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A sectoral review of India's energy transition

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Catapult Energy Systems

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1 Background

At the end of 2019 (pre-COVID), India's emissions were comprised of power generation (34%), industry (28%), agriculture (18%), transport (9%), water and waste (6%), and buildings (5%)[1]. This report covers those sectors expected to be a significant strain on India's grid in the future, namely power, the two most greenhouse gas (GHG)-emitting industries of steel and cement, agriculture, transport and cooling. Decarbonising these sectors, whilst also enabling economic development, will be an extremely difficult challenge, but one which is critical to the global effort to limit climate change. Despite this challenge, the Indian Government has announced that India will commit itself to reaching net zero emissions by 2070. At COP26, Prime Minister Modi laid out several goals, which he called 'elixirs', in order to reach this goal:

- Reaching a renewable electricity generation capacity of 500 GW by 2030, compared to around 173 GW by the end of 2022
- Fulfilling 50% of India's energy requirements via renewable energy by 2030[2]
- India will reduce total emissions projected between 2022 and 2030 by one billion tonnes
- A GDP emissions-intensity target of 45% below 2005 levels by 2030[3]

However, during the conference, India, alongside China, Cuba, and others, opposed the use of the phrase 'phase out' with regards to coal power, preferring to use 'phase down'. India's Environment Minister stated:

> *"Developing countries have a right to their fair share of the global carbon budget and are entitled to the responsible use of fossil fuels within this scope... Developing countries still have to deal with their development agendas and*

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[1] https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/decarbonizing%20india%20charting%20a%20pathway%20for%20sustainable%20growth/full-report-decarbonising-india-low-res.pdf

[2] This caused some confusion and it later transpired that he meant that half of installed capacity would be from non-fossil sources

[3] https://pib.gov.in/PressReleasePage.aspx?PRID=1768712

poverty eradication. Towards this end, subsidies provide much needed social security and support."[4]

It is worth noting that these comments were made in the context of over 50% of India's installed electricity generation capacity being made up of coal plants in 2022, with 74% of system demand being met by coal in the same year.

After the COP26 conference ended, these verbal commitments were codified, with slight modifications, in the country's updated Nationally Determined Contribution, dated August 2022. The document states that India hopes to:

- Reduce the emissions intensity of its GDP by 45% by 2030 from the 2005 level
- Reach a non-fossil capacity of 50% of installed power generation capacity by 2030[5]

Changes compared to Modi's speech include:

- The NDC refers to 'non-fossil' installed capacity, not renewable, allowing other sources of low carbon generation, like nuclear, to be counted.
- The specific 500GW target for 2030 renewable capacity has been dropped, although there is still a domestically-held target of 450GW of renewable energy capacity. This is still a 160% increase compared to 2022 levels[6]

Changes compared to India's 2015 NDC are:

- The non-fossil electricity generation capacity target has increased to 50%, up from 40%
- The GDP carbon intensity reduction target has increased to 45% from the 2005 baseline of 33-35%
- The target to create an additional carbon sink of 2.5-3 billion tons of CO_2 equivalent (by increasing tree and forest cover) by 2030 has stayed the same

This is summarised in Table 1.

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[4] https://www.bbc.co.uk/news/science-environme. nt-59269886; https://www.reuters.com/business/cop/coal-trajectory-is-set-whether-its-phase-out-or-phase-down-russell-2021-11-14/

[5] https://unfccc.int/sites/default/files/NDC/2022-08/India%20Updated%20First%20Nationally%20Determined%20Contrib.pdf

[6] https://unfccc.int/files/adaptation/application/pdf/all__parties_indc.pdf

Indicators	Targets for 2030			Progress in 2022
	First NDC (Oct 2015)	Modi's COP26 speech (Nov 2021)	NDC update (Aug 2022)	
Emissions intensity of GDP reduction (compared to 2005)	33-35%	<45%	45%	24% reduction between 2005 and 2016**
CO_2 emission reduction	-	1GtCO_2 per year from 2021 to 2030	-	-
Quantified LULUCF Carbon Sink target	2.5-3 GtCO_2e through additional forest and tree cover by 2030	Not mentioned	As pledged in the first NDC	Compared to the last Forest Survey of 2017, there was an increase of 0.65% or 156 MtCO_2e in 2019
Non-fossil share of electricity generating capacity by 2030, conditional on international finance and technology transfer	40%	"India will meet 50% of its energy requirements from renewable energy by 2030"	"about 50%"	Around 40% of electricity is now non-fossil, and the Indian government considers the target met[7]
Installed capacity of non-fossil energy	-	500 GW non-fossil "energy capacity" by 2030	This was reduced to 450 GW	-

Table 1: India's indicators, targets and progress

These goals provide a foundation, but they lack specific details. Notably, The Climate Action Tracker identifies the following issues:

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[7] https://economictimes.indiatimes.com/industry/renewables/india-achieves-40-non-fossil-capacity-in-november/articleshow/88056037.cms?from=mdr

- **Separate reduction & removal targets** – India's NDC has not provided any information regarding its intention to communicate separate targets for emission reduction and removal.
- **Review process** – India has indicated its plan to establish a review cycle for its net zero and intermediate targets, but no further information.
- **Carbon dioxide removal** – India's NDC does not clarify its stance on the utilisation of carbon dioxide removal. According to media reports, carbon capture technology is being considered as part of its long-term emissions pathway development.
- **Comprehensive planning** – India is yet to communicate a comprehensive plan on how it intends to achieve its net zero target, or publish analysis of emission reduction pathways, measures for reaching net zero, and sector-level (interim) targets. According to media reports, planning for such an emissions pathway is underway[8].

This report will now turn to a sector-by-sector analysis of several major carbon-emitting sectors and explore some of the challenges each sector will face to decarbonise.

[8] https://climateactiontracker.org/countries/india/

2 The power sector

The power sector currently accounts for around 35% of India's total carbon emissions. Between 2011 and 2019, emissions increased from 930 $MtCO_2e$ to 1100 $MtCO_2e$, an annual growth rate (CAGR) of around two percent, roughly half the electricity demand growth in the period[9]. Demand for power is set to rise further as India's population grows at an annual rate of just over 0.8% - with the country's population only starting to plateau after 2050. Furthermore, industry and transport will electrify, increasing per capita annual consumption from the current low levels of around 1,200 kWh[10] – which is only around one-seventh of the OECD average[11].

