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POWERING INDIA'S FUTURE

Towards a People-Positive Energy Transition

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EDITOR

Attribution: Mannat Jaspal, Ed., *Powering India's Future: Towards a People-Positive Energy Transition,* November 2023, Observer Research Foundation.

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Design: Rahil Miya Shaikh
Layout: Simijaison Designs

ISBN: 978-81-19656-74-5
ISBN Digital: 978-81-19656-55-4

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Editor's Note

In a world grappling with the multifaceted challenges of climate change, environmental degradation, and disruptions in the pursuit of sustainable development, India stands at the crossroads of an energy transition critical for its future and the planet's well-being. Given India's growing economy and rising population, its energy needs are expected to quadruple in the coming decades. India faces the unique challenge of having to balance its ambitious clean energy targets with the economic development needed to ensure prosperity for its 1.4 billion citizens.

At COP26 in 2021, India pledged to achieve net-zero carbon emissions by 2070, which will require sharply increased reliance on renewables and clean technologies over fossil-fuel-based energy. India is aiming to achieve an installed renewable capacity of 500 GW by 2030 and has declared plans to add 50 GW annually for the next five years to realise these targets.[1] The country has also committed to reduce its carbon emissions by 45 percent compared to 2005 levels by 2030.[2]

Technological developments, investments in climate-friendly fuels, steady policy support, and a vibrant private sector will be critical in accelerating the pathway to clean energy. This will require greater political and policy space for collective action and solutions than what is currently available. At the same time, India must create the right conditions for sustainable economic growth and ensure a people-positive energy transition, particularly salient in the context of communities that are dependent on fossil fuels industries.

Achieving these goals will require a massive scaling up of green finance, and cumulative investments of approximately US$6–8 trillion will be required between the period 2015–2030.[3] It will be imperative upon the different levels of government to shore up unprecedented collaborative efforts, and work in concert with industries and civil society. Essentially, energy transition factors will need to be incorporated into strategy at every level of government—national, state, and local. Energy transition considerations also need to be mainstreamed into the conversation around jobs, growth, livelihood, and quality of life in India and other emerging economies.

However, substantial hurdles persist including volatile commodity prices, financially ailing electricity distribution companies, lack of reliable electricity supply, and increasing energy security risks. To create the right conditions for an inclusive and pro-people transition, knowledge gaps will have to be bridged across multiple areas of the energy transition space. These, in turn, will inform efforts to overcome existing policy and regulatory gaps. These include: identifying plausible and cost-effective strategies for achieving carbon neutrality through modelling and scenario-building; identifying appropriate regulations and instruments to increase investment by global private sector capital in clean energy solutions; creating favourable industrial policies for green technologies; and creating newer economic opportunities for those reliant on fossil fuels.

This compendium, *Powering India's Future: Towards a People-Positive Energy Transition*, delves into the complex landscape of India's energy transformation journey. This collection of essays hopes to serve as a guide, offering insights, analyses, and innovative ideas that can shape India's path to a cleaner, more equitable, and sustainable energy future.

In Section 1, the essay, "Household Energy Transitions in India: Lessons from the Past and Future Prospects," delves into the historical transitions in household energy use. We explore how households have evolved in their energy consumption patterns, drawing vital lessons from the past that can inform future strategies to decarbonise household electricity and cooking fuels. We also address "The Role of New and Emerging Technologies in India's Path to Net-Zero," underscoring the transformative potential of innovation and technology in propelling India towards carbon neutrality. The third chapter in this section, "Transforming Eastern India's Electricity Sector to Meet Renewable Energy Goals," illustrates the pivotal role that regions like Eastern India play in the country's pursuit of renewable energy while ensuring a just and inclusive energy transition.

Section 2 opens with the article, "Financing a People-Positive Energy Transition in India: Options and Challenges," which highlights the criticality of finance in India's energy transition. It scrutinises the options available and the challenges to overcome as the nation seeks to redefine its energy landscape. We also discuss "The Central Bank's Role in Energy Transition," emphasising the critical role of regulators in shaping energy policies and providing the necessary policy signals that are required to attract global finance in green sectors. The piece, "Transition Finance: Supporting India's Net-Zero Goals" then delineates the importance of transition finance and explores innovative financial solutions that can facilitate India's ambitious journey towards net-zero.

In Section 3, the first essay, "Green Industrial Policy for India's Energy Transition" emphasises the role of green industrial policies in not only fostering economic growth, but also prioritising sustainable development and the creation of jobs and markets. "The Promise of Affordable Renewable Energy" then analyses the opportunities that affordable clean energy sources provide to India. Additionally, "Ensuring a People-Centric Energy Transition: The Case of Informal Workers in Coal Regions" underscores the importance of inclusivity and addressing the needs of the most vulnerable and marginalised in the energy transition journey.

In Section 4, we delve into the significance of "Building Resilient Solar Supply Chains" to underline the importance of international partnerships and creating reliable and robust supply chains to support renewable energy proliferation. The essay, "A Global Climate Alliance for Accelerated Climate Action" then unpacks the concept of a global alliance for concerted climate action as a collaborative approach to problem-solving. We conclude with the essay, "Mobilising Climate Finance: The Transformative Role of Multilateral Development Banks," emphasising the role of international financial institutions in facilitating the climate and energy transition goals of emerging economies.

As India seeks to power its future, this compendium aims to act as a guiding light, showcasing the way forward and urging a holistic approach that considers environmental sustainability, social inclusivity, and economic growth. It is a testament to the synergy between innovation, policy, finance, and grassroots efforts in shaping a cleaner, more equitable energy future. As we explore the many facets of this transition within the pages of this compendium, may it inspire and inform, driving us all towards a future where the power of energy is harnessed for the well-being of people, leaving no one behind.

We extend our sincere gratitude to the contributors who have shared their expertise and insights to enrich this compendium. Their dedication to the cause of a people-positive energy transition is evident in the depth of their research and the vision they present in their essays.

– Mannat Jaspal

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Household Energy Transitions in India: Lessons from the Past and Future Prospects

Lydia Powell

Introduction

The ongoing energy transition from fossil fuels to low-carbon renewable energy (RE) is not India's first policy-driven energy transition. More than seven decades ago, India had pushed for energy transitions at the household level as soon as it became an independent country.[1] The first policy-driven energy transition initiated in the late 1940s and early 50s was designed to overcome inadequacies of the market in providing equitable access to electricity to poor rural households.[2] Two decades later, in the 1980s, the second energy transition was designed to replace wood as fuel for cooking, initially with kerosene and later with liquefied petroleum gas (LPG).[3]

These transitions have enabled India to achieve higher levels of access to modern energy sources than those in other South Asian countries with higher per capita incomes.[4] They moved households from traditional fuels to fossil fuels—electricity derived from coal combustion and cooking fuels derived from petroleum. The ongoing energy transition requires households to move away from fossil fuels towards low-carbon fuels. This is not likely to be straightforward as there are no perfect substitutes for grid-based electricity and LPG that are robust, convenient and affordable. In addition, the very factors that contributed to the success of these early transitions are now the biggest barriers to the current low-carbon transition.

India's Early Energy Transitions

Access to Electricity

India's first energy transition was driven primarily by the need to increase electricity access to the rural poor. The goal was to extend the supply of electricity to rural areas to drive irrigation pumps for agriculture and to replace oil lamps as a source of lighting in homes. The process was slow but the transition was largely successful. In 1947, only one in 200 villages were electrified and electricity consumption per person was as low as 14-kilowatt hour (kWh).[5] In 2022, all inhabited villages were electrified and the per-person electricity consumption was over 1,000 kWh—an annual average increase of over 5 percent.[6]

In the 1960s and 70s, the overwhelming national concern was food security, and electricity policy was closely intertwined with policy for food production.[7] The green revolution that substantially increased grain production required intensive use of water.[8] This made increasing electricity access to villages for pumping groundwater a strategic goal of the Union government.[9] This, in turn, facilitated increase in village- and household-level electrification.[10] However, two developments initiated in this period are posing critical challenges to the transition towards cleaner energy sources.

First, the increase in investment in coal-based power generation capacity and the consequent increase in domestic coal production to fuel electricity access has entrenched the role of coal in India's power sector. Indeed, India's coal consumption has increased 20-fold since 1965.[11] In February 2023, coal-based power generation capacity accounted for about 51 percent of total capacity[12] but almost 74 percent of power generation.[13] Mining and quarrying (dominated by coal) along with utility supply of electricity, water and gas accounted for more than 5 percent of gross value added in 2022-23.[14] The number of people employed directly and indirectly, formally and informally in the coal sector is estimated to be at least 13 million.[15] The deep roots of coal and related sectors in the Indian economy and society makes the task of phasing out coal—required by the ongoing energy transition—not just an energy challenge but an economic and social challenge as well.

The idea of enabling a just transition for those who depend on fossil fuels for livelihood is widely discussed, but there is no firm political or financial commitment from countries that have large populations dependent on fossil fuel extraction. The just transition declaration, agreed at the United Nations (UN) Climate Change Conference in Glasgow (COP 26) in 2021, recognised the need to ensure that no one is left behind in the transition to net-zero economies—particularly those working in sectors, cities, and regions reliant on carbon-intensive industries and production.[16] None of the less wealthy developing countries, including India, are signatories to the declaration.[17]

The second source of inertia in the electricity sector that is impeding decarbonisation of the electricity grid is the supply of electricity to consumers in the agriculture and household sectors below the cost of supply initiated across the nation decades ago.[18] Though subsidies on electricity tariff substantially increased electricity access to households that could not afford to pay for electricity, it contributed to the deterioration of electricity sector finances.[19] State electricity boards (SEBs) that mediated the provision of electricity to households shouldered most of the financial burden.[20] The accumulated financial liabilities of SEBs, later divested as autonomous distribution companies (discoms) estimated to be over ₹ 5 trillion in 2020-21, is among the critical hurdles in the path towards decarbonisation of India's energy system.[21] Burdened with financial liabilities, discoms are reluctant to accommodate RE-based power that imposes additional costs in terms of storage required to overcome the inherent problem of intermittency and costs of exiting old power purchase agreements.[22] While industrial consumers are willing to adopt RE-based power because industrial tariff for grid-based electricity is high, households are not necessarily eager to move away from grid-based electricity.[23]

Access to Modern Cooking Fuels

The policy-driven energy transition to replace biomass with fossil-fuel-derived modern cooking fuels such as LPG that began in the 1980s shares some of the critical drivers of the current energy transition.[24] It was driven by environmental concerns but at the local rather than global level. As in the case of the current energy transition, incentives were offered to promote the use of solar, wind energy and biofuels.[25] The transition also involved the setting up of several institutions that are now leading the ongoing low-carbon transition.

In the 1960s and '70s, the use of dried animal dung as cooking fuel was seen as wasteful because animal dung was thought to be more valuable as manure to strengthen food production.[26] Wood used as household fuel was blamed for rapid deforestation by government planners and environmental groups alike.[27] Solar cookers, and stoves that burnt bio-gas derived from animal dung labelled "non-conventional energy", were promoted as replacements for biomass.[28]

In 1981, the Commission for Additional Sources of Energy (CASE) was set up, and a year later was recast as the Department of Non-Conventional Energy Sources (DNES) under the Ministry of Energy to enable households to transition from traditional fuels to alternatives.[29] In 1992, DNES was upgraded as the Ministry of Non-conventional Energy Sources (MNES). The government renamed MNES as the "Ministry of New and Renewable Energy Sources (MNRE)" in 2006, signalling a more positive view of RE as a mainstream source of energy. MNRE is now the country's leading institution in implementing RE policies. The Integrated Rural Energy Programme (IREP) announced in the late 1980s recommended incorporating the environmental aspect in the micro and macro level rural energy planning framework.[30] In 1987, the Renewable Energy Development Agency (IREDA) was established under the administrative control of MNRE to act as a dedicated public sector financing arm for RE projects.[31] Today IREDA is playing a critical role in financing India's RE projects, with a loan disbursement of over INR 1 trillion in 2022 alone. In the 1990s, IREDA channelled international fund flows for wind and solar (mostly solar thermal) demonstration projects. The Union Government offered subsidies to set up wind turbines, biomass gasifiers, biogas units, improved cookstoves, solar water heaters and cookers.[32]

As cattle raising was part of every rural household, it was believed that biogas derived from animal dung burnt in a stove similar to that of an LPG stove and a high temperature blue flame would displace the use of biomass and kerosene as the primary fuel for cooking in rural households.[33] In the 1980s, about 75,000 biogas units were reportedly operating in the country;[34] this failed in the longer term and many of them were abandoned. Various reasons were cited for the failure: the high initial cost of the stove (INR 9,000); the fact that the financial assistance was being channelled to farmers rather than women, who had the primary responsibility for cooking; and the difficulty in maintaining the biogas units. The idea of promoting simple box solar cookers as an option for rural kitchens did not go beyond the pilot and demonstration stages.[35]

However, the shift away from biomass was eventually facilitated by subsidised access to LPG. In 1977, there were only 3.2 million LPG connections across India (or 2.5 percent of the households).[36] LPG connections grew at an average rate of 14 percent in the period between 1977 and 1990, above the rate of growth for electricity connections though the starting base for LPG was meagre.[37] Subsidies offered by the government that amounted to roughly half the cost of an LPG cylinder was the primary driver behind this growth which benefited middle class families in cities and towns.[38] In the rural districts, the adoption of LPG was initiated by State-level programmes, especially in Southern States that provided free LPG connections to families below poverty level (BPL). Later, the Union government adopted the model and implemented free and low-cost access to LPG to poor households across the country.

In 2019-20, 88.6 percent of urban households used LPG or piped natural gas (PNG) as primary cooking fuel, while 42 percent of rural households used LPG or natural gas.[39] Overall, about 56.2 percent of the population used LPG or PNG as primary cooking fuel. This is a remarkable transition that was facilitated by policy interventions including subsidies and increase in LPG supply agencies in rural areas. Though this transition is yet to be completed, the Government is contemplating a shift away from petroleum-based cooking fuels towards solar and electric stoves[40] as LPG combustion emits carbon dioxide (CO_2) that contributes to climate change.

Low-Carbon Energy Transition

Decarbonising Household Electricity

In the early 2000s, it was presumed that 300 days of free sunlight on 300 million households in India would swiftly enable household shift away from grid-based electricity.[41] In reality, however, Indian households have been reluctant to adopt decentralised rooftop solar photovoltaic (PV) systems promoted by the Central and State governments. In 2014, the MNRE set a target of installing 175 GW of RE capacity by the year 2022, which included 100 GW from solar, 60 GW from wind, 10 GW from bio-fuels, and 5 GW from small hydropower.[42] Under the 100 GW target set for solar capacity, the share of grid connected rooftop solar was 40 GW. In December 2022, the total installed capacity of RE was about 122 GW, falling short of the 175 GW target by 30 percent.[43] The installed capacity of decentralised rooftop solar projects that aimed at residential and other buildings was in the order of 8 GW in 2022, falling short of the target by over 80 percent. Of this, the share of the residential sector was estimated to be about 17 percent, at 1 GW.[44]

The government has since extended the target date for solar rooftop systems to 2026 without any increase in financial outlay.[45] However, it is unlikely that India will see mass adoption of decentralised solar systems by households even by 2026, for various reasons primary of which is high upfront cost. This is despite the fact that the Government offers 40 percent capital subsidy for the first 3 kW (kilowatt) and 20 percent subsidy beyond 3 kW and up to 10 kW.[46] The lack of robust rooftops that can support solar PV systems is holding up widespread adoption; as do the lack of space in shared rooftops, inability to use rooftop or other space in rented households, and the high transaction costs involved in maintaining rooftop solar systems compared to grid-based electricity.[47] Even among relatively affluent households, multiple reasons impede the adoption of solar rooftop systems: the absence of bidirectional metering which could double the upfront costs due to investment in storage; the absence of aggregators to mediate electricity flow to the grid from rooftop solar installations; and the divergence in rooftop solar policies across states. The availability of subsidised, dependable grid-based electricity that enabled the first transition is, however, the most important barrier to the voluntary adoption of solar rooftop systems.

Decarbonising Household Cooking Fuels

Clean cooking is essential in achieving the Sustainable Development Goals (SDGs), not only because of the environmental benefits at the local and global level, but also for improved outcomes in public health, development, and gender equality.[48] Studies have shown that indoor and outdoor air with high concentrations of $PM_{2.5}$ (particulate matter)[a] is among the leading causes of lung diseases, infant mortality and premature deaths in India. Transition from traditional stoves burning biomass (fuelwood) to LPG for cooking has resulted in significant reduction in indoor $PM_{2.5}$ levels, reducing respiratory illnesses, especially among women, and bringing down infant mortality.[49] A 2020 household-level study in Southern India showed that households switching from biomass to LPG saw a 93-percent reduction in $PM_{2.5}$ concentration in the kitchen and a 78-percent reduction in mean personal $PM_{2.5}$ exposures over the two-month period covered by the survey.[50]

At the same time, however, the production and use of LPG contributes to climate change which means alternatives have to be found in the longer term. A 2020 life-cycle assessment (LCA) study of cooking fuels found that biogas derived from animal dung had advantages in many pollution impact categories.[51] The use of electricity generated with coal made the highest contribution to climate change through CO_2 emissions, followed by kerosene and LPG, largely due to the combustion emissions of CO_2. Biogas had much lower CO_2 emissions but fuel wood had the lowest CO_2 emissions, seven times lower than that of electricity from fossil fuels. Overall, biogas was found to be the most environmentally

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a Particulate matter of diameter 2.5 micro-meters.

sustainable cooking fuel, with 16 lowest life-cycle impacts out of 18 categories considered. As noted earlier in this article, however, the programme to facilitate adoption of biogas in rural households in the 1970s and 80s in India largely failed. While the government is reviving the biogas programme under current policies for decarbonisation of the energy system, most of the current initiatives focus on larger projects.

The electric induction stove is also being studied as a clean cooking fuel option. As part of a programme on 'access to clean cooking alternatives in rural India', induction stoves were introduced in nearly 4,000 rural households in Northern India in 2016.[52] An evaluation of primary usage revealed that a shift from firewood to electricity as primary cooking fuel was observed in only 5 percent of the households studied.[53] Overall, the results indicated that induction stoves will have limited potential in reducing the consumption of firewood and LPG even in areas where there is ample electricity supply. Moreover, if the electricity supply is generated from coal combustion, it will contribute to increasing CO_2 emissions at a global level even if there is reduction in household pollution.

India aims to introduce the *surya nutan,* a twin-top solar cooking stove developed by the Indian Oil Corporation (IOC), in 30 million Indian households.[54] However, the announcement was not followed up by the government with credible policy measures, mandates or timelines and the target of adoption by 30 million households is unlikely to be realised in the near future. The solar cooker is based on a hybrid model designed to use both solar energy and alternative fuels and it is efficient as the design minimises radiative and conductive heat loss. The solar stove offers a payback time of one to two years, assuming annual consumption of six to eight LPG cylinders per year per household, according to IOC.[55] Earlier models of solar cookers required the stove to be outdoors and the cooking process was slow. The cooker could not be used at night, during cloudy days, or when it was raining. The new solar cooking system overcomes some of these challenges with the use of thermal energy storage (TES) that enables cooking indoors and cooking even when there is no visible sunshine. If the programme for solar cooker adoption succeeds, it will hail a new chapter in India's household-level energy transition.

Challenges

In the past, household-level energy transitions encountered economic, behavioural and technological challenges. Some of the incentives offered to overcome these challenges such as subsidies and the substantial increase in fossil fuel-based energy supply are casting a shadow on the current low-carbon energy transition. Earlier efforts to introduce decentralised RE energy solutions for lighting and cooking hold valuable lessons for the current energy transition. Decentralised RE solutions such as solar rooftops and solar stoves shift the technology, albeit rudimentary, to the consumers' premises.[56] This transfers the burden of maintenance to the consumer. Typically, users have little time and information to maintain these devices. In other words, the transaction costs of using solar panels and cookers are higher than those of traditional alternatives such as grid-based electricity and LPG.[57] Poor maintenance of RE devices installed or distributed through Central Government programmes also contributed to the failure of this initiative, as did inadequate buy-in from rural areas partly because these devices were imposed on them and also as a result of the subsidies which reduced households' sense of ownership.

The past efforts did not enable mass adoption of RE technologies by rural households also because of the perception that these were "lower quality" energy sources meant for poor rural households while the affluent urban households had access to high-quality grid-based electricity and LPG.[58] The focus on affluent urban households to adopt decentralised solutions first, could alter this perception. In Western Europe and North America, for example, the success of decentralised RE technologies is being spearheaded by affluent urban households.[59]

In the case of low-carbon cooking fuels, financial incentives may have to be offered for adoption along with a reduction in subsidies for alternatives such as LPG. Evidence on outcomes of the use of laboratory-validated improved cookstoves from a large-scale four-year randomised control trial in India showed that smoke inhalation fell initially but the effect disappeared by the second year.[60] There were no changes in health outcomes or greenhouse gas (GHG) emissions. The study found that households used the stoves irregularly and inappropriately, failed to maintain them, and usage declined over time. One critical insight from the study was that willingness to pay for reduction in indoor air pollution and the related longer term health benefits was low.

To facilitate an increase in adoption of solar rooftop systems and cookers, policy may have to focus less on voluntary transitions and more on mandated transitions. For example, the state-level mandate to install solar rooftop systems in certain buildings may be extended to affluent urban households, initially, and eventually to all households. The economic value of households with solar rooftop systems may be increased through lower taxes and other incentives. However, in the longer term, investment may have to be diverted to utility-scale solar systems that supply low-carbon electricity to the grid. Subsidies offered to utility-scale solar systems rather than decentralised RE projects such as rooftop solar systems deliver better value for subsidies dispensed.[61]

Conclusion

The household-level energy transitions initiated in the early years of independence have enabled India to achieve higher levels of access to modern energy sources than those in other South Asian countries with higher per capita incomes. They moved households from traditional fuels to fossil fuels—electricity derived from coal combustion and cooking fuels derived from petroleum. Some of the incentives offered to overcome barriers during the early transitions such as subsidies and the substantial increase in fossil fuel-based energy supply are casting a shadow on the current low-carbon energy transition.

The ongoing energy transition requires households to move away from fossil fuels towards low-carbon fuels. Earlier efforts to introduce decentralised RE energy solutions for lighting and cooking hold valuable lessons for the current energy transition. Decentralised RE solutions such as solar rooftops and solar stoves shift the technology, albeit rudimentary, to the consumers' premises. This transfers the burden of maintenance to the consumer. Typically, users have little time and information to maintain these devices. In other words, the transaction costs of using solar panels and cookers are higher than those of traditional alternatives such as grid-based electricity and LPG.

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The Role of New and Emerging Technologies in India's Path to Net-Zero

Shirish Bhardwaj and Bhaskar Natarajan

Introduction

Climate change is today the world's greatest existential challenge, and India has stepped forward on the global stage and announced its enhanced climate commitments at UNFCCC CoP26, including a commitment to reach net-zero carbon emissions by 2070.[1] Achieving these targets will require a significant transformation of the country's energy, industry and transportation sectors, which are the largest emitters of greenhouse gases (GHG) in India.[2]

New and emerging technologies have a crucial role to play in India's path to net-zero. This essay explores these technologies and their potential impact on India's journey towards a sustainable future.

