Transforming Eastern India's Electricity Sector to Meet Renewable Energy Goals

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Introduction

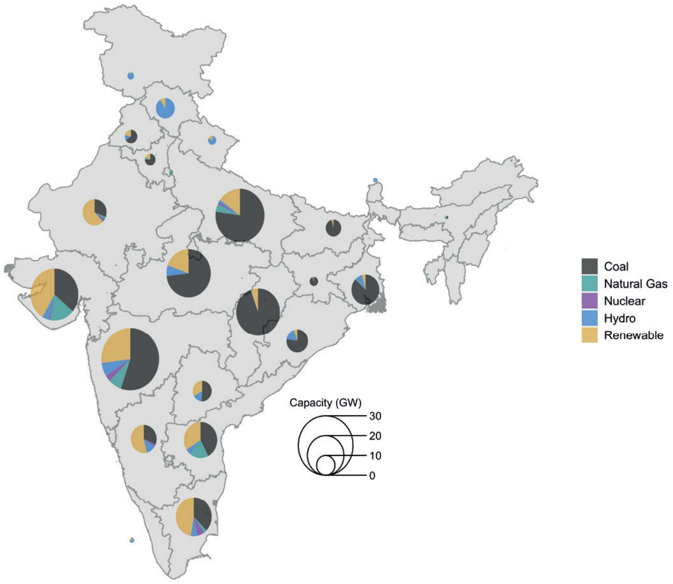
The growth of India's renewable energy sector over the last decade has been a bright spot for the country's economic development and energy transition efforts. Since 2010, solar and wind generation capacity has increased sevenfold, from 16 gigawatts (GW) to over 121 GW in 2023, accounting for about 30 percent of India's total generation capacity.[1] Accompanying the capacity addition is a steep decrease in costs; for instance, the cost of solar energy has decreased by a factor of ten since 2010.[2] Although India missed its 2022 target of 175 GW renewable energy, the country is a step closer to achieving its 2030 target of 500 GW.[3] Amid growing electricity demand, efforts to boost uptake mean that renewable energy must meet an increasing share of the new demand.[4]

Amid the turn to renewables in India, there has been an understanding of the role of the states in the energy transition. Indeed, state governments have as much influence on the country's energy transition as the central government.[5] Most of India's renewable energy capacity is contained in a few states in the west and south, with the east having the least renewable capacity and remaining largely coal-dependent.[6] Although there has been some discourse on enabling the coal-dependent communities in eastern India to transition to renewables,[7] this will require significant efforts to boost renewable energy generation capacity in this region. To meet India's ambitious renewables goals in the medium term (2030) and net-zero goals by 2070, regional disparities in capacity must decrease even as the overall capacity grows.

India's Renewables Capacity: Current Status

In India, renewable electricity capacity, and indeed all electricity capacity, shows strong geographic patterns. Eight states in the west and south—Gujarat, Rajasthan, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, and Madhya Pradesh—collectively house 88 percent of the 121 GW of solar and wind power plants in India (installed capacity as of December 2022); hydroelectricity is primarily generated in the Himalayas in northern and northeastern India; and although coal power plants are located across the country, coal accounts for over three-quarters of installed capacity in eastern India, primarily in West Bengal, Odisha, Chhattisgarh, Bihar, and Jharkhand (see Figure 1).[8]

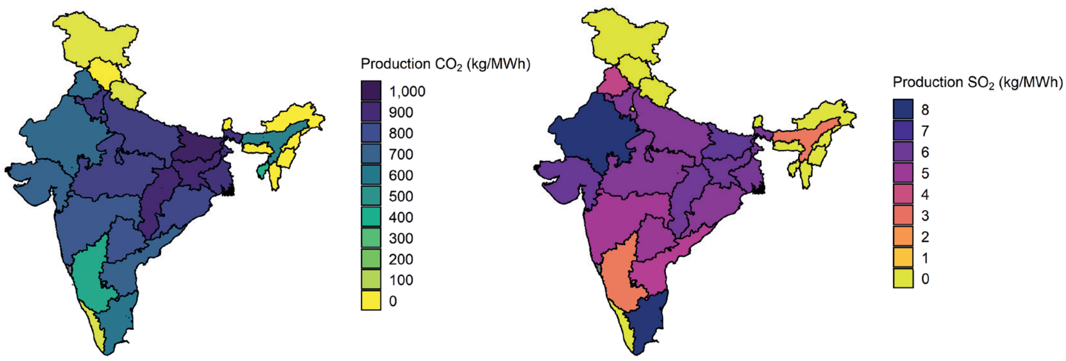
Figure 1: Installed Electricity Capacity Across India