Most of the emissions in the sector are from coal-based thermal power plants, which currently meet around three-quarters of India's power demand[12]. However, the share of coal generation in the power generation mix peaked in 2015 at 78% and has been declining since[13]. This decline is driven by significant growth in renewables capacity due to increasing cost competitiveness. In 2021, India had the fourth-highest global solar-power capacity and fourth-largest global solar and wind capacity[14]. Government initiatives over the past decade – such as holding reverse auctions, creating solar parks and de-risking evacuation and offtake – have also managed to attract significant investment and enable this shift.

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9 https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/decarbonizing%20india%20charting%20a%20pathway%20for%20sustainable%20growth/full-report-decarbonising-india-low-res.pdf

10 Calculations from both https://ember-climate.org/app/uploads/2022/07/yearly_full_release_long_format-1.csv and https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf both yield around 1,200 kWh per person

11 Calculations from both https://ember-climate.org/app/uploads/2022/07/yearly_full_release_long_format-1.csv and https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf both yield around 8,000 kWh per person

12 https://coal.nic.in/en/major-statistics/generation-of-thermal-power-from-raw-coal

13 https://iea.blob.core.windows.net/assets/1de6d91e-e23f-4e02-b1fb-51fdd6283b22/India_Energy_Outlook_2021.pdf

14 https://www.investindia.gov.in/sector/renewable-energy#:~:text=India%20stands%204th%20globally%20in,Renewables%202022%20Global%20Status%20Report)

However, several barriers to furthering renewables expansion are starting to emerge. For example, India has limited flexible generation capacity compared to many other countries. Already, renewables (RE) integration issues are emerging, leading to solar power curtailment and a slowing down in terms of signing new Power Purchase Agreements. Current market arrangements are somewhat unsuited to RE integration. The wholesale market share is under 10%; there is no ancillary services market; incentives for peak-load plants are currently insufficient; and time-of-use tariffs are limited. As most of this RE capacity is likely to be in the south and west, the country will likely need to increase interconnection capacity. Finally, RE addition must be complemented by a large amount of storage or alternative flexibility mechanisms.

A range of actions could potentially unlock latent demand for renewable energy, including:

- removing barriers to open access (for example, through banking, net metering, inter-state open access and extension of the interstate transmission system charges waiver)
- promoting innovative contracting mechanisms (like virtual PPAs) to enable RE procurement for smaller commercial and industrial customers (less than 100kW)
- reducing the financial impact on electricity distribution companies ("DISCOMs");
- improving the bankability of RE projects; and encouraging DISCOMs to launch green tariffs

However, many public DISCOMs in India are loss-making, leading to increased financial stress on power generators and reluctance to promote open access RE for commercial and industrial (C&I) customers[15]. Improving the financial health of DISCOMs could be a key enabler to attract low-cost capital for the transition. This lack of funds has also had a knock-on effect on RE generators. DISCOMs owed over £8 billion as outstanding amounts at the end of January 2020 to various generators, including RE generators. When DISCOMs face cash flow issues, this results in RE producers also facing a liquidity crisis. As such, public sector banks are hesitant to grant loans to RE projects, and private sector banks are not always forthcoming with loans. Additionally, the interest rate of existing loans to RE companies has witnessed a rise due to this risk. Industry specialists have also pointed to the difficulties of

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[15] Under open access arrangements C&I customers can contract directly with RE developers/generators (also known as "offsite renewable energy private power purchase agreement (PPA) market") at negotiated prices. Typically C&I customers gain from negotiating lower energy prices (and avoiding price increases from DISCOMs which often seek to cross-subsidise household tariffs) even though such open access sales are usually subject to a levy set by state regulators to compensate DISCOMs for loss of high-value customers. https://www.pwc.in/assets/pdfs/publications/2015/renewable-energys-transformation.pdf

raising funds from federally owned financial institutions, such as the Indian Renewable Energy Development Agency Limited (IREDA) and the Power Finance Corporation (PFC), as well as the challenges of accessing foreign funds [16].

Overall, despite encouraging signs of growth in renewable energy in recent years, the Indian power sector faces major challenges in navigating a long-term pathway to a lower carbon future. The financial sustainability of DISCOMs remain a challenge, partly reflecting substantial problems around losses and power theft. This inhibits the development of a stable market and policy framework to shape investment in a cost-efficient transition away from its still substantial reliance on coal generation. Reform of wholesale electricity markets at national level remains in its infancy – and this will be key in shaping an improved economic framework to shape power sector decarbonisation and the efficient integration of new renewable resources[17].

[16]https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/decarbonizing%20india%20charting%20a%20pathway%20for%20sustainable%20growth/full-report-decarbonising-india-low-res.pdf; https://www.teriin.org/article/indias-energy-transition-challenge-decision-making-time-rapid-change

[17] https://www.prnewswire.com/in/news-releases/indias-proposed-market-based-economic-dispatch-mechanism-aims-to-optimize-power-sector-resources-rmi-301759778.html

3 Buildings

The frequency of severe heat waves has increased over the last few decades in India, leading to thousands of deaths across the country. The country is experiencing higher temperatures that arrive earlier in the year and last far longer. In August 2021, the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) warned that the Indian subcontinent would suffer more frequent and intense heat waves over the coming decade[18]. The G20 Climate Risk Atlas also warned in 2021 that heat waves across India were likely to last 25 times longer by 2036-65 if carbon emissions remain high, as in the IPCC's worst case emission scenario[19]. In fact, in a 2021 study by the Lancet Planetary Health Journal, researchers found that nearly 740,000 excess deaths in India annually can be attributed to abnormal temperatures related to climate change, with 84,000 being specifically attributable to heat[20].

Moreover, up to 75% of India's workforce, or 380 million people, depend on heat-exposed labour, at times working in potentially life-threatening temperatures. With heat-exposed work contributing to nearly half of the country's Gross Domestic Product (GDP), the country is extremely vulnerable to job losses associated with heat stress. By 2030, India may account for 34 million of the projected 80 million global job losses from heat stress associated productivity decline[21]. In December 2021, a Nature study found that India showed the largest heat exposure impacts on heavy labour among South Asian countries, with more than 101 billion hours lost a year[22]. Analysis by McKinsey shows that lost labour from rising heat and humidity could put up to 4.5% of India's GDP – approximately US$150-250 billion – at risk by the end of this decade[23].