India's Net-Zero Efforts

Promotion of Renewable Energy (RE)

India's renewable energy targets have progressively become more ambitious over time. In 2018, the goal was set for generating 175 GW by 2022, as declared at the Paris Summit.[3] The target was increased to 450 GW by 2030 during the UN Climate Summit in 2020. More recently, at the COP26 in 2021, India raised its target to 500 GW by 2030. Furthermore, India aims to achieve 50 percent installed power generation capacity from non-fossil energy sources by 2030, surpassing the current target of 40 percent, which has already been nearly accomplished as per India's statement at COP26.[4]

Sustainable Transport

To shift away from petroleum products, India launched its Ethanol Blended Petrol (EBP) programme in 2003 to promote the use of alternative and environment-friendly fuels and reduce import dependency for energy requirements. In 2018, ethanol became part of the National Policy on Biofuels. India achieved 10-percent ethanol blending in June 2022, five months in advance, and set a target of 20-percent blending of ethanol in petrol by 2025-26 under the National Biofuels Policy Adoption of Sustainable Mobility Technologies.[5] Moreover, Under the SATAT (Sustainable Alternative Towards Affordable Transportation) initiative, various waste streams such as animal dung, agricultural residues, and MSW (Municipal Solid Waste), are being looked into as feedstock for the production of Biogas/CBG (Compressed Biogas).

India is rapidly accelerating its transition towards e-mobility through the implementation of the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) Scheme. On April 1, 2020, India made the leap from Bharat

Stage-IV (BS-IV) to Bharat Stage-VI (BS-VI) emission standards.[6] Additionally, the government has introduced a voluntary vehicle scrapping policy to phase out old and unfit vehicles .[7]

Notably, the Indian Railways is also making significant strides towards full electrification of all broad-gauge routes by 2023.[8] In support of this transition, India is among a small number of countries actively supporting the global EV30@30 campaign, which seeks to achieve a target of at least 30 percent of new vehicle sales being electric by 2030.[9]

Furthermore, to develop and promote the EV ecosystem, India has taken a number of measures such as revamping the FAME II scheme and launching the Production-Linked Incentive (PLI) scheme for Advanced Chemistry Cell (ACC) for the supplier side. In September, 2021, India also introduced the PLI scheme for Auto and Automotive Components to encourage the manufacture of electric vehicles.[10]

India has set an ambitious target to set up 5,000 commercial plants by 2024-25 and produce 15 MMT of CBG, which would replace other gaseous fuels being used in the country. India has already commissioned 46 compressed biogas plants under the SATAT Scheme, and there were 100 outlets currently dispensing the compressed biogas across the country.[11]

Industry Decarbonisation

There are a number of crucial elements required to establish a productive and low-emissions industrial system, including energy and material efficiency, process and fuel substitutions, circular economy approaches, electrification, and the adoption of low-carbon fuels. These measures can help reduce the carbon footprint of industrial processes, increase resource efficiency, and create more sustainable and resilient production systems. Some of the prominent current policies and programmes towards industry decarbonisation are outlined in the following points:

- The National Mission on Enhanced Energy Efficiency (NMEEE) is a government initiative in India aimed at promoting energy efficiency (EE) in various industrial sectors. One of the key components of NMEEE is the Perform, Achieve, Trade (PAT) scheme–a market-based mechanism that incentivises industries to improve their EE. The scheme has been successful in improving EE in several industries, including iron and steel, cement, paper, chemicals and power distribution. To further widen the coverage of the PAT scheme, the government of India has proposed to extend the scope of the scheme to other energy-intensive industries such as airports, ports, chemicals, ceramics, sugar, and mines.[12]

- Energy conservation and efficiency guidelines for MSME sectors[13]
- Energy Efficiency Financing Platform for capacity-building on energy efficiency.[14]
- Standards & Labelling Scheme for Industrial appliances and domestic applications.
- Waste management policies such as Construction and Demolition Waste Management Rules 2016.[15]
- National Programme on Energy Efficiency and Technology Upgradation to address challenges of MSMEs[16]

Nurturing a Green Hydrogen Economy

The National Green Hydrogen Mission, launched in August 2021, aims at promoting the development of green hydrogen using renewable energy sources such as solar and wind power. Its primary goals are to create a cost-competitive ecosystem for green hydrogen production, storage, transport, and utilisation, which can replace fossil fuels and reduce carbon emissions.[17] The following are the targets of the project by 2030:

- Development of green hydrogen production capacity of at least 5 MMT (Million Metric Tonne) per annum with an associated renewable energy capacity addition of about 125 GW in the country
- Over INR eight lakh crore (8 trillion) in total investments
- Creation of over six lakh (6 hundred thousand) jobs
- Cumulative reduction in fossil fuel imports over INR one lakh crore
- Abatement of nearly 50 MMT of annual greenhouse gas emissions

This initiative has the potential to transform India's energy landscape, contribute to global climate change mitigation efforts, and create new opportunities for investment, innovation, and job creation in the renewable energy sector.

Emerging Technologies for Decarbonisation

Green steel

The Indian steel industry is a vital component of the country's economy and has been integral to its industrial progress. Given its importance as a key ingredient for multiple sectors, steel is poised to play a crucial role in enabling India to bolster its infrastructure, drive urbanisation through housing, and power industrialisation through machinery and tools. In order to meet these requirements, the Indian steel sector will require substantial expansion in the forthcoming decades.

The steel industry is responsible for around 7 percent of the country's greenhouse gas emissions.[18] India needs to adopt an ambitious strategy for emissions reduction if it is to continue to show global leadership on climate action and, specifically, to future-proof its steel industry for a net-zero world. A potential strategy for reducing emissions from the steel industry is to shift to renewable energy sources, such as solar or wind, to power steel plants. Improving the energy efficiency of steel plants could also help reduce emissions, as would adopting new technologies, such as carbon capture and storage.

Furthermore, the use of green hydrogen instead of fossil fuels to produce steel, is under serious consideration. When burned, hydrogen emits only water. If that hydrogen is produced via electrolysis using just water and renewable electricity, then it is completely free of CO□ emissions. The use of hydrogen in steel production has garnered worldwide attention through various collaborations and partnerships in the industry. A project called Hydrogen Breakthrough Ironmaking Technology (HYBRIT) was initiated in 2016 by Swedish companies SSAB, Luossavaara-Kiirunavaara Aktiebolag (LKAB)[19] and Vattenfall with the aim of achieving fossil-free steel production by 2035. In parallel, Voestalpine, an Austrian steel manufacturer, partnered with Siemens and VERBUND to set up a 6 MW electrolyser at their steel plant in Linz as part of the H2Future initiative.[20]

In India, large buyers such as the Indian Railways are considering the question of procuring 'green steel' at some point in the future. As per recent estimates, India will produce 15-20 million tonnes of green steel by 2030.[21]

Hydrogen Fuel cell

Heavy-duty freight transport facilitates the transportation of goods and is thus a crucial aspect of modern societies. It is also, however, an emitter of global carbon dioxide. According to the International Energy Agency, heavy-duty vehicles account for approximately 1,776 $MtCO_2$ emissions and are one of the fastest-growing sources of emissions in the transportation sector.[22] To address this issue, the electrification of heavy-duty vehicles is a potential solution. Electric trucks offer numerous benefits over traditional diesel-powered vehicles, including lower emissions, quieter operation, and potentially lower operating costs. However, there are several challenges to the widespread adoption of electric trucks, particularly for heavy-duty freight transport, such as the current state of battery technology and the lack of infrastructure for charging electric trucks. While there has been some progress in developing charging networks for passenger cars, there are currently very few charging stations designed for heavy-duty electric trucks. This means that operators may need to invest in expensive charging infrastructure, further adding to the cost of electric trucks.

Fuel cell trucks are another option for decarbonising freight transport, as they can avoid tailpipe emissions and reduce the use of fossil fuels.[23] These vehicles use fuel cells to generate electricity by reacting hydrogen with oxygen, producing water as a by-product. This process makes them a zero-emission technology, and because hydrogen can be produced from renewable sources, fuel cell trucks have the potential to be a carbon-neutral option for freight transport.

One advantage of fuel cell trucks compared to battery electric vehicles is their long range. Battery electric trucks typically have a range of 100-200 miles, while fuel cell trucks can have ranges of 300 miles or more. This makes fuel cell trucks more suitable for long-haul freight transport, where range anxiety can be a significant concern.

Another advantage of fuel cell trucks is their fuelling time, which is comparable to conventional diesel trucks. While battery electric trucks can take several hours to recharge, fuel cell trucks can be refuelled in a matter of minutes, making them more suitable for time-sensitive freight transport operations.

However, there are also challenges to the widespread adoption of fuel cell trucks, including the lack of infrastructure for producing, storing, and distributing hydrogen fuel. While there are some pilot projects and demonstration programmes underway, there are very few hydrogen refuelling stations available for commercial use.

In summary, fuel cell trucks offer a promising option for decarbonising freight transport, particularly for long-haul operations where range and refuelling time are critical factors. However, significant infrastructure development is needed to make hydrogen fuel available and accessible to commercial trucking operators.

Carbon capture and storage

India is the 3rd largest emitter of CO_2 in the world after only China and the US, with estimated annual emissions of about 2.6 gigatonnes (Gt) per annum.[24] Carbon Capture Utilization and Storage (CCUS) plays a critical role in decarbonising the economy and especially the industrial sector, which is difficult to electrify and decarbonise due to the use of fossil fuels in both energy production and the manufacturing process itself. CCUS also has a vital role in decarbonising India's power sector, as coal currently provides over 70 percent of the country's electricity needs.[25] Even if India achieves its goal of installing 500 GW of renewable energy capacity by 2030, there will still be need for dispatchable power from fossil fuels or other sources to meet baseload demand due to the intermittent and non-dispatchable nature of solar and wind power.

Direct Air Capture (DAC) is a method of capturing CO_2 directly from the air, regardless of the source or concentration of the emission stream. This technology has the potential to be widely applicable, but it is still in the early stages of development, and its economics and operational scale have yet to be established. At present, the cost of DAC is estimated to range between US$ 125-335 per tonne of CO_2.[26]

The following are some of the application areas of CCUS:

- The hard-to-electrify and CO_2-intensive sectors, including steel, cement, oil & gas, petrochemicals & chemicals, and fertilisers, are essential for the continued growth of the Indian economy and for ensuring energy, materials, and food security for the country. CCUS is currently the only known technology that can effectively decarbonise these sectors.

- The utilisation of CCUS is anticipated to have a significant impact on the development of the hydrogen economy in India, specifically through the production of blue hydrogen. This involves coal gasification-based hydrogen production combined with CCUS, utilising India's abundant coal resources. As green hydrogen is currently expensive at US$5-6 per kilogram, producing blue hydrogen at the cost of around US$2 per kilogram can create a viable path for the future of the hydrogen economy.[27]

In India, there are several opportunities for CO_2 utilisation, including the production of green urea from captured CO_2 and cost-competitive green hydrogen, which can replace or complement LNG/NG-based production and import of ammonia and urea. CO_2 can also be used in food and beverage applications such as carbonated drinks and modified atmosphere packing. In addition, CO_2 can be utilised for producing building materials like concrete and aggregates, as well as chemicals like methanol and ethanol, which have important fuel substitution applications and offer significant import substitution opportunities. Conversion of CO_2 to various polymers and enhanced oil recovery are other possible CO_2 utilisation routes. Overall, carbon utilisation technologies offer several pathways for large-scale CO_2 utilisation and disposition while reducing India's import bill and contributing to the circular economy. According to estimates, theoretical CO_2 storage capacity in India is in the range of 395 to 614 Gt.[28]

Digitalisation

Digitalisation has become a game-changer in the way energy is consumed and used, revolutionising different sectors of the economy. The use of sensors, networked devices, and data analytics have transformed how energy is generated, distributed, and consumed, presenting an opportunity to optimise energy use and reduce greenhouse gas emissions.

The power sector stands to benefit from digitalisation as it improves the grid's ability to integrate more variable renewable energy, creating an interconnected grid with a multi-directional power flow. This allows for the expansion of demand response strategies, including smart charging of electric vehicles. In the transportation sector, digitalisation enables electric vehicles to provide flexible load and storage resources for the power grid while improving fuel efficiency through route optimisation and enabling autonomous driving systems.

The digitalisation of buildings has made it possible to manage energy use through energy management systems, smart heating and cooling systems, and connected appliances. It improves the comfort of occupants while reducing energy consumption. Similarly, the industry sector can optimise energy and resource use, improve supply chain management, and allow for the differentiation of products based on environmental attributes through "smart manufacturing" approaches.

However, achieving the full potential of digitalisation in decarbonising the economy requires grappling with a variety of challenges. These include a lack of knowledge and capacity, high upfront capital costs, outdated regulatory models, lack of interoperable standards, cybersecurity vulnerabilities, limited access to broadband, and concerns about compromised privacy and proprietary business information.

Conclusion

India is thinking ahead in terms of how new technologies can play an important role in achieving emission intensity reduction as well as the path to net-zero by 2070. Funds and targets are being discussed. A number of large Indian and international investors see the potential for investing in India in EVs, hydrogen, CCUS and fuel cells.

While technologies are under development, there is parallel work needed on standards, safety, and awareness for consumers on the use of the new technologies. The Department of Science & Technology, along with the Bureau of Indian Standards and other relevant agencies, is actively addressing these issues. They are collaborating with industry stakeholders, researchers, and academia to develop practical solutions.

India is moving towards the goal of a US$5-trillion economy. To achieve this, the demand for the new technologies is large and provides significant potential for investors, manufacturing, and for India to be an export hub.

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

Shayak Sengupta

Introduction

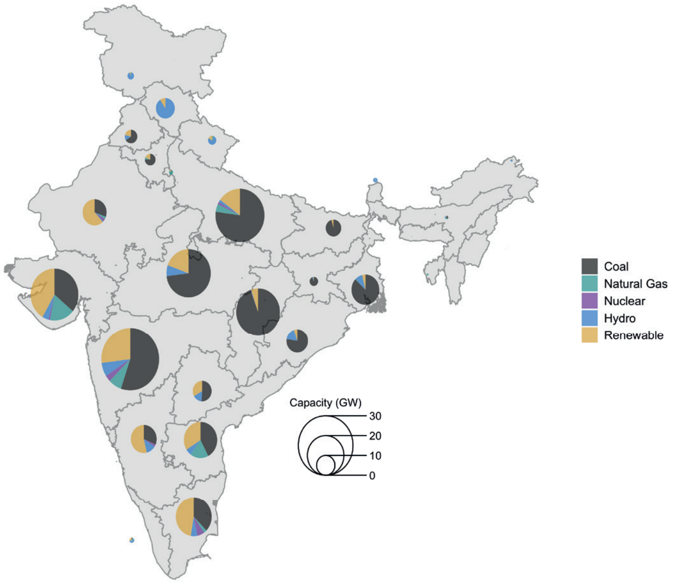
The growth of India's renewable energy sector over the last decade has been a bright spot for the country's economic development and energy transition efforts. Since 2010, solar and wind generation capacity has increased sevenfold, from 16 gigawatts (GW) to over 121 GW in 2023, accounting for about 30 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]

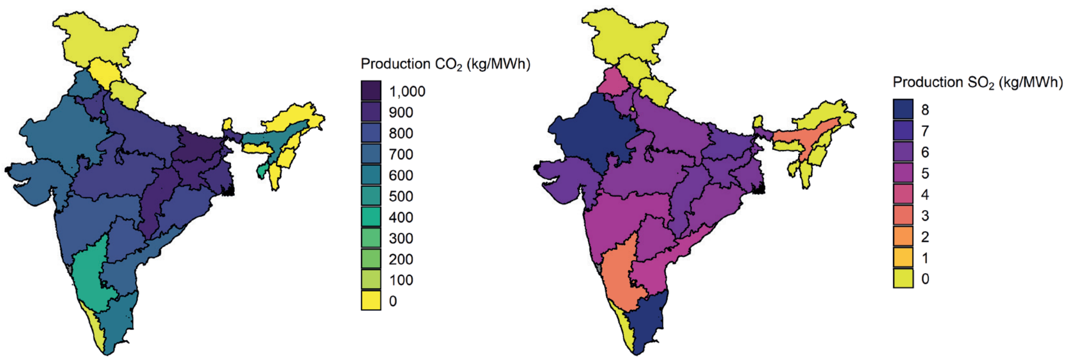
Figure 1: Installed Electricity Capacity Across India



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.

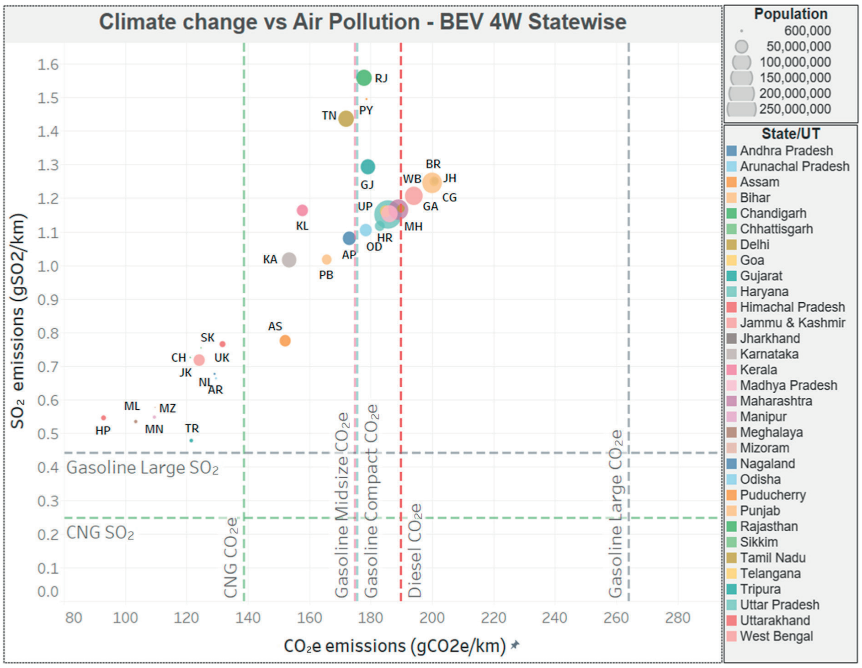
Figure 2: Carbon Dioxide (L) and Air Pollution (R) Emissions from India's Electricity Sector



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



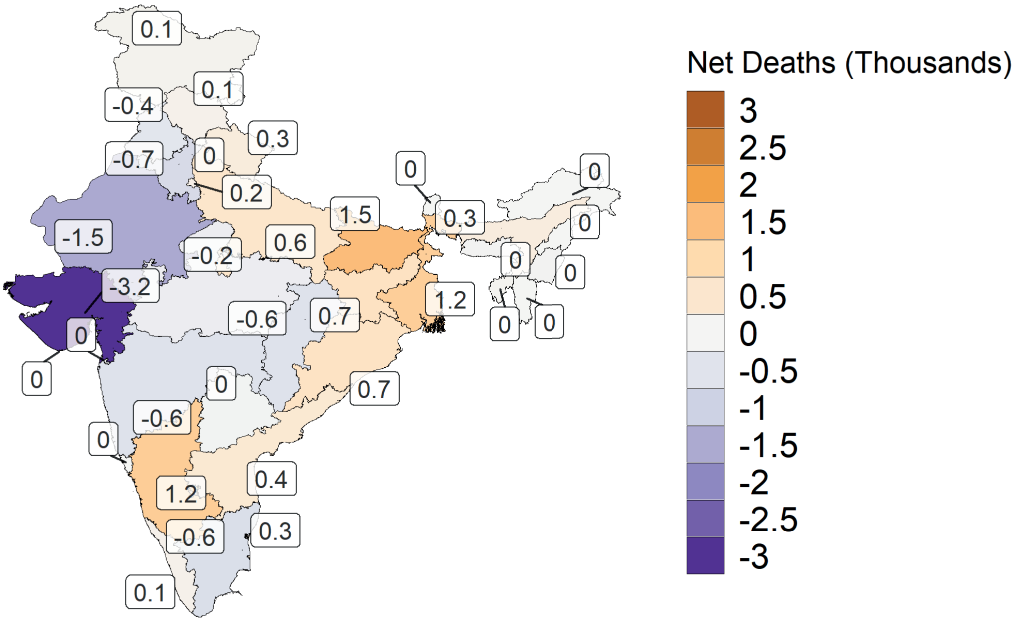
Source: Reprinted with permission from Peshin et al. (2022)[12] Copyright 2022 American Chemical Society.

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



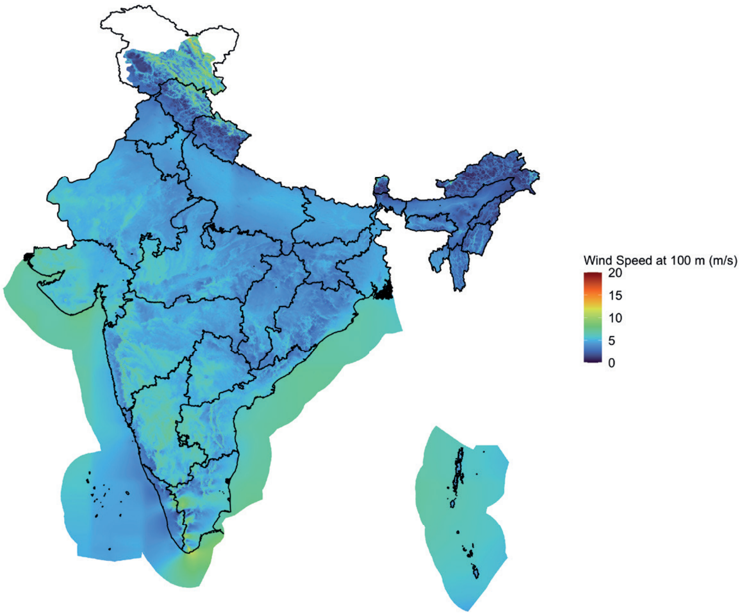
Source: Adapted from Sengupta et al. (2023).[15]

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]

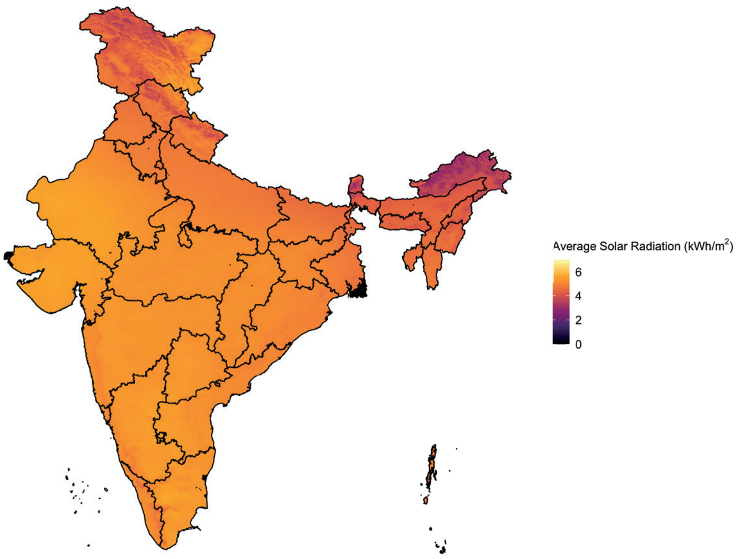
In addition to solar and wind resources, availability of land, especially for solar energy, induces disproportionate choices for where renewable energy projects are located. Sophisticated analyses quantifying the land available for renewable energy which account for existing land use have shown land 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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II

Financing a People-Positive Energy Transition in India: Options and Challenges

Suranjali Tandon

Introduction

As India prepares to transition to net zero (NZ) emissions by 2070, many related aspects will occupy policymakers' minds. Critical among them is how people—as workers and consumers—will be impacted by transition. The signatories to the 2015 Paris Agreement at the Conference of the Parties (COP) 21 agreed to ensure just transition of the workforce and the creation of decent work and quality jobs in accordance with nationally defined development priorities, and to safeguard human rights.[1] This implies that energy transition should not occur at the cost of certain sections of the workforce. At the COP 26 in Glasgow in 2021, more than 30 countries, including coal producers, signed the Just Transition Declaration.[2]

This approach needs to be formalised. The best way to do so is not only to define a list of activities and sectors that are compatible with the NZ pathway, but also to ensure that the interests of those not in the list are not compromised.

