Grant Thornton

Alternate energy

How can it shape the vibrant future of India?

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01
Introduction

India has set an ambitious target to become energy independent by 2047 and achieve Net Zero status by 2070. The Government of India is committed to set up 50% of cumulative power generation from resources by 2030. India is committed to become carbon neutral by 2070 and made five commitments as Panchamrit at COP26[1]. The five commitments made at the global conference were:

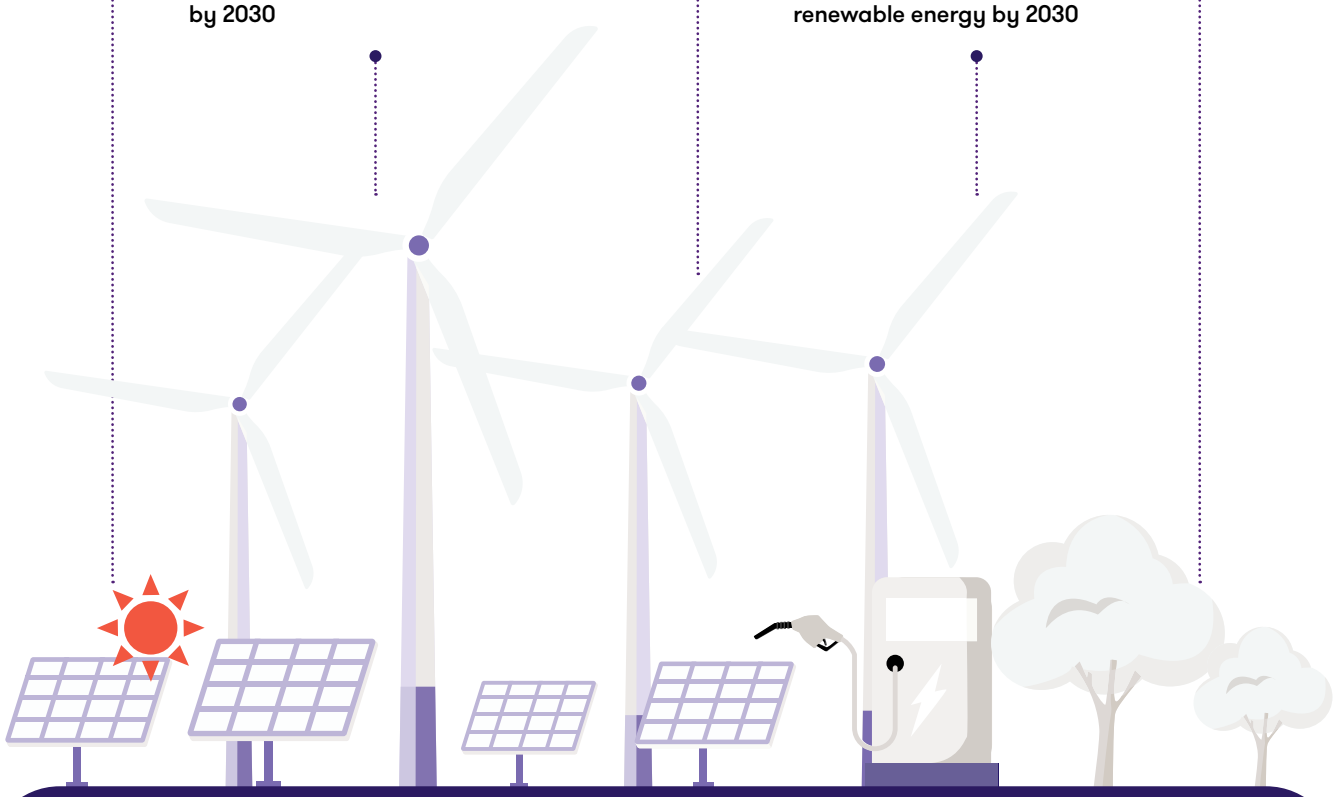
India will increase its non-fossil fuel-based energy capacity to **500 GW** by 2030

India will achieve net **zero emissions** by the year 2070

India will reduce the carbon intensity of its economy by **45%** by 2030

India will reduce its total projected carbon emissions by **01 billion tonnes** by 2030

India will meet **50%** of its energy requirement with renewable energy by 2030



Increasing use of domestically available renewable energy is key to India's Energy Transition to achieve this target.

1. https://pib.gov.in/PressReleasePage.aspx?PRID=1795071

1.1 India's transition to Net Zero: Journey so far and road ahead

India, the world's third-largest carbon emitter, has embarked on a strategic journey towards achieving net zero emissions by 2070. This monumental commitment commands a closer look at India's climate action journey so far, as well as the roadmap that lies ahead.

Journey So Far

Since the Paris Agreement in 2015, India has committed to reduce its emissions intensity significantly by 33–35% by 2030. Bolstered by various government initiatives promoting renewable energy, the country is steering towards sustainable development. India's renewable energy capacity has steadily increased, with an ambitious goal to hit 175GW of green energy capacity by 2022. Predominantly driven by solar and wind energy, the surge in green energy has positioned India as one of the global frontrunners in the renewable energy sector. The country has also adopted strategic approaches towards energy efficiency. The Perform, Achieve and Trade (PAT) scheme and Energy Conservation Building Code (ECBC) aim to promote energy-efficient practices across multiple industrial sectors and construction. Furthermore, the Government's push towards the electrification of the transport sector is a major stride towards reducing India's fossil fuel dependence.

The Path Ahead

Despite these significant strides, the journey to net zero is fraught with challenges. India grapples with its substantial dependency on coal, which remains its primary energy source. Decisive action is needed to balance this high-carbon resource with a more sustainable, clean energy portfolio. The Government of India plans to gradually reduce reliance on coal, amplifying the use of cleaner fuels such as renewable energy. Accelerating this transition necessitates extensive investment in renewable infrastructure and advanced technologies. Technology and innovation will play key roles in India's journey to net zero. Enhancing research and development towards scalable and cost-effective clean energy solutions is vital. Here, international partnerships and collaborations can expedite progress and foster shared learning.

Effective policy support forms the backbone of India's roadmap to net zero. While the government has introduced several policies and initiatives, flexible regulatory frameworks that accelerate the adoption of green energy and efficient practices are needed for a sustainable transition. Public awareness and participation are instrumental in driving change at a grassroots level. Active engagement of individuals and communities, supported by educational initiatives, can catalyse a shift towards sustainable practices and clean energy options. The journey to net zero is a formidable feat but a necessary one. India has committed to a more sustainable future by actively investing in renewable energy, efficient practices, and green transport. The real test, however, lies in successfully negotiating the difficult shift from coal, fostering radical innovation, strengthening policy support, and eliciting public participation. With concerted effort, India can lead transitional change towards a sustainable and low-carbon future despite obstacles.

1.2 The Role of alternative energy in achieving net zero commitment

India, being the world's third-largest emitter of greenhouse gases[2], has pledged to reach net-zero emissions by 2070. Alternative energy is central to achieving this ambitious goal, which will play a pivotal role in decarbonising India's energy landscape.

1

Solar and wind power

Solar energy has been a monumental player in India's alternative energy landscape, with the country housing the then world's largest solar park, the Pavagada Solar Park in Karnataka. With reducing prices of photovoltaic equipment and strong governmental support, India's solar capacity has seen robust growth.

Equally significant is wind energy, where India is making substantial strides. The country has the fourth-largest onshore wind capacity globally[3], harnessing high-potential wind zones mainly situated along its western coastline and southern states.

2

Hydropower and biomass

Though often overlooked in discussions of renewable energy, hydropower plays a vital role in India's energy matrix, offering electricity generation and crucial grid support services. Micro-hydropower plants are particularly beneficial for remote and hilly regions, underlining the importance of localised solutions.

Biomass energy, derived from waste materials, is another pivotal alternative energy source in India. Biomass power and cogeneration projects have assuaged waste management issues while simultaneously providing renewable energy.

3

Emerging alternative energy sources

India sees potential in other alternative energy sources, with a broader spectrum of renewables emerging prominently on its energy horizon. These include bioenergy, tidal power, and especially, hydrogen energy. In its pursuit of a hydrogen economy, the Indian Government has launched the 'National Hydrogen Mission' to aid research, development and deployment of hydrogen technologies.

2. https://www.bbc.com/news/world-asia-india-58922398
3. https://gwec.net/global-wind-energy-council/taskforces-committees/india/

Challenges and way forward

Despite significant progress, certain challenges in harnessing alternative energy remain. These mainly revolve around infrastructural needs, storage issues, intermittency of renewable energy sources, and land acquisition problems.

Continued strong policy and regulatory support, financial incentives for capacity addition, and sizable investment in research and development are required to overcome these challenges. It is also essential to transition the existing grid infrastructure to accommodate the upsurge in variable renewables and prioritise energy storage systems development.

Furthermore, enhancing public awareness and encouraging energy conservation can additionally aid in achieving net-zero targets. Public-private partnerships could also facilitate rapid technology transfer, promote investment, and accelerate growth in the renewable sector.

The transition to a net-zero future is a challenging yet feasible task. India's commitment to amplify its renewable capacity demonstrates its resolve to align economic development with climate action objectives. Harnessing the potential of alternative energy sources marks a significant step towards achieving this commitment. The country's success in achieving net-zero emissions will not only be momentous but will significantly influence global endeavours towards a sustainable future. Therefore, India's journey highlights the indispensable role of alternative energy in paving a sustainable, prosperous, and net-zero path for other countries across the world.

