Confederation of Indian Industry

Global champions for advancing renewable energy innovation and manufacturing

4th International Conference & Exhibition on **'AatmaNirbhar Bharat for Clean Energy Transition'**

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Foreword

CII

AatmaNirbharta in renewable energy technology supply chains is vital to advance the security, sustainability and affordability of India's energy transition goals. The strategy for self-reliance must foster R&D in clean energy technologies to develop indigenous solutions, encourage collaborations between government, industry, and academic institutions to foster innovation, and cultivate a stable and predictable policy environment that encourages investments in clean energy. It must develop transportation and logistics infrastructure to support supply chains, promote export-oriented incentives for sustained access to global markets, and strengthen critical minerals and raw material supply chains. Promoting recycling to ensure a circular economy for steady supply of necessary raw materials, building a skilled workforce in clean energy sectors and creating financial instruments to de-risk investments will be critical.

This report includes valuable insights from ındustry members in the context of India's energy transition investment opportunities and evolving policy ecosystem to advance renewable energy innovation and manufacturing. The Energy Transition Investment Monitor is a collaborative platform for investors to identify and track energy transition investments from concept to commissioning.

We appreciate the support from EY, our knowledge partner for this conference, and the valuable insights from Government and Industry stakeholders in shaping this report.

Chandrajit Banerjee
Director General
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EY

India's energy transition is gaining momentum with potential to emerge as a global champion for advancing renewable energy innovation and manufacturing. The ongoing transition to renewable energy sources like wind, solar, hydro, biofuels etc. requires a vast array of technologies and equipment to produce, store, transform and deliver energy for various end-use applications. These technologies are composed of innovative materials and components, some of which are currently sourced from specific regions subject to vulnerabilities. Building local manufacturing capacities can help reduce dependence on imports and build supply chain resilience for India and rest of the world. Most importantly, AatmaNirbhar innovation and manufacturing will help bridge the sustainability-affordability gap for mass adoption of renewable energy technologies.

This report sheds light on the demand and supply chain dynamics of renewable energy technologies, government initiatives and policy interventions for building further momentum. The Energy Transition Investment Monitor is a collaborative platform for global investors to identify and track energy transition investments from concept to commissioning.

We appreciate the valuable insights and cooperation from CII, Government and Industry stakeholders in shaping this report.

Somesh Kumar
Partner & Leader – Power & Utilities
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CONTENTS

Acronyms

ACC	Advanced Chemistry Cell
ALMM	Approved List of Module Manufacturers
APAC	Asia Pacific
BCD	Basic Customs Duty
BESS	Battery Energy Storage Systems
BPL	Below Poverty Line
BU	Billion kWh
C&I	Commercial & Industrial
CAGR	Compounded Annual Growth Rate
CEA	Central Electricity Authority
DISCOM	Distribution Company
EEZ	Exclusive Economic Zone
EIA	Environment Impact Assessment
EPS	Electric Power Survey
ESS	Energy Storage System
EU	European Union
FCEV	Fuel Cell Electric Vehicle
FDI	Foreign Direct Investment
FY	Financial Year
GDP	Gross Domestic Product
GST	Goods & Services Tax
GUVNL	Gujarat Urja Vikas Nigam Limited
GW	Giga Watt
GWEC	Global Wind Energy Council
IEA	International Energy Agency
IIFCL	India Infrastructure Finance Corporation Limited
INR	Indian Rupee
IPCC	Intergovernmental Panel on Climate Change
IRA	Inflation Reduction Act
IREDA	Indian Renewable Energy Development Agency
ISTS	Inter State Transmission System
ITC	Investment Tax Credit
KREDL	Karnataka Renewable Energy Development Limited
kWh	Kilo Watt Hour
LATAM	Latin America
LCOE	Levelized Cost of Electricity
LIB	Lithium Ion Battery
ME	Middle East
MNRE	Ministry of New & Renewable Energy
MT	Million Tons
Mtoe	Million Ton Oil Equivalent
MW	Mega Watt
MWh	Mega Watt hour
NDC	Nationally Determined Contributions
NIWE	National Institute of Wind Energy
NTPC	National Thermal Power Corporation
OEM	Original Equipment Manufacturer
PEM	Proton Exchange Membrane
PFC	Power Finance Corporation
PLI	Production Linked Incentive
PSU	Public Sector Undertaking
PTC	Production Tax Credit
REC	Rural Electrification Corporation
RPO	Renewable Power Purchase Obligation
SDS	Sustainable Development Scenario
SECI	Solar Energy Corporation of India
STEPS	Stated Policies Scenario
T&D	Transmission & Distribution
UNEP	United Nations Environment Program
VGF	Viability Gap Funding

01 Executive summary

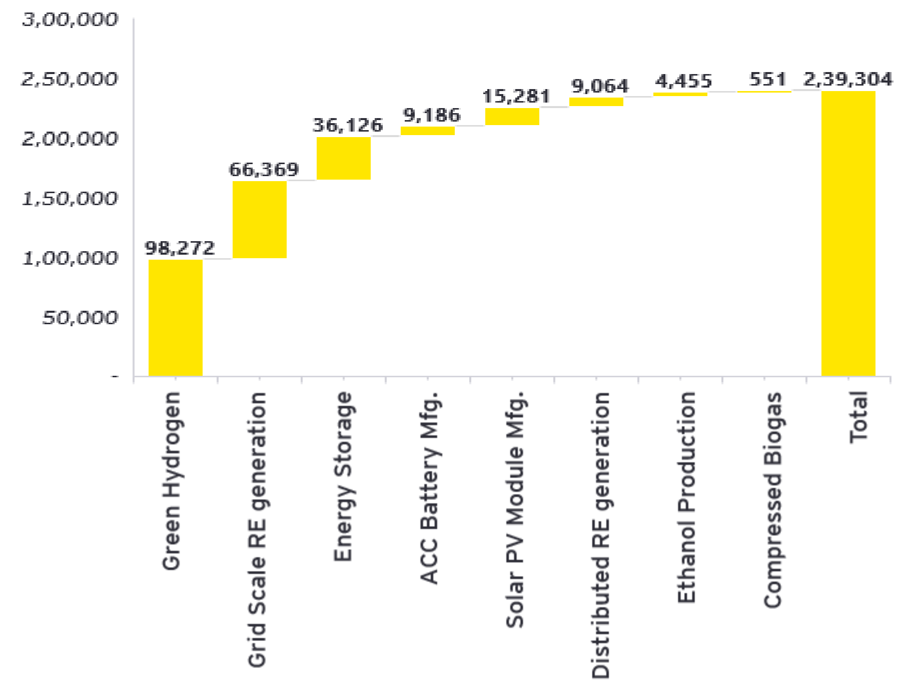
India's energy transition holds potential to become a global champion for advancing renewable energy innovation and manufacturing

- During the 26th session of the Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change (UNFCCC), India expressed its commitment to intensify climate action by presenting five key strategic elements, referred to as the "Panchamrit,". India's climate actions, despite having low GHG per capita, will be an example for the world to raise their climate ambitions.
- The principal driver and enabler for India's net zero emissions goal is reducing dependence on imports and building supply chain resilience. The government has put policies in place to encourage the demand and supply of energy transition technologies in various sectors.
- The ecosystem for government support to global investors in India's energy transition markets and domestic supply chains include but not limited to demand side incentives, production linked incentives (PLI), purchase obligations and bidding trajectory for competitive procurement, de-risking instruments, offtake guarantees and minimum pricing, demand aggregation and centralized procurement, domestic value addition and content regulations, green energy open access rules, tax waivers and exemptions, single window systems, land pooling and allocation for projects, infrastructure development, harmonization with international standards, CAPEX subsidies, concessional financing, public funding for skilling, R&D and technological advancements, labor market reforms, etc.
- The total pipeline for domestic energy transition investments including supply chain innovation and manufacturing, is about US$240 billion in the present scenario. India has the potential to play a pivotal role in achieving global supply-chain resilience for renewable energy technologies and critical components. Over the past few years, India has increasingly positioned itself as an alternative global hub for renewable energy innovation, manufacturing, services and trade for the world. For India to realize its full potential in achieving global supply-chain resilience, it must address demand side challenges including affordability, strive for maximum domestic value addition and improve competitiveness of supply chains for serving global markets, fix inconsistent policy and regulatory environments and accelerate infrastructure building. With appropriate measures, India can indeed serve as a cornerstone for a more resilient global supply chain.

Panchamrit of India's climate action

- 500 GW of non-fossil energy capacity by 2030
- 50% of energy requirement from renewable sources by 2030
- One billion tons of projected carbon emissions reduction by 2030
- 45% reduction in carbon intensity of the economy by 2030
- Net zero emissions by 2070

Total pipeline of investments towards renewable energy innovation and manufacturing (USD Million)



Sources: EY analysis

Energy transition investment pipeline and enablers for advancing supply chain resilience

Utility scale RE power generation

Project pipeline and impact

275 projects	**97 GW** of pipeline capacity	**INR 1.61** lakh crore equity
INR 3.75 lakh crore debt	**5,220 MT** avoided CO_2 emissions	

Energy storage systems

Project pipeline and impact

72 projects	**243 GWh** of pipeline capacity	**INR 87,785** crore equity
INR 2.04 lakh crore debt	**2,106 MT** avoided CO_2 emissions	

Theme: Distributed RE and corporate open access

Enablers

- Harmonized adoption of green energy open access rules at state level
- Long-term predictability and consistency of open access charges
- Compliance and enforcement of RPO and ESO on obligated entities
- Demand aggregation services for RE RTC supply to OA consumers
- Predictable grid banking regulations

Project pipeline and impact

198 Projects	**16.0 GW** of pipeline capacity	**INR 22,552** crore equity
INR 52,622 crore debt	**625 MT** avoided CO_2 emissions	

Theme: Green hydrogen and Electrolyser manufacturing

Enablers

- National program to incentivize/compensate state utilities for implementing annual grid banking facility for captive open access RE power supply
- Blended innovative low-cost financing instruments
- Promote export-oriented incentives
- Setting up shared common desalination facilities in emerging green hydrogen clusters
- Boost availability of skilled workers and professionals

Project pipeline and impact

51 Projects	**10 GW/Year** of electrolyser manufacturing capacity
INR 7.96 Lakh crore investment	**10.17 MT** Green H2/Ammonia production per year

Sources: EY analysis

Theme: ACC Battery manufacturing

Enablers

- Gradually increase domestic content requirements for incentives in mobility and stationary grid applications with a time-bound mandate.
- Expedite mining and exploration activities of critical minerals used in ACC batteries
- Uniform GST @5% application on all ACC batteries used in mobility and grid storage applications with renewable energy
- Production linked incentives for active material extraction from recycled ACC batteries
- Boost availability of skilled workers and professionals

Project pipeline and impact

27 Projects	**96,700 MWh/Year** Production Capacity
INR 87,400 crore investment	

Theme: Bio-fuels

Enablers

- Promote biomass aggregation and storage
- Blending mandates
- Creation of a market ecosystem for bio manure and promotion of FOM
- Production linked incentives
- Establish feedstock pricing mechanism

Project pipeline and impact

60 Compressed Biogas projects	**640+ Tons/Day** Production Capacity
INR 4,464 crore investment	
217 Ethanol production projects	**28,500+ Kilo Litres/Day** Production Capacity
INR 36,081 crore investment	

Sources: EY analysis

Theme: Solar PV module and wind turbine manufacturing

Enablers

- Production linked incentives for solar PV module and system ancillaries manufacturing
- Policy consistency and predictability for ALMM implementation
- Blended innovative low-cost financing instruments
- Promote export-oriented incentives
- Boost availability of skilled professionals
- Uniform GST @5% applicable on all renewable energy manufacturing equipment, raw materials and ancillaries
- Access to round the clock affordable electricity
- Promote raw material supply chain industry
- Production linked incentives for wind turbine grade ancillary manufacturers and rare earth mineral processing
- Strengthening transportation and logistics for wind turbine installations
- Setting up shared testing facilities for wind turbine components in PPP mode

Project pipeline and impact

33 Projects	**88 GW/Year** Solar module pipeline capacity	**68 GW/Year** Solar cell pipeline capacity
41 GW/year Wafer pipeline capacity	**INR 1.24** lakh crore investment	

Sources: EY analysis

Energy Transition Investment Monitor

A collaborative platform for global investors to identify and track energy transition investments from concept to commissioning

EY is collaborating with the Confederation of Indian Industry (CII) to enable global investors to identify and track energy transition investments in the pipeline (announced, under bidding, permitting, construction, etc.) from concept to commissioning. The platform tracks over 930 energy transition investment opportunities in the pipeline with tremendous potential for economic development, jobs and ultimately contributing towards India's long-term climate action goals and energy security objectives. Project level information was gathered from a mix of primary and secondary research tools including a wide variety of sources in the public domain, consultations with project developers, OEMs, investors etc. (on a sample basis) with the support from a leading market research agency. Proprietary databases were also leveraged to identify the long list of infrastructure projects in the pipeline. The project pipeline identified have the desired potential to create social, environmental and economic value in the immediate future.

Limitations

The project pipeline identified in this platform and analyzed in the report represents just a fraction of the overall low carbon infrastructure investment under development in India. The project pipeline information was put together from our assessment of their status of development until March 2023. This is only a fraction of all low carbon infrastructure projects under development in India. It is important to note that the project pipeline identified in this report is illustrative and should not be read as a full policy/commercial endorsement.

