Chapter 5: Climate Change Mitigation - Energy, Transport and Forestry

5.1. Introduction

Karnataka is one of the most industrialised and urbanised states in the country. The state ranked 4th in its contribution to India's gross domestic product (GDP) in 2016-17[1] (RBI, 2019). Karnataka is a leader in the IT (information technology) and biotechnology industries. The service sector is the largest contributor to the state GDP (with almost a two-thirds share), followed by manufacturing and agriculture[2]. With growing population, urbanisation, and industrialisation, the state's energy demand has increased—catalysing a subsequent surge in greenhouse gas (GHG) emissions. GHG emissions in Karnataka have grown at a compound annual growth rate (CAGR) of 4.4% for a decade, from 64 million tonnes of carbon dioxide equivalent (MtCO2e) in 2005 to 98 MtCO2e in 2015 (GHGPI, 2018).

Overview of the Chapter

This chapter is divided into four sub-sections. The first details all the major policies and programmes implemented in the state from 2012 onwards and its GHG implications. The second provides the inputs and assumptions considered for identifying the future mitigation actions, which could be prioritised by the state until 2030. The third sub-section identifies the list of GHG mitigation actions, its mitigation potential, investments required and barriers identified for its implementation. The fourth sub-section provides a broad implementation plan for the mitigation activities listed in the earlier section.

5.2. Ongoing Major Policies and Programmes: Effect and Implications for GHG Mitigation

The study analysed policies implemented from 2012 onwards, and also the targets, finance allocated and barriers (if any) for implementation in the state.

5.2.1. Power

GHG emissions from electricity generation contribute to about 50% of the emissions from energy sector in Karnataka. The emissions grew from 11.4 $MtCO_2e$ in 2005 to 28.6 $MtCO_2e$ in 2015. Emissions from the power sector grew at a CAGR of about 12% from 2005 to 2012 and then slowed down to 5% from 2012 to 2015 (GHGPI, 2017). The slowdown in emission growth rate can be attributed to the various policies and programmes implemented in the state as detailed below.

[1] At constant prices (2011-12 base year)

[2] In 2015-16, service sector contributed 66% to the state GDP, manufacturing 23% and, agriculture 11%.

Karnataka stands seventh in terms of installed capacity among all Indian states (CEA, 2020b). The state has a total installed capacity of 28.2 GW—9.5 GW coal, 13.8 GW renewable energy (RE), 3.7 GW large hydro, and 0.88 GW nuclear as on March 2019[3]. Karnataka's solar generation portfolio is impressive. The state is home to one of the largest solar power parks in the world, the Pavagada Solar Power Park, with a capacity of 2.05 GW (KSPDCL, 2020). The solar-installed capacity in the state rose from 13 MW in 2012 to 5.8 GW (including rooftop PV) in 2018. This accounted for nearly 21% of Karnataka's total installed capacity in 2018. Moreover, the state also has wind-power installations—stood fourth in wind-installed capacity in 2018, with a total installed capacity of 4.7 GW (17% of the total installed capacity) (PIB, 2019). Other RE-generating sources, such as small hydro and biomass-based power plants (including cogeneration in industries), accounted for 1.1 GW and 1.7 GW, respectively, in 2018. To sum up, nearly half of Karnataka's installed capacity in 2018 came from RE sources (Figure 5.1). Commensurately, the share of RE generation increased from 12% in 2012-13 to 31% in 2018-19[4], which is higher than the national share (22% in 2018- 19) (MNRE, 2019a).