As such, the need for cooling will dramatically increase over the next few decades. Currently, only 8% of Indian households possess an air conditioning unit. This demand is set to grow eleven-fold by 2037, with growth rates of over 15-20% annually[24]. By 2050, space cooling could drive almost 28% of India's total energy

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[18] https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf
[19] https://www.g20climaterisks.org/india/
[20] https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(21)00081-4/fulltext
[21] https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_711919.pdf
[22] https://www.nature.com/articles/s41467-021-27328-y
[23] https://www.mckinsey.com/capabilities/sustainability/our-insights/will-india-get-too-hot-to-work
[24] http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf

consumption and 45% of its peak electricity load[25]. Even by 2027, both energy consumption and carbon emissions from space cooling could double compared to 2017 levels[26]. This sort of growth will put significant pressure on the grid, requiring sizable investments in creating costly peak generating capacity and as such, could also result in a significant increase in GHG emissions. Suitable low-energy alternatives must be found to meet India's cooling needs.

In addition, over the next two decades, India will experience significant growth in residential and commercial floor space. With 10 million new homes required to be built annually to keep up with demand, an opportunity exists to introduce natural cooling techniques into new construction. Integrating passive cooling strategies into buildings could achieve a 20-30% reduction in projected energy use by 2038[27]. This has significant potential to improve thermal comfort, especially for poorer communities with limited access to space cooling technologies.

According to the World Bank, already extant efficient cooling technologies have the potential to achieve 30% energy savings from projected demand by 2038[28]. Robust efficiency standards and market initiatives that address higher up-front costs, especially for high impact cooling technologies such as ceiling fans, room air-conditioners and chillers can support the transition to best available technologies sooner. In areas with significant cooling demand, shifting to highly efficient District Cooling Systems (DCS) would offer the best energy savings potential. Thirty percent of the commercial space cooling demand in 2038 can potentially be met through DCS, if viable business and implementation models are established in the Indian context. Cooling as a Service could be a major way to make this happen[29].

As well as cooling, a major source of energy demand is cooking and water heating, often provided by fossil fuels such as LPG (cylinder gas). These two activities make up about a quarter of urban residential energy consumption, and most of rural energy consumption. Incentives and public awareness campaigns will be required to allow for the uptake of low-carbon alternatives, which would otherwise be unaffordable

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[25] https://openknowledge.worldbank.org/bitstream/handle/10986/38340/P15743300f4cc10380b9f6051f8e7ed1147.pdf?sequence=5&isAllowed=y

[26] https://openknowledge.worldbank.org/bitstream/handle/10986/38340/P15743300f4cc10380b9f6051f8e7ed1147.pdf?sequence=5&isAllowed=y

[27] https://openknowledge.worldbank.org/bitstream/handle/10986/38340/P15743300f4cc10380b9f6051f8e7ed1147.pdf?sequence=5&isAllowed=y

[28] https://openknowledge.worldbank.org/server/api/core/bitstreams/9314e3a6-25e7-59f4-9bfd-67eb1b6b1650/content

[29] https://eeslindia.org/wp-content/uploads/2021/03/Final-Report_National-District-Cooling-Potential-Study-for-India.pdf

and hard to access. These include plug-in induction stoves, solar water heaters, and heat pump water heaters. In the longer-term future, low-carbon hydrogen and biofuels could be a viable option, although the applications and limitations of both fuels must first be examined and understood well[30].

[30] https://rmi.org/insight/whole-system-approach-to-decarbonize-indias-buildings/

4 Agriculture

The agricultural sector is a bedrock of the Indian economy, contributing 14% of the country's GDP and providing over 40% of its employment. It is also very vulnerable to climate change, as 60% of agricultural land in India is rain-fed. Furthermore, the sector accounts for nearly 20% (585 $MtCO_2e$) of India's emissions. Around 77% of these agricultural emissions come from rice farming (22%) and livestock (55%). India is the second-largest rice producer in the world, and over 80% of its rice fields are estimated to practice continuous flooding - resulting in high methane emissions. More than 70% of India's total methane emissions are driven by enteric fermentation in livestock and the standing water from rice cultivation. Over-application of nitrogen-based fertilisers is also a major issue, contributing to around 70 $MtCO_2e$ of emissions in 2019 (12% of agricultural emissions in the same year). India comprises around a quarter of global over-applied nitrogen volumes, second only to China. The country applies fertiliser at over 110kg/ha/year, more than double the European Union average of 52kg/ha/year[31].

Food demand is expected to increase by two or three percent per annum until 2070, with rice production expected to increase from around 170 Mt in 2020 to 320 Mt by 2050 and 360 Mt by 2070, and meat production expected to grow from 3 to 7 Mt by 2070, with exports continuing to drive production[32]. In the absence of abatement efforts, this ongoing demand will lead to a continued increase in emissions.

However, agricultural emissions are extremely difficult to abate because this depends on engaging with 150 million farmers, over 95% of whom are smallholder farmers (owning less than five hectares of land).

A number of actions could help decarbonise the sector. Analysis by McKinsey suggests that annual carbon abatement of 292 $MtCO_2e$ - or nearly half of all expected annual emissions from agriculture – by 2050 is possible. This would mainly be driven by cultivating rice sustainably (20% of abatement), reducing nitrate fertilisers (16%) and shifting towards sustainable consumer alternatives such as plant-based protein (15%) and millets (7%).

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[31] https://www.mckinsey.com/capabilities/sustainability/our-insights/decarbonising-india-charting-a-pathway-for-sustainable-growth

[32] https://www.mckinsey.com/capabilities/sustainability/our-insights/decarbonising-india-charting-a-pathway-for-sustainable-growth

Reducing paddy farming emissions could be done by practicing rice-straw upcycling, dry seeding and rice intensification (SRI). Reducing livestock emissions could be done by adopting efficient feeding and manure management practices, such as improving feed digestibility and adding additives to ruminant diets. Total electrification of tractors and irrigation pumps could abate all emissions from agricultural energy use. The cost savings from fuel and the declining expenditure on EVs could offset the costs. Introducing slow-release fertiliser forms and nitrification inhibitors would reduce fertiliser-induced field emissions and fertiliser consumption, subsequently reducing emissions from its production and transportation.