There are various estimates of the total required cost of energy transition. Standard Chartered Bank says US$94.8 trillion is required to achieve NZ by 2060, in addition to the US$44.4 trillion that emerging market economies are expected to raise. This investment will have to be in several sectors, including clean transport and smart buildings. It includes the cost of early scrapping schemes and environmental subsidies.[3]

Raising Private Finance through Reporting Frameworks

Finance readily flows into profitable projects. However, to attract investments into projects where the social outcomes are clear but financial returns are insufficient, the risks from non-action must be demonstrated. These include the costs of past negligence, adaptation, re-skilling the workforce and communities that have thus far remained at the periphery of commercial decisions. It is often argued that such social costs should be borne by public finance institutions and multilateral development banks (MDBs).

At the same time, social investments through private finance can also be encouraged. To do so, it is important to understand that under the veil of ‘business’ lies a network of human relations that determine commercial profits. Dissatisfied employees, displaced communities, and financially constrained consumers cannot sustain business-as-usual profits. Growing consciousness among stakeholders can lead to businesses losing markets and being flooded with lawsuits. Already, companies in a wide range of sectors such as H&M[4] (apparel), Volkswagen[5] (automobiles), and Delta[6] (aviation) are being held accountable for exaggerated claims of carbon neutrality and sustainability.

A growing number of countries are adopting disclosure frameworks for corporations and financial institutions to bring transparency to corporate behaviour. India introduced responsibility and sustainability reporting with its Business Responsibility Report (BRR) in 2012. The Securities and Exchange Board of India (SEBI) has since raised the bar with its Business Responsibility and Sustainability Reporting (BRSR) that calls for deeper reporting for the 1,000 top listed companies (by market cap) from 2022-23 in a phased manner, at first voluntarily and later compulsorily. It has also proposed that reasonable assurances be adopted for the supply chains of the top 250 companies in 2023-24, expanding to 500 companies in 2024-25 and 1,000 in 2025-26.[7]

This reporting framework goes beyond energy transition. It also captures the following non-financial obligations:

1. *Employee/worker-related*: These are disclosures on gender and social diversity, including measures to improve access for persons with disabilities, turnover rates, median wages, welfare benefits to permanent and contractual employees/workers, occupational health and safety, and trainings. One of the BRSR questions, for example, relates to the transition assistance programme for employees and how frequently it is used to facilitate continued employability.

2. *Community-related*: These involve disclosures on Social Impact Assessments (SIA), Rehabilitation and Resettlement (R&R), and Corporate Social Responsibility (CSR). Such information on the concerns of vulnerable and marginalised groups of stakeholders helps in establishing a framework while formulating policy.

3. *Consumer-related*: These include disclosures on product labelling, product recall, consumer complaints about data privacy, and cyber security.

Reporting under such a framework will be both qualitative and quantitative. There are some metrics an investor can use to compare across companies; there are others for which company-level engagement will be necessary to understand each one's internal framework and decide if it aligns with the investor's own perception of just transition. A well-known criticism of reporting frameworks is that they often lack objectivity or are used poorly. Companies struggle to find out how investors have reacted to their disclosures, while investors do not know how to compare companies, with ratings having conflicting interpretations.[8] Investors need to define broad principles of just transition, which can then enable them to tick boxes and thereby decide if a company aligns with the process.

But what are the incentives for investors to apply such principles? Social costs are a lot less easy to price, as compared to emissions or compliance with laid down standards. Investors seeking to value companies working on just transition could start by looking at studies that have sought to estimate its cost. For example, the International Forum for Environment, Sustainability and Technology (iForest) has estimated the cost of such transition at US$900 billion: US$600 billion as investment in new industries and infrastructure and the remaining in grants or subsidies to support the transition of the coal industry, its workers, and affected communities.[9] Similarly, the National Foundation of India has identified the sector-wise impact of such transition in India on jobs in the carbon-based value chain which includes brick, cement and transport.[10]

iForest has noted that there are eight components of just transition in coal mining regions—mine reclamation and repurposing; decommissioning of thermal power plants; labour support and transition; economic diversification; community resilience; green energy investments; revenue substitution and energy price support; and planning and governance. A number of these are bound to impact coal companies and the regions where they operate. Investors can use such information to identify companies whose value will be affected in the move towards NZ emissions.

The Role of Banks

The balance sheets of Indian companies underscore the importance of debt. At present, bank debt still dominates corporate loans.[11] In recent years, however, there has been a rise in targeted bonds—green bonds (for green projects overall),[12] blue bonds (for preserving marine diversity),[a] yellow bonds (for solar-related projects),[b] transition bonds (which support transition of industries to lowered emission processes),[c] and sustainability linked bonds (SLBs) (which promote long-term sustainability). These can help investors looking for socially impactful projects that are aligned with their internal mandates.

It is true that there have been instances of 'greenwashing'—i.e., claims of such bonds turning out to have been exaggerated as compared to actual use of proceeds. The impact assessment of such bonds is scant. Ul Haq and Doumbia (2022) showed that SLBs with performance-linked step up costs are somewhat blunt instruments.[13] Similarly, an analysis by Julian Kölbel and Adrian-Paul Lambillon of the Swiss Finance Institute found that, compared to conventional bonds, SLBs enable issuers to extract a lower cost of capital even when they

a SEBI (Issue and Listing of Non-Convertible Securities) Regulations, 2021, last amended on Feb 7 2023; funds raised for sustainable water management including clean water and water recycling, and sustainable maritime sector including sustainable shipping, sustainable fishing, fully traceable sustainable seafood, ocean energy and ocean mapping.

b Funds raised for solar energy generation and the upstream industries and downstream industries associated with it.

c Funds raised for transitioning to a more sustainable form of operations, in line with India's Intended Nationally Determined Contributions.

fail to meet sustainability performance targets and have to pay the average coupon step-up penalty.[14] The cost of non-compliance for these kinds of bonds needs to be set appropriately with clear key performance indicators.

In India, the market for green and sustainable securities has picked up despite a relatively illiquid corporate bond market. It remains to be seen if the hurdles of currency risk, higher rating requirements, and predefined target returns can be overcome by such directed financial instruments.

Stable financing remains every bank's primary objective, including in India. However, priority sector lending (PSL), within the realms of financial tolerance, can be extended to socially compliant enterprises. The largest allocations of PSL currently go to agriculture and allied activities, as well as small and medium enterprises (SMEs). With a clear vision on green industrial policy, linked to the economic diversification required to cope with transition, the banking sector can support just transition.

There has been an increase in trading of PSL certificates, which suggests that banks are currently unable to meet their PSL targets. Enhancing PSL may not be prudent in the circumstances, but it is possible to rework its scope. The government is considering, for instance, including deposits in rural infrastructure development funds as an additional PSL category.[15] Needless to say, proof of concept, expert guidance and caution is needed while making any changes.

The Reserve Bank of India (RBI) has expressed its intent to issue guidelines on green deposits, reporting framework on Climate Related Financial Disclosures and scenario analysis for stress testing.[16] Its 2023 currency and finance report also lays out social risk as a consideration while assessing climate risks. The question then is if financing social aspects of transition can be integrated into the traditional approach of Indian banks.

Banks in some countries have done so. The Bank of England considers the social and economic impacts of climate change and transition risks in its stress testing exercises for banks and insurance companies.[17] Similarly, in its monetary policy strategy review of 2021, the European Central Bank pledged to align its operations with the goals of the Paris Agreement and promote inclusive and equitable transition.[18] The Bank of Canada and the Reserve Bank of New Zealand have done the same to protect vulnerable communities and workers. Since the RBI's functions include engaging in a "range of promotional functions to support national objectives,"[19] it too, can consider similar steps. RBI may also recommend stress tests based on social implications of transition as a first step.

Corporate Practices

Unlike in most countries, India's Companies Act 2013 mandates certain companies to contribute towards CSR. It applies to companies with net worth of more than INR 500 crore, or turnover of INR 1000 crore or more or net profit of more than INR 5 crore in the immediately preceding year. Relatively large companies must use 2 percent of their profits on corporate social responsibility (CSR)[d] activity, clearly listing the activities permitted.[e] Unspent balances have to be transferred to the government. Thus, there is potential to pool public finances such as the District Mineral Foundation[f] funds and unspent CSR funds to provide first loss capital, though this will require amendments to the Companies Act. Such pooling can ensure transparency in the use of such funds for just transition purposes.

Technology can also be used to trace the journey of a company's products and thereby understand its social footprint. QR codes,[g] for instance, can be employed to share information with customers, such as its manufacturing locations and worker strength in each.

State Action for Just Transition

Government budgets for social objectives such as health, education and employment are allocated every year, but there is a need to document how these relate specifically to transition—as has been done in the case of the Sustainable Development Goals (SDGs). Such a move would also bring out the links between the social aspects of transition and SDGs. Various existing sovereign financing mechanisms can also be used to fund just transition. The sovereign green bonds issued by India early this year are one such example. The framework ensures that social co-benefits can be embedded (wherever possible to quantify) within pure play green projects.[20]

The funds raised through sovereign green bonds will also be available for projects of states and local bodies. However, their use could face the same challenges that SLBs have done in the past. It is thus suggested that the

d Section 135(1) of Companies Act 2013 mandates it for a company having net worth of rupees five hundred crore or more, or turnover of rupees one thousand crore or more or a net profit of rupees five crore or more during ` preceding financial year.

e Schedule VII of Companies Act 2013.

f This has been set up in all mining districts, to help people affected by such mining.

g This is already being used by brands to communicate better with consumers about the product. See Jane Hanson, "Brands Are Now Communicating to Consumers About Sustainability Through QR Codes- Here's How," *Forbes*, May 25, 2022.

sovereign green fund employ a co-benefits approach with the states rather than issue SLBs. Also, state borrowing will have fiscal limits. The RBI's state finance report of 2022[21] makes it clear that states are already heavily leveraged due to overextended budgets and the legacy loans taken by their power distribution companies (discoms). Moreover, the so-called 'greenium' on issue of sovereign green instruments may not be available where the states issue such instruments or the use of such instruments becomes more prevalent. As a result, the cost advantages that in turn can have budgetary benefits may reduce over time.

States will have to find innovative approaches to monetise their assets through investment vehicles to raise funds for green projects. They will need to identify assets that can be pledged to generate cash flow. Public sector units (PSUs) in India account for a large share of the assets that will need to transition; all the 13 maharatnas are in power, fossil fuel and minerals or hard to abate sectors. Just two PSUs – Coal India and Nevyeli Lignite – produce 90 percent of the country's coal. Transition could well turn some of them into stranded assets;[22] it may be strategically sound for them to find ways to unlock their capital to raise investments in alternatives as early as possible. PSUs also provide a sizeable number of jobs and low-skilled workers should not have to bear the brunt of transition. One possible way to prevent job losses is to scale up skilling programmes alongside a transition plan and financing. Fortunately, MDBs and development finance institutions (DFIs) are well aware of this. More finance can be channelled to promote the transition of the workforce.[23]

Blended capital—a mix of philanthropic and commercial capital—should be used, but it is not a magic potion that takes away concerns of returns and risks. Mandates, risk profiles and return requirements can be combined in different ways using blended capital structures.[24] Often investors ask for first loss capital and guarantees, and specific public finance institutions can provide this. But profiles need to be mapped and the grant capital of philanthropies added carefully to the mix. The Skill Impact Bonds issued by the National Skill Development Corporation (NSDC) in collaboration with a consortium of partners[h] can be explored for programmes with outcomes of interest to funders. Tamil Nadu has already used these bonds, issuing a pooled finance municipal bond for water and sanitation projects across urban local bodies where 50 percent of the principal amount is guaranteed by the United States Agency for International Development (USAID).[25] More states and municipalities could follow suit.

Instruments such as development impact bonds (DIBs) and social impact bonds (SIBs) exist, but they are few. Pooled financing facilities have varying investment

h Michael & Susan Dell Foundation (MSDF) as risk investors, The Children's Investment Fund Foundation (CIFF), JSW Foundation, HSBC India, and Dubai Cares as outcome funders, the British Asian Trust as the transaction manager, USAID and FCDO (UK Government) as technical partners, Oxford Policy Manager as the independent evaluator, and NSDC and Dalberg Advisors as performance managers.

horizons and a responsibility to report returns to investors that in turn also necessitates exit options. Increasing liquidity in markets where social outcomes are sought can thus be another way of overcoming the dearth of 'patient capital'. Tradable impact bonds may be added to social stock exchanges. There are, no doubt, concerns that some NGOs do not currently report in comparable and transparent formats, but standards will improve if it means increased sources of financing.[26]

Suggestions for reforms in the current global financial system, such as those put forth by the Bridgetown Initiative,[i] need to be made more practicable. To lend more, and on easier terms, MDBs should be able to count their callable capital as available for lending, and should also be allowed to scale up adaptation finance, no matter where the funding comes from. However, the large equity contribution from G-7 countries in many of them, as well as the conditions placed by bondholders who expect, say, AAA rated investments, will not be easy to waive off. Even so, it is encouraging that many of the leading MDBs and DFI partners not only have explicit just transition policies, but are also turning these into real finance flows.[27] The Asian Development Bank (ADB), for instance, has upgraded its energy policy, recognising that planning for just transition will be critical. It has launched an energy transition mechanism in partnership with developing member countries, and is leveraging a market-based blended finance approach to accelerate the transition to clean energy.[28] At the COP 27 in Cairo in November 2022, ADB launched a Just Transition Support Platform that supports capacity building in finance. Other MDBs can replicate this to raise more financial support for just transition.

International Dimensions of Just Transition

Ensuring that people are not adversely affected by energy transition is not just a domestic agenda. It also means taking care that no country is left behind. For decades, global industrial policy has been lopsided, with polluting industries like chemicals being shifted to developing countries such as India and China.[29] Low value chain and high emitting industries thus became the mainstay of many small developing countries. Global logistics evolved around such patterns of demand as primary commodities travelled long distances to the European Union and the United States. As the lights turn red on carbon emissions, developed countries have begun arguing for trade-related measures to ensure that their domestic taxes and emission trading systems work well. Yet again the developing countries are in the crosshairs of such demands. The need for finance goes beyond domestic transition policies. It has been argued

i The Bridgetown Initiative, spearheaded by Barbados Prime Minister Mia Mottley, and unveiled at the COP 27 in Cairo in November 2022, proposes a radical reform of the prevailing global financial system to enable developing countries respond better to the current and future financial crises.

that revenues from the Carbon Border Adjustment Mechanism (CBAM)[j] will be made available to developing countries. Legal provisions will determine if this is tenable. The EU will also have to explain its decision to redistribute revenues to developing country markets to its member countries—a task that is by no means easy.To finance transition, countries like India will have to devise tax mechanisms that retain the costs domestically while requesting the EU to accommodate its pace of transition.

Conclusion

Disclosures, bonds, banking credit and public finances can all be used to finance just transition. None of these, however, are without constraints. People-positive energy transition tries to improve previous growth outcomes. But when all financial instruments have been devised within the existing understanding of risk and returns, there will be limits to the scale and nature of the capital available for it.

One of the ways to increase availability is to demonstrate the costs of inaction, so that investors can ask the right questions in terms of risks to their investments. Another would be to bring about permanent behavioural changes through appropriate pricing mechanisms. The returns to investors and costs of inaction can be made quantifiable if there is a monetary price attached to them. This would change the attitudes of those who compare high-risk transition investments with low-risk, business-as-usual. In the interim, structured taxes can be used to raise more capital for public budgets. A combination of both methods would help with inclusive transition.

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The Central Bank's Role in Energy Transition

Shantanu Srivastav and Saurabh Trivedi

Central banks and financial regulators across the globe are increasingly recognising the importance of addressing climate change risks. Since these risks can have a material impact on financial and macroeconomic stability, many central banks have developed micro- and macro-prudential frameworks that account for climate risks.

There are three types of climate risks that can impact the financial system—transition, physical, and liability risks. *Transition risk* involves uncertainties in policy, price, and valuation changes during climate-change mitigation efforts; *physical risk* is the result of natural hazards like floods and storms that can damage economies directly and indirectly; and *liability risks* constitute potential financial losses and compensation claims from climate change-related natural hazards.

Central banks, globally, are gaining a better understanding of climate-related risk exposure in various sectors of the economy, estimating the magnitude of its effects, and gauging its implications on long-term financial stability. Consequently, banks are undertaking climate disclosure regimes, climate stress tests, and scenario analyses, either voluntarily or according to set regulatory policy. A number of central banks, such as the European Central Bank,[1] the US Federal Reserve,[2] the Banque de France, and the Bank of England, have all undertaken or are planning to undertake stress-test exercises either at a system or bank level. Climate-related risk disclosure regimes are also becoming mainstream. The G7 finance ministers and a number of central banks have supported mandatory climate risk disclosure in line with the recommendations made by the Task Force on Climate-related Financial Disclosures (TCFD).[3]

The Emergence of Green Central Banking

The measures undertaken by central banks to address climate-related risks are commonly referred to as 'green central banking',[4] which is rapidly gaining traction among central banks globally. Central banks possess the necessary tools to maintain financial stability goals, such as achieving price stability and managing economic fluctuations within the economy, which can cause major shifts in investment allocation within the economy, thereby assisting energy transition efforts. Through monetary policy and prudential regulations, central banks can incentivise capital providers to favour investments in low-carbon assets, leading to the wider adoption of green technologies and business models.

As of June 2023, 127 central bankers and financial regulators are part of the Network for Greening the Financial System (NGFS). The overarching purpose of the NGFS is to help strengthen "the global response required to meet the goals of the Paris agreement" and to enhance the role of the financial system in mobilising capital for green and low-carbon investments.[5] Several central banks have released prudential and monetary policy regulations to incentivise their exposure to low-carbon assets and technologies.

RBI's Efforts in Taming Climate Risks

In May 2021, the Reserve Bank of India (RBI) set up a Sustainable Finance Group (SFG) that falls within its Department of Regulation to coordinate climate change issues with other national and international agencies. In 2022, the RBI released a consultation paper on climate risk and sustainable finance.[6] In February 2023, RBI announced that it would issue regulatory guidelines on climate risk and sustainable finance, which would include a framework for green deposits, climate disclosures framework, and guidance on scenario analysis and stress tests.[7]

India requires more than US$10 trillion to reach its net-zero target by 2070, with more than 80 percent needed for energy sector decarbonisation.[8] Most of these projects—such as solar and wind generation, green hydrogen, and battery storage—require significant upfront capital, which in turn necessitates tapping into domestic and foreign capital sources. RBI has several tools to ensure that domestic banking institutions and foreign investors have due incentives to invest in low-carbon assets to support India's energy transition efforts.

Channelling Domestic Financing for India's Energy Transition

Indian banks have implemented measures to address climate risks in lending, but regulatory interventions are necessary to ensure the proper management of climate risk. Therefore, diversifying loan books away from climate-risk sectors is crucial. RBI's forthcoming guidelines are expected to help take stock of climate risk and prepare to align lending portfolios with a low-carbon trajectory.[9] Therefore, the RBI needs to establish prudential regulations and monetary policy interventions to ensure that regulated entities (REs) lend to low-carbon technologies and sectors, which will help diversify their portfolio.

The role of monetary policy

Like most central banks, the RBI focuses on keeping inflation in check and usually refrains from engaging in sectoral interventions to manage inflation. This is despite climate-related economic shocks resulting in an increased trade-off between balancing inflation and growth. For instance, the central bank of the Philippines, Bangko Sentral ng Pilipinas, acknowledges that extreme weather events cause negative supply shocks that can result in inflationary pressures due to the reduced supply of agricultural commodities.[10] In India, inflation is often high due to the effects of food inflation as well as fuel and power inflation on the consumer price inflation (CPI) bucket. Further, climate change has ongoing rather than cyclical impacts, such as droughts,[11] which can lead to systemic changes in the economy. Therefore, the RBI needs to consider monetary policy interventions in order to counter the effects of climate risk on inflation.

- **Adjusting SLR collateral framework**

RBI uses the statutory liquidity ratio (SLR)—the ratio of liquid assets to time and demand liabilities—as one of the primary tools to reserve requirements for maintaining price stability in the economy. It also uses SLR to ensure REs' solvency.[12] As per RBI regulations, only state- and central-level debt are eligible as SLR deposits, while corporate bonds are not eligible, despite the large number of high-rated and liquid corporate (public and private) bond issuances in Indian markets.[13] Deliberations on including corporate debt as SLR deposit eligible security have never fructified.[14]

Some US$8.5 billion of sustainable debt was issued in India in the financial year (FY) 2022,[15] with corporates raising a large part of the total amount. The domestic sustainable finance market will experience a boost if the RBI designates sustainable bonds from top-rated issuers in the country to be eligible for SLR. This will help channel capital into low-carbon activities. Globally, central banks, such as the US Federal Reserve,[16] the European Central Bank, and the Bank of England,[17] take corporate debt exposure on their books.

- **Adjusting collateral framework for liquidity facilities**

The RBI is also a member of the NGFS, which has provided several options for adjusting operational frameworks to climate-related risks. One is adjusting the collateral framework that defines the range of assets that REs can pledge to secure central bank credit operations. The RBI has two short-term liquidity facilities for REs—the marginal standing facility (MSF) and the liquidity adjustment facility (LAF). A market can be created in India for these instruments by providing medium- and long-term liquidity facilities which REs can avail by using green debt securities as collateral and allowing credit deployment only in low-carbon green and transitionary assets. Several central banks, including the European Central Bank and the People's Bank of China (PBoC),[18] accept green debt as eligible collateral while accessing liquidity facilities. PBoC also has a carbon emission reduction facility (CERF) and provides discounted central bank credit for lending to enterprises working on carbon emission reduction.[19]

To support specific sectors and entities, the RBI has used unconventional monetary policy tools such as targeted longer-term refinancing operations (TLTROs) to ease liquidity stress during the COVID-19 pandemic.[20] The RBI also adopted unconventional tools at that time, such as providing liquidity to financial institutions through special refinancing facilities, due to the unprecedented nature and economic impact of the pandemic. While preparing for the impending climate risk, the RBI's efforts towards transitioning to accept sustainable debt will significantly help build economic resilience.

The role of prudential regulations

The prudential regulations for India's banking institutions are guided by the Basel Committee on Banking Supervision (BCBS). BCBS regulations serve as benchmarks for all central banks. The committee has acknowledged that climate risks have potential financial stability implications for the banking system and, in June 2022, released a set of 18 principles for the effective management and supervision of these risks.[21] The RBI's impending climate risk regulations will incorporate some of these principles through enhanced disclosures[22] and guidelines for climate scenario analysis and stress tests. Guidelines for the acceptance of green deposits have already been announced.

- **Credit risk management**

The BCBS climate principles recommend mitigating climate-related credit risks by adjusting underwriting criteria, conducting targeted client engagement, or imposing loan restrictions such as shorter-tenure lending, lower loan-to-value (LTV) limits, and discounted asset valuations. These measures would penalise high-carbon loan applications and sectors and benefit disbursals to low-carbon assets and economic activities. RBI can regulate the credit risk management considerations of its REs through changes and additions to its regulations around these aspects, such as through facilitating longer-tenure lending to sectors like renewable energy, reducing long-term loan disbursals to fossil-fuel sectors, and bringing down LTV limits for fossil-fuel sector assets.

