coal); **Ashish Sethi** (gas, captive power); and **Daniel Wetzel** (jobs). **Laszlo Varro**, the IEA Chief Economist, and **Nicole Thomas**, India programme manager, provided valuable guidance and support. **Eleni Tsoukala**, **Teresa Coon** and **Marie Fournier-S'Niehotta** provided essential support.

Edmund Hosker carried editorial responsibility. **Erin Crum** was the copy-editor.

The study also benefited from input provided by numerous IEA colleagues, in particular Carlos Fernández Alvarez, Heymi Bahar, Adam Baylin-Stern, Sylvia Beyer, Piotr Bojek, Daniel Crow, Eric Fabozzi, Peter Fraser, Paolo Frankl, Timur Gül, Pablo Gonzalez, Craig Hart, Maxine Jordan, Lilly Lee, Peter Levi, Akos Losz, Laura Maiolo, Ariane Millot, Brian Motherway, Michael Oppermann, Céline Rouquette, Keisuke Sadamori, Disha Sharma, Melanie Slade, Masatoshi Sugiura, Vida Rozite, and Kartik Veerakumar. Mechthild Wörsdörfer, Director for STO, provided support and guidance throughout. Air quality data was provided by the International Institute for Applied Systems Analysis. The water analysis was conducted in partnership with the Council on Energy, Environment and Water (CEEW), led by Vaibhav Chaturvedi, Kangkanika Neog and Surabhi Singh. Varun Sivaram, Center on Global Energy Policy at Columbia University, provided valuable insights on energy investment and technology.

Thanks go to the IEA Communications and Digital Office (CDO) for their help in producing the report and website materials, particularly to Jad Mouawad, Head of CDO, and Astrid Dumond, Tanya Dyhin, Merve Erdem, Grace Gordon, Christopher Gully, Jethro Mullen, Robert Stone and Therese Walsh. The IEA's Office of the Legal Counsel, Office of Management and Administration, and Energy Data Centre provided assistance throughout the preparation of the report.

We would like to thank the Government of India for the co-operation during the preparation of this report, and numerous Indian interlocutors in research organisations and companies who kindly provided their time and assistance in answering our queries and sharing their insights.

Data from a number of Indian sources were essential to bring this study to completion. Among the Indian institutions that submit energy data to the IEA we are particularly grateful to NITI Aayog, the Bureau of Energy Efficiency, the Ministry of Power, the Ministry of Coal, the Ministry of New and Renewable Energy, the Ministry of Petroleum and Natural Gas, and the Ministry of Statistics and Programme Implementation.

The work could not have been achieved without the support and co-operation provided by many government bodies, organisations and companies worldwide, notably: Ministry of Economy, Trade and Industry, Japan; and the IEA Clean Energy Technologies Programme, particularly through the contributions of the United Kingdom and of the European Union via the Horizon 2020 research and innovation programme under grant agreement No 952363.

Various experts, research institutes, companies, government bodies and international stakeholders provided input at various stages and reviewed preliminary drafts of the report. Their comments and suggestions were of great value. They include:

Prasoon Agarwal	International Renewable Energy Agency (IRENA)
K.V.S. Baba	Power System Operation Corporation Limited (POSOCO)
Abhay Bakre	Bureau of Energy Efficiency
Manjushree Banerjee	Independent consultant
Paul Baruya	IEA Clean Coal Centre
Samuel Beatty	US Department of Energy
Shikha Bhasin	CEEW
Nick Butler	King's College London
Russell Conklin	US Department of Energy
Anne-Sophie Corbeau	BP
Rita Roy Choudhury	Federation of Indian Commerce and Industries (FICCI)
Ganesh Das	Tata Power Delhi Distribution Limited

Enrique De Las Morenas Moneo	ENEL
Kaushik Deb	King Abdullah Petroleum Studies and Research Center (KAPSARC)
Pamli Deka	World Resources Institute
Vivek Kumar Dewangan	Ministry of Power
Swati D'Souza	National Foundation for India
Navroz Dubash	Centre for Policy Research
Ashwin Gambhir	Prayas Energy Group
Arunabha Ghosh	CEEW
Abhishek Goel	Global Infrastructure Partners India
Akash Goenka	Alliance for an Energy Efficient Economy (AEEE)
Abhinav Goyal	World Bank
Kavita Jadhav	UK Department for Business, Energy and Industrial Strategy (BEIS)
Dinesh Dayanand Jagdale	Ministry of New and Renewable Energy
Amit Jain	World Bank
Anil Jain	Ministry of Coal
Neelima Jain	Center for Strategic and International Studies (CSIS)
Gauri Jauhar	IHS Markit
Madhura Joshi	Natural Resources Defense Council (NRDC)
Premanand Jothy	Ministry of External Affairs
Satish Kumar	AEEE
Marc LaFrance	US Department of Energy
Jennifer Li	US Department of Energy
Sangeeta Mathew	AEEE
Ajay Mathur	The Energy and Resources Institute (TERI)
Rohit Mittal	World Bank
Mitheel Mody	Tata Cleantech
Swetha RaviKumar Bhagwat	Florence School of Regulation Global (FSR)
Rajnath Ram	NITI Aayog
Bijoy Samanta	Ministry of Coal
Rakesh Sarwal	NITI Aayog
Chandana Sasidharan	AEEE
Gurdeep Singh	NTPC
Kartikeya Singh	CSIS

Raina Singh	National Institute of Urban Affairs (NIUA)
Sumant Sinha	ReNEW Power
Scott Smouse	US Department of Energy
Glenn Sondak	Shell
Jim Spaeth	US Department of Energy
Elena Thomas-Kerr	US Department of Energy
Rahul Tongia	Centre for Social and Economic Progress (CSEP)
Nikos Tsafos	CSIS
Tomoko Uesawa	Mitsubishi
Manoj Kumar Upadhyay	NITI Aayog
Miles Weinstein	UK COP26 Team

The individuals and organisations that contributed to this study are not responsible for any opinions or judgements it contains. All errors and omissions are solely the responsibility of the IEA.

