

Decarbonization of India's energy sector

Policy roadmap to achieve
clean energy targets

June 2022



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Overview



Recognizing the importance of combatting climate change, India has set itself the target of becoming net-zero by 2070¹. Besides the overall goal for 2070, India also has set targets² for 2030:

- ▶ Meet 50% of its energy requirements from renewable energy
- ▶ Reach non-fossil fuel capacity of 500 GW
- ▶ Reduce carbon emissions by 1 billion tonnes
- ▶ Reduce carbon intensity by 45%

The significant progress by the renewables energy sector in India - including a four-fold increase in renewable energy capacity in less than eight years is a remarkable success story.³ Key flagship policy initiatives are also underway to further promote Government's agenda, in addition to energy efficiency which has been an area of focus for India over the years.

Despite the progress, India's current energy reliance is primarily from coal and crude oil. It would take large investments to replace these with clean energy sources. India has been and is projected to be amongst the fastest growing economies globally. Availability of reliable and competitively priced energy would be a key prerequisite to ensuring high levels of economic growth for India. According to CEA estimates, India would require 3.5 trillion units (TUs) of electricity by 2036-37 to support a 7.3% economic growth rate as against 1.37 TUs, in 2021-22⁴.

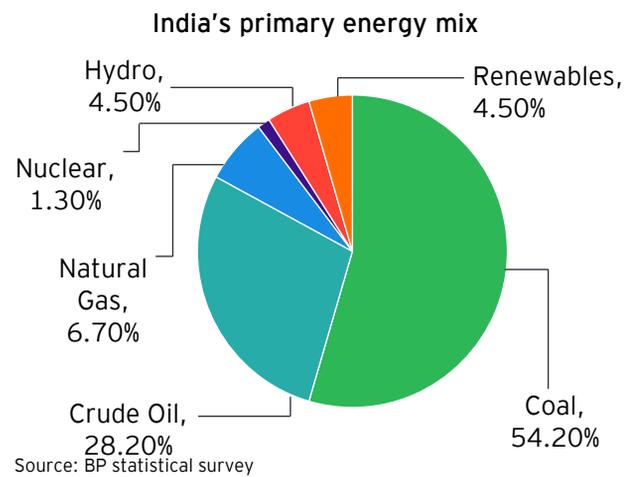
Renewable energy capacity has increased from **39.5 GW** in 2014 to **151 GW** in 2021⁵

Solar tariff reduced by **70%** and wind tariff reduced by **50%** between 2014-2021⁶

Under the intra-state transmission system of Green Energy Corridors **7,362 circuit km** lines have been constructed⁷

➔ India's energy transition and decarbonization agenda is to create a new clean energy system with reliability, affordability, sustainability and energy independence.

A cleaner energy system would also result in a more competitive Indian economy, in context of implementation of measures such as Carbon Border Adjustment Mechanism under discussion in the EU.



Several schemes launched for enhancing domestic manufacturing capacity - especially in the areas of solar PV, electric vehicle, batteries

Government flagship policy initiatives:

- ▶ Green hydrogen policy
- ▶ Offshore wind policy
- ▶ Promotion of electric vehicles
- ▶ Introduced green day-ahead market
- ▶ Eased terms for open access to buy green energy

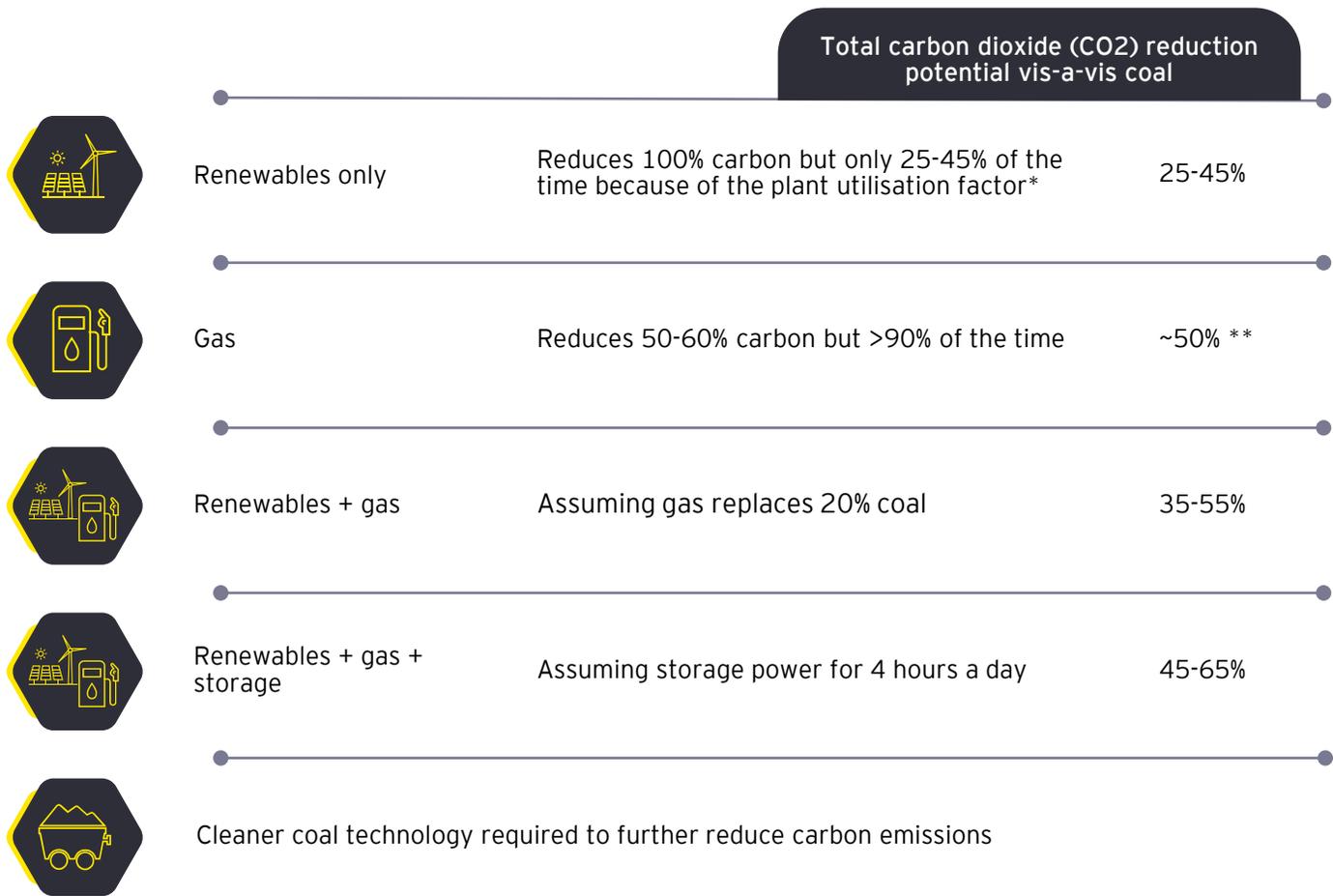
1,2. India's new climate action targets at the COP- 26 Summit in Glasgow, announced by the Prime Minister of India

3. EY Analysis

4. Central Electricity Authority

5, 6, 7. Ministry of New and Renewable Energy, Annual Report 2020-21

 Illustrative paths towards phasing down coal: Renewables ++ strategy would be most effective



Source: EY & GE Analysis
 * Assuming complementary use of solar and wind
 ** As per CEA CO2 baseline database 2021
 Note: Impact of CO2 on building and land not captured

Pathway for phasing down coal in power generation to reduce CO2 emissions requires complementary strategies.

