24

Aligning Energy, Development, and Mitigation

Ashok Sreenivas and Ashwin Gambhir

India's approach to climate-related actions has been governed by its development concerns, which include widespread poverty, the need for significant and urgent improvement in education and health, insufficient access to clean drinking water and sanitation facilities, and providing employment for a 'youth bulge', among others. In this context, energy is one of the most pivotal links between climate change and development. On the one hand, it is closely linked to a country's development and on the other, it contributes most to greenhouse gas (GHG) emissions. Energy use contributed 83 per cent of India's GHG emissions in 2013, with this share increasing over time (Figure 24.1). Thus, shifting to a less carbon-intensive energy mix is invariably the centrepiece of any discussion around climate change mitigation. With its long coastline, rainfall-dependent agriculture, and glacial-fed rivers, India is also highly vulnerable to the impacts of climate change, and workable solutions to the problem are, therefore, in India's interest. While developmental concerns and climate concerns do not always come into conflict, often there

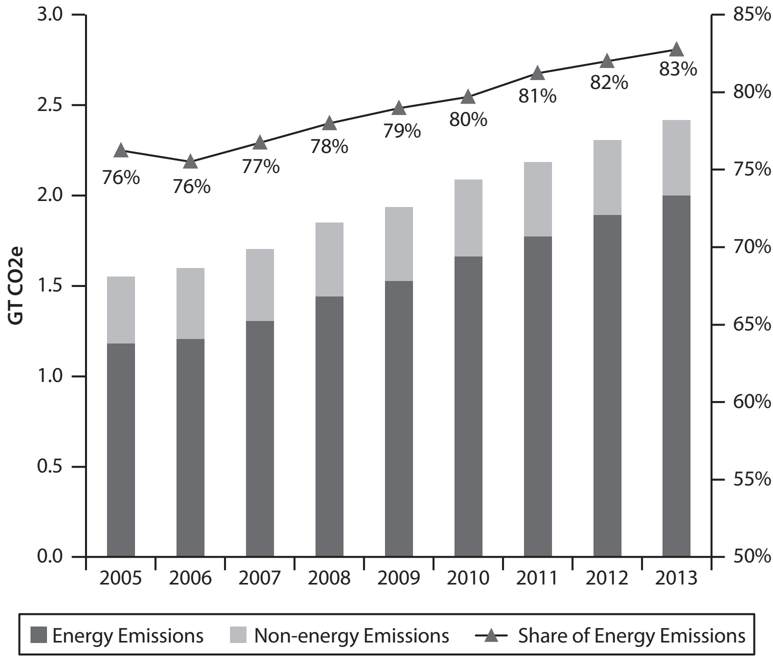

Figure 24.1 Share of Energy in India's GHG Emissions
Note: Energy emissions include those from fuel combustion and fugitive emissions, while non-energy emissions include those from 'industrial products and process use', 'waste', and 'agriculture, forestry and other land use'.
Source: 'GHG Platform India 2005–2013 National Estimates—2017 Series', July 2016. Available at http://www.ghgplatform-india.org/; accessed on 14 June 2019.

are difficult choices to be made between the two, calling for exploration of multidimensional approaches to understand and minimize trade-offs.

The fundamental dilemma that India faces may be summarized in a somewhat simplified manner as the relative importance to accord the short term versus the long term. In the short term, it may appear that focusing exclusively on developmental concerns is preferable for a country such as India. However, this does not take into account the extremely rapid changes that are taking place in the energy sector and the potential risks of lock-in and path dependence that may arise out of certain choices made in the short term. On the other hand, focusing on the long term exclusively can be morally questionable and politically suicidal when faced with such pressing developmental concerns. As John Maynard Keynes famously said, 'But this long run is a misleading guide to current affairs. In the long run we are all dead' (Keynes 1923: 80).

In this chapter, we try to describe a few pivotal elements or trends within the energy sector which will determine how India responds to this dilemma in the coming years. We begin by presenting the key role that energy plays in India's climate policy and India's approach to international climate negotiations. We follow that by looking at the important trends in energy consumption and energy supply that will shape the future of energy and climate discourse in India. Next is a brief analysis of some of the crucial governance and institutional aspects around energy that will also play a very important role in how the sector unfolds.

The Role of Energy in India's Climate Policy

Access to reliable and affordable modern energy is crucial to India as it enables many productive economic activities and can hence address many developmental challenges faced by the country. As shown in Figure 24.2, a small increase in per capita modern energy consumption correlates to a significant improvement in human development index (HDI) levels for countries such as India. However, as discussed earlier, energy also contributes to over 80 per cent of India's GHG emissions.

It is this dual relationship of energy to climate change and development that has informed India's position in climate negotiations. While India has recognized the need to mitigate climate change, it has also reserved its right to increase its consumption of modern energy keeping all possible options open. As a result, India has resisted taking on GHG emission restrictions and instead adopted 'measures that promote our development objectives while also yielding co-benefits for addressing climate change effectively' as part of the National Action Plan on Climate Change or NAPCC (Government of India [GoI] 2008). This views climate change mitigation as one among many objectives to strive for, along with others, such as employment generation, economic growth, improved well-being of its citizens, and better local environment.