Sources: Andrew (2021)[9] and Andrew (2023)[10]

This geographic skewedness of installed energy capacity has severe consequences for India's energy transition. Quantifying carbon dioxide and air pollution emissions associated with electricity generation from such capacity also shows strong geographic patterns (Figure 2). Though India today has a single synchronous electricity grid, each state still contracts and schedules power plants, thus impacting the electricity they produce. States with the most renewable energy capacity, such as Karnataka or Gujarat, have cleaner electricity; those with the most coal power, mainly in eastern India, produce the dirtiest.

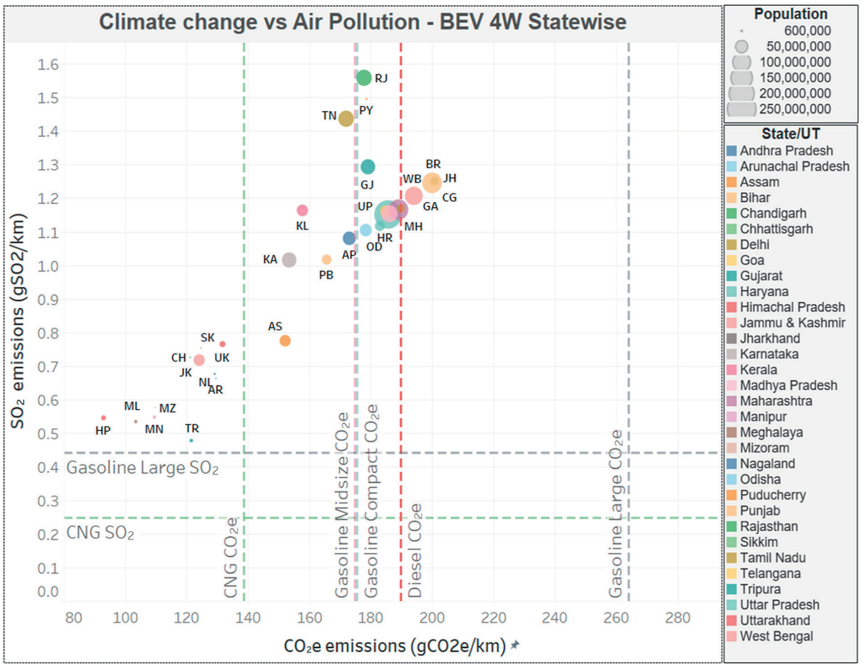
Figure 2: Carbon Dioxide (L) and Air Pollution (R) Emissions from India's Electricity Sector



Source: Adapted from Sengupta et al. (2022)[11]

The differing emissions levels from electricity generation shape the viability of each state's energy transition strategies. For example, the state in which an electric vehicle (EV) is plugged-in determines whether that electric vehicle is cleaner than conventional diesel, petrol, or natural gas vehicles. Because renewable energy reduces emissions in certain states, using electricity generated in those states to power EVs results in lower emissions than conventional alternatives.