- **Adjusting risk-weighted assets**

RBI is also guided by the Basel III norms, which came into effect in the aftermath of the financial crisis of 2008. The BCBS designed the Basel III norms to improve the banking sector's regulation, supervision, and risk management. The capital adequacy requirements of these norms require maintaining a strong capital-to-risk weighted assets ratio (CRAR). Similarly, RBI mandates banking institutions in the country to maintain a CRAR ratio. The CRAR works as a buffer that can absorb unforeseen losses in banks. Different items on a bank's balance sheet have weightages, which are used to calculate risk-weighted assets to derive the CRAR. Assigning favourable risk weights to assets and sectors with low climate risk can encourage banks to lend more to them. For instance, the EU's capital requirement regulations (CRR) provide a potential risk weight discount for infrastructure lending exposures that meet certain environmental, social, and governance (ESG) characteristics.[23]

- ***Countercyclical climate buffers***

The Basel III norms also introduced two capital buffers for all banks—the capital conservation buffer and the countercyclical capital buffer (CCyB). The former provides additional usable capital during losses, while the latter protects against periods of excess aggregate credit growth that often lead to the build-up of system-wide risks.[24] While RBI has implemented the capital conservation buffer, it is yet to implement CCyB. Climate risk poses a potential systemic risk to the financial system and warrants a dedicated capital buffer. The European Central Bank has identified that current capital buffers do not capture climate-related financial risks owing to underlying risk weights that do not reflect the full extent of climate-related risks.[25] Mandating a climate risk buffer linked to the composition of the overall loan book of an RE will nudge banks to lend more to low-carbon assets.

RBI Interventions for Foreign Investments in India's Energy Transition

India requires approximately US$3–5 trillion of foreign capital to bridge the investment gap to reach its net-zero targets by 2070.[26] However, despite the high demand for foreign capital and significant untapped foreign investment, there are numerous obstacles in the energy transition sector.

Classifying green infrastructure as a separate asset class

The absence of a standardised classification system for green infrastructure in India hinders foreign investment in such infrastructure or companies. The lack of a green taxonomy creates ambiguity among investors, making the identification of and investment in environmentally sustainable projects difficult. This impedes the pace of India's transition to a low-carbon economy by limiting the flow of foreign capital into the green infrastructure sectors.

To overcome this challenge, RBI could classify green infrastructure as a separate asset class, adopting India's Sovereign Green Bond framework that specifies several categories of green projects. A clear classification of green infrastructure assets would create a level of certainty for foreign debt investors and improve transparency in the investment process. It will also help RBI design conducive policies and regulations catering to the unique needs of the green infrastructure sector. Furthermore, this would give investors a clear signal about India's commitment to transition to a low-carbon economy. Overall, this may help reduce the financing costs of green infrastructure projects.

Relaxing external commercial borrowing (ECB) norms

External commercial borrowings (ECBs) are popular among eligible Indian entities, including clean energy companies, to raise loans from foreign investors. ECBs have made it easier for Indian entities to access foreign capital in general. However, providing preferential terms for the clean energy sector could unlock significant foreign debt capital for India's clean energy transition. RBI has already classified certain sectors, such as oil marketing companies (OMCs) and startup firms, as special categories under the ECB framework, giving them preferential terms. These preferential terms allow OMCs to raise ECB for working capital purposes with a minimum average maturity period of three years from all recognised lenders through the automatic route. This arrangement eliminates the mandatory hedging and individual limit requirements, subject to an overall ceiling of US$10 billion, and mandates prudent risk management policies. RBI should also extend similar preferential treatment to the clean energy sector.

- *Borrowing limit*

RBI can consider relaxing the borrowing limit under the ECB route to enable clean energy borrowers to raise more than the current limit of US$750 million annually through the automatic route. This would allow companies to raise more funds for their energy transition projects, potentially accelerating the growth of India's clean energy sector. The RBI has previously raised such limits to US$1.5 billion across sectors; implementing this adjustment, particularly for clean energy sectors, should not pose significant challenges.

- *Borrowing cost*

All-in cost, which includes the interest rate, other fees, expenses, and export credit agency charges, determines the borrowing cost of ECB loans. RBI should start taking steps to lower borrowing expenses like fees and other charges to reduce the landed cost for borrowers in the clean energy space.

- *Currency risk hedging cost*

The risk of the depreciation of the Indian Rupee is a significant deterrent to foreign capital inflows in India. Hedging against currency risk can be expensive, particularly for loans with longer tenures. There are also limited available options for hedging. To address this issue, RBI should take steps to lower the cost of hedging and work towards deepening India's hedging market. One potential solution is to ask the central government to establish a hedging pool for Indian companies that borrow through ECBs, enabling them to combine their needs and access better rates, ultimately lowering costs. Additionally, RBI could suggest that the government offer subsidies or other incentives to encourage currency risk hedging through a fund it manages.

Innovative use of foreign exchange reserves

A number of central banks have started incorporating climate-related risk into their foreign exchange reserve management. For example, Sweden's Riksbank has allocated climate-related risk weightages to a section of its SEK500 billion (US$48 billion) foreign exchange reserves and eliminated bonds from heavily fossil fuel-dependent areas, such as Alberta in Canada and Western Australia and Queensland in Australia.[27] The Banque de France has committed to enhancing the examination of ESG aspects in its investment choices per its responsible investment charter.[28] Hungary's Central Bank (MNB) established a specialised green bond portfolio within its foreign exchange reserves in 2019.[29]

India has one of the world's top five forex reserves, at over US$598 billion. RBI should use a small portion of the reserve to mobilise foreign investment into India's clean energy infrastructure. The Indian government can create funds that the RBI will manage, using capital from forex reserves to provide risk-mitigation facilities such as subsidies for currency hedging costs and credit guarantees to clean energy borrowers. If used judiciously, even 1–5 percent of the total reserve capital can catalyse billions of dollars of foreign investment in India's clean energy infrastructure.

Conclusion

It has become vital for central banks to play an active role in ensuring a smooth transition towards clean energy while averting any adverse effects on the financial stability of economies. In this regard, India's RBI can adopt several short- to medium-term measures to attract domestic and foreign capital towards India's energy-transition projects. These measures do not require a significant overhaul of its policy framework or monetary tools. Therefore, RBI must take these steps and embark on a new phase in greening India's financial system.

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Transition Finance: Supporting India's Net-Zero Goals

Neha Khanna, Saarthak Khurana, and Dhruba Purkayastha

Introduction

The 2015 Paris Agreement on climate change set an ambitious target of keeping the global temperature rise to "well below 2 degrees, preferably 1.5 degrees Celsius", above pre-industrial levels, and countries committed to Nationally Determined Contributions (NDCs) accordingly. A number of countries have committed to a net-zero emissions target. To transition to net-zero, countries will need to scale up zero or near-zero emission technologies such as renewable energy and associated grid infrastructure including storage and clean transport, while simultaneously reducing emissions by decarbonising hard-to-abate sectors[a] and creating carbon sinks. It is estimated that capital investments of approximately US$3.5 trillion per year will be required by 2050 to build a global net-zero economy and avert a climate catastrophe.[1] As for India, it will need cumulative investments of US$10.1 trillion by 2070 to achieve its net-zero ambitions.[2]

So far, tracked financing flows towards climate change mitigation in India are barely a quarter of the total required.[3] Transition to net-zero thus requires a significant rise in climate investment towards not only cleaner energy and transport but also the hard-to-abate sectors. Tracking at both the global and domestic levels shows that there is substantial financing for clean energy in 42 percent of total tracked finance flows—the highest for any sector. Within clean energy, finance to the solar segment stood at 41 percent. The problem lies with the hard-to-abate sectors which are far more difficult to finance. Finding solutions involves deploying and scaling up new and innovative technologies, often called 'transition technologies'.

Moreover, there is often confusion between 'financing transition' and 'transition finance'. 'Financing transition' includes any investment that reduces emissions, while 'transition finance' aims to address the financing gap by defining a class or category of finance that may not be classified as green but is still directed towards emissions reduction. 'Transition finance' as a concept has gained popularity, but there is no global consensus on its definition. What is common to all the conceptualisations, however, is a focus on decarbonising hard-to-abate sectors. Some definitions include enabling technologies such as battery storage, and could theoretically also encompass more efficient, less polluting fossil-fuel-based energy usage.

Capital (or finance) is traditionally technology-agnostic. It takes decisions based on appetite for risk and expectations of return, or expected credit losses in cases of debt (which then defines capital to be set aside – capital adequacy) and pricing of debt, unless stated otherwise. This is a hurdle to increasing transition finance, for the following reasons:

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a These are sectors whose processes make emissions hard to avoid, such as steel, cement and petrochemicals.

1. Transition finance often cannot be classified under green financial instruments such as green bonds or sustainability linked bonds.

2. An enabling environment, including facilitative policy and regulatory frameworks for transition activities and taxonomy of transition finance, is largely absent.

3. Cost of capital to transition finance technologies is typically higher because of higher technology risk, and also because transition is more of an issue in developing countries—i.e., the 'country risk' is also higher.

4. Capital investment required for new technologies may be prohibitively high.

Challenges in Mobilising Transition Finance

Absence of universally accepted definitions

For transition finance to be recognised as a class of directed financing, a universally accepted definition for it is essential.

As per European Union (EU) taxonomy,[4] transition activities are those that promote technologies whose greenhouse gas (GHG) emissions are "substantially lower than sector or industry average" in sectors that are hard-to-abate and cannot be aligned to the Paris Agreement, and "do not lead to a lock-in of carbon intensive assets" for long periods of time or turn them into stranded assets. More specificity is added by the conditions that (a) they should be important for future development and have no low-carbon alternatives, and (b) they should deploy 'best in class' technologies which emit less than the industry or sectoral average.

As Japan's Ministry of Economy, Trade and Industry has noted, transition to net-zero has to include a transition phase. In this phase, all sectors maximise efforts to decarbonise through process efficiencies, fuel switching, material circularity, and more, till technologies such as carbon capture, utilisation and storage (CCUS) become economically viable.

Another perspective is given by the International Capital Markets Association (ICMA),[5] which views transition finance as "investments that effectively address climate-related risks and contribute to alignment with the goals of the Paris Agreement." Meanwhile, the Climate Bonds Initiative (CBI) defines it as investment required to reduce GHG emissions to levels "commensurate with meeting the goals of the Paris Agreement."[6] While CBI retains a broader scope including both transition and transition-enabling activities, the Organisation for Economic Co-operation and Development's (OECD) definition is more limited in scope.[7] It says transition finance is for "economic activities that are emissions-intensive, do not currently have a viable green substitute (technologically, economically or both), but are important for socio-economic development."

The Asian Development Bank (ADB), for its part, calls it "a concept where financial services are provided to high carbon-emitting industries—such as coal-fired power generation, steel, cement, chemical, paper-making, aviation and construction—to fund the transition to decarbonisation."[8]

It is clear that while some definitions make transition finance a part of green or sustainable finance, for others, its scope is broader. Many technologies that could be eligible for 'transition finance', may in fact be emitters. For example, there are some sustainable cooling technologies that may not eliminate emissions but are essential for adaptation. Again, some recent developments in global space cooling initiatives following the Kigali Convention[b] can replace hydro flouro carbons (HFCs) by lower GHG emission refrigerants so as to reduce overall GHG emissions from cooling (but without eliminating them entirely). Use of nuclear energy (which has a waste disposal problem) or natural gas (which is less polluting than coal or oil, but far from emission-free) are two more examples of transition activity that do not seem to align with net-zero approaches. Thus, unless specified by taxonomy or regulation, the uptake or mainstreaming of the concept will continue to be hampered. The reality is that before aiming for net-zero, developing countries will have to go through a transition phase that will also need to be financed. Current instruments and market readiness for it are either nascent or minimal.

Lack of Enabling Environment

Most developing countries, including India, are yet to develop a decarbonisation pathway for hard-to-abate sectors and there is still no clarity on the preferred transition technologies. This, combined with the lack of a clear definition of 'transition finance', the fact that the nature of investments required may not align to net-zero goals in the short-term, and the inherent risk in funding new technologies especially in developing economies—disincentivise investment.

For commercial financial institutions, it only adds to the complexity of supporting climate action. Instruments that have been designed for addressing climate action traditionally fall under the classification of 'green' or 'sustainable' instruments. Even the few that provide transition finance—such as transition bonds—can support only proven and mature technologies. However, as discussed earlier, the technologies that need such funding are largely unproven or lack the

b The Kigali Convention, or the Kigali Amendment to the Montreal Protocol, adopted in October 2016 and enforced from January 2019, seeks to phase out use of hydro fluoro carbons (HFCs) with low-emission alternatives. (The Montreal Protocol of 1987 sought to prevent depletion of the ozone layer by stopping the use of ozone depleting substances (ODS). Many of the alternatives adopted, especially in refrigeration and air conditioning, were HFCs.)

typical risk-return profile expected by commercial capital. (This includes energy efficiency projects, CCUS among them.) Supporting them calls for innovation from both equity and debt financiers. Incubators, dedicated funds and other such mechanisms can also be enablers and support such businesses as they go through the stage that is called 'valley of death'.[9]

Most technologies needing transition finance are in their nascent stages and would require high upfront investment. An analysis of cost of capital for solar projects in different countries reveals that expected returns vary from 7 percent to 52 percent,[10] despite solar being a proven technology.

Table 1: Expected Returns on Investment in Solar Projects in Select Countries

Country	S&P Rating	Climate Investment Risk Premium (CIRP)	Cost of Debt (Climate Project)	Required Rate of Equity Return (Climate Project)
Germany	AAA	1%	2.8%	8.3%
Australia	AAA	3%	5.4%	8.5%
Sweden	AAA	2%	3.4%	9.3%
USA	AA+	2%	5.3%	10.3%
UAE	AA	2%	4.5%	12.6%
Saudi Arabia	A-	6%	9.3%	14.3%
Chile	A	10%	12.1%	14.4%
Indonesia	BBB	9%	9.1%	14.7%
Morocco	BBB-	10%	12.8%	15.9%
India	BBB-	9%	11.4%	17.2%
Vietnam	BB	12%	14.0%	19.4%
Peru	BBB	8%	11.7%	21.3%
Brazil	BB-	14%	7.8%	22.2%
South Africa	BB-	15%	20.3%	25.8%
Ghana	B-	19%	22.7%	28.3%
Tanzania	B	18%	24.1%	29.6%
Nigeria	B+	17%	25.2%	30.8%
Egypt	B	18%	29.5%	35.1%
Uganda	B+	17%	30.2%	35.8%

Mozambique	CCC+	22%	32.8%	38.3%
Tunisia	CCC+	23%	36.5%	42.1%
Sri Lanka	D	16%	38.1%	43.7%
Zambia	CCC-	29%	45.4%	51.0%
Argentina	CCC+	24%	54.1%	59.7%

**Based on data as of January 2023*

Source: CPI, 2023. Cost of Capital for Solar Energy Investments in Developing Economies[11]

The Way Forward

Getting the Definitions Right

While a taxonomy is important for uptake of any category of finance, in the case of transition finance it is critical. Given that India, before it reaches net-zero, will have to go through a transition that requires substantial funding, it is important to get definitions in place. The taxonomy should address the following aspects:

a. Inclusionary activities required for India's green transition, but which may align to net-zero only in the medium to long term;

b. Ensuring activities that support India's transition to a low-carbon economy are not hindered;

c. The need for a measurement, reporting, and verification system that enables accurate benchmarking of climate action technologies.

Instituting a Global Risk Mitigation Structure

There is need for an unbundled risk mitigation facility to address the steep cost of capital in emerging markets. A study mandated by the International Solar Alliance (ISA)[c] suggests creating a Common Risk Mitigation Mechanism (CRMM) that will develop an easily accessible first demand financial guarantee instrument. Such an instrument could comprise a bundle of different risk management instruments including guarantees, insurance, and swaps, which will cover risks in both local currencies and hard currencies.

c It was conducted by a task force comprising both global and Indian experts, drawn from the Terrawatt Initiative, the World Bank Group, the Currency Exchange Fund (TCX), along with the Confederation of Indian Industry (CII) and the Council on Energy, Environment and Water (CEEW).

Though the CRMM has not yet materialised, it has been widely discussed. It can be set up through a global credit guarantee facility, which would provide overall credit risk mitigation to cross-border debt financing through bonds or loans. However, this proposed facility only addresses sovereign and off-taker credit risk, and not sector-wise or project-level risks within a country.[12]

Setting Up a Global Innovation Public Fund

A global innovation public fund would promote venture investments for nascent climate technologies, including those which support transition, and push them to technological readiness. This readiness has various levels (see Figure 1), and typically, the most innovative funding—which is hard to come by—is needed at levels (TRLs) 4 to 9. Therefore, the need for a global innovation fund that supports intellectual property (IP) protection while enabling scaling of technologies. Contributors to the fund could comprise bilateral and multilateral development banks, philanthropic organisations and other public funds.

Figure 1. Levels of Technology Readiness

Concept	1	**Initial Idea** *Basic Principles have been identified*
	2	**Application Formulated** Concept and application of solution have been formulated
	3	**Concept needs validation** *Solution needs to be prototyped and applied*
Small Prototype	4	**Early prototype** *Prototype proven in test condition*
Large Prototype	5	**Large prototype** *Components proven in conditions to be deployed*
	6	**Full prototype at scale** *Prototype proven in conditions to be deployed*
Demonstration	7	**Pre-commercial demonstration** *Solution working in expected condition*
	8	**First of a kind commercial** *Commercial demonstration, full-scale deployment in final form*

Early Adoption	9	**Commercial operation in relevant environment** *Solution is commercially available, needs evolutionary improvement to stay competitive*
	10	**Integration needed at scale** *Solution is commercial and competitive but needs further integration efforts*
Mature	11	**Proof of stability reached** *Predictable growth*

Source: IEA[13]

Creating Specialised Institutions

Special institutions or divisions supporting transition finance—and not only in the financial sector—are also needed. In financial institutions, this could be in the form of a transition finance window which not only supports transition but also ensures that the institution's commitment to and green and sustainable technology is maintained. In the real sectors, there could be decarbonisation service companies (DESCOs), modelled on the lines of energy saving companies[14] which could help mainstream transition finance for decarbonisation of hard-to-abate sectors.

For developing countries to cross the transition phase successfully, mainstreaming of transition finance is required. If India is to meet its net-zero ambitions, it is critical that the basics are put in place to increase international finance flows. With the right actions, transition finance could play a pivotal role in the path to net-zero.

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III

Green Industrial Policy for India's Energy Transition

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The Need for Energy Transition

The Intergovernmental Panel on Climate Change (IPCC) has underscored the urgent need for rapid energy transition to mitigate the impacts of climate change and achieve global sustainability, recommending a range of actions to support the energy transition. These include the adoption of renewable energy resources, an increase in the energy efficiency of production and consumption, and the development of new green technologies.[1] As the fourth highest greenhouse gas emitter globally,[2] India bears a responsibility to decarbonise and help mitigate climate change. While historically, India has contributed less to global carbon emissions, it recorded the highest emissions growth among the biggest emitters in 2021—a trend likely to worsen if India does not peak and decarbonize, even as the EU and US record reduced emissions.[3] India is also one of the countries most vulnerable to global warming, which necessitates climate-resilient development and industrialisation within the country.

Unmitigated climate change could cost India over US$6 trillion in economic losses by 2050.[4] The country may be able to avoid these losses through more cost-effective energy transition investments. However, as a rapidly growing economy with a population of 1.4 billion citizens, India must diversify. It has limited financial resources while battling massive developmental needs, among them climate mitigation and adaptation. The country must therefore adopt a co-benefits approach,[5] with development at the centre of its climate and energy transition efforts.[6] Energy transition offers significant economic opportunities for India, because the technologies and industries required by countries to mitigate and adapt to the threat globally need to be developed, manufactured, and deployed at scale.

In the process, job creation and sustained economic growth objectives are of paramount importance. Also required is rehabilitating regions that are heavily dependent on fossil fuels and will decline in a low-carbon economy; as well as reskilling and upskilling affected workers in the fossil-fuel sectors; increasing access to productive energy in rural areas and meeting the growing energy demand for development and industrialisation; and ensuring that the energy transition does not lead to spatial inequality in terms of economic progress.

In addition to addressing climate and development imperatives, energy security is an essential objective for the government. While shifting away from fossil fuels decreases India's dependence on imported fossil fuels, increased dependence on imported clean energy components and raw materials is likely to compromise the country's energy security. Integrating with global clean energy value chains enables India to capitalise on the global innovation in clean energy technologies and manufacturing to accelerate its energy transition. However, most economic value creation in clean energy technologies happens up front, in innovation and manufacturing, and a failure to participate in these activities as part of the transition compromises India's economic and energy security objectives.

A number of modelling studies have attempted to estimate the economic and technological opportunities associated with India's energy transition.[7,8,9,10,11,12] The McKinsey India decarbonisation study, for example, estimates that India needs to add up to 2,700 GW by 2050, with up to 600 GW of battery storage, in order to peak and decarbonise the country's electricity sector.[10] Decarbonising the transport sector means the addition and replacement of several million two-wheelers, cars, and buses in the passenger and freight segment with electric and hydrogen vehicles, respectively.[10] . Finally, India needs 60–100 GW of electrolyser capacity to achieve its target of five million metric tonnes of green hydrogen production by 2030 to decarbonise the industry sector.[13]

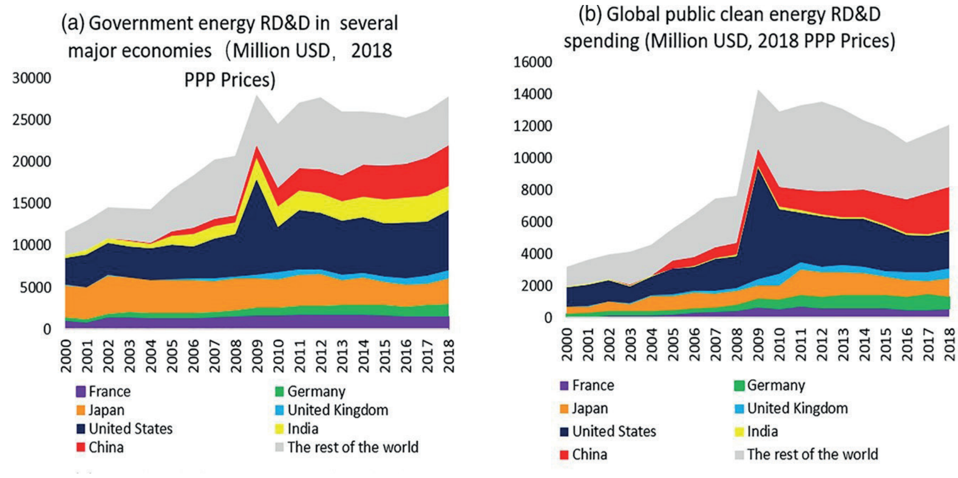
While deployment at such scale has the potential to generate economic and employment opportunities, more is needed as most of the clean-energy value creation is located upfront in innovation and manufacturing. India's existing manufacturing capacity in clean energy technologies pales in comparison to future deployment needs (see Table 1). Moreover, India's lack of clean energy Research, Development, and Demonstration (RD&D) investments as a share of its overall energy RD&D investments is insufficient to meet its energy deployment trends and the impending energy transition (see Figure 1).[14] This highlights the need for a strategic policy approach to India's energy transition to identify and implement policies that capitalise on the economic synergies of decarbonisation efforts.

Table 1: India's Manufacturing Capacities in Clean Energy Technologies

Technology	Manufacturing capacity (2022)
Solar	39GW modules 4.7GW cells
Wind	15 GW
Battery (Advanced cell chemistry)	50 GWh commissioned under PLI
Electrolysers	Negligible

Source: Mercom, "State of Solar PV"; MNRE, "Top Achievers in Wind Energy Adoption"; MHI, "Allotment made for 50 GWh"[15,16,17]

Figure 1: Government Energy and Clean Energy RD&D Investments Across Countries



Source: Zhang et al., "From Fossil to Low Carbon" [14]

Green Industrial Policy, Defined

Over the past decade, green industrial policy has taken centrestage across countries in the context of climate mitigation. Emerging economies consider the energy transition as an opportunity to climb up the innovation ladder and the manufacturing value chain, raise their competitiveness and income levels, and provide job opportunities to the millions entering their workforce.[18] Advanced industrialised economies consider green industrial policies vital to retain their competitive advantage and high value-added jobs and make a political case to domestic voters to invest in a clean energy transition.