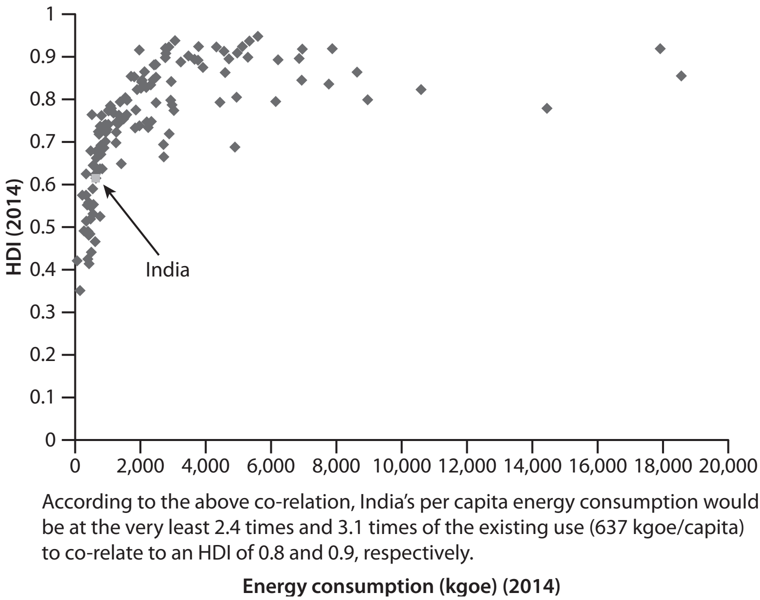

Figure 24.2 Correlation between Per Capita Energy Consumption and HDI
Note: kgoe: kilograms of oil equivalent.
Source: World Bank data indicators, Human Development Report (2016).

This approach, which focuses on decreasing the carbon intensity of India's future growth, informs India's international pledges. India's pledge at Copenhagen in 2009 stated that India would voluntarily reduce its emissions intensity of gross domestic product (GDP) by 20–5 per cent by 2020 compared to the 2005 levels (Lok Sabha Debate 2009). Under its Nationally Determined Contribution (NDC) to the 2015 Paris Agreement (GoI 2015), India's equivalent 2030 commitments are to reduce the emissions intensity of its GDP by 33–5 per cent compared to 2005 levels. As Figure 24.3 shows, this corresponds to roughly continuing the 16 per cent reduction in carbon intensity realized from 2005 to 2016. The NDC also included a pledge to achieve about 40 per cent cumulative installed electricity capacity from non-fossil fuel–based sources by 2030, as compared to a share of about 35 per cent by March 2018 (see Figure 24.4).

While international climate-driven processes such as missions and pledges have played a role in focusing attention on climate change,

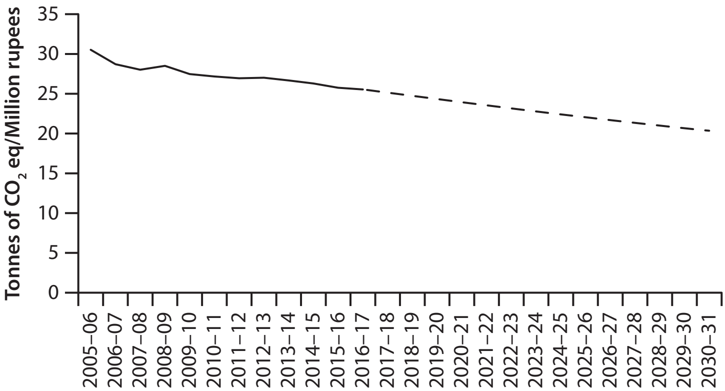

Figure 24.3 Emissions Intensity of India's GDP

Note: Projections (dotted line) based on past trends.

Source: Prayas (Energy Group) analysis based on GDP (in 2011–12 rupees) data from Reserve Bank of India; emissions data from GHG Platform India.

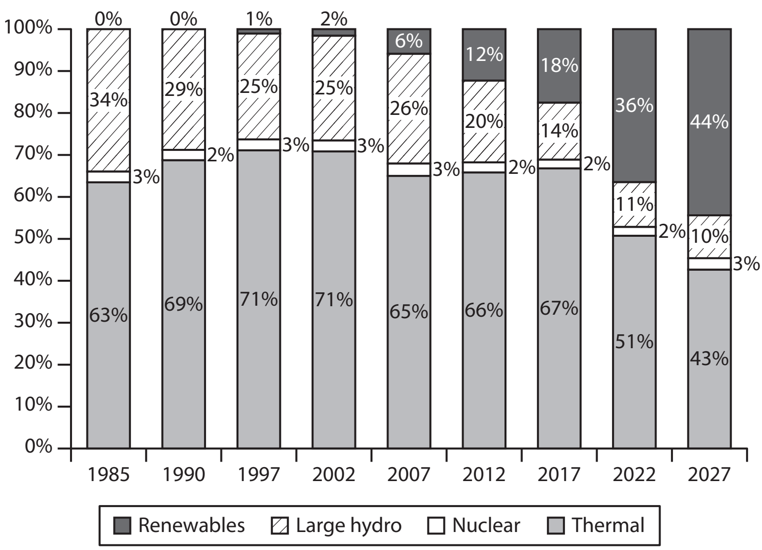

Figure 24.4 Share of Fossil Fuel–Free Capacity in India's Power Generation Capacity

Note: This does not include captive power generation. Data for 2022 and 2027 are projections based on CEA studies.

Source: Central Electricity Authority (CEA 2017a, 2018a).

specific actions have more frequently been driven by domestic concerns, such as energy security, addressing energy poverty, constraints like the poor financial health of electricity distribution utilities, and rapidly changing techno-economics. This has led to a wave of national programmes and schemes summarized in Table 24.1, many of which have an indirect but large effect on India's climate mitigation, even if they are driven by domestic motivations.

This gives a sense of the many changes underway in the Indian energy sector, with many more likely in the coming years, driven by policy and changes in economics of various technologies. The form, speed, and manner of these changes will determine how the energy sector would impact human development in India, as well as India's contribution to global GHG emissions and climate change. In the subsequent sections, we focus on a few issues that we believe would be critical as determinants of the future of the energy–climate–development troika. Consistent with the co-benefits approach of India, the trajectory of these issues would be determined by a combination of domestic factors (such as energy access and affordability, energy security and strategic considerations, employment generation, economic growth, and air and water pollution) and climate change.