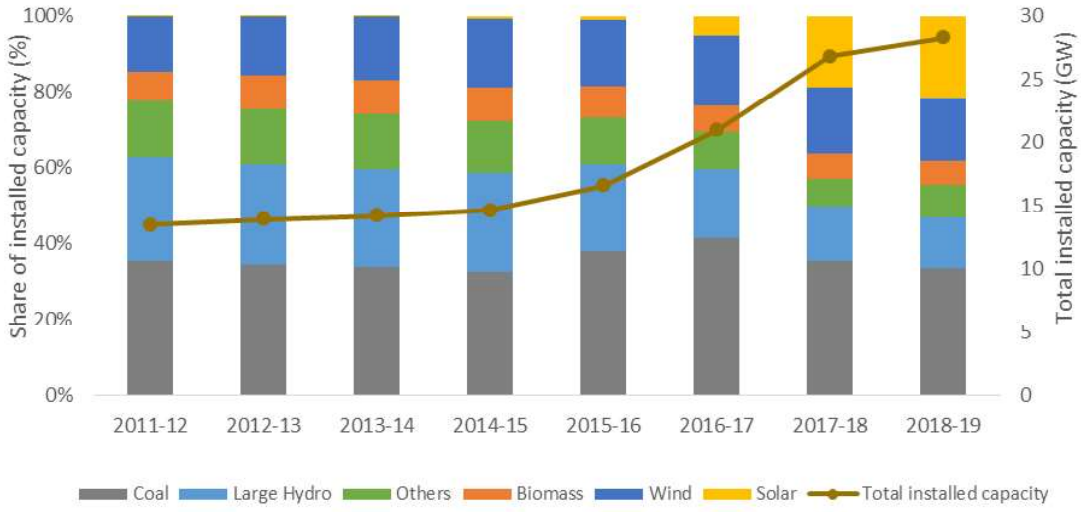

Figure 5.1: Share of installed capacity of various generating sources[5]

Source: (CEA, 2012, p. 2, 2020a; MNRE, 2019a); Data from Energy Department, Karnataka

The increase in RE electricity generation is mainly attributed to progressive RE policies in the state, such as the Karnataka Solar Policy, Renewable Energy Policy, and the Surya Raitha Scheme. Such initiatives helped Karnataka install the highest RE capacity among all Indian

[3] Year-wise renewable energy installed capacity data is from Energy Department, Government of Karnataka

[4] Excluding electricity purchase from other states (apart from power purchase agreements); the capacity utilisation factor of RE-based sources is very low compared to conventional power plants, the share of electricity generation will be lower than the installed capacity share.

[5] Others include nuclear, small hydro, waste to energy, diesel, and gas-based power plants

states. As a state nodal agency, the Karnataka Renewable Energy Development Limited (KREDL) is formulating and implementing policies to promote solar and other forms of RE.

The key objectives of these policies are to encourage public and private participation in the sector and boost decentralised RE generation where access to grid electricity is difficult. Along with setting up guidelines and activities to promote RE, these policies established installed capacity targets. The Solar Policy 2014–21 has a target of 6 GW (including 2.4 GW of rooftop photovoltaic–RTPV) of additional installations between FY 2014-15 and FY 2020-21. The state added 6 GW of solar-installed capacity between FY 2014-15 and FY 2018-19. Though ground- mounted solar installations saw a significant growth during this policy period, solar RTPV achieved only 240 MW of cumulative installed capacity as of March 2020. Procedural delays at nodal agencies and lack of state-governmental incentives have been major barriers to RTPV installation. The only incentive was the 30% capital subsidy provided by the central government to residential consumers (GEDA, 2016). Nonetheless, Karnataka was declared the best state for setting up RTPV solar projects based on the State Rooftop Solar Attractiveness Index—SARAL[7](MNRE et al., 2019).

Karnataka has recently introduced regulatory changes to make RTPV investment attractive (KERC, 2016). In March 2020, Bengaluru's power utility, Banaglore Electricity Supply Company (BESCOM), launched an RTPV subsidy scheme—Saura Gruha Yojane. This scheme is applicable for 30 MW grid-connected RTPV under the Central Finance Assistance (CFA) of the Ministry of New and Renewable Energy (MNRE) (BESCOM, 2020). Karnataka Electricity Regulatory Commission (KERC) approved three business models for RTPV installation— utility-centric, consumer-centric, and third-party owned (RESCO) models—and approved a generic tariff irrespective of the project model (KERC, 2020). In addition, to encourage investment, RTPV tariff has not been decreased for FY 2020-21, even though the PV module cost has come down drastically.