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Comments and questions are welcome and should be addressed to:

Tim Gould

Directorate of Sustainability, Technology and Outlooks

International Energy Agency

9, rue de la Fédération

75739 Paris Cedex 15

France

E-mail : weo@iea.org

Foreword.....	3
Acknowledgements.....	5
Executive summary	11
1 <i>Energy in India today</i>	17
1.1 Introducing the India special focus.....	19
1.2 Mapping India’s energy system.....	22
1.3 Energy and India’s development path.....	40
1.4 Which way from here?	58
2 <i>Urbanisation and industrialisation in India</i>	69
2.1 Overview of energy demand	71
2.2 The forces and uncertainties shaping energy demand.....	76
2.3 The built environment and mobility.....	82
2.4 Industrial transformations.....	97
3 <i>Fuels and electricity in India</i>	109
3.1 Overview of energy supply.....	111
3.2 What’s next for India’s power sector?	115
3.3 Exploring prospects for a gas-based economy	133
3.4 Transforming traditional fuels: Coal and bioenergy	152
4 <i>Implications for India and the world</i>	169
4.1 Overview of energy sustainability and security.....	171
4.2 India and the Sustainable Development Goals.....	174
4.3 Clean energy investment and finance	190
4.4 India in global energy	207
Annexes	219

India's future prosperity will hinge on affordable, clean and reliable energy...

India has seen extraordinary successes in its recent energy development, but many challenges remain, and the Covid-19 pandemic has been a major disruption. In recent years, India has brought electricity connections to hundreds of millions of its citizens; promoted the adoption of highly-efficient LED lighting by most households; and prompted a massive expansion in renewable sources of energy, led by solar power. The gains for Indian citizens and their quality of life have been tangible. However, the Covid-19 crisis has complicated efforts to resolve other pressing problems. These include a lack of reliable electricity supply for many consumers; a continued reliance on solid biomass, mainly firewood, as a cooking fuel for some 660 million people; financially ailing electricity distribution companies, and air quality that has made Indian cities among the most polluted in the world.

...and the scope for further growth in energy demand and infrastructure is huge

India is the world's third-largest energy consuming country, thanks to rising incomes and improving standards of living. Energy use has doubled since 2000, with 80% of demand still being met by coal, oil and solid biomass. On a per capita basis, India's energy use and emissions are less than half the world average, as are other key indicators such as vehicle ownership, steel and cement output. As India recovers from a Covid-induced slump in 2020, it is re-entering a very dynamic period in its energy development. Over the coming years, millions of Indian households are set to buy new appliances, air conditioning units and vehicles. India will soon become the world's most populous country, adding the equivalent of a city the size of Los Angeles to its urban population each year. To meet growth in electricity demand over the next twenty years, India will need to add a power system the size of the European Union to what it has now.

India has a wide range of possible energy futures before it

This special report maps out possible energy futures for India, the levers and decisions that bring them about, and the interactions that arise across a complex energy system. The increasing urgency driving the global response to climate change is a pivotal theme. India has so far contributed relatively little to the world's cumulative greenhouse gas emissions, but the country is already feeling their effects. This report's analysis is based on a detailed review of existing or announced energy reforms and targets. These include the aims of quadrupling renewable electricity capacity by 2030, more than doubling the share of natural gas in the energy mix, enhancing energy efficiency and transport infrastructure, increasing domestic coal output, and reducing reliance on imports. Progress towards these policy goals varies across our report's different scenarios, none of which is a forecast. Our aim is rather to provide a coherent framework in which to consider India's choices and their implications.

- The **Stated Policies Scenario** (STEPS) provides a balanced assessment of the direction in which India's energy system is heading, based on today's policy settings and constraints and an assumption that the spread of Covid-19 is largely brought under control in 2021.

- The **India Vision Case** is based on a rapid resolution of today's public health crisis and a more complete realisation of India's stated energy policy objectives, accompanied by a faster pace of economic growth than in the STEPS.
- The **Delayed Recovery Scenario** analyses potential downside risks to India's energy and economic development in the event that the pandemic is more prolonged.
- The **Sustainable Development Scenario** explores how India could mobilise an additional surge in clean energy investment to produce an early peak and rapid subsequent decline in emissions, consistent with a longer-term drive to net zero, while accelerating progress towards a range of other sustainable development goals.

Covid-19 will leave lasting scars

Prior to the global pandemic, India's energy demand was projected to increase by almost 50% between 2019 and 2030, but growth over this period is now closer to 35% in the STEPS, and 25% in the Delayed Recovery Scenario. The latter would put some of India's hard-won gains in the fight against energy poverty at risk, as lower-income households are forced to fall back on more polluting and inefficient sources of energy. It would also extend the slump in energy investment, which we estimate to have fallen by some 15% in India in 2020. Even though the pandemic and its aftermath could temporarily suppress emissions, as coal and oil bear the brunt of the reduction in demand, it does not move India any closer to its long-term sustainable development goals.

India's size and dynamism will keep it at the heart of the global energy system

An expanding economy, population, urbanisation and industrialisation mean that India sees the largest increase in energy demand of any country, across all of our scenarios to 2040. India's economic growth has historically been driven mainly by the services sector rather than the more energy-intensive industrial sector, and the rate at which India has urbanised has also been slower than in other comparable countries. But even at a relatively modest assumed urbanisation rate, India's sheer size means that 270 million people are still set to be added to India's urban population over the next two decades. This leads to rapid growth in the building stock and other infrastructure. The resulting surge in demand for a range of construction materials, notably steel and cement, highlights the pivot in global manufacturing towards India. In the STEPS, as India develops and modernises, its rate of energy demand growth is three times the global average.

The Indian electricity sector is on the cusp of a solar-powered revolution...