Energy Consuming Sectors

India's per capita energy consumption was about 550 kilograms of oil equivalent (kgoe) in 2016, which was about one-third the global average of about 1,780 kgoe. Notably, these numbers do not include 'non-commercial' energy forms, such as biomass, dung cakes, and agricultural residue, which are still used in large quantities in India and are important energy sources for the poor. Unfortunately, data on these sources remains poor and, in this chapter, we are limited to commercial energy sources. As the government moves to address this energy poverty through various schemes as listed in Table 24.1, it is expected that energy demand would increase significantly in the coming years. The demand side of the energy equation is relatively less studied, because demand is a lot more disaggregated (millions of households, vehicles, shops, and so on) and is also influenced by less tangible aspects such as cultural and behavioural elements. However, India's future energy supply needs, and therefore GHG

Table 24.1 Important Recent Energy-Related Programmes and Schemes

Name	Description	Year	Reference
Rajiv Gandhi Grameen Vidyutikaran Yojana, Deen Dayal Upadhyaya Gram Jyoti Yojana, and Saubhagya	Targeting rural and household electrification.	2005, 2014, 2017, respectively	PIB (2005); MoP (2014); PIB (2017c), respectively
Pradhan Mantri Ujjwala Yojana (PMUY)	Promoting the use of LPG for cooking in poor households.	2016	PIB (2016c)
Ujwal DISCOM Assurance Yojana (UDAY)	Improving financial situation of electricity distribution utilities.	2015	UDAY (2015)
175 GW renewables by 2022	A large up-scaling of India's renewable energy targets consisting of 100 GW of solar and 60 GW of wind.	2015	PTI (2015)
SHAKTI and introduction of commercial coal mining	Reforms in the coal sector to auction coal linkages and a proposal to introduce commercial coal mining.	2017	MoC (2017); PIB (2017a)
Open Acreage Licensing Policy	Reforms in the oil and gas sector and a new revenue-sharing mechanism.	2016	PIB (2016a)
National Electric Mobility Mission Plan (NEMMP)	Ambitious announcements to electrify transport in India building upon NEMMP.	2015, 2017	PIB (2015); PTI (2017b); Srivastava (2017)

(*cont'd*)

Table 24.1 (*cont'd*)

Name	Description	Year	Reference
Promoting energy efficiency	A bulk procurement approach to lower costs, introduce market transformation, and promote energy efficiency as seen in the UJALA scheme for LED bulbs.	2014	UJALA (n.d.)
Biofuels	A renewed thrust on second-generation biofuels and introducing cleaner fuels.	2017	PIB (2017e); Sood (2017)
Smart Cities Mission	Proposes that these cities should source 10% of their electricity from solar sources and adopt transit-oriented development.	2015	http://smartcities.gov.in/content/

Note: GW: gigawatt; LED: light-emitting diode; LPG: liquefied petroleum gas; MoC: Ministry of Coal; MoP: Ministry of Power; PIB: Press Information Bureau; PTI: Press Trust of India.

Source: Compiled by authors.

emissions, would be directly determined by how energy demand increases.

In this section, we look at four energy demand sub-sectors, namely, residential, industrial, agricultural, and transport, that account for more than 90 per cent of India's energy consumption. Figure 24.5 gives a snapshot of energy consumption by sector in 2013. As can be seen, the industrial sector is the largest consumer of energy, followed by the transport sector, residential sector, and agriculture, respectively.

Residential Sector

India's residential energy consumption is likely to increase rapidly in the coming years given various enabling factors, such as the currently low base, aggressive government efforts to provide access to

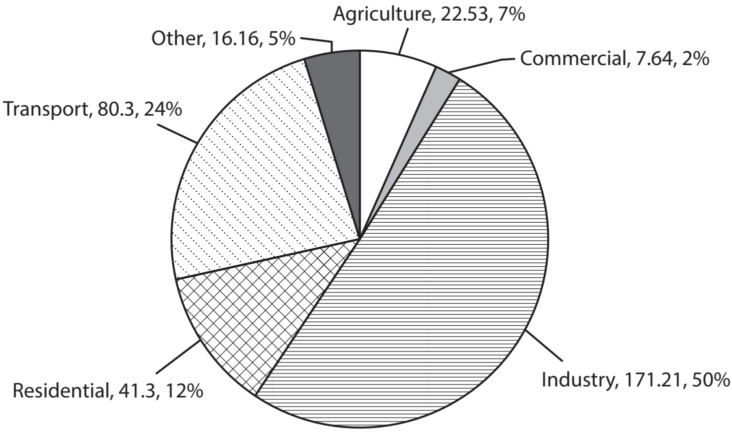

Figure 24.5 India's Final Energy Consumption in 2012–13 (in mtoe)
Notes: (i) More recent official data from sources such as Ministry of Statistics and Programme Implementation (2018) and NITI Aayog (2017b) have a large 'Others' component that distorts the real energy consumption, possibly because they classify most of the retail sales of petroleum products under the 'Other' category.
(ii) mtoe: million tonnes of oil equivalent.
Source: The Energy and Resources Institute (TERI). 2013. *TERI Energy and Environment Data Diary and Yearbook, 2012–13*. New Delhi: TERI.

modern energy forms, the aspiration to move to modern energy forms, increasing urbanization, and increasing household incomes. In particular, future residential energy consumption would be driven by how electricity use and cooking fuel use change in India.

Residential electricity use in India has more than doubled in the last 10 years, from 97 terawatt hour (TWh) in 2006 to 228 TWh in 2016, and now forms 25 per cent of total electricity consumption (NITI Aayog 2017b). This growth has been driven by increased household electrification (from 55 per cent in 2001 to over 80 per cent in 2017), faster urbanization, and rising incomes. It should be noted that, in spite of this increase, India's consumption of 90 kilowatt hour (kWh)/household/month is still only a third of the world average.[1] Residential electricity consumption has been

[1] Average consumption in India is three-fourth of China's, and a tenth of the United States (US) (World Energy Council 2016).

growing faster than other sectors, and will hence occupy a larger share of the country's total consumption in future. It is expected that residential electricity consumption will be two to three times its 2015 level by 2030. If increased appliance use is accompanied by adoption of energy-efficient solutions, it would not only reduce energy consumption and GHG emissions but also, in most cases, lower life cycle costs, though upfront costs may be higher.