Switching to lower emissions farming would require extensive education, access and incentives given the mostly non-intensive make-up of Indian agriculture, and the poverty experienced by many smallholder farmers. Education will be crucial in creating awareness of the downsides of conventional practices, such as the deterioration of soil health caused by excessive fertiliser use. Setting up carbon markets for farmers could also be a crucial enabler for encouraging uptake of sustainable agricultural techniques and securing buy-in from farmers by allowing them to financially benefit. Funding schemes will be required to allow the initial uptake of more environmentally friendly fertilisers and higher quality feed for livestock. Since 85% of rural women in India are engaged in agriculture, there is also potential for cross-cutting gender-based action[33].

In rural areas across India, biomass burning is ubiquitous[34] (estimated at over 90% in some areas) for heat and cooking, comprising use of agricultural residues, dung and wood fuel. This has a significant impact on emissions, as well as air quality. A transition away from biomass burning is often seen via conversion to liquid petroleum gas, which while cleaner in terms of indoor air quality, is still a fossil fuel. Therefore the energy transition in rural areas may involve a mix of approaches to reduce biomass burning, to increase the use of agricultural residues for farm nutrients, to maintain soil quality and to reduce the reliance on synthetic fertilisers. There are still major challenges to be resolved in determining the pathway to

[33] https://www.financialexpress.com/opinion/decarbonising-indian-agriculture-chunk-of-capital-needed-for-sustainable-agri-pathways-can-come-from-repurposing-existing-subsidies/2475424/; https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/decarbonizing%20india%20charting%20a%20pathway%20for%20sustainable%20growth/full-report-decarbonising-india-low-res.pdf?shouldIndex=false; https://sustainabilitymag.com/articles/upl-on-role-of-agriculture-in-decarbonisation-strategies

[34] https://www.cfr.org/blog/matter-particular-concern-indias-transition-biomass-burning

substantially reduced agricultural emissions and in how to promote sustainable fuels and nutrient cycling in rural areas.

5 Iron and steel

India is the second largest producer of steel in the world after China, and whilst Chinese demand is set to contract in coming years, India's is set to explode. The size of the country's steelmaking industry is projected to nearly double by 2030 and almost quadruple by 2050, relative to 2019 production levels. Indeed, it has already grown over fourfold since 2010. Steel will be essential to all of India's economic growth areas – whether it be infrastructure, housing, or others. Currently, steel is mostly consumed by the construction industry (35% of current total steel consumption), infrastructure development (20%) and the automotive industry (12%).

The iron and steel sector is already the largest single contributor to both industrial energy demand and industrial emissions, with a strong reliance on coal (85% of energy inputs). Currently, the steel industry has a final energy demand of around 70 million tonnes of oil equivalent (Mtoe), representing approximately 23% of total energy demand by the industrial sector.

There is a similar story when it comes to carbon emissions. The Indian iron and steel sector is highly carbon intensive, contributing around a third of India's direct industrial carbon dioxide emissions (emitting around 250 Mt CO_2 in 2019). Of these direct emissions, around 90% come from coal. Many of the remaining direct emissions are process emissions resulting from the use of lime fluxes and ferroalloy production, with only small contributions from gas and oil consumption. Further indirect emissions come from the consumption of electricity (10% of the energy used in the sector is electricity). Most electricity in India is generated from coal, resulting in large indirect emissions attributable to the iron and steel sector. In total, the iron and steel sector makes up around 10% of the country's total energy system carbon dioxide emissions.

India's steel industry is much more energy- and emissions-intensive than in many other countries, due to the presence of many small production facilities. Steel production in these smaller facilities relies heavily on coal-based direct reduction, which carries a very high carbon dioxide intensity. Many of these smaller blast furnace facilities are relatively old – around twenty-five years since installation, on average – and consume more energy per unit of output as a result. The wide-spread availability of coal reserves, lack of natural gas reserves, and the low quality of domestic coal and iron ore are also contributing factors to the sector's high emissions. Furthermore, there is a low proportion of scrap in total metallic input compared to the global standard (23% vs 32%), in part due to a lack of high-quality scrap.

Larger facilities and producers use blast furnace-basic oxygen furnace (BF-BOF) facilities, which are slightly less emissions-intensive than the smaller local direct reduced iron (DRI) facilities, but they are still very coal-intensive. A major issue is that most steel capacity planned in the country is BF-BOF, as opposed to the less polluting electric arc furnaces (EAFs). This is because:

- Large-scale production capacity of BF-BOF: In order to increase production beyond a certain level, it is important that the technology being adopted enables large-scale production. BF-BOF is the only existing technology in India that has been proven to produce steel at the required scale. The EAF technology experimented with in India has, to date, a much lower production capacity compared to BF-BOF.
- Poor quality and non-availability of scrap: EAF technologies are dependent on scrap as a raw material but the availability of scrap is currently an issue in the country. Even the scrap available is often poor quality, which can result in poor quality steel production, especially in induction furnaces. This has forced EAF plants to use direct reduced iron or sponge iron in combination with steel scrap, which of course increases the emissions associated with the process.
- Non-availability and high prices of natural gas: Natural gas pipelines are not available in many parts of the country where steel plants are located. The high price of natural gas is another reason that makes it an option that is not pursued.

There are also many other issues that India will face in decarbonising its steel industry. India's production fleet is not particularly old, with an average age of 12 years for its gas-based DRI furnaces, 14 years for its coal-based blast furnaces and 17 years for its coal-based DRI furnaces (all figures take into account the year of last major refurbishment). As such, the steel-producing fleet in India is around a third of the way through its typical lifetime, which is around 40 years on average for assets of this type. There will be no major wave of retirements in the near or even mid-term future that will allow carbon intensive plants to be replaced. Even excluding additional plants built through to 2030, cumulative emissions of around 6 Gt of carbon dioxide can be expected from the existing capacity if nothing is done to address these assets.

Furthermore, many of the low-emission steel-making technologies that will be relied upon to deliver deep emission reductions in the future will not be sufficiently developed in time to provide the next 10-15 years of capacity additions. In the next ten years, India is projected to bring online 40% of the steelmaking capacity that will still be operating in 2050. This massively complicates the question of how to deal with existing emissions-intensive infrastructure, both now and with respect to facilities installed over the next decade. It also means that investments in less carbon intensive technologies need to be made as soon as possible.