'Green industrial policy' may be defined as an inclusive industrial policy that considers environmental objectives as an added imperative along with the social and economic objectives of traditional industrial policies.[19] Traditional industrial policy approaches, particularly the former industrial policies of East Asian countries, were primarily government interventions aimed at changing the distribution of resources across economic sectors and activities[20,21] to support industrial development and address the country's science, technology, trade, and competition objectives.[22] Along these lines, Altenburg and Rodrik broadly define green industrial policy as any government measure aimed at accelerating structural change towards a low-carbon, resource-efficient economy in ways that also enhance economic productivity.[23] The primary challenge faced by governments has been the identification of a green industrial policy mix that is suitable for their objectives, implementation processes, institutional capacities, barriers, sectors, and targeted technologies.[24] This involves the technocratic process of optimising normative decisions and prioritising some objectives over others. It also involves striking a balance between competing yet important policy objectives,[25] managing policy rents,[26] and ensuring reciprocal control with the industry[27] to steer the economy in the direction of a low-carbon transition.

At an operational level, green industrial policy comprises a set of policy tools that governments use to promote clean energy innovation, manufacturing, and deployment to become globally competitive,[28] creating and sustaining employment in the long term. Deployment policies comprise instruments that are primarily meant to diffuse clean energy technologies by mandating emissions reduction using clean energy technologies, encouraging cleaner consumption with voluntary programs, and incentivising clean energy technologies using tax credits, generation-based incentives, and other market-based instruments. Green manufacturing policies aim to incentivise individual component manufacturing in the value chain through policy tools such as local content requirements (LCRs) and incentives like special economic zones, investment tax credits, public procurement, and the exemption of tariffs on imported components. Green innovation policies aim to develop and commercialise new technologies while investing in ideas to adopt clean energy technologies to local conditions.[29]

Global Experiences

A number of countries have outlined their green industrial policy strategies in the last two decades. For instance, the Republic of Korea has been implementing green industrial policies to promote renewables and electric vehicle technologies since the mid-2000s. Its policies have been geared towards significant investments in RD&D to drive the innovation and manufacturing of high-tech clean energy components.[30] Korea's green industrial policy echoes its traditional industrial policy strategy, with policies focused on leading or catching up in the technological domain. Domestic deployment policies are sequenced to ensure that its domestic national champions have the time to develop capabilities to offer globally competitive products. In 2009, Korea launched its Green Growth Strategy to integrate economic growth with environmental sustainability. This led to the establishment of a Green Technology Center for developing and commercialising green technologies; a Creative Economy Initiative to foster innovation and entrepreneurship in the clean energy sector; and several deployment incentives for renewables including, recently, electric vehicles.[31] In 2018, ROK introduced a Green New Deal, which included ambitious investments in green infrastructure, renewable energy, and sustainable industries to create jobs and to transition to a low-carbon economy.[32]

Germany is one of the pioneers in green industrial policymaking, with its Energiewende strategy that aimed to promote renewable energy development as early as the late-1990s. Energiewende, meaning 'energy transition', has evolved over the last two decades, with the addition of various policies and milestones, starting with feed-in-tariffs for renewables in 1991 and its upgrade in 2000, to the introduction of a Climate Protection Act in 2019 that enshrines sector-specific climate targets in law.[33] Energiewende has gained international recognition as a model energy transition strategy to accelerate renewable energy deployment and reduce carbon emissions. However, the socio-economic benefits of the strategy have been extensively debated. Till the mid-2000s, the global solar industry was dominated by German solar companies such as SolarWorld and SMA Solar. Their scale needed to catch up with the demand created by Energiewende's generous feed-in-tariff (FIT) policy. Some analysts argue that Germany's FIT policy benefitted global solar PV manufacturers more than domestic ones, with domestic PV manufacturers either closing down or shifting their focus to niche, high-efficiency panels and modules.[34]

Germany's energy transition policies led to the evolution of ambitious techno-industrial policy approaches in China. Chinese entrepreneurs and provincial governments used global market formation to scale up solar PV cell and module manufacturing in the country. Provincial-level industrial policies, followed by the inclusion of solar as a strategic industry in the 11th Five-Year Plan enabled China to dominate the global solar market.[35] However, when the US and EU governments began imposing tariffs on Chinese solar PV components, China turned to its large, untapped domestic market through generous FIT policies in order to absorb the industrial overcapacity.[36] China's preference for economically second-best policies to promote industrial development in clean energy technologies led to gainful employment from Renewable Energy (RE) manufacturing and deployment. Today, China employs the most significant number of people in the renewables sector globally.[37] Unlike Germany, most of the jobs in the solar and wind industries are in manufacturing technology components. While this came at the higher cost of renewable-based electricity to the consumer, in the short to medium term, China's green industrial policies rapidly brought down the costs of technology components, thus allowing for more cost-effective renewable energy deployment within the country and globally.[38] Several countries, including India, saw the global decrease in solar PV component prices as a crucial opportunity to accelerate renewable energy deployment in a cost-effective way within their countries.

Green Industrial Policy in India

India's green industrial policies reflect a high level of support for cost-effective renewable energy deployment. While the Indian government invested in the innovation and commercialisation of solar and wind technology components in the early-2000s, its focus shifted towards deployment following the Copenhagen Climate Summit.[39] Substantive action on renewable-energy promotion in India can be traced to the late 1980s and early 1990s, which particularly focused on public institution-building to explore alternative sources for energy security.

India became one of the first countries to establish a dedicated Ministry of Non-Conventional Energy Sources in 1992 (renamed the Ministry of New and Renewable Energy in 2006) and Indian Renewable Energy Development Agency in 1987 to promote and finance renewable energy projects.

While the priority was to demonstrate wind and solar energy viability, government support throughout the 1990s enabled the domestic manufacturing of wind energy technology, making Suzlon a leading global manufacturer of wind turbines. Deployment policies began with the Electricity Act of 2003, which made provisions for the promotion of co-generation and generation of electricity from renewable sources and for mandating the purchase of a fixed share of electricity from such sources. In 2008, prior to the Copenhagen Climate Summit, the government launched the National Action Plan on Climate Change (NAPCC), with eight national missions aimed at addressing climate change and sustainable development.[40] The NAPCC proposed a target of 5 percent Renewable Purchase Obligation (RPO) policy on state discoms by 2010 and an increase of 1 percent per year up to 15 percent by 2020.[41] The Jawaharlal Nehru National Solar Mission (JNNSM, or NSM) was the most significant of the eight national missions and aimed to deploy 20 GW of grid-connected solar power by 2022.[42] The mission further aimed to accelerate solar PV development through large-scale deployment, aggressive R&D efforts, and domestic production of solar components to achieve grid tariff parity by 2022.[43]

India capitalised on the rapid decline of costs of global solar PV components after 2007, owing to China's export-oriented green industrial policies.[44] Before the Paris Summit in 2015, the Indian government revised the 20 GW solar target to 100 GW of deployment by 2022, accelerating the process of renewable energy deployment. This was the first significant step towards a low-carbon transition in the country. However, an accelerated deployment strategy provided less room for Indian manufacturers to reap economic benefits from the energy transition. Nevertheless, this did not happen abruptly; under the various phases of the NSM, the Indian government provided policy support for industry localisation. Limited early RD&D investments were a drawback to India's efforts to develop local renewable manufacturing capabilities, particularly solar capabilities. Localisation efforts without prior investments in clean energy R&D and technological upgrade meant that India locked itself into a different form of import dependence for clean energy components to secure its energy needs.

One of India's earliest efforts to invest in semiconductors and clean energy components—the Modified Special Incentive Package Scheme (M-SIPS), a capital subsidy program for electronics component manufacturing from the Ministry of Electronics and Information Technology—rarely delivered solar RD&D incentives to manufacturers on time.[45] Besides the lack and consistency of RD&D investments, pressure from state-level discoms to generate affordable renewable energy meant that there was less price room for project developers to consider procuring domestic solar PV components.

Domestic manufacturing and the promotion of clean energy industries has been a part of the energy transition rhetoric in India, but the actions are driven by the deployment of low-cost renewable energy technologies. Launching the National Solar Mission in 2010, then Prime Minister Manmohan Singh envisioned 'solar valleys', which "will become hubs for solar science, solar engineering and solar research, fabrication and manufacturing".[46] However, subsequent deployment was driven by Indian states' urgency to tap into low-cost options, which resulted in import dependency on Chinese manufacturers, who have since supplied nearly 90 percent of India's solar components.[47] Along with national policies, state solar policies have played a significant role in shaping this pattern. Although the national policies have periodically sought to place restrictions on imports, in the absence of complementary enabling conditions, such an approach does not automatically promote domestic industries.

Overall, India's prioritisation of short-term cost-efficiency in policy, while justified, given the political economy constraints, has resulted in lost opportunities to build a strong renewables industry and create employment opportunities along the value chain. Despite its early achievement of significantly low RE deployment costs through competitive auctions, the mechanism provided little room for the government to pursue industry localisation and employment objectives.[48,49]

Nevertheless, there has been a recent reorientation of India's approach to the energy transition. The introduction of production-linked incentives for promoting the manufacture of solar PV, battery technology, and electric vehicle components is attracting attention among global component manufacturers.[50] The National Hydrogen Mission 2022 and the National Electric Mobility Mission Plan 2020, with their explicit goals to develop domestic manufacturing capabilities alongside technology deployment, indicate a shift towards a techno-industrial policy approach aimed at reaping economic benefits from technologies that have highly skewed upfront value creation.

Besides the domestic targets and ambitions, India is positioning itself as a frontrunner and orchestrator of the global energy transition through championing initiatives like the International Solar Alliance and One Sun One World One Grid. In the recently concluded G20 summit, India, under its leadership, managed to build a consensus among major economies on tripling global renewable energy capacity and energy efficiency levels by 2030.

Opportunities and Challenges in India's Energy Transition

Emissions-economy models forecast the rapid deployment of solar PV, wind, battery storage, electric vehicles, and green hydrogen in the next 30–50 years to peak India's Greenhouse Gas (GHG) emissions and set the country on a decarbonising path to achieve its net-zero goal by 2070. While domestic solar PV module manufacturing has picked up pace in the last few years,[51] the manufacturing capacity of other high-technology clean-energy components pales in comparison to estimated future deployment needs (see Table 1). Policy instruments such as PLIs for manufacturing these technology components are beginning to reap economic benefits.[52] However, more than PLIs are required to bridge the existing manufacturing gap in India's energy transition. India needs a significant thrust in the innovation and commercialisation of emerging clean technologies to reap their economic benefits in the next three to five decades. Developing local capabilities is also crucial to ensure that India's energy security and trade balance remain healthy in the transition.

The mismatch in India's clean energy RD&D and its energy deployment trends as well as the impending energy transition (Figure 1) are crucial points that need to be addressed. Reorienting its RD&D investments and providing a strategic thrust to clean energy innovation and manufacturing will be imperative to ensure that India is able to capture economic opportunities in the domestic and global energy transition. Nevertheless, the development of local innovation and manufacturing capabilities is dependent on India's ability to access low-cost financing for clean energy.

A strategic industrial policy approach is particularly important in the evolving global context of deglobalisation of clean energy value chains and onshoring production activities by countries that are usually the lead markets for export-oriented development. For instance, the US Inflation Reduction Act (IRA) champions green industrial policy to accelerate clean energy technology adoption in the country while creating local employment opportunities and delinking the sector's heavy dependence on imported components from China. This is not the first time that the US has pursued an industrial policy; its loan guarantees program, as part of the American Recovery and Reinvestment Act, encouraged solar technology adoption. However, with the IRA, it embraces trade principles to localise economic benefits from energy transition.

The EU's Green Deal Industrial Plan, announced in February 2023, adopts a friend-shoring approach to clean energy value chains by proposing to create trade clubs for critical raw materials and clean-tech/net-zero industrial partnerships. While Germany championed the Energiewende program to accelerate clean energy adoption, it was China that used Germany's market formation policies to pursue green industrial policy. Within these rapidly changing global clean energy value chains and trade environment, and given that the champions of free trade and the lead markets for export-oriented development are desirous of capturing upfront value creation by onshoring or friend-shoring the manufacturing of clean energy technologies, the question remains whether India's existing localisation policies will be sufficient.

Finally, a strategic industrial policy approach to the energy transition is crucial as the lead markets implement policies to tax carbon-intensive imports. The EU's implementation of the Carbon Border Tax Adjustment Mechanism (CBAM) is one example of a major export market becoming difficult to access for countries and their firms engaging in carbon-intensive production. India's annual steel exports to the EU are estimated to reduce by up to 40 percent under a CBAM policy regime, compromising the competitiveness of Indian steel firms.[53] While the CBAM policy is likely to hurt India's competitive edge as a low-cost producer in the short term, it provides India with an opportunity to accelerate its energy transition by reducing the carbon intensity of export-oriented production. With every exporting nation to the EU about to face a border carbon-tax adjustment, India's export-oriented industries have an early-mover window to reduce the country's carbon intensity in production and position itself as a cost-effective low-carbon producer of goods in the medium to long term.

Similarly, the EU's CBAM could provide India with the opportunity to move towards green hydrogen production and reduce energy-related emissions in its industry sector. While the emerging subsidy wars to localise green hydrogen and other clean energy production (for example, green hydrogen subsidies under the US IRA policy) among lead markets is discouraging, they can be mitigated through bilateral trade agreements that allow India's export-oriented firms to access these markets and their policy incentives. A strategic approach to the emerging global policies will not only prepare India's industry sector to be better prepared for climate-constrained industrial production but will also help accelerate India's own energy transition.

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The Promise of Affordable Renewable Energy

Sugandha Srivastav

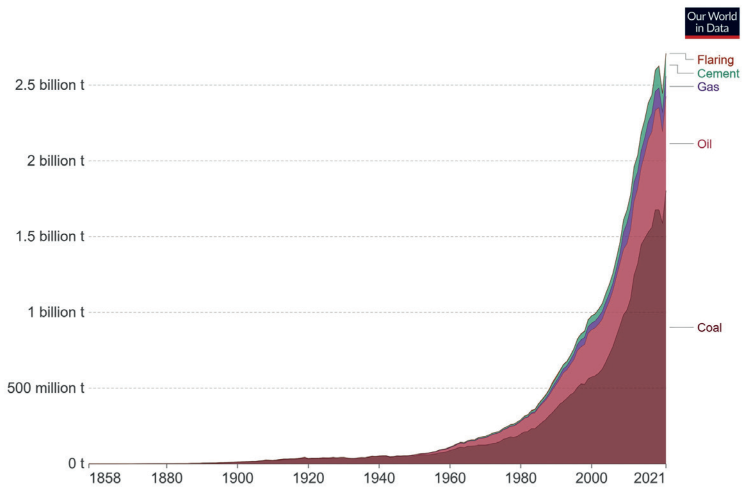
Introduction

In the early 1990s, only half of India's entire population had access to electricity; today, that proportion is 99 percent.[1] With increasing access to electricity, the living conditions of ordinary Indians have drastically improved. There are large gains across multiple development indicators; since 1990, life expectancy has increased by 10 years and child mortality has fallen from 3.4 million annual deaths to 800,000 over the same period.[2] Electricity has played a role in these developments by powering hospitals, schools, and households.

The same period (1990-2022) saw a substantial increase in the consumption of fossil fuels (see Figure 1). This came at a hidden cost. A fossil fuel paradigm replete with coal-fired power plants, kerosene cookstoves, diesel generators, and automotives powered by petrol or diesel has led to the emergent reality that nearly one in every five deaths in India can be attributed to air pollution.[3] About 660 million Indians are exposed to air that does not meet national air quality standards,[4] and coal is responsible for over half of the nitrogen dioxide and sulfur dioxide emissions, which contribute to acid rain, respiratory disease, and child mortality.[5]

India's per capita electricity consumption is around one-third of the global average. As a growing nation, India's energy demand will only rise. The challenge is meeting this growing energy need in a way that ensures affordability and does not lead to deadly air pollution. Renewable energy, with its lower costs, offers an opportunity. In 2017, India witnessed a historic inflection point: the cost of solar energy fell to INR 2.44 per kWh, 23 percent below the cost of coal-fired power.[6] This meant households could access energy that was not only hugely affordable but also clean and safe. As a testament to this new reality, Prime Minister Narendra Modi said that solar energy was "pure, sure and secure".[7]

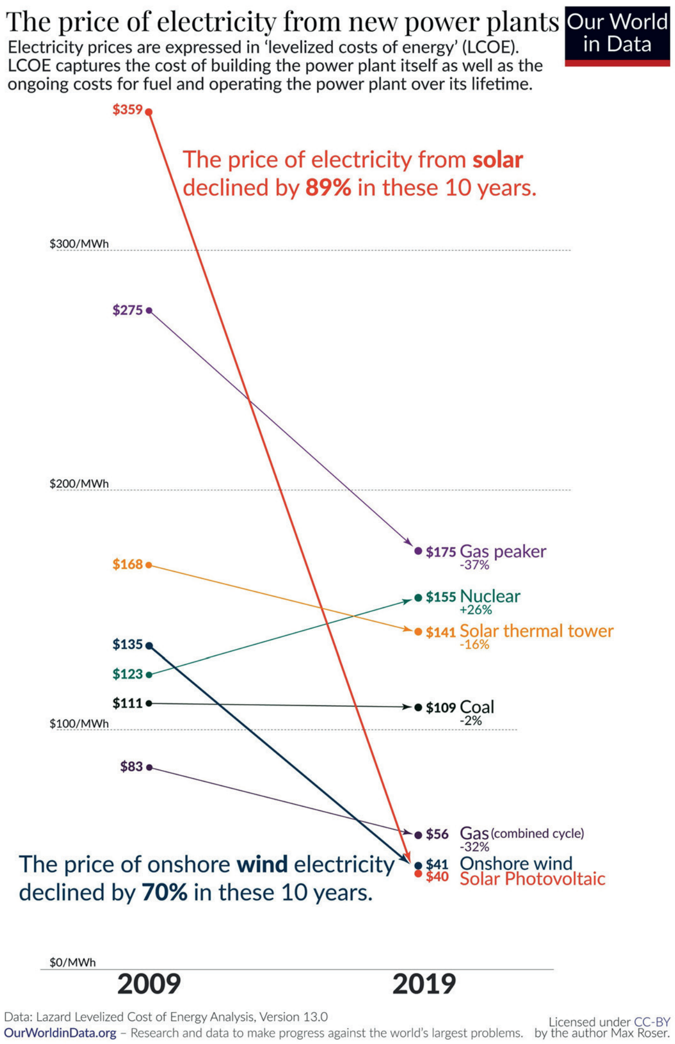
Figure 1: Carbon Dioxide Emissions in India, by Fuel or Industry Type



Source: Our World in Data[8]

Many commentators continue to think that renewable energy is expensive. This is not unsurprising given that in the clean energy sector, where change is highly rapid, those who base their perceptions on data that is merely two years old are vastly out of tune with the most recent cost structures (see Figure 2). Since 2010, the cost of solar-based electricity has fallen by 89 percent. Similar cost declines are visible for onshore and offshore wind power (see Figure 2).

Figure 2: Global Levelised Cost of Electricity



Source: Our World in Data9

Note: Solar costs for India tend to be lower than global averages

Solar PV, wind energy, and batteries are observed to follow a pattern known as Wright's Law: with every doubling of cumulative production, unit costs fall by a stable percentage—such as, for example, a staggering 20 percent for solar. This pattern is not observed for fossil fuels whose net costs have remained stagnant (see Figure 2).[10] Since exponential cost declines are notoriously difficult to comprehend, many commentators fail to recognise the cost savings that can be achieved from switching to clean technologies. In the vast majority of the world, renewable energy now provides the cheapest form of new electricity.[11] In India, 80 percent of the existing coal fleet has running costs that are higher than those of new renewable energy, even when the integration costs of intermittent power are considered. By implementing a phased switch to solar or wind-based energy technologies, savings worth at least US$6.5 billion can be realised every year in India.[12]

Indeed, many countries in the Global South have capitalised on low-cost renewable energy. In Chile, solar power now accounts for 17 percent of total electricity production and has helped reduce power prices by 75 percent.[13] In Namibia, 25 percent of the total electricity generation comes from solar power. In Uruguay, wind power accounts for 33 percent of generation.[14] In India, renewable energy contributes to 12 percent of total generation, with the proportion set to rise.[15]

In addition to delivering lower cost electricity, renewable energy has numerous other benefits. It does not involve extraction costs; the 'fuel source'—i.e., sunshine and wind—are free. Renewable energy is democratic; solar panels can be arranged in the form of a large utility-scale farm or a humble rooftop installation, offering opportunities not only to large developers but also to ordinary citizens and small businesses. Renewable energy can also be implemented in an off-grid fashion to deliver access to remote communities who do not benefit from access to grid infrastructure. Finally, by sourcing from cheaper renewable energy, distribution companies can find a more financially viable route towards keeping prices low for end-users.

Government Policies

The Indian government recognises the opportunities from renewable power and have put in place ambitious missions and policies around clean energy. These include the target to reach 500 GW of installed capacity by 2030 and the National Solar Mission of 2010—both of which have already made India an early adopter and innovator in clean energy. India ranks fourth in terms of having the largest base of installed solar in the world and is home to the largest solar farm, the Bhadla Solar Park, located in Rajasthan.[16]

Current policies that promote renewable energy include a renewable purchase obligation (RPO), which requires state distribution companies to source 21 percent of their power from renewable energy. Karnataka, Andhra Pradesh, Tamil Nadu, Himachal Pradesh, Sikkim, and Nagaland have successfully met RPO targets.[17] On the household level, innovation in payment methods for rooftop solar, such as zero down-payment contracts (also known as 'pay-as-you-go' schemes), are making the economics of rooftop solar highly attractive, alongside subsidies and net metering policies. The National Portal for Rooftop Solar makes it particularly accessible for households to apply for support schemes to facilitate adoption.

The government has also launched the Green Energy Corridor scheme to build transmission capacity that connects renewable energy generation hotspots to demand centres. An example of a key piece of infrastructure is the Bikaner Moga Line that will allow Rajasthan to export 4000 MW of solar power.

Policies around demand-side management are also important as they focus on incentivising consumers to use electricity when it is plentiful and economise in times of scarcity. In India, there is a policy proposal to reduce daytime electricity prices by 10-20 percent to encourage users to shift consumption to periods when there is abundant solar power.[18]

The policy ambition is not limited to the power sector. The Indian Railways has a target to be electrified by 2030 and powered by 20 GW of solar energy. Further, the Faster Adoption and Manufacturing of Electric Vehicles scheme, which was launched in 2015 under the National Electric Mobility Mission, seeks to incentivise greater electric and hybrid vehicle uptake through financial support.

Innovation

The Indian government is also hosting innovative renewable energy procurement auctions to push the boundaries of what renewable energy can do. In 2020, there was an auction to source 1,200 MW of renewable power during peak time blocks in the morning and evening.[19] The aim was to see if renewable generation could deal with its perceived Achilles heel of not being able to serve the evening peak. One of India's most prominent renewable energy developers, ReNew Power, successfully bid in this auction to install 300 MW of clean energy with a utility-scale battery installation of 150 MWh, making it India's largest battery installation thus far.[20] ReNew also won a second auction where the government released a tender for 400 MW of 'round-the-clock' power in which it required a plant load factor of 80 percent.[21]

Advances in machine learning to nowcast and forecast solar and wind energy output by location are making it easier to manage grids. Further, innovations in rotating stabilisers and synthetic inertia are helping manage issues related to grid stability. The persistent decline in battery costs is also noteworthy since, alongside other energy storage options such as pumped hydro, batteries can help balance intermittent generation.