The Renewable Energy Policy 2009–14 set a target of 4.2 GW of additional non-solar RE capacity during the policy period (KREDL, 2009). The state achieved only 30% of targeted capacity additions between 2011 and 2014. The Renewable Energy Policy 2016–22 (draft) has provided a non-solar RE capacity addition target of 6 GW between 2016-17 and 2021-22 (KREDL, 2018b). The year-wise targets and capacity addition are provided in Table 5.1. The state overachieved its targets in 2016-17 and 2017-18, while the achievement was low in 2018-19.

Table 5.1: Year-wise targets and achievement for non-solar RE (2016-22)

Year	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**
Target (MW)	850	900	950	1,025	1,075	1,200
Achievement (MW)	1,030	1,141	149	Not applicable		

Source: Karnataka Energy Department; KREDL, 2018b

The major barriers to non-solar RE are surplus power (installed capacity) in the state, cost decline of solar power projects, and long-term power purchase agreements (PPAs) between

distribution companies (DISCOMs) and thermal power plants (TPPs). In addition, KERC recently notified a levy of 25% of normal transmission charges as wheeling charges for RE projects commissioned (open-access consumers) on or after 1 April 2018 (KERC, 2018). This regulatory change could impede future RE investments in the state.

Along with state policies, national programmes such as National Solar Mission and Renewable Purchase Obligations (RPOs) played a significant role in increasing RE share in the state's energy mix (MoP, 2018b). DISCOMs in Karnataka, such as Bangalore Electricity Supply Company (BESCOM), Mangalore Electricity Supply Company (MESCOM), and Gulbarga Electricity Supply Company (GESCOM) were able to purchase electricity generated from RE sources, surpassing the RPO target from FY 2014-15 onwards[6].

Though the key drivers of RE installation have been policy and programmes, other factors also played a part. These include decreased RE capital cost, better market conditions (supply-chain competitiveness), and financial stress of coal power plants in the state (high coal price and coal availability issues) (IEEFA, 2019). However, an analysis of these factors is beyond the scope of the current study.

The state had also attempted to improve the energy efficiency and plant load factor (PLF) of old coal-based power plants. A considerable lump sum amount of around INR 310 crore from the Karnataka Power Corporation limited (KPCL) budget was allocated for renovation and modernisation (R&M) and life extension (LE) activities at Raichur Thermal Power Station (RTPS) (KPCL, 2017). The key activities undertaken at RTPS are R&M and LE of boiler, turbine- generator, and control and instrumentation[7]. Alongside KPCL's activities to improve energy efficiency in its plants, other coal TPPs in the state had to improve their energy efficiency as part of the PAT scheme (BEE, 2012, 2016). Of the four power plants (4,280 MW) listed in the PAT-1 scheme, only two plants (860 MW) achieved the target. On the other hand, all TPPs under PAT-2 scheme in the state were able to meet the targets[8].

The PLF of coal-based power plants in Karnataka showed decreasing trend during 2012-18 (CEA, 2012, 2019). The PLF of coal TPPs decreased from 51% in 2011-12 to 34% in 2018-19. Coal shortage was a major challenge that Karnataka's thermal power plants faced in 2012– 18[9]. Issues in coal availability severely affected electricity generation in RTPS, Bellary TPP, and Yermarus TPS during this period (Shreyas, 2018). The coal supplied to RTPS and Bellary 1&2 units in 2018-19 were 12% and 10% lower than the coal supplied in 2012-13 (KPCL, 2013, 2019). The significant increase in RE-based installed capacity and their must-run status also adversely impacted coal-based electricity generation during this period.