Moreover, India's very rapid growth trajectory means that increases in the domestic supply of scrap will be insufficient to meet all the growth in steel demand. Scrap availability could well grow considerably – perhaps by around 120 Mt by 2050 – but this is far less than the more than 310 Mt growth in steel production. The remainder that cannot be met by scrap-based production will need to be met by primary production. This contrasts with China, where increasing scrap availability and declining steel production enable a greater reliance on less emissions-intensive secondary production in order to reduce emissions.

To resolve this, the National Resource Efficiency Policy 2019, an initiative of the Indian Ministry of Environment, Forest and Climate Change, aims to enhance resource efficiency and promote the use of secondary (i.e. recycled) raw materials, including in the steel sector. The suggested interventions to increase domestic resource efficiency in the steel sector include incentives to invest in steel recycling technologies and joint ventures between scrap trading and steel companies (to reduce procurement costs), together with the imposition of an import duty on scrap imports above a certain threshold (to promote domestic scrap collection). The most ambitious targets of this policy include the goal to eliminate scrap imports by 2030 (they are at 20-25% today), increase the steel recycling rate to 90% and increase the slag utilisation rate to 50% by 2025 and 85% by 2030[35].

[35] https://www.energy-transitions.org/wp-content/uploads/2022/08/Achieving_Green_Steel_Roadmap-2.pdf; https://www.cseindia.org/content/downloadreports/11434; https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/decarbonizing%20india%20charting%20a%20pathway%20for%20sustainable%20growth/full-report-decarbonising-india-low-res.pdf?shouldIndex=false

6 Cement

Cement accounts for about 5% of India's current emissions (156 MtCO_2e in 2019) and is among the hardest sectors to abate, since two-thirds of the carbon emissions derive from the separation of carbon dioxide from limestone, whilst only a third are from the use of fossil fuels. Without any proactive initiatives, emissions will likely grow by more than 2.1% per annum, leading to annual emissions of 431 MtCO_2e by 2070 (nearly three times the 2019 level). Moreover, an additional annual 93 MtCO_2e could be emitted due to higher clinker use driven by a diminishing supply of fly ash and slag from the coal-based power plants and steel sectors, increasing total emissions to 524 MtCO_2e by 2070.

Considering the Indian cement sector performs better than global sector averages on clinker ratios (65% vs 70% globally) and is also more energy efficient (due to the younger age of Indian cement plants), traditional levers alone will not be sufficient to decarbonise fully. Alternative ideas include:

- Adopting green fuels such as biomass to replace fossil fuels like coal and petroleum coke. Alternative fuels, such as carbon-neutral biomass and RDF (refuse-derived fuel), could supply 40% of the heat demand for cement kilns by 2070, up from the current 3%. For example, Indian plants could use crop residue biomass from up to 50 kilometres around cement plants and utilise RDF from surrounding towns and cities. This could lead to an annual reduction in energy emissions from the sector of 52 MtCO_2e by 2070.
- Maintaining the clinker-to-cement ratio at the current level of 65% by sourcing alternatives to fly ash and slag, like pozzolan and calcined clay. The industry may need to explore multiple options for clinker substitutes to meet the gap created by curtailed fly ash and slag supplies. This would also help maintain cement production costs, since clinker manufacturing is usually more expensive than clinker substitutes.
- Lower carbon cement production is supported by state governments providing expedited environmental clearance to construction projects with green building certifications. Furthermore, capital can be raised at better interest rates for construction projects with lower emissions. As a result, there has been a 37% increase in green certified buildings in the past five years. Sustainable design, use of recycled raw materials and lean designs are some of the criteria included in these certifications. In India, demand for cement could be about 15% lower in 2050 (21% in 2070) versus a business-as-usual scenario if innovative construction methods, such as lean design, are adopted.

- Reducing the clinker-to-cement ratio to 60% by 2070 versus its current levels of 65% could reduce emissions by 22 $MtCO_2e$ per annum. A faster adoption of clinker substitutes could potentially save up to $15/tonne cement and thus add value to a growing green cement opportunity.
- Accelerating the adoption of recycled concrete paste through improved circularity of construction and demolition (C&D) waste could achieve up to a 20% reduction in the clinker-to-cement ratio.
- Increasing the use of alternative fuels could potentially replace fossil fuels in cement kilns and help reduce emissions by 45 to 50 $MtCO_2e$ per annum by 2050 (with reduction continuing at a similar pace thereafter till 2070). The alternative fuels could include carbon-neutral green fuels, such as agricultural waste, crop residue and bagasse, to meet 70% of heat demand. Between 45 Mt and 50 Mt of crop residue annually may be needed by 2070 to meet this demand and would likely require collection of crop residue from farmers up to 100 km away. RDF from municipal solid waste, as well as plastic, tyre and other waste material could also be used. About 30–40 Mt of RDF may be needed annually by 2070. Other potential fuels that could be used as green fuels for cement kilns including green hydrogen and others which are at a nascent stage of development.
- Adopting new CCUS technologies may be necessary for capturing 65% of the remaining emissions and abating about 160 $MtCO_2e$ per annum by 2070. However, this would require extensive investment in carbon capture set ups at cement plants, as well as in the utilisation, transportation and storage of the captured carbon. There are several proven carbon capture technologies available that can mitigate between 70% to 90% of direct emissions from cement production. However, the current cost of abatement is about 100 USD/tCO2 (nearly 50% more than the steel sector). Market entry in India is expected by 2035-2040, by when the cost of abatement is expected to fall to 60 USD/tCO2, but this could be accelerated with policy, regulations and investments (including international development finance) in pipeline infrastructure for carbon dioxide transportation, and exploration for new storage potential. Part of the captured carbon could be utilised in the cement industry for carbon cured concrete, artificial limestone and other applications.

Policy enablers for the cement transition could include:

- Blending mandates for recycled concrete as clinker substitutes of up to 20% by weight of cement, or the mandated use of bio-ash as a clinker substitute.
- Green fuels prioritisation policy, which could help prioritise crop-residue use as biomass for cement kilns (and other applications) and avoid crop residue burning as a result.

- Demand signals for green cement such as carbon pricing, carbon emissions trading and green building certifications. This could be especially useful for high-cost decarbonisation levers like CCUS and could incentivise investments.
- Construction and demolition waste management policy enforcement, which, in addition to blending mandates, could drive recycling in cement.
- Investment in research will be needed to develop and scale up CCUS. A CCUS hub model, with policy and investment support, could also enable a cost-efficient route for transportation and storage (further detailed in the CCUS section)[36].

