India is largely dependent on fossil fuels to meet its energy requirements and imports are an important part of such supply. Sectors like power and transport have shown significant progress in terms of the transition, while others, such as industry, building, waste and forestry have just begun the process. The political motivation towards the net-zero commitment is clearly shown by recent policies and initiatives taken at the national level. As part of its Long-Term Low Emission Development Strategy (LT LEDS), India is all set to focus on the strategic transition of several high-emission sectors, namely electricity and transport; urbanisation; carbon dioxide removal for industry; forests; finance and investments. The plan will also focus on improving research, innovation, climate adaptation and resilience.

While these initiatives are necessary, their success will largely depend upon the synergy between national and state government policies and actions across various economic and social sectors. In addition, adequate financial resources at the required scale, as well as knowledge and technology transfer, will play an important role in this process.
Political economy context
India is the third largest carbon emitter in the world, being responsible for approximately 7.3% of global emissions. However, the CO2 output per capita is only 1.9 tons, about a quarter of China’s per capita emission (7.4 tons\(^3\)) and 12% of the US’ (15.5 tons\(^3\)). India’s per capita emissions have increased by 4% (Compound Annual Growth Rate – CAGR) between 2000-2016 while growth of total emission was 5.6%. Approximately half of the country’s emissions are attributed to the power sector (51.7%), followed by industry (22%), transport (10.7%) and buildings (7.5%). At the UN climate conference in 2021 in Glasgow, COP26, Prime Minister Narendra Modi announced the country’s aspiration to achieve net-zero emissions by 2070, along with 4 interim goals to be reached by 2030. These include a reduction of carbon intensity of the economy by 45 per cent by 2030 over 2005 levels, achieving 500 GW of non fossil fuel energy capacity by 2030, achieving 50% of its energy requirements from renewable energy by 2030, and reducing total projected carbon emissions by 1 billion tonnes between 2021-2030\(^3\). While India’s NDC announcements are considered ambitious from a responsibility and capability point of view, they present a challenge when considering growing energy needs, energy-related emissions and the ability to achieve the net-zero goal earlier given the urgency to stay in line with global warming limits of 1.5 or 2 degree Celsius above pre-industrial levels. Due to India’s existing coal dependent power generation system, at COP26, India proposed to phase down all fossil fuels instead of only focusing on coal. However, this target was not incorporated in the final list of accepted proposals. Furthermore, at COP27 India released its report on The Long-Term Low-Carbon Development Strategy, laying out a vision for the sustainable future. The strategy elaborates on the transition path from fossil fuels to more sustainable energy sources. The expansion of green hydrogen production, increasing electrolyzer manufacturing capacity in the country, and a three-fold increase in nuclear capacity by 2032 are some of the milestones that are envisaged alongside the overall development of the power sector.

Call to Action
There is a big opportunity to accelerate India’s net-zero transition and make the country a pioneer in the clean energy space. The scale of investment required for this to happen is enormous, estimated at USD 10.1 trillion by 2070 and USD 5.7 trillion by 2050\(^3\), while the current GDP is about USD 3.5 trillion. The national government has provided a mandate to support the transition but operationalising it will require strategic policy focus across key intervention areas, namely:

Socially just and climate resilient growth path
The social cost of energy transition, in terms of regional and sectoral inequality, poverty and affordability, adds another layer of complexity for the policymakers. The focus should be towards enabling access for energy transition-based technologies, raising capital for hard-to-abate sectors like industry and long-distance transport, and technically skilling the workforce to help them get a job in green industries.

Financing Plan
Financial support from the private sector, as well as national and international development finance institutions (DFIs) is imperative. Knowledge sharing, technology transfer, and new research on the market opportunities can stimulate investment and growth of the clean energy sector.

Technological strategic development
For an effective and efficient transition, India needs a holistic approach. This should include the strengthening of power sector capabilities (storage, offshore wind, transmission), as well as technological innovation and investment in clean energy applications in energy-intensive industries, forestry and agroforestry. In addition, energy supply chains should be diversified as part of external trade and progressive fiscal policies should be adopted with appropriate coordination between various sectors, agents, and institutions.

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Energy - Technology

Issue
Due to their reliability and affordability, fossil fuels are expected to be the dominant energy source in India at least in the near future, despite the issue of import dependency and the growing climate emergency. However, thanks to proactive initiatives by the Indian government, the renewables industry is developing at a fast pace. The current share of renewables in India’s total energy supply is still low, but the country’s targets are among the most aggressive in the world. India ranks third globally for total renewable power capacity additions, with 15.4 GW in 2021, following China (136 GW) and the US (43 GW)*.