Thus far, India's record in promoting energy-efficient appliances has been mixed. The Unnat Jyoti by Affordable LEDs for All (UJALA) programme was launched by the Energy Efficiency Services Limited (EESL) to promote efficiency in lighting. This initiative involved the guarantee of bulk procurement of light-emitting diode (LED) bulbs by EESL and did not involve any subsidies. It resulted in more than 300 million LED bulbs being sold by May 2018 (UJALA n.d.). While this initiative has created a large and sustainable market for LED bulbs at reduced prices, low-income households and small commercial establishments continue to buy incandescent bulbs due to their lower upfront costs, thus raising a doubt about the stated savings from the programme (Chunekar, Mulay, and Kelkar 2017).

The Bureau of Energy Efficiency (BEE) has instituted a Standards and Labelling (S&L) programme which lays down minimum energy performance criteria and mandates display of energy performance labels. The S&L programme is mandatory for some appliances such as refrigerators and air conditioners, while it is voluntary for others such as fans and washing machines. While S&L holds a lot of promise in increasing efficiency through informed consumer choice, the programme's experience has been mixed as well. While BEE's standards for 5-star frost-free refrigerators are comparable with international benchmarks, there is significant room for improvement in 1-star frost-free refrigerators and air conditioners (Abhyankar et al. 2017; Chunekar 2014).

Many studies predict a huge rise in electricity demand for cooling in India as air conditioner penetration increases (International Energy Agency [IEA] 2018; Phadke, Abhyankar, and Shah 2014). However, there is also an opportunity to mitigate this rise through other means, such as improved building architectures and designs. In India, this is being attempted through the Energy Conservation

Building Code (ECBC). The ECBC only had a code for commercial buildings until it recently introduced a code for residential buildings. Both these codes are voluntary, making them less effective. India's ability to come up with an effective building code and implement it would be a key factor in determining its future residential electricity consumption.

Access to clean cooking fuel is a second area of transformation in residential consumption: in 2011, 70 per cent of households used biomass and dung cakes as the primary cooking energy source (Census of India 2011). The Global Burden of Disease estimated that in 2016, household air pollution from solid fuels contributed to 0.78 million deaths and 22.4 million disability-adjusted life years (DALYs) lost in India, which constitute 13 per cent and 10 per cent, respectively, of deaths and DALYs from all causes and risk factors (Institute for Health Metrics and Evaluation 2017). With women doing most of the cooking, and women and girls primarily fetching solid fuels, this problem is also starkly gendered. Moreover, combustion of solid fuels results in significant GHG emissions in the form of black carbon.

To address this challenge, the government launched the Pradhan Mantri Ujjwala Yojana (PMUY) in 2016. This programme aims to provide subsidized liquefied petroleum gas (LPG) connections to 8 crore (80 million) poor households by 2020; and over 3.35 crore (33.5 million) connections have been released within two years (Press Information Bureau [PIB] 2016c, 2017f, 2018a). While this is a welcome initiative and an impressive beginning, the problem of clean cooking fuel access requires that those acquiring these connections consistently use them for their cooking needs to see significant health benefits. This would require addressing issues such as affordability, reliability, and last-mile delivery. If successful, this initiative can have a transformative impact on the country's development agenda, while also having a corresponding impact on energy consumption. However, since this is a multidimensional problem involving not only cooking fuels but also health and gender, it requires careful programme design based on consideration of the roles of various fuels and relevant stakeholders (Prayas [Energy Group] 2018b).

To summarize, India's residential energy consumption trajectories would be determined by the success or failure of a variety of initiatives, such as its appliance efficiency programmes, building efficiency codes, and modern cooking fuel access programmes, and notably there are a number of such programmes underway.

Industry

Industry has traditionally been the largest energy consuming sector and uses close to half the final modern energy consumption in the country. Industrial energy consumption is likely to increase further in the coming years, driven not only by economic growth but also by programmes such as 'Make in India', which attempt to promote domestic industry so that it can contribute to 25 per cent of the country's GDP by 2020 and also provide more employment.[2] The key factor determining future industrial energy consumption is the energy efficiency of future industry.

Industrial energy use has doubled from 86 million tonnes of oil equivalent (mtoe) to 173 mtoe in 10 years from 2006 to 2016 (see Figure 24.6). Coal contributes to about 60 per cent of total energy consumed in the industry sector, followed by electricity and petroleum products. The largest energy consuming industries are iron and steel, chemicals and fertilizers, and cement. According to IEA (2015), energy demand from the industrial sector is likely to grow by 2.4–3.3 times, to 417 and 572 mtoe by 2030 and 2040, respectively, with corresponding GHG emissions implications.

The climate implications of the industry sector would depend on the future trajectory of energy-intensive industries, the success of the 'Make in India' initiative, and the efficiency programmes proposed for the industry sector, such as the Perform–Achieve–Trade (PAT) scheme launched by BEE. Under the first cycle of PAT, a set of 'designated consumers'—representing 478 industrial units from 8 sectors—were given reduced targets for specific energy consumption. Those who achieved more than the target were allowed to 'sell' the extra savings to those who underachieved. However, in the first cycle, targets were overachieved by most designated consumers (BEE 2017), suggesting that the targets were weak. The second cycle of

[2] Make in India web portal. Available at http://www.makeinindia.com/about; accessed on 14 June 2019.