Solar power is set for explosive growth in India, matching coal's share in the Indian power generation mix within two decades in the STEPS – or even sooner in the Sustainable Development Scenario. As things stand, solar accounts for less than 4% of India's electricity generation, and coal close to 70%. By 2040, they converge in the low 30% in the STEPS, and this switch is even more rapid in other scenarios. This dramatic turnaround is driven by India's policy ambitions, notably the target to reach 450 GW of renewable capacity by 2030, and the extraordinary cost-competitiveness of solar, which out-competes *existing* coal-fired

power by 2030 even when paired with battery storage. The rise of utility-scale renewable projects is underpinned by some innovative regulatory approaches that encourage pairing solar with other generation technologies, and with storage, to offer “round the clock” supply. Keeping up momentum behind investments in renewables also means tackling risks relating to delayed payments to generators, land acquisition, and regulatory and contract uncertainty. However, the projections in the STEPS do not come close to exhausting the scope for solar to meet India’s energy needs, especially for other applications such as rooftop solar, solar thermal heating, and water pumps.

...while rising demand for air-conditioning pushes up the peak in power demand

India’s electricity demand is set to increase much more rapidly than its overall energy demand. But a defining feature of the outlook is a sharp rise in variability – both in electricity output, from solar PV and wind, and in daily consumption. On the supply side, output from renewables in some Indian states is set to exceed demand on a regular basis (typically around the middle of the day) before 2030. On the demand side, the key contributor to variability comes from rapid growth in ownership of air-conditioning units. Energy efficiency measures targeting both cooling appliances and buildings avoid around a quarter of the potential growth in consumption in the STEPS, but electricity demand for cooling still increases six-fold by 2040, creating a major early evening peak in electricity use.

India requires a massive increase in power system flexibility

The pace of change in the electricity sector puts a huge premium on robust grids and other sources of flexibility, with India becoming a global leader in battery storage. India has a higher requirement for flexibility in its power system operation than almost any other country in the world. In the near term, India’s large grid and its coal-fired power fleet meet the bulk of India’s flexibility needs, supported by hydropower and gas-fired capacity. Going forward, new power lines and demand-side options – such as improving the efficiency of air conditioners or shifting the operation of agricultural pumps to different parts of the day – will need to play a much greater role. But battery storage is particularly well suited to the short-run flexibility that India needs to align its solar-led generation peak in the middle of the day with the country’s early evening peak in demand. By 2040, India has 140 GW of battery capacity in the STEPS, the largest of any country, and close to 200 GW in the Sustainable Development Scenario.

As solar takes power, the focus for coal switches to industry ...

Coal’s hold over India’s power sector is loosening, with industry accounting for most of the increase in coal demand to 2040 in the STEPS. Once the coal-fired power plants currently under construction are completed over the next few years, there is no net growth at all in India’s coal fleet. Coal-fired generation was most exposed to the dip in electricity consumption in 2020. It picks up slightly in the STEPS as demand recovers, since renewables do not cover all of the projected increase in electricity demand. However, coal suppliers looking for growth increasingly have to turn to India’s industrial consumers rather than the

power sector. The share of coal in the overall energy mix steadily declines in the STEPS, from 44% in 2019 to 34% in 2040, and more rapidly in other scenarios.

...while oil continues to dominate a fast-growing transport sector in the STEPS

Energy demand for road transport in the STEPS is projected to more than double over the next two decades, although this growth is cut dramatically in the Sustainable Development Scenario. Over half of the growth in the STEPS is fuelled by diesel-based freight transport. An extra 25 million trucks are travelling on India's roads by 2040 as road freight activity triples, and a total of 300 million vehicles of all types are added to India's fleet between now and then. Transport has been the fastest-growing end-use sector in recent years, and India is set for a huge expansion of transportation infrastructure – from highways, railways and metro lines to airports and ports. Today's policy settings are sufficient to prevent runaway growth in transport energy demand. And some parts of the system shift rapidly to less energy-intensive options, with one example being a strong increase in the use of two-or-three-wheeled vehicles for road transport. Nonetheless, in the STEPS, India's oil demand rises by almost 4 million barrels per day (mb/d) to reach 8.7 mb/d in 2040, the largest increase of any country. In the Sustainable Development Scenario, by contrast, a much stronger push for electrification, efficiency and fuel switching limits growth in oil demand to less than 1 mb/d.

India's building spree will shape its energy use for years to come

India is set to more than double its building space over the next two decades, with 70% of new construction happening in urban areas. The model of urbanisation that India follows and the extent to which new construction follows energy-efficient building codes will shape patterns of energy use far into the future. The shift towards urban living accelerates transitions in residential energy use away from solid biomass and towards electricity and modern fuels. Buoyed by rising appliance ownership and demand for cooling, the share of electricity in residential energy use nearly triples. Nonetheless, in the STEPS, firewood and other traditional fuels are still widely used for cooking by 2030. It would take an additional push – as in the India Vision Case and the Sustainable Development Scenario – to move all households to LPG, improved cook stoves, gas or electricity.

Today's clean energy momentum enables India to outperform its Paris pledges

In the STEPS, India exceeds the goals set out in its Nationally Determined Contribution (NDC) under the Paris Agreement. The emissions intensity of India's economy improves by 40% from 2005 to 2030, above the 33-35% set out in its existing NDC. And the share of non-fossil fuels in electricity generation capacity reaches almost 60%, well above the 40% that India pledged. India's leadership in the deployment of clean energy technologies expands its market for solar PV, wind turbine and lithium-ion battery equipment to over \$40 billion per year in the STEPS by 2040. As a result, 1 in every 7 dollars spent worldwide on these three types of equipment in 2040 is in India, compared with 1 in 20 today. India's clean energy workforce grows by 1 million over the next ten years. If the approach embodied in today's policies can be realised in full, as in the India Vision Case, higher economic growth than in

the STEPS need not mean higher energy demand and emissions. In this Case, and especially in the Sustainable Development Scenario where the equipment market for solar, wind, batteries and water electrolyzers rises to \$80 billion per year, the industrial and commercial opportunities from clean energy are even larger.