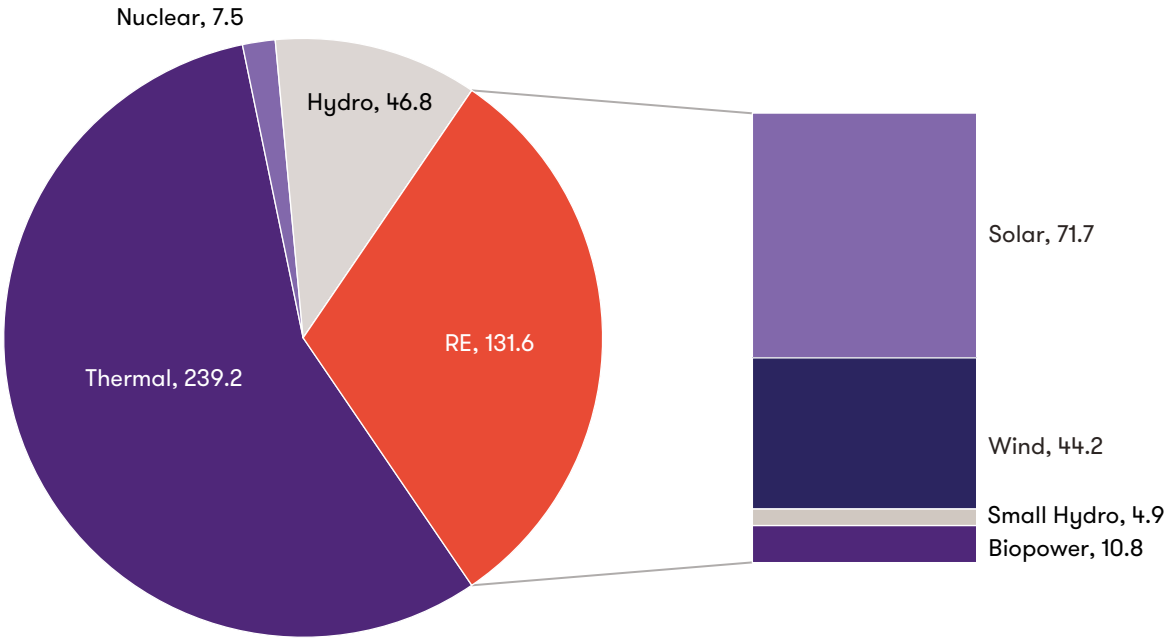
02

Overview of renewable energy development in India

2.1 Alternative energy landscape in India: Current status and targets

India perceives alternative energy playing a key role in both economic growth and environmental protection. The Indian renewable energy market ranks fourth in the world in terms of installed capacity, with an impressive 178.6 GW as of October 2023[4]. Solar power leads the way with 71.7 GW, followed by wind power at 44.2 GW. Other renewable sources include biomass, small hydropower, and waste-to-energy. This capacity is set to increase further, underpinned by a target to attain 175 GW of renewable energy capacity by 2022 and 500 GW by 2030.

All India Installed capacity (in GW) as on Oct'23



According to the Energy Statistics India 2023 report, clean energy sources (including hydro, nuclear, and other renewable energy sources) experienced the highest growth (6.83% CAGR[5]) in commercial energy production between 2012–13 and 2021–22. In contrast, total commercial energy production reported a CAGR of 2.62% during the same period. Energy production from coal, on the other hand, only achieved a CAGR growth of 3.8% and accounted for 73% of total commercial energy production in 2021–22.

Clean energy sources contributed 8.24% of total commercial energy production in 2021–22. Additionally, renewable energy sources such as solar, wind, and others (excluding hydro and nuclear) made up 11.51% of total commercial energy production in the same year. This indicates a significant reliance on coal in India's commercial energy production mix, with an increasing proportion of clean, sustainable, and renewable energy sources playing a vital role.

4. https://pib.gov.in/PressReleasePage.aspx?PRID=1795071
5. https://www.bbc.com/news/world-asia-india-58922398

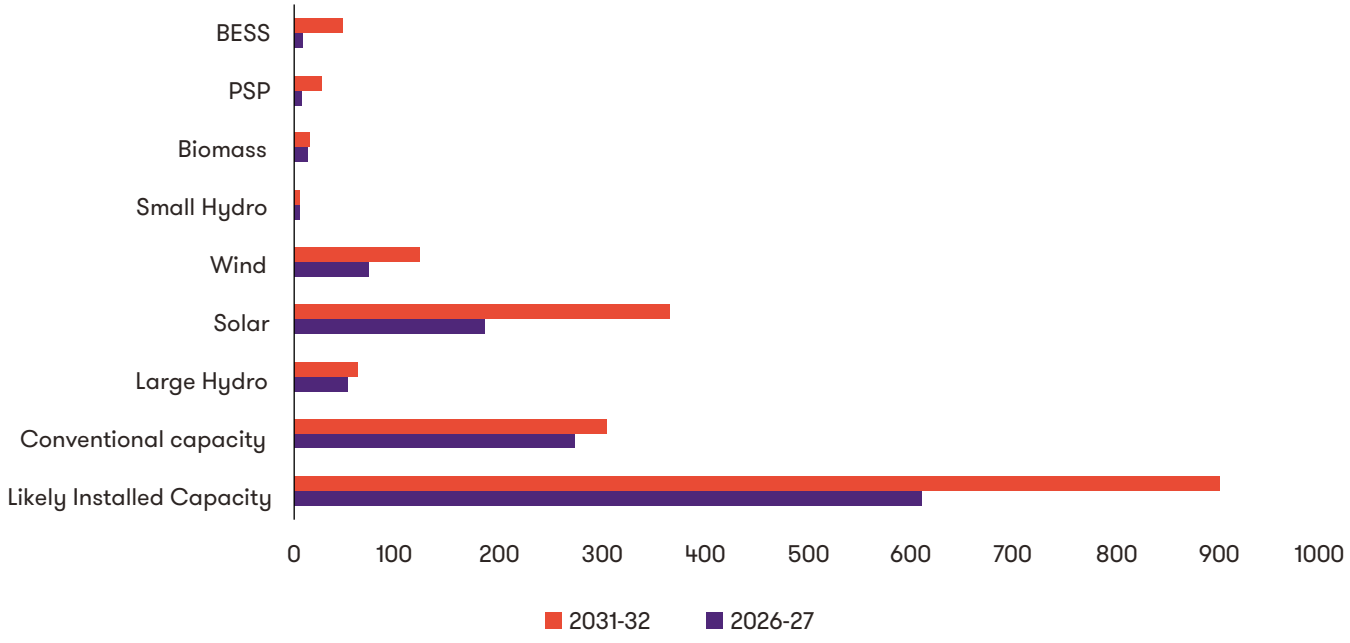
2.2 Key policies and regulations in the alternative energy sector

The Electric Act 2003 requires the Central Government to issue a National Energy Policy and a tariff policy occasionally. Additionally, every five years and based on the national energy policy, the central Government is required to issue a National Electricity Plan.

In March 2023, the Ministry of Power (MoP) issued the National Electricity Plan (NEP)[6] (Vol-I Generation) for 2022–32. According to the NEP document, the projected All India peak electricity demand and electrical energy requirement is 277.2 GW and 1907.8 BU for 2026–27 and 366.4 GW and 2473.8 BU for the year 2031–32 as per the 20th Electric Power Survey (EPS) demand projections. The Energy Requirement & Peak Demand are inclusive of the impact due to increased adoption of electric vehicles, installation of solar roof tops, production of green hydrogen, Saubhagya scheme etc.

Based on generation planning studies carried out under the purview of preparation of National Electricity Plan for 2022–27 and 2031–32, the likely installed capacity for 2026–27 is 610 GW and 900 GW, respectively. The detailed breakup is as follows:

Likely installed capacity for years 2026-27 and 2031-32 in GW as per NEP



The projection of total capacity addition is in line with the target of the country to achieve a non-fossil based installed capacity of around 500 GW 2029–30. NEP envisages that the share of non-fossil-based capacity is likely to increase to 57.4% by the end of 2026–27 and may likely to further increase to 68.4% by the end of 2031–32 from around 42.5% as on April 2023.

6. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1928750 https://powermin

Key policy developments impacting RE development in India are as follows:

Competitive Bidding Guidelines

To promote fairness and standardisation in the competitive bidding process, the Indian Government has notified guidelines for tariff-based competitive bidding processes for grid-connected solar, wind, hybrid and RTC projects (the Competitive Bidding Guidelines).

The Competitive Bidding Guidelines apply to long-term procurement of electricity by the distribution licensees from projects that are above the respectively prescribed capacities, through competitive bidding. Any deviation from the relevant Competitive Bidding Guidelines needs to be approved by the relevant regulatory commission.

RTC tender issued by Solar Energy Corporation of India

The problems faced by power distribution companies (discoms) in incorporating variable renewable energy (VRE) can be reduced by purchasing power from VRE-integrated sources that operate in real-time. This means that the power developers who generate renewable energy also provide stable power to the grid. This method takes advantage of the developers' expertise in understanding how various renewable energy sources perform in different locations and improves the integration of VRE into the system. By using the real-time control (RTC) mode of power supply, discoms can fulfill their electricity demand either through a fixed continuous supply, fixed supply in specific time slots, or procurement based on real-time demand. In Jun'23, Solar Energy Corporation of India Limited (SECI) hereby intimated its intent to carry out selection of Project Developers for Selection of RE Power Developers for Setting up of 800 MW RE Projects for Round-the-Clock supply of power to Haryana DISCOMs under Tariff-Based Competitive Bidding (SECI-RTC-IV).

Captive generating plants

A captive generating plant is a power plant set up by any person or association of persons to generate electricity primarily for their own use that meets the following criteria:

1. Captive users must collectively hold not less than 26% of the equity share capital (with voting rights) in the project company that owns such a plant; and

2. Captive users must collectively consume not less than 51% of the aggregate electricity generated by such plant in a financial year and such consumption (i.e., up to 51%) must be proportionate to each captive user's equity share capital, with a permissible variation of plus or minus 10%.

However, the Appellate Tribunal for Electricity (APTEL) has held that the proportionality requirement is not required to be complied with if the captive generating plant is set up by a special purpose vehicle (SPV). The advantage of structuring a project as a captive generating plant is that such plants are exempted from payment of certain regulatory charges, such as the cross-subsidy surcharge and additional surcharge.

Renewable purchase obligations

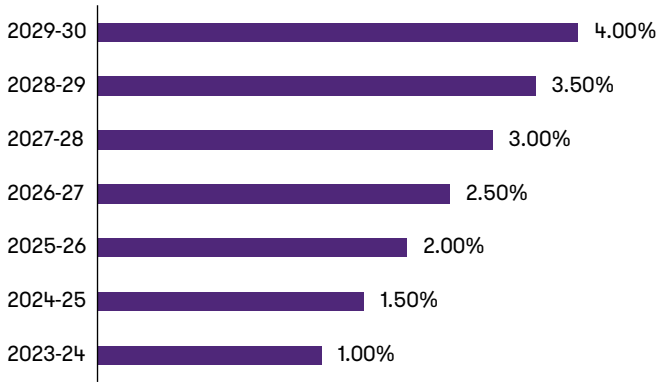
Section 86(1)(e) of the EA 2003 states that each state electricity regulatory commission (SERC) must specify a percentage of electricity to be purchased from RE sources. Pursuant to this, various SERCs have notified regulations specifying the renewable purchase obligations (RPO) for the obligated entities as defined under each state's regulations, typically including the distribution licensees and open access consumers for such states.