Improving the Health of Distribution Companies

Distribution companies (discoms) are under tacit pressure to keep power tariffs low but are locked into sourcing relationships with coal units that experience cost overruns. The discoms bear the brunt of these overruns due to cost-plus contracts. Since a loss is often made on each unit of electricity sold, one way that discoms avoid mounting debt is to simply sell less of it (i.e., load-shedding). Every so often the debt becomes so large that a bailout must be provided. The poor financial health of discoms means critical investment in grid infrastructure gets postponed.

Since the health of discoms underpins the overall state of the power sector, contracts need to be revised such that coal plant overruns are not 'entirely' passed onto discoms. The burden of a cost overrun should be shared in a fair manner between the coal-fired power plant and the discom—this will incentivise the former to improve efficiency. If cost overruns are frequently incurred, there should be some allowance for the discom to raise tariffs. Finally, the contract should have a clear end date so that space can be created for cheaper sources of power, such as solar energy.

Better management within discoms is also required. A model of success is Delhi's discom, which was privatised in 2002. Prior to privatisation, it was experiencing aggregate technical and commercial (AT&C) losses of 50 percent. Within a decade, efficiency gains were realised; AT&C losses fell to 15 percent owing to reduced theft, better metering, and tariff revisions that helped cover the cost of supply.[22]

Conclusion

Economics, rather than any form of altruism, is driving the adoption of renewable energy in India. Markets are internalising these trends; international and domestic financing to fund new coal assets has dried up, and those investors that failed to recognise this are now contending with coal units that have lower utilisation rates since they have been outcompeted by cheaper renewable energy.

Renewable energy holds promise because it provides the cheapest form of electricity thus far. This turns the narrative on climate action around—from burden to opportunity. Cheap and abundant clean power can lift large populations out of poverty, boost economic productivity, and promote liveable cities. Data-oriented narratives are needed that highlight the existing potential of renewable power and acknowledge the role that innovation has already played, and will continue to play, in delivering a prosperous and affordable clean energy future.

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Ensuring a People-centric Energy Transition: The Case of Informal Workers in Coal Regions

Srestha Banerjee

Introduction

The growing body of scientific research on climate change in recent years has made it clear that transitioning away from a fossil fuel-reliant economy is necessary. The Paris Agreement in 2015 and the report of the Intergovernmental Panel on Climate Change (IPCC) in 2018 have also indicated the timeframe for this transition. To avoid the "catastrophic impacts"[1] of climate change, the world needs to limit global warming to well below 2°C above the pre-industrial levels and pursue efforts to limit the temperature increase even further to 1.5°C.[2] For this and to achieve net-zero carbon dioxide (CO_2) emissions by mid-century, global CO_2 emissions will have to reduce by 45 percent by 2030 from 2010 levels.[3] This will require a massive reduction in the extraction and use of fossil fuels; 90 percent of coal reserves and 60 percent of oil and gas reserves will have to remain unextracted.[4]

In response to the need to support accelerated climate action and the green transition, the Indian government has also announced important and ambitious targets for emissions reduction and clean energy augmentation, including a net-zero emission target by 2070.[5] India's updated Nationally Determined Contributions (NDC) under the Paris Agreement (as submitted to the United Nations Framework Convention on Climate Change in August 2022) has also set a target of achieving 50 percent of the cumulative electric power installed capacity from non-fossil fuel-based energy sources by 2030.[6] Achieving these targets for India will require a significant reduction in the consumption of fossil fuels in the coming decades.[7] For example, modelling studies have suggested that under a 2070 net-zero scenario, coal-based power generation needs to reduce by 99 percent between 2040 and 2060, and coal use in the industrial sector needs to reduce by 97 percent between 2040 and 2065.[8]

However, planning and implementing the fossil fuel transition will require more than a technical solution. The transition will have significant implications for the workers and local communities that are dependent on jobs and livelihoods in this sector. It will also have implications for economic vitality, government revenue, and social sector investments in regions where these industries are located. Therefore, a strategic and systemic approach is necessary to plan and implement the energy transition that is also people-centric and ensures net-positive socio-economic and environmental outcomes for the workers, and local communities impacted by the transition.

Informality in India's Coal Regions

Planning and implementing an energy transition that is people-centric and inclusive entails addressing several issues. These include economic diversification and green investments in fossil fuel-dependent regions, repurposing of land and infrastructure available with the fossil fuel industries, supporting worker transition, building resilient communities through investments in social and physical infrastructure, and securing the necessary financial resources to support transition measures.[9]

A core imperative is addressing the issues of workers who will be directly and indirectly impacted by the fossil fuel transition. Therefore, workforce transition, including ensuring their livelihood security and providing other social safety nets, lies at the heart of just transition-related policies, plans, and programmes developed by various national and subnational governments across the globe. Besides developing specific policies and programmes, strengthening baseline labour and social welfare policies has been crucial for supporting informal and indirect workers particularly associated with the coal mining-related activities and coal-based power plants.[10]

For India, too, the just transition of the workers and local communities directly or indirectly dependent on the fossil fuel industries is one of the most important aspects of the energy transition. The issue requires specific attention, given the informal nature of the Indian economy. Government assessment shows that more than 90 percent of the workforce can be accounted to the informal economy.[11]

While there are no specific estimates on the number of informal workers associated with various fossil fuel industries, district-level studies in India's major coal regions can provide useful insights. There are 417 coal and lignite mines in India spread across 51 districts in 12 states. These mines are estimated to formally employ more than 0.35 million workers, including departmental and contractual workers. Besides mining-related activities, coal companies also have employees in various headquarters. In addition to these formal workers, there are millions of workers engaged informally, including those who are engaged in various coal mining-related activities such as loading and unloading, levelling, cleaning, and miscellaneous labour work.[12] As per district-level studies, the proportion of such informal workers is at least twice that of formal workers.

Additionally, many workers engaged in coal transportation are mostly informal. For example, a worker assessment undertaken in the Korba district of Chhattisgarh, one of India's top three coal districts, shows that coal transportation by road employs at least 15,300 people in the district. This is only 15 percent less than the number of formal workers engaged in the coal mines in the district. Moreover, 188 operational coal power plants across 17 states formally employ about 0.18 million workers. Moreover, various district-level data suggests that the informal workforce is at least 1.7 times the formal workers.[13]

Apart from informal workers engaged in coal mining-related activities and coal power plants in many old coal districts, such as in the coal regions of Jharkhand and West Bengal, many people earn a living by gathering and selling coal and are part of the informal coal economy.[14] Those part of the informal coal economy remain highly vulnerable due to their low income, poor skills and education, and lack of social safety net. District-level assessments in the country's coal regions provide an understanding of the economic vulnerability of the informal workers. The daily wage rate for informal workers depends on the work they are engaged in and the contractor or sub-contractor through whom they get engaged. Unskilled workers and those with fewer school years earn between INR 300 and INR 400 (about US$5) daily. Typically, they work 16 to 20 days a month, with their monthly earnings between INR 6,000 and INR 8,000 (US$83-US$110). For semi-skilled workers engaged in technical maintenance and transportation work, the wages are comparatively higher, ranging between INR 700 to INR 750 (US$9) per day.[15] For coal gatherers and sellers, the wage rate depends on the selling price of coal in the local market. Interactions with coal gatherers and sellers in the coal districts of Jharkhand and Odisha suggest that people who sell coal (coal sellers) after buying it from local coal gatherers earn about INR 400 (US$5) per day. Their average monthly earning from such coal sales is about INR 5,000 (US$63).[16]

There is also a distinct gender dimension in the informal economy, and women work under harsher conditions. Consultations with women workers in Jharkhand, Chhattisgarh, and Odisha show that they are engaged primarily in low-skilled or unskilled labour work. These include cleaning activities and casual labour work such as carrying coal and coal gathering. They also receive wages that are at the lowest rung of the informal economy.[17]

Overall, poverty and underdevelopment in many of the coal districts, particularly in the rural areas, and a coal-centric economy in most of these districts sustain a labour market condition where the supply-demand of labour is highly distorted. In many of the coal districts, the people belonging to poor economic conditions are compelled to engage in such daily-wage work. For example, in coal districts such as Ramgarh and Chatra of Jharkhand, Angul of Odisha, Singrauli of Madhya Pradesh, and Korba and Raigarh of Chhattisgarh, the highest earning member in about 90 percent of rural households earns below INR 5,000 (US$63) per month.[18] Further, an assessment of multidimensional poverty indicators (that exhibits the status of healthcare, education, and living standards of local communities) of all coal mining districts in India (51) found that in nearly 69 percent of the districts, more than 25 percent of the population are multidimensionally poor, which indicates a proportion worse than the India average (of 25 percent).[19]

Policy Interventions

The issue of informal workers should be a key consideration for formulating just energy transition policies and plans at the national and subnational levels to ensure that the process remains inclusive, creates opportunities for all in the low-carbon economy, and leaves no one behind. The following are the key policy interventions that will be necessary to ensure a just transition of the informal workers in the low-carbon economy.

Strengthening labour laws

The country's labour laws must be strengthened to address the issues of the informal workers engaged in fossil fuel sectors and fossil fuel-dependent industries. Existing labour laws, such as the Industrial Disputes Act, 1947, do not account for transition support and any necessary compensation for informal coal workers in the event of industrial closures. The law also does not create any liability for the principal employer or the contractor to provide any compensation, transition support, alternate means of employment, or skilling assistance to the workers when facilities are being closed.[20]

Therefore, the provisions of the labour laws need to be strengthened to support and provide security for informal workers with respect to their terms of engagement, retrenchment, and transition support in the event of industrial closure. An important opportunity also lies with implementing the Social Security Code, 2020, as promulgated by the central government. Four particularly important provisions of the Code provide support to the unorganised sector workers. These include the formulation of welfare schemes by the central and the state government(s) for providing social security benefits to unorganised workers; development of a Social Security Fund, development of Social Security Boards at the national and state levels, and the establishment of career centres for worker's support. The implementation of the Code will also be important for addressing the issues of workers in the informal coal economy, such as the coal gatherers and sellers, who are beyond the scope of the industrial laws dealing with workers' protection.

Economic diversification of fossil fuel-dependent regions to support green jobs and green growth

Considering the large number of jobs that will be required to compensate for the formal and informal job loss in the fossil fuel sector, the development of green industries, including those based on agricultural and forest products will be important to create sustainable jobs while also harnessing the potential of local resources.

Investments in skilling and reskilling of workers

Specific skill development programmes will need to be developed at the state and district levels to provide targeted support to informal workers and increase their access to such programmes. Simultaneously, investments by the government and industry will be required in technical and vocational training institutes, including specifically for girls and women, to develop foundational skills.

Strengthening of social infrastructures

Social infrastructure will need to be strengthened to reduce vulnerability of the poor in the fossil fuel-dependent regions and build and enhance their adaptive capacity in the event of transition. This will include, consolidation of access to basic amenities, including clean energy, and improving affordable healthcare and education, particularly for women. While the Indian government has made significant investments to improve these sectors, further targeted interventions are necessary as evident from the high proportion of multidimensional poverty in many coal regions. The convergence of various government programmes, particularly at the state and district levels, will provide a crucial opportunity to enhance necessary investments.

Overall, ensuring a people-centric transition, particularly to guarantee security for the most vulnerable communities, will require a broad-based intervention to ensure transformative changes. This will require the development of policies and plans and mobilising the necessary financial resources through the cooperative engagement of national and state governments. The process must also ensure sufficient scope for engagement of informal workers that can capture their needs and aspirations for secure and dignified livelihoods in a low-carbon economy.

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IV

Building Resilient Solar Supply Chains

Philippe Macé, Gaëtan Masson, Alexander Hogeveen Rutter, and Ajay Mathur

Solar energy is now the cheapest form of new electricity for much of the world, especially tropical countries, where solar irradiation is highest. To support energy access, reduce electricity costs, and promote decarbonisation, solar manufacturing must ramp up from ~300 GW in 2022 to about 1900 GW by 2030. At present, China provides over 70 percent of the world's solar photovoltaic (PV) manufacturing, including over 95 percent of the world's wafer production.[1] Other countries, especially the G20, must work aggressively to build their solar manufacturing capacities in order to continue to drive down costs and build resiliency into global supply chains.

The concentration of the solar PV supply chain in certain geographies presents multiple risks, both geopolitical and economic. The development of local solar PV manufacturing in more parts of the globe would have several advantages for the entire sector, from end customers to project developers and public authorities. Even if local solar PV manufacturing is unlikely to be as cost competitive as China's, many other sources of value can be found. In addition to reducing geopolitical supply or economic risks, developing regional supply chains can increase energy independence and reduce the cost and emissions of logistics around the world.

However, the road to a more diversified and resilient global solar PV supply chain remains full of obstacles. First, investments to the order of US$150 billion will be needed globally by 2030 to develop the hundreds of GW of production capacities required along the value chain. Therefore, creating the conditions to unlock financing will be a crucial consideration for decision-makers. Second, there are enormous labour needs associated with the estimated production capacity expansions. Depending on the step of the value chain, the level of qualification of the required workforce can vary from unskilled labour, such as for warehousing purposes, to highly skilled labour, as in the case of research and development (R&D) or production supervision. Countries with limited available workforce or are lacking the necessary skills would be heavily constrained in terms of local manufacturing. This employment aspect is a powerful lever, as the creation of local jobs can also help increase social acceptance, triggering a virtuous circle where local manufacturing and local market deployment reinforce each another.

Overcoming Barriers

The unique momentum for local PV manufacturing can be leveraged even in emerging markets. However, multiple barriers still need to be overcome.

a. Decision-makers need to design holistic national strategies for solar PV, targeting both upstream and downstream elements of the value chain through specific measures and inputs from all stakeholders. This must include long-term objectives, with intermediary milestones and clear indicators allowing the measurement and verification of the achievement.

b. Different policy tools can help unlock investments:

   - As part of direct upstream measures, public entities can give grants or provide other support mechanisms, such as low-cost loans, production-linked incentives, direct tax rebates, or equity investments.

   - As part of indirect upstream measures, state guarantees and preferential tax regimes can be provided. Public authorities must also invest in infrastructures that will be essential for factories, such as those related to energy (electricity, water, or gas networks) and transportation (roads or ports). This core infrastructure must first be built prior to developing the solar PV value chain.

   - Downstream measures can also help reduce the level of risk associated with local solar PV manufacturing, especially for first entrants. For instance, tenders with strict local content requirements (within limits set by the World Trade Organization or WTO) and conditions on the origin of the installed equipment can help ensure the off-taking of part of the production by guaranteeing a certain demand level. Trade agreements with neighbouring countries can also be enacted for the same purpose.

c. Programmes can be developed to train the local population and create a pool of employment-ready workforce, supporting the demands of the local industry. Regional and international collaborations can also support skill development, including through curriculum development and trainings.

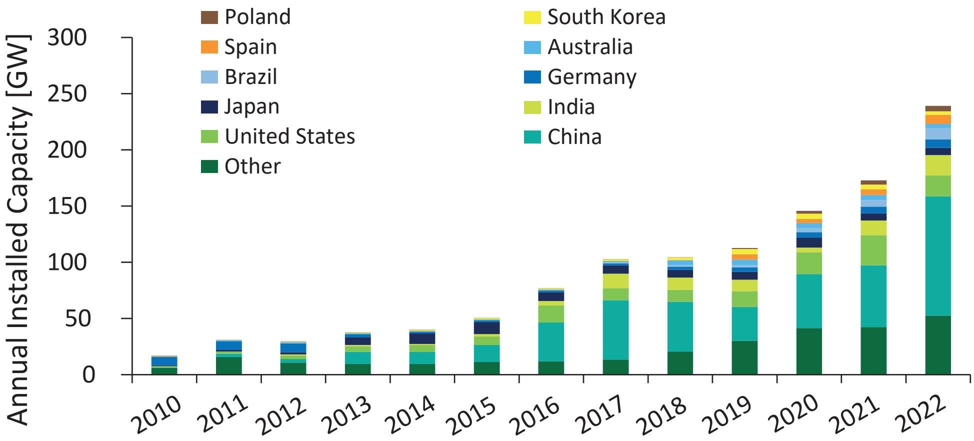
d. Investment in R&D could support technological innovation and the solar PV ecosystem.

The booming solar PV market will create opportunities to develop local PV manufacturing industrial ecosystems, if accompanied by adequate measures to support this development. However, not all countries will have the ability nor the interest to establish all steps of the PV manufacturing value chain locally. If sufficient scale cannot be reached, or if some requirements are not met for a certain step, it is preferable to focus on existing strengths, specialise in a specific domain, and evolve progressively.

Robust Solar PV Markets

In the last two years, the global PV market grew by 64 percent,[2] despite the turmoil of the COVID-19 pandemic and price and delivery tensions across the supply chain. Around 175 GW of solar PV capacity was installed globally in 2021, while first estimations indicate a market of approximately 235 GW in 2022, bringing the cumulative installed capacity to nearly 1.2 TW.[3] This represents significant growth rates and proves the resilience of the solar PV market, with 19.4percent year-on-year between 2021 and 2020 and 35.1 percent between 2022 and 2021, after six consecutive years of annual markets above 100 GW.

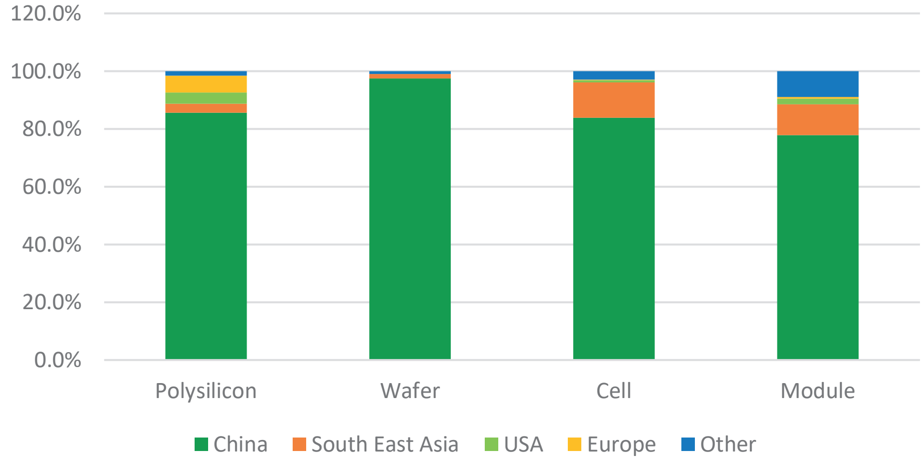
Figure 1: Market Evolution of the Top 10 Solar PV Markets (2010-2022)



Source: Masson Gaëtan, Kaizuka Izumi, et al, Trends in PV Applications 2022, International Energy Agency PVPS, 2022

With around 55 GW installed in 2021 and 106 GW in 2022, China continues to dominate the global PV market and has now been the leading market for 10 consecutive years. In 2022, it represented nearly half of all installations across the globe. The next two biggest markets are the United States (US), with approximately 25 GW in 2021 and 21.1 GW in 2022, and India, with 14 GW in 2021 and 18.1 GW in 2022. In 2022, the rest of the top 10 countries were Brazil (9.9 GW), Spain (8.5 GW), Germany (7.2 GW), Japan (6.7 GW), Poland (4.9 GW), Australia (4.2 GW), and the Netherlands (3.9 GW). Evidently, the solar PV market has remained robust in spite of recent price shocks and delivery delays, even as the leadership has shifted in the last decade—from Europe and the US to Asia, and especially China.[4]

Figure 2: Geographical Distribution of Production Capacities for the Main Steps in the PV Value Chain, 2022



Source: Masson Gaëtan, Kaizuka Izumi, et al, Trends in PV Applications 2022, International Energy Agency PVPS, 2022

China has dominated the crystalline silicon (c-Si) PV value chain for a decade, enabling tremendous cost reductions and setting global technological mainstream trends. This is true for all steps of the solar PV value chain. In the first stage, metallurgical-grade silicon, 71 percent of total production in 2021 took place in China, with all other producers (Russia, US, Brazil, and Norway) contributing less than 10 percent.

The next stage, polysilicon production, surged from 216.6 kt (equivalent to 31 GW) in 2012 to more than 1000 kt (equivalent to around 400 GW) in 2022 globally. China represented an 86 percent market share in 2022, whereas Korean and Japanese production became negligible and European and North American production stagnated. It is at this stage that the 2022 price surges occurred, which negatively impacted the downstream steps and triggered massive production capacity expansions.[5]

The next stage, global wafer production, was almost exclusively (98 percent) concentrated in China, with the remaining 2 percent located in other Asian countries and Norway. This segment of the value chain was already dominated by China in 2012, contributing over 70 percent of the global production of 36 GW. In 2022, global wafer production amounted to 381 GW.[6]

In terms of global cell production capacity, China represented 84 percent of the total estimated at 599 GW in 2022, while the rest of the world, mostly concentrated in Asia, contributed the remaining 16 percent.[7]

The final stage of module production capacity has slightly less geographic concentration compared to the other steps, mainly due to the lower energy intensity and complexity of this step, as well as the capital intensity. China represented ~80 percent of the total production capacity in 2022 while the remaining 20 percent was concentrated in Asia.[8]

Upstream Policy Measures for Solar PV Manufacturing

The International Solar Alliance, along with its partner organisations, in 2022 analysed successful cases of industrial development across sectors and regions of the world.[9] It identified public and private measures and their efficiencies across countries and evaluated replicable models in regions that are willing to develop a local solar PV industry. Despite the different contexts and varying successes of the models, some patterns emerge from the analysis. In general, holistic plans, which often indirectly support supply, are more effective because they allow the entire ecosystem to develop over the long term, through better training of the workforce and improved infrastructure. Such plans bring together different stakeholders such as public officials, large production companies, and local suppliers to make them succeed. On the other hand, in cases where the entire ecosystem does not grow at the same time, bilateral agreements between a government and a company may be effective in the short term but do not promise sustainable development over time unless the entire ecosystem does not grow with them.

The best way to support the development of solar PV manufacturing projects is direct support to upstream actors, such as through financial incentives like tax exemptions, low-cost financing, or direct subsidies (e.g., for land or infrastructure investments). Triggering demand, therefore stimulating downstream players, is also an efficient way of developing the industry, but it must necessarily be followed by further investments upstream.[10] The Indian Performance Linked Incentive (PLI) scheme and the US Inflation Reduction Act (IRA) are examples of mechanisms that enable this. In contrast, local content requirements, which have been tested in many regions, have subpar effectiveness, especially if non-mandatory but restrictive import rules are often circumvented because of loopholes.

Continued Growth of the Solar PV Market

The global solar PV market is bound to continue growing and needs to cumulatively increase by a factor of 10 between now and 2030 in order to reach the targets set by the Paris Agreement.

There are many scenarios regarding the potential of solar PV manufacturing, as highlighted by various organisations. The projected scenarios may seem daunting, but the solar PV market is already strong, with nearly 1.2 TWp of cumulative installed capacity worldwide at the end of 2022.[11] Thus, to reach 5 TWp by the year 2030, as envisaged in the 'minimum transition' scenario, an additional 4 TWp would have to be installed within ten years. Considering the development in the current market, this seems feasible.

In any case, the industry is ready to absorb such a demand, as the total annual production capacity of PV modules already stands above 250 GWp. The other two scenarios, especially the 'total transition' scenario, which has very large capacities and which would allow the Paris Agreement objective to be met, hardly appear feasible without deep awareness and the full support of the population and political decision makers. Indeed, in this scenario, the cumulative PV capacity would have to be multiplied by more than 10, from approximately 1.2 TWp by the end of 2022 to more than 12 TWp by the end of 2030. From a geographical-distribution perspective, Asian countries, mainly China and India, are expected to maintain or increase their share of annual world production in 2035, while current European and American players are expected to see a slight decrease in their market shares.

New Opportunities

The booming global solar PV market will create opportunities for new industry players, but these opportunities will not be distributed evenly across the solar PV value chain's steps.