At the same time, India is the second largest importer of coal and crude oil in the world (second to China). The country relies heavily on international supplies to meet its domestic energy demand, with 85% of its crude oil requirements and over 80% of its solar energy production components (modules, cells) coming from abroad. As regards energy storage, India meets its lithium battery demand mostly through imports, which increased by 300% between 2016 and 2020 (December). With the further electrification of the transport sector, the financial implications and geo-political risks of this growing demand and import reliability, could become a real challenge. The Indian government has made a clear commitment to reach net-zero carbon emissions by 2070 and announced 2030 interim goals, namely:

- reducing total emissions by 1 billion tons
- reducing carbon intensity per GDP by 45% over 2005
- sourcing 50% of energy requirements from renewable sources
- increasing non-fossil fuel power generation capacity to 500GW.

However, targeted policies at both national and state level are still in the process of being formulated.

Challenge
India’s existing power generation is primarily coal dependent (84% of total generation is from thermal) while its transport sector is mainly dependent on non-coal fossil fuels. There has been significant development in recent years within the power sector to generate electricity from renewable sources while a sizeable part of the vehicle fleet have also been electrified. Thus, the electric vehicles are actually getting supply mainly from coal. However, there are many countries (for example, USA, Russia and Iran from natural gas and Venezuela and Saudi Arabia from oil) whose power generation is non-coal fossil fuel dependent. Due to this coal dependency, decarbonization focussing on coal phase out places India in a disadvantaged position compared to other non-coal fossil fuel dependent countries. As such, at CoP27, India proposed to include phase down of all fossil fuels within the draft text instead of coal alone, however, this proposal was not incorporated in the final list of accepted proposals.

Moreover, as the proposed Just Energy Transition Partnership (JETP) has a specific focus on a coal-phaseout centric transition program, India’s involvement with JETP initiative of G7 is still under discussion. India wants its ‘transition plan’ to be structured on the basis of it’s NDC and future LTS. There is also a focus on climate funds which could be used for development of renewable energy, technology transfer and promotion of green jobs rather than simply phasing out of coal plants without corresponding restructuring of assets.

India’s existing energy supply is dominated by fossil fuels, with a significant portion (especially petroleum products) dependent on imports, although import sources are diversified. The transition towards renewables is solar-centric, however, due to the lack of domestic technology and production capability, solar modules need to be imported in this case predominantly from China. For battery storage, an intrinsic component of the energy transition, especially for transport, the supply is primarily dependent on China too. Even if it develops domestic capacity in solar modules or battery storage, India would still significantly depend on China for raw materials (lithium, rare earths and other critical materials). Given the geopolitical situation, this concentrated import source could lead to vulnerability in the future. A contributing factor to the continued reliance on other countries is that the national renewable energy manufacturing sector, including modules and components for solar panels or EVs, is not yet competitive, both in terms of price and quality.

The financial dependence of the Indian economy on fossil fuels is another challenge to be overcome for an effective energy transition. Royalties as a share of non-tax revenue for coal-producing Indian states are high. The share reaches 24% in Chhattisgarh, 23% in Jharkhand, 18% in Madhya Pradesh and 15% in Odisha. Moreover, the Indian railway, one of the country’s major employers, also depends on fossil fuel transportation (coal transportation from mine to industry) to meet its revenue targets. An economy centred around renewable energy cannot provide royalties and revenues to states or the railway company in the same way.

4 https://www.investindia.gov.in/sector/renewable-energy
5 https://www.teriin.org/sites/default/files/2021-06/Coal-Dependence-Need-Just-Transition_WP1.pdf
Furthermore, coal-producing states are different to those generating solar power (except for Andhra Pradesh). Thus, the energy transition could also lead to significant regional imbalances in terms of power supply and revenue generation.

Other challenges include the lack of suitable technology options for micro, small and medium enterprises (MSMEs) as well as the lack of appropriate and affordable solutions for the deep decarbonization of industries that require a lot of energy at high temperatures and parts of the transport sector (aviation, heavy-duty trucks, water transport etc.).

To incentivise renewable industry, some subsidies and incentives for specific technologies, such as domestic solar installation and electric vehicles, do exist at the local and state level but these vary across states and suffer from a lack of proper synchronization with national policy targets and initiatives.

Opportunity
The disruptions of business activities and global supply chains suffered during the pandemic due to the over-reliance on China, and the global energy crisis following the conflict in Ukraine, represent an opportunity for India to become a renewable energy technology developer, manufacturer and exporter. Nations across the world are looking for viable trading partners in the clean energy space, especially within the South Asia region. The establishment of the One Sun One World One Grid (OSOWOG) initiative which aims to connect different regional grids through a common grid that will be used to transfer renewable energy power and, thus, realize the potential of renewable energy sources, especially solar energy, provides further chance for growth in this sector through regional and global coordination.