In July 2022, MoP defined the new targets for RPO as well as Hydro Power Obligations (HPO), Energy Storage Obligations (ESO) and Other RPO beyond 2021-22 as follows:[7]

	Wind*	HPO (from LHP including SHPs)**	Other RPO***
2022-23	0.81	0.35	23.44
2023-24	1.6	0.66	24.81
2024-25	2.46	1.08	26.37
2025-26	3.36	1.48	28.17
2026-27	4.29	1.80	29.86
2027-28	5.23	2.15	31.43
2028-29	6.16	2.51	32.69
2029-30	6.94	2.82	33.57

shall be met only by energy produced by WPPs commissioned after 31st Mar 2022
** shall be met only by energy produced by LHPs including PSPs commissioned after 8th Mar 2019
***met from any other source than wind and HPO
****percentage of total energy consumed shall be solar/ wind along with/ through storage

Energy storage obligation(Storage on energy basis)**



Renewable generation obligations

The MoP released a notification related to Renewable Generation Obligation (RGO) for coal-fired thermal power plants that commence operation on or after 1 April 2023. After stakeholder consultations, the renewable purchase obligations for such plants have been increased to at least 40% of their coal power capacity, up from 25% previously. The Ministry has also set different targets for RGO based on the commercial operation date of each individual plant.

For instance, for plants commissioned between 1 April 2023 and 31 March 2025, there are two options:

- Either establish 40% renewable power capacity or
- Procure and supply renewable energy equivalent to such capacity by April 2025

Additionally, for any power plant that commences operation after 1 April 2025, must generate renewable energy from the date of operation. To comply with this mandate, coal power plants may either produce renewable energy within their premises or enter agreements with other entities to procure and supply an equivalent amount of renewable energy. This notification was released under the 2016 National Tariff Policy, which directed electricity generating companies to establish renewable energy generating capacity as guided by the Central Government, or procure and supply renewable energy equivalent to such capacity. The policy also allows for bundling renewable energy alongside thermal energy by these generators for power sale to electricity distributors.

7. gov.in/sites/default/files/Renewable_Purchase_Obligation_and_Energy_Storage_Obligation_Trajectory_till_2029_30.pdf

Offshore wind

In 2015, the Government of India introduced the 'National Offshore Wind Energy Policy', establishing a framework for the development of the offshore wind sector in the country. Following the policy notification, the Government has issued the 'Guidelines for Offshore Wind Power Assessment Studies and Surveys' through the National Institute of Wind Energy. These guidelines enable private investors to conduct assessments of offshore wind resources. Additionally, the Government is currently conducting offshore wind resource assessments and related studies in identified locations off the coast of Gujarat and Tamil Nadu. The objective is to validate the offshore wind resource potential in these areas. To further support offshore wind development, the Ministry has established a committee to create a roadmap for the country's existing and upcoming offshore wind projects.

The Government has allowed Foreign Direct Investment (FDI) of up to 100%[8] through the automatic route for renewable energy projects, including offshore wind energy projects. This decision aims to attract foreign investors and promote the growth of the country's offshore wind sector.

In a strategy paper published on 26 Sep 2023[9], the Ministry of New and Renewable Energy (MNRE) in India proposed three models for the development of offshore wind energy projects.

Model-A (VGF Model):

This approach will be followed for demarcated offshore wind zones for which MNRE/NIWE has carried out or proposed to carry out detailed studies/surveys. Presently, part of identified Zone B3 (365 Sq.km) equivalent to 0.5 GW off the coast of Gujarat and 0.5 GW equivalent site off TN coast will be considered in phase-1 of this model. MNRE, through its implementing agencies, will come up with bids for procurement of offshore wind power capacity under this model. Necessary central financial assistance, such as Viability Gap Funding (VGF), will be available to achieve a predetermined power tariff.

Model- B (Non-VGF but with exclusivity over seabed during the study/survey period):

This approach will be followed for sites identified by NIWE. Proposed offshore wind sites demarcated within identified zones will be allocated for a fixed period on a lease basis through single-stage, two-envelope bidding. Project development will be carried out by the prospective developer in these sites without any Central Financial Assistance (CFA).

The power generated from such projects will be either used for:

1. Captive consumption under open-access mechanism or
2. Sold to any entity through a bilateral power purchase agreement or
3. Sold through power exchanges

The Government may also call for bids for procurement of power for DISCOMs based on tariff after two years. Benefits such as provision of power evacuation infrastructure from the offshore pooling delivery point, waiver of transmission charge and additional surcharge, renewable energy credits with multipliers, carbon credit benefits etc. as determined by GoI/ state governments from time to time will be applicable.

Model- C (Non-VGF and without exclusivity over seabed during the study/ survey period):

In this model, developer may identify any offshore wind site within the EEZ excluding the sites considered under Model-A and Model-B. They will also undertake studies and surveys. The Government will come up with bids for project development/ allocation of the seabed.

The bidding may include any one of the following methods:

1. Bidding on lease/allocation fee or revenue sharing in case of projects for captive consumption/third party sale/sale through exchange under open access mechanism
2. Tariff-based competitive bidding in case of power procurement by DISCOMs or Central Government or state governments
3. Any other transparent bidding mechanism identified by the Government

8. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1737806
9. https://mnre.gov.in/document/strategy-paper-for-establishment-of-offshore-wind-energy-projects/

Electric vehicles

India is steadily adopting policy initiatives for electric vehicles. By 2024,[10] states such as Delhi aims to have one out of every four vehicles sold to be an electric vehicle. NITI Aayog, which is a policy think tank of the Government of India, has also released a report highlighting the need for increased investment to speed up India's transition to electric mobility.

Energy storage

The Government agrees that in the initial phase of adoption of energy storage technologies, market mechanisms and innovative economic models will be required the development and deployment of energy storage technologies, which would be most beneficial to the country in the long-term.

The following initiatives have been taken to promote growth of energy storage technologies:[11]

1. Legal status for Energy Storage Systems (ESS) has been issued by the MoP on 29 January 2022 wherein ESS has been designated as a Power System element, which can be utilised as a generator, transmission or distribution element.
2. Energy Storage Obligation trajectory till 2029–30 has been notified by the Ministry vide Order dated 22 July 2022.
3. Waiver of ISTS Charges on Hydro Pumped Storage Projects (PSP) and BESS Projects, commissioned up to 30.06.2025, has been provided vide order dated 23 November 2021. The waiver will be applicable for a period of 25 years for Hydro PSP and for a period of 12 years for BESS, or for a period subsequently notified for future projects by the Central Government from the date of commissioning of the power plant.
4. Revised Scheme for Flexibility in Generation and Scheduling of Thermal/ Hydro Power Stations through bundling with Renewable Energy and Storage Power has been notified vide order dated 12 April 2022.
5. Bidding Guidelines for Battery Energy Storage Systems (BESS) have been notified by MoP vide Resolution dated 10 March 2022.

10. https://www.downtoearth.org.in/blog/energy/how-close-is-delhi-to-its-electric-vehicle-adoption-target-87017
11. https://pib.gov.in/PressReleasePage.aspx?PRID=1881940

2.3 Challenges in integrating RE sources into the grid

Grid integration includes effective ways of providing variable renewable energy (VRE) to the grid. While maintaining or increasing the system stability, robust integration methods maximise the cost-effectiveness of adding variable renewable energy into the power system. It also incorporates renewable energy, energy storage technologies, demand response, and distributed generation into the power distribution and transmission system.

As the penetration of variable renewable energy (VRE) increases in the Indian grid, real time balancing operations becomes critical. The intermittent and variable nature of RE sources, coupled with the vast scale of integration required, demands innovative solutions and strategic planning.

Few major challenges are as discussed below:

Intermittency and variability

Solar and wind power, the primary RE sources in India, are inherently intermittent and variable, depending on weather conditions. This unpredictability poses a challenge for grid operators who need to maintain a balance between electricity supply and demand.

- Impact on grid stability: The fluctuating output of RE sources can cause voltage and frequency fluctuations, potentially destabilising the grid and leading to power outages
- Forecasting and scheduling: Accurate forecasting of RE generation is crucial for grid operators to plan and schedule dispatch of conventional power plants to compensate for RE variability.

Grid infrastructure and management

The Indian power grid, designed for conventional power plants, faces challenges in accommodating large-scale integration of RE sources.

- Transmission bottlenecks: The existing transmission infrastructure may not be adequate to handle the increased power flow from RE-rich regions to demand centres, leading to congestion and curtailment of RE generation.
- Grid flexibility and control: Grid operators need enhanced flexibility and control mechanisms to manage the variability of RE sources and maintain grid stability.

Land acquisition and environmental concerns

Large-scale RE projects require significant land acquisition, which can raise concerns over land use, displacement of communities, and environmental impacts.

- Land availability and acquisition: Securing suitable land for RE projects can be challenging due to competing land uses, ownership issues, and regulatory hurdles.
- Environmental impact assessments: Proper environmental impact assessments and mitigation measures are necessary to address concerns over habitat loss, biodiversity impacts, and visual impacts of RE projects.

Policy and regulatory framework

A comprehensive policy and regulatory framework is essential to facilitate RE integration and address market distortions.

- Renewable purchase obligations: Renewable purchase obligations (RPOs) mandate a certain percentage of electricity procurement from RE sources, but may need adjustments to ensure grid stability.
- Pricing and market mechanisms: Appropriate pricing mechanisms and market reforms are needed to incentivise RE integration while ensuring grid stability and fair competition.

Storage solutions and demand-side management:

The intermittent nature of RE sources necessitates energy storage solutions to store excess RE generation and provide a reliable power supply during periods of low RE output.

- Energy storage technologies: Investments in battery storage technologies, pumped hydro storage, and other innovative storage solutions are needed to complement RE integration.
- Demand-side management: Demand-side management strategies, such as load shifting and demand response programmes, can help balance RE variability and reduce peak demand.

Technological advancements and innovation:

Continuous research and development in RE technologies and grid management systems are crucial to address integration challenges.

- Grid modernisation: Investments in smart grid technologies, advanced forecasting tools, and real-time monitoring systems can enhance grid flexibility and stability.
- RE Technology advancements: Research into grid-friendly RE technologies, such as hybrid systems and distributed generation, can improve integration and reduce variability.

Financial viability and investment

Ensuring the financial viability of RE projects and attracting investments is crucial for large-scale RE integration.