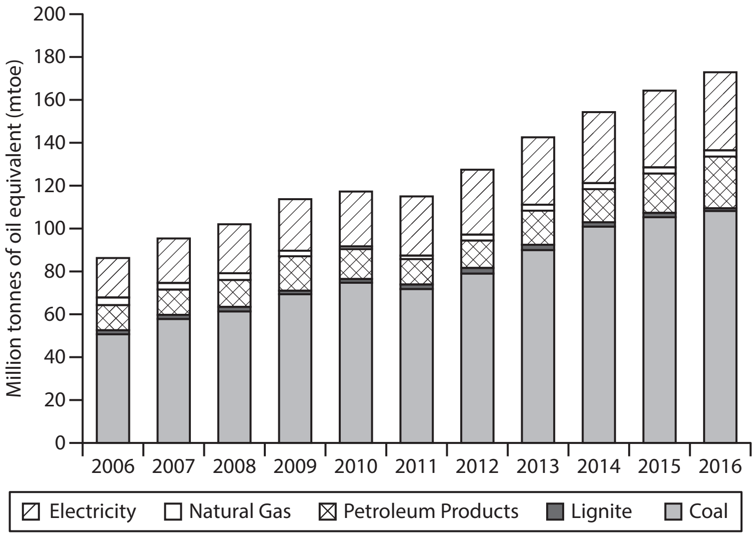

Figure 24.6 Energy Use in the Industry Sector
Source: NITI Aayog (2017b).

PAT (2016–17 to 2018–19) expanded its scope by adding three new sectors, but the targets still appear to be weak. For example, the PAT standards for some performance parameters of thermal generation and electricity distribution companies (DISCOMs) are weaker than those defined by regulators and government programmes such as Ujwal DISCOM Assurance Yojana (UDAY).

Some industrial sectors in India (such as cement) are among the most efficient in the world, while others are not. For example, India is the only major country to use coal to produce sponge iron or direct reduced iron to make steel, because of insufficient natural gas and lower upfront costs (IEA 2015). About 100,000 small-scale units using traditional methods of brick production are very energy intensive and a large source of local air pollution. In such a situation, future energy consumption of the industry sector would depend critically upon proper design and implementation of programmes such as PAT and other initiatives to promote industrial energy efficiency.

Transport

The transport sector is one of the major consumers of energy in the country. Some trends, such as the rapid growth in personal vehicle ownership and aviation, increasing urbanization, and increased movement of goods, suggest that this sector would continue to be an important energy consuming sector in the years to come. Since its predominant energy source is petroleum based, this sector is also a major cause for the country's energy import dependence, as India imports about 80 per cent of its petroleum requirement (PTI 2019).

One major change that is likely to drive the sector in future is an attempt to electrify the transport sector. A National Electric Mobility Mission Plan (NEMMP) was introduced in 2013 and up-scaled in 2015 (PIB 2015). This has been followed by more ambitious statements about selling only electric vehicles by 2030 in India (Press Trust of India [PTI] 2017a). These have been backed up by other research and regulatory studies, state-level initiatives, and bulk procurement initiatives to accelerate the adoption of electric vehicles (Forum of Regulators [FoR] 2017b; Government of Karnataka 2017; NITI Aayog and Rocky Mountain Institute [RMI] 2017; PIB 2017d). This is complemented by initiatives such as introduction of a new biofuels policy (PIB 2018b), which aims to reduce India's import dependence.

In addition to this, there are other initiatives that will impact the future of the transportation sector. The smart city mission is expected to give a fillip to public transport, particularly metro rail systems, while NITI Aayog and RMI have proposed that MaaS (Mobility as a Service) should be encouraged to disincentivize private transport, promote electric mobility, and provide cheaper, more accessible, and better-quality mobility (NITI Aayog and RMI 2017). Other initiatives in transport include: the dedicated freight corridors under construction; the proposed high-speed rail (PIB 2017b); the UDAN programme to provide air connectivity to smaller towns (PIB 2016b); and earlier-than-planned introduction of Bharat Stage VI standard of clean fuels (PIB 2017e).

The cumulative effect of these changes in the transport sector will be quite significant. If the electric mobility programme succeeds, it would have a huge impact not only on the domestic oil and gas sector but also on India's energy imports and current account deficit, as oil imports cost India in excess of Rs 4 lakh crore (Rs 4 trillion) in 2015–16 in spite of relatively subdued oil prices (NITI Aayog 2017b). It would also significantly reduce vehicular air pollution, while its impacts on GHG emissions would depend on the electricity mix in use. The success or failure of initiatives to promote public transport and MaaS would also have a big impact on these factors.

Agriculture

Agriculture is the primary livelihood provider in rural India, contributing to food security and also providing raw material for agro-industries. Two-thirds of the total irrigated area in the country is irrigated through groundwater pumping, which accounts for most of the energy consumption in agriculture. Mechanization and fertilizer use are two other drivers of energy consumption in the agriculture sector. India's low level of mechanization and fertilizer use, coupled with the need to increase food and other agriculture production to meet the needs of its still-growing population, implies that there could be a significant increase in energy use for agriculture in future.

There are close to 2.1 crore (21 million) electricity grid-connected pumps and 0.7 crore (7 million) diesel-powered pumps in India (Central Electricity Authority [CEA] 2017b; Ministry of Power [MoP] 2011). In 2014–15, agriculture consumed about 169 billion kWh (about 18 per cent of India's electricity consumption) and about 10 billion litres of diesel for irrigation and mechanization.[3] Electricity demand from agriculture is expected to double to 353 billion kWh by 2027 as per the 19th Electric Power Survey (CEA 2017c).

Reliable and affordable energy access to agriculture is an important developmental issue as it concerns livelihoods and food security. However, as illustrated by the case of Punjab, where electricity supply to farmers was free in 2016–17 when the cost of supply was Rs 6.07/kWh, the combination of farmers' low-paying ability and

[3] Author's estimate for diesel use. KPMG (2014) puts the irrigation share of diesel at 4 billion litres.

high cost of supply to them makes this a difficult problem to solve (Sreekumar et al. 2013). Agricultural electricity subsidies can also place a significant demand on the exchequer and DISCOM finances. For example, agriculture received Rs 6,545 crore (Rs 65 billion) as a combination of cross-subsidy and direct subsidy in 2015–16 in Maharashtra, which is about Rs 15,400 per pump-set per year.[4] On the other hand, agriculture continues to get low-quality, unreliable power, leading to problems such as frequent burnouts of pumps and electricity supply during non-peak hours, including late nights, making farmers distrustful of DISCOMs. This vicious cycle can only be broken through innovative solutions that can provide reliable, daytime electricity supply to farmers at reasonable tariffs, and gradual increase of mutual trust between the supplier and consumer while reducing the state's subsidy burden. Examples of such solutions include solar-powered agriculture feeders[5] with efficient pumps (Gambhir and Dixit 2015) and better estimation of agricultural electricity consumption through feeder-level automatic metering.