Karnataka had also put in efforts to reduce its transmission and distribution losses (T&D). The T&D losses in the state fell from 19.96% in 2011-12 to 16.16% in 2018-19. Major policies

[6] Data from Energy Department, Government of Karnataka
[7] Data from Energy Department, Government of Karnataka
[8] Based on the data shared by Karnataka Renewable Energy Development Ltd.
[9] The coal supplied to RTPS was 7.73 million tonnes in 2012-13 and 6.84 million tonnes in 2018-19. The coal received in 2018-19 also accounts the coal supplied to Yermarus TPS and Bellary TPP.

and programmes to reduce T&D losses were undertaken as part of Ujjwal DISCOM Assurance Yojana (UDAY), Integrated Power Development Scheme (IPDS), Restructured Accelerated Power Development and Reforms Programme (R-APDRP), and Perform, Achieve and Trade (PAT) scheme. The state undertook various activities to reduce T&D losses; these include feeder segregation, distribution-transformer (DT) metering, energy audit (11 kV lines), installation of Device Language Message Specification (DLMS) smart metering (feeder level), and mapping of feeders to DTs and DTs to consumers (DISCOMs, 2020)[10]. Schemes such as Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUJY) and Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) helped to separate agricultural and non-agricultural feeders, electrify villages, and strengthen the transmission infrastructure in rural areas (MoP, 2018a). About INR 59 crore was disbursed in the 12th Five-Year Plan (2012-17) under the DDUGJY scheme for Karnataka (MoP, 2020). In addition, solar-based decentralised electricity generation in the state increased from 0.254 MW in 2011-12 to 7.7 MW in 2018-19 (MoSPI, 2013, 2020). However, ground-level studies conducted by the Center for Study of Science, Technology and Policy revealed discrepancies—owing to data-entry errors—in the DISCOMs' energy-audit process for T&D loss reduction. Also, a majority of distribution transformers were neither metered nor maintained properly in the state (CSTEP, 2019).

5.2.2. Industry

Karnataka is the fifth most industrialised state in the country. The industrial sector grew at CAGR of about 6% between 2004-05 and 2014-15, while contributing about 26% to the state GSDP (PRS, 2018). The major industries include iron and steel, cement, and petroleum refineries. The iron and steel, and cement sectors in the state contribute to nearly 80% of the total energy emissions in the state's industrial sector, while the refineries contribute an additional 9% in 2015 (GHGPI, 2018). The study focusses on these three industries for further analysis.

Karnataka produced about 17 Mt of crude steel in the year 2017-18 accounting to about 16% of the total steel production in India during the same period. The majority of the steel production in the state is based on the Blast Furnace-Basic Oxygen Furnace technology, in addition to production from coal-based sponge iron plants. It also hosts the country's only COREX-based steel production unit in JSW, Vijayanagar. The cement production from the state in 2017-18 totalled about 19Mt, contributing to about 8% of the national cement production. Iron and steel, and cement industries are the major energy-intensive industries in the state, accounting for more than 63% of the total industrial energy demand.

The state's industrial policies from 2009-14 to 2014-19 focus on improving the growth of the sector, with a 12% per annum target (GoK, 2016). The latest policy (2014-19) aims to enhance the contribution of the manufacturing sector to the state GDP, attract investment, etc. However, on energy conservation and emissions mitigation, the state's industrial sector is

[10] Based on discussions with KPTCL

mainly steered by national policies, such as the National Steel Policy (Ministry of Steel, 2017) and the PAT scheme under the National Mission on Enhanced Energy Efficiency.

Under PAT Cycle-I between 2012 and 2015, designated consumers[11] across key industrial sectors reduced their energy consumption by 0.36 million tonne of oil equivalent (MToE) against a target of 0.223 MToE (KREDL, 2018a) (BEE, 2016). As a result, the total reduction in CO_2 emission was 0.5 $MtCO_2e$ in the assessment year 2015-16. Despite achieving its PAT Cycle-I targets, the industrial sector is still one of the highest CO_2 emitters of the state.