Energy Transition Investment Monitor

Sources: EY analysis

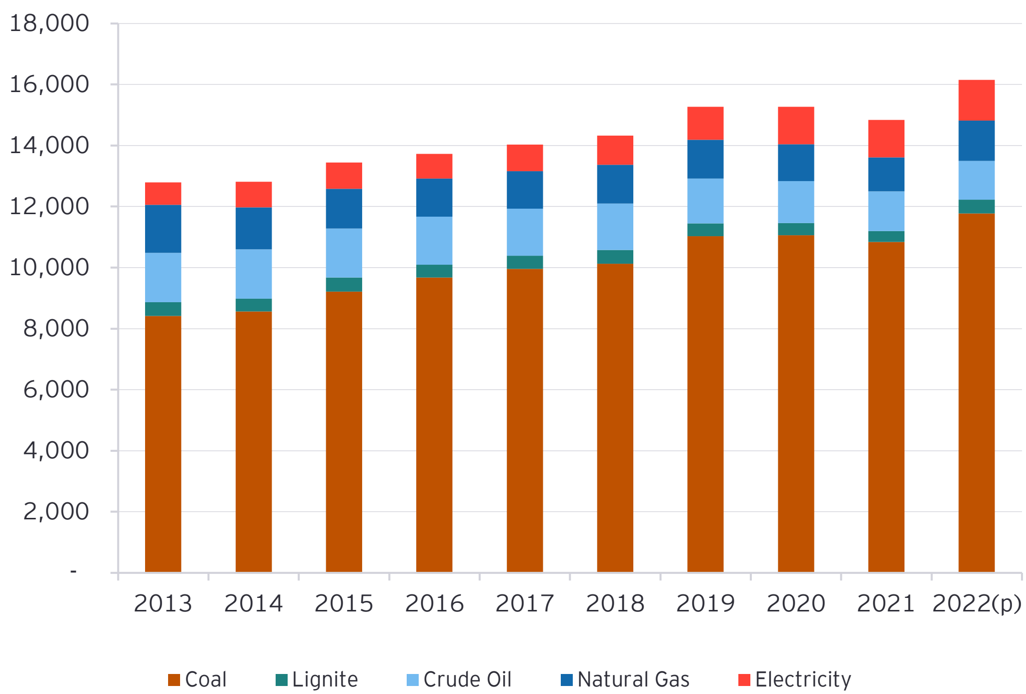
02

India’s energy transition journey and supply chain dynamics

Clean energy sources witnessed the highest growth (CAGR) of commercial energy production in the last decade

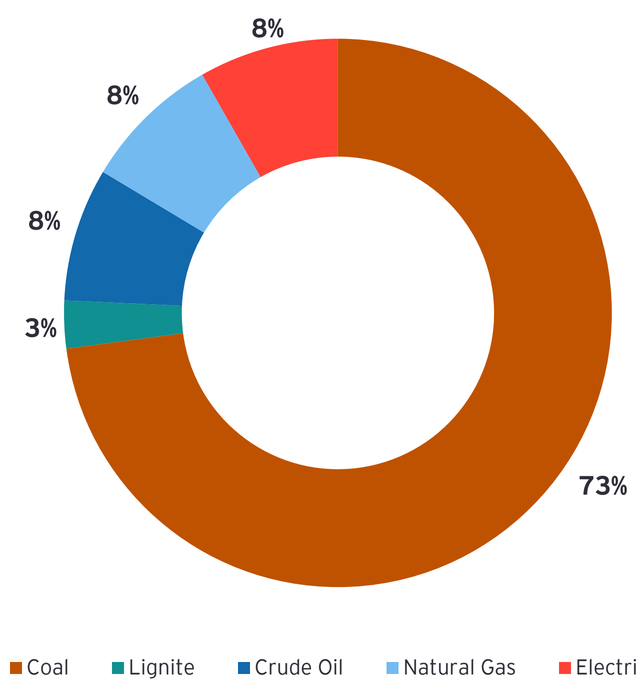
As per Energy Statistics India 2023, clean energy sources (Hydro, Nuclear and other RES) witnessed the highest growth (6.83% CAGR) in commercial energy production between 2012-13 and 2021-22. The total commercial energy production witnessed a 2.62% growth (CAGR) during this period. Coal energy production has witnessed only a 3.8% CAGR growth during the period and accounted for 73% of total commercial energy production in 2021-22. Clean energy sources (Hydro, Nuclear and other RES) contributed to 8.24% of total commercial energy production in 2021-22. Renewable energy sources such as solar, wind and other sources (excluding Hydro and Nuclear) accounted for 11.51% of total commercial energy production in 2021-22. India's commercial energy production mix reflects a high reliance on coal and an increasing share of clean, sustainable, and renewable energy sources.

All India commercial energy production in Peta Joules



Source: Energy Statistics India, MOSPI-2023

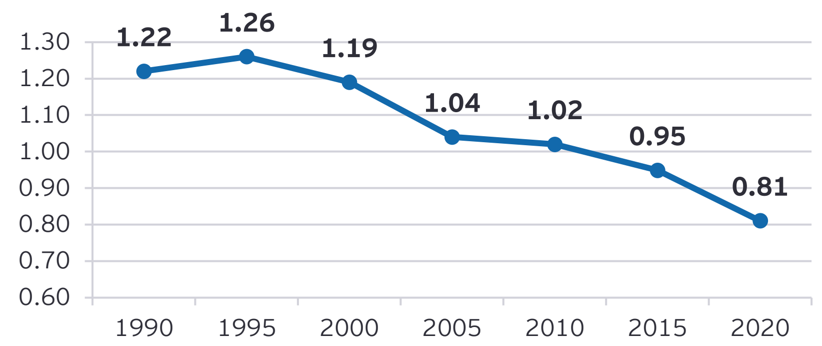
Share of commercial energy production in FY-22(P)



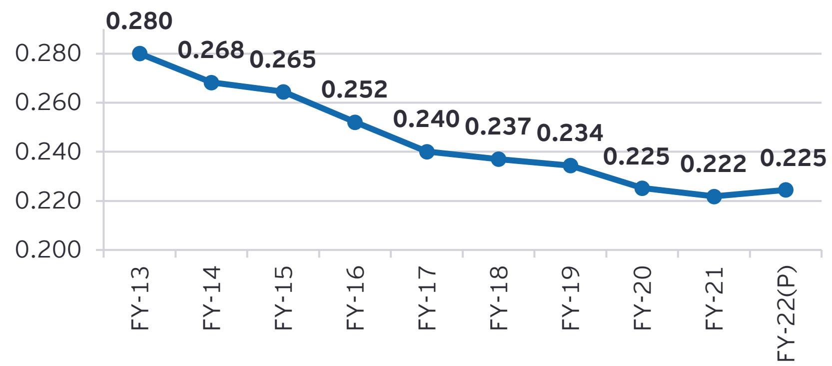
The declining energy and emissions intensity signals a growing focus on shifting towards cleaner energy sources

- As per the UN Emissions Gap Report 2022, India's per capita emissions at 2.4 tCO2e are far below the world average of 6.3 tCO2e. The decreasing trend of energy and emissions intensity is a testament to the growing emphasis on clean energy transition for commercial production and end-use in all sectors of the economy.
- The Intergovernmental Panel on Climate Change (IPCC) estimated that starting in 2020, the total carbon budget remaining, for a 50% chance of temperature rise to remain below 1.5 degrees Celsius, as 500 gigatons CO2 (IPCC 2022). At the current annual average emissions
- rate of ~50 GT observed during 2010-19 (IPCC 2022), this budget will be exhausted before 2030. Global emissions must be reduced by 45% by 2030 and decline drastically thereafter (UNEP 2022). Globally, 88 parties, including the major emitters, have adopted net zero targets, covering approximately 79% of global GHG emissions (UNEP 2022). Emerging economies globally will witness rising energy demand, and 88% of the overall global growth in electricity demand between 2019 and 2040 is expected to come from these economies as per CEEW.
- The challenge to meet India's rising energy demand through clean energy transition pathways that ensure reliability, affordability, sustainability, and security of energy supply is unprecedented. Given that the clean energy transition is expected to be driven by multiple technology pathways including solar, wind, hydro, nuclear, energy storage, green hydrogen, biogas, and ethanol, self-reliance (AatmaNirbharta) in manufacturing and innovation of clean energy technologies, equipment, and raw materials supply chain is critical for achieving the above four pillars of future energy ecosystem. Most importantly, the government of India's commitment to reduce import reliance on fossil fuel commodities along with the five-fold (PANCHAMRIT) climate strategy (see below) committed in COP26 will ultimately hinge on AatmaNirbharta of manufacturing and innovation for critical RE technologies and raw materials.

All India GHG Emission Intensity trends (CO2/USD)



All India Energy Intensity trends (Mega Joules/INR)

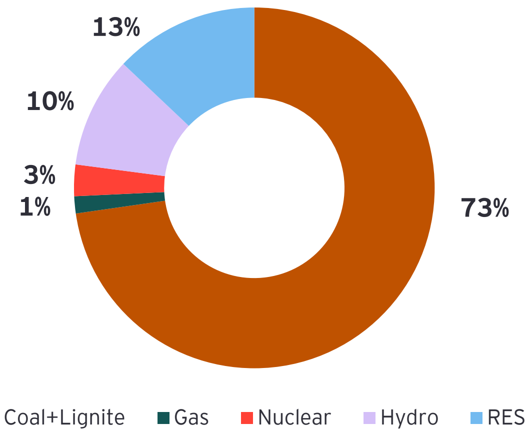


Source: IEA, 2021, Energy Statistics India, MOSPI-2023

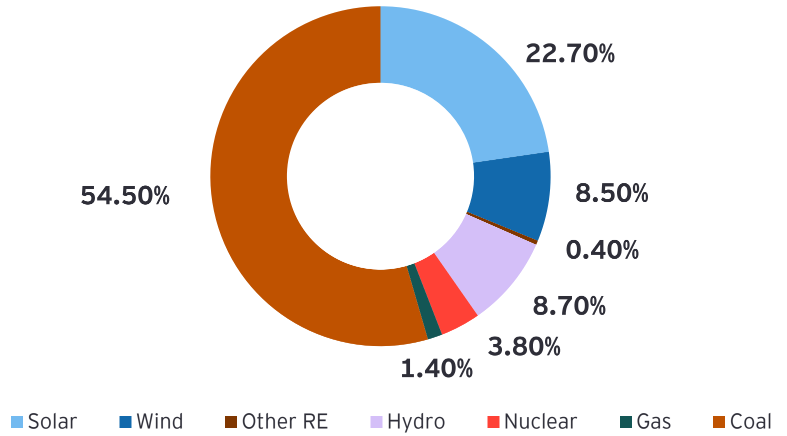
500 GW of non-fossil energy capacity by 2030	50% of energy requirement from renewable sources by 2030	Reduce CO2e emissions by 1 billion tons till 2030	Reduce carbon intensity of economy to less than 45% by 2030	Achieve economy wide net zero emissions by 2070

Power sector will continue to lead the energy transition through 2030, with ~64% share of non-fossil sources in all India installed capacity and ~44% share in gross power generation

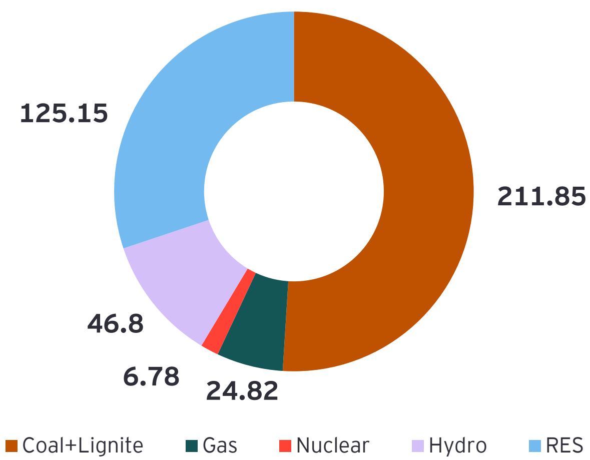
Gross generation in FY-23 : 1624 billion units



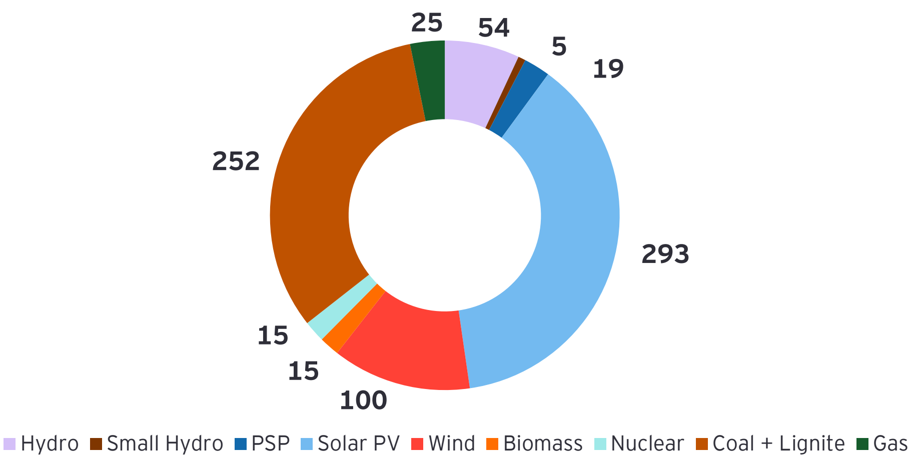
Projected source wise generation in FY-30