First, starting at the very beginning of the solar PV value chain, the required quantity of quartz to be extracted each year in order to cover the demand of the (c-Si) solar PV value chain would have to increase significantly in order to keep up with the growing demand of the solar sector, at least until 2030, especially in the case of the 'total transition' scenario. As the global annual production of quartz (and quartzite) is estimated to amount to around 5,000 to 6,000 kilotons today, the competition for this resource will increase. On the other hand, it creates opportunities to develop mining sites in new locations or expand existing ones. Additionally, as prices will probably be impacted upwards, sites that were previously unprofitable might become economically attractive. This step might be the real bottleneck for the industry. The analysis of metal-grade polysilicon's production step tells the same story.

The estimations of required production capacities from polysilicon to modules show that overall, the solar PV industry is already on a path that could allow the sector to achieve the defined scenarios. It also means that incumbent actors are well-positioned and that the opportunities for new entrants would be far more limited in the 'minimum transition' scenario and, to a lesser extent, in the 'ambitious transition' scenario, especially since most of the growth is expected to occur prior to 2030, which leaves limited time for new actors to prepare and act. This is particularly true for polysilicon to wafers, whereas the field would be more open in the case of cells and modules, where the technology turnover is higher (useful lifetime of equipment of 5–7 years) and will create opportunities, especially after 2025. On the other hand, the 'total transition' scenario, which might appear to be an extreme challenge, would create massive opportunities for new entrants at all steps of the value chain, as the production capacities for development are significant.

Even in the least ambitious scenario, the demand for input materials, components, and consumables would be multiplied by a factor of three within less than ten years. In more bullish scenarios, this factor could grow to four or even nine, depending on the considered component. Thus, the industry, in terms of supply of somewhat less crucial inputs, will have to adapt extremely fast. There has already been evidence of shortages, such as in terms of glass or encapsulant supply, which demonstrates that shortages and competition could arise that could have negative impacts in terms of cost and market deployment. Even if efficient recycling develops in the future, it will fail at easing tensions, as decommissioned capacities are far from possessing the levels of capacity to be installed in the coming years. On a more positive note, this can be seen as an opportunity for new actors to enter the field of photovoltaics.

There is also tremendous opportunity for new entrants to leverage emerging technologies to gain market share in solar PV. For example, emerging technologies such as TOPCON[a] (expected to be the largest form of solar PV by 2035) requires new equipment and processes relative to existing technologies, which creates an opportunity for countries to 'leapfrog' into the most efficient technology. Similarly, investments in R&D to increase the stability and efficiency of perovskites/tandem cells could create an opportunity for technology leaders to carve out a new niche in the market.

The assembly of solar cells into modules appears to be the easiest entry point among the four main steps of the c-Si solar PV value chain, thanks to reduced constraints, such as in terms of capital-intensity. New entrants in the PV manufacturing field facing multiple constraints should start with the least-complex steps, using mainstream technologies, and progressively integrate vertically. The strategy to enter the solar PV manufacturing field and the associated recommendations vary according to the characteristics of the concerned region or country as well as the pursued objectives. There is significant opportunity

a TOPCON technology has an N-Type Silicon substrate and a thin tunneling oxide is applied, followed by a layer of highly doped with n or p poly silicon that contacts the metal at the ends. These tunneling oxide blocks one type of carrier and thus they are called passivating contacts. The TOPCON solar cell efficiency was reported at the laboratory scale in the first and second quarters of 2013 at about 21.8%. By 2017, it had reached 25.8%. The efficiency is estimated to increase to 28% after 2028.

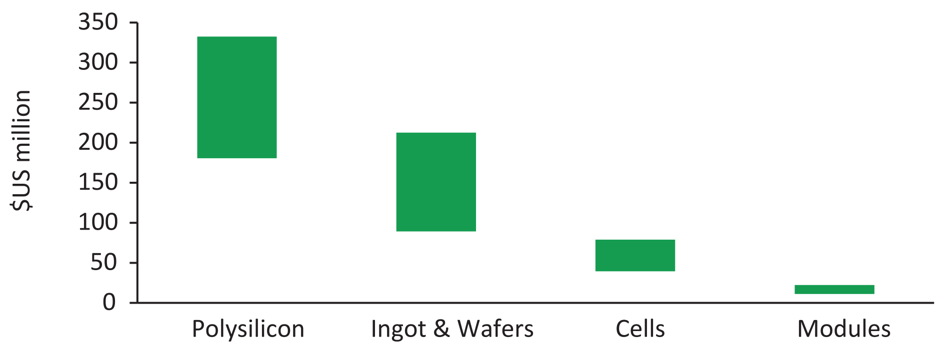
and value for new entrants in the solar manufacturing space, though training of workforce, equipment, and financing must be addressed.

The rapid increase in production will create a strong demand for a trainer workforce, with total direct employment of 500,000 people in the minimal transition and up to 2.5 million in the total transition scenario by 2025. However, 30–40 percent are expected to require training and a specific diploma, which creates a significant need to rapidly scale and train the workforce.

There is also a risk of bottlenecks in equipment suppliers, particularly in the ingot and wafering stages. It is crucial for different regions to redevelop local expertise and rebalance the distribution of the solar PV value chain across the globe.

Finally, the scale of investment required to set up solar manufacturing is significant, as shown in Figure 3. At less than US$50 million, module manufacturing may be an appropriate first step, particularly for emerging markets with less access to capital.

Figure 3: Average Minimum Investment Required Per Value Chain Step



Source: Becquerel Institute analysis based on IEA, Solar PV Global Supply Chains, IEA, Paris, 2022 12

The total capex required between 2026 and 2030 is about US$110 billion. This may be a challenge, especially for emerging markets. However, relative to the scale of capital investments in the fossil fuel industries, this figure is achievable. In a diversified supply chain scenario, investments would be much more evenly spread across regions.

Conclusion

Transforming the energy system is not easy. It requires forward-looking choices to deliver radical action and extraordinary levels of international cooperation. Building new solar manufacturing facilities can cost billions of dollars, and companies need assurance of demand to justify such large investments. It is crucial that countries show policy consistency in continuing to support solar deployment, rather than vacillating on energy and climate policies. Countries, industry, and organisations must collaborate on further improving global access to components and raw materials while also focusing on R&D for renewable energy (RE) technologies.

More countries, especially the G20, need to develop solar manufacturing capabilities to meet energy access, affordability, and decarbonisation goals. Countries must promote pro-solar policies, coordinate on standards, and invest in technical development to ensure that the enormous challenge is met. In addition, continuous capacity building, shifting of energy subsidy from fossil fuels to RE, and coordination on standards could serve as the pieces of the puzzle that must be solved to avoid catastrophic failure.

This article is based on an International Solar Alliance–Becquerel Institute report "Building Resilient Global Solar PV Supply Chains", published in 2023 by the International Solar Alliance.[13]

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A Global Climate Alliance for Accelerated Climate Action

The Global Climate Alliance (GCA) Collaborative

Introduction

Climate change poses an existential crisis for our planet. The Paris Agreement set an ambitious target of limiting the increase in average global temperatures to 2°C above pre-industrial levels by the year 2100 to contain the most damaging effects of climate change. However, while countries have reiterated their decarbonisation targets, greenhouse gas emissions (GHG) have continued to rise.

Immediate and substantial action to address this crisis is only possible if the Global South[a] and the Global North engage in partnerships to formulate mitigation, adaptation, and resilience policies. Over the past two years, several global institutions have collaborated and pooled their individual research efforts to form the Global Climate Alliance (GCA) Collaborative.

The GCA Collaborative is proposing an open and inclusive Global Climate Alliance to accelerate and catalyse the Global South's ability to undertake climate action. This 'coalition of the willing' aims to facilitate mutually beneficial decarbonisation pathways between the Global North and the Global South through financial and technology partnerships.

"As GCA members, countries would:

a. commit to binding Paris Agreement–aligned transformation pathways with absolute near-term targets, both economy-wide and sectoral;

b. develop transformation roadmaps in key tradable sectors to prevent carbon leakage; and

c. implement a comprehensive climate finance package that would result in trillions of dollars of incremental climate financing from the Global North to the Global South."[1]

The Need for a Global Climate Alliance

There is academic consensus that previous climate agreements have failed to achieve their desired targets owing to the problem of free riding.[2] Even with current policies in place, the United Nations Environment Programme (UNEP) projects a significant rise in average global temperatures, with a 2.8°C rise expected by the end of the century.[3] The global climate simulator, En-ROADS,[4] projects a 3.6°C temperature increase by the year 2100 if we the current trajectory is not reversed.

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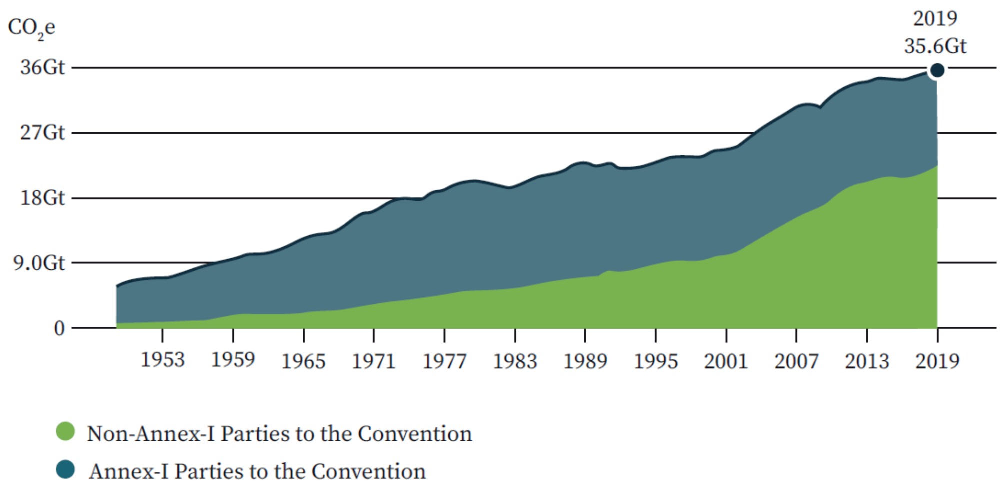
a The global South is a term used to refer to non-OECD-and-China countries. China, owing to its economic size, has demonstrated the capacity and resources to undertake decarbonisation activities on its own.

Global climate action needs to be dramatically accelerated to achieve the critical target of keeping warming to below-2°C by 2100. To facilitate global climate action, platforms such as the United Nations Framework Convention on Climate Change (UNFCCC) have held multiple rounds of discussions that have resulted in landmark agreements such as those negotiated in Rio (1992), Kyoto (1997), and Paris (2015). However, as suggested by Figure 1, CO_2 emissions have continued to rise significantly over the last seven decades. The agreements have struggled to set differentiated targets for developed and developing countries, ensure compliance with set targets, and provide sufficient incentives to countries to remain within the agreement framework.

Figure 1: Historical CO_2 Emissions—Annex-I and Non-Annex-I Countries



Source: Authors' reconstruction[5]

An Alliance for Mutual Benefit[b]

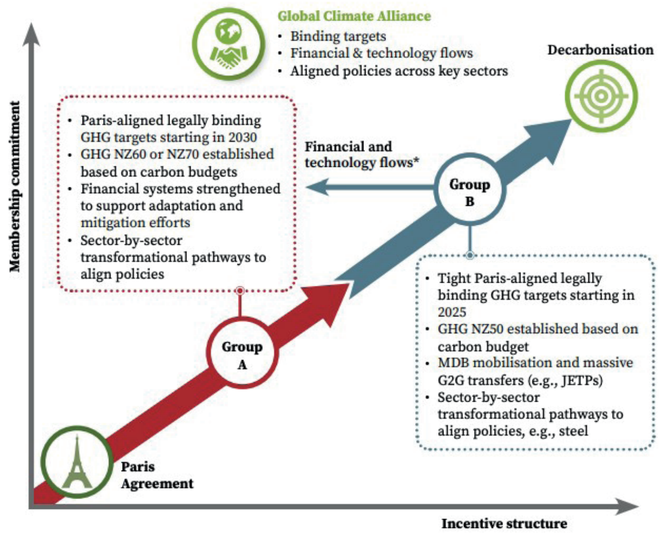
The proposed GCA seeks to resolve existing challenges by facilitating mutually beneficial agreements between the Global North and the Global South. With these compacts, the Global South commits to legally binding targets and receives financial incentives from the Global North for compliance.

The proposed GCA will comprise two groups: Group A members, who would commit to following net-zero pathways to lead to significant GHG-emission reductions, starting in 2030, and to net-zero emissions by 2060 or 2070; and Group B members, who would commit to following net-zero pathways by 2050 that would lead to quantifiable and transformative results in key sectors. Nations willing to participate in the GCA would be free to join either group. However,

b The proposal seeks to build on N. Stern et al., Collaborating and Delivering on Climate Action through a Climate Club: An Independent Report to the G7 (London: London School of Economics and Political Science, 2022).

since the principle of 'common but differentiated responsibilities' (CBDR) is at the heart of the proposed alliance, Global North countries are expected to join Group B, whereas Global South countries will join Group A. Regardless of the groupings, member countries can pursue transformative cooperation in decarbonising a particular sector, and both groups can obtain and provide mutual support for such transformative activities.

Figure 2: Proposed CBDR-Based Global Climate Alliance Framework



Note: Developing countries in Group B will be entitled to the same financial flows as Group A developing countries/least-developed countries (LDCs). NZ stands for net-zero.

Source: As conceptualised by the authors

Most Global North countries have already made firm legal commitments to achieve their net-zero targets by 2050. Data from the Intergovernmental Panel on Climate Change (IPCC) suggests that the majority of the emissions (>60 percent) in the next seven decades will be from the Global South. The focus of the GCA shall therefore remain on facilitating decarbonisation in this region, primarily through return-generating investments by investors and companies in the Global North.

Net-Zero is Net-Positive

Such a transformation will be vastly beneficial for countries. Certain modelling studies[6] indicate that a full economy-wide transformation in the Global South countries, India, Indonesia, and Brazil, will require an annual investment in the range of 4.5-9.5 percent of national GDP. Such a large-scale green transformation will significantly enhance the development of Global South countries.

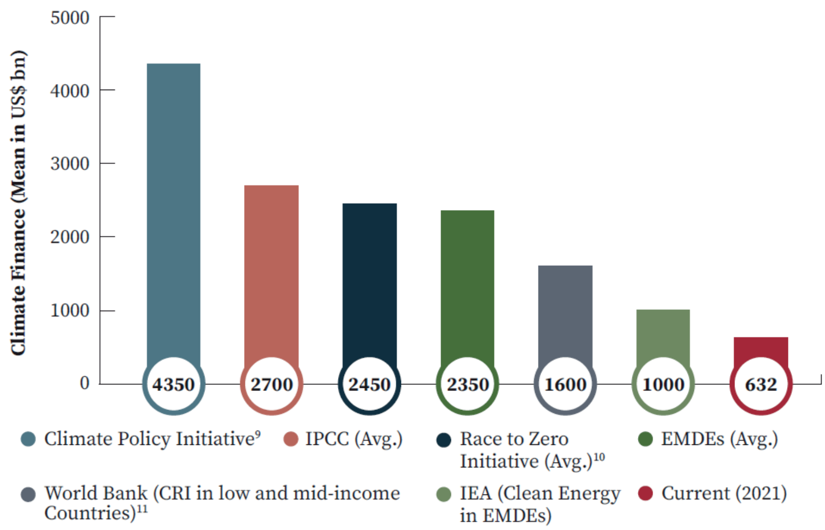
Unfortunately, given their limited resources and fragmented financial systems, it is not feasible for low- and middle-income Global South countries to finance such an economy-wide transformation within the next two or three decades. Additionally, even as the Global South struggles to finance mitigation measures, it is forced to deal with the negative consequences of unabated climate change. Extreme weather events such as flooding, storms, and droughts require disaster management and climate insurance, along with massive relief operations.

The commitment of developing countries to sector-specific transformation pathways will focus investments from developed countries to support the transition. Such financial support will further incentivise an increase in commitment levels, creating a mutually beneficial situation for both sides while strengthening collaboration.

Membership Incentives: Financing Solutions for Adaptation and Mitigation

By 2030, trillions of dollars in investments need to be mobilised annually in the Global South to mitigate the effects of climate change and to adapt to its consequences (Figure 3). This is far more than the US$100-billion pledge made by the developed countries in Paris.

Figure 3: Climate Finance Requirements in 2030



Source: Compiled by the authors based on data from Climate Policy Initiative,[7] IPCC,[8] Race to Zero Initiative,[9] World Bank,[10] and IEA.[11]

Current levels of climate investments and climate finance in the Global South are critically inadequate and need to be considerably scaled up to effectively tackle climate change. As per data from the International Energy Agency, emerging markets and developing economies invested only around US$773 billion in clean energy in 2022 as opposed to the annual requirement of US$ 1.7–2.2 trillion. Two-thirds of this investment was in China, which has the financial resources to make the energy transition on its own. Meanwhile, Africa accounted for just 4.1 percent of global climate investments.[12] Statistics from the Organisation for Economic Co-operation and Development (OECD) show that the annual US$100-billion pledge by the Global North countries was not met in any year.

The Global South does not generate sufficient domestic savings or investible capital to undertake climate action that is compatible with the goals of the Paris Agreement. Consider India: the annual incremental investment required for the country to achieve net-zero by 2070 is estimated to be in the range of US$50–100 billion, while total annual corporate capital expenditure (capex) is only around US$60–80 billion.[13] The transition to green steel alone would cost the Indian economy an additional capex of US$10 billion every year.[14] To meet its renewables Nationally Determined Contributions (NDCs), India would need to ramp up its current capex by five times. Given India's scarce domestic capital, these vast investments will have to be sourced from the Global North. Moreover, the bulk of this projected amount will have to be market-driven, because decarbonisation entails fundamental changes in the means of production, consumption, and other economic activities which are concentrated in the private sector, such as wholesale power, transportation, steel, cement, fertilisers, real estate, and food processing.

Climate Financing Gap in the Global Financial System

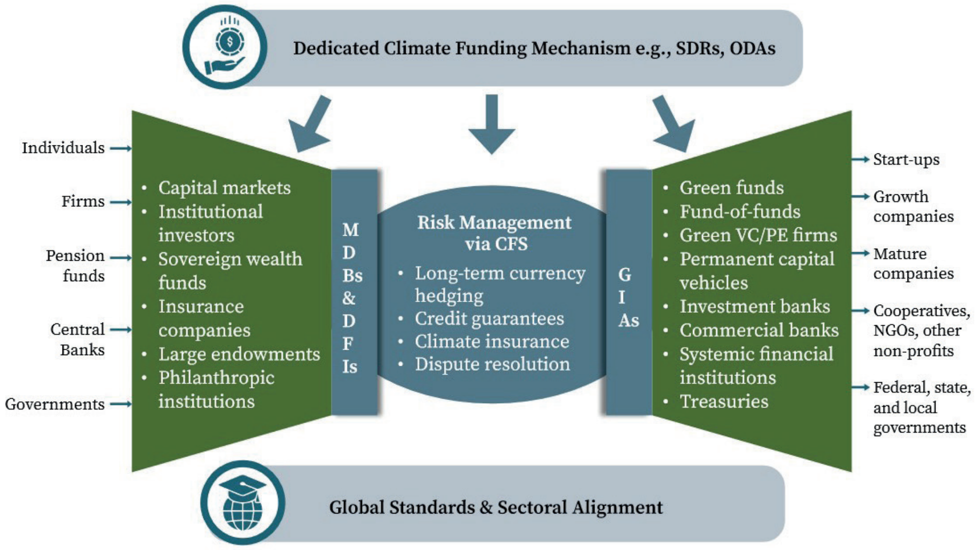
Multilateral institutions such as the International Monetary Fund (IMF), the World Bank Group, and other Multilateral Development Banks (MDBs) have been unable to bridge this vast financing gap despite having a mandate to provide financial intermediation. Private sector capital mobilised by MDBs amounted to approximately US$17 billion and US$31 billion in 2019 and 2020, respectively.[15] The bulk of development finance revolves around public sector concessional loans. For example, guarantees and risk-management products represent only around 4 percent of the International Finance Corporation's (IFC) mobilisation, at US$475 million and US$40 million, respectively.

The Global North has sufficient investible capital to meet this large climate financing gap, housed in pension funds, sovereign wealth funds, and private insurance companies, among others. However, this money has yet to find its way to the Global South. Investors from the Global North perceive multiple risks in investing in the Global South, which drives up the cost of capital for Global South companies. At these high costs of capital, very few green investments are possible. Some of the key risks pertinent to Global South countries are currency risks, counter-party risks, and policy risks. These systemic risks are separate from the usual business risks that investors face, necessitating policy attention. Further, these risks have been compounded by inadequate financial systems in Global South countries, which have been unable to deploy finance in the right bankable green projects.

Re-Engineering the Global Financial System for Climate Finance

The global financial system needs to be re-engineered on both the demand and supply sides to enable climate finance to flow smoothly. The GCA can aid the process of building the entire climate financing pipeline—from raising public finance through novel means to deploying them in relevant projects.

Figure 4: Climate Finance System (CFS) to be Supported by GCA



Source: As conceptualised by the authors

The handbook detailing the financial proposal for a GCA recommends a three-fold transformation of the global financial system.[16] First, at the foundational level, the GCA can act as the appropriate forum to shape a cohesive regulatory framework for green investing. This entails defining sectoral policies and regulations, delineating the processes of investments, setting the standards on climate reporting, and identifying the institutions that will oversee the transfer of financial flows. Establishing a consistent green taxonomy and an effective disclosure policy is of utmost importance.

Second, the GCA could work with multilateral institutions to catalyse private capital flows in two ways—by reducing risk for private financial institutions investing in Global South countries and by increasing investment flows to these countries. Both activities will require significant changes to existing MDBs in terms of skill enhancement, management depth, and balance sheet expansion. There are at least four products/structures that can be aggressively scaled up by MDBs to help reduce investment risks:

a. Long-term currency hedging via currency swap lines;

b. Credit guarantees via identified payment-guarantee institutions;

c. Climate insurance via a global risk pool; and

d. Climate fund-of-funds to anchor venture capital funds.

The focus on mitigation does not imply a neglect of adaptation finance. Broadly, this can be channelled through specifically targeted funds, namely:

a. Just Energy Transition Partnerships targeted at Global South countries willing to take on more demanding transformation targets;

b. A Climate Resilience Fund to help countries face and respond to loss and damage arising from climate disasters; and

c. A Climate Innovation Foundation to strengthen research capabilities for climate change solutions—both for adaptation and mitigation.

Finally, the GCA can facilitate the creation of local green investment agencies (GIAs) to help identify and deploy blended finance. The GIAs can mobilise in-country financial expertise and engage diverse stakeholders within a climate transformation ecosystem. In addition, the GIAs can play a key role in sharing best practices, business models, and financing approaches. They can be modelled along the National Investment and Infrastructure Fund (NIIF) in India or the Indonesian Investment Authority.

Raising Resources to Facilitate Financial Intermediation

Countries in the Global North need to forego modest budgetary outflows to support the smooth flow of climate finance. Several studies have advocated novel ways of raising climate finance:

a. Raghuram Rajan has outlined a proposal called the Global Carbon Incentive (GCI) Program,[17] which offers a mechanism for mobilising funds through a fair and objective calculation. Through this, each country that emits more than the global average per-capita emissions would make annual payments to a GCI fund, calculated by multiplying excess emissions per-capita by the country's population—anything above the global average—by the GCI—a predetermined 'price' per ton of emissions.

b. Other studies advocate for meeting Official Development Assistance (ODA) targets and scaling bilateral concessional loans to bolster risk financing and adaptation needs.

c. Repurposing and recycling the IMF's Special Drawing Rights through strengthening MDB balance sheets or issuing SDR-backed bonds are other ways to scale public finance.[18]

d. Finally, private philanthropy can supplement the entire process, particularly in building knowledge institutions.