Domestic Energy Supply

Coal has traditionally been the largest source of energy in India, supplying more than half of India's primary energy requirements (see Figure 24.7). Though it is used for industrial heating in sectors such as iron and steel, cement, and aluminium, its main use is for electricity generation. Various factors, such as rapidly falling prices of renewable-based electricity, increasing concerns about the social and local environmental impacts of coal, and increasing costs of coal-based electricity, are shifting the balance away from coal and towards renewable sources. This also has big implications for climate change.

[4] Prayas (Energy Group) estimate based on electricity regulatory data.

[5] These are grid-connected, tail-end solar photovoltaic (PV) plants of 1–5 megawatt (MW) deployed at 33/11 kilovolt (kV) substations having separate agricultural feeders. They are being piloted in Maharashtra, with plans to scale it across the state under the chief minister's solar feeder policy. In areas where feeder separation has not taken place or where the grid cannot reach, solar pumps may also be a viable option.

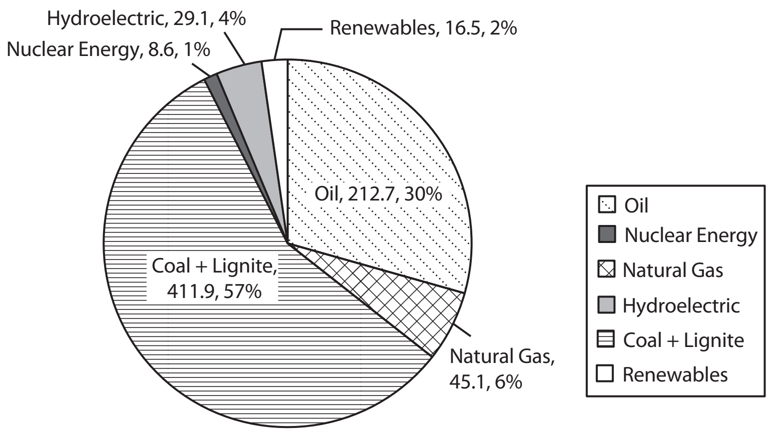

Figure 24.7 India's Total Primary Energy Supply in 2016
Source: BP (2017).

Coal and renewables are significant in another way for India: these are the two energy sources that India has in abundance. India is dependent on imports for more than 80 per cent of its oil requirements; in addition, hopes that India would be able to produce most of its natural gas requirements have been belied, with import dependence over 30 per cent in 2014–15 (NITI Aayog 2017b). Two energy sources with low import dependence are large hydro and nuclear energy. However, these sources do not play a significant role in the energy basket currently nor are they likely to in future for various reasons such as economics, safety, and ecological concerns (Dubash et al. 2018; NITI Aayog 2017a). Therefore, we analyse the drivers behind the evolution of the coal and renewables sectors in this section. We also analyse the drivers behind the evolution of electricity distribution in India, as this segment is the most challenging, and most crucial, in the electricity sector for providing affordable, reliable power to all.

Coal and Thermal Power

Coal has been India's primary source of energy and electricity. However, as discussed earlier, this sector is undergoing a transformation due to various reasons. In 2017–18, for the first time, India added more renewable energy-based electricity generation capacity than all other sources combined (CEA 2018b: 29). However, the complete phase out of coal is likely to be gradual and take place over a few decades, since most energy investments have long lifetimes.

India's coal and thermal power sectors are riddled with various inefficiencies and have significant socio-environmental impacts (Prayas [Energy Group] 2017). Some policy documents indicate that future demand for coal is likely to be robust (Coal India Limited [CIL] 2017; NITI Aayog 2017a). These assumptions underpin some proposed reforms in the coal sector, such as auction-based allocation of coal to consumers under the SHAKTI scheme (PIB 2017a) and introduction of commercial mining (Ministry of Coal [MoC] 2017). The government has also been reluctant to revisit the ambitious coal production target of 1.5 billion tonnes by 2022 (PTI 2017c). However, these seem to be inconsistent with some ground realities and other policy measures announced by the government, as discussed further in the chapter.

India's coal-based electricity generation capacity expanded rapidly in the recent past to outstrip demand growth (Josey, Mandal, and Dixit 2017). Existing coal-based capacity is underutilized and plants have been running at utilization factors of around 60–5 per cent, rather than the norm of 80 per cent (Sharma 2017). As a result, thermal power companies form a major portion of the stressed assets of banks and the Parliamentary Standing Committee on Energy has taken serious note of the situation (Ministry of Finance 2017; Parliamentary Standing Committee on Energy 2018). Recently, private sector investment in coal-based electricity has tapered off, with most of the capacity under construction being government owned (Prayas [Energy Group] 2018a). The government proposed the introduction of stricter environmental norms for thermal power plants from December 2017,[6] which could add Rs 0.22–0.50/kWh to the costs of coal-fired power (Centre for Science and Environment 2016; Sethi 2017). This will make coal-based electricity even less attractive in comparison to alternatives and is likely to accelerate the shift away from coal. These suggest

[6] The norms have not come into force as of May 2018 and their implementation is likely to be delayed by a few years.

that the medium- to long-term outlook for coal demand may not be as bright as previously thought.

Thus, this sector is in a curious situation with a not-so-bright outlook but with ambitious plans. The pace of coal phase-out, the manner in which India deals with this situation, and whether it can do so without burdening ordinary citizens and electricity consumers will be a determinant of the future of thermal power in India.