Installed capacity as of March-2023 in GW - 415 GW

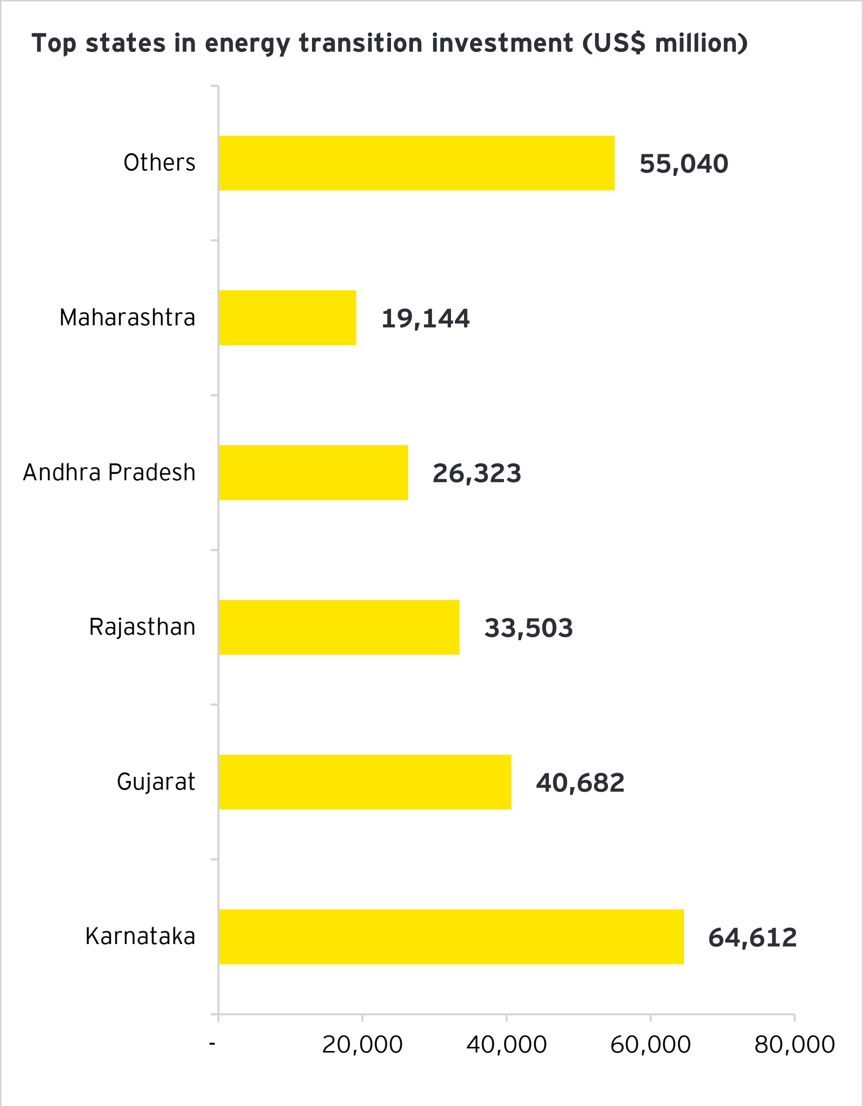


Projected installed capacity in GW in FY-30 - 777 GW



Source: CEA Power Sector Dashboard March 2023, Optimal Energy Mix Report, CEA 2023

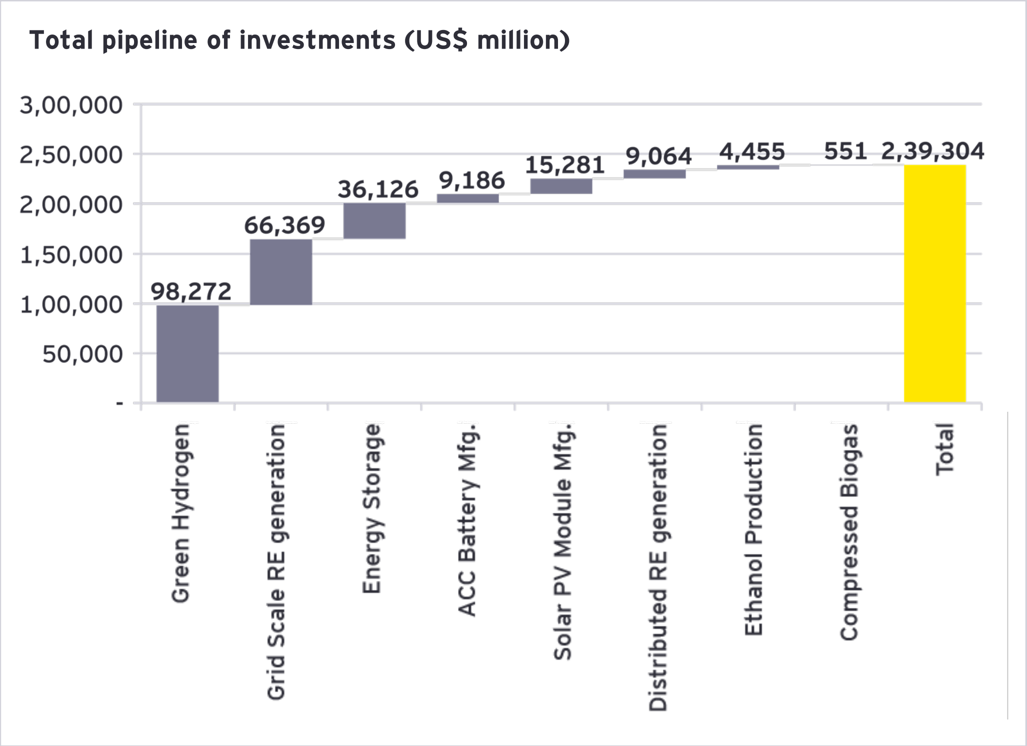
Private sector investment towards innovation, manufacturing and supply chain of critical RE technologies and raw materials will further unlock energy transition potential



Source: EY Analysis

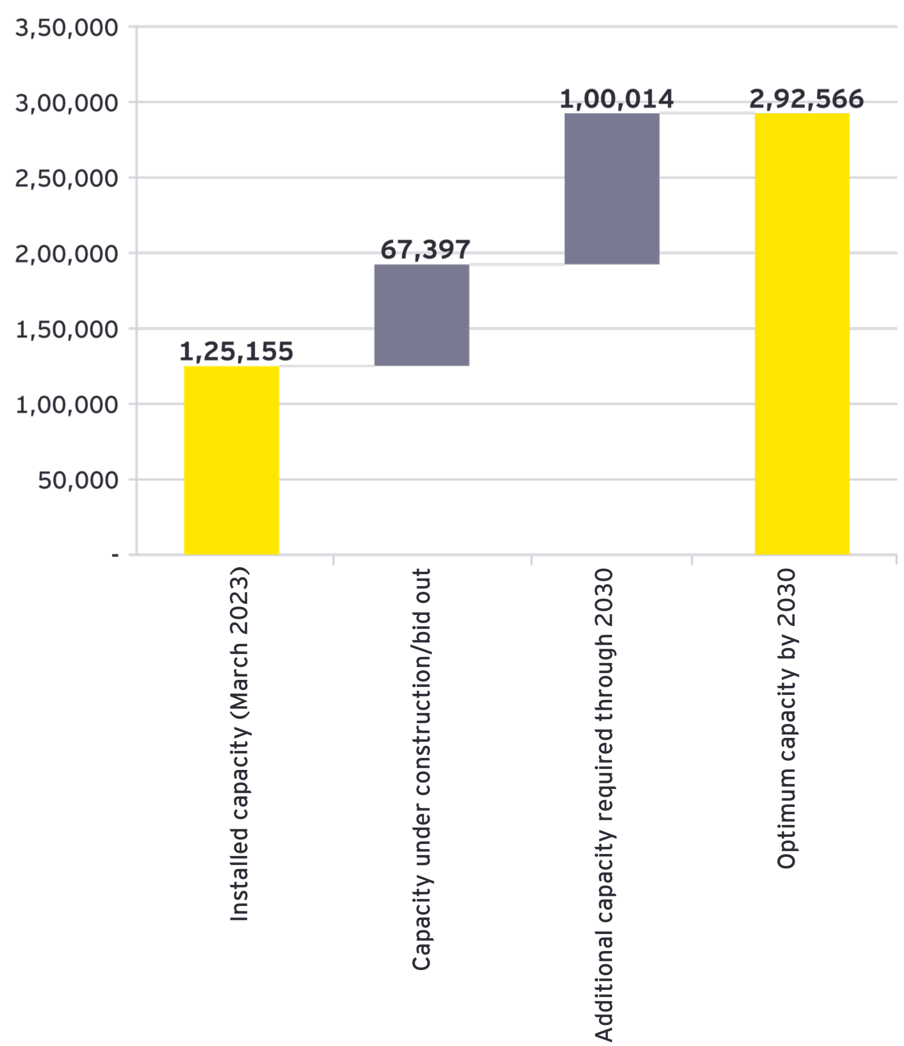
India's ambitions and goals to expand renewable power generation, energy storage, electrification of hard-to-abate sectors, green hydrogen/ammonia, ethanol, biogas, etc., will continue to be driven largely by private sector investments in the foreseeable future. More importantly, private sector investments towards manufacturing and innovation of critical RE technologies, equipment, and raw materials supply chain will determine the speed and scale of India's energy transition.

India's robust domestic demand outlook for RE technologies, policy commitments, and targets along with growing consensus among G20 leaders for building resilient supply chains, serves the best interests of private sector companies, both domestic and international, to collaborate, innovate and make in India for the world.

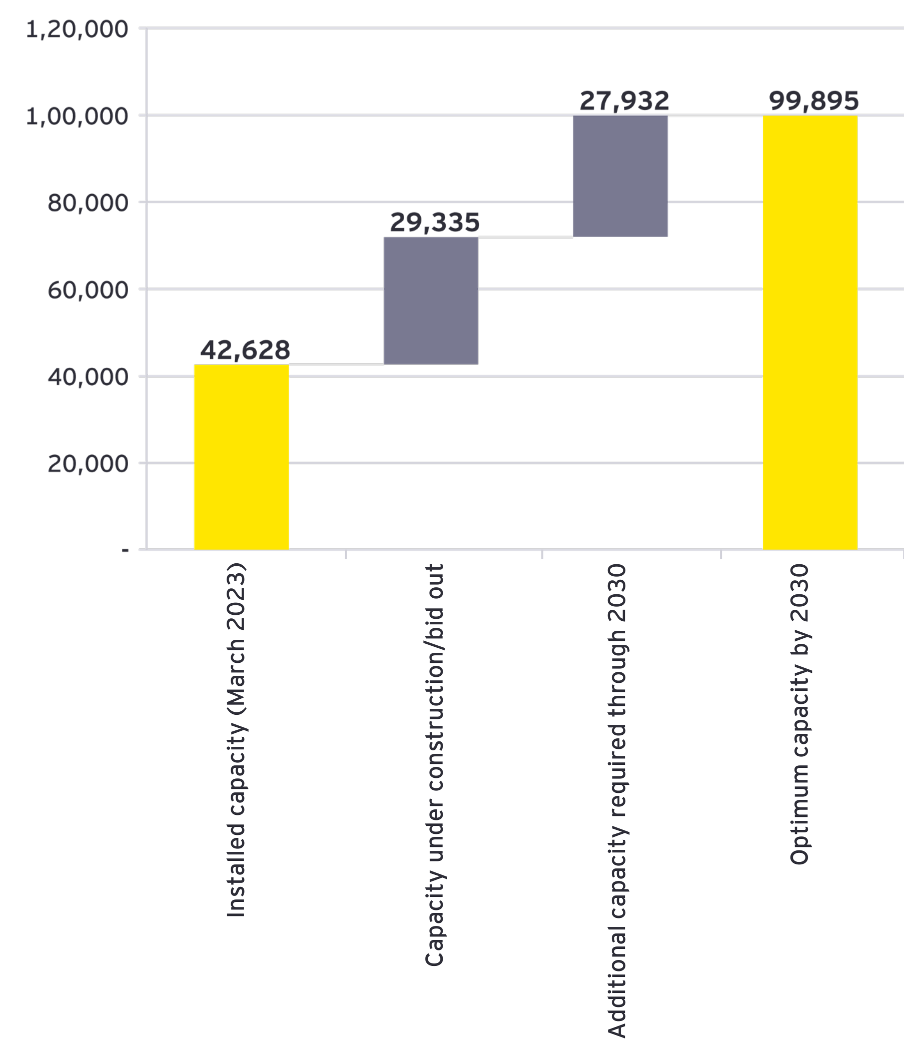


Demand for solar and wind energy generation through 2030

Demand for solar PV systems through 2030 (MW)



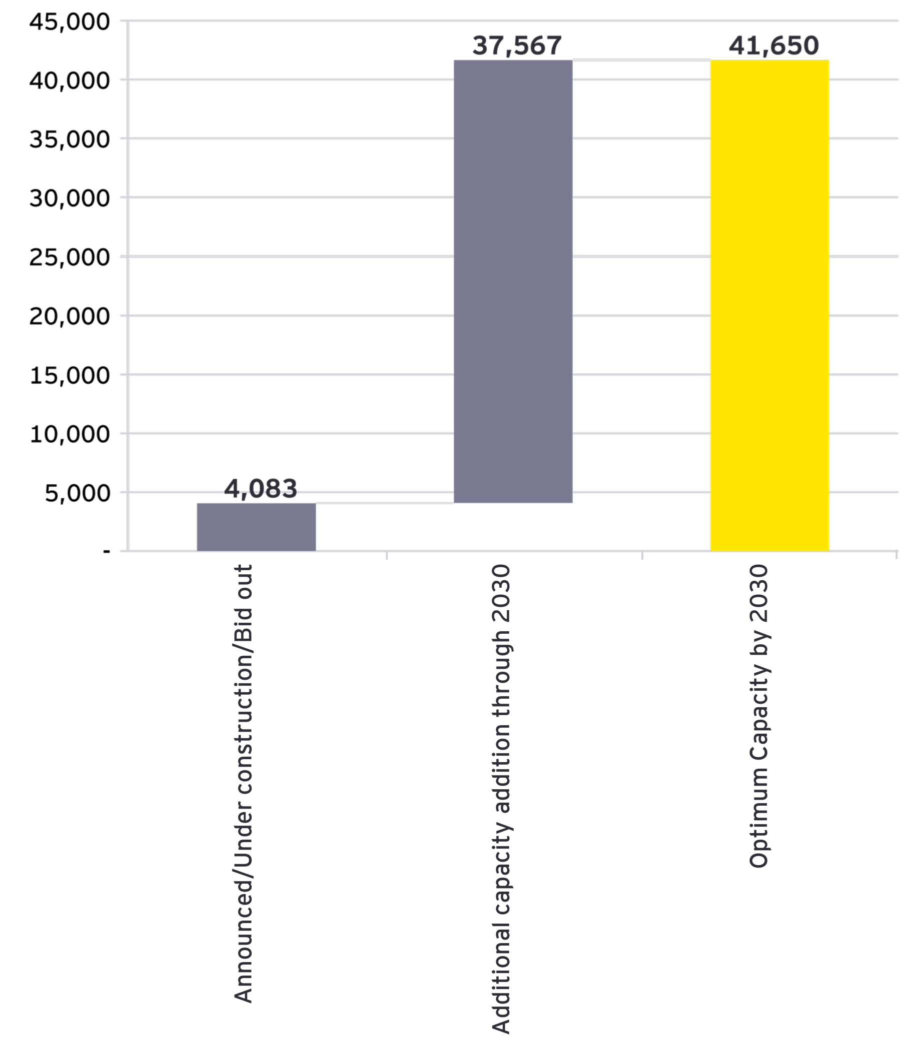
Demand for wind power generation through 2030 (MW)