Mobilising climate finance with a thrust on commercial capital will generate positive returns, both for private investors and governments in the Global North. In fact, the Global North's financial resources will largely go towards supporting investments by Global North investors and companies in the Global South.

Membership Commitment: Driving Transformation Pathways

Global South countries may find it challenging to introduce economy-wide transformation reforms. The best way to get started would be to focus on the key emitting sectors. Countries would have the agency to chart their own transformation pathways under the GCA but would coordinate on identifying sectoral targets and working sector-by-sector to achieve GHG neutrality in the chosen sectors. These pathways to near-zero emissions for key sectors will be collaboratively aligned through sectoral working groups under the GCA. "Countries will work on their sectors of choice—those where they can maximise emissions reductions in accordance with their capabilities and commitments."[19]

Coordination with the Global North to achieve climate neutrality would be beneficial to Global South countries especially in hard-to-abate sectors such as steel, aluminium, cement, fertilisers. By reconciling policy goals in proportion to those of the Global North, the Global South would be able to mitigate policy risk, thus, allowing them to attract significant investments at lower costs. For example, energy efficiency standards are quite ubiquitous across the world without any cost to exporting or production capacities in developing countries. Additionally, sectoral working groups can serve as a forum for investors to support industries in developing countries.

Steel Case Study

The steel sector is an important case study for the implementation of the GCA through deep collaboration. The GCA has held initial discussions with steel sector representatives and policymakers from India and the European Union. The conclusions were reported in the GCA Handbook:[20]

- "Emphasis on the importance of identifying ambitious and transparent transition pathways, including the establishment of a standardised definition of low-carbon steel and the target share of primary low-carbon steel production and steel recycling, while recognising differentiated rates of change in the short term for the Global North and South;
- The importance of credible and effective policies in national markets, including both price-based and non-price-based climate change mitigation instruments; and
- A vital role for international climate cooperation and partnerships that can address financing challenges to transform industries through investments in new technologies and technology research and development, including in carbon capture and storage (CCS) and green hydrogen."

Conclusion

Although the proposed GCA is based on collaboration and trust with a system of positively reinforcing incentives, ensuring compliance and transparency are at the heart of the Alliance. Governance and compliance support for the GCA will need to be provided by a permanent secretariat. The GCA could also have several committees, including on key sectors for policy alignment; implementation agencies to ensure monitoring, reporting, and compliance; and one to facilitate the delivery of the financial package. In its briefing to the G20 Presidency, the GCA Collaborative asserted that "the Indian presidency (representing lower-income and Asian countries) along with two other co-chairs (one representing OECD countries, and the other representing middle-income countries and South America)"[21] could co-sponsor the GCA initiative.

The GCA could be a historic, game-changing alliance. The design builds on multiple existing climate agreements to provide real and renewed momentum to combating climate change. It is envisaged to be a coalition of the willing with the audacious hope that all G20 countries—representing 85 percent of global GHG emissions—will join the Alliance.

If Global South countries commit to the Paris Agreement's target of limiting temperature increases to 1.5°C above pre-industrial levels by end of the century, they will benefit from faster GDP growth, better public health outcomes, higher levels of job creation, and greater energy security. It is, therefore, in the interest of Global South countries to decarbonise. In return for binding near- and longer-term transformation targets, Global South countries in the GCA will receive highly attractive financial returns to accelerate adaptation and mitigation measures—a majority of which will come from the private sector, with steady long-term returns. The GCA could yet be a triple win—for the Global South, the Global North, and the planet.

Endnotes

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Mobilising Climate Finance: The Transformative Role of Multilateral Development Banks

Gopalika Arora

Introduction

The world is at a critical juncture marked by both risks and opportunities: there is the promise of robust growth and development, while formidable challenges impede progress. Low- and middle-income countries already grapple with issues like stagnant growth and productivity, accelerating inequality, inflationary pressures, and worsened fiscal conditions leading to debt distress. Simultaneously, tackling climate change is becoming increasingly important as the window for taking collective action is narrowing rapidly. Globally, there has been increased focus on green and inclusive development, especially as part of countries' growing commitments towards the SDGs. However, the pandemic has worsened the existing disparities between countries and their ability to effectively address the climate crisis and allocate resources towards initiatives related to climate change and green development. Additionally, compared to pre-pandemic projections, the economic losses from the COVID-19 emergency are much larger in low-income countries (LICs) and are likely to persist over time, further derailing the progress made in the pursuit of sustainable development.

Developing countries need approximately US$4.5 trillion annually till the end of this decade to meet their SDG financing needs.[1] The current annual investment is approximately US$1.4 trillion, and there is an annual financing gap of US$3.1 trillion.[2] The annual SDG financing gap increased by 56 percent—reaching as much as US$3.9 trillion—in 2020.[3] Government revenue, which is one of the primary and largest sources of development finance, accounted for about 80 percent of the total decrease in SDG financing in 2020.[4] Least developed countries (LDCs) have been grappling with the challenges of inadequate development finance over a long time. The gap in financing critical SDGs in LDCs is expected to be as high as 10 percent of the GDP by the end of this decade.[5] Approximately 27 percent of the average GDP of LDCs is required to finance SDG investments, with private investments constituting 73 percent of the investments and public investment constituting about 26 percent, with the remaining 1 percent accounted for by public-private partnerships. Financing critical SDGs will require an additional 10.4 percent of the GDP allocation annually till 2030, compared to the current 2.9 percent.[6]

Despite notable advancements in both bilateral and multilateral public financial contributions since 2013, the commitment to provide US$100 billion annually by 2020 was not fulfilled.[7] Multilateral development banks (MDBs) have played a pivotal role in assisting nations in their transition towards a low-carbon economy. However, these institutions are at a critical turning point. Having navigated post-conflict resurgence, developmental initiatives, and crisis rehabilitation over the preceding decades, they are now confronted with the dual challenge of advancing development imperatives and reconciling them with emerging global priorities. These institutions find themselves under duress due to the cumulative impact of successive crises. While MDBs played a pivotal role in orchestrating a substantial segment of the global response to the COVID-19 pandemic, their capacity to sustain such exceptional levels of financial support is hindered by their financial and operational frameworks. In 2019, their disbursements accounted for less than 0.3 percent of the recipient country's GDP (excluding China)—a stark contrast to the 0.55 percent recorded in 1990.[8] Additionally, due to increasing interest rates, the net transfers from MDBs could soon turn negative. Despite the numerous initiatives aimed at reforming MDBs—such as the Bridgetown Agenda, the World Bank Group's Evolution Roadmap, and recommendations from the G20 expert panel assessing MDB capital adequacy frameworks—there is now growing agreement on the necessity to re-evaluate the mandates, operational approaches, and the scale and nature of the financial aid provided by MDBs.

In this context, this analysis aims to articulate the existing challenges for MDBs in bolstering development finance for climate action and provide comprehensive recommendations to create space for innovation, revamp the operational model of MDBs, and accelerate progress towards sustainable development.

Development Finance Landscape: Current Objectives and Discrepancies

Despite the significant improvements in both bilateral and multilateral climate financial support, the commitment to deliver US$100 billion each year by 2020 was unmet, leaving a deficit of approximately US$17 billion in 2020.[9] According to the Independent Experts Group report, funding for climate action and sustainable infrastructure in developing countries (excluding China) needs to increase fourfold by 2030.[10] Simultaneously, funding for other SDGs, especially in areas like healthcare and education, need to go up by at least 75 percent. Additionally, US$740 billion per year will need to be funded by private sources. The report further specified that, for every dollar they lend directly, MDBs currently bring in just US$0.6 from private investors. This ratio needs to be doubled, and MDBs must aim for at least double the private capital for every dollar they lend directly. Some US$500 billion each year in official development funding will be required by 2030, out of which US$260 billion should come through MDBs. Of this, US$200 billion should be in the form of additional regular lending and US$60 billion, in additional grants and loans with favourable terms. Thus, MDBs need to triple their yearly commitments, aiming for US$300 billion in regular lending and US$90 billion in grants and favourable loans by 2030.[11]

The growth in financial support from MDBs between 2019 and 2022 was underwhelming. Multilateral climate finance in low-income economies only rose by US$1 billion in 2022, whereas MDB climate finance for middle-income economies increased only from US$33 billion in 2019 to US$48 billion in 2022[12] (Figure 1).

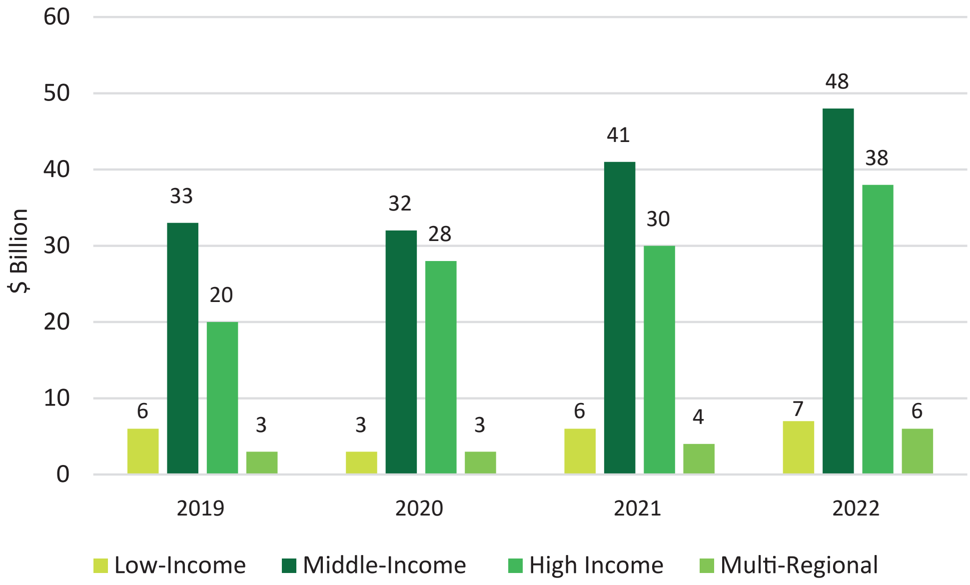


Figure 1: Climate Funding by MDBs, Categorised According to the Income Levels of the Receiving Economies

Source: Joint Report on Multilateral Development Banks' Climate Finance 2022[13]

In 2022, MDBs allocated US$60.7 billion worth of funds to support climate finance in low and middle-income economies.[14] These funds were divided, with US$37.9 billion, representing 63 percent, allocated to mitigation efforts, and US$22.7 billion, constituting 37 percent, earmarked for adaptation initiatives.[15] Additionally, according to the Joint Report on MDB's Climate Finance (2022), in 2022 the World Bank made a commitment of US$311.6 billion, representing 52 percent of the total MDB climate finance for low and middle-income economies. Additionally, the Asian Development Bank has committed US$7.1 billion, representing 12 percent of the total MDB climate finance in 2022.

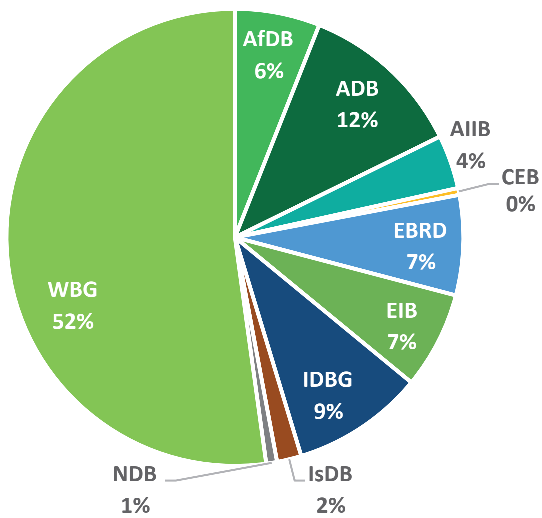
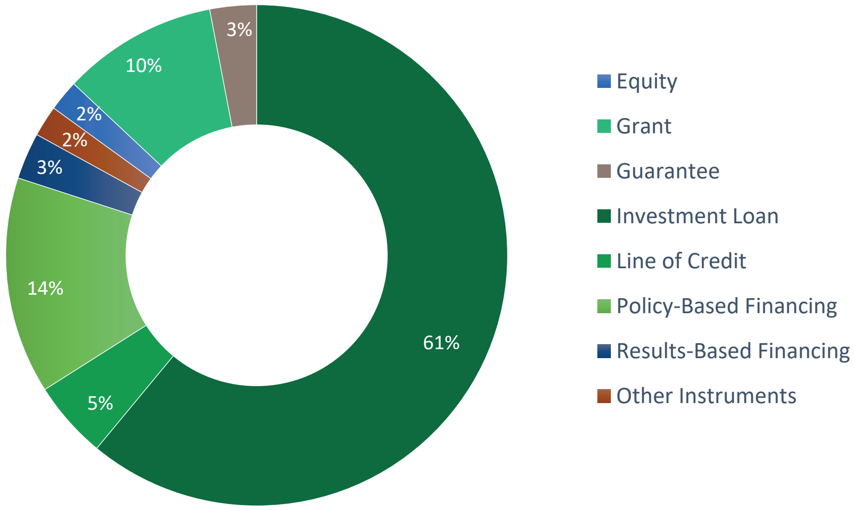


Figure 2: Total MDB Climate Finance for Low- and Middle-Income Economies

Source: Joint Report on Multilateral Development Banks' Climate Finance 2022[16]

Further, 61 percent of climate finance for low- and middle-income economies has been committed through investment loans, followed by policy-based financing (14 percent) and grants (10 percent).

Figure 3: Total MDB Climate Finance by Type of Instrument (%)



Source: Joint Report on Multilateral Development Banks' Climate Finance 2022[17]

It is important to note that the report only provides overall figures for their historical commitments to climate finance. However, there is a lack of detailed project-level data to support these figures. Such data is crucial to ensure transparency and accountability of the MDBs. In low- and middle-income countries, where external funds can be easily redirected, transparency becomes significant for all stakeholders.

Additionally, as seen from the analysis presented in this section, climate adaptation receives significantly less funding compared to mitigation; MDBs have allocated two-thirds of their climate financing to mitigation and only one-third to adaptation. This skewed distribution needs to be balanced. Furthermore, the proportion of concessional funding within multilateral contributions has consistently been less than 50 percent of total climate financing. This raises the question of whether multilateral climate finance might increase the debt load on these institutions, potentially undermining its intended purpose of enhancing capacity, especially for adaptation in developing nations.

Existing MDB Reforms and Identified Shortcomings

There has been a notable increase in the initiatives for the reformation of MDBs. The Independent Review of MDBs' Capital Adequacy Frameworks, published in July 2022, focuses on ways to optimize the financial capabilities of non-concessional programs while simultaneously boosting total MDB financing using their current capital.[18] At COP27, an independent high-level expert group released a report advocating for substantial boosts in climate finance from MDBs.[19] Before COP27, the Bridgetown Initiative agenda of September 2022, led by the Prime Minister of Barbados, aimed to achieve lower borrowing costs.[20] It further provides strategies that would enable entities like MDBs to obtain funds at reduced interest rates, which can then be extended to those in need, sparing them from the higher borrowing costs associated with conventional banks. Additionally, it proposes extending assistance to nations in financial need due to natural calamities. The agenda primarily targets middle-income countries, which can sustain without extremely low-interest loans. The World Bank Group Evolution Roadmap was also designed to prepare institutions to deal with the impacts of a changing climate regime. This initiative also largely focused on middle-income countries to address the contentious issue of distribution of concessional finance.[21]

Despite these initiatives, there is still a long road ahead for MDBs to accelerate climate action, especially in lower-income countries. The combined impact of the global pandemic, the Russia-Ukraine conflict, food and energy insecurity, debt crises, and severe climate-related disasters has caused multiple shocks to the development sector. MDBs are inadequately equipped for this evolving landscape, as they are primarily mandated to respond to a single moderate global shock every decade. However, this seems to be an outdated perspective, which is reinforced by the following challenges.

a. The international financial architecture is misaligned with the climate agenda.

The current international financial architecture remains a legacy of the developments after the Second World War, and while development has been a key mandate for public institutions, climate change and green transitions have been completely off their radar. In an evolving world order, where governments and institutions acknowledge the pressing challenges posed by global warming, the mandates, standards, and regulations driving capital have failed to keep pace with the complexity and urgency of the climate crisis. The international financial architecture overseeing the allocation of private capital also suffers from 'short-termism', which renders a risk-return profile incompatible with green transition investments. Moreover, public finance and private capital are also not deployed in a way that would help draw complementarities and optimise investments for green development. The international financial architecture in its current form fails to internalise the cost of emissions, presenting a significant market failure and requiring urgent public policy action.[22]

b. Increasing debt distress in LICs

The Russia-Ukraine war is exacerbating financial instabilities and widening economic disparities between the Global North and the Global South. The LDCs suffer the most, and the pandemic further worsened their existing debt, with the total external debt amounting to US$31 billion in 2021.[23] As of April 2022, more than half of the LDCs were in high risk of debt distress.[24] The cost of SDG financing is also increasing in these countries.[25] Amid the rising debt distress, the G20 leaders launched the Debt Service Suspension Initiative (DSSI), which extended the same debt treatment to all requesting countries, allowing temporary liquidity relief through the suspension of debt service.[26] Additionally, the Common Framework for Debt Treatments was established to address liquidity and insolvency problems.[27] However, these measures have been insufficient to meet the requirements of countries seeking debt relief. The action on delivering debt relief has also been slow. Moreover, although the burden of a changing climate regime falls disproportionally on LICs, they still lack adequate climate finance. The MDB reform agenda till date has been skewed towards MICs, despite LICs requiring greater financial assistance to tackle the growing demands of climate mitigation and adaptation.

c. Lack of adequate institutional capacities

Large-scale investments are necessary to fuel green development and green transition in developing countries. While domestic mobilisation of capital will be crucial, the bulk of the investments will have to be provided by international sources. However, weak institutional capacity and governance have been common challenges precluding the movement of finance towards the Global South. Insufficient capacity to prepare long-term investment strategies and develop green bankable projects remains the most persisting constraint. The development of policies and institutional frameworks alone will be inadequate to create an increased influx of foreign capital for green investments, and these must be accompanied by effective implementation to demonstrate political commitment and appropriate policy signals to purveyors of global finance.[28]

Revolutionising Multilateral Development Banks: A Transformative Four-Point Agenda

1. Augmenting the capital base

The Capital Adequacy Framework (CAF) suggests that MDBs should more assertively leverage their capital by adopting fewer conservative approaches to manage their financial risks.[29] The framework also promoted the idea that MDBs should treat a portion of their callable capital as regular capital when assessing their capital adequacy. While this might allow MDBs to leverage both paid-in and callable capital and expand their financing at no cost, it might not be a good idea in the long-run. Regular capital, often referred to as paid-in capital provided by member countries during the bank's establishment, serves to ensure an institution's operations and protect its shareholders. On the other hand, callable capital becomes necessary when regular capital is insufficient to meet bondholder payments, thereby safeguarding the interests of bondholders. Considering these two forms of capital as equivalent could potentially obscure the distinctions in their functions.[30] Therefore, the solution that needs to be prioritised on the MDB reform agenda is preserving invested capital to enable increased lending. Resources from global institutions like the International Monetary Fund (IMF) should be accessible for MDBs for lending or as a source of capital; alternatively, such institutions could serve as last-resort lenders.

2. Increasing the focus on LICs within the MDB reforms paradigm

The primary reform agendas for MDBs largely focus on issues faced by the MICs; however, their goals also need to focus on LICs. The Bridgetown agenda does not emphasise the necessity for concessional finance, which is crucial for LDCs. On the other hand, the CAF recommendations underscore the importance of boosting MDB finance using their current resources rather than concentrating on concessional finance windows that permit MDBs to provide loans to LICs.[31] Therefore, it is important that any expansion of the MDB mandate is accompanied by a significant increase of their financial capacities. It is imperative that all efforts towards augmenting development finance are directed in a manner that benefits all income groups.[32] The foremost way of achieving this is to increase the level of concessional finance. Concessional finance is the most substantial provider of affordable finance to LICs, although the current volume of finance is insufficient for climate action. According to the Report of Independent Experts Group, concessional finance needs to triple by 2030 to meet development objectives, especially in low-income economies.[33] Concessional funding can be increased by bringing in different types of funding—such as reusing special drawing rights (SDRs)—and transferring financial risk to both private and public players, which can help unlock more capital and increase capacity significantly. Furthermore, utilising innovative instruments, including SDRs, voluntary carbon markets, philanthropy, and guarantees will help expand the scope of concessional finance.

3. Mobilising greater private finance by fostering collaboration with the private sector

MDB reforms discussions have largely overlooked the subject of mobilising private finance. Currently, MDBs attract a mere 60 cents in private capital for every dollar they invest independently. MDBs should aim to double this figure,[34] which will require them to undertake innovative de-risking mechanisms to make use of the private capital. Innovative public finance will need to complement and facilitate private capital towards green opportunities in developing geographies. Public finance will also need to contribute to areas where there are significant spillovers or where revenue streams are inadequate to attract private capital. Risk reduction and blended finance mechanisms must be deployed at scale to reduce the cost of capital, which is particularly critical for transition and development in emerging economies. Most importantly, MDBs will need to play a much larger role to infuse their own capital at almost three times their current annual flows but also catalyse public and private finance for green investments globally, particularly in LICs.

Private finance can also be leveraged by introducing innovative financing instruments that can be tapped to mobilise finance. These instruments have a plethora of benefits, including high capital flows, greater liquidity, and enhanced transparency.

The development finance landscape has evolved significantly since the first green bond was issued in 2007. Today, there are various thematic bonds, such as sustainability-linked, blue, green, and sustainable bonds. The worldwide market for these bonds surged to US$3.5 trillion in 2022, nearly tripling the amount from 2021, and it can be additionally utilised to attract substantial financing.[35] Additionally, de-risking instruments such as blended finance can also aid in leveraging larger private investment.

4. Building capacities and improving data accessibility

Mobilising large-scale public and private capital is critical to accelerate sustainable solutions and realise the SDGs. While the provision of such capital from both domestic and international sources needs to be prioritised, ways to increase the absorptive capacity of low and middle-income countries for this capital also need to be examined. Promoting new development paradigms and pushing for technology transfers, knowledge sharing, and resource building among the government, business, civil society, and philanthropy will be necessary to achieve this shared vision and the goal of green development. The knowledge building of various stakeholders in the ecosystem, including policymakers, regulators, investors, and industry personnel on issues across the spectrum of climate, nature, and social issues is essential for the establishment of a concerted and combined effort towards the green development imperative.[36] In addition to capacity limitations, there are significant gaps in information that pose challenges to assessing needs and distributing the limited development funds. Having access to reliable data and information is therefore crucial to attract and retain investments. It is essential to address data issues and create new platforms by prioritising technology, big data, and machine learning.

Conclusion

Recent discussions in prominent global forums, including the G20, COP27, and COP15, have highlighted shortcomings in the current international development financing framework. This is especially evident in the face of interconnected challenges such as climate change, increasing living costs, and the debt issues confronting developing nations. Global financing architecture is at a critical turning point. Having dealt with reconstruction, development, and crisis recovery over the past several decades, global institutions are now grappling with the dual challenge of advancing ongoing development goals while addressing new global priorities. This has led to issues arising from a changing climate regime and persistent development challenges, which MDBs and the fragmented global finance architecture are not equipped to address. Enhancing the climate and development initiatives of MDBs necessitates a substantial broadening of their initiatives as well as a boost in their funding.

The developing world needs to collectively adopt the role of being a cornerstone of stability, particularly in terms of mobilising and utilising larger resources to tackle global challenges. In this process, they can be assisted by multilateral institutions that demand better integration of their immediate priorities in the strategic global reform agenda.

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