Renewables alone are not sufficient as power generation from solar and wind is not round the clock. Gas power would be necessary to complement coal and increase the CO2 impact. Gas power produces about 50% less emissions than coal⁸ and can be used as base load power complementary to solar and wind.

In addition, storage systems are crucial to meet the gap between time of power generation and consumption.

Finally, despite the above efforts, in the near term, India would have to continue to rely on coal power which means that emphasis on cleaner coal is very important.

8. Central Electricity Authority CDM CO2 Base Line Database version 17.0 Survey



Policy considerations for energy decarbonization with reliability, affordability and energy independence:

Energy independence

Currently, India is dependent on imports for 35-40% of its primary energy requirement⁹. Economy becomes susceptible to volatility in global energy prices.

Government will have to consider the creation of domestic capabilities across the entire clean energy value chain through initiatives like production-linked incentives (PLI) in other products besides solar panels and advanced chemistry cell (ACC) batteries.

Innovation

Achieving net-zero is both a technological and a financial challenge. There are various possible pathways to achieving the net-zero target based on the technological choices made. Large scale commercial exploitation is dependent on further innovations that can bring down the costs or achieve other technological challenges. Policies should not predict the future setting or narrow pathways for technologies and sources of power. Policies should create the right incentives for innovations to happen.

Creation of markets

Creation of India-specific carbon markets that create market incentives for adoption of clean energy and technologies. While currently one of the strategies being followed is open access to buy green energy directly by businesses, widespread adoption of such measures may make the grid increasingly complex. In addition to policy initiatives such as development of green open access, other market measures that incentivize decarbonization of businesses and address the needs of a complex energy system through market-based prices would become very important.

Mobilizing investment

India would also need significant amounts of capital as it transitions towards net-zero. Current estimates of investment requirements are about US\$ 10.1 trillion by 2070¹⁰.

While the estimates may vary, the policymakers would have to consider ways of mobilizing the required capital.

9. As per EY estimates

10. Centre for Energy Finance (CEEW-CEF)- 18 November 2021: CEEW

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Clean energy sources and strategies



Wind energy



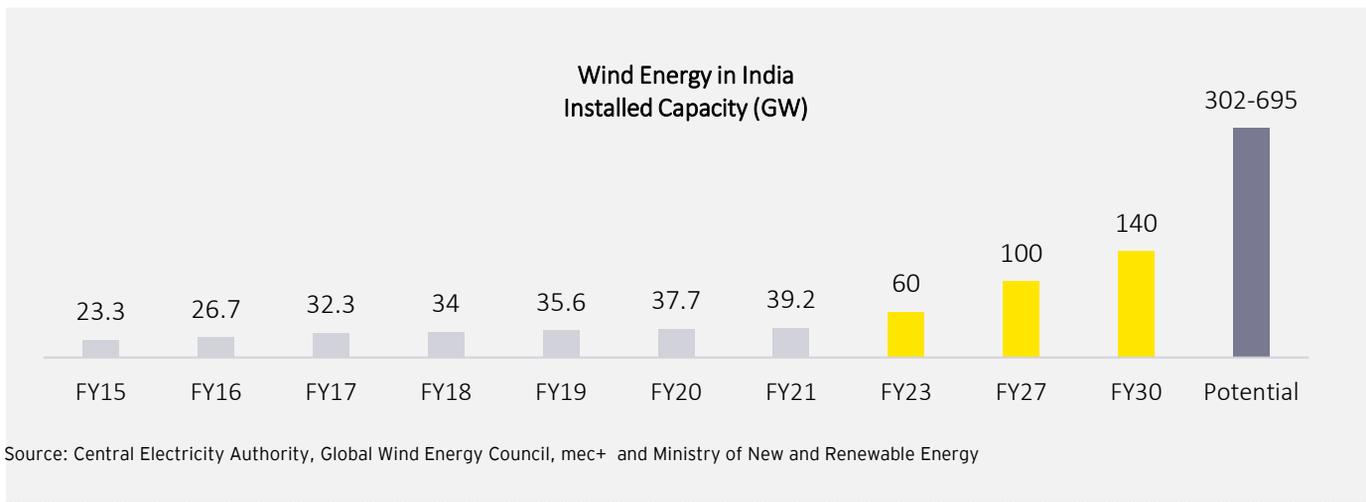
Wind energy is crucial for India to achieve green energy transition

- ▶ India has already made significant headway in terms of growth of solar energy. Wind energy will play a crucial complementary role to other renewable energy sources such as solar for round the clock power generation
- ▶ Wind energy (for example offshore wind projects) would be important for production of green hydrogen due to higher capacity utilization factor and greater generation period
- ▶ India is already the 4th largest¹¹ in the world in terms of installed wind energy capacity and has potential to grow to a much larger size.

Currently India lacks the domestic manufacturing technology for offshore wind such as longer rotor blades with high tech materials such as newer composite materials (for instance carbon fiber) that are stronger, more reliable, environmentally friendly and can be produced economically and at scale.

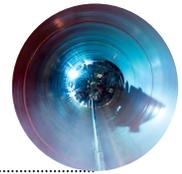
Creation of a domestic manufacturing ecosystem for large-scale wind turbine and components projects may reduce costs and increase adoption of the new technologies. Government initiatives such as production linked incentives for such projects would help increase wind energy adoption, besides leading to energy independence as well as creation of exports hubs for a growing technology being used globally.

The obligated entities must be strictly required to follow the renewable purchase obligations (RPO) trajectory to promote generation and consumption of renewable energy, including wind energy, across states. It is needless to state the importance of adhering to must run status of existing wind farms, except for grid stability reasons.



11. Ministry of New and Renewable Energy: Overview of Wind Energy: <https://mnre.gov.in/wind/current-status/>

Gas



Natural gas currently accounts for about 6.7% of India's energy mix¹² which the Government targets to raise to 15% in 2030. As per Central Electricity Authority (CEA), the current gas-based generation capacity is 25,000 MW.

Gas plays an important role in clean energy strategy besides renewable owing to the flexibility it provides to power grid. Plants can come on - and go offline quickly, adjust power output levels, and turn down to a very low output level to balance supply and demand as needed. Because electricity supply and demand must always be in balance, renewables require dispatchable backup power such as natural gas power plants or storage such as batteries to ensure system reliability. Gas is well suited due to its high energy density (requiring less land which is a concern in big metros), and lower environmental impact. However, the utilization of gas-based power plants in India is low.