- Cost competitiveness: While RE costs have declined significantly, ensuring cost competitiveness with conventional sources is essential for sustained growth.
- Investment incentives: Government incentives, such as subsidies, tax breaks, and risk mitigation measures, can encourage private sector investment in RE projects.

Stakeholder collaboration and public awareness

Effective collaboration among stakeholders, including government agencies, power utilities, RE developers, and communities, is crucial for successful RE integration.

- Policy coordination and implementation: Coordinated policy formulation and implementation across central and state governments can streamline RE integration efforts.
- Public awareness and acceptance: Educating the public about the benefits and challenges of RE integration can foster support and address concerns over land use and environmental impacts.

Integrating RE sources into the Indian grid presents a multifaceted challenge that requires a holistic approach. Addressing grid infrastructure, storage solutions, policy frameworks, technological advancements, financial viability, and stakeholder collaboration is essential to achieve India's ambitious RE targets and transition to a sustainable energy future.

03

Renewable Energy manufacturing in India- Prospects and Challenges

3.1 Understanding RE generation ecosystem in India

Solar Module Manufacturing

The Indian module manufacturing market has also grown in recent years. It has been competing at the global level in terms of technology, quality, costs etc. The Indian module manufacturers have been able to turn around products that are high in quality and performance. These products have also quickly adopted to latest technological developments with focus on quality and reliability.

The PLI initiative is a pivotal force propelling the expansion of India's entire photovoltaic (PV) manufacturing landscape. In addition to bolstering the infrastructure across all facets of PV manufacturing, from polysilicon production to module assembly, it will concurrently foster the growth of a complementary market. As a result of the combined impact of both phases of the PLI programme, the scheme is anticipated to directly increase module capacity by 51.6 GW and integrated polysilicon-to-module capacity by a minimum of 27.4 GW.

Moreover, post restrictions in the US against China, the developers are enthusiastic in buying modules from India players than China counterparts. Indian modules are well accepted in the US market even when the Indian modules are 5% more expensive than Chinese ones and are considered a credible option for US.

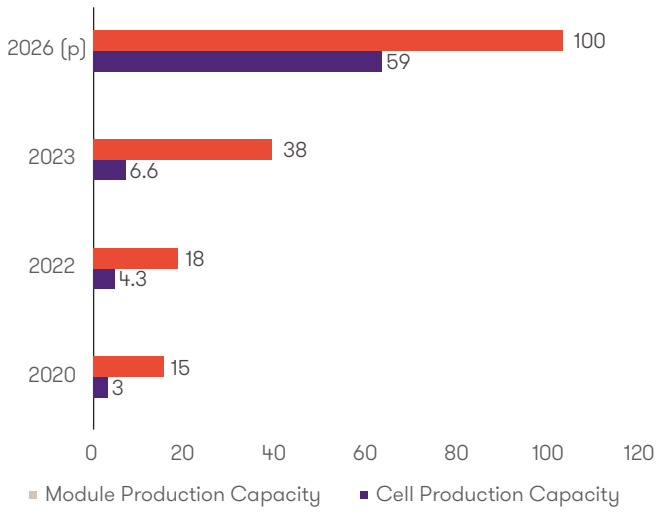
This has led to a 60-70% rise in exports. Therefore, Indian manufactures have its place in the global markets and performed excellently.

Post restrictions, the incentives offered by the US to manufacturers and developers are attracting investment opportunities in the US. The Indian module manufacturers are planning to set up factories in the US. There is a significant opportunity for Indian module manufacturers with its mix of Make in India for the US and Made in the US for the US. India has also been supplying cells to the US module manufacturers and there is substantial demand coming from the US. However, India has not been able to fulfill that demand.

With the availability of latest technology and improved supply chain, the cells that are being manufactured in India or going to be manufactured in will also have the best quality. Moreover, the manufacturers feel that India has equally high-quality wafers, cells and modules.

Going forward, India is not likely to have issues with quality of modules and hopes to have more than 100 GW of module manufacturing with best-in-class quality and performance.

Growth of Domestic PV Manufacturing Capacity



3.2 Supporting policies and regulations

In 2021, the Government announced import duties, compiled a pre-approved list of modules for usage in projects, and announced a manufacturing-linked subsidy scheme. In March 2021, MNRE announced a basic customs duty (BCD) of 25% on imported solar cells and 40% on imported solar modules from April 2022. The MNRE released the first Approved List of Models and Manufacturers (ALMM) for solar modules in 2021. As per government orders, almost all projects planned to be set up in India must use only the modules included in the ALMM list.

While India's solar manufacturing sector has seen slow growth, domestic manufacturers have the opportunity to aggressively expand their presence and benefit from a favourable policy landscape. In 2020 and 2021, there were large-scale supply chain disruptions and global shortages in polysilicon and other raw materials, which have led to a 40% increase in the price of imported solar modules.

The Government of India supports sustainable growth in the solar PV manufacturing industry by promoting both demand and supply of domestic PV products. Initiatives such as PM-KUSUM and CPSU Scheme boost demand with domestic module requirements and schemes such as PLI provide financial assistance to manufacturers to enhance supply.

India needs to ramp up domestic solar manufacturing to meet the ambitious target of 500GW RE by 2030 and net zero target by 2070. This will help reduce the risks of global supply chain issues such as shortag and price increases.

3.3 Challenges and recommendations going forward

Technology Development Fund

To match the quality at the global level and players, producing Top-con and moving to Heterojunctions cells and modules, India needs to invest significantly on R&D and technological developments. For this, India needs separate Technology Development Funds.

The technology gap has gone down significantly. India is not behind the curve in terms of latest technologies and by next year the Top-con solar manufacturing and new manufacturing lines are coming up.

Formation of independent bodies

India needs to form a body that works on future technologies and tracks global development.

Long-term, stable firm policy

India needs to develop a long-term, stable firm policy that instills confidence in manufacturers to ramp up their capacity. It also needs visibility in the long term, providing them with sustainable business.

The solar sector is growing at a considerable rate, and the manufacturing sector is also seeing a significant investment coming in. There is a need to have a stable policy to protect that investment where investors consider their businesses sustainable.

Policy stability will also help manufacturers plan their business and allocate their capital in R&D, expansion etc. This will help clarify whether to invest in wafer manufacturing, cell manufacturing, or module manufacturing plant.

Fostering R&D

The Council of Scientific & Industrial Research (CSIR) laboratory has already launched a policy and has chosen two laboratories, i.e., CSIR Chandigarh and CSIR Central Electronics Engineering Research Institute (CSIR-CEERI), Pilani. The CSIR will soon invite industry partners to conduct R&D in the right direction. The Government is focussed on R&D and is doing the best possible for the intervention.

Apart from the above, for the PLI Scheme, entry barriers are high for the players who want to invest in manufacturing. There should be policy measures to support business entry. Barriers should also be toned down. Moreover, the policies should be consistent.

Strengthening export opportunities

Another way to boost manufacturing and export could be by providing finances from prescribed banks or state at a 3–4% interest rate. Like in Germany, if someone imports machines from Germany, the manufacturer gets financing at low interest rates, thereby saving costs. They can pay by giving jobs and other benefits in that particular factory. So, instead of giving straight subsidy, they are making their product cost competitive. This could help in developing the ecosystem.

In the Indian context, EXIM bank has previously similarly supported Indian companies in executing projects in India as well as in other countries. However, there could be improvement in terms of considering more countries and considering not just those tenders where PPAs are given to specific entities. In case power is given directly to the Government even if it is done through any public sector undertaking, support should also be available in that case. Such models will increase the project visibility holistically and accelerate the development.

The outlook for India's PV manufacturing sector appears promising. In the next two to three years, as India achieves self-sufficiency, it should shift its attention towards broadening its presence in international markets and positioning its PV products as competitive alternatives to China, emphasising quality and price. Meanwhile, maintaining stable policies is imperative to uphold investor confidence within the market.

04

Prospects for new and emergent technology in India

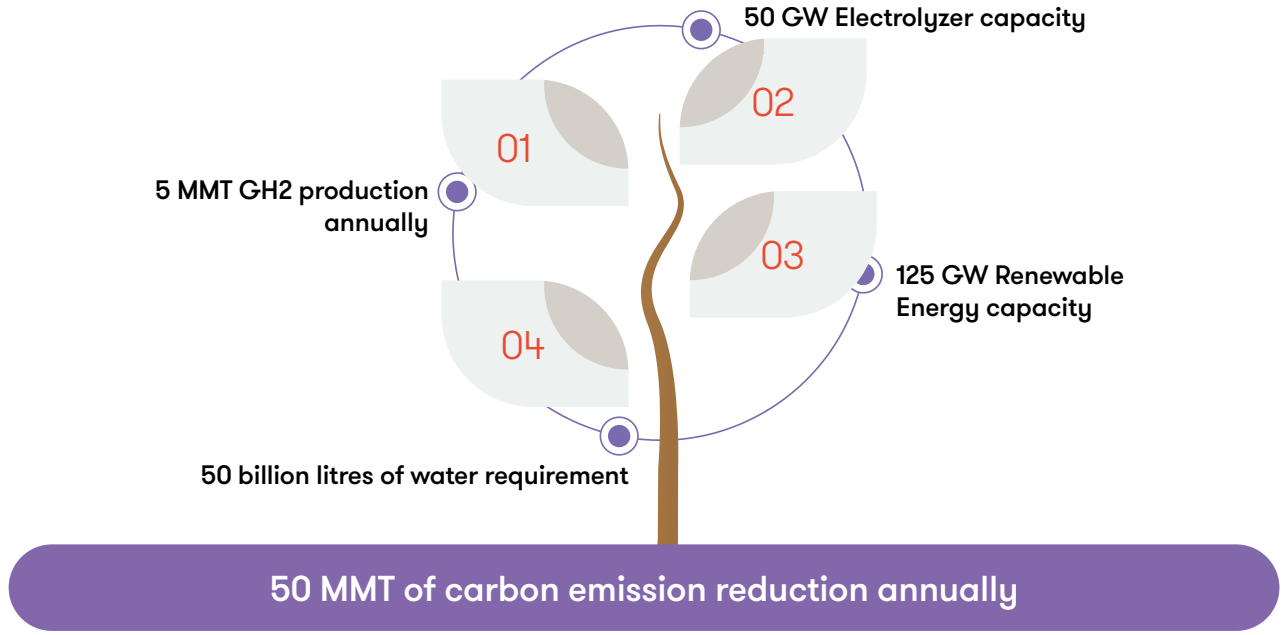
4.1 Introduction to new and emergent RE technologies

4.1.1 Green hydrogen

Hydrogen is an energy carrier and can be used for a range of energy and industrial applications. It can also be stored for a long time. The opportunities and challenges of hydrogen emerge from its energy characteristics as its specific energy, energy content per unit of mass, is higher than most hydrocarbon fuels while its volumetric energy density is the lowest. This dictates the need for pressurisation or liquefaction for hydrogen to be used as a fuel. These two properties drive the value as well as the applicability of hydrogen for various possible end-use cases.