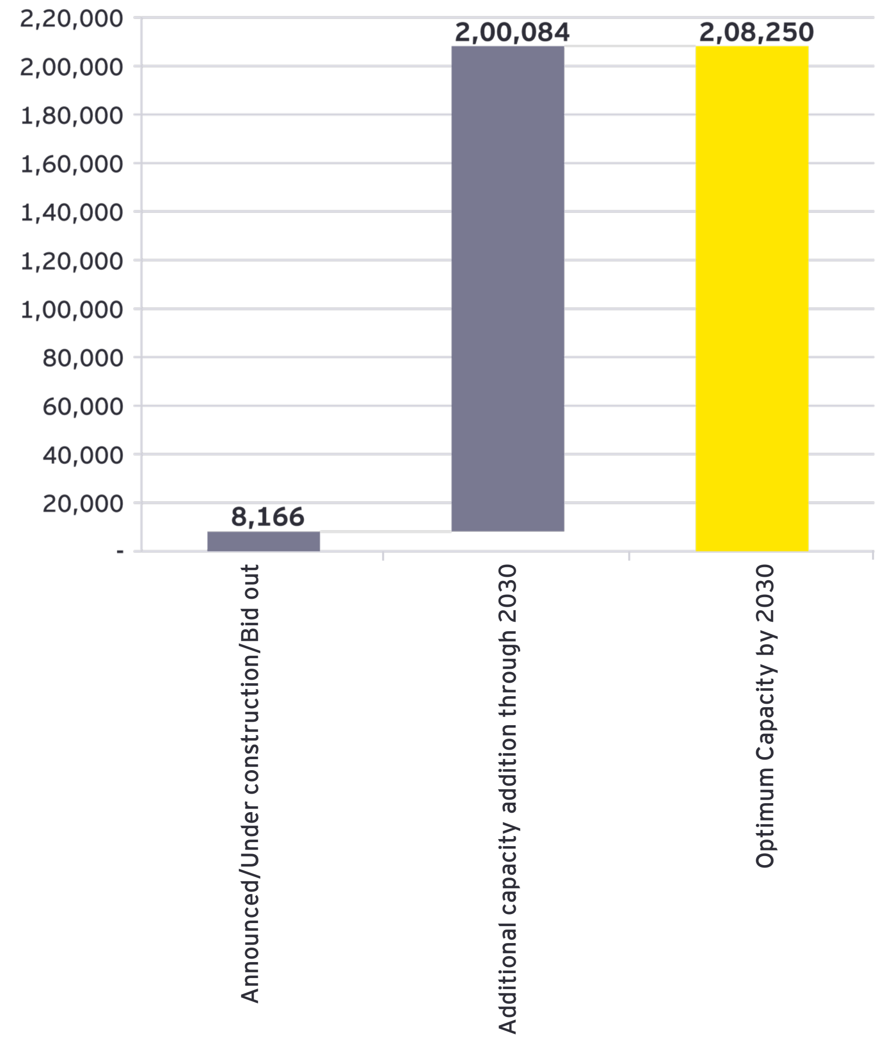
Source: EY analysis from CEA optimal generation mix 2023

Demand for BESS technologies through 2030

Demand for battery energy storage systems through 2030 (MW)



Demand for battery energy storage systems through 2030 (MWh)

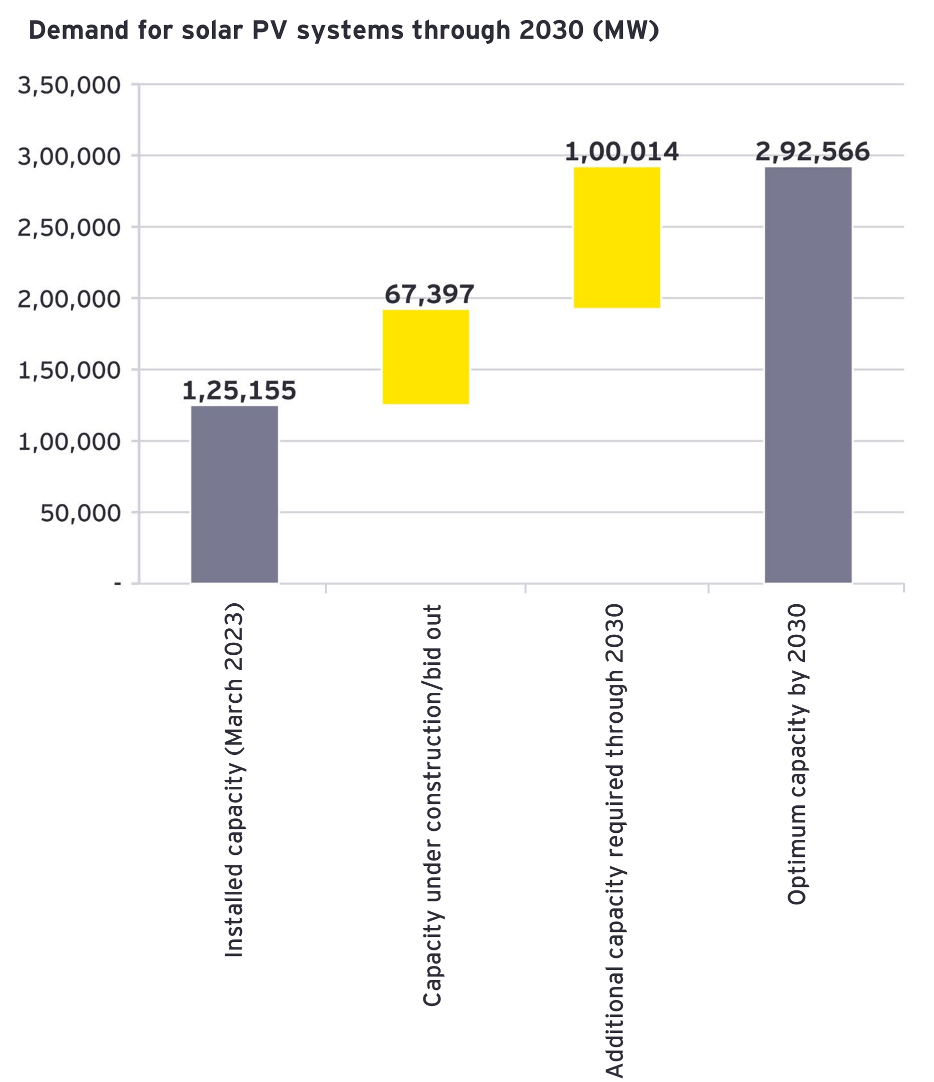


Source: EY analysis from CEA optimal generation mix 2023

03

Building supply chain resilience for solar PV cells, modules and ancillaries

Crystalline silicon PV system demand and value chain for domestic value addition



Source: EY Research, CEA Power Sector Dashboard, CEA Optimal Energy Mix 2030 report

Wafer-based crystalline silicon (c-Si) currently contributes to over 95% of the market. According to CEEW, the production of polysilicon and wafers is a technically complex process that demands reliable and continuous electricity. Additionally, these manufacturing units are large and require substantial capital for set-up and operation. Hence, the cost of capital becomes an essential factor for competitiveness, resulting in significant concentration within the industry. The next step is solar cell manufacturing, which encompasses various types of solar cells with varying efficiencies.

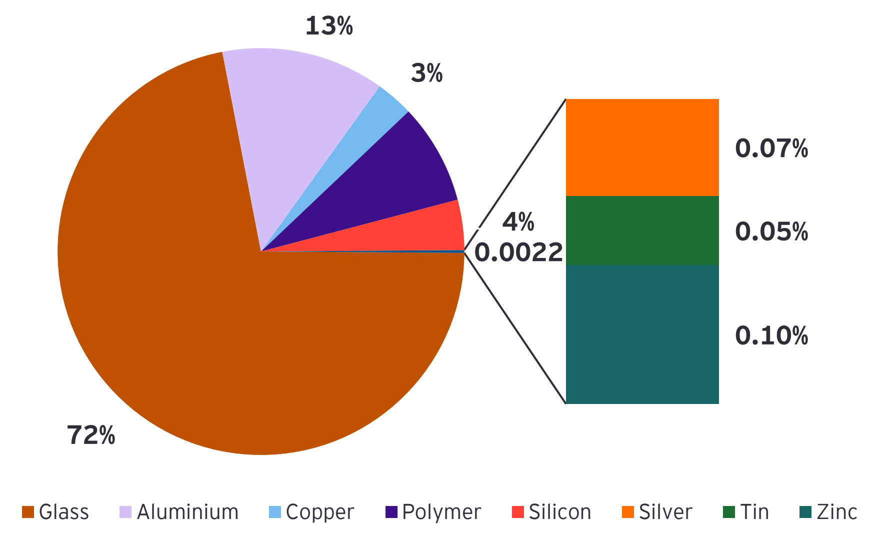
Solar PV module value chain and main consumables

Solar grade Mg-Si	Quartz, low ash coal, limestone, pre baked electrodes etc.
Ingot pulling and wafer slicing	Doping material, argon gas, diamond wire, etc.
Cell manufacturing	Nitrogen, oxygen, ammonia and silane, silver and aluminum paste, etc.
Module assembling	Backsheet, encapsulant, ribbons, solar glass, AL-frame, junction box
PV system installation	Inverter, string – combiner box, cables, transformers, MMS

Bill of materials in the production of crystalline silicon PV cells and modules

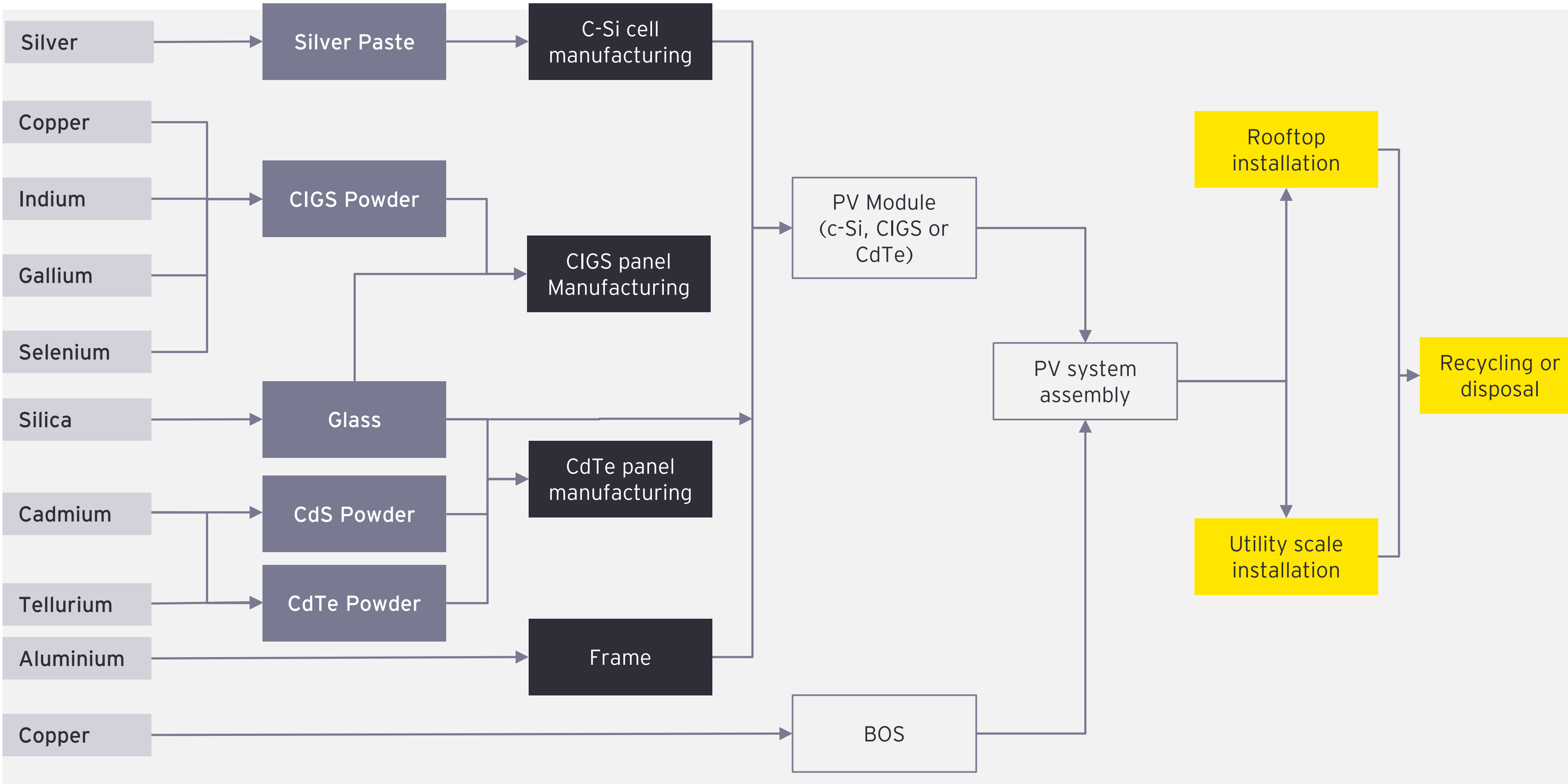
A typical crystalline silicon (c-Si) PV panel, which is currently the dominant technology, with over 95% of the global market, comprises approximately 76% glass (panel surface), 10% polymer (encapsulant and back-sheet foil), 8% aluminum (frame), 5% silicon (solar cells), 1% copper (inter-connectors), and less than 0.1% silver (contact lines) and other metals (e.g., tin and lead). Thin film technologies, such as copper-indium-gallium-(di)selenide (CIGS) and cadmium telluride (CdTe), constitute the remaining portion of the market. These technologies require less material overall compared to crystalline silicon. For CdTe panels, the composition is approximately 96% to 97% glass, 3% to 4% polymer, and less than 1% semiconductor materials (CdTe) and other metals (e.g., nickel, zinc, tin). CIGS contains about 88% to 89% glass, 7% aluminum, 4% polymer, and less than 1% semi-conductor material (indium, gallium, selenium) and other metals (e.g., copper).