Challenges in increasing the usage of natural gas are high import reliance, high and volatile prices and inadequate gas infrastructure. However, given the importance of gas in the overall clean energy strategy, India should consider using gas plants selectively.

Currently, gas-based power plants generate about 50% lower emissions than coal-based power plants as per the database maintained by the CEA. The carbon impact of natural gas-based power plants can be further lowered by the use of carbon capture, utilization and storage (CCUS), or the use of low-carbon fuels, such as hydrogen, making them future-proof investments for immediate emissions reductions.

Need to expand investments in infrastructure and gas sourcing

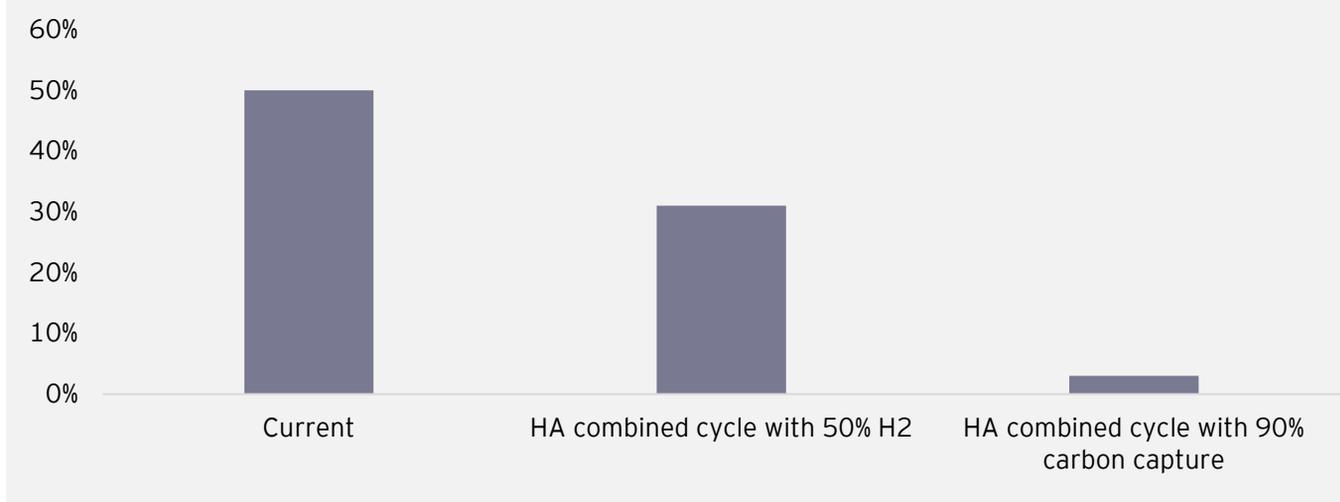
The existing gas plants may require revival and retrofitting for usability, particularly in round-the-clock power projects.

There is a need to expedite the expansion of gas infrastructure (Pipelines and LNG terminals) to cater to the expected multi-fold demand in the long-term by promoting frequent biddings and capacity expansion plans. Volumes are required to underpin the growth of the pipeline network. Power generation is the largest application of gas globally.

Gas pricing competitiveness

- ▶ Gas may be included in India's new Goods and Services Tax (GST) regime to increase gas competitiveness.
- ▶ Producers may be given greater freedom to invest and produce more gas, extracting it economically and viably.
- ▶ The country could put in place a clearly defined gas pricing policy, especially for gas plants for round-the-clock power projects.
- ▶ Promote the use of hydrogen - blended with natural gas in gas power generation via pilot projects under the National Hydrogen Mission.

Carbon emissions intensity for gas turbines vis-a-vis coal



Green hydrogen



Today, hydrogen is carbon-intensive and used in the industrial sector, with 96% of hydrogen having a high carbon footprint¹³. Low carbon hydrogen is expected to play a central role in decarbonization efforts across the globe.

While it is highly debatable to discuss the adoption of fossil fuel-based hydrogen rather than green hydrogen, it is likely that both blue and green forms of hydrogen will be necessary to drive hydrogen-based economy. The path for the deployment of hydrogen will require an amalgam of technological maturity and its cost competitiveness with other existing methods. The cost associated with the production of green hydrogen is many times higher than blue or grey hydrogen, which will impact its deployment at an early stage of value chain development.

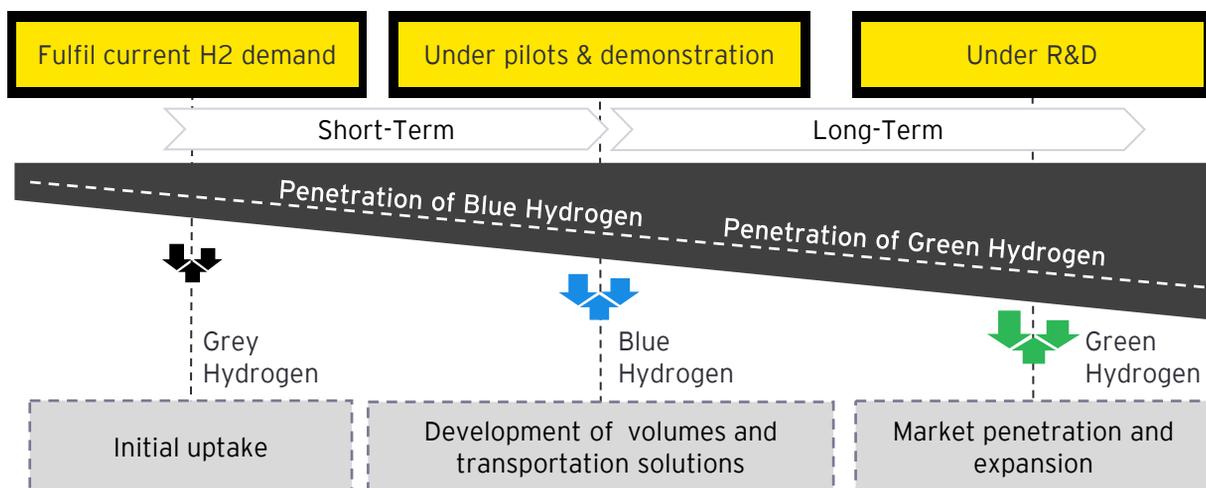
In the short term, India has an opportunity to support blue hydrogen using carbon capture, utilization and storage technology. With the creation of demand and infrastructure, green hydrogen will eventually enter the market and utilize existing storage, transmission and distribution infrastructure.

Green hydrogen can be used as fuel in aero-derivative gas turbines that can burn 100% hydrogen with the ability of quick ramp-up/ramp-down and tolerance to multiple daily cycles provide an ideal solution for round-the-clock (RTC) green electricity. A solution along these lines can provide 90 to 95% time-based reliable availability of green energy¹⁴ which is very difficult to achieve with other conventional storage technology-based solutions. Technological breakthroughs and system-level integration to achieve these solutions may require governmental support in form of pilot studies.