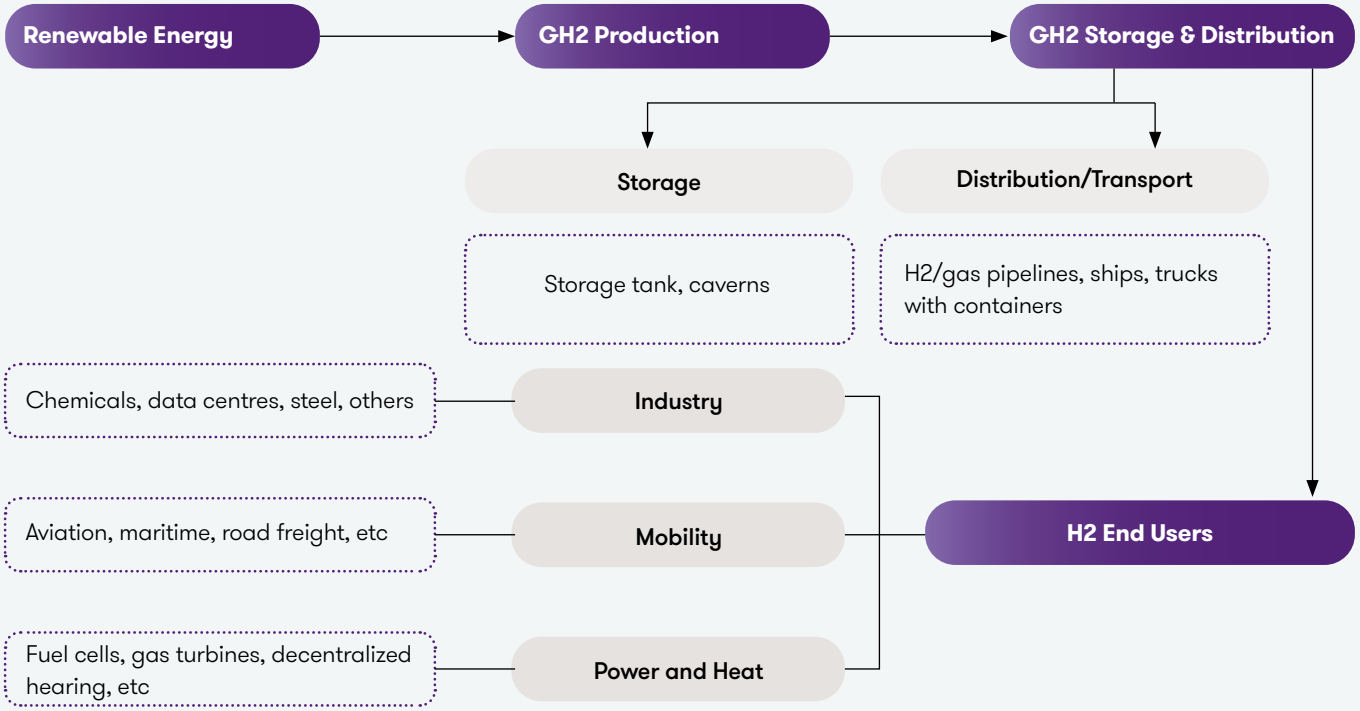
Globally, hydrogen demand has increased by 17% between 2010 and 2018[12] predominantly to produce ammonia and in refineries. With growing focus on decarbonisation and net zero targets, hydrogen demand is expected to reach 528 million tonnes resulting in mitigation of giga tonnes of carbon emissions by 2050.

Current green hydrogen demand to meet the needs is as follows



Hydrogen produced using water electrolysis, a process that splits water into hydrogen and oxygen, by consuming electricity from renewable energy sources is termed as green hydrogen. There are three main electrolysis technology — alkaline, proton exchange membrane and solid oxide. Green hydrogen is produced using electrolysis of water with electricity generated by renewable energy. The schematic of the entire process and potential use cases is captured below.

12. https://www.niti.gov.in/sites/default/files/2022-06/Harnessing_Green_Hydrogen_V21_DIGITAL_29062022.pdf



In the near term, industrial applications are expected to drive demand and other use cases such as power and transportation will drive the long-term market. With growing focus on use cases and net zero ambitions, global green hydrogen demand is expected to reach 63 million tons by 2030[13] resulting in development of large-scale renewable energy capacity and electrolyser capacity.

While the ecosystem for renewable energy is matured, electrolyser technology development is central to ensure ramp-up of green hydrogen production. In the current market, Alkaline and polymer electrolyte membrane (PEM) electrolysers are the two commercially viable technologies and technologies such as solid oxide and anion exchange are expected to achieve commercialisation in coming years.

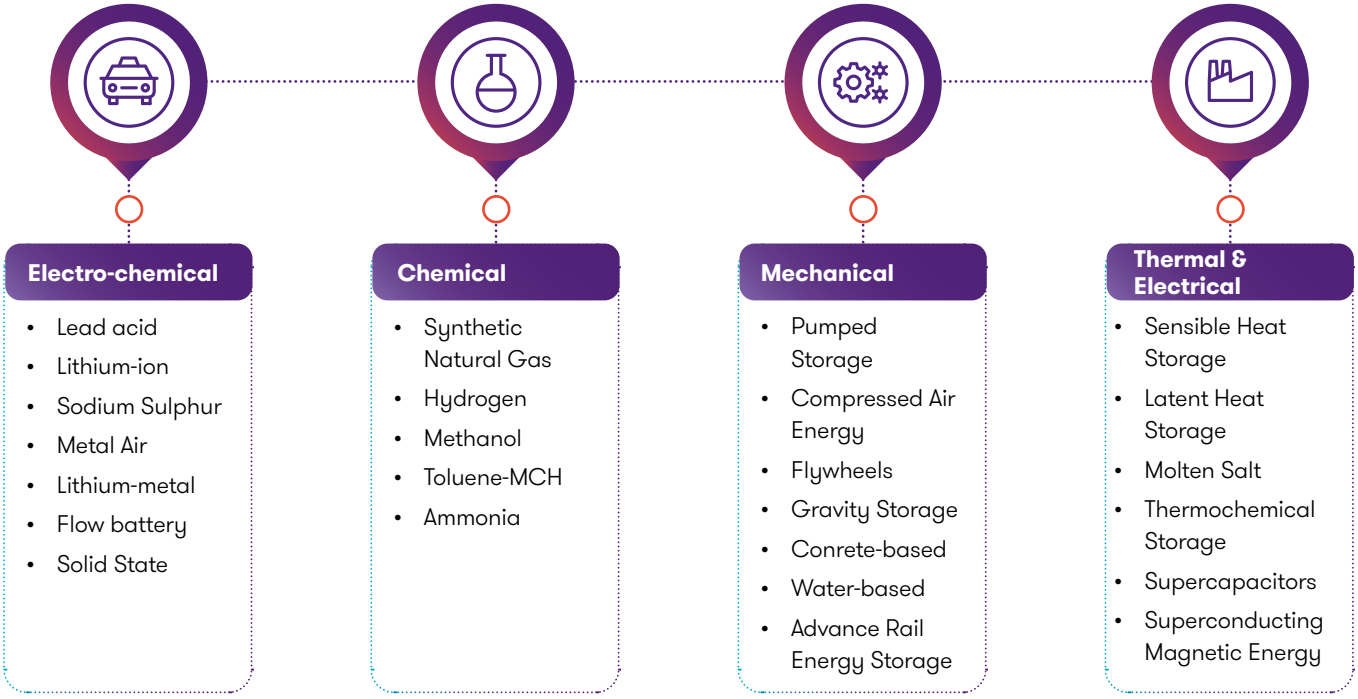
13. https://energy.economictimes.indiatimes.com/news/renewable/global-green-hydrogen-capacity-to-hit-21-mtpa-by-2030-cii-ey-report/103817213

4.1.2 Battery storage

Energy storage system (ESS) is fast emerging as a crucial part of the energy transition process. With growing renewable energy capacity in overall energy mix, storage is going to play a critical role in grid integration, management of renewable energy, back up during peak demand or unexpected outages. Broad ESS services are highlighted below:

Ancillary services	Bulk energy services	Transmission infrastructure services	Distribution infrastructure services	Energy management services
• Fast Frequency Response • Primary/ Secondary/ Tertiary Reserve • Voltage Support • Black Start	• Electric energy time-shift (arbitrage) • Electric Supply Capacity	• Upgrade Deferral • Congestion Relief	• Upgrade Deferral • Congestion Relief • Voltage Support • Ramp Support	• Power Realiability • Retail Electricity Time Shift • Power Quality • Demand Side Management

Basis operating principle, ESS technologies can be classified into following categories:



While multiple use cases and application of each technology varies according to business models, considering the rapid developments and expected price trends, we will focus on battery energy storage systems.

India has been pushing manufacturing of EV battery cells to reduce dependence on China. The Government has developed an INR 18,000 Crore PLI scheme for local manufacturing of cells for EV batteries and approved National Programme on Advanced Chemistry Cell (ACC) battery storage for achieving manufacturing capacity of 50 GWh. The emphasis is to achieve increased domestic value addition and ensure levelised cost of battery manufacturing in India is globally competitive.

In April this year, India got its first indigenous lithium-ion cell manufacturing facility with a capacity of 50 MWh which can power 25,000 electric two wheelers. It is estimated that 60-65% of batteries are to be consumed in the electric mobility segment and the remaining will be used in ESS or appliances segment.

India has a very well-developed supply chain infrastructure. The country is catching up with latest technology development and is not lagging. The battery life is 20 years which is very well established. It is imperative to understand the Indian environmental conditions and developing technologies accordingly which works well. India has all the resources for developing Li-ion cells and has developed technology that will work efficiently at various environmental conditions. Li-ion cells are designed carefully keeping in mind Indian operating conditions, climate, and customers, and are hence going to play a crucial role in making India self-reliant.