Composition of materials in crystalline silicon PV modules



Source: Developing Global Resilient Clean Energy Supply Chains, CEEW 2023

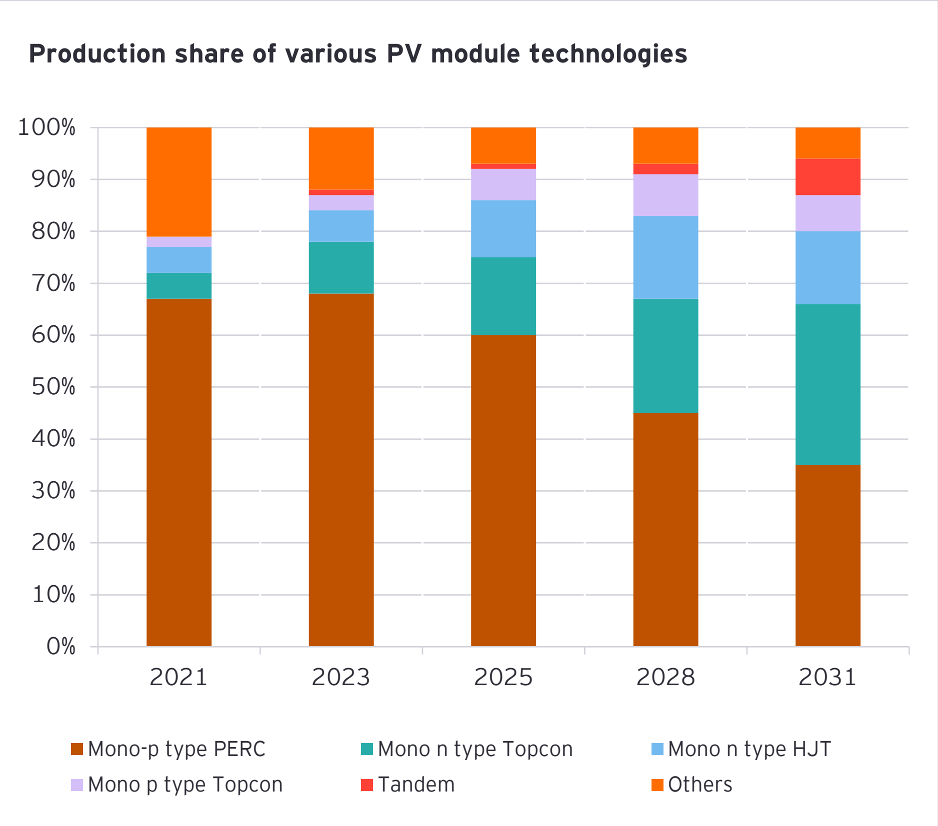
Solar PV supply chain



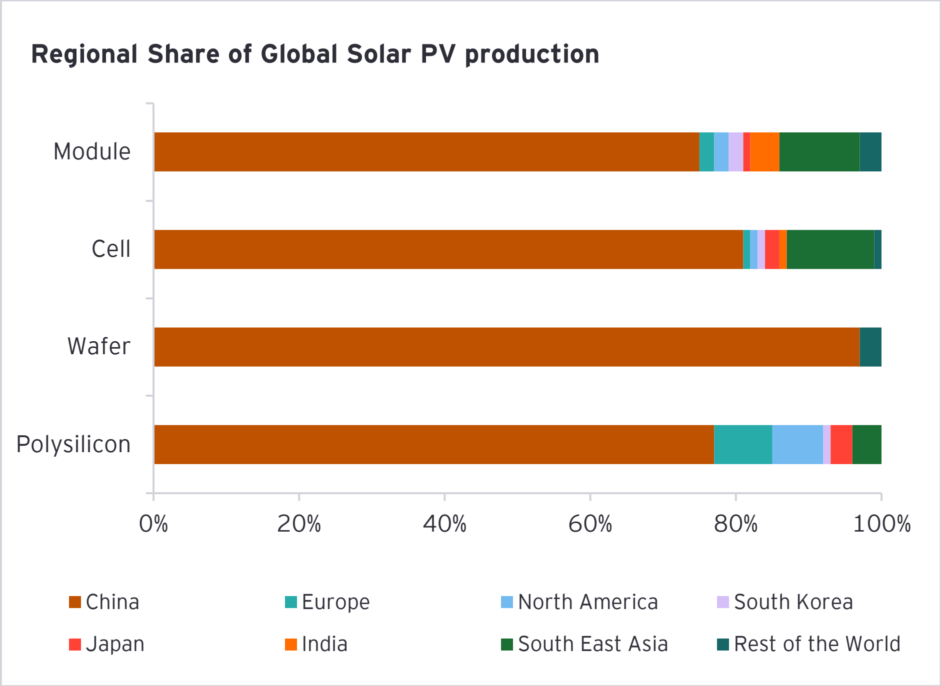
Source: Achieving the paris climate agreement goals, Springer publication, 2019

Global capacity for solar PV manufacturing and supply chain

According to CEEW, the global manufacturing capacity of solar PV modules and other raw materials has significantly increased over the last decade. At the same time, growth is concentrated. Many countries have taken initiatives to scale up domestic solar manufacturing, and shares of other regions may increase in the coming decade. Global polysilicon, wafer, cell, and module manufacturing capacities were 294 GW, 414 GW, 441 GW, and 482 GW, respectively.

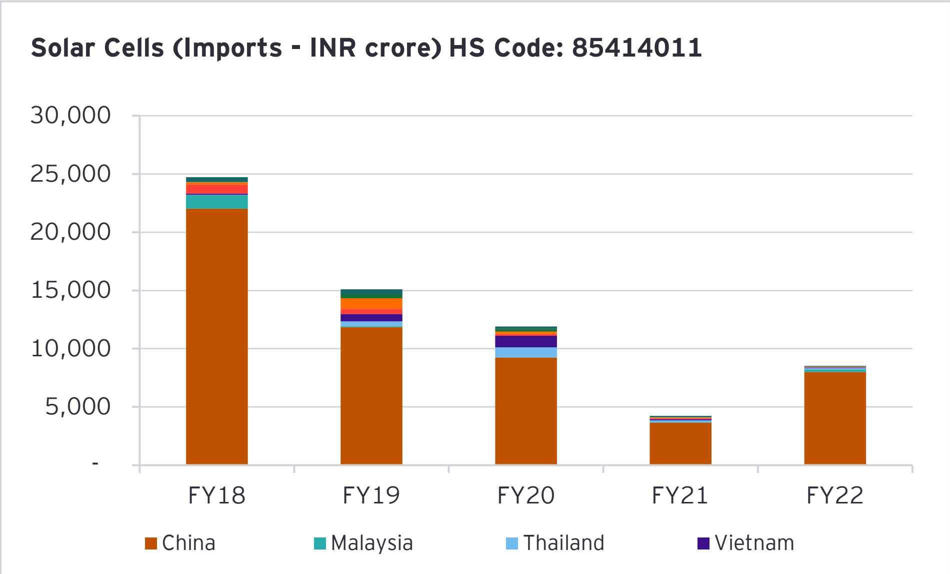


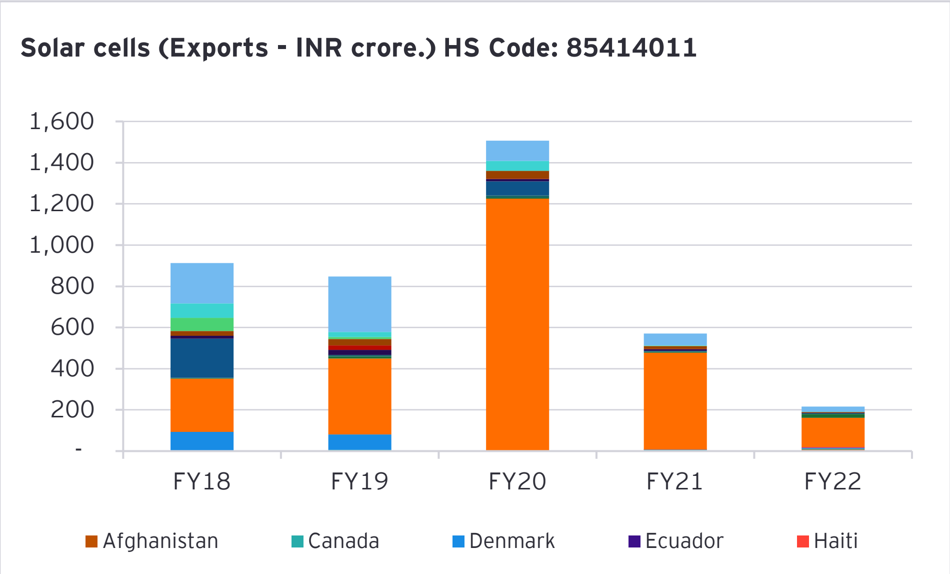
Source: Developing Global Resilient Clean Energy Supply Chains, CEEW 2023

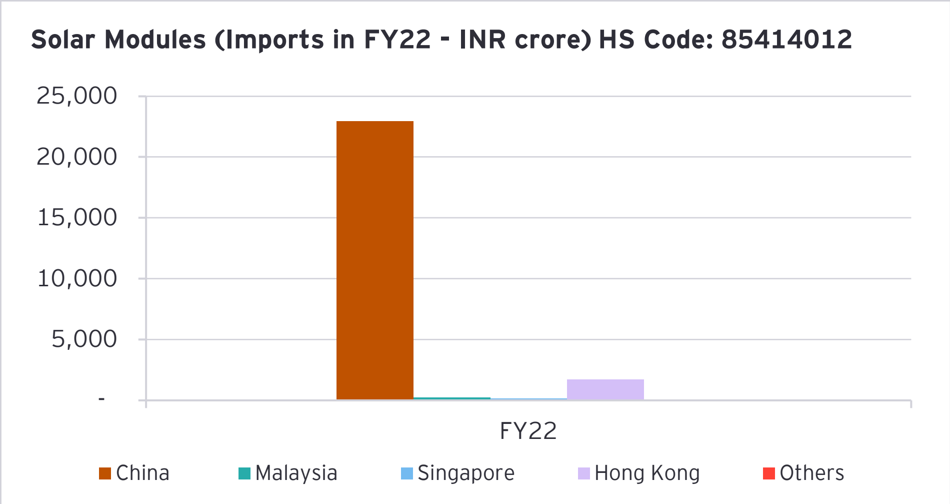


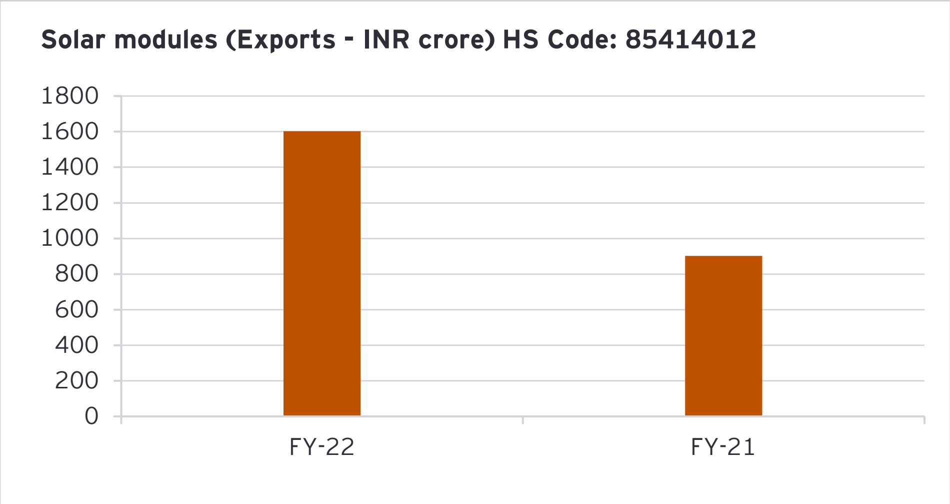
According to CEEW, in 2021, mono p-type PERC accounted for over 80% of the market share of solar PV modules. However, emerging technologies, such as hetero junction technology (HJT), TOPCon, and interdigitated back contact (IBC), are expected to become more cost-competitive by the end of the decade. These emerging cell types offer higher efficiencies but come with greater cost and complexity. By 2030, the share of mono p-type PERC is expected to decrease, with new technologies like TOPCon and HJT occupying more than 50% of the market share.