Figure 3: EVs Location and Emissions



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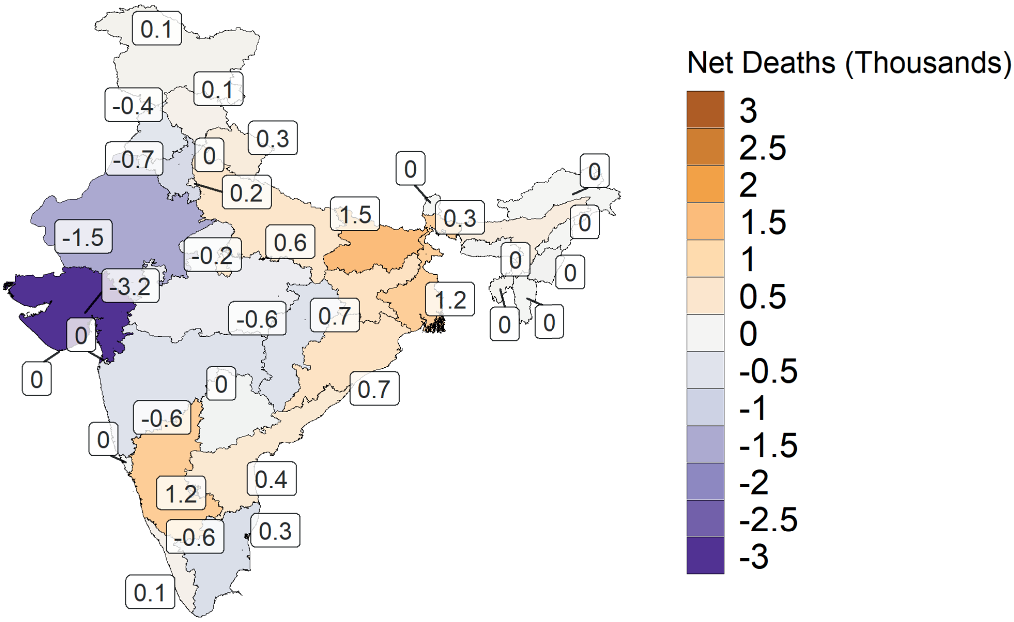
Note: The climate (horizontal axis) and air pollution emissions (vertical axis) of four-wheeled electric vehicles for Indian states. Points to the right of the vertical lines mean four-wheeled electric vehicles have more climate emissions (CO_2) than their conventional alternatives. States with the most renewable energy (Karnataka, Tamil Nadu, Andhra Pradesh) are further left of the vertical lines, while states with the least renewable energy West Bengal, Bihar, Jharkhand) are further right of the vertical lines.

States with the highest renewables capacities are poised to reap the most climate benefits from electrifying transportation. Electric two- and three-wheel vehicles produce lower levels of climate-warming CO_2 emissions than conventional-fuel vehicles in all states. For buses, CO_2 emissions benefits are similar in almost all states, with lower emissions from electric than conventional-fuel buses.[13] However, for emissions from four-wheel EVs, there is a greater variation across states compared to conventional vehicles. Overall, states in the east record higher emissions levels (see Figure 3).

Lastly, reduced emissions associated with more renewable energy in certain parts of India mean there is an unequal burden of premature deaths from uncontrolled air pollution caused by electricity generation.[14] Compared to their fair share, wealthier states with the highest renewable energy penetration levels in southern and western India face a disproportionately lower burden of deaths (violet-shaded states in Figure 4). Meanwhile, poorer states with the lowest penetration of renewable energy in eastern India face disproportionately higher burdens from uncontrolled air pollution from electricity generation (orange-shaded states in Figure 4).

Figure 4: Deaths Caused by Air Pollution from Electricity Generation



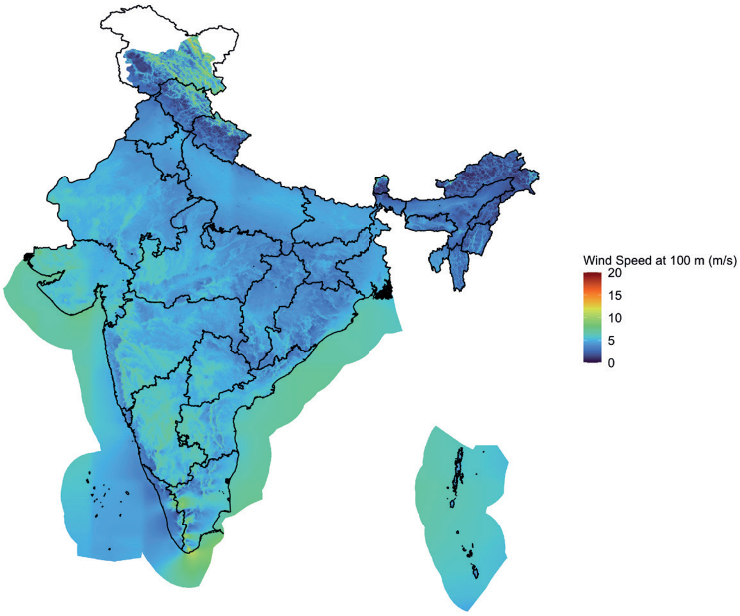
Source: Adapted from Sengupta et al. (2023).[15]