- The progressive policy and regulatory steps adopted by the Indian government present a huge opportunity for the production and consumption of energy storage batteries in the country. In 2021 the central government announced plans to set up 13GWh and 14GWh grid-scale energy storage systems in Ladakh and Kutch, respectively. In the same year the government also announced the intention to invite bids for 4000MWh grid-scale battery storage systems across various regional load dispatch centres. In addition, in 2022 the Ministry of Power issued an order revising the tariff policy around the Energy Storage Obligation (ESO), specifying the percentage of total energy consumed from solar and/or wind, with or through energy storage, should be set at 1% in 2023-2024, gradually rising to 4% by 2029-2030.

- In the wake of nationwide energy crises, the share of renewable sources in power generation rose to 14.1% in May 2022 from 10.2% in April, despite a 23.5% growth in power demand. Building on these results, technical research and analysis can further help understand the impact of renewable energy in supporting power demand and avoiding energy crises in the future. Furthermore, it is important to effectively channel the flow of renewable energy into the diverse state-run grids for efficient load management and to reduce the demand-supply gap.

- The green hydrogen/ green ammonia policy was launched by the central government to improve and support the production and usage of hydrogen and ammonia-based fuels. The government is looking at a production output of 5 million tonnes by 2030. This move can help address various challenges simultaneously, for example reducing imports and dependency on China, while supporting the clean transition in the transport sector and the deep decarbonization in selected industries. Additionally, the production cost of green hydrogen from RE sources is in the range of $3-6.50 per KG (around Rs 225-490 per KG). The government's intention through this policy intervention is to bring down the costs to below $2 per KG (around Rs 150 per KG).

- Research-based policy analysis may help understand patent regulations in some of the critical sectors and suggest ways in which India could improve them for its own benefit.

- There is strong potential for the growth of offshore wind, also considering that it has a longer lifecycle and a higher plant utilisation factor than onshore wind. In addition, since India has a strong wind turbine manufacturing base, the price of offshore installations and the tariff rates are expected to be competitive and on a par with onshore wind, especially for large-scale deployment.

- There are also significant investment opportunities for the development of the domestic energy storage manufacturing industry, given the recent government announcement of the battery swapping policy (policy that allows corporations to set up automobile battery charging stations, enabling customers to exchange discharged batteries for charged ones) and other initiatives and incentives in this area.

High reliance on imports of energy products (both fossil fuels and renewable energy equipments) makes India vulnerable to global price fluctuations and source countries’ policies, therefore jeopardising its energy security. Energy affordability and accessibility also remains an issue, even after commendable improvements in the last decade. Crude oil and natural gas production have been stalling in India over the past few years, which has led to an increase in fossil fuels imports. Crude oil net imports soared by 12% between 2015 and 2020, while India’s production capacity decreased by 13% in the same time period.

Similarly, imports of natural gas accounted for 40.7% of India’s total natural gas production in 2015-2016, and has increased to 53% in 2019-2020. Natural gas net imports increased by more than 58% between 2015 and 2020, while its total production declined by 2.7%. In financial year 2019-20, India imported 51.84 million tonnes of coking coal at a total cost of USD 10.32 billion, up 11.76% in comparison to the previous year. Coking coal imports covered 70% of total coking coal demand in the country and 2% of overall imports.

In the past 8 years India has achieved 100% electrification of villages and 99.9% of households. However, the reliability of power supply remains a problem, especially in rural areas and the most remote parts of the country. Moreover, India has a poor grid infrastructure, poor energy demand management and high transmission and distribution (T&D) losses (20% compared with a global average of 6-8%). Similarly, even after a significant success in providing access to liquified petroleum gas (LPG), actual usage is low due to affordability. A significant amount of subsidies would be required to enhance clean energy access in rural areas and among the poor and fossil-fuel dependent parts of the population. As a result of these challenges, India also lags behind on its SDG (Sustainable Development Goals) targets of universal access to affordable and clean energy.