The path to a “gas-based economy” is not fully mapped out

The market for natural gas is growing fast in India, but its role varies by sector, by scenario and over time. The 6% share of natural gas in India’s current energy mix is among the lowest in the world. It almost doubles in the STEPS as gas use rises in the industrial sector and in city gas distribution. In the India Vision Case, natural gas also helps to displace coal in power generation, bringing India’s aspiration of a “gas-based economy” closer still. However, affordability is a sensitive issue for consumers, especially given the complex patchwork of additional charges and tariffs that, on average, doubled the cost of wholesale gas by the time it reached end-users in 2019. As India builds out its gas infrastructure, natural gas can find multiple uses in India’s energy system, including to help meet air quality and near-term emissions goals if supply chains are managed responsibly. But the Sustainable Development Scenario also underlines that a long-term vision for gas needs to incorporate a growing role for biogases and low-carbon hydrogen, for which India has large potential.

India’s faces energy security hazards ahead

India’s combined import bill for fossil fuels triples over the next two decades in the STEPS, with oil by far the largest component, pointing to continued risks to India’s energy security. Domestic production of oil and gas continues to fall behind consumption trends and net dependence on imported oil rises above 90% by 2040, up from 75% today. This continued reliance on imported fuels creates vulnerabilities to price cycles and volatility as well as possible disruptions to supply. Energy security hazards could arise in India’s domestic market as well, notably in the electricity sector if the necessary flexibility in power system operation does not materialise. An additional systemic threat to the reliability of electricity supply comes from the poor financial health of many electricity distribution companies. Improving the cost-reflectiveness of tariffs, the efficiency of billing and collection and reducing technical and commercial losses are key to reforming this sector.

Booming industry and transport push up CO₂ emissions and harm air quality

A 50% rise in India’s CO₂ emissions to 2040 is the largest of any country in the STEPS, even though India’s per capita CO₂ emissions remain well below the global average. The increase in India’s emissions is enough to offset entirely the projected fall in emissions in Europe over the same period. The remarkable rise of renewables arrests the growth in India’s power sector emissions in the STEPS, although this still leaves the coal-fired fleet – the fifth-largest single category of emissions worldwide today – as a major emitter of CO₂. Alongside the option of early retirement in some cases, this puts a strong premium on policy approaches that can retool this fleet for more limited and flexible operation and/or on technologies such as carbon capture, utilisation and storage (CCUS). But the main reasons for the increase in

India's CO₂ emissions in the STEPS lie outside the power sector, in industry and transport (especially from trucks). These two sectors are also responsible for a much larger share of air pollutant emissions than the power sector in the STEPS, and a rising urban population means that more people are exposed to air pollution and suffer its ill effects. Water stress is likewise an increasingly important factor for India's energy sector and its technology choices.

All roads to successful global clean energy transitions go via India...

As the world seeks ways to accelerate the pace of transformation in the energy sector, India is in a unique position to pioneer a new model for low-carbon, inclusive growth. Many aspects of such a model are already evident in India's policy vision, and many more are highlighted in the Sustainable Development Scenario that points the way for India towards net-zero emissions. If this can be done, it will show the way for a whole group of energy-hungry developing economies, by demonstrating that robust economic expansion is fully compatible with an increasing pace of emissions reductions and the achievement of other development goals. India is already a global leader in solar power – and solar combined with batteries will play a massive part in India's energy future. But India will need a whole host of technologies and policies to chart this new path. As new industrial sectors emerge and clean energy jobs grow, India will also need to ensure that no one is left behind, including in those regions that are heavily dependent on coal today.

...and India's energy destiny will be forged by government policies

More than that of any other major economy, India's energy future depends on buildings and factories yet to be built, and vehicles and appliances yet to be bought. Within 20 years, the majority of India's emissions in the STEPS come from power plants, industrial facilities, buildings and vehicles that do not exist today. This represents a huge opening for policies to steer India onto a more secure and sustainable course. India's ambitious renewables targets are already acting as a catalyst for the transformation of its power sector. A crucial – and even more challenging – task ahead is to put the industrial sector on a similarly new path through more widespread electrification, material and energy efficiency, technologies such as CCUS, and a switch to progressively lower-carbon fuels. Electrification, efficiency and fuel switching are also the main tools for the transport sector, alongside a determined move to build more sustainable transport infrastructure and shift more freight onto India's soon-to-be-electrified railways. These transformations require innovation, partnerships and capital. The additional capital required for clean energy technologies to 2040 in the Sustainable Development Scenario is \$1.4 trillion above the level in the STEPS. But the benefits are huge, including savings of the same magnitude on oil import bills. Government policies to accelerate India's clean energy transition can lay the foundation for lasting prosperity and greater energy security. The stakes could not be higher, for India and for the world.

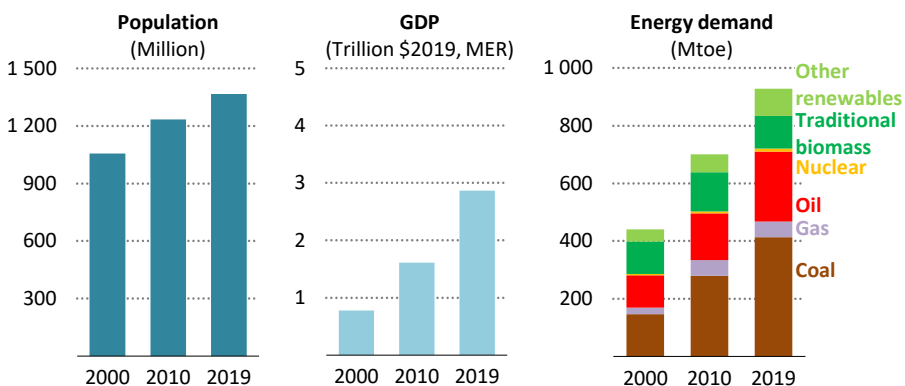
Energy in India today

Is 2020 a turning point?