In February 2022, the Ministry of Power notified the Green Hydrogen Policy, which is the first part of policies under the National Hydrogen Mission. The policy provides various incentives with respect to the renewable energy to be used for manufacturing of green hydrogen such as waiver on inter-state transmission charge, 30 days banking of energy, and open access within 15 days of complete application¹⁵.

However, for green hydrogen to become a viable and feasible green energy alternative, the following are critical:

- ▶ Reduction in cost of manufacturing green hydrogen which requires continuous research on technology and achievement of a certain scale of manufacturing (for instance gas turbines are being developed with the capability to burn up to 50 per cent hydrogen by volume blended with natural gas, with technology pathway to 100 per cent)
- ▶ Demand push for green hydrogen through measures such as green hydrogen purchase mandates
- ▶ A milestone-based National Roadmap for green hydrogen which would encourage green hydrogen production and usage through incentives
- ▶ Policy focus on the entire manufacturing ecosystem for green hydrogen including electrolysers, supply of water for the electrolyser, use of the oxygen generated through electrolysis, etc.
- ▶ Extension of schemes such as PLI for electrolyser manufacturing



13. Howarth R. W. and Jacobson M Z. (2021) How green is blue hydrogen? Energy Science & Engineering published by Society of Chemical Industry and John Wiley & Sons Ltd

14. GE analysis

15. Green Hydrogen Policy 2022, Ministry of Power

Cleaner coal



Coal would remain a part of India's energy systems for the foreseeable future given the time required for other new technologies to develop and scale-up.

Coal is the highest contributing fuel for greenhouse gas emissions in India. To minimize the impact of the overall power sector on the environment, carbon emissions can be captured at the power plant level and can be utilized for hydrogen generation or biofuel generation. Clean coal technologies (CCT) include a variety of technologies to reduce air emissions and other pollutants from Thermal power plants. For example, newer technologies like ultra-supercritical or advanced ultra-supercritical result in fewer carbon emissions.

» Role of carbon capture technology and potential impact on CO₂ reductions

Carbon capture and storage (CCS) is the process of removing CO₂ from industrial processes such as power plants that burn fossil fuels. The CO₂ is then transported and placed in long-term storage, typically in underground geologic formations. The CO₂ that is removed can either be taken out before combustion occurs or after.

- ▶ **CCS can reduce emissions at the source:** The International Energy Agency estimates that CCS could be responsible for removing as much as 20% of total CO₂ emissions from industrial and energy production facilities¹⁶.
- ▶ **Other pollutants can be removed at the same time:** During oxyfuel combustion, high concentrations of oxygen used for combustion leads to a significant reduction of nitrogen oxide and Sulphur dioxide gases¹⁷.

» Creation of a sustainable coal fleet

The Government has already notified rules on 31 March 2021, for carbon emission norms for thermal power plants across three categories, those near Delhi-NCR or large cities with a million-plus population, those near critically polluted areas or non-attainment cities and others with the deadlines for compliance in 2022, 2023 and 2025. These rules require implementation and adherence to the deadline in order to create a cleaner coal fleet.

Strict adherence to the timelines would provide certainty to the industry and ensure capital expenditure programs are undertaken. The government also needs to consider creating a scheme for supporting investments in emission control by thermal power plants, particularly at the state level.

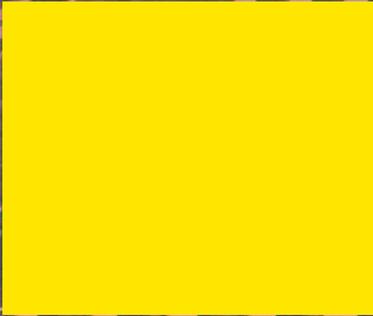
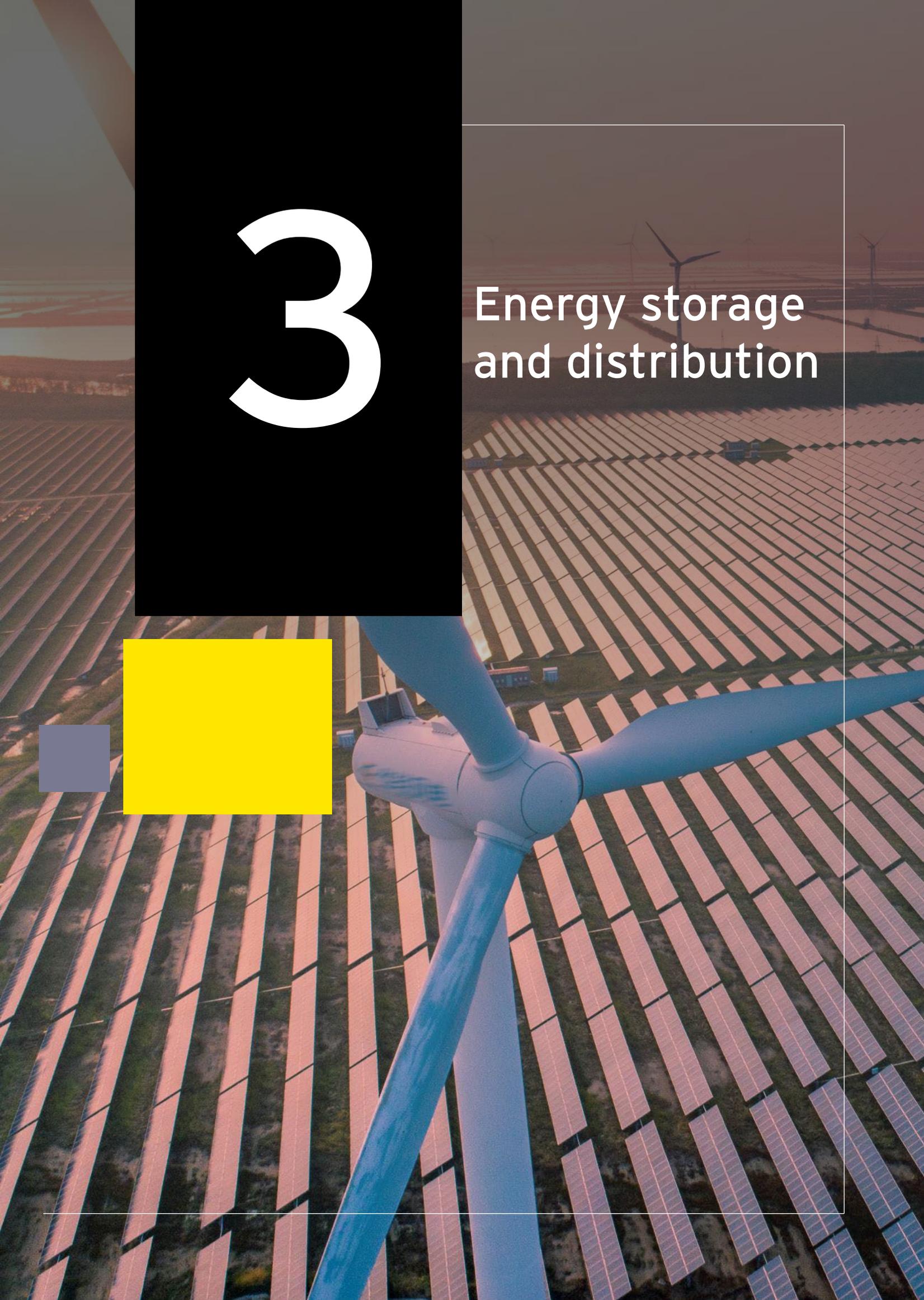
16. The Role of CO₂ Storage - Analysis - IEA