Causes for India's unequal renewables capacity

The unequal renewable energy capacity across India stems from the geographic, economic, and policy differences between the states. Due to favourable climate and geography, southern and western India offer the best solar and wind resources and more land to develop renewable power plants. India's total wind energy resources (and generation capacity) are concentrated in states that experience the highest wind speeds—Tamil Nadu, Gujarat, Karnataka, Maharashtra, Rajasthan, Andhra Pradesh, and Madhya Pradesh (see Figure 5).[16] Solar resources, on the other hand, are more dispersed across the country, but the sunniest places are in states such as Rajasthan, Gujarat, Maharashtra, and Karnataka (see Figure 6).[17] Eastern and northeastern regions receive less solar radiation but still enough to be suitable for solar energy development relative to other parts of the world, such as Germany.[18]

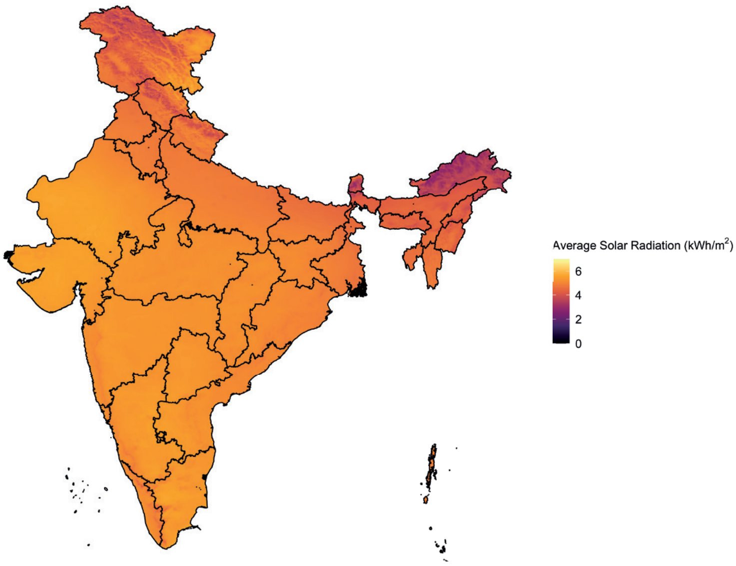
In addition to solar and wind resources, availability of land, especially for solar energy, induces disproportionate choices for where renewable energy projects are located. Sophisticated analyses quantifying the land available for renewable energy which account for existing land use have shown land and associated solar energy potential to be lower in eastern states than in the west and south.[19]

Figure 5: Wind Speeds and Energy Resources Across India



Source: Global Wind Atlas[20]

Figure 6: Solar Resources Across India



Source: Global Solar Atlas[21]

Cost competitiveness with coal power is also a factor for the disproportionate renewables capacity across the country. Coal power is the cheapest when power plants are closest to coal mines, which are predominantly located in eastern India (in Chhattisgarh, West Bengal, Jharkhand, and Odisha). States where power plants are far away from the mines pay more to transport coal, increasing the cost of power. Many of these costlier plants are in southern and western India where renewable energy offers cheaper options to build new electricity capacity. The converse is true for the coal-mining states in eastern India.[22]