The coal and thermal power sectors are also important because they provide employment, albeit hazardous, to many people. Therefore, meeting multiple objectives, such as optimizing investments, avoiding undesirable lock-ins, providing affordable and reliable power to all, providing employment, and protecting local and global environment, requires careful navigation. Since India's coal reserves are in thickly forested areas, its exploitation may also conflict with its NDC of increasing afforestation (GoI 2015). Prudent capacity addition to avoid lock-ins, enhancing competition, handling old and new regulatory challenges, addressing social and environmental impacts better, and managing costs will be some of the challenges that will have to be addressed going forward. Perhaps more than other sectors of Indian energy, the ability of the coal and thermal power sectors to develop in an equitable, fair, and optimal manner will have the greatest bearing on the future of India's energy sector and its GHG emissions.

Renewables

There is now little doubt that renewables will form the foundation of the future of India's electricity sector in particular, and energy sector in general. However, there are doubts about how soon this shift can happen and how smoothly the shift can happen—given the specific technical and regulatory challenges associated with renewables.

Renewable energy-based electricity generation has seen a strong annual growth of 20 per cent over the last 15 years, with total installed capacity as of March 2018 at 69 gigawatt (GW) or 20 per cent of total capacity (CEA 2018b).[7] Renewables contributed 102 billion kWh (7.8 per cent) to India's electricity generation in

[7] This does not include the 45 GW of large hydro capacity.

2017–18 (CEA 2018c). India has announced an ambitious target of 175 GW of renewable capacity by 2022, and the CEA reckons that this would contribute 20 per cent to total electricity generation (CEA 2018a). The drastically falling prices of wind and solar power and ever-increasing capacity have compelled even sceptics to acknowledge that renewable energy will play a major role in the future.

Auctions for solar and wind power in 2017 have discovered record low prices of Rs 2.44/kWh and Rs 2.43/kWh, respectively, for solar PV and wind (Das et al. 2017; Ramesh 2017). This underscores the price competitiveness of renewable energy, especially when contrasted with new coal-fired capacity being contracted in the price range of Rs 4–5/kWh (FoR 2017a). Note that these prices of wind and solar power only reflect their direct generation costs, and do not value its other benefits in terms of minimal environmental externalities, enhanced energy security, low gestation periods, and low price volatility.[8] Therefore, generation prices are not going to be a hurdle for increased adoption of renewable energy in India.

The major challenge that now remains is of reliable and cost-effective grid integration, which requires state-of-the-art modelling to understand the additional stress and complexity on system planning and operations due to renewables. It also requires a framework to equitably distribute the additional costs of grid integration among the various stakeholders. If states can evolve a mechanism to share resources across their boundaries to further reduce the cost of system operation, it would significantly ease the integration of large quantities of renewables into the grid. As the penetration of renewable energy—which typically has 'must-run' status—increases, the 'peakiness' of the net load increases, which means that the rest of the generation fleet must have greater flexibility to respond to changes in

[8] Being a variable source of energy, procuring renewable energy (especially wind and solar) potentially entails higher system-integration costs (especially for balancing), which need to be factored in for comparing its price with that of any baseload capacity. However, a recent study by CEA found that 'even after including the financial implication on account of variable renewable generation, it would still be cheaper in the future to set up renewable generation capacity, as compared to coal-based capacity' (CEA 2017d: 2).

load. Other major challenges going ahead would be optimal generation capacity planning, robust demand forecasts (including seasonal and peak/off-peak variation), capacity addition planning exercises, and appropriate system operation rules.

While the growth of renewables thus far has been nurtured through policy–regulatory instruments, such as preferential tariffs, minimum purchase obligations, and waiver from scheduling, they will increasingly have to confront the mainstream sectoral challenges. These include the poor financial health of DISCOMs, poor supply quality and weak grids, generation capacity 'surplus' in many states, the need to provide 24×7 universal and affordable access, and the differing priorities of the central and state governments. Another crucial variable that would determine the future trajectory of renewables is the development of technology and the regulatory regime around storage, as this can greatly help eliminate the intermittency associated with renewables.

Electricity Distribution Utilities

Electricity DISCOMs are the vital link between the electricity sector and its consumers. With the rapid changes in the electricity sector where 'consumers' are also 'producers' of electricity through on-site solar rooftop systems and the increasing likelihood of direct electricity trade between generators and (typically large) consumers, DISCOMs would have to reinvent themselves. They would have to evolve from their current role as the sole suppliers of electricity to primarily providing the physical wire infrastructure for electricity supply, fulfilling other technical functions to maintain grid stability, and perhaps be the electricity supplier to rural and small consumers.

The DISCOMs are currently beset by challenges of financial viability due to past liabilities, loss of cross-subsidy from migration of large consumers to other supply options, and increasing cost of supply, mostly due to inefficiencies in generation and distribution. This has been a long-standing problem that has evolved out of various political economy considerations as a result of which they are able to provide neither adequate access and good quality of supply nor competitive tariffs for large consumers (Dubash, Kale, and Bharvirkar 2018; Dubash and Rajan 2001; Prayas [Energy Group] 2017).

As non-DISCOM renewable energy options, such as rooftop solar pv or captive systems and procurement through the open-access/captive route, become increasingly competitive with DISCOM supply, many industrial and commercial consumers whose DISCOM tariffs are high would switch to such sources. For example, rooftop solar prices are already in the range of Rs 4–5/kWh, which is much lower than the tariffs charged to such consumers. As of 2017, for many DISCOMs, more than 50 per cent of their sales were at prices higher than rooftop solar PV costs (Sarode et al. 2017). As storage becomes more economical, this trend will only accelerate.

To deal with such an uncertain and different future, it is essential to plan and prepare the distribution sector for the inevitable transition. Indeed, the transition can be used as an opportunity to bring about meaningful reforms in the distribution sector, such as moving away from the 'cost-plus' approach to a benchmarking approach for distribution costs and retail tariffs, mandating and facilitating long-term sales migration through effective markets, and undertaking more realistic capacity addition planning while accounting for changing generation costs. This requires improving the efficiency and accountability of DISCOMs by addressing their governance and capacity deficits, and it is possible that the government would have to provide some form of transition financing for this purpose (Prayas [Energy Group] 2018a).