17. Dennis Y.C. Leung, Giorgio Caramanna, M. Mercedes Maroto-Valer (2014). An overview of current status of carbon dioxide capture and storage technologies. Renewable and Sustainable Energy Reviews, Volume 39, Pages 426-443,



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Energy storage and distribution



Storage



Recognizing the important role that storage can play with the increased adoption of renewable energy (with its inherent variability), the government has been supporting the adoption of various energy storage options including batteries and pumped hydro storage systems. The Ministry of Power has provided initial guidance on the usage of energy storage systems, providing for both energy storage systems to be operated as part of generation, transmission and distribution or as standalone energy projects and making it a delicensed activity.

However, given the scale needed to achieve round-the-clock power with renewable sources of energy and the cost involved, there is a need for focused support for further development of existing technology (like pumped-storage hydropower) and adoption of new technologies, including long-term storage solutions like compressed air energy storage. Going forward, the regulatory framework needs to be strengthened towards all forms of storage to spur the development, innovation and adoption of new technologies. Specifically, policies need to be created around:

- ▶ Providing flexibility for projects to add/change storage after commissioning without any impact on the incentives provided to the project as storage technologies will contribute to grid stability.
- ▶ Encouraging innovation and adoption of newer storage technologies including providing flexibility to update/upgrade storage technology adopted by plants from time to time.

▶▶ Pumped-storage hydropower (PSH)

Presently, the major technology of energy storage globally is pumped storage hydropower (PSH) contributing to more than 95% of the total installed¹⁸ storage capacity. It works on a simple principle, at times of low demand when electricity prices tend to be lower, water is pumped from a lower reservoir to an upper reservoir, and then released at times of high demand to drive a turbine and generate electricity.

While hydro projects in India have raised environmental concerns in the past, PSH may mitigate these concerns:

- ▶ PSH projects may have the relatively low scale and work in a closed-loop configuration, meaning they present minimal environmental impact as they are not connected to existing river systems. In addition, they do not need to be located near an existing river and can therefore be located where needed to support the grid.
- ▶ PSH could be integrated within some of the existing dams by placing them in-between two reservoirs in cascades
- ▶ Developing PSH projects in disused mines, non-powered dams and conventional hydropower plants are different options that allow leveraging of existing infrastructure, and thus lower the costs and environmental footprint.

India has a potential of around 120 GW of PSH spread across 120 sites¹⁹. Policy push can support private investments in this area. According to the International Forum on PSH, India has commissioned only nine plants (with an installed capacity of 4,785 MW)²⁰ with three plants (with a capacity of 1,580 MW) under construction. Further, 12 PSH projects (public and private) (with an installed capacity of 10,000 MW) are under either under pre-feasibility study, detailed surveys and investigations, detailed project reports, or obtaining clearances²¹.

Faster environmental clearance is required for PSH projects to become viable. For this, separate guidance for PSH projects by the Ministry of Environment and Forest and Climate Change may be beneficial.

There is also a need to create a separate economic model and tariff determination for PSH projects, as appropriate for any storage solution. At present, PSHs in India are being dealt through the conventional model approach.

Smart Grids



The conventional grid systems are highly centralized and have a one-way power flow from producers to consumers. These grids are increasingly facing challenges related to :

- ▶ Supporting a two-way nature of power flow from distributed rooftop solar PV and other projects
- ▶ Intermittent power output of renewable energy
- ▶ Likely increase in energy demand and change in its mix from electric vehicles and new industries
- ▶ Integration with energy storage systems
- ▶ Climate-change resilience (to withstand extreme weather events)

Smart Grid (SG) helps improve the reliability of the electricity networks and also makes them amenable to inputs from distributed renewable energy units.

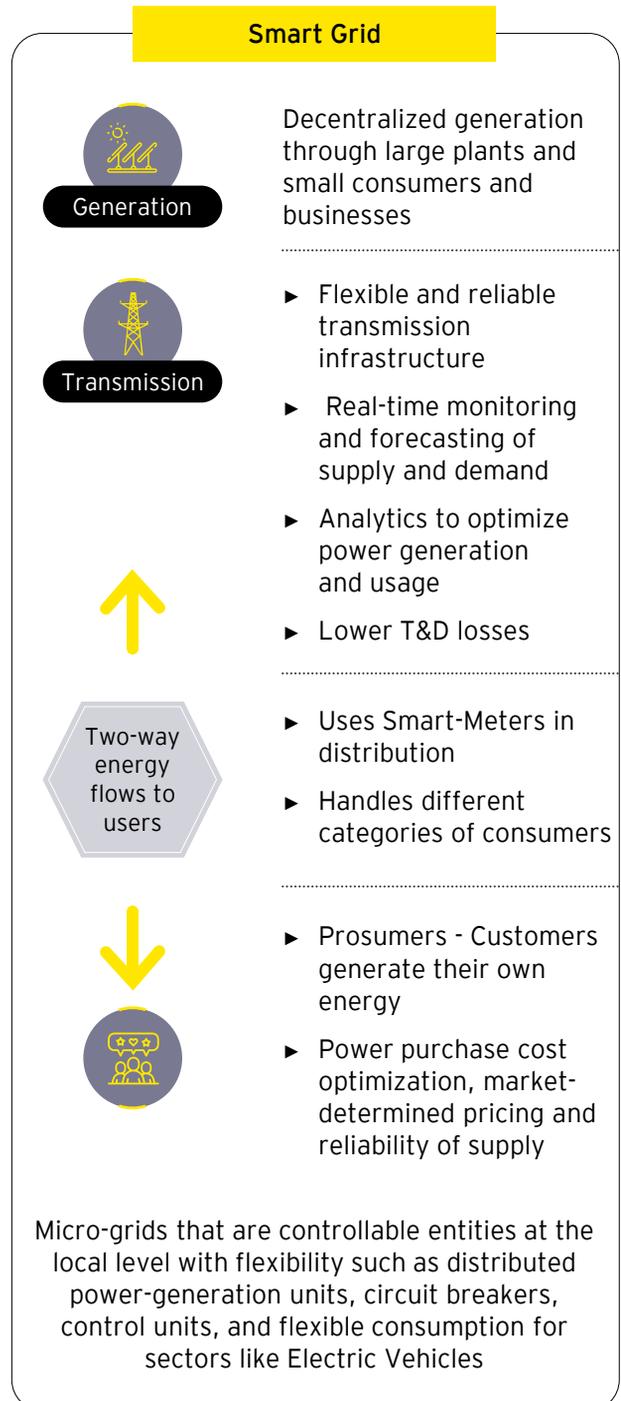
To harness the benefits of the Smart Grid, the Ministry of Power (MoP) has launched the National Smart Grid Mission on a pilot basis in 12 locations²² across the country. However, implementing the SG systems is a complex process that requires investments in technology, skilled labour and incentivizing the stakeholders.