India trade scenario in solar PV cells and Modules









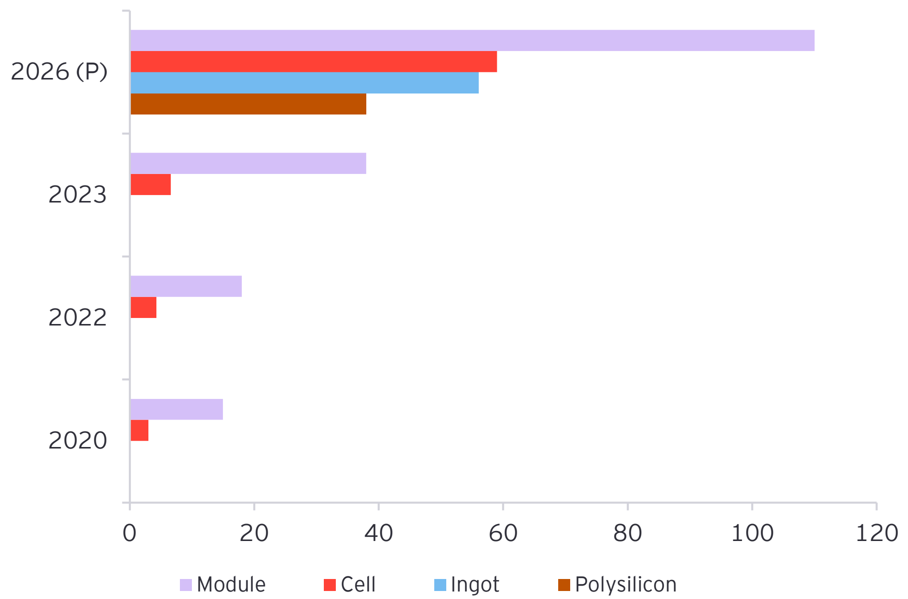
Source: www.dgft.gov.in

India's PV module manufacturing capacity surpassed ~38 GW in 2023 and poised to exceed ~110 GW by 2026

As of March 2022, India's cumulative PV module manufacturing (nameplate) capacity was approximately 18 GW. However, by March 2023, this capacity had surged to around 38 GW, representing a remarkable addition of over 100%. Furthermore, there is a pipeline of approximately 90 GW of PV cell and module capacity announced, in permitting and construction stages. In terms of PV cell manufacturing, the cumulative capacity increased from about 4.3 GW in March 2022 to around 6.6 GW by March 2023. Additionally, there is a pipeline of approximately 68 GW of cell capacity under various stages of implementation.

There are currently few players in ingot-wafer manufacturing, and no presence of polysilicon manufacturing in India, due to its complexity, lack of technology / IPR, raw materials, and high capital expenditure. Over the past decade, India has heavily relied on China for its solar PV modules, leading to an increased risk in the supply chain. In FY-22 alone, India imported solar modules valued at INR 22,931 crores, along with solar cells worth INR 8,013 crore, primarily from China. To address this dependency, the Indian government took significant measures. A Basic Custom Duty (BCD) was introduced to make domestically manufactured products more competitive. Additionally, the Ministry of New and Renewable Energy mandated manufacturers to empanel their models and manufacturing units under the Approved List of Models and Manufacturers (ALMM) for availing policy incentives. This initiative aimed to streamline and regulate the quality and performance standards of solar modules in the market, further encouraging domestic production. These initiatives helped boost domestic production of solar PV cells and modules and reduce dependency on imports.

India Solar PV manufacturing capacity, GW



Source: IEEFA & JMK Research, 2023

By 2026, India's capacity for critical upstream components in the solar PV value chain, such as polysilicon and ingot/wafer, is expected to reach 38 GW and 56 GW, respectively. PV cell and module capacity is likely to exceed 59 GW and 110 GW, respectively. This expansion is driven by factors such as the Production Linked Incentive (PLI) scheme for integrated solar PV module manufacturing and the significant market potential both within India and globally.

However, the availability of critical raw materials, technology development/acquisition, infrastructure and skilling for complex production processes plays a crucial role in this expansion. For instance, in the manufacturing of metallurgical silica, which is an essential component in the production of solar modules, India relies on the import of raw materials such as low ash coal and charcoal.

By strengthening the upstream supply chain, India seeks to build a robust and integrated solar PV manufacturing ecosystem sector to meet both the growing domestic and international demand.

As India strives for self-reliance, it should prioritize building competitive products for the global markets, expanding its presence, positioning itself as a credible alternative for markets looking to diversify supply chains and build resilience towards global disruptions. The government should ensure a stable and predictable policy outlook for sustained investor confidence and growth.

Government awards INR 18,395 crore for 25,800 MW solar PV manufacturing capacity under PLI incentives across the value chain of polysilicon, ingot, wafer, cells and modules

In April 2021, the Government of India launched its first Production Linked Incentive (PLI) scheme aimed at promoting the manufacturing of solar modules across the entire value chain. The Indian Renewable Energy Development Agency (IREDA) was designated as the nodal agency responsible for implementing the scheme. Under this initiative, granted a cumulative capacity of 6 GW for fully integrated (Polysilicon-Module) manufacturing to three companies, with an approximate investment of INR 4,455 crore.

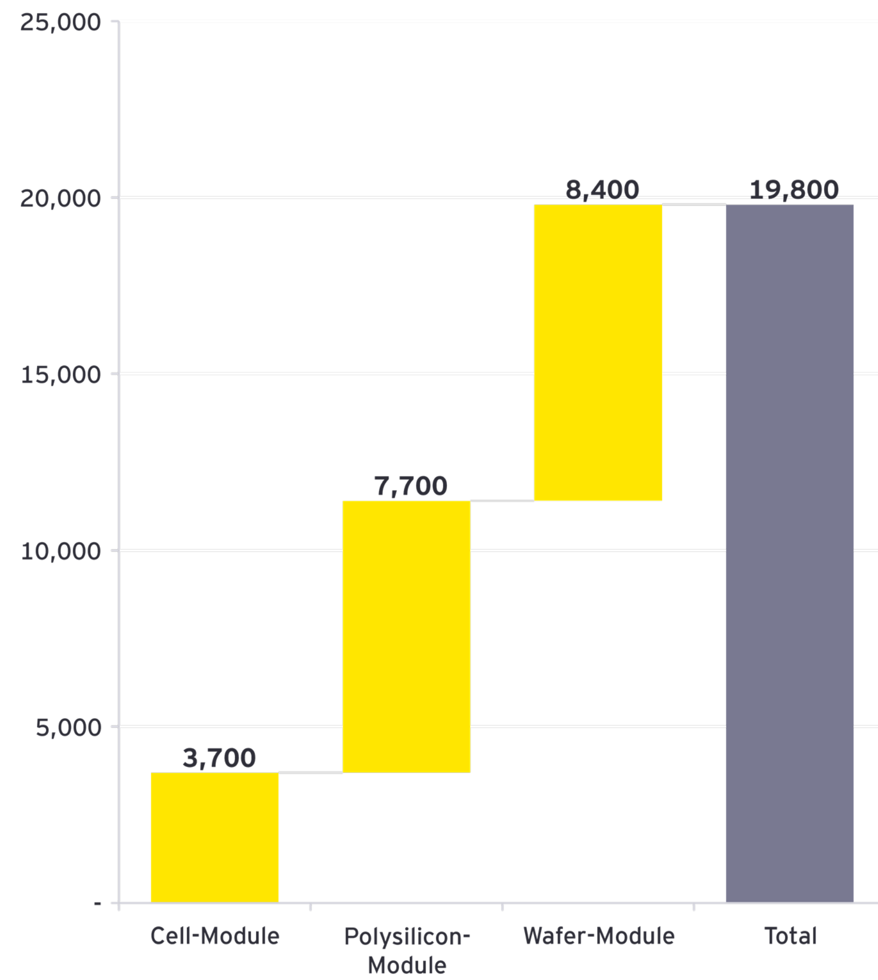
Furthermore, the Solar Energy Corporation of India (SECI) assumed the role of the nodal agency for the second phase of the PLI scheme. Under tranche-II, SECI awarded a total capacity of 19,800 MW to 11 different players, distributing the capacity across three distinct value chain categories. The estimated investment for this allocation amounted to INR 13,940 crore.

These PLI schemes were designed to incentivize and boost domestic manufacturing in the solar module sector, ultimately reducing reliance on imports and strengthening India's self-reliance in renewable energy production. This initiative holds the potential to significantly enhance the manufacturing capabilities and competitiveness of the solar PV industry in India.

Capacity awarded in PLI-1 (MW) (Polysilicon-Module)

Source: PLI Tranche-1 Results, IREDA

Capacity awarded in PLI-2 (MW)



Source: PLI Tranche-2 Results, SECI

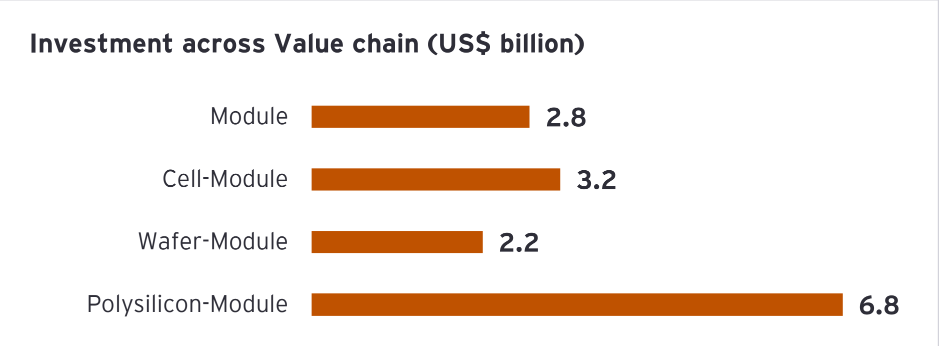
The pipeline of solar PV manufacturing projects (announced, under permitting and under construction) will need US$15.2 billion in investments

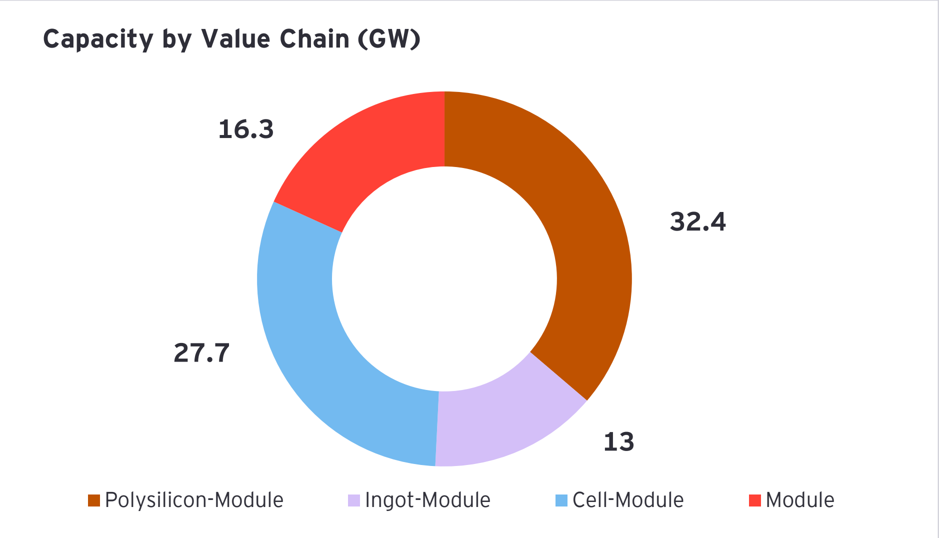
Location of the Facility	Module Manufacturing capacity under pipeline (GW/year)	Cell Manufacturing capacity under pipeline (GW/year)	Ingot/Wafer Manufacturing capacity under pipeline (GW/year)
Gujarat	35.65	21	18
Himachal Pradesh	0	0.5	0
Karnataka	3	1.5	0
Maharashtra	1	0	0
Rajasthan	4	4	0
Tamil Nadu	9.4	9.4	3.4
Telangana	13	12.25	11
Uttarakhand	0.25	0	0
West Bengal	3	3	0
Facility Location not reported	20	20	13
Total	89.4	71.6	45.4

Source: EY analysis

Investment mobilization

A total of INR 1.23 lakh crores (US$ ~ 15.28 billion) of capital investment will be mobilized to operationalize these projects in the pipeline.





Policy enablers

Production-linked incentives for solar PV module and system ancillaries manufacturing

As solar PV technology continues to dominate global electricity mix, the ancillary industry will play a crucial role in ensuring reliability, efficiency, and integration of solar energy systems. India's Solar PV industry, primarily focused on the manufacturing and installation of solar panels, is supported by a vast network of ancillary components and services essential for the efficient functioning, integration, monitoring, and maintenance of a solar power system.

India's solar energy landscape is characterized by a significant disparity between the country's solar glass production capacity (approximately 6 GW) and the overall module production capacity (approximately 38 GW). This glaring gap necessitates the import of the remaining 34 GW equivalent of solar glass for modules, hindering the nation's journey towards self-sufficiency in solar PV value chain.

Beyond solar glass, other indispensable components such as ethylene-vinyl acetate (EVA), various encapsulants, backsheets, junction boxes, semiconductor components for Inverters (including IGBT, MOSFET etc.) rely on imports. These components collectively constitute the backbone of solar module fabrication. While India succeeds in manufacturing solar cells and modules domestically, the comprehensive objective of "Atmanirbhar Bharat" cannot be fully realized if the country continues to rely extensively on imported ancillary components for module and systems assembly.

In this context, AatmaNirbhar policy must focus on establishing a robust ecosystem for the manufacture Solar PV module and system ancillaries, such as solar glass, MOSFET and IGBT components for inverters, etc.

Policy consistency and predictability for ALMM implementation

A critical factor in promoting the growth of domestic PV cell and module manufacturing industry is ensuring domestic demand certainty. The implementation of Approved List of Models and Manufacturers (ALMM) as a mandatory rule for procuring solar PV modules for domestic projects emerges as a pivotal catalyst in this regard. By establishing a clear framework for permissible models and manufacturers, the ALMM mandate effectively provides domestic module manufacturers with a reliable demand estimate. This is particularly valuable when considered alongside India's ambitious capacity addition plans within the renewable energy sector.

The ALMM mandate effectively restricts the unregulated import of solar modules. This influence on imports creates a conducive ecosystem wherein domestic manufacturers can recalibrate their production strategies to meet the anticipated demand. Crucially, the implementation of ALMM, by constraining imports, fosters an environment where the domestic module manufacturing sector can thrive.

Blended innovative low-cost financing instruments

The intricate interplay of demand volatility and policy uncertainty has led Indian financial institutions to adopt a cautious approach when it comes to supporting domestic solar module manufacturers. The uncertainties surrounding the demand for solar modules, influenced by factors such as regulatory changes and market dynamics have instilled a sense of risk aversion among financial entities. Even when financial institutions are willing to provide funding, the terms of financing often come at a cost. Notably, the interest rates associated with the debt offered to solar module manufacturers are significantly higher. This financial burden, stemming from increased interest costs, directly impacts the cost structure of domestic solar modules.