5.2.3. Buildings

Karnataka's building sector (residential and commercial) consumed 35% of the state's total power demand in 2015-16 (CEA, 2016). This is slated to rise to 38% by 2026-27. With a growing population and an expanding service sector, the demand for energy is set to increase further, impacting emissions. Bengaluru's commercial floor space alone is expected to increase almost three-fold to reach 300 million sq. feet by 2030, driven by high growth in the services sector (CSTEP, 2014).

The buildings sector comprises the necessary infrastructure for the growth of the state economy, thus making it pertinent to ensure the sector's sustainable development. Buildings offer immediately available, highly cost-effective opportunities to reduce growth in energy demand, while helping meet other key sustainable development goals including poverty alleviation, energy security, and improved employment. Karnataka has in place several policies and programmes that promote energy efficiency in this sector. These policies not only enable the sector to save fuel but, as a result, also help mitigate GHG emissions from the sector.

One of the most important policies adopted by the state is the Energy Conservation Building Code (ECBC), which sets minimum energy performance standards for buildings. ECBC-compliant buildings are expected to consume 30%–40% less energy than conventional buildings. This was notified for adoption in all commercial buildings in November 2014. Twenty-five government buildings have been planned for ECBC compliance; four ECBC-compliant buildings are constructed and are operational. A noteworthy project is the ECBC-compliant Kumara Krupa Government Guest House in Bengaluru. The guest house has a built-up area of around 19,800 sq. m, with an energy performance index[12] (EPI) of 52 kWh/m^2. The state has also implemented the Street Lighting National Programme (SLNP), which aims to replace conventional street lights with efficient LED lights. About 9,882 conventional street lights have been replaced with LEDs by 2018-19.

On the domestic-housing front, Hosa Belaku/ Unnat Jyoti by Affordable LEDs and Appliances for All (UJALA) scheme has been one of the most popular schemes in Karnataka. UJALA scheme is the world's largest zero-subsidy LED-bulb distribution scheme and is

[11] Designated consumers are industrial units for which the government has notified mandatory energy savings targets as part of the PAT scheme under the Energy conservation Act 2001.

[12] Energy performance index (EPI) is total energy consumed in a building over a year divided by the total built-up area.

implemented by the Energy Efficiency Service Limited (EESL). EESL procured LED bulbs in large quantities through competitive bidding using a 'bulk-procurement model'. All of these are distributed via kiosks set up by either DISCOMs in the state. EESL makes the entire upfront investment for ensuring product availability at the outlets, and no upfront capital cost is borne by the DISCOMs/OMCs (barring manpower and space). Apart from LED bulbs, the UJALA scheme distributed LED tube lights and energy-efficient fans as well at a subsidised rate. The appliances are sold to the consumers at INR 70/LED bulb[13], INR 290/LED tube light and INR 1,110/ fan respectively, much below the market price. By June 2020, a total of 2.34 crore LED bulbs have been distributed in the state, against a target of 6 crore (by March 2019), making it a leader amongst the southern states of India. About 4.12 lakh LED tube lights and 72,000 energy-efficient fans were sold within the state through the scheme. As on 31st August 2018, about 0.8% of the LEDs with technical faults sold under this scheme were replaced free of cost by EESL (EESL & MoP, n.d.).

As one out of three urban households and nine out of ten rural households, do not have access to LPG as a primary cooking fuel, the Pradhan Mantri Ujjwala Yojna (PMUY) is also an important scheme in the state (CSTEP, 2014). As of September 2019, 31.5 lakh LPG connections have been sanctioned in the state. The LPG coverage[14] in the state increased from 79.9% to more than 100% from March 2017 to October 2019 (PPAC, 2019).