While the role of the DISCOMs may change, a robust grid and economically viable distribution sector is critical to absorb a large share of renewables. If the serious challenges facing the distribution sector are not squarely addressed, this may not be achievable, and the poor and marginalized consumers would be the most affected.

Governance and Politics

Most of the energy sector is characterized by a few traits, such as an investment-heavy nature, long gestation, long life, technical complexity, and close connections to other sectors such as the wider economy and environment. This makes effective governance of the energy sector crucial as well as challenging. The challenges are around planning, concession and contract design, and regulation. Energy governance is also very political as it involves various stakeholder groups whose different interests have to be balanced. Electricity is a concurrent subject in the Indian Constitution, thus bringing its own challenges related to federalism.

India has traditionally grappled with serious governance challenges in the energy sector (Dubash, Kale, and Bharvirkar 2018; Dubash and Rao 2007; Kale 2014; Pargal and Mayer 2014; Prayas [Energy Group] 2017). There is insufficient capacity, accountability, and transparency in various institutions. There have been challenges regarding planning, contract enforcement, implementation, and oversight. Institutions have structural weaknesses which limit their effectiveness. Some sectors such as coal, petroleum, and thermal power have too little competition, and some of them have weak or no independent regulatory regime. These have led to suboptimal development of these sectors leading to high costs; low access, affordability, and reliability; poor infrastructure; and adverse socio-environmental impacts.

Integrated planning of the sector has also been a challenge in India as illustrated by two examples: (i) the aggressive push for 175 GW of renewable capacity coexisting with ambitious plans for the coal sector in the presence of sluggish demand; and (ii) ambitious plans to move the transport sector towards alternative fuels such as electricity and biofuels coexisting with an equally ambitious plan to augment the country's petroleum refinery capacity (Reuters 2018).

These traditional governance challenges would get amplified with the changing nature of the energy sector, particularly the electricity sector. Introduction of intermittent renewable sources of electricity brings additional regulatory challenges, such as managing grid stability, ensuring adherence to forecasting and scheduling protocols, and fairly allocating the costs of any deviations. The techno-economic changes in the sector have already led to some regulatory disputes, such as some states trying to renegotiate contracts and the possibility of some suppliers reneging on their commitments (Bhaskar 2017; Jainani 2017). The evolution of the coal–thermal power sector, with the need for cycling of coal power plants and need for redesigning tariffs, will pose its own regulatory challenges, as will the emergence and uptake of new technologies such as electric storage or second-generation biofuels. Regulatory issues would also arise from increased penetration of electric vehicles around issues such as their tariffs, safety and standards, and regulation of MaaS services. Energy efficiency, which should be a key component of the puzzle, can only be given the attention it deserves if the capacity, authority, and responsibility of the BEE are significantly enhanced. If the cooking fuel access problem has to be addressed effectively, the regulatory regime governing the LPG and piped natural gas (PNG) sectors has to significantly improve.

Since the energy transition would invariably involve some winners and losers, some tricky political questions would also have to be addressed. The 'losers' are likely to be the traditional energy sectors of coal and thermal power. Since these sectors, particularly the coal sector, are concentrated in the eastern and relatively poorer part of the country, the political impact of any job and royalty losses due to a decline in the role of coal are likely to be significant. These states are also less renewable resource rich, and therefore less likely to benefit from the 'new' energy sector. Similarly, a shift in the transport sector towards greater electrification and MaaS is likely to lead to fundamental shifts in the petroleum industry, automobile industry, and its ancillary services, with repercussions for the economy and employment.

As DISCOMs lose their high-paying consumers to captive or open-access renewables (with or without storage), the challenge of providing affordable and reliable electricity to the poorer households will become more acute. Similarly, politically sensitive railway passenger fares will come under pressure as the Indian Railways' revenue from coal—the largest contributor to freight revenue—tapers off, reducing the ability of freight to subsidize passenger traffic.

The central government and state governments in India often have differing priorities. The Centre's perspective is informed by macroeconomic stability, economic growth, and geostrategic issues, while states are driven more by local concerns and political realities, including energy access and affordability, and local jobs and economies. A transition in the energy sector would bring these differences into sharper focus. For example, the Centre may want to promote renewable energy more aggressively to reduce costs, energy imports, and pollution, as well as to meet international obligations. However, the ramifications at the state level may be different and will differ from state to state. For example, coal-rich states may lose jobs and royalty revenue, while states with excessive renewable energy (such as Tamil Nadu) may either face grid instability or have to back down renewable energy if it cannot be despatched and sold elsewhere.

Thus, India's energy sector future and its ability to combat climate change are not only dependent on how it deals with the sectoral aspects discussed in previous sections but also on how it manages these tricky governance and political questions.

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Various factors, such as a desire to improve energy access, reduction of energy import dependence, changing economics, and India's international commitments, are likely to shape India's energy sector. This is likely to result in increased electrification of the economy and an increased share of renewables, among many other changes. In order to ensure that these changes result in a fair, optimal, and sustainable development that provides its citizens with affordable and reliable access to energy while minimizing GHG emissions, India has to tread a very careful path that considers the multiple dimensions of the challenges, understands the trade-offs, and picks the best possible option (Khosla et al. 2015). This would require policy formulation to adopt a different frame of reference that includes such considerations, and adopts a much more deliberative and inclusive process.

The impending transition also provides an important opportunity. If negotiated well, India could avoid many inefficient lock-ins with significant economic and environmental costs. India can chart a new exemplary development path in which it can provide its citizens with modern energy services without necessarily compromising on other resources such as land, air, and water, while potentially opening up employment and investment opportunities in many new sectors associated with the transition. Charting such a development path would not be easy given the nature of challenges to be faced and existing institutional and systemic weaknesses, but the opportunity to do so exists in practically every sector discussed in the chapter. Whether India can rise up to this challenge will determine not only its energy future but also India's contribution to combating climate change.

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