The establishment of the solar module manufacturing facility is inherently capital intensive, demanding substantial investments in infrastructure, technology, and skilled manpower. Recognizing the significance of domestic module manufacturing in realizing India's renewable energy goals and fostering self-reliance, the government is poised to explore strategic measures to facilitate the growth of this critical sector. One such approach involves enabling access to low-cost blended instruments for domestic module and ancillary equipment manufacturers. Robust risk-mitigation instruments at scale deployed by IFI, MDBs, institutional capacity and reforms in the development finance and banking sector by involving private sector stakeholders can help create investment platforms for access to low-cost capital.

At the core of this initiative is the acknowledgment that the cost of capital significantly influences the viability of manufacturing endeavors, particularly in an infrastructure-intensive sector like solar modules. The financial burden imposed by high-interest debt can amplify the overall cost of production, making domestically manufactured modules less competitive against their imported counterparts. To address this, the government may consider mechanisms to provide domestic manufacturers with access to low-cost debt.

Promote export-oriented incentives

Given the current surplus of solar module manufacturing capacity in India, domestic module utilization within the country is facing challenges due to factors such as the dynamics of reverse auctions. Additionally, in the global market, Indian modules encounter fierce competition from their Chinese counterparts, which often have cost advantages. To address this situation and bolster the global competitiveness of Indian solar module manufacturers, the government could contemplate implementing export-oriented incentives.

By offering incentives tailored toward exports, the government would provide Indian solar and solar module component manufacturers with a competitive edge in international markets. These incentives could encompass various forms, such as financial support, tax benefits, streamlined export procedures, or even research and development grants, incentivizing manufacturers to enhance the quality, efficiency, and affordability of Indian modules for the global market.

Boost the availability of skilled professionals

Quartz mining and module assembling are the simplest processes in terms of requirements. They require low labor costs, low-to-medium skills, reliable and developed infrastructure, and, in the case of quartz mining, raw-material availability. Cell manufacturing requires slightly more capital than module manufacturing, its infrastructure requirement is similar to solar modules. The success of cell manufacturing requires a skilled workforce and the presence of research and development (R&D) centers if innovative technologies, like n-type monocrystalline, are being targeted by the facility. Access to patents and intellectual property rights (IPRs) is also crucial for this step. Upstream manufacturing steps, such as metallurgical-grade silicon, solar-grade silicon, and ingot and wafer manufacturing, are very complex. They are the most capital-intensive and require highly skilled workers. The industry requires trained technicians, engineers, and operators who are familiar with the latest manufacturing technologies and quality standards. The availability of skilled manpower needs to be improved through training programs and collaborations with industry professionals and academic institutions.

Addressing the shortage of skilled workforce is essential for efficient manufacturing operations. Establish skill development programs in collaboration with educational institutions and industry experts from EU and US. Provide training on advanced manufacturing technologies, quality control processes, and safety standards. Offer incentives to attract skilled professionals to the solar module manufacturing sector.

Uniform GST @5% application on all renewable energy manufacturing equipment, raw materials and ancillaries

The crucial raw material polysilicon attracts a GST rate of 18% and a custom duty of 5.5%, resulting in an overall tax burden of 23% for the PV manufacturing industry. These taxes contribute to bottlenecks in the solar industry, hampering domestic manufacturing and hindering the achievement of India's renewable energy goals.

Implementing a reduction or waiver of custom duty on polysilicon would have far-reaching benefits for the solar upstream manufacturing sector in India. By reducing the cost burden associated with importing polysilicon, domestic manufacturers would be encouraged to invest in local production facilities. This would not only enhance the self-reliance of the industry but also ensure a stable supply chain, reducing vulnerability to international market fluctuations and supply disruptions. Moreover, a favorable duty structure would make solar upstream manufacturing in India more cost-effective and competitive, attracting both domestic and foreign investments.

Similarly, establishing a uniform GST rate of 5% on all renewable energy manufacturing equipment, raw materials and ancillaries would bring in the required clarity and simplicity to the tax regime. The current variation in GST rates for different components and equipment adds complexity and hampers the growth of the sector. A uniform GST rate would level the playing field for manufacturers, facilitating their decision-making processes and encouraging long-term investments. It would also streamline tax compliance, reducing administrative burdens and promoting a more conducive business environment.

By providing certainty in the duration and applicability of these taxes and duties, the government can offer stability to manufacturers operating in the renewable energy sector. This stability allows manufacturers to accurately assess costs, plan their operations, and make informed investment decisions. It also enables them to develop strategies to navigate changing market dynamics and to remain resilient in the face of uncertainties. Ultimately, these policy measures would not only bolster the growth of the renewable energy sector but also contribute to India's self-sufficiency in clean energy production and enhance its competitiveness in the global market.

Access to round-the-clock affordable electricity

Access to reliable and affordable electricity around the clock is essential for upstream components in the value chain. Electricity constitutes a significant portion, approximately 30% to 40% of the operational expenses in solar PV manufacturing. India has comparatively high industrial tariffs compared to domestic tariffs. These elevated industrial tariffs contribute to increased production costs for modules, thereby making Indian products less competitive in the global market.

The financial health of state power utilities and electoral promises of free power supply does not leave fiscal room for accommodating affordable industrial tariffs. Exploring a National scheme to incentivize / compensate state utilities for reducing industrial tariffs or promoting green energy open access transactions for round-the-clock supply can be considered. Implementing policies that enable longer duration of banking would allow manufacturers to store excess energy and utilize it when needed, ensuring a continuous and uninterrupted power supply from DISCOMs.

Promote raw material supply chain industry

The second phase of government supported PLI, approximately 7.7 GW of capacity has been allocated for polysilicon to module facilities. For other less integrated facilities, the availability of raw materials is a critical factor and poses challenges in terms of supply chain disruptions and price volatility. Even for polysilicon manufacturing, the availability of key raw materials such as PV grade quartz, charcoal, limestone, and low-ash coal is limited. The import of raw materials poses risks, including delays in shipments, customs and logistics issues, and fluctuations in international market prices. These uncertainties can significantly impact the manufacturing process, leading to production delays and increased costs.

To ensure the growth and stability of the fully integrated solar module manufacturing industry, it is crucial to establish a stable and secure supply of raw materials. Encouraging investments in domestic raw material mining, extraction and processing capabilities can help create a more self-reliant supply chain and reduce vulnerabilities associated with international sourcing.

04

Strengthening wind turbine manufacturing ecosystem in India for exports

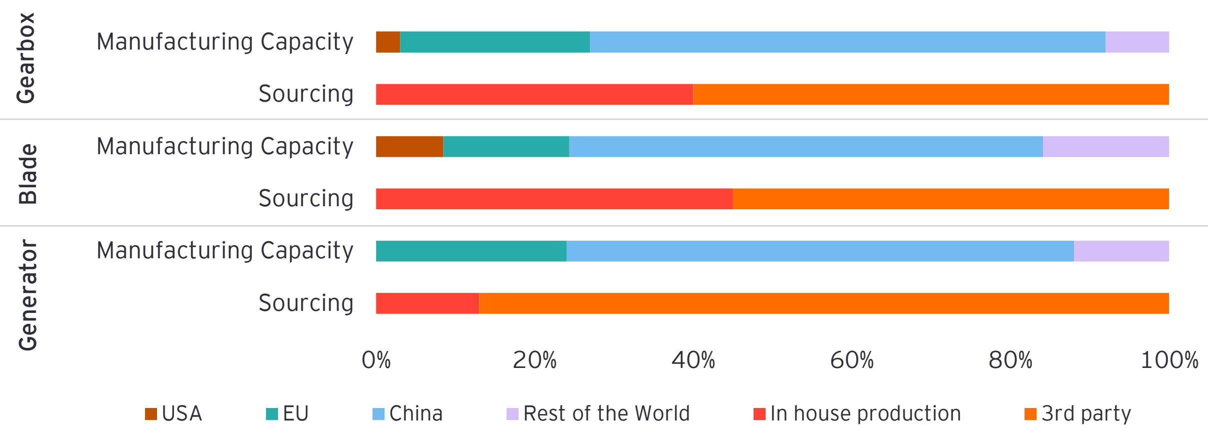
Wind turbine and component manufacturing ecosystem: A snapshot

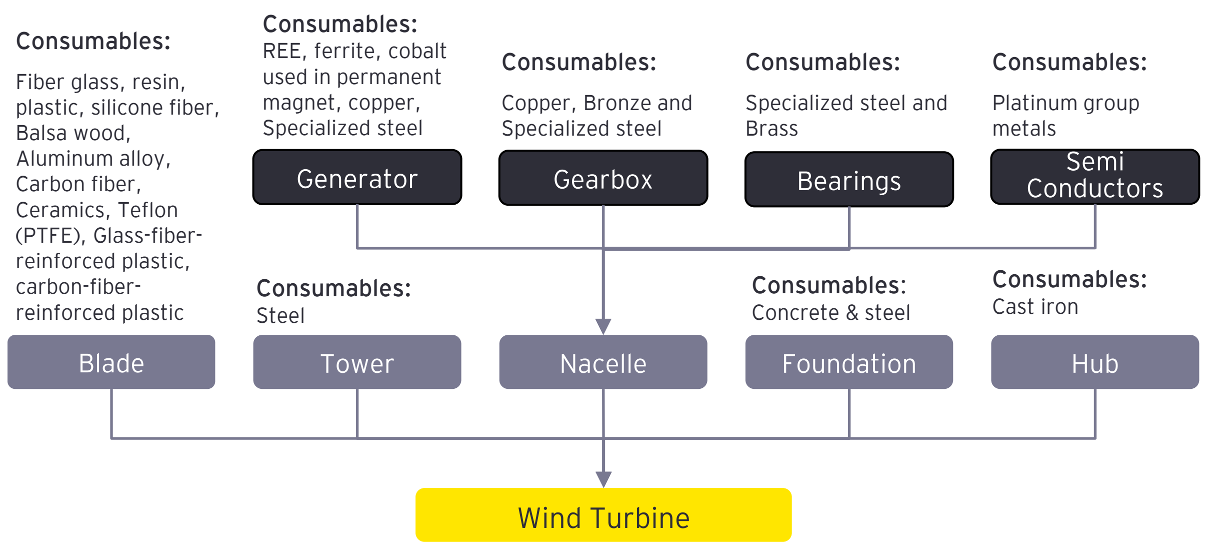
According to CEEW analysis, the wind supply comprises various assembly lines,. The global supply chain involves participation by (i) original equipment manufacturers (OEMs) that set up assembly lines or turbine-manufacturing facilities to supply finished products (wind turbines) for installation at project sites, (ii) suppliers of individual components and sub-components, and (iii) manufacturers of equipment and machinery used for producing key components and installation of turbines on project sites. The logistics of installation, construction, operation, and maintenance are also crucial steps in the wind supply chain.

As per GWEC analysis, manufacturers must strike the right balance between the in-house production of components and outsourcing to third parties to deliver on their turbine designs. In 2020, the total nacelle manufacturing capacity was 120 GW, with major countries or regions including China (58%), Europe (18.5%), the US (10%) and India (8.5%). Since blade manufacturing is labor intensive, countries with low labor costs, primarily developing economies provide competitive grounds for meeting global demand.

A concentrated ecosystem for manufacturing critical components implies a higher risk of interruptions in the availability of these components if the manufacturing locations get affected due to geopolitical developments, price volatility of materials, and climate risks. Therefore, new manufacturing capacities must be developed in a relatively more distributed fashion to ease trade and reduce the impact of supply disruptions.

Region wise production share and Sourcing of Components



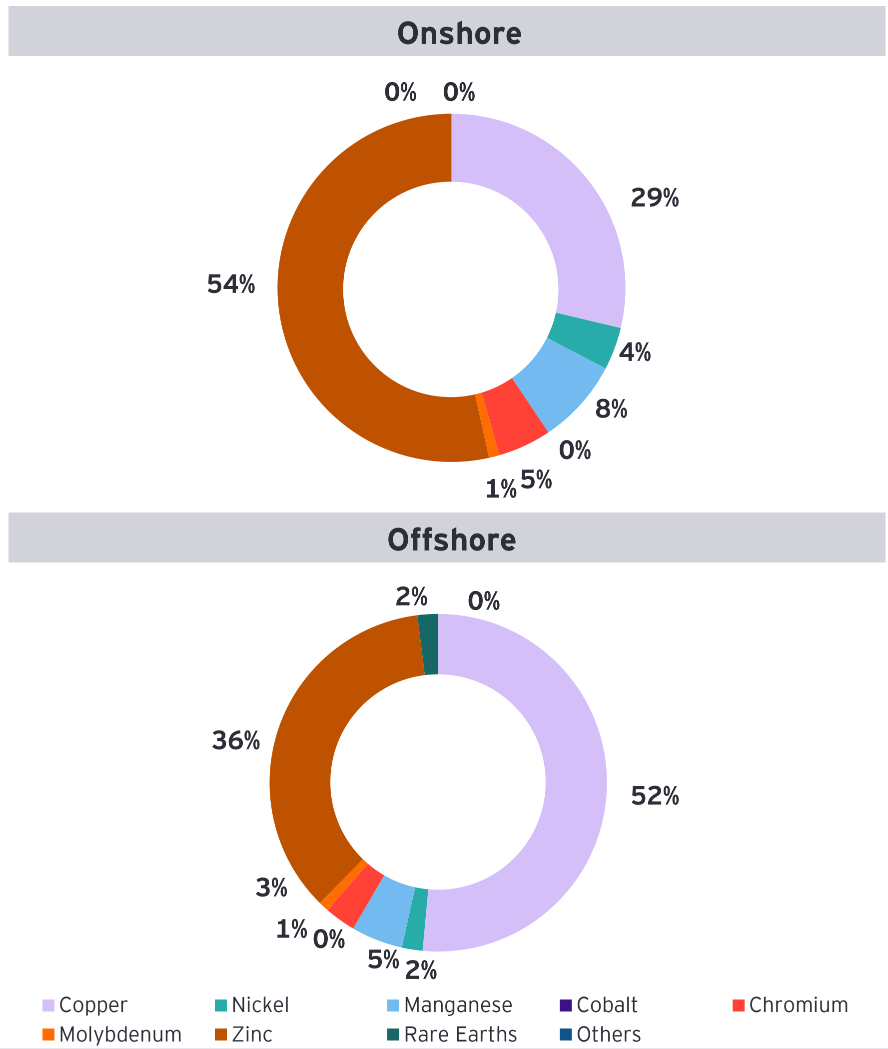


Source: Developing Global Resilient Clean Energy Supply Chains, CEEW 2023

Critical minerals, infrastructure and skilled resource requirements for world class wind turbine manufacturing ecosystem

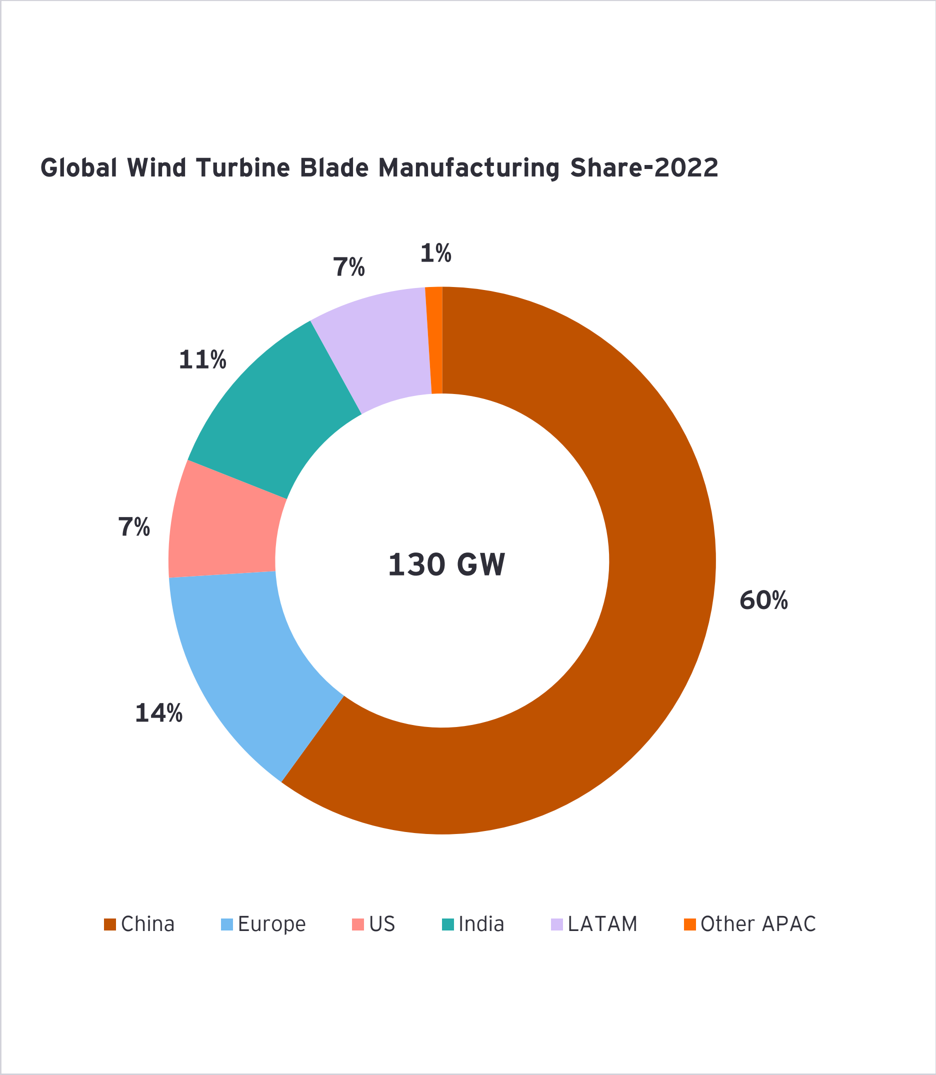
- Innovations are essential for making supply chains more cost-effective and resilient. For example, according to DOE analysis, innovations in material science and engineering could make rotor blades lighter reducing transportation and manufacturing costs, using locally available raw materials, or enabling hybrid and cost-effective tower designs that can be assembled on-site can also contribute to reducing transportation costs.
- The CEEW analysis indicated that continuous changes in technology and turbine sizes necessitate additional investments in upgrading manufacturing facilities for key components and assembly lines. While these upgrades are beneficial for the growth of the wind sector, they also require significant financing capabilities and workforces with civil and electrical engineering skills.
- As per GWEC, a larger number of science, technology, engineering, and mathematics (STEM) professionals are required in the workforce, particularly for onshore projects when compared to other mature RE technologies, such as solar PV. This implies that extended lead times and additional efforts are needed to generate a workforce suitable for the wind industry. There is a significant skill overlap between the offshore oil and gas industry and the offshore wind industry, suggesting that the offshore oil and gas sector could help meet the skill needs for an accelerated deployment of offshore wind systems in India.
- The IEA analysis highlights that while training systems for the onshore wind sector are already established, the growth of offshore wind will require newer and more diverse skill sets. This includes training to adhere to safety guidelines relevant to professionals working at heights and sea survival.
- As per GWEC, the construction of wind farms requires several materials such as concrete and steel, along with key minerals like copper, zinc, and manganese. Concrete and steel constitute 90% of the material requirement for onshore wind farms, whereas steel accounts for 90% of the material required for offshore wind farms. As per IEA analysis, within the overall requirement of key minerals, copper and zinc account for 83% and 88% of the mineral requirement in onshore and offshore wind turbines, respectively.

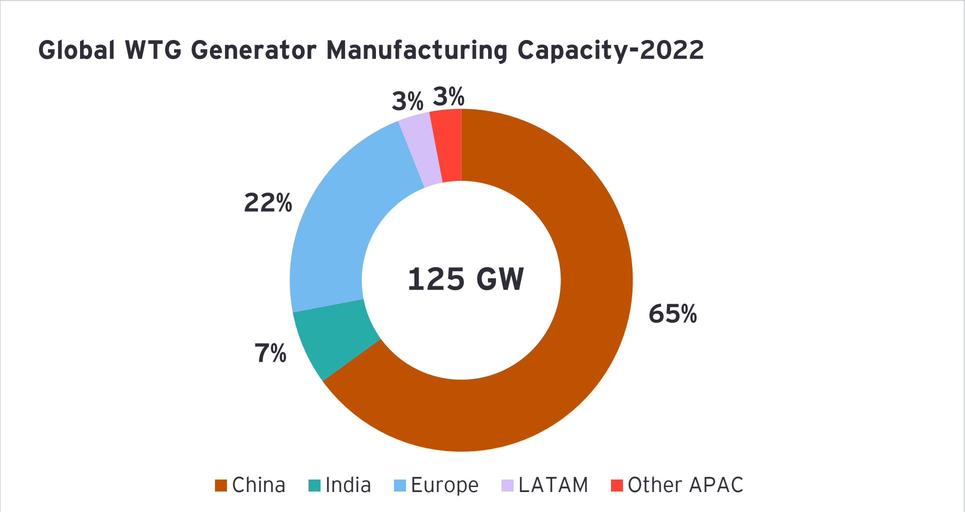
Wind turbine material composition

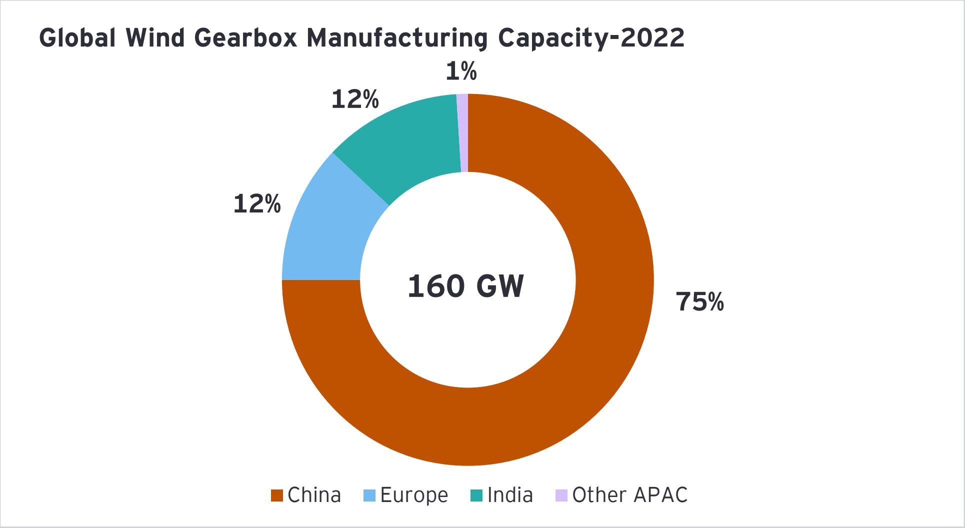


Source: Developing Global Resilient Clean Energy Supply Chains, CEEW 2023

Global wind turbine blade, generator and gearbox manufacturing ecosystem

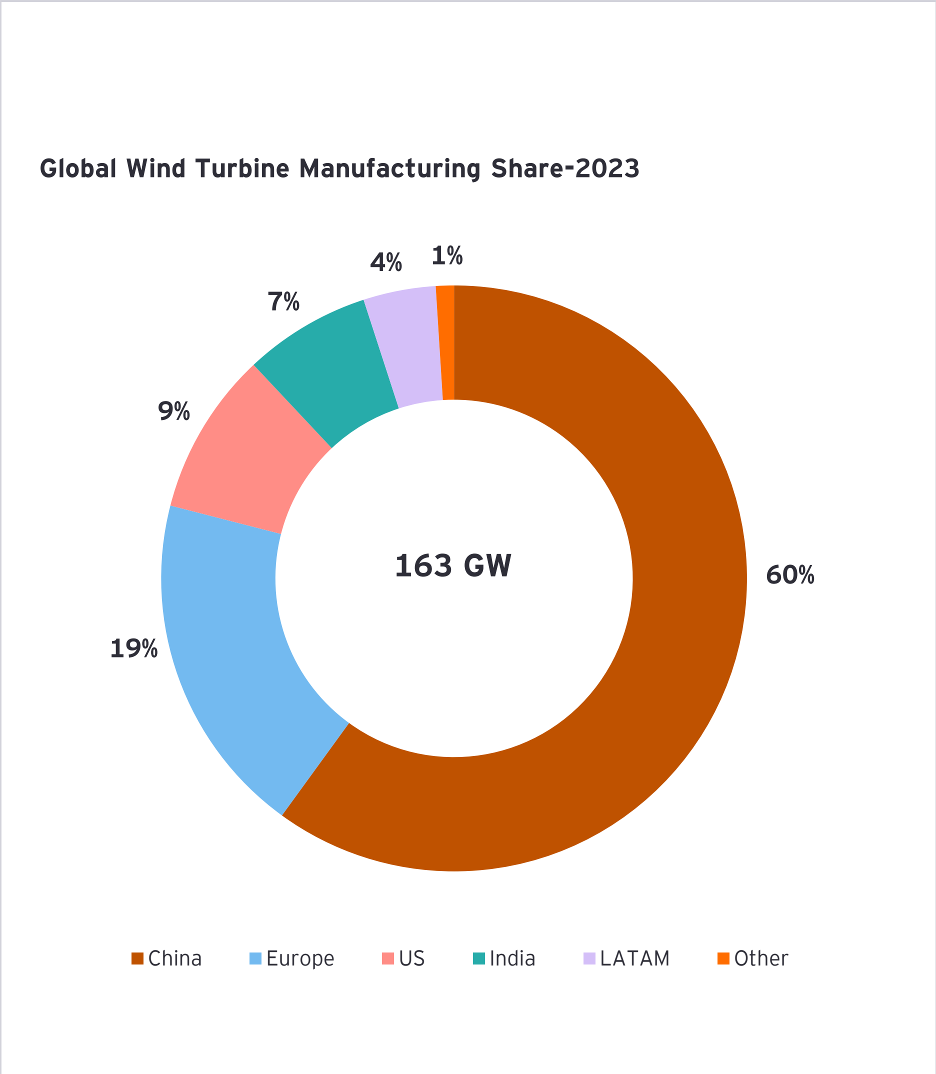


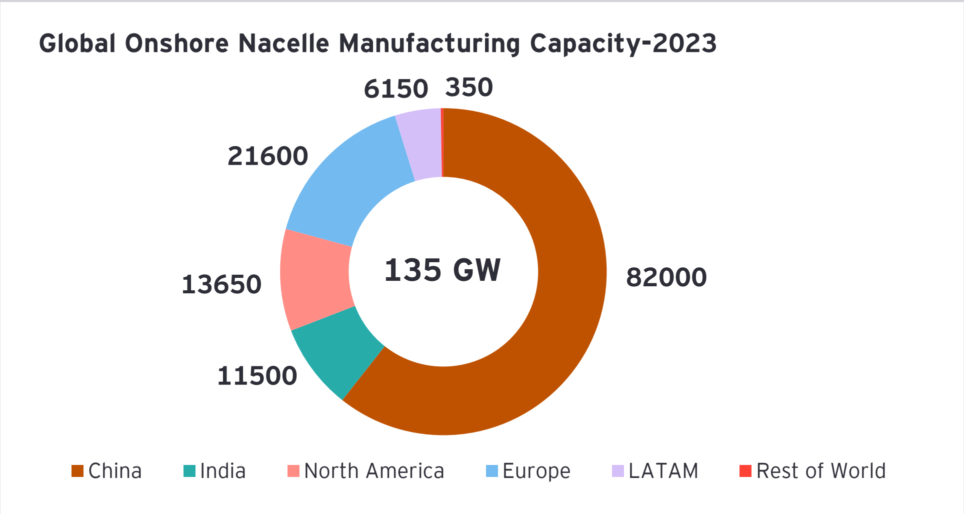