5.2.4. Agriculture

Agriculture is a major energy-intensive sector in Karnataka, especially for irrigation pumping. Agriculture sector accounts for 39% of the annual electricity consumption of the state (CSTEP, 2018). As of 2018-19, Karnataka had around 29 lakh irrigation pump sets, growing at a CAGR of 5.28% from 2012-13 to 2018-19[15]. In 2012, 98% of pumps were electrified in the state; and the share further increased to 98.2% by 2014 (Karnataka State Directorate of Economics and Statistics, 2012, 2015). The highly subsidised rates of electricity provided to farmers and unmetered connections have created a financial burden— ~25% of the total revenues excluding subsidy—to the government[16]. In particular, Karnataka has seen an upsurge of 86% in the agricultural subsidies— from INR 4,993 crore in FY13 to INR 9,295 crore in FY18. Farmers use inefficient pump sets and rewind old pumps, as the electricity consumed for irrigation is unmetered, leading to more-than-necessary electricity consumption.

Agricultural demand side management (DSM) was taken up by distribution companies such as BESCOM, CESC, and HESCOM on a pilot basis, replacing conventional irrigation pumps with energy-efficient pumps with net energy savings of about 30%. By 2014-15, a total of 2,204 conventional pump sets were replaced in these pilot projects. In addition, the Ganga

[13] A 9W LED bulb sold through UJALA is available at INR 70 compared to INR 140 – INR 200 in the retail market (ICICI Securities, 2017)

[14] LPG coverage is calculated based on number of active connections and estimated households in the state

[15] Data from Energy Department, Government of Karnataka

[16] All pumps up to 10 HP are provided with free electricity

Kalyana Scheme was introduced in 2017, mandating installation of 4- or 5-star rated pump sets to get power supply.

The state government, along with the Ministry of New and Renewable Energy (MNRE), has initiated policies and schemes for installation of solar water pumps. From 2018, the Surya Raitha Scheme has been in effect in the state, aiming to provide solar-powered pump sets to farmers. The solar water-pump systems in Karnataka are installed by the agriculture department and other departments in coordination with KREDL. A total of 2,810 solar-powered pump sets have been installed during 2018-19[17].

The Pradhan Mantri Kisan Urja Suraksha Utthan Mahabhiyan (PM KUSUM), unveiled in 2019, was expanded further in the 2020-21 Budget. The scheme has three nation-wide components: 10,000 MW of decentralised ground-mounted grid-connected renewable power plants, installation of 17.5 lakh stand-alone solar-powered agriculture pumps, and solarisation of 10 lakh grid-connected solar-powered agriculture pumps (MNRE, 2018). The targets and budget for the KUSUM scheme for the state of Karnataka are yet to be announced.

Table 5.2. summarises the existing policies in Karnataka from 2012 to 2018.

Table 5.2: Ongoing major policies/programmes in major energy sub-sectors

Sub-Sector	Major Policies	Major Programmes/Schemes
Power	• Solar Power Policy 2011-16, 2014-21 • Renewable Energy Policy 2009-14, 2016-22 (draft)	• Perform, Achieve and Trade scheme (PAT) • Ujwal DISCOM Assurance Yojana scheme • Restructured Accelerated Power Development and Reforms Programme (R-APDRP) • Integrated Power Development Scheme (IPDS) • Renovation and modernisation (R&M)/Life extension (LE) / Retirement of existing power plants • Renewable Purchase Obligations (RPOs) • National Solar Mission
Transport	• FAME –2015 • Karnataka State EV and Energy Storage Policy • Metro Rail - National Metro Rail Policy	• Incentives for purchase of EVs • Tax rebate for purchase of EVs • Construction of Namma Metro • Improvement in bus fleet in road transport corporations • Implementation of bus rapid transit system
Industry	• Karnataka Industrial Policy 2014-2019 • PAT scheme	• Capital subsidy for practising energy conservation measures - up to INR 7.5 lakh • Capital subsidy for the use of non-conventional energy sources up to INR 15 lakh • Encourage industries with a connected load of above 100 KW to adopt energy audit

[17] Based on data from Energy Department