[36] https://www.weforum.org/agenda/2022/12/here-s-how-india-cement-net-zero/; https://www.climatepolicyinitiative.org/blog-the-path-to-decarbonizing-indias-steel-and-cement-industry/; https://www.ifc.org/wps/wcm/connect/0bd665ef-4497-4d6d-9809-9724888585d2/india-cement-carbon-emissions-reduction.pdf?MOD=AJPERES&CVID=jWEGLpL; https://www.teriin.org/sites/default/files/files/low-carbon-pathway-iki-report.pdf; https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/decarbonizing%20india%20charting%20a%20pathway%20for%20sustainable%20growth/full-report-decarbonising-india-low-res.pdf?shouldIndex=false

7 Transport

Transport is a key contributor to carbon dioxide (CO2) emissions in India, making up 14% of energy-related direct CO_2 emissions. Within the transport sector, road transport is responsible for 90% of total energy consumption. This sector will see massive growth in the next few decades, with most business-as-usual (BAU) models showing that vehicle activity will increase 3 to 3.5 times between 2020 and 2050. Most models also show two-wheelers and passenger cars contributing to around 65% of vehicle activity both in 2020 and 2050, which implies huge dependence on personal vehicles. CO_2 emissions would likely quadruple by mid-century in the BAU scenarios.

Of course in India, as elsewhere globally, the problem is the high purchase cost of EVs, although the Indian government has put in place ambitious plans and policies to accelerate the electrification of transport. One development at COP26 was India signing the 100% EV declaration, with a specific focus on two and three-wheeler vehicles. The government is working on plans to require all two-wheelers to be electric by 2026, much sooner than the COP26 timeline. Two and three-wheelers are the fastest-growing mode of transport in the country by sales.

In 2012, the Department of Heavy Industry launched the National Mission for Electric Mobility (NMEM). Its aim was to promote domestic manufacturing and build the necessary conditions for widespread adoption of plug-in hybrid and electric vehicles (PiVs). The initiative set a target of total PiV sales of 6-7 million units by 2020. The plan suggested the following proposals to achieve the below goals:

- Create demand for PiVs by making these mandatory in government fleet and public transportation, and by offering incentives of reduced price and tax exemptions to buyers of various types of vehicles.
- Strengthen the PiV manufacturing ecosystem in the country by offering tax exemptions to domestic manufacturers, thus reducing dependence on imported oil and PiV parts.
- Support PiV research and development (R&D), including international collaboration for designing cost-effective solutions, and lowering vehicle costs.
- Augment existing infrastructure of power generation and transmission. This will include the set up of EV charging stations in public places, workplaces, bus depots, and homes, in partnership with the private sector.
- Inform the public about the benefits of PiV technologies.

To build on the NMEM, the 'Faster Adoption and Manufacturing of Electric Vehicles in India (FAME)' scheme was rolled out, beginning in 2015. It consists of two phases, 2015-2019, and 2019-2024. The first phase was to be implemented through four focus areas:

- Demand creation
- Technology platform
- Pilot projects
- Charging infrastructure.

Phase 1 aimed to create a market through demand incentives for several vehicle types like two-wheelers, three-wheelers, passenger four-wheeler vehicles, light commercial vehicles and buses. As per the scheme, depending on technology, battery operated scooters and motorcycles were eligible for incentives ranging between Rs 1,800 and Rs 29,000, three-wheelers for incentives in the range of Rs 3,300 and Rs 61,000. In the four-wheeler segment, the incentives range from Rs 13,000 to Rs 138,000; in light commercial vehicles it is from Rs 17,000 to Rs 187,000, and for buses, it is from Rs 34,000 to Rs 66,000.

Under Phase 1:

- 280,000 PiVs were supported with incentives totalling approximately INR 3.6 billion.
- 425 electric and hybrid buses were deployed across the country with incentives of about INR 2.8 billion.
- 520 charging stations were commissioned, costing INR 430 million.

Phase 2 of the scheme began in 2019 and overwhelmingly focuses on shared and public transport.

Phase 2 aims to support 7,090 eBuses, 500,000 e-3 wheelers, 55,000 e-4 wheeler passenger cars and 1 million EV two-wheelers.

In addition, the Government aims to support the establishment of 2,700 charging stations. The Ministry of Power aims to ensure that there is at least one charging station available in a 3 km^2 grid, and that the electricity tariffs paid by EV owners and charging station operators are affordable. The Government aims to cover highways as well and establish charging stations on both sides of the road with a gap of 25km between two consecutive stations.

On June 11, 2021, the Ministry of Heavy Industry announced further amendments to the FAME II scheme, by increasing the subsidy per Indian-made electric two-wheeler, which is linked to the battery size, to INR 15,000 (US$204.60) per Kilowatt-hour (KWh) from INR 10,000 (US$136.40) KWh. The scheme was extended by two years, to March 31 2024. As of February 2022 the second phase has supported:

- Around 469,000 PiVs with around INR 18.7 billion
- 6,315 e-buses sanctioned to 65 cities/STUs/CTUs/state government entities for intracity and intercity operations across 26 states
- 2,877 charging stations sanctioned in 68 cities across 25 states
- 50 Original Equipment Manufacturers (OEMs), both start-up and established manufacturers, have registered and revalidated their 106 electric vehicle models for eligibility[37].

On a state/sub-national level, policies include:

State	Key policy targets
Jharkhand ***Jharkhand Electric Vehicle (EV) Policy 2022***	• The first 10,000 purchasers of electric vehicles made in the state will receive a discount of 100%, the next 10,000 to 15,000 purchasers will receive a discount of 75%, and the final purchasers will receive a discount of 25%. • Purchasers of brand-new electric scooters or bikes will receive a rebate of up to Rs 10,000, of up to Rs 30,000 for an electric car and of up to Rs 2,000,000 for an electric bus. • Proposes the installation of at least one charging station in a 3km-by-3km grid or a minimum of 50 charging stations per 1 million people. On National Highways, charging stations will be constructed every 25 kilometres. • A 50–60% subsidy has also been earmarked for the costs of establishing EV charging stations in the state. The state government will also provide subsidies ranging from Rs 20 million crore to Rs 300 million for setting up EV manufacturing plants in Jharkhand.