However, one major challenge that still remains is the sourcing of raw materials and manufacturers are finding it difficult to procure raw materials for battery manufacturing. India recently has developed a comprehensive report on critical minerals, including 30 such minerals. Critical minerals play an increasingly vital role in various clean energy technologies, including advanced batteries.

Critical mineral aspect

- Critical minerals, including lithium, cobalt, nickel and spherical graphite, are vital to manufacturing of BESS in India.
- India needs to reduce its reliance on imports of these minerals through localising the mining and refining value chain
- Even under conservative scenario to meet a demand of 100GW annually, India's Lithium-Ion Battery cell manufacturing industry will need ~193 thousand tons/ annum of cathode active material and ~98 thousand tons/ annum of anode active material.
- Critical minerals and their active materials contribute between 33–48% of the cost for Lithium-ion battery pack based on cell chemistry.
- India's LIB import bill was at USD 1,193 million, in FY 21, with majority of these imports~87% coming from China and Hongkong.
- India needs to reduce the cost of manufacturing through innovation and optimising the process and systems.

Recycle and Reuse

The Prime Minister of India has been promoting the Lifestyle for Environment (LiFE). On the occasion of the UN Climate Change Conference (UNFCCC COP26), the Honourable Prime Minister Narendra Modi introduced the mission of "LiFE" to engage individuals in mitigating the adverse effects of climate change.

This initiative encourages a lifestyle that focuses on mindful and deliberate utilisation of resources and aims to change the present 'use and dispose of' consumption habits. This is specifically true for batteries which use a particular type of material and reutilising the investments and resources that have been made.

Policies for recycling of lead acid batteries already exists and same should be applied and implemented for Li-ion batteries. Although there is enough time for recycling of Li-ion batteries as they have a life of 15-20 years as guaranteed by the manufacturers and as of today there are hardly any Li-ion batteries for recycling.

There is also an increased interest from start-ups that are coming in the recycling of batteries. Therefore, recycling is not a challenge and major recycling will happen around FY 2027-28.

4.1.3 Biofuels

Biofuels have already been acknowledged as one of the most feasible solutions to the diminishing fossil fuels reserves along with many key advantages such as cost benefits, empowering rural economy, and reducing carbon footprint. They are made from biomass using various materials such as plants, food and animal waste as well as farm residue. They have the ability to decompose naturally in the environment, which implies that they do not have the same negative impact on the environment as fossil fuels and do not add to pollution in the same way.

In addition to reducing dependence on fossil fuels, biofuels also serve as a catalyst to strengthen the economy by reducing government expenditure on fossil fuel imports, increasing farmers' income by turning them from food producers to fuel producers, supporting new businesses, mainly start-ups, and achieving energy security and energy independence. At this juncture, it is encouraging to see the Indian Government providing much-needed assistance to biofuels production. Due to the Government's efforts, the country achieved the target of 10% ethanol blending in 2022 and saved as much as INR 53,894 crore[14] in forex outgo from 10% blending besides benefiting the farmers. Buoyed by this, the Centre has already advanced the target of 20% ethanol blending in petrol from 2030 to 2025, which is promising. Additionally, policy intervention and schemes such as a policy for co-firing of biomass in thermal power plants, mandating minimum 5% co-firing of biomass along with coal, Sustainable Alternative Towards Affordable Transportation (SATAT) scheme to promote use of CBG in transportation sector, along with several incentives are giving the much-needed impetus to the sector.

India maintains its biodiesel blending goal target of 5% for on-road use by 2030. The national average blend rate remains unchanged at 0.1% for 2023. Due to import restrictions on palm stearin, a disorganised supply chain of used cooking oil (UCO) and animal fats, high feedstock costs, and a shortage of supply of palm oil, India's biodiesel usage remains extremely low. Post forecasts that India will produce approximately 200 million liters of biodiesel in the forecast year, up from 185 million liters in 2022. Due to government incentives and interventions, post estimates consumption can go up marginally to 190 million litres in 2023.

India's Biofuel Policy 2018

The Indian Government has amended its 2018 National Policy on Biofuels to support improved domestic biofuel production. The policy includes an accelerated national E-20 mandate from 2030 to 2025, which aims to increase ethanol production capacity in India from 7 billion liters (BL) in 2021 to 15 BL in 2025. The National Biofuel Coordination Committee, which consists of 14 different ministries, amended the policy to allow the conversion of excess cereal grains for ethanol under the EBP programme.2 The amended policy permits additional feedstocks for biofuel production. The revisions allow for the manufacturing of ethanol from corn (maize), food grains including broken rice, wheat, non-suitable grains for human use, and other non-food sources (2G). Other additions to the policy include the domestic production and sale of flexible-fuel vehicles (FFV), and the promotion of domestic biofuel production of biofuels through Special Economic Zones and Export Oriented Units under the "Make in India" campaign.

The policy focuses on four points:

1. Low cost of oil imports and increased self-sufficiency
2. Safeguarding farmer financial stakes
3. Emphasis on reduced carbon emissions
4. Enhanced economic efficacy due to innovation

14. https://timesofindia.indiatimes.com/blogs/voices/how-india-can-rapidly-grow-its-biofuel-usage-as-an-alternative-fuel/

4.2 Key promotional policies to aid the sectoral growth

A. Battery Storage

National policies supporting battery energy storage system (BESS) projects in India

1. **Bidding guidelines:** The MoP on 11 March 2022, notified bidding guidelines for the procurement and utilisation of BESS, establishing provisions to enable their implementation.
2. **Draft National Electricity Plan:** In September 2022, projections were made for 51.5 GW of BESS installations by 2031–2032.
3. **Ancillary services regulations:** In January 2022, new regulations for ancillary services, crucial to maintain grid voltage and frequency was notified. BESS plays a key role in balancing intermittencies of wind and solar power.
4. **Interstate transmission charges waiver:** In June 2021, the MoP ordered the waiver of interstate transmission system charges for battery storage and pumped hydro systems commissioned until June 2025.
5. **Renewable purchase obligations (RPO) trajectories:** In July 2022, the MoP issued RPO trajectories until 2029–2030, which, for the first time, included energy storage obligations trajectories until 2029–2030.
6. **Production Linked Incentive (PLI) Scheme:** The PLI scheme incentivises the development of a localised value chain for the battery industry. Under the National Programme on Advanced Chemistry Cell (ACC) Battery Storage, the Government has allocated INR 181 billion (USD 2.49 billion) in financial allocations. The programme is designed in such a manner that it is technology agnostic. The beneficiary firm shall be free to choose suitable advanced technology and the corresponding plant and machinery, raw material, and other intermediate goods for setting up cell manufacturing facility to cater to any application.

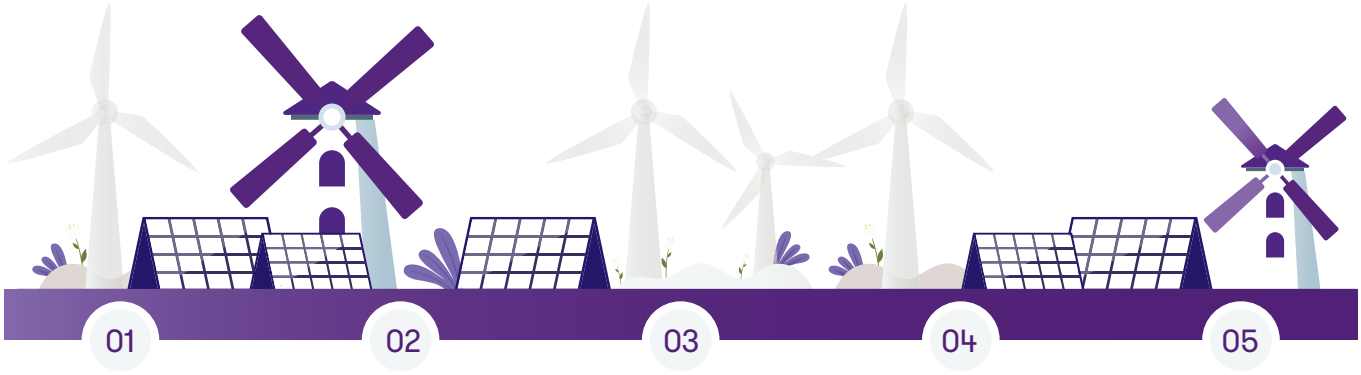
Incentives for battery energy storage projects in India

- The Government of India (GOI) plans to provide incentives totaling INR 37.6 billion (USD 455.2 million) to companies undertaking battery storage projects.
- Earlier this year, GOI revealed plans for battery storage projects with a total capacity of 4,000 megawatt hours (MWh); specific details of the scheme will be published in the next few weeks.
- The primary objective of this scheme is to promote battery storage projects in the country, considered important to meet India's ambitious target of expanding its renewable energy capacity to 500 gigawatts (GW) by 2030.
- The scheme will cut the cost of battery energy storage from the current range of INR 5.5-6.5 per unit.
- The scheme shall foster the development of large-scale battery energy storage systems by encouraging competitive bidding to drive down costs.
- GOI anticipates the scheme will generate private investments worth INR 56 billion (approx. USD 680.47 million) through this initiative.

B. National Green Hydrogen Mission

On 4 January 2022, the Union Cabinet of India announced National Green Hydrogen Mission with a financial budget of USD 2.4 billion (INR 197 billion), to become a global leader in green hydrogen production, reduce carbon emissions and fossil fuel dependency, and generate economic growth. India's targets include developing a capacity of 5 MMT of green hydrogen and 125 gigawatts (GW) of renewable energy capacity by 2030 and establishing green hydrogen bunkering and refueling facilities at major ports by 2035[15].