S U M M A R Y

- India is a major force in the global energy economy. Energy consumption has more than doubled since 2000, propelled upwards by a growing population – soon to be the world’s largest – and a period of rapid economic growth. Near-universal household access to electricity was achieved in 2019, meaning that over 900 million citizens have gained an electrical connection in less than two decades.
- India’s continued industrialisation and urbanisation will make huge demands of its energy sector and its policy makers. Energy use on a per capita basis is well under half the global average, and there are widespread differences in energy use and the quality of service across states and between rural and urban areas. The affordability and reliability of energy supply are key concerns for India’s consumers.
- The Covid-19 pandemic has disrupted India’s energy use; our updated assessment shows an estimated fall of about 5% in the country’s energy demand in 2020 due to lockdowns and related restrictions, with coal and oil use suffering the biggest falls. The pandemic has also hit investment in the energy sector, which fell by an estimated 15% in 2020, exacerbating financial strains across the board, in particular among India’s electricity distribution companies. How long the impacts last will depend on how quickly the spread of the virus is brought under control, and on the policy responses and recovery strategies that are put in place.

Figure 1.1 ▶ Selected indicators for India, 2000, 2010 and 2019



Rising population and incomes since 2000 have underpinned a doubling of energy use in India, but per capita energy use is still less than 40% of the world average.

- Over 80% of India's energy needs are met by three fuels: coal, oil and solid biomass. Coal has underpinned the expansion of electricity generation and industry, and remains the largest single fuel in the energy mix. Oil consumption and imports have grown rapidly on account of rising vehicle ownership and road transport use. Biomass, primarily fuelwood, makes up a declining share of the energy mix, but is still widely used as a cooking fuel. Despite recent success in expanding coverage of LPG in rural areas, 660 million Indians have not fully switched to modern, clean cooking fuels or technologies.
- Natural gas and modern renewable sources of energy have started to gain ground, and were least affected by the effects of the Covid-19 pandemic in 2020. The rise of solar PV in particular has been spectacular; the resource potential is huge, ambitions are high, and policy support and technology cost reductions have quickly made it the cheapest option for new power generation.
- India is the third-largest global emitter of CO₂, despite low per capita CO₂ emissions. The carbon intensity of its power sector in particular is well above the global average. Additionally, particulate matter emissions are a major factor in air pollution, which has emerged as one of India's most sensitive social and environmental issues: in 2019, there were well over one million premature deaths related to ambient and household air pollution.
- India has a wide range of policies in place that aim to bring about a secure and sustainable energy future. This *Outlook* does not have a single view on how India's energy future might look. Instead, based on a detailed examination of today's energy markets, technologies and policies, our scenarios explore the implications of different circumstances and choices, and the linkages between them.
- The **Stated Policies Scenario (STEPS)** assumes that the pandemic is gradually brought under control in 2021. Against that backdrop, it assesses the direction in which today's policy settings and targets seem likely to take the energy sector in India, taking into account a range of real-life constraints that might affect their realisation in practice.
- The **India Vision Case (IVC)** takes a more optimistic stance on the speed of economic recovery and long-term growth, and also on the prospects for a fuller implementation of India's stated energy policy ambitions.
- The **Delayed Recovery Scenario (DRS)**, by contrast, examines the implications of a more prolonged pandemic with deeper and longer-lasting impacts on a range of economic, social and energy indicators than is the case in the STEPS.
- The **Sustainable Development Scenario (SDS)** takes a different approach, working backwards from specific international climate, clean air and energy access goals, including the Paris Agreement, and examining what combination of actions would be necessary to achieve them.

1.1 Introducing the India special focus

It has been six years since the International Energy Agency (IEA) last completed a special focus on India in its *World Energy Outlook* series. This new report updates and expands the analysis of India, and it does so from the exceptional starting point of 2020. Many things have changed in India and in global energy since the last *India Energy Outlook* was published, but the Covid-19 pandemic has caused more disruption to the energy sector than any other event in recent history. The impacts will continue to be felt, in India and around the world, for years to come.

However, while the pandemic affects the new *Outlook* in numerous ways, it does not alter the fundamental considerations underpinning this special focus on India. The potential for growth in energy demand and energy infrastructure in India remains enormous. How these needs are met will have a crucial impact on the aspirations of what will soon become the world's most populous country. It will also have a huge influence on global trends, including the prospects for a successful global response to climate change.

As a result of the country's own efforts and the falling global costs of some key clean energy technologies, there is scope for India to chart a course for its energy development that is significantly less emissions-intensive than those followed by other countries in the past. In India, there are signs – especially in the power sector – that such a clean energy transition is under way. But there is still a wide range of possible ways in which it could play out, with much depending on near-term uncertainties over the pandemic and the shape of the economic recovery, as well as on the policy choices that India makes. The next decade will be critical to India's energy future, since many of the policy actions taken today – including short-term actions to manage the effects of the pandemic – are likely to have long-lasting consequences.

Our aim in this new *India Energy Outlook* is not to prescribe these choices or to forecast the future, but rather to provide a coherent framework in which India's options can be assessed. And, while very different, there is one thing on which all our scenarios agree: whichever way the global energy economy evolves from here, India will be firmly at its centre.