[37] https://www.orfonline.org/research/electric-vehicles-in-india-filling-the-gaps-in-awareness-and-policy/; https://www.iea.org/policies/12517-faster-adoption-and-manufacturing-of-hybrid-and-electric-vehicles-fame-scheme-phase-i-ii; https://static.pib.gov.in/WriteReadData/specificdocs/documents/2022/jul/doc202271169601.pdf; https://pib.gov.in/newsite/PrintRelease.aspx?relid=191377; https://timesofindia.indiatimes.com/blogs/voices/fame-india-phase-ii-scheme-has-boosted-ev-oems-for-faster-adoption/; https://www.team-bhp.com/forum/attachments/electric-cars/2339968d1659178296-ev-sales-india-cross-9-million-units-2027-electrifying-indian-mobility_ey-ivca-induslaw.pdf; https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/decarbonizing%20india%20charting%20a%20pathway%20for%20sustainable%20growth/full-report-decarbonising-india-low-res.pdf?shouldIndex=false

Maharashtra ***Maharashtra Electric Vehicle Policy, 2021***	• Issued in July 2021. Valid till March 31 2025. • Budget outlay of INR 9.3 billion (US$124.97 million). • Achieve 10% share of EVs in all new vehicle registrations by 2025. • Attain 25% electrification of public transportation and last mile delivery vehicles in the five targeted urban agglomerations of Greater Mumbai, Pune, Nashik, Nagpur and Aurangabad by 2025. • Several purchase incentives across all segments of EVs, including e-buses. • Incentives for battery recycling. • Set up at least one Gigafactory for manufacturing of Advanced Chemistry Cell (ACC) batteries in the state. • Establish charging infrastructure across the state as well as connecting highways. Incentives for setting up charging stations.
Odisha ***Odisha Electric Vehicle Policy, 2021***	• Issued in August 2021. Valid for five years. • Achieve adoption of 20% EVs in all vehicle registrations in the state by 2025. The focus segments are two-wheelers, three-wheelers, four-wheelers, and electric buses. • Waivers on road tax and registration fees during policy period. • Incentives for EV and component manufacturing, including batteries. • Additional incentives for setting up both public and private charging infrastructure. • Additional SOPs for lithium ion battery manufacturing.

Assam
 	
Assam Electric Vehicle Policy, 2021
	• Issued in September 2021. Valid for five years.
	• Achieve 25% penetration of EVs in the total number of vehicle registrations in Assam.
	• Support deployment of 200,000 EVs over the next five years:
	    o Two-wheeler EVs – 100,000 units
	    o Three-wheeler EVs – 75,000 units
	    o Four-wheeler EVs – 25,000 units
	• Offer incentives for EV and component manufacturing.
	• Focus on recycling policy for batteries.

Gujarat
 	
Gujarat State Electric Vehicle Policy, 2021
	• Issued in June 2021. Valid until 2025.
	• Budget outlay of INR 8.7 billion (US$116.90 million)
	• Support deployment of 2,00,000 EVs over next four years:
	    o Two-wheelers EVs – 1,10,000 units
	    o Three-wheelers EVs – 70,000 units
	    o Four-wheeler EVs – 20,000 units

	• The incentives on EVs will be based on battery capacity, available up to INR 10,000 (US$134.40)/kwh. • All EVs will be exempt from payment of registration fees. • Policy incentives for boosting the charging infrastructure in the state.
Rajasthan ***Rajasthan Electric Vehicle Policy, 2021***	• Issued in July 2021. Valid until March 31 2022. • All EVs purchased before March 2022 will be eligible for State Goods and Services Tax (SGST) refund. • Additional purchase incentive for electric two-wheelers and three-wheelers.
West Bengal ***West Bengal Electric Vehicle Policy, 2021***	• Issued on June 3 2021. Valid for five years since notification. • Goal of one million EVs in the state across all segments during the policy implementation period. • Goal of establishing 100,000 public/semi-public charging stations in the next five years. • Achieve EV/Public charge point ratio of eight. • Recycling and reusing old batteries and discarding unusable batteries in an environmentally-friendly manner. • Establishment of "EV Accelerator Cell". • Facilitate public charging infrastructure for EVs through DISCOMs.
Meghalaya ***Meghalaya Electric Vehicle Policy, 2021***	• Issued in March 2021. Valid for period of five years since notification. • Seeks adoption of at least 15% EVs in the state in next five years by offering incentives. • Facilitate adoption of 20,000 EVs during the policy implementation period. • All types of EVs purchased during policy period shall be exempt from payment of registration fees and road tax. • Purchase subsidy of INR 10,000 (US$134.40)/kwh for the first 3,500 electric two-wheelers priced below INR 150,000 (US$2016.06). • Purchase subsidy of INR 4,000 (US$53.76)/kwh for first 200 electric three-wheelers priced below INR 500,000 (US$6720.20). • Purchase subsidy of INR4,000 (US$53.76)/kwh for the first 30 hybrid four-wheelers priced below INR 1.5 million (US$20,160). • Boost charging infrastructure by encouraging private investment. • Encourage reuse and recycling of batteries.
Andhra Pradesh	• Goal of one million EVs by 2024.