The Mission will result in the following likely outcomes by 2030:



Integrated	Demand creation	Incentivising Supply	Key enablers	Expected outcomes by
Focused and co-ordinated steps to be taken by about 13 Central Ministries (incl. Ministry of Steel, Power, Road Transport and Highways,etc.)	**Domestic Demand creation** by substituting Grey with Green – GoI to specify guidelines on min. consumption by designated consumers	Under Strategic Interventions For Green Hydrogen Transition (**SIGHT**), **distinct fiscal incentives** to be given to boost domestic manufacturing of **electrolysers and green hydrogen**	Emphasis on R&D, **pilot projects**	Renewal Energy capacity addition ~ 125 GW
State Govts. to frame fair and rational policies for provision of land, water, suitable tax structures, etc.	**Capturing global markets** by building mechanism for dollar denominated bids for Green Hydrogen / NH_3		**Availability of resources (renewable energy, banking & storage, transmission, land, water, etc.)**	Attract over INR 8 lakh crore investment
	Subsituting imports of fossil fuels, fertilisers		Infra & Supply chain - **re-fueling, hydrogen hubs, pipelines**	Create over 6 lakh full time jobs
			Formation of regulations & Standards	50 MMT p.a. of CO_2 Emissions are expected to be averted

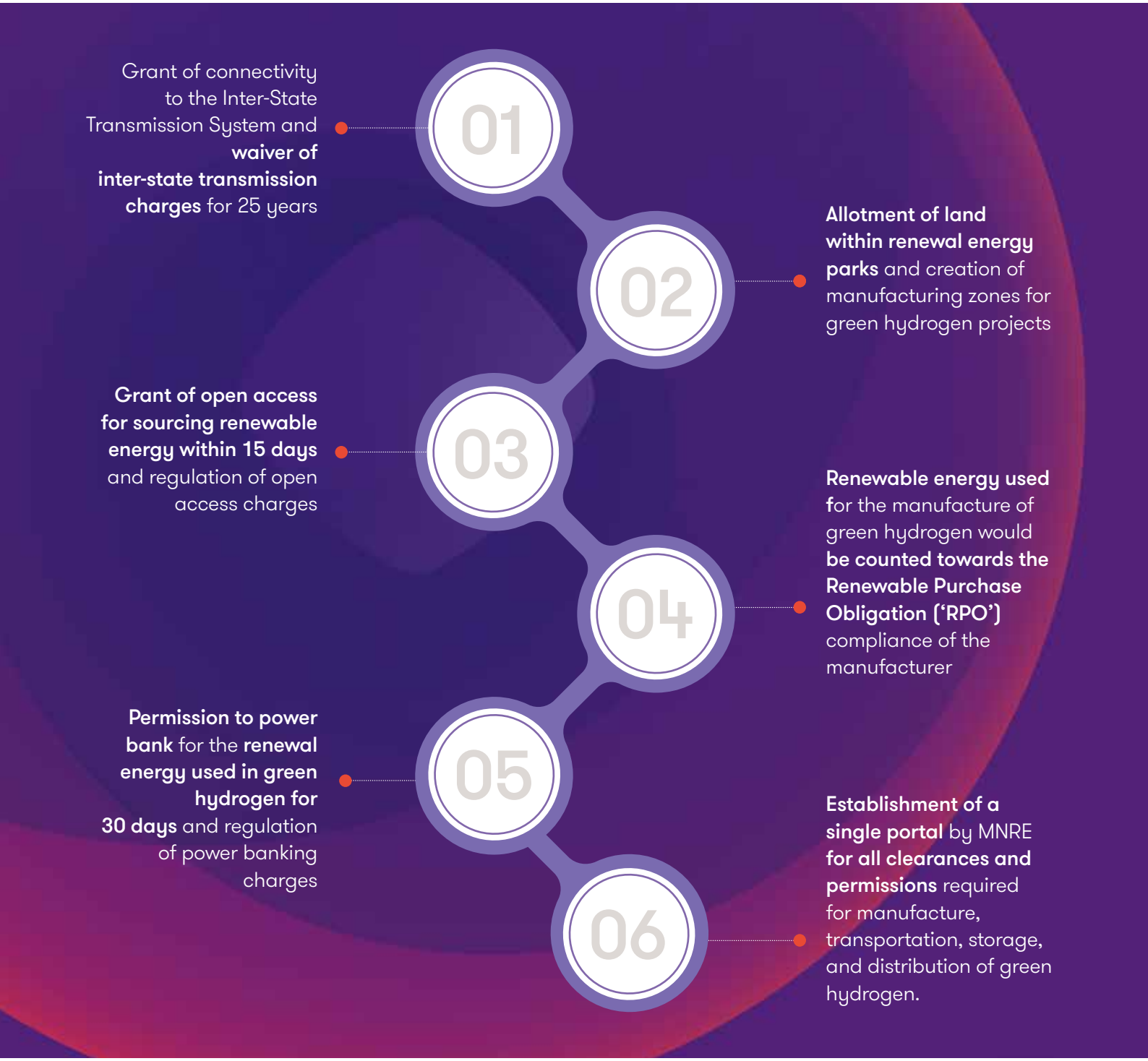
The Mission will facilitate demand creation, production, utilisation and export of Green Hydrogen. Under the Strategic Interventions for Green Hydrogen Transition Programme (SIGHT), two distinct financial incentive mechanisms – targeting domestic manufacturing of electrolysers and production of Green Hydrogen – will be provided under the Mission. The Mission will also support pilot projects in emerging end-use sectors and production pathways. Regions capable of supporting large scale production and/or utilisation of hydrogen will be identified and developed as Green Hydrogen Hubs.

The Mission is in its early stages—a government committee has been formed to facilitate activities in the production, storage, and distribution, for applications to be used in application for automobiles, rail, shipping, agricultural equipment and generator sets. Despite state-level incentives to attract venture capital, constraints in India's renewable energy setting, insufficient regulations and certifications, and a lack of scientific and technical knowledge challenges achieving the ambitious green hydrogen goal.

15. MoPNG, National Green Hydrogen Mission

Green Hydrogen Policy

In line with the goals of the Hydrogen Mission, a significant portion of the Green Hydrogen Policy deals with initiatives that encourage the production of green hydrogen. The Green Hydrogen/ Green Ammonia Policy was notified by the Central Government in February 2022. It is a major step to help India achieve its climate targets and aid in the smooth implementation of the National Hydrogen Mission. The policy also aims to make India an export Hub for Green Hydrogen and Green Ammonia.



Initiatives by few state governments

Apart from the SIGHT Programme launched by the Central Government, several states are now coming up with new policies offering fiscal incentives for green hydrogen production.

State	Initiatives taken
Andhra Pradesh	• Andhra Pradesh Green Hydrogen and Green Ammonia Policy, 2023 provides for following incentives: • 100% net SGST reimbursement from sale of Green Hydrogen/Green Ammonia within the State for five years • 25% reimbursement of intra-state transmission charges for wheeling of power for five years • Reimbursement of cross-subsidy surcharge on energy drawn from renewable energy plant located in the state for five years • Land allotment at concessional rates and 100% exemption on stamp duty
Maharashtra	• Maharashtra is the first State to launch Green Hydrogen Policy With an outlay of INR 8,500 crore. The Scheme will inter-alia provide for following fiscal benefits: • Exemption of "cross subsidy surcharge" and additional surcharge for energy procured • 50% exemption on intra-state transmission charges and 60% concession on wheeling charges for electricity procured from renewable energy plants for a period of 10 years • 100% exemption from electricity duty • Subsidy of Rs 50 per kg will be given for blending green hydrogen into gas for five years • First 20 green hydrogen refueling stations - 30% capital cost subsidy up to a maximum of INR 4.50 crore
Gujarat	• State is framing a new policy for green hydrogen manufacturing by giving it a status of "priority sector"

C. Biofuel Policy

Selected Specifics on Ethanol, Biodiesel, and "Other" Biofuel Policy National Ethanol Blend Rate - Ten Percent Achieved in 2022 and 20 Percent Goal by 2025

Under the 2018 National Biofuels Policy, the Indian Government has set targets for the national average ethanol blend rates in gasoline. By 2022, they aim to achieve a blend rate of 10 % (E-10), and by 2025, they aim to reach a blend rate of 20 % (E-20).

The objective of this programme is to increase the production of ethanol from various feedstocks, including sugarcane, grains, and derivative products. The Government plans to achieve the E-20 target by increasing domestic yields of biofuel, including 1G, 2G, and 3G, through the diverse application of feedstocks. Additionally, they promote biofuel blending to supplement gasoline and diesel use in cars, machinery, stationary power applications, and portable power applications.

To achieve the E-20 target by the end of the Indian financial year 2024/2025 (ESY), the Government is encouraging sugar mills and stand-alone distilleries to divert surplus sugar and derivatives and procure excess grains from the Food Corporation of India (FCI) to produce ethanol under the Ethanol Blending Programme (EBP). India has already met its E-10 target, briefly reaching a national blending average of 10.1%[16] in June 2022, and they have additional projects in place to reach the E-20 targets.

16. See: "What is E20 Petrol, and How Will it Affect Your Vehicle?" Times of India; published February 7, 2023

Excluding union territories, Oil Marketing Companies (OMCs) are responsible for nationwide blending of ethanol into gasoline. The Cabinet Committee of Economic Affairs (CCEA) has approved the Government's Pradhan Mantri JI-VAN Yojana[17], which provides "viability gap funding" to 2G bioethanol manufacturing projects to increase ethanol production for blending[18].

The EBP has established an organised and regulated domestic marketplace where ethanol produced by sugar mills or stand-alone distilleries can enter into long-term agreements to sell ethanol to the OMCs at fixed rates. This initiative aims to prevent scattered ethanol diversion from mills for localised purchasing and provides safe purchasing alternatives, secure transportation costs, and timely payments to safeguard mills.

As of November 2022, OMCs have invested USD 91 million (INR 7.5 billion) to enhance their ethanol storage capacity, totaling 344 million liters. According to the Ministry of Petroleum and Natural Gas (MoPNG), this provides ethanol storage for a 20-day turnaround period at their depots. Furthermore, the Government's financial assistance programme to sugar mills for ethanol production increased by 54% in FY2023 –2024, compared to FY2022–2023.

Biodiesel Policy

India maintains an ambitious diesel blending goal (on-road use) target of 5 % with biodiesel by 2030. According to the Indian Government, the national average blend rate has marginally increased from 0.07 % in 2022 to 0.10 % in 2023[19]. India's biodiesel production is primarily produced from animal fats, limited quantities of non-edible oils, UCO, and imported palm oil and palm stearin. Biodiesel utilisation in India remains exceptionally low due to import limitations, a lack of an organised supply chain, and excessive costs and non-availability of feedstocks. Approximately 3 MMT of UCO are produced annually, but a lack of stable procurement mechanisms results in limited uptake. Around 80 % of biodiesel production expenses stem from feedstock procurement.