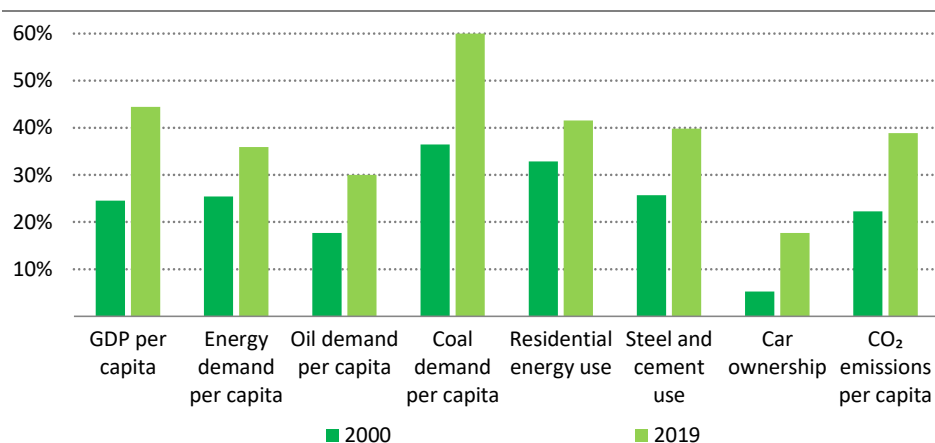
After this introductory chapter, which sets the scene, the remainder of this *Outlook* contains deep dives into topics that will define India's energy landscape in the coming years. Chapter 2 explores the key factors that will drive energy demand in India, including urbanisation, buildings, transport and industries. Chapter 3 looks at aspects of energy supply, including transformations in the power sector, the potential for natural gas in India's economy, and the role of bioenergy and coal in a rapidly changing energy system. The final chapter explores the implications of developments in energy on the United Nations (UN) Sustainable Development Goals (SDGs), including energy access, air quality and greenhouse gas (GHG) emissions; the implications for energy investments and finance; and the emerging role of India in the energy world.

1.1.1 The context

India has a major presence on the world stage. It is currently the world's second-most populous country after the People's Republic of China (hereafter, "China"), and is set to become the most populous in the 2020s. India has been one of the world's fastest-growing economies in recent years, and has become the fifth-largest in nominal terms, behind the United States, China, Japan and Germany. Expressed in terms of purchasing power parity (PPP), which adjusts for Indian buying power relative to other countries, India is the third-largest economy behind China and the United States. However, India continues to be a low-income economy, with a PPP per capita income that is less than half of the world average. With half of India's population under the age of 25, India's economy has the potential to grow very rapidly.

Since 2000, India has been responsible for more than 10% of the increase in global energy demand. On a per capita basis, energy demand in India has grown by more than 60% since 2000, although there are widespread differences across different parts of the country as well as across socio-economic groups. On a range of economic and energy-related indicators, India has been catching up with the rest of the world in recent years (Figure 1.2). Coal demand per capita increased from 25% of the world average in 1990 to 60% in 2019 and, mainly for this reason, carbon dioxide (CO₂) emissions per capita increased from a little over 15% of the world average to a little under 40% over this period.

Figure 1.2 ▶ Key indicators in India as a percentage of global averages



Key energy and economy indicators of India are well below the global average, although they have been steadily rising.

Note: GDP = gross domestic product.

There is huge potential for further growth in energy service demand in India due to an expanding economy and the forces of urbanisation and industrialisation. There are, however, critical questions about how demand growth will be met. With the notable exceptions of

solar, coal and wind, India is generally resource-constrained. India is also very densely populated, with relatively high levels of water stress and land-use constraints, and structural poverty and other socio-economic factors mean that the affordability of energy is a major issue.

India is characterised by the co-existence of shortage and abundance in several parts of its energy system. India possesses the world's fifth-largest coal reserves, but nonetheless is one of the world's major coal importers. India is a major centre for global oil refining, but relies overwhelmingly on imported crude. Many consumers face unreliable electricity supply, and there are significant commercial and technical losses at the distribution level, but in aggregate there is currently a surplus of generation capacity over demand. There is significant potential consumer demand for liquefied natural gas (LNG), but this cannot always be met because of infrastructure bottlenecks and pricing constraints.

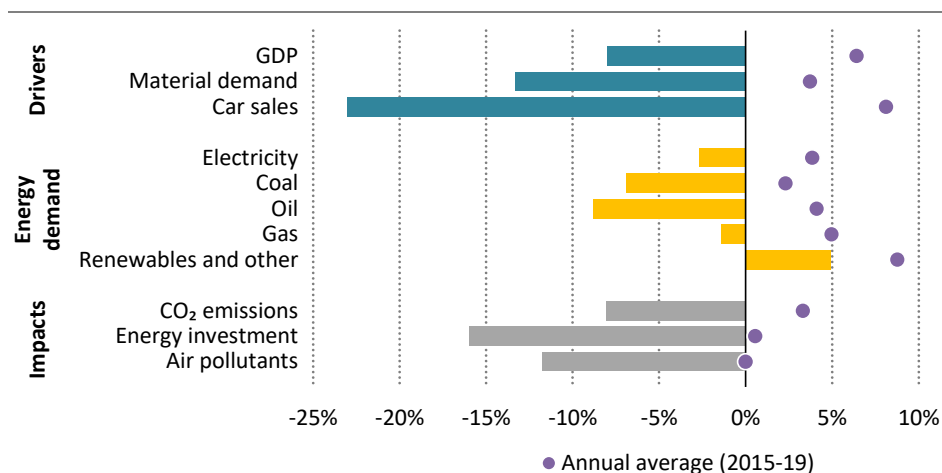
The choice of per capita or absolute values for India makes a big difference in the way India looks in energy terms. The absolute values are large and growing, while per capita values remain low by international standards. Despite India being one of the world's largest energy users, Indians on average still consume significantly less than their counterparts elsewhere in the world, and much less than in advanced economies. India's annual CO₂ emissions are now the third-highest in the world, but barely make the top 100 as measured by emissions per capita, and are lower still if historical emissions per capita are considered.