SG needs an interactive technology that provides information on power generation and transmission. There is a need for digital substations for real-time monitoring of power consumption and generation. SG also requires microgrid solutions, and advanced circuit breakers to improve grid resilience and reliability.

The government can offer the following policy support for increasing the rollout of SG:

- ▶ Design the roadmap and define the standards for SG
- ▶ Focus on capacity building for discoms, including investment in skilled workforce and digitisation
- ▶ Develop models for cost-sharing among the consumers, power producers, discoms, and state governments
- ▶ MoP's Revamped Distribution Sector Scheme (RDSS) for financially assisting the public-sector discoms should also layout targets for expanding areas under SG

- ▶ Provide incentives for increased adoption and innovation in SG solutions
- ▶ Increased digitisation would also make the grid susceptible to cyberattacks. Investments by the government in cyber security along with a comprehensive cyber security policy would be important.



22. National Smart Grid Mission: SG Pilot Projects <https://www.nsgm.gov.in/en/sg-pilot>

Open access



With the transition by global and Indian firms towards clean energy, there has been a shift towards sourcing renewable electricity from captive/third party projects with energy being delivered to the consumers through open access.

The Central Government and various State Governments have been supporting the adoption of renewable energy through various policies and regulations enabling open access. Recently, the Ministry of Power notified the Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022 further supporting open access for green energy. These rules have tried to address certain practical issues that hindered the ability of interested consumers to transition to clean energy. This includes:

- ▶ The minimum contract demand/sanctioned load requirement for open access: Many states allow open access for consumers with at least 1 MW load only, which hinders the ability of smaller consumers to meet their clean energy demand through open access. Some states however exclude renewable energy-based projects from this restriction and the recent Green Energy Open Access rules further reduce the minimum load requirement for consumers to 100 KW²³. However, it remains to be seen whether in practice the same may be allowed or technical and operational challenges would create hindrances.
- ▶ Indirect barriers to entry such as documentation requirements or the need for consent from distribution companies may also act as a deterrent for consumers wishing to source energy through open access. The Green Energy Open Access Rules provide for a single window to be set up and operated by a Central Nodal Agency to streamline the approval process.
- ▶ Some states also impose conditions related to voltage requirements and feeder types which impact the ability of consumers to source electricity through open access.
- ▶ There are variations across states with respect to the banking of energy for both, the banking period, and those who can avail of the facility (captive versus third party consumers). The Green Energy Open Access Rules provide for a uniform facility of at least monthly banking for green energy.

Ease of transmission and distribution of green energy through open access can catalyze India's clean energy transition. This can be further facilitated through the following measures:

- ▶ Adoption of the uniform minimum 100 KW load requirement for open access consumers
- ▶ Where a customer is unable to meet the minimum load requirement, allow a group of consumers connected on a feeder to jointly avail open access if together they meet the load requirement.
- ▶ Allow open access at all voltage levels
- ▶ Uniformity in the definition of short-term, medium-term, and long-term open access across states (presently definitions vary across states)

23. Ministry of Power, Green Open Access rules, notified on 7 June 2022. Press Information Bureau (pib.gov.in)

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Enablers for decarbonization



Carbon markets



There are two broad types of policy instruments available with policy makers for bringing about changes in consumption and production practices in an economy. First is the traditional regulatory approaches (sometimes referred to as command-and-control approaches) that set specific standards across polluters or mandate the usage of cleaner fuels. Mandatory purchase of renewable energy and mandatory usage of CNG vehicles in a city are examples of such an approach. The second option are around deploying economic incentives or fiscal tools or market-based instruments that rely on market forces to incentivize changes in production and consumption behavior. An example being waivers on inter-state transmission charges for electricity used for green hydrogen/ammonia production in India.

From an economic standpoint, emissions are a “negative externality” i.e., cost from generating emissions are not reflected in the costs incurred by the producers of goods or paid for by the buyers. The impact is felt outside the markets to the society at large and are therefore referred to as a negative externality. A carbon price applied directly or implicitly to carbon emissions ensures that the negative externality gets reflected in costs and prices of goods using inputs with a high emission footprint.

Businesses that seek to maximize profits respond to high input prices by finding ways of limiting the use of such inputs.

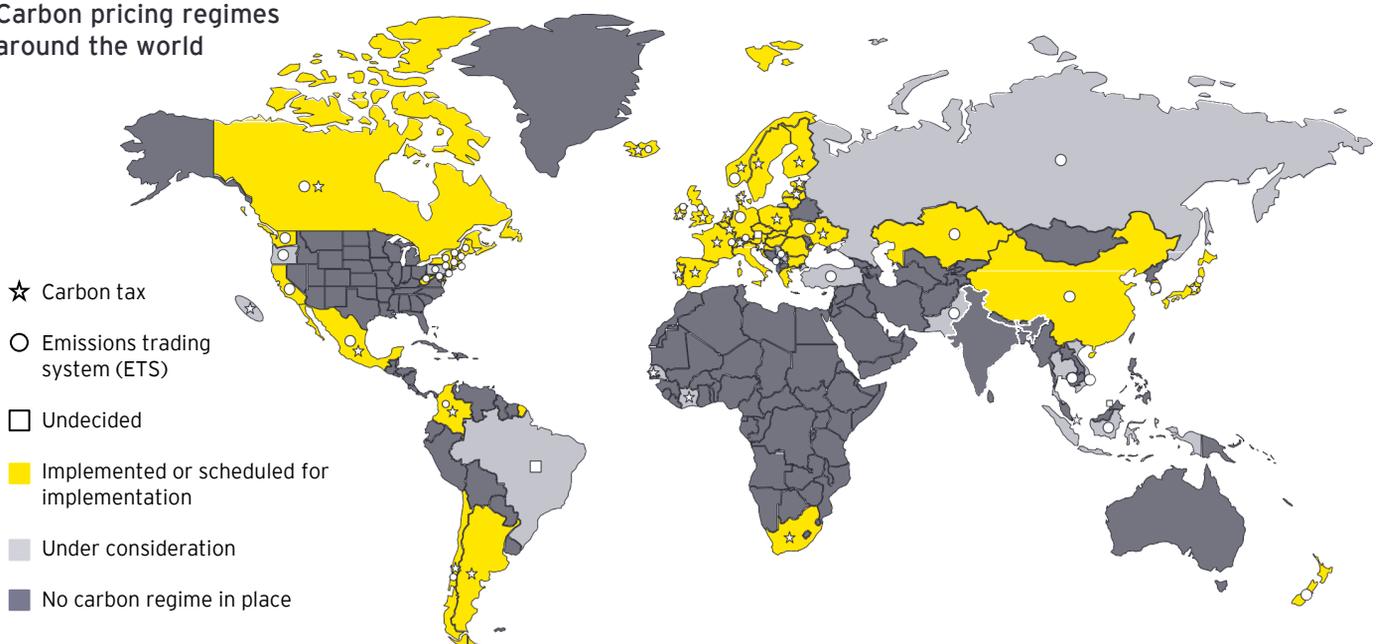
- ▶ Carbon price by increasing the price of high-emissions inputs, provides economic incentive for economizing the use of such inputs and reducing the production of products causing pollution
- ▶ Incentivizes businesses to measure their carbon footprint
- ▶ Creates incentives for innovation by developing technologies that would result in emission reduction
- ▶ It also results in economically efficient decisions, where those technologies and solutions are deployed that have the greatest economic impact

Imposing the same cost of emissions on all sources of pollution is fair given that whoever pollutes pays the same price.