Other Biofuels: Drop-in-fuels, Bio-CNG, Bio-Hydrogen, Bio-methanol, Di-Methyl-Ether

On November 2, 2022, the Ministry of New and Renewable Energy (MNRE) extended its National Bioenergy Programme from IFY 2021/2022 to 2025/2026, to focus on three areas, notably waste to energy, biomass, and biogas[20]. On December 15, 2022, the Indian Government announced various initiatives for establishing domestic bio-compressed natural gas (CNG) plants, including via the Sustainable Alternative Towards Affordable Transportation programme (SATAT), which has the goal to establish 5,000 bio-CNG operations to produce a cumulative 15 MMT of bio-CNG by IFY 2023/2024[21].

First launched in 2018, the goal of SATAT is enhancing the application various biomass feedstocks including municipal solid waste, press mud and agricultural residues (bio-manure). The compressed biogas would be sold at OMC fuel stations as a green transport fuel alternative. According to MoPNG, 38 compressed biogas plants have been commissioned with an installed capacity of 125 million metric tons[22]. In June 2022, a compressed biogas/bio-CNG plant was commissioned in Sangrur, Punjab to produce 33 metric tons (MT) of compressed biogas and 600 MT of organic manure daily. According to some estimates, India uses only 0.5 % of its potential and produces 80,000 MT of CBG daily[23].

The Ministry of Science and Technology has invested in technologies to scale enhanced biofuels production including biohydrogen, biobutanol, and synthetic hydrocarbons[24] . The Department of Biotechnology-Indian Oil Corporation Centre established the first pilot programme to produce biodiesel using carbon dioxide through "high value" lipids technology[25]. The laboratory is also producing biohydrogen using sugars derived from various biomass sources through anaerobic fermentation.

17. https://pib.gov.in/PressReleasePage.aspx?PRID=1843441
18. Funding provided to support infrastructure projects is considered economically justified but lacks financial viability
19. Remarks by Nirmala Sitharaman: Union Budget 2023-2024, Government of India, February 1, 2023
20. Source: "MNRE Notifies National Bio Energy Programme." MNRE, published November 7, 2022.
21. Source: "Establishment of Bio-CNG Plants." Press Information Bureau, published on December 15, 2022
22. "38 CBG/Biogas Plants with Installed Capacity of 225 MT per annum Commissioned", ICN Bureau, published on December 9, 2022
23. See: S. Kalamdhad, A. and Singh, P., 2022. Biomethane Plants Based on Municipal Solid Waste and Wastewater and its Impact on Vehicle Sector in India - An Environmental-Economic-Resource Assessment, Environmental Technology & Innovation
24. See: Scientific Decision Units, Department of Biotechnology, Ministry of Science and Technology
25. The process separates chemical production from commodity feedstocks and converts carbon dioxide into acetic acid and the later to lipids (algal oil) including omega 3-fatty acids and biodiesel.

4.3 Technical, policy, and financial recommendations to aid sector growth

A. Green hydrogen

The Indian green hydrogen sector faces various technical, regulatory, and financial challenges. Below are these challenges along with some recommendations for overcoming them:

1. Technical Challenges:

- High production cost: Currently, the production of green hydrogen is expensive due to the cost of electrolysis, which uses abundant electricity
- Scaling up production: There is a challenge in ramping up the production of green hydrogen to meet growing demand because of the limited availability of renewable resources
- There are gaps in standards across the hydrogen value chain, such as in production, storage, transport, dispensation, and utilisation

2. Regulatory Challenges:

- Infrastructure integration: Incorporating green hydrogen production and usage into the existing energy structure is essential and needs regulations to guide the process.

3. Financial challenges:

- High capital investments: Establishing green hydrogen production facilities requires significant capital investment.
- Limited market demand: Currently, there is a lack of strong market demand for green hydrogen, which can deter investors.

Recommendations:

- Encourage research and development in green hydrogen production technologies to decrease costs. Also, prioritizing the upscaling of renewable resources to meet the production demand
- India should lead the effort to harmonise standards across the hydrogen value chain both domestically and globally, to realise the vision set out in the National Green Hydrogen Mission.
- The Government should develop clear policy frameworks and guidelines that encourage the production and utilisation of green hydrogen. Establishing regulations that facilitate the integration of green hydrogen into the current energy infrastructure can also promote its usage
- Promoting public-private partnerships can help attract needed investments. The Government can also provide financial incentives, grants, or subsidies to companies willing to venture into green hydrogen production. Furthermore, creating demand by promoting or mandating green hydrogen in certain sectors can also encourage investment.

India's pursuit of a sustainable hydrogen economy stands ready for revolutionary expansion. Despite challenges such as water dependence and economic barriers, strategic initiatives such as the Green Hydrogen Mission and other supportive policies demonstrate the nation's commitment. Addressing technical obstacles, reducing costs, and clarifying regulatory frameworks will be crucial. India seeks to secure a leadership position in the global hydrogen landscape by focusing on technological innovation and holistic approaches, fostering economic growth, sustainability, and energy independence.

B. Battery storage

India's battery storage sector faces several technical, regulatory, and financial challenges. Few are listed as follows:

1. Technical challenges:

One of the most significant technical challenges is in the R&D and implementation of sustainable, efficient, and cost-effective battery storage technologies. This ranges from developing batteries with high energy density and longevity to establishing infrastructure for recycling and disposal of used batteries. Furthermore, the integration with the existing grid and the variability of renewable energy generation are other substantial technical challenges.

2. Regulatory challenges:

Lack of a robust policy framework is a major regulatory hurdle. India needs to establish comprehensive guidelines on the use, safety aspects, and environmental impact of battery storage technology. This includes regulations concerning battery manufacturing, deployment, transportation, and end-of-life battery management. Currently, the absence of specific norms and frequent policy changes creates unpredictability, hindering the sector's expansion.

3. Financial challenges:

One considerable financial challenge is sourcing investment for the battery storage sector. With high initial setup costs, the financial viability of storage solutions is a concern for many investors. Moreover, the high cost of the batteries themselves—largely due to the cost of raw materials like lithium—makes it more challenging.

Addressing these challenges will require a concerted effort from stakeholders, ranging from the Government to research institutions and the private sector. Policy support, research and development, and innovation in business models will be needed to unlock the sector's full potential and ensure its contribution to India's renewable energy goals.

Recommendations:

- India requires more supportive policies for grid-level storage and introducing daytime tariffs. There is an advantage towards battery-powered productions as these may supply power at peak times. And saving towards high tariffs during peak hours.
- India needs to have a policy framework that pulls in battery storage utilisation.
- Ensuring the charging happens through green power or through renewable energy instead of grid electricity.

Another area could be having a very clear policy direction which brings in demand creation, actual utilisation of batteries and create a market for energy storage segment.

- Promote R&D along with a strategic focus on mining and extraction efforts.
- Promote circular economy for batteries through a focused policy and framework to promote battery recycling and reuse market in India.
- Focus on customer needs and providing the right solution and infrastructure. Subsidies can support the growth in initial years but to have long-term sustained growth and to keep driving the adoption. And some innovative ways to provide solutions to customers in terms of OPEX instead of CAPEX in the batteries and EV segment and move from transaction to solutions. Solutions can be in the form pay-per-KM or pay-per-usage. Focus on different solutions to different sets of customers.
- Policy focusing on standardisation on battery swapping stations in terms of specified technical, safety and performance standards. This will help in mass adoption of EV vehicles.
- Support from the Government for technological collaborations and financial investments from abroad for mid-size players willing to enter the segment.
- Customer commitments for specific volumes can create enough market demand to give manufacturers confidence and clear visibility.
- Recognising the fact that the recycling of batteries and extracting back the critical minerals, regulations and policy framework has to be in place so that it goes to organised and responsible manufacturers. And checks on the movement of recyclables across geographies.

C. Biofuel

1. Technical challenges

- Technological progress: The development of advanced biofuel technologies, such as second-generation biofuels and waste-to-energy conversion, is still in its early stages in India. This limits the commercialisation of these technologies and the production of sustainable biofuels.
- Availability of feedstock: The availability of sustainable feedstock is critical for the growth of the biofuel sector in India. However, competing land uses and the diversion of food crops for biofuel production pose challenges to feedstock security.
- Conversion efficiency: The conversion efficiency of biofuel production processes is relatively low, leading to higher costs and lower yields.
- Quality control: Establishing and enforcing quality standards for biofuels is essential to ensure their performance and safety. However, limited testing facilities and weak enforcement mechanisms pose challenges to quality control in India.

2. Financial challenges

- High investment costs: The upfront investment costs for biofuel projects are high, especially for second-generation biofuels and waste-to-energy projects. This can deter potential investors and hinder the development of the sector.
- Lack of subsidies and incentives: Government subsidies and incentives are essential to make biofuels competitive with conventional fuels. However, the current level of support in India is inadequate.
- Price volatility: The prices of agricultural feedstocks and biofuels are volatile, making it difficult for biofuel producers to plan and operate their businesses profitably.
- Limited market access: The market for biofuels in India is still limited, due to factors such as consumer awareness, lack of infrastructure, and blending mandates.

3. Regulatory challenges

- Complex regulatory framework: The regulatory framework for the biofuel sector in India is complex and fragmented. This can create uncertainty for investors and make it difficult to navigate the regulatory landscape.
- Delayed approvals: The approval process for biofuel projects can be lengthy and cumbersome, delaying project implementation.
- Limited enforcement: Weak enforcement of existing regulations can lead to unfair competition and discourage investment in the sector.
- Lack of coordination: There is a lack of coordination among different government agencies involved in the biofuel sector. This can lead to policy inconsistencies and delays in implementation.

By addressing the technical, financial, and regulatory challenges, India can accelerate the growth of the biofuel sector and achieve its ambitious biofuel targets. Few recommendations proposed are as follows

Recommendations:

- Support research and development in advanced biofuel technologies: The Government should support research and development in advanced biofuel technologies, such as second-generation biofuels and waste-to-energy conversion. This will help to reduce the cost of biofuel production and improve its competitiveness
- Promote sustainable feedstock production: The Government should promote the production of sustainable feedstocks for biofuels, such as non-food crops and agricultural residues. This will help to address concerns about food security and land use.
- Develop and enforce quality standards: The Government should develop and enforce quality standards for biofuels to ensure their performance and safety. This will boost consumer confidence in biofuels and promote their adoption
- Increase the use of non-food biofuels such as jatropha, palm oil, and coconut oil
- Develop a robust supply chain management system to ensure efficient transportation and distribution of biofuels
- Encourage the use of advanced biofuels such as cellulosic ethanol and algal oil
- Promote the development of biofuel production facilities in various parts of India
- Collaborate with international organisations to gain access to advanced biofuel technologies and best practices

Acknowledgements

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