An additional factor for the diverse renewables capacity in the country are the policy and political economy differences between the states. High renewable energy states such as Karnataka have detailed policies to attract renewable energy development. Indeed, Karnataka, in 2009, became the first Indian state to establish a renewable energy policy, and its current policy outlines increased deployment until 2027 through incentives and targets to simplify renewable energy development.[23] Meanwhile, although West Bengal has announced plans to increase its share of renewable energy to 20 percent, the state lacks the level of detail and planning as Karnataka; Bengal's last renewable energy policy was released in 2012.[24] Meanwhile, other coal-heavy states like Chhattisgarh, Bihar, Jharkhand, and Odisha have offered updated renewable energy policies since 2017, conveying varying levels of interest to increase renewable energy in eastern India.[25]

The political economy of coal in the eastern states also drives some of the policy inertia, limiting renewable uptake. Coal is vital for government revenues and job opportunities in eastern India.[26] For example, coal was responsible for 7 percent of Jharkhand's state budget in 2018.[27] Moreover, in 2021, approximately 2.5 million people were dependent on coal for employment in West Bengal, Jharkhand, Chhattisgarh, Odisha, and Madhya Pradesh.[28] Importantly, coal mined in eastern India accounts for 44 percent of the annual budget of the Indian Railways.[29] In addition, there is an impression among certain power sector stakeholders that renewables are not reliable sources of power compared to coal.[30]

An Unsustainable Path

In the short-term, states with higher renewable energy could sell and transmit it to states with lower penetrations, mitigating some impacts of the disproportionate capacity. However, in the medium term (over the next decade), India will need to lower this disparity in capacity to meet the goal of generating 500 GW of renewable energy by 2030.[31] Given that renewable energy in eastern states remains a fraction of its potential even after considering land constraints, there is substantial room for growth.[32]

Boosting the eastern states' renewables capacity is also necessary to meet India's goals of net-zero emissions by 2070, which will require the closure of many coal power plants. Analyses suggest that India's coal fleet will need to start retiring or use carbon emissions capturing technology beginning around 2040.[33] Although coal plants in the eastern states may be slow to shutter due to their lower costs, there must be a sustained and consistent policy environment to encourage the growth of renewables in the region over the next 20 years.

The Way Forward

The disparity in renewable energy deployment in India has implications for climate, air pollution, and the country's energy transition. Ensuring that India's eastern regions become part of its clean energy future is vital to ensure a just transition based on equity. Without concerted policy efforts to incorporate the eastern states into India's renewable fold, the region risks being left behind in reaping the benefits of transition.[34]

To reduce the impacts of the disparity in renewable energy capacity and increase renewables penetration in eastern India, the following options can be considered:

- **Enforce air pollution emissions norms:** Indian coal power plants fail to meet global standards of air pollution control. Emissions norms by the Indian government have been repeatedly delayed since 2015 partly due to capital constraints from installing pollution scrubbing technology.[35] Enforcing these norms by installing scrubbers in large power plants in eastern India will reduce air pollution impacts and make EVs more attractive.

- **Incentivise rooftop solar in eastern states:** India has been lagging in the deployment of rooftop solar.[36] Given land constraints in the eastern states, smaller rooftop solar is a viable option by putting solar on land already in use with appropriate incentives for landowners and electricity distribution companies.

- **Use central government funding and guarantee schemes:** Viability gap funding from and payment security mechanisms by the Solar Energy Corporation of India could focus on solar projects in eastern states that lack economic viability to reduce the risk for private developers and financiers. There is precedent for central government schemes preferring certain states for solar deployment.[37] Moreover, central government schemes should consider pooled smaller rooftop projects instead of large grid-scale.

- **Partnerships with civil society:** State governments that lack capacity to establish policy environments conducive to renewable energy development can partner with civil society organisations with clean energy expertise. Jharkhand and Odisha have already set a precedent on this front.[38]

- **Incorporate eastern states into the nascent but growing energy storage value chain:** India's energy storage needs will increase going forward. The new value chains and associated jobs that will emerge from this can leverage the mining and steel expertise and infrastructure in the eastern states. Institutions such as the Indian School of Mines, Dhanbad, and the Indian Institute of Technology-Kharagpur can offer the human resources and expertise required.

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