Similarly, economic fiscal measures such as incentives related to production and use of goods and services with a low carbon footprint help businesses be competitive and minimize costs.

While government has been working on this, an early announcement of the government's plan may help in stimulating investments and mobilizing stakeholders.

Carbon pricing regimes around the world



Source: World Bank, State and Trends of Carbon Pricing 2021.

The explicit cost of carbon emissions can be achieved through both a carbon trading scheme and as well as through carbon taxes. In a carbon trading scheme, Government sets a cap on the level of permissible emissions. It then gives emission allowances to entities, where the total allowances equal the cap. Entities can buy and sell these allowances based on their needs and the secondary market reveals the cost of emissions. Therefore, like carbon taxes, a carbon trading scheme also provides a transparent and tangible cost of carbon emissions.

Governments around the world are using a variety of carbon pricing regimes and incentives to reduce emissions and meet their commitments.

While India does not have an implicit carbon tax or a carbon price, some of these outcomes have sought to have been achieved through measures such as a levy on coal, high excise duties and VAT on petrol and diesel, perform achieve and trade scheme, trading of renewable energy certificates, lower GST rates on EVs vis-à-vis automobiles using combustion engines, etc.

Similarly, incentives under the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles scheme for EVs or PLI schemes for Advanced Chemistry Cell batteries, electric vehicles and solar panels are further examples of using fiscal tools to drive the energy transition.

The government may therefore consider the following:

- ▶ Increased usage of tax incentives and other fiscal measures to drive economy-wide decarbonization
- ▶ Design and development of carbon markets based on successful examples internationally. These would need to be adopted specifically to the Indian conditions.



Green finance



The global green bond market has grown into a significant pool of capital for green projects. In 2022, it is expected to reach US\$1 trillion. The energy sector is the largest recipient of green bonds.

For India, tapping into the green bond capital is important to meet the investment requirement towards decarbonization of its economy and growth of clean energy systems. India has already become a major economy in issuing green bonds into the global market, primarily for the renewable energy sector. India can undertake several policy measures to help deepen the green bond market.

Creation of a common green taxonomy and framework

A common green taxonomy needs to be developed by the government that can standardize the classification system for investment projects that are environmentally sustainable. The basic premise of the green taxonomy is to avoid greenwashing and help green investors in the evaluation of the green projects.

The government can also pilot creation of technology tools to enable generation of real-time data for climate impact of green projects. This could be created in the form of a public digital utility that could aggregate information from various sources

and use technologies such as blockchain to create a platform for reporting, monitoring and verifying green outcomes.

Sovereign green bonds

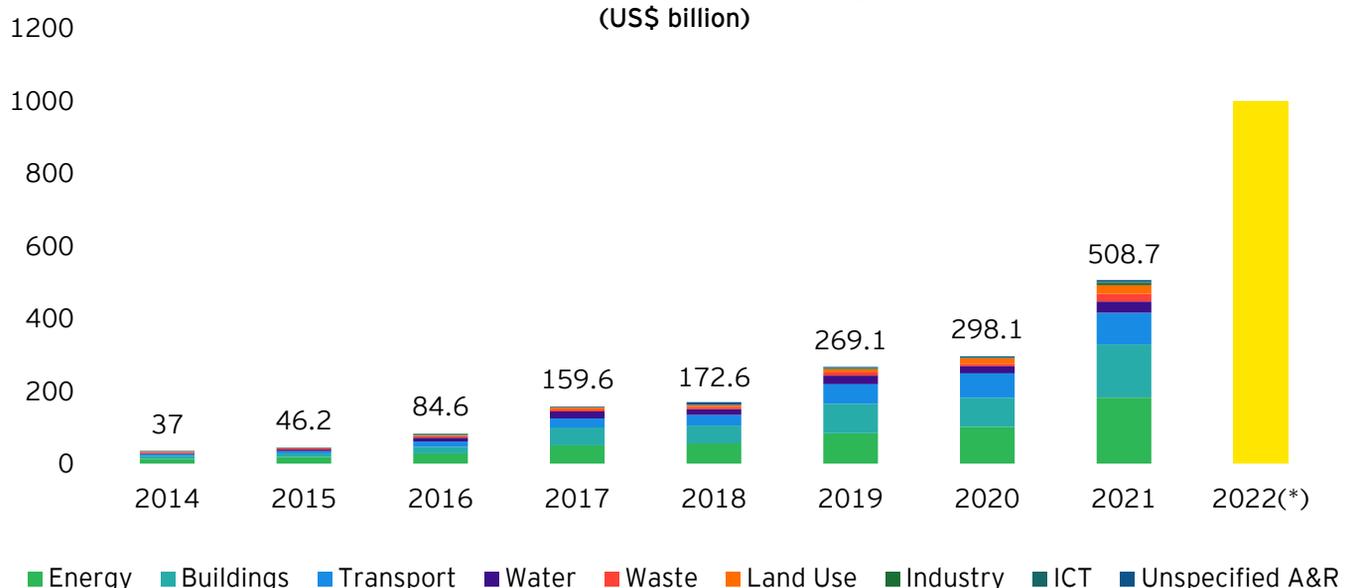
The Union Budget 2022-23 included an announcement of a new framework for issuances of sovereign green bonds. This would help in the creation of a green bond benchmark for India for both offshore and onshore financing. Further, the government needs to set targets for green financing from its fiscal sources, especially for areas such as smart grids and other green utilities.

Incentives and reduction of risks

The government may consider providing fiscal incentives for green bonds/financing to investors to encourage greater mobilization of green financing towards clean energy sectors. Further, the Reserve Bank of India could consider adopting some best-case practices for encouraging green financing by domestic financial institutions, including changes in regulatory norms for green financing, setting targets for green capital, etc.

Finally, clean energy projects can be de-risked through greater regulatory clarity and long-term contracts to enable a lower cost of capital for such projects.

Green Bond issuances have continued to grow rapidly (US\$ billion)



Source: Climate Bond Initiative

24. Climate Bonds Initiative: First annual green trillion could arrive in 2022

Targeting embodied carbon



A strategy for clean energy would also have to consider embodied carbon in the material used for energy projects (for example, solar panels, rotor blades and other turbine parts, thermal turbines etc.). Reduction in embodied carbon would help advance the goals of net-zero economy by 2070 and also reduce the overall carbon impact on Indian businesses. This can facilitate the exporters to minimize their carbon impact and therefore withstand any carbon pricing mechanisms imposed in the future.