Electric Mobility Policy (2018-23)	• Goal of 100,000 slow and fast EV charging stations by 2024. • Government plans to stop registration of petrol and diesel cars by 2024 in the upcoming capital city of Amaravati. • All government vehicles, including corporations, boards, and government ambulances to be electric by 2024.
NCT of Delhi ***Delhi Electric Vehicles Policy, 2020***	• Aims to have at least 50% e-buses for all new stage carriage buses procured for the city fleet, starting with 1,000 e-buses by 2020. • Aims for 25% of new vehicle registrations to be electric by 2024. • A purchase incentive of INR 5,000 (US$68) per kWh of battery capacity provided for two-wheelers and subject to a maximum incentive of INR 30,000 (US$409) per vehicle. • Incentive for scrapping and de-registering old highly-polluting two-wheelers. • A purchase incentive of INR 10,000 (US$136) per kWh of battery capacity provided for electric four-wheelers (cars) (subject to a maximum incentive of INR 150,000 (US$2,039) per vehicle) for the first 1,000 e-cars registered in New Delhi after issuance of the policy. • Purchase incentive of INR 30,000 (US$409) per vehicle to owners of e-autos, e-rickshaws, and e-carts.
Karnataka ***Electric Vehicles and Energy Storage Policy, 2017***	• 100% of three- and four-wheelers moving goods will be encouraged to transition to electric by 2030. • Local public transport bus fleets to introduce 1,000 EV buses. • Aim to set up 112 EV charging stations in Bengaluru. • Focus on venture capital fund for e-mobility start-ups and creation of secondary market for batteries. • Incentives such as interest free loans on net SGST for EV manufacturing enterprises.
Kerala ***Electric Vehicle Policy, 2019***	• Target of bringing one million EVs to the state by 2022 and 6,000 e-buses in public transport by 2025. • Viability gap funding for e-buses and government fleet. • Incentives such as tax breaks, road tax exemptions, toll charge exemption, free permits for fleet drivers and free parking. • Priority to EV component manufacturing.
Telangana	• 100% exemption of road tax and registration fee for the initial electric vehicles purchases. • EV sales target to achieve 80% two- and three-wheelers (motorcycles, scooters, auto-rickshaws), 70% commercial

Electric Vehicle and Energy Storage Solution Policy, 2020	cars (ride-hailing companies, such as Ola and Uber), 40% buses, 30% private cars, 15% electrification of all vehicles by 2025. • Job creation for 20,000 workers by 2025 through EVs in shared mobility, EV manufacturing, and charging infrastructure development.
Uttar Pradesh ***Electric Vehicles Manufacturing and Mobility Policy, 2019***	• Rolling out 1 million EVs combined across all segments by 2024. • Goal of 1,000 electric buses deployed in the state by 2030. • Target of achieving 70% electrification of public transportation by 2030 on identified green routes in 10 identified EV cities (Noida, Ghaziabad, Meerut, Mathura, Agra, Kanpur, Lucknow, Allahabad, Gorakhpur, and Varanasi). • Set up around 0.2 million slow and fast charging and swapping stations by 2024. • Establishes single-window system in place for all approvals required for EV and battery manufacturing units.
Madhya Pradesh ***Madhya Pradesh Electric Vehicle Policy, 2019***	• Rapid EV adoption and contribution to 25% of all new public transport vehicle registrations by 2026. • Some cities will stop registering new internal combustion engine (ICE) autos. • Enable faster adoption by ensuring safe, affordable, and accessible charging infrastructure. • Shared e-rickshaw and electric auto-rickshaw incentives: free cost of permits, exemption/reimbursement from road tax/vehicle registration fees for five years and 100% wavier on parking chargers at any municipal corporation-run parking facility for 5 years.
Tamil Nadu ***Electric Vehicle Policy, 2019***	• Electrify 5% of buses every year by 2030, and convert shared mobility fleets, institutional vehicles, and e-commerce delivery and logistics vehicles to EVs by 2030. • Convert all auto rickshaws in six major cities to EVs within a span of 10 years. • Establish venture capital and business incubation service hubs to encourage electric vehicle start-ups. • EV-related and charging infrastructure manufacturing units will receive 100% exemption on electricity tax till 2025.
Uttarakhand	• Aimed at 100% electrification of public transport, including e-buses; shared mobility, including e-bikes, e-taxis; and goods transport using electric two-, three-,

EV Manufacturing, EV Usage Promotion and Related Services Infrastructure Policy, 2018	and four-wheelers and other mini goods transport vehicles in five priority cities by 2030. • 100% electricity duty exemption and stage carriage permit exemption for five years from date of commercial production. • Exempts the first 100,000 EV buyers from motor vehicles tax for five years.
Bihar ***Draft Bihar Electric Vehicle Policy, 2019***	• Priority to electrification of rickshaws. Target of converting all paddle rickshaws to e-rickshaws by 2022. • Promotion to manufacturing of e-rickshaws. • Set up fast-charging stations at intervals of 50 km on state and national highways and charging stations at commercial and residential locations.
Himachal Pradesh ***Draft Electric Vehicle Policy, 2019***	• Aims for 100% transition to EVs by 2030. • Draft promotes creation of dedicated charging infrastructure and includes a provision for charging points in commercial buildings.

Table 2: State/sub-national level, policies

As for aviation, the sector accounts for small but growing emissions - roughly 5% of the transport sector's overall emissions. These emissions are expected to increase as demand for air travel continues to rise at 3.5% per annum over the next 50 years and could grow from 16 $MtCO_2$ e93 per annum in 2019 to 126 $MtCO_2$e94 per annum by 2070. It is a hard-to-abate sector as the technologies needed for decarbonisation, such as electric aviation and hydrogen-powered jets, are in a nascent stage of development. The most feasible abatement option, sustainable aviation fuel (SAF), faces feedstock constraints for scaling up production[38].

[38] https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/decarbonizing%20india%20charting%20a%20pathway%20for%20sustainable%20growth/full-report-decarbonising-india-low-res.pdf?shouldIndex=false

8 Acronyms

Acronym	Definition
ACC	Advanced Chemistry Cell
BAU	Business-As-Usual
BF-BOF	Blast Furnace-Basic Oxygen Furnace
C&D	Construction and Demolition
C&I	Commercial and Industrial
CAGR	Compound Annual Growth Rate
CCUS	Carbon Capture, Utilisation and Storage
DCS	District Cooling Systems
DISCOMs	Electricity Distribution Companies
DRI	Direct Reduced Iron
EAF	Electric Arc Furnace
EV	Electric Vehicle
FAME	Faster Adoption and Manufacturing of Electric Vehicles in India
GDP	Gross Domestic Product
GHG	Greenhouse Gas
ICE	Internal Combustion Engine
IPCC	Intergovernmental Panel on Climate Change
IREDA	Indian Renewable Energy Development Agency Limited
KWh	Kilowatt-hour
LULUCF	Land Use, Land-use Change, and Forestry
NDC	Nationally Determined Contribution
NMEM	National Mission for Electric Mobility
OECD	Organisation for Economic Co-operation and Development
OEMs	Original Equipment Manufacturers
PFC	Power Finance Corporation
PPA	Power Purchase Agreements
R&D	Research and Development
RDF	Refuse-derived Fuel
RE	Renewables
SAF	Sustainable Aviation Fuel
SGST	State Goods and Services Tax
SRI	Seeding and Rice Intensification

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