The expansion of micro and mini grids over the last few years has helped provide electricity to some of the remotest parts of the country, for example in the states of Jharkhand and Chhattisgarh. In India affordability of electricity is an important political issue, and over the last couple of years the concept of free and reliable power has been a key political ambition. Investing in micro-grids to provide reliable and affordable power to rural parts of India can prove to be an effective political tool. On the other hand, transmission grids for renewable power and green energy corridors could also provide immense investment opportunities in the near future. According to recent estimates by the Institute for Energy Economics and Financial Analysis (IEEFA), India needs to invest USD 60-80 billion in the next 5 years for the development of the grid transmission infrastructure. To connect 20 GW of renewable energy projects with the grid through transmission lines, the central government has already approved a plan of USD 1.61 billion for 5 years under the green energy corridor-phase II. Furthermore, while India has one of the most sophisticated energy management systems at the transmission level, the grids are not resilient enough. The notion of self-healing grids that reconfigure automatically in the event of a fault has seen significant developments in some areas of Europe and India also presents opportunities for digital management and grid automation.

Additionally, as the power sector seeks efficient demand management through digitalisation, smart meters are being rolled out in residential buildings. This can provide an opportunity to understand how the existing smart meters have helped grids effectively managed load capacity.

Another significant opportunity lays in the reform of energy pricing. Due to various types and stages of taxes and subsidies, energy pricing in India is complicated. Providing targeted subsidies to sections of population most in need is difficult and, in most cases, they would get misused. Thus, a robust energy pricing reform could facilitate direct transfers to consumers in need without affecting the financial position of DISCOMS.
Energy - Just transition

**Issue**
The latest data by the Ministry of Statistics (MoSPI), in 2020-2021, shows that India produced 716 million tonnes of coal and imported 215 million tonnes to meet the domestic demand. Within the total 956 million tonnes of coal, 581 million were used in power plants, while 325 million tonnes were used in various industries. Iron and steel are the major coal consumers, followed by construction, paper-pulp-print and chemical-petrochemical industries. According to recent data by the Central Electricity Authority (CEA), the share of thermal (power from coal) generation was 85% in 2021-2022, which represents a marginal increase over 2011-2012 (83.3%). This shows that the share of coal in total energy production and investment has more or less stabilised.

At the state and community level, the domestic fossil fuel sector, which primarily consists of coal mining, offers employment to many low-skilled workers. As a result, the energy transition could impact the livelihood of over 13 million people directly and indirectly dependent on coal mining, including transport and associated sectors. India's coal mining states have several 'coal cities' whose infrastructure and livelihood revolve around this energy source. If the transition is not managed efficiently, these regions face economic and socio-economic collapse.

However, while the government is bringing the Indian workforce into the formal economy, coal miners often do not have formal contracts and workers' rights are not properly implemented. As a result, the reskilling of coal miners who have lost their jobs due to mine closure and mechanisation has not been successful. Employees in the coal industry represent a small proportion of people re-trained under skill-enhancement programmes initiated by the government. Moreover, a large number of people are directly and indirectly employed in transport, automobile, auto-component and ancillary sectors. Many of these workers also do not have formal contracts. As India's EV sector is still in its early stages, a transition away from fossil fuels can thus destabilise a sizable portion of the population.

The transition should ensure sufficient economic diversification, not just shifting the focus from one industry to another. In this way it will be easier for the fossil fuel workers to find a suitable alternative based on the nature of their skills and preferences. However, the rentier economic nature of fossil fuel-rich states, institutions and industries, makes diversification difficult and poses a significant challenge to an inclusive and equitable transition.

**Challenge**
Currently, there is a lack of credible examples demonstrating the socio-economic benefits of the net-zero transition for local communities, which contributes to maintaining the status quo. In many parts of India, coal is also viewed as a ‘way of life’ as for some communities it is the only source of income, and in most cases no alternative viable jobs are available. Also, many cities were founded on the back of coal mining and primarily depend on this energy source for infrastructure (roads, power supply, medical and education facilities) and livelihoods. Moreover, coal production and transport are continuous processes, while for renewable generation the transport of machineries and modules is required mostly in initial phase.

The clean energy transition therefore requires motivation and commitment from the state government, alongside investment, to retrain and upskill the coal mining workforce. It also requires industrial and economic diversification and the development of value chains that facilitate the growth of alternative energy sources. Moreover, the lack of large-scale viable energy alternatives and associated financial assistance is a significant hurdle for the just transition in India. Due to disproportionate job opportunities for women in comparison to men, significant presence of an informal sector in most industries and unfair working conditions for female workers, the gender issue needs to be carefully addressed during the just transition through social inclusion and dialogue.