Besides carbon emissions, there are also challenges in managing waste from energy projects. Efforts toward managing waste and creating a circular economy would also be important.

Strategies towards this could include the following:

» Using low carbon embodied materials

There is a need to push R&D towards low carbon materials while developing new technologies and for the upgradation of older technologies. For example, this could include lower carbon embodied solar PVs.

» Recycling / circular economy

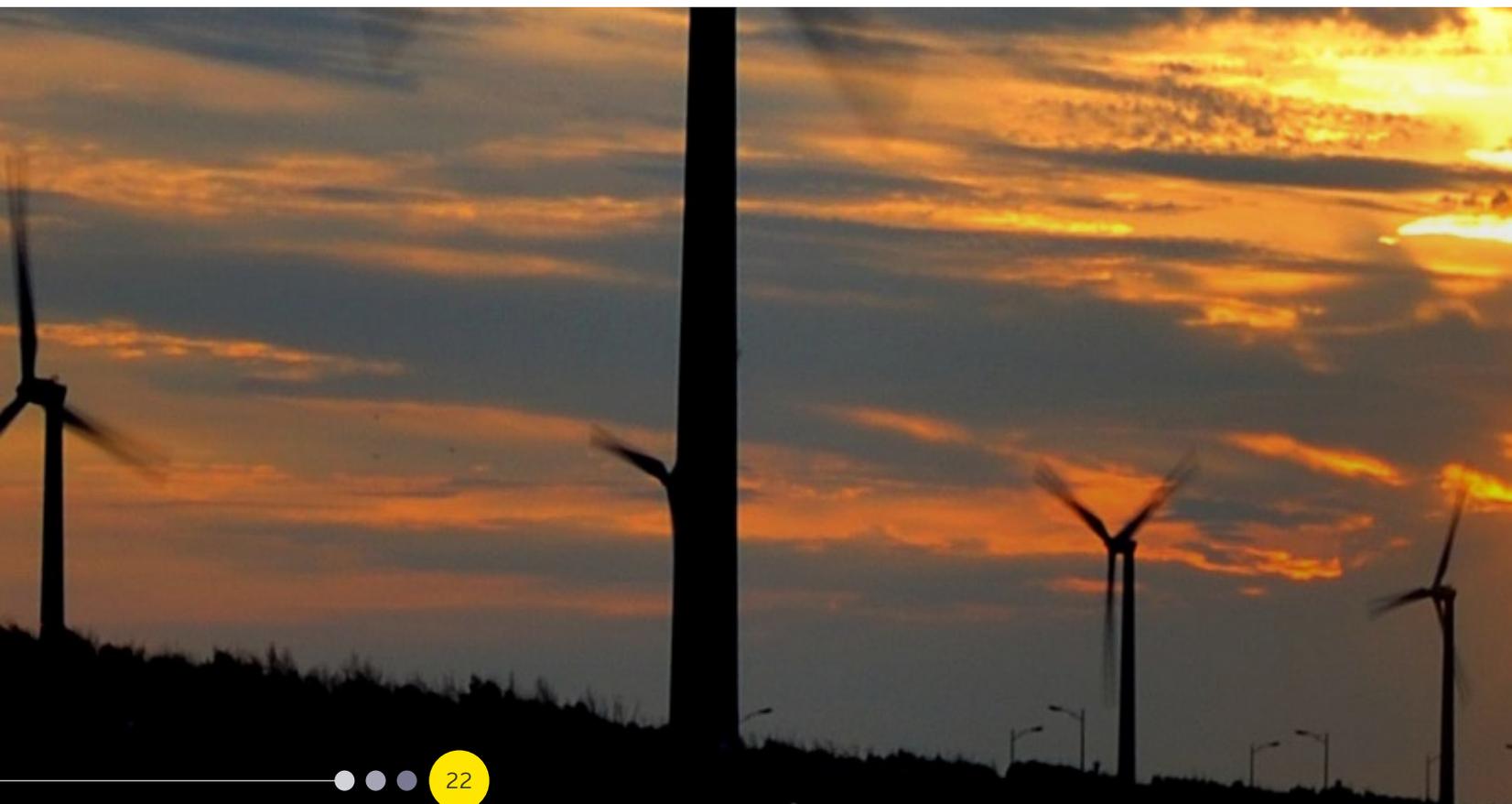
R&D towards the development of recycled material to be used in energy projects and creating an overall circular economy to deal with waste. This would also include a waste management policy.

» Use of renewable energy/carbon capture technologies in the manufacturing process

The manufacturing process for equipment used in power sector needs to be carbonized through the use of cleaner energy and other carbon capture technologies. The government needs to devise an incentive mechanism to enable the transition, through the creation of appropriate carbon markets or fiscal interventions.

» Promoting technologies with low embodied carbon

Within the renewable energy sector, different technologies may not be similar in terms of embodied carbon. Such considerations may be important when considering incentives by the government towards any particular technology.





5

Conclusion



Conclusion



India has been decarbonizing its economy primarily through the promotion of renewable energy, electrification of transportation systems and energy efficiency.

India has committed to a net-zero target by 2070. It also needs to grow its energy sector at a fast pace to support its overall economic growth. Keeping objectives and economic requirements, India needs to create a clean energy system with reliability, affordability, sustainability and energy independence as the cornerstones.

Ensuring the above agenda, and supporting strong economic growth, is both a technological and a financial challenge, with multiple pathways to choose from. There is therefore a strong need for the government policy to be technology agnostic across the energy delivery pathways and continue its support for innovation, development and implementation of green energy projects.

The following levers hold the key to large-scale decarbonization in India:

- ▶ Maximizing the production of renewable energy including offshore wind underpinned by domestically produced equipment promoted by introduction of appropriate production linked incentives e.g., for rotor blades. While designing incentives, Government policies should target minimizing usage of embodied carbon in the equipment used
- ▶ Creation of carbon capture technologies for the usage of coal-based energy, which is the largest source of primary energy and is domestically sourced
- ▶ Facilitating the usage of renewable energy through the promotion of both new and proven storage technologies
- ▶ Increasing the utilization of existing natural gas-based power generation capacity and selectively increase the usage of natural gas to leverage its flexibility in delivering energy and its lower carbon footprint
- ▶ Promoting green hydrogen through demand-side incentives and policies to bring down costs through policy support like production-linked incentives for electrolysers, while recognizing that the transition to green hydrogen may be through blue/grey hydrogen
- ▶ Taking steps to transform the electricity grid from a centralized one-way carrier of electricity to a more decentralized grid with the capability to move electricity in both directions
- ▶ Incentivizing decarbonization initiatives of large commercial and industrial energy users through the development of carbon markets and streamlined and effective implementation of green open access
- ▶ Supporting green financing through the development of common green taxonomy and framework to finance the investments



Notes



A series of horizontal dotted lines for writing notes.

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