# India's Strategy for Achieving Net Zero[*]

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## Abstract

This paper reviews and assesses India's energy policy in the context of its commitment to achieve the target of Net Zero carbon emissions by 2070. It discusses policies outside the energy sector that need to be part of a strategy of achieving this target. Furthermore, it examines possible policy options for accelerating the target date to 2050. The paper also discusses the possible financial and growth implications of various strategy options.

**Keywords:** Climate change, carbon emissions, Net Zero, India, energy policy

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## Introduction

The recent Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2021, 2022a, 2022b) made it clear that the world faces catastrophic consequences of rising temperatures unless nations make significant new efforts to alter this course, by reducing greenhouse gas emissions. 'Net Zero' refers to offsetting new greenhouse gas emissions with other actions, to (supposedly) make net emissions zero. This concept has become the focal point for action to deal with global warming and climate change induced by human activities.

At the 2021 COP26 – the 26th Conference of Parties that signed the United Nations Framework Convention on Climate Change in 1994 – many countries agreed to goals of achieving Net Zero by 2050. While these goals may be too timid to stave off catastrophe, they do represent progress over previous agreements. However, countries like India, which are still relatively poor (China is four times as rich as India, for example), have been reluctant to commit to goals that could keep large segments of their populations from improving their material well-being to the point that they can enjoy decent lives. The case here is that advanced countries, which created the current situation with their past emissions, should rightfully do more to fix the problem (Ahluwalia and Patel, 2022). At COP26, India did agree to a goal of Net Zero by 2070, and how it might achieve that goal is a central focus of this paper.

It has to be recognized that Net Zero targets do not take account of past emissions, which have already led to significant climate impacts. Furthermore, the temporal pattern of reduction is also important, since cumulative future emissions will depend on this pattern. Tongia (2021) notes that the more appropriate target would be minimizing the area under the cumulative emissions curve, and suggests that policy should be focused on "flattening" that curve. Tongia also highlights different starting points for various countries, in terms of past emissions, current per capita GDP, and current energy intensity. All these considerations will enter this paper, but the virtue of the Net Zero framing is its simplicity, even if India is unique in its position for coordinated global efforts to tackle the climate change challenge.

A focus on a long-run end point and simple target also runs the risk of reducing a sense of urgency. Initially, the methods used to achieve Net Zero goals announced by various countries may also be subject to manipulation and fuzziness, so that actual reductions may not be as advertised. Avoiding this scenario will require continued monitoring and assessment of individual countries, as well as sharing of lessons across countries. A clear policy framework and action plan for each country will be an important next step to follow target setting.

India is an important single case, because of its population size and its relative poverty compared to the United States, the European Union, and (even) China, these being the three largest contributors to global emissions. Its per capita emissions are comparatively low, but the pattern of its economic activity raises both concerns and opportunities. For example, it relies heavily on coal for energy, but has a low share of manufacturing in its economy. Persisting with coal while pursuing manufacturing growth to create much-needed employment could pose problems for its Net Zero target as well as the path to that target. On the other hand, India's lag in infrastructure development could provide opportunities for incorporating "greenness" into its infrastructure buildup. The next section provides an overview of basic energy policy actions that India needs to address for its Net Zero target. This is followed by a consideration of changes that would be needed in other parts of the economy, in terms of how they use energy. The fourth and fifth sections discuss possibilities for accelerating the achievement of the Net Zero goal, and the financial aspects and growth implications of doing so. The final section offers a summary conclusion.

## Energy Policy for Net Zero

India's per capita energy consumption is less than 40% of the world's average (IEA, 2020, 2021), but its energy system relies heavily on coal for power generation, as well as for industrial production. Oil is most important for transport, and biomass for residential heating and cooking. Excluding biomass, in 2019, India's total primary energy supply (TPES) was 734 million tonnes of oil equivalent (Mtoe), with just over half of this being covered by domestic production.[1] Total final consumption (TFC) was 410 Mtoe, with industry accounting for the largest share, 42%, followed by the residential sector and transport.

India's pattern of electricity generation and energy use imply that policies to achieve Net Zero have to have two main foci. The first is greatly increasing the role of cleaner sources of electricity generation, and the second is electrification of industrial production. Several studies have modeled pathways for these changes as part of achieving Net Zero by 2070 (BP, 2020; Chaturvedi, 2021; IEA, 2021; TERI & Shell, 2021; Chaturvedi and Malyan, 2021).[2] There are differences across the studies, in terms of modeling and assumptions, but they all emphasize cleaner electricity and electrification, as they must.

Currently, electricity accounts for just over a quarter of TFC (Ahluwalia and Patel, 2021). Electricity generation capacity in 2020 was 455 GW, of which 10% was hydropower, and only 1.5% was nuclear power.[3] Neither source affords much scope for growth in capacity. On the other hand, solar and wind power capacity was about 20% of the total, or 90 GW. The Ministry of New & Renewable Energy estimates potential capacity of over 1000 GW for these two sources (Ahluwalia and Patel, 2021), which would be a tenfold increase in the short run.

[1] The data is from https://www.niti.gov.in/edm/#balance, accessed June 17, 2022. See also Ahluwalia and Patel (2021).
[2] The TERI/Shell report has a target date of 2050, while the IEA target date is 2065.
[3] See https://www.niti.gov.in/edm/#elecCapacity.

However, to achieve the requisite substitution of green energy for fossil fuels, and accommodate growth of the economy as well as electrification, the total capacity of solar and wind power would have to be (depending on other assumptions) 8,000 to 9,000 GW by a Net Zero year of 2070, with more than three-fourths of that being solar power (Chaturvedi and Malyan, 2021). Furthermore, in this kind of scenario, solar power would have to account for over 60% of India's electricity generation. These estimates imply growth rates of about 10% for solar power capacity, and 6% for overall generation capacity, not out of line with recent growth rates of about 8%, but sustained for a much longer period.[4]

These calculations imply that a massive expansion of and shift to solar power has to be a centerpiece of energy policy to achieve a Net Zero target. What are the implications of this target for the electricity generation industry? First, the 2070 target date assumes that the real transition and transformation begins in 2030, with peak emissions occurring another decade later. Meanwhile, coal would continue to play an important role in electricity generation. Much of this scenario is driven by the political economy challenges and switching costs of moving out of coal. These are best discussed in the context of possibilities for moving the Net Zero target date forward to 2050, a goal that was pushed for at COP26, but not adopted by India.

A major problem for electricity generation in India is the quality of the grid. While it is a national grid in theory, the actual transmission infrastructure is far from robust. New transmission infrastructure will have to be supplemented by substantial new storage capacity, to deal with the problem of intermittency of solar and wind power. In any case, even without a green transition, India will need to upgrade its entire electricity grid.[5] This is also important for reducing transmission and distribution losses, which are very high in India, in the order of 20%, though this is an improvement on previous decades. Some of these problems are associated with the inefficiency of power distribution companies, which are almost always run by state governments, and play an employment provision role that stifles improvement. These institutional problems have been relatively intractable, but not insurmountable – in some cases, privatization has been politically feasible and has helped – but a green transition for electrification will require a concerted national effort.[6] In all of this, it is important to realize that solar power, even with costs for storage included, is already very close to being cost competitive with coal for electricity generation, so a major push on this front should not require subsidies to work, merely strategic intent and focus.

Green electricity will also provide the underpinnings for shifting industrial production and transport away from fossil fuels. In both cases, substantial new investments will be required. Not all industrial processes are amenable to shifting from fossil fuels to electricity, but India has an unusually high reliance on coal, which needs to be addressed. Electric road and rail transport are

[4] Since there are several alternative scenarios, we choose to present approximate growth rates to provide ballpark figures, rather than offering false precision.

[5] There are some efforts, particularly by the Rockefeller Foundation, to introduce decentralized, small-scale solar power grids for rural areas, but these may be relatively costly (Tongia, 2021). Nevertheless, they may be a useful supplementary approach for electrifying more isolated areas.

[6] There is a large literature on power sector reform, but a good summary of the issues for current purposes is in Ahluwalia and Patel (2021).

a prominent candidate for energy policy, since the impacts are more directly visible to consumers. Achieving Net Zero targets will require at least 80 percent of vehicles to be electric, rather than using fossil fuels. In practice, a completely new infrastructure will have to be developed to facilitate a switch, with public transport and commercial vehicles being obvious points of initial attack. Battery exchanges and charging stations are two examples of new infrastructure. Furthermore, infrastructure for consumers cannot be developed in a piecemeal or gradual manner, so here, too, there has to be a big push. Electrification of transport puts further emphasis on increased electricity generation and increased use of renewables in that process.

Green hydrogen (from electrolysis of water) represents a possible alternative or supplement to green electrification (Hydrogen Task Force 2020; Friedmann et al. 2020; Hall et al. 2020). Detailed modeling (Chaturvedi and Malyan, 2021) indicates that if hydrogen technology can be deployed at scale, it can substitute substantially for electrification. However, the projections suggest that, even if this technology is successfully developed, its likely impact will not be significant for the next three decades. For India, in particular, despite the announcement of a National Hydrogen Mission, (PIB, 2021), the short-term focus should be on green electrification and increased energy efficiency.

**Additional Policy Issues**

The main message of this paper so far is that India is relatively well-positioned to achieve a Net Zero target by 2070, precisely because of where it is in its development trajectory. It has a long way to go in terms of electrification of its economy, as well as energy efficiency. The biggest challenges are not technological, but political and financial. Aspects of these will be discussed in the next two sections, but first we examine some other aspects of policymaking that will tie in with the nation's Net Zero goal.

The most obvious policy area is pricing. Electricity pricing in India is poorly managed (Abeberse, 2017) reflecting unclear welfare goals and hurting the growth of firms, while subsidizing better-off consumers. The expansion of electricity generation has to be accompanied by more rational electricity pricing, as well as markets to improve the allocation of electricity across groups and regions (Ahluwalia and Patel, 2021). There can be significant challenges in designing markets for electric power, since they can be subject to market power and manipulation (Wolak, 2019; Graf, et al., 2021), but they are not insurmountable, especially after the last two decades of experience in developed economies.

Similar considerations apply to the transport sector, where pricing of road use and railways (passengers vs freight) displays similar characteristics of cross-subsidization without explicit welfare calculations. On the other hand, there are significant specific taxes on petroleum products that are used in most road transport. It is estimated that these are the equivalent of a carbon price of $100 per ton-CO2 (Ali and Tongia, 2020; Tongia, 2021), which is much higher than a recent recommendation of $25 per ton-CO2 for India (Parry et al., 2021; Ahluwalia and Patel, 2021). On the other hand, Indian government revenues from petroleum taxes in the transport sector are in no way earmarked for the country's green transition. In any case, explicit

or implicit carbon pricing has to play a role in managing demand, along with changes in technologies, since the global warming externality will remain even with greener technologies (Stiglitz and Stern, 2017). Designing and implementing carbon pricing schemes is not an easy task, either technically or politically. Furthermore, Tongia (2021) points out the additional complications for carbon pricing associated with flattening the emissions curve, rather than just focusing on an end date for net emissions. Chandra (2021) reviews India's current implicit and piecemeal approach to carbon pricing, and the political economy factors that come into play for implementation of a more comprehensive, explicit approach. Solving these intellectual and practical challenges in policy design is important for effectively implementing new technologies and infrastructure.

Along with electrification, an important complementary policy goal for India should be a build out of its digital infrastructure. While much attention has been paid to the rapid growth of the use of cell phones, and smart phones in particular, India's population has much more limited access to high quality broadband internet access, and to cheap devices for that access that offer more functionality than smart phones. Both knowledge work and education in India will benefit from developing digital infrastructure, and offer opportunities for reducing transport usage in some cases. A robust electricity infrastructure is essential as a foundation for this digital infrastructure.

More directly, new commercial and residential buildings, which will be a part of India's growth and development, are another important aspect of infrastructure. Together, these categories of buildings account for a greater share of TFC than the transport sector. Intermittent and unreliable electric power supplies result in wasteful investments in diesel generators, so a big push in electricity generation and distribution will have an impact. Building design is already receiving significant attention, as is more efficient LED lighting. Digital infrastructure of a different kind, which enables more efficient climate control in buildings (almost exclusively cooling in the Indian context) will also be an important contributor to making new buildings energy efficient, beyond their structural features. Setting effective standards and introducing best practices in these dimensions offer immediate gains for energy efficiency, and doing so quickly will be important in ensuring a green trajectory for India's building infrastructure, especially as it urbanizes more rapidly.

India has been relatively slow in pulling people out of agriculture or rural areas, into a more modern urban economy. This has contributed to inefficient scale in agricultural holdings, and to policies such as heavy subsidization of water and chemical fertilizer. India is the most water-constrained large economy (Singh, 2014), and access to water is often facilitated by providing subsidized or even free electricity for pumping groundwater, with disastrous environmental consequences (Singh et al., 2020). Introducing solar power in India at the scale required for its Net Zero target will require significant amounts of rural land as well. Thus, the agriculture sector will also require concerted policy attention with respect to land and water use, production technologies, cropping patterns and electricity pricing and access (Ahluwalia and Patel, 2021).

A final policy dimension to note in the context of green electrification is the aspect of energy security. The Russian invasion of Ukraine has highlighted this issue for many oil and gas importers. India relies heavily on imported oil, and a substitution of green electricity for oil as an

energy source will have the added benefit of increase energy security. While solar panels or some of their components may still be imported, because of cost advantages or domestic capacity constraints, the long-term potential for reducing reliance on imported oil is significant.[7]

**Accelerating the Transition**

At COP26, India rejected a Net Zero 2050 target in favor of the year 2070. This decision can be seen as being motivated by several factors. One is the issue of climate justice (Tongia, 2021; Ahluwalia and Patel, 2022), which requires that countries which have contributed more to the current accumulation of greenhouse gases should take greater responsibility for fixing the problem. In this regard, India's agreement to any target at all was a step forward, recognizing the seriousness of the current situation. The second motivation is India's relative poverty and its heavy reliance on coal for its TPES. The envisaged trajectory to Net Zero by 2070 involves continued, even increasing, use of coal in the short term for India's energy needs as its economy grows.

There is a defensible position for continuing to use coal (Tongia, 2021), even if one avoids getting into rhetorical corners with complaints of "carbon imperialism." Electrification with coal-based generation to serve those currently without any access at all can be important for quickly and cost-effectively reducing "energy poverty," with a minimal total impact on global emissions. To the extent that countries like India have relatively new coal-based generation plants, they may have higher efficiency than older plants in developed countries. Finally, the negative employment, fiscal, restructuring, and overall development impacts of abandoning coal too quickly can be too high to be tolerable or even economically rational.[8] Indeed, model projections (Chaturvedi, 2021; Malyan and Chaturvedi, 2021) indicate that fossil fuels in primary energy production would have to fall to 5 percent of the total by 2030 if Net Zero by 2050 is the goal, without some additional steps. This is unrealistic.

While green hydrogen is too uncertain as a way of accelerating the transition, Carbon Capture, Utilization and Storage (CCUS) may be mature enough to play an important supporting role and accelerate the green transition. CCUS is still to be deployed at scale, but experience in other countries suggests it may be a useful part of emission reduction, through use in retrofitted coal-fired power plants, as well as other industrial plants (Hu and Zhai, 2017; Townsend and Gillespie, 2020). Its current costs mean that it will require subsidies or tax credits to be deployed (something the US is doing: Nagabhushan and Thompson, 2019), but these can be set off against the high costs and disruption of trying to restructure the energy system too quickly. The initial subsidies required may be less than the global social cost of carbon.

[7] At present, there are concerns about a small number of nations controlling supplies of key elements used in solar panels or battery storage, but these constraints may well be overcome with new exploration and discovery, unlike the case of oil and gas, where new, economically viable discoveries are less likely. See Ahluwalia and Patel (2021) for additional discussion.

[8] Because most coal used is domestic, its implications for energy security are very different than oil, the second most important fossil fuel for India.

CCUS is not a panacea, and one perspective rejects it as a diversion from pursuing renewable energy generation, energy efficiency and energy conservation (CAN International, 2021). The criticism is that many of the technological approaches that come under the heading of CCUS are risky, unproven and unscalable. For example, Tongia (2021) points out that direct air capture is unproven and expensive. At the same time, he notes that carbon capture may be useful at the project or plant level.[9] This is precisely where it might play a supporting role for India's transition, if it seeks to accelerate to a target of Net Zero by 2050. For that goal, with CCUS, fossil fuels could still provide 30 percent of India's total energy in 2030, which is much more attainable than the 5 percent without it (Malyan and Chaturvedi, 2021). There are still questions of feasibility and cost. CCUS will also require an ecosystem of new infrastructure, as well as testing and refining the new technologies. But it may be more likely to be useful in India's situation, which involves dealing with a difficult transition away from coal.

One additional benefit of carbon capture in the context of coal-based power plants and industrial production is the reduction in air pollution. This could be an enormous benefit beyond considerations of global warming. Currently, many of the world's cities with the worst air quality are in India. The health and mortality costs of this air pollution in India are quite large (e.g., Cropper et al., 2021). Retrofitting coal-based generation plants and factories to capture particulate pollution in general would seem to be socially optimal at the national level, without taking account of the global benefits. There is also evidence that reducing particulate air pollution would improve rainfall patterns over South Asia (Fadnavis et al., 2021): these have already begun to suffer from climate change, with serious implications for agricultural productivity. All of these factors suggest that an accelerated timeline for Net Zero that also reduces air pollution might be worth pursuing for India. More generally, India is one of the most vulnerable countries to climate change, as measured by the negative impacts of extreme weather events (Eckstein, et al., 2019): this could also support an accelerated timeline.

## Financial and Growth Implications

India's relatively low GDP per capita compared to other large contributors to greenhouse gas emissions means that it is less well positioned to finance a green transition. This fact, along with the fairness argument, can be taken to favor a slower trajectory for India, allowing it to grow rapidly in order to generate more resources for the transition. However, this reasoning is not ironclad. To the extent that pursuing a business as usual approach to economic growth makes it more difficult to switch later, it may make sense to make the requisite investments earlier along the transition path. At several points earlier in the paper, it has been argued that rapid investment in areas where long run changes are necessary, such as solar power for generation and various kinds of green infrastructure, is the right approach.[10] More explicitly, this makes sense when

[9] CAN and many others positively emphasize the separate case of carbon capture through afforestation as an important component of policy for a green transition.

[10] Even without considerations of emissions reduction, calculations based on a growth model and input-output data suggest that electricity supply is the most important constraint to growth for India (Singh, 2007).

there are dynamic economies of scale, since cumulative future benefits can be set against initial costs.

India has a general problem of building an adequate infrastructure of various kinds to support rapid economic growth, so the real question is to what extent will a green transition add to that challenge. If new power generation from solar and wind is cost competitive with coal, as suggested by recent estimates (Ahluwalia and Patel, 2021, based on historical data from IRENA, 2021), then the incremental cost of making future growth greener might be relatively small. However, if existing coal-based power plants have to be retrofitted for carbon capture, the additional costs of going green can be more substantial. But to the extent that India has to step up new infrastructure investment across many areas of the economy, it may be that the additional cost of greener growth may not be too great. Or, put another way, the growth cost of going green with given resources might not be too large. One can also re-emphasize the benefits of pollution reduction, which might not show up in conventional GDP calculations, since increased health expenditures appear as a positive contributor to measured economic activity.

Despite the optimistic assessment above, the incremental investments required will not be negligible. An earlier IPCC special report (IPCC, 2018, based on McCollum et al., 2018) estimated the incremental annual energy investment costs for India to make the green transition at $82 to $135 billion, for the period 2016 to 2050.[11] These figures represent 2.7% to 4.5% of current GDP, but allowing for growth, the average over the period would be below 2%. To put these numbers in perspective, India's tax-to-GDP ratio for the national and state governments combined is about 18%. Clearly, the incremental investment needs for India's transition to green energy cannot simply be financed by additional public expenditure.[12] With appropriate improvements in energy markets and pricing to provide adequate returns on capital, domestic and global private investors may be a source for much of this funding.

Multilateral development banks and bilateral assistance may also be significant future sources of finance, although these channels have done relatively little so far. There may be some areas of investment, such as carbon capture associated with retrofitting of coal plants, where private and international investment will shy away (Tongia, 2021; Malyan and Chaturvedi, 2021), and actions may be required from the government. But subsidies or tax credits do not have to be the only approach, and could be combined with some form of carbon pricing. In other words, carrots and sticks can be combined. A major challenge may be effective monitoring, since existing pollution controls are often not well monitored or enforced.

The numbers from McCollum et al. (2018) only pertain to energy investments. However, the earlier discussion suggests that this is by far the most important point of attack in the case of India. Rapid green electrification of India will be the foundation of any strategy for achieving

[11] These numbers are different from what is reported in Ahluwalia and Patel (2021). They are calculated directly from Table 1 in McCollum et al. (2018), by taking the difference of the 2° and 1.5° scenarios relative to the baseline. In both cases the confidence intervals are extremely wide.

[12] Close to 20% of government tax revenues come from fossil fuels (Bhandari and Dwivedi, 2022), so decarbonization will have to be accompanied by a shift in the tax structure to compensate for lost tax revenue as fossil fuels are replaced.

Net Zero in the next decades. Therefore, the numbers also suggest that the financial resources needed for a green transition are quite manageable, if prices are allowed to send appropriate signals to investors, producers and consumers. In that case, greener growth does not have to mean lower growth.

## Conclusion

India has a little over one sixth of the world's population, but contributes just over 7% of global CO2 emissions (Tongia, 2021). Its cumulative emissions are proportionately even lower compared to its population. This situation reflects the fact that it is still in the early stages of its development trajectory. Given this situation, India's adoption of a Net Zero target of 2070 is quite reasonable. This paper has reviewed the evidence for a feasible strategy for India to achieve this goal. A centerpiece of such a strategy has to be rapid adoption of renewable energy, especially solar power. India needs rapid electrification for development, and focusing on green electrification can make it possible to achieve Net Zero goals without sacrificing economic growth. India's strategy will require large new investment in solar power (Chaturvedi and Malyan, 2021).

This is not to say that the task is an easy one, but many of the challenges that will need to be overcome are broadly similar to those that arise in any effort for sustained development. These challenges include managing adjustment costs associated with structural change, overcoming vested interests, catalyzing innovation, and coordinating different aspects of change across sectors. Incorporating green objectives into development adds one more constraint to policymaking, but arguably also changes the objective function in a direction that better measures welfare. As in any situation of externalities and public goods, the government has a role to play in setting standards and making sure that market prices more accurately signal social costs and benefits.

In the case of climate change, the global nature of the problem means that a country like India should be receiving financial support from countries that have historically been much greater cumulative contributors to the current dire situation. Estimates by McCollum et al. (2018) suggest that India will need additional annual investment in the energy sector of 2.7% to 4.5% of its current GDP. This is beyond the government's own resource capacity, but is certainly feasible with a mix of bilateral and multilateral contributions, made in ways that also incentivize private investment. National policies also have to be coordinated appropriately. To the extent that current and future costs of global warming and correlated outcomes such as air pollution and water scarcity are disproportionately borne by poorer segments of the population, a strategy of green development can also be more inclusive and equitable than business as usual approaches.

While a target of Net Zero by 2070 is well within India's capability, accelerating that goal by a decade or two, or flattening the emissions curve without changing the Net Zero target date, may be more challenging. In particular, dealing with the dominance of coal in electric power generation and industrial processes may require special attention to carbon capture at the project and plant level (Malyan and Chaturvedi, 2021). Clear estimates of the resource costs and degree

of technological innovation needed for improvement over a baseline strategy of emission reduction can help clarify the connection between national strategy and international resource commitments and financial flows (Tongia, 2021). In this respect, India can serve as a role model and leader for all developing countries in achieving global coordination of the reduction of greenhouse gas emissions.

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