**Opportunity**
There is an opportunity to support the government’s commitment to improve workers’ rights and bring the workforce into the formal economy developing a renewables sector that ensures better rights, better data and information on employees, and improved development outcomes. On the other hand, as some mines have already been shut down across coal regions, these barren lands may be converted into solar parks. Research showing the socio-economic benefits of the net-zero economy could also help accelerate the transition. The alternative development of industrial parks, utility-based solar parks and sustainable manufacturing facilities can reinvigorate the local economy while helping reduce overall emissions. Furthermore, economic diversification needs to be ensured as part of transition roadmap, for example, people displaced because of the closure of fossil fuel-based industries could be reskilled to work in various clean energy sectors, such as wind farms, electric mobility manufacturing facilities and solar energy parks. Another opportunity exists in providing data on how multiple sustainable development indicators can be achieved as part of the just transition. Knowledge sharing across countries and pilot projects can play a part too. Projects catering to the redevelopment of coal areas from an eco-tourism and wildlife sanctuary perspective can serve as a potential revenue generation avenue for state governments.

India currently holds the G20 presidency and this is an opportunity for India to push the agenda of a low carbon energy transition and focus on preparing a financing plan for such a transition roadmap.
As a large economy, India requires significant financial support for the transition to net-zero emissions. Financial research literature suggests that the level of investment required for the transition may vary between USD 10 and 18 trillion. Given that India's current GDP is USD 3.3 trillion, financing the net-zero pathway will be a major burden for the national economy. The government has introduced financial tools such as green bonds, but the effectiveness and the financial implications and coverage of such initiatives is yet to be measured.

Private investors generally have a risk-averse attitude towards renewable energy development in India and this limits their support. Moreover, to date there are only few on-the-ground examples to demonstrate the opportunities they could benefit from. Without a proper success story, it is difficult to encourage Indian private entrepreneurs to invest in this sector. Another barrier is represented by insufficient regulatory and institutional arrangements to give private investors confidence, including a lack of financial instruments to support public-private partnerships.

The inflow of international climate finance has slowed down over the past few years. Between 2017 and 2020, the inflow of international climate finance grew by only 10%, compared to more than 24% between 2013 and 2018. Global climate finance to India reached USD 632 billion during 2019 and 2020, an extremely low amount given the country’s needs. The commitments made by developed countries to enhance and support climate finance, as mandated in the United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement, have not translated into reality. This has hampered financing efforts for all developing nations, including India. Moreover, the lack of sufficient and effective funding from international development finance institutions (DFIs) is also hindering the country’s net-zero transition.

The order of investment required across sectors for the net-zero target is very large. The Centre for Energy Finance estimates that to achieve net-zero by 2070 (with peak emissions in 2040), the power sector requires USD 8.4 trillion in investment, while the industrial sector requires 1.5 trillion and transport 0.2 trillion. However, if net-zero has to be achieved by 2050 (with peak emissions in 2030), the total investment required is USD 5.7 trillion; 4.8 trillion for the power sector, 0.8 trillion for the industrial sector and 71 billion for transport. This is a monumental challenge for the Indian economy and India thus requires both domestic (private and public) and international financing.

New research and information is needed on existing private finance and on how ESG funds could be mobilised in India to seize the opportunity of changing external financiers’ attitude and drawing in more private funds in support of the net-zero transition. The Securities and Exchange Board of India (SEBI)’s reform of ESG reporting standards last year can improve private climate financing within the country. The ramifications of this move, however, need to be better studied. The Reserve Bank of India (RBI), the country’s central bank, earlier this year published a Discussion Paper on Climate Risk and Sustainable Finance, but it could play a more important role in guiding appropriate regulatory measures. RBI announced that it is working on a framework to issue sovereign green bonds in line with global standards. In the union budget, the central government also announced that sovereign green bonds will be used under the 2022-2023 market borrowings to mobilise resources for climate-friendly infrastructure. The proceeds from these bonds will be deployed in public sector projects that help reducing the carbon intensity of the economy. This regulatory change creates an opportunity to understand how such interventions will impact India’s financing needs and progress towards the 2070 net-zero mission.

Recently a “10 principles for policymaking in the energy transition” was published by Economics of Energy Innovations and System Transition (EEIST) to provide a new framework (based on Risk and Opportunity) to support policy makers for effective and efficient energy transition. This can provide a guideline to attract investment opportunity for deployment of technology to facilitate energy transition through influencing and incentivising various government policies.

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9 https://eeist.co.uk/eeist-reports/
This report presents opportunities for international climate mitigation philanthropy to accelerate the net-zero transition in India. The priority topics identified are based on analysis undertaken by the authors, augmented with their own expert opinion of the national context. While we aim to cover key sectors and draw on the latest national insights, the report should not be considered an exhaustive list of opportunities. Rather, the report provides an initial overview of potentially impactful interventions. The briefing is the work of the authors and does not necessarily represent the views of Climate Strategies or ClimateWorks Foundation.