1.1.2 The impact of Covid-19

A lot has changed in India's energy sector since the last in-depth *India Energy Outlook* was published in 2015 (Box 1.1). While there has been progress on many fronts over these years, the extraordinary disruption caused by the Covid-19 pandemic in 2020 has cast a cloud over the future. To avoid the spread of the virus, the Indian government put in place a series of lockdowns starting in late March 2020, with varying levels of stringency, with the latest estimates showing a contraction in GDP of about 8% in 2020 (IMF, 2021). There was inevitably a considerable impact on energy demand. Full-year estimates see India's primary energy demand falling 5% from 2019 levels, with coal and oil expected to take the largest hit due to far-reaching restrictions on mobility and a reduction in economic activity. Natural gas demand has been resilient, as low prices have offset some of the forces driving down demand. Renewables have also fared relatively well, with generation from wind and solar growing by 15%.

The pandemic is not over, and its full implications are not yet visible. In the coming decade, India might see some durable, structural changes alongside temporary adjustments and breaks in trend. As we survey India's energy landscape, we explore how the outlook for various sectors might be affected by the shock caused by Covid-19. This new *Outlook* has been conducted during a period of extraordinary disruption, felt across all parts of Indian society. Its scenarios consider and incorporate the impact of this in different ways, including in the form of reduced GDP growth rates, reduced demand, a slightly lower turnover of capital stock, and a lower rate of investment across different parts of the energy sector.

Figure 1.3 ▶ Percentage annual change in key indicators for India in 2020



Covid-19 has caused a significant break in India's development trajectory; a key uncertainty is the extent to which changes lead to structural shifts or temporary disruption.

Sources: IEA analysis and IEA (2020b); IEA (2020c); IEA (2021); IEA (2021b); IMF (2021); POSOCO (2021).

Box 1.1 ▶ What has changed since the 2015 India Energy Outlook?

In the six years since the last *India Energy Outlook* was published, India's GDP has grown at an annual average rate of 6.7%. Among a range of economic reforms, one of particular importance was the introduction of the Goods and Services Tax (GST), which has created a uniform tax code for most economic activity in India, with the notable exception of petroleum products, natural gas and electricity.

Electricity access has been achieved much more quickly than projected in the 2015 *Outlook*, reflecting a major additional policy push on this issue. Over the last decade, India has provided electricity to nearly 50 million new users every year, equal to the entire population of Spain. This is one of the most significant achievements in global energy in recent years. However, issues of reliability remain.

Progress on renewables deployment has been immense since 2015, especially for solar: in 2019, India added nearly five times as much solar capacity as it did in 2015. A key driver of this has been the global decline in costs. The actual deployment of solar photovoltaic (PV) has been nearly identical to what was projected in the *India Energy Outlook 2015* under the Indian Vision Case scenario, helped by ambitious policy targets and auctions.

India has also made some significant progress on energy efficiency policy. The commercial building Energy Conservation Building Code was revised and strengthened in 2017, and Eco-Niwat Samhita, the energy conservation code for residential buildings, was launched in 2018. The existing industrial efficiency programme was expanded to include additional consumers and targets, and new appliances were added under the standards

and labelling programme. Despite the growing deployment of renewables, air pollution has taken on much greater significance. India is home to some of the most polluted cities in the world. Visibly improved air quality from the nationwide lockdown in 2020 illustrated the impact of air pollution very clearly.

Despite a new policy for hydrocarbons exploration and production, domestic production of natural gas has been lower than projected in 2015, while demand growth has been marginally higher. India is emerging as a bigger player in global gas markets, with the industry expecting India to absorb a large part of LNG supply growth.

Globally, crude oil prices have fallen since 2015 and have remained at a much lower average level than before then. The previously high price levels had increased India's petrol and diesel subsidy burden, which has since been slashed to zero on the backs of subsidy reform and low crude prices. The focus of subsidies has now shifted to liquefied petroleum gas (LPG) to meet clean cooking access objectives.

The share of coal in the energy mix has not really changed since 2015. The tremendous growth in renewables has tempered growth in coal capacity, but not prevented it. The rise in installed coal-fired capacity was in fact higher than that of solar and wind over the 2015-19 period (58 gigawatts [GW] coal thermal capacity installed versus 49 GW solar and wind), although renewables have outpaced coal-fired capacity additions since 2017, and there have also been a number of cancellations in the pipeline of approved coal projects.

Oil consumption has increased in lockstep with urbanisation and GDP growth. There are signs of growth in the use of alternative fuels for transport, but increasing levels of petrol and diesel vehicle ownership (and the growing popularity of sports utility vehicles [SUVs] in particular) means emissions trends continue upwards. There has also been some growth in urban light rail, although cities in general lack modern mass transit options.

Electricity distribution companies continue to remain in poor financial health despite policies and reforms to address a range of issues.

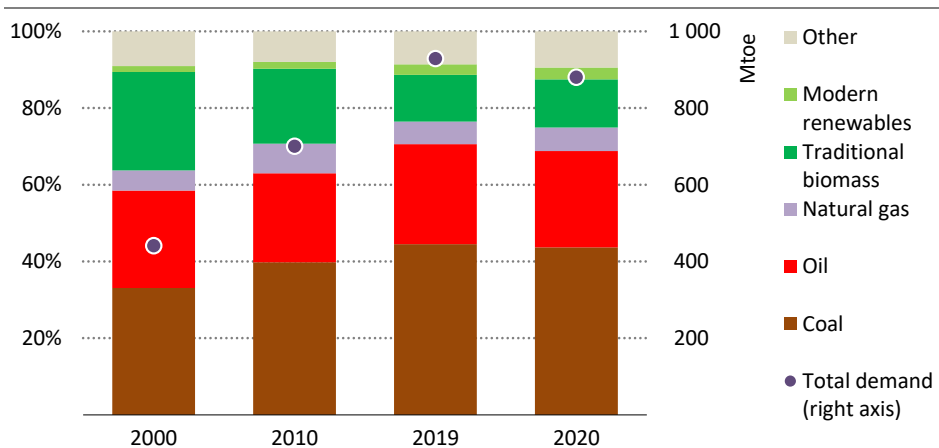
1.2 Mapping India's energy system

India's energy needs are largely met by three fuels – coal, oil and biomass. These sources have, in aggregate, consistently met over 80% of India's total energy demand since 1990. Coal has strengthened its role as the dominant energy source, maintaining its strong position in power generation as well as being the fuel of choice for many industries (especially heavy industries such as iron and steel). Coal demand nearly tripled between 2000 and 2019, accounting for half of primary energy demand growth. Today, coal meets 44% of India's primary energy demand, up from 33% in 2000. Coal has played a significant role in India's economic development while also contributing to air pollution and growing GHG emissions.

Traditional biomass – primarily fuelwood but also animal waste and charcoal – was the largest energy source in India in 2000 after coal, constituting about one-fourth of the primary

energy mix. Overall energy demand has doubled since then, but the share of traditional biomass in the energy mix has been decreasing: it fell to 12% in 2019, largely as a result of efforts to improve access to modern cooking fuels, in particular LPG.

Figure 1.4 ▶ Total primary energy demand in India



India's energy demand has tripled over the last three decades: the share of traditional biomass has fallen, leaving coal and oil dominant.

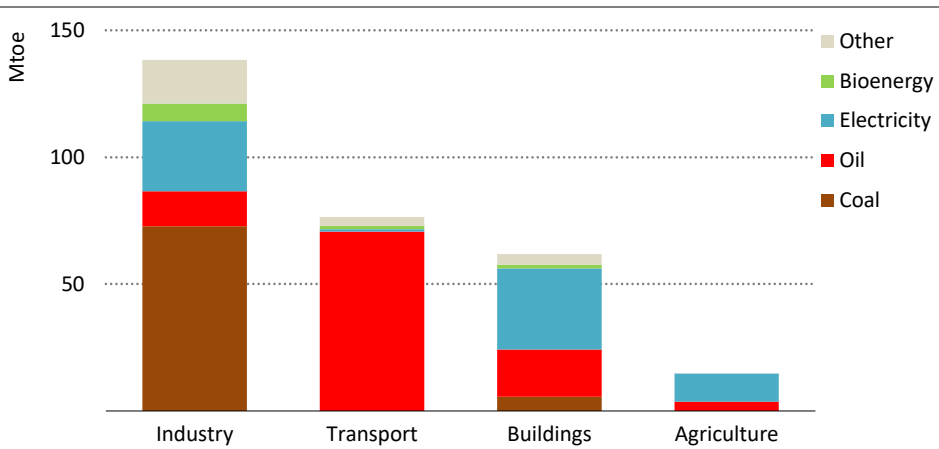
Note: Mtoe = million tonnes of oil equivalent.

Oil demand has more than doubled since 2000 as a result of growing vehicle ownership and road transport use. LPG has also contributed to the growth of oil demand, in part because its use in cooking applications has been subsidised and promoted by the government. A lack of domestic resources means that India's dependence on imports of crude oil has been steadily rising, reaching around 75% in 2019.

Among end-use sectors, India's industry sector has been the main source of energy demand growth since 2000, around half of which was met by coal. Transport energy demand grew 3.5 times, while demand in buildings has grown by 40% since 2000, largely as a result of growing appliance ownership and increased access to modern cooking fuels. The declining share of agriculture in India's economic output, and the continued use of traditional farming methods, mean that the agriculture sector has seen the smallest amount of growth in energy use.

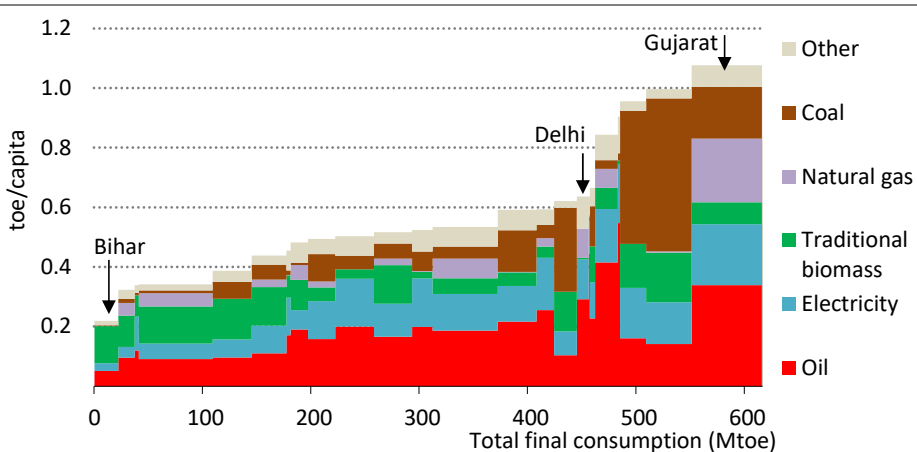
Electricity consumption has nearly tripled over the past two decades – growing faster than total energy demand – as urbanisation and rising incomes push up the use of household appliances. Industry has also contributed to the increase in electricity demand through its increasing use of electrical motors and other machinery. On the supply side, coal remains the predominant force in the power sector, contributing over 70% of total generation in 2019. Solar PV and wind accounted for 18% of the capacity mix in 2019, but their combined share of generation was less than 10%.

Figure 1.5 ▶ Change in energy demand by fuel in selected end-use sectors, 2000-19



Among end-use sectors, the growth in energy demand has been larger in industries than in transport and buildings, and this growth has largely been fuelled by coal.

Figure 1.6 ▶ Final energy consumption per capita by state, 2018



The traditional use of biomass dominates in states with lower per capita energy use; states with an energy-intensive industrial base account for the bulk of direct coal use.

Note: toe = tonnes of oil equivalent.

Within India, there is considerable variation in overall energy use across states, resulting from differences in economic and demographic trends, resource availability and industrial profiles. While India's total final energy consumption per capita is a third of the global average, a detailed review of the available state-by-state data shows that the range between