

# Approaches towards Attaining Net Zero Emissions in India: A Research Perspective

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**Abstract:** In order to accomplish India's lofty target of having net-zero carbon emissions by 2070, this article critically assesses the country's energy policy. The statement highlights the crucial significance of green electrification, including the extensive integration of solar power generation. It also explores non-energy sector strategies that are essential to achieving this goal, including smart use of information technology, infrastructure development, and improved transportation networks. It also looks at possible legislative avenues for accelerating the goal date to 2050, with a focus on utilizing carbon capture technology to ease the shift away from a strong coal dependency. It also looks at how various approach options would affect the economy and finances, arguing that India can achieve its net-zero goals without slowing down its economic growth trajectory if it receives reasonable financial support from abroad.

**Keywords:** energy strategy, India, carbon footprint, carbon neutrality, and climatic crisis

## 1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) has released its Sixth Assessment Report, which emphasizes the critical need for immediate global action to prevent the catastrophic effects of rising temperatures brought on by increasing greenhouse gas emissions. A key idea that aims to achieve zero net emissions by balancing new emissions with compensatory activities is known as "net zero." In order to solve the issues of global warming and human-induced climate change, this strategy has become essential.

Many countries committed to achieving net zero emissions by 2050 in the 2021 COP26, the 26th Conference of Parties to the United Nations Framework Convention on Climate Change. Even if these promises might seem insignificant in the face of an imminent disaster, they represent a major advancement above previous accords. But nations like India, which are still struggling with relative poverty (China, for example, is four times wealthier than India), have been reluctant to embrace goals that could obstruct the advancement of the material well-being of their citizens, as stated in the Sustainable Development Goals of the United Nations.

These countries contend that wealthier countries ought to take the lead in resolving the climate catastrophe because their previous emissions have contributed more to it (Ahluwalia and Patel). However, during COP26, India agreed to set a goal of having net zero emissions by 2070, which prompted this article to investigate ways to meet this objective. Although this goal is oriented toward the future, it is important to take historical energy and climate policy trends into account.

However, net-zero targets ignore historical emissions that have already had a major influence on the climate. Furthermore, since future cumulative emissions rely on this trend, the timing of emissions reductions is critical. A more sophisticated approach is advocated by Tongia [7], who highlights the significance of minimizing the cumulative emissions curve and supports initiatives meant to "flatten" this curve. In addition, Tongia emphasizes the various origins of many nations in this undertaking.

Three important factors that will be examined in this research are current energy intensity, current per capita GDP, and historical emissions. Even Nevertheless, implementing a net-zero framework makes sense because of India's special situation, which calls for concerted international action to tackle climate change.

The strategy can be made simpler by concentrating on clear, long-term goals, but there's a chance that this will lessen the sense of urgency. Furthermore, early approaches to achieving net-zero objectives could be manipulated or unclear, which could lead to reductions that are not accurately reported. Countries must continuously monitor, appraise, and share knowledge in order to prevent such situations. It is essential that each country have explicit policy frameworks and action plans in order to successfully accomplish these aims.

India is unique in comparison to other big emitters such as the United States, the European Union, and China because of its enormous population and relative poverty. Despite having relatively low emissions per person, the pattern of economic activity offers both opportunities and challenges. Concerns are raised by the high reliance on coal for energy and the low manufacturing share. Achieving net-zero targets involves striking a balance between the need to reduce reliance on coal and the expansion of industry to create jobs. On the other hand, India's delayed infrastructure development offers chances to include sustainability into its growth strategies.

The ensuing parts will delineate the essential energy policy measures required to achieve India's net-zero goal, succeeded by an examination of energy use across diverse industries. In addition, methods for accelerating the achievement of net-zero targets and analyzing the financial and growth opportunities will be covered. The paper will end with a summary of the most important discoveries.

Aspect	Information
IPCC Sixth Assessment Report	Emphasizes the urgent need for global action to combat rising temperatures and greenhouse gas emissions.
Net Zero Strategy	Aims to achieve zero net emissions by balancing new emissions with compensatory activities.
COP26 Commitments	Many countries committed to achieving net zero emissions by 2050 at the 2021 COP26 conference, representing significant progress in climate agreements.
India's Reluctance	India, facing relative poverty compared to wealthier nations like China, has been cautious about goals that could hinder citizens' material well-being, aligning with the UN's Sustainable Development Goals.
India's Net Zero Commitment	India agreed to a net zero emissions target by 2070 during COP26, prompting further investigation into achieving this goal.
Historical Emissions	While net-zero targets focus on future emissions, it's crucial to consider historical emissions' impact on climate change.
Tongia's Approach	Tongia advocates for a sophisticated approach to minimize the cumulative emissions curve and flatten it, considering various nations' diverse backgrounds in emission reduction efforts.
Factors to Examine	Research will examine current energy intensity, current per capita GDP, and historical emissions as crucial factors.
Simplification of Strategy	Simplifying strategies with clear, long-term goals may reduce urgency but could enhance clarity.

Aspect	Information
Implementation Challenges	Early approaches to net zero objectives may face manipulation or lack clarity, requiring continuous monitoring and assessment to ensure accurate reporting and progress.
Unique Aspects of India	India's unique characteristics, including its large population and relative poverty, present both opportunities and challenges in achieving net zero emissions.
Focus Areas in Research	The paper will delve into essential energy policy measures, energy use across industries, methods for accelerating net-zero targets, and analyzing financial and growth opportunities.

Table 1

## 2. Energy Policy for Net Zero

India uses less than 40% of the world's energy per person, which is significantly less than the norm (IEA [9,10]). Nonetheless, the country mostly depends on coal for industrial production and power generation, with oil controlling the transportation industry and biomass meeting domestic heating and cooking needs. Just over half of India's 734 million tons of oil equivalent (Mtoe) total primary energy supply (TPES) in 2019 came from domestic sources. With biomass excluded, the total final consumption (TFC) was 410 Mtoe, with the industrial sector accounting for 42% of the consumption, followed by the residential and transportation sectors.

Policies to achieve net-zero emissions must have two main emphasis because of India's energy landscape. First and foremost, there is an urgent need to greatly increase the share of cleaner sources in the production of power. Secondly, electrification is necessary for industrial output. With varying modeling and assumptions, but a continuous focus on cleaner electricity and electrification, several studies (BP [12], Chaturvedi [13], IEA [10], TERI and Shell [14], Chaturvedi and Malyan [15]) have presented approaches to attain net-zero aims by 2070.

Currently, significantly more than 25% of TFC is made up of electricity. The capacity to generate electricity by 2020 was 455 GW, of which nuclear and hydropower contributed very little. On the other hand, the capacity of solar and wind power made up around 20% of the total, while projections of their prospective capacity exceeded 1000 GW. However, solar and wind power capacity has to reach 8000–9000 GW by 2070 in order to accommodate economic expansion and electrification while also efficiently replacing fossil fuels with green energy. In order to achieve this ambitious objective, solar power must account for more than 60% of India's electricity production.

To reach its net-zero energy goal, India's energy strategy must prioritize the switch to solar power. Nonetheless, issues like grid quality and political-economic barriers need to be resolved. Because of its fragility, the country's current grid has to be significantly upgraded and its storage capacity increased in order to handle the intermittent nature of solar and wind electricity. Effective power grid management also requires utilizing information technologies, especially artificial intelligence.

The move away from fossil fuels in industrial production and transportation will be accelerated by the switch to green electricity, requiring large investments. Crucial elements of this shift include the electrification of commercial vehicles and public transportation, as well as electric road and rail transportation. Green hydrogen also offers an additional or substitute for electrification, albeit its effects are probably only going to be felt in the long run.

Though a National Hydrogen Mission has been announced, India's immediate priorities should be improving energy efficiency and green electrification. To effectively guide the country towards accomplishing its net-zero goals, this strategic approach is important.

3.Additional Policy Issues

This paper's main claim is that, mostly as a result of its current level of development, India is well-positioned to accomplish a net-zero target by 2070. Even while the country still has a long way to go before electrifying its economy and improving energy efficiency, the majority of the obstacles are more financial and political in nature than scientific. The upcoming sections will examine these issues in more detail as well as different parts of policymaking that are essential to achieving India's goal of being net-zero.

Economists pay close attention to energy price, which includes carbon pricing, as one crucial area of policy. While some contexts have shown that clean electricity regulations and subsidies are beneficial in lowering carbon intensity, others argue that the main mechanism for reducing emissions in India should be a carbon tax. Furthermore, there is a focus on raising industrial energy efficiency requirements and lowering demand in important industries including water usage, steel, and cement. Nevertheless, strengthening institutional capacity is necessary to solve these issues, especially when it comes to controlling energy pricing and making sure that it is distributed fairly among various industries and geographical areas.

Comparably, high taxes on petroleum goods coexist with problems in the transportation industry such as cross-subsidization and insufficient price mechanisms. Even though these taxes imply an implicit cost of carbon, they are not designated for green transition projects. Therefore, in order to properly manage demand and promote technical breakthroughs to address global warming, explicit carbon pricing becomes essential. However, creating and executing such plans presents formidable political and technical obstacles.

Concurrent with electrification initiatives, India ought to give top priority to building its digital infrastructure, since this has enormous potential for information sharing and lowering reliance on transportation. In addition, as residential and commercial buildings account for a significant portion of overall final consumption, it is imperative to address their energy inefficiencies. Improving building standards and utilizing digital technologies can result in immediate energy efficiency advantages, especially when urbanization picks up speed.

The report also emphasizes how inefficient use of land and water, made worse by significant subsidies, calls for coordinated governmental attention to the agriculture sector. India needs to give serious thought to its policies pertaining to electricity access, water management, and agricultural practices as it works toward net-zero emissions.

The last major concern is energy security, which is particularly relevant given the global unrest and India's substantial reliance on imported oil. By switching to renewable energy sources, you may improve long-term energy security and lessen your reliance on foreign oil. Although there are obstacles in the way of obtaining essential components for renewable energy technology, there is a significant chance that this will lessen dependency on foreign oil, unlike the unpredictable nature of new oil and gas finds.

Achieving India's ambitious net-zero aim and progressing towards green electrification essentially depend on effectively managing these complex policy factors.

Aspect	Information
Main Argument	India is relatively well positioned to achieve net-zero emissions by 2070 due to its stage in the development trajectory, with challenges primarily political and financial rather than technological.
Policy Area - Energy Pricing	While energy pricing receives significant attention, clean electricity standards and subsidies can effectively reduce carbon intensity. Swamy et al. advocate for a carbon tax, alongside industrial energy efficiency standards. Malhotra et al. stress the importance of building institutional capacity for effective policy implementation.
Transport Sector	Pricing of road use and railways exhibits cross-subsidization, with significant taxes on petroleum products. Explicit or implicit carbon pricing is necessary to manage demand, but its design and

Aspect	Information
	implementation pose technical and political challenges. Tongia highlights complications associated with flattening the emissions curve. Chandra reviews India's current approach to carbon pricing and the challenges in implementing a comprehensive approach.
Digital Infrastructure	Developing digital infrastructure, beyond smartphones, is crucial for knowledge, education, and reducing transport usage. A robust electricity infrastructure is essential to support digital infrastructure development.
Building Infrastructure	Development of new commercial and residential buildings is vital, accounting for a greater share of total final consumption (TFC) than the transport sector. Investments in electricity generation and distribution are necessary to eliminate wasteful investments in diesel generators. Adoption of energy-efficient building designs and digital infrastructure can enhance energy efficiency.
Agriculture Sector	Policy attention is needed for the agriculture sector regarding land and water use, production technologies, cropping patterns, and electricity pricing and access. Heavy subsidization of water and chemical fertilizer has led to inefficient agricultural practices and environmental consequences. Introducing solar power requires significant rural land, necessitating policy measures for land and water use.
Energy Security	Substituting green electricity for oil enhances energy security, particularly as India heavily relies on imported oil. Concerns about reliance on a small number of nations for key elements in solar panels or battery storage may be overcome with new discoveries, unlike oil and gas reliance.

Table 2

#### 4. Accelerating the Transition

India chose, under the impact of several circumstances, to pursue a net-zero aim of 2070 instead of the suggested 2050 target during COP26. First, there is the climate justice concept, which states that nations that have historically contributed more to the accumulation of greenhouse gases should be more accountable for mitigation actions. The fact that India is willing to accept any target shows how serious the climate situation is. Second, given India's current economic situation and significant reliance on coal for energy, a gradual shift towards net zero is required, with coal continuing to be used in the near future to sustain economic growth.

There are many reasons to keep using coal, especially when it comes to combating energy poverty by quickly and affordably supplying electricity to people who don't currently have it. Furthermore, compared to older plants in rich countries, India's relatively new coal-based power plants might have superior efficiency. Furthermore, early coal abandonment may have negative effects for employment, budgetary stability, and general development. The majority of coal used in India is domestically sourced, which contributes to energy security in contrast to oil, which is mainly dependent on imports.

While carbon capture, utilization, and storage (CCUS) holds potential in assisting the green transition, green hydrogen as a means of accelerating the shift is still unclear. While CCUS is still in its infancy, it has the potential to significantly lower emissions through the retrofitting of industrial and coal-fired power plants. To mitigate the costs of a quick energy system reorganization, its deployment may require initial subsidies or tax credits.

Opponents contend that CCUS might draw focus away from conservation, energy efficiency, and renewable energy initiatives. On the other hand, it might help India shift away from coal at the project or plant level, especially if the country is aiming for an expedited net-zero target by 2050. In addition to lowering emissions, carbon capture also has the added advantage of lowering air pollution, which helps India's health and environment.

In view of India's susceptibility to climate change and the detrimental effects of extreme weather, it may be beneficial to combine air pollution reduction efforts with an expedited net-zero timescale. Ultimately, India's transition to a sustainable, low-carbon future depends on a comprehensive strategy that takes into account economic, environmental, and social concerns.

## 5. Financial and Growth Implications

Financing a green transition is hampered by India's relatively lower GDP per capita when compared to other major emitters of greenhouse gases. Fairness and economic growth considerations support a slower trajectory; but, postponing required investments could make future transitions more difficult. Rather, focusing early investments in important sectors like green infrastructure and solar power generation supports dynamic economies of scale and yields long-term advantages that exceed outlay of capital. India's rapid economic growth depends on addressing its infrastructure deficit, which raises the question of how much more work a green transition will require.

The incremental cost of greener growth may be low if newly developed renewable energy sources, such as wind and solar, outperform coal in terms of cost. However, adding carbon capture to already-existing coal-based plants would come at a hefty price. However, considering the amount of money India needs to invest in new infrastructure across a number of industries, the additional expense of making the switch to greener growth might not be too high. Furthermore, even though they are not entirely captured by traditional GDP measures, the advantages of pollution reduction provide more evidence in favor of green investments.

The additional costs needed for a green transition are not negligible, notwithstanding the possible advantages. According to estimates from previous IPCC studies, the yearly expenses of energy investments between 2016 and 2050 are expected to be between USD 82 and USD 135 billion, or 2.7% and 4.5% of the GDP as it is today. Even while public spending might not be enough on its own, changes to the tax code combined with private and foreign investment might be able to close the funding gap. Nonetheless, with the current shortcomings in pollution management, efficient monitoring and enforcement systems are essential.

The key point of intervention being energy investments highlights the need of rapid green electrification as the cornerstone of India's journey towards net zero emissions. Greener growth need not obstruct economic advancement with the right price signals. In fact, a number of modeling techniques indicate that, given sufficient investment and regulatory support, sustained growth trajectories are achievable.

## 6. Conclusions

Considering its early stage of development, India accounts for little over 7% of global CO<sub>2</sub> emissions despite having slightly over one-sixth of the world's population. In light of this, India's decision to establish a net-zero target by 2070 seems reasonable and doable. The evidence regarding India's ability to achieve this target has been examined in this report, with an emphasis on the country's urgent need for the rapid adoption of renewable energy, especially solar power. Even while the work is difficult, many of the challenges—such as controlling adjustment costs, getting past vested interests, encouraging innovation, and coordinating change across sectors—are typical of development challenges.

While incorporating green objectives into development adds another layer of restriction to policymaking, it also improves welfare assessment by improving the objective function. In each scenario where public goods and externalities are involved, the government plays a crucial role in establishing guidelines and guaranteeing that market pricing fairly represent the costs and benefits to society. Standards and subsidies can also be used to balance distributional transition costs and encourage structural change.

Given the global scope of climate change, India ought to acquire financial assistance from historically significant contributors in order to properly address the issue. According to estimates, India needs to invest an extra yearly amount in the energy sector. This can be achieved by combining bilateral and multilateral contributions with incentives for private investment. National policies that are coordinated can improve equality and inclusivity, particularly in light of the fact that the poorer sections of society are disproportionately affected by climate change.

India can achieve net zero by 2070, but there are obstacles in the way of accelerating the goal or flattening the emissions curve without modifying the target date. The necessity of carbon capture at the project and plant levels is shown by addressing the dominance of coal in power generation and industrial processes. Aligning national strategy with

international commitments and funding flows can be facilitated by providing precise estimates of resource costs and technical innovation requirements. India can set an example for underdeveloped nations by leading the way in securing international cooperation to cut greenhouse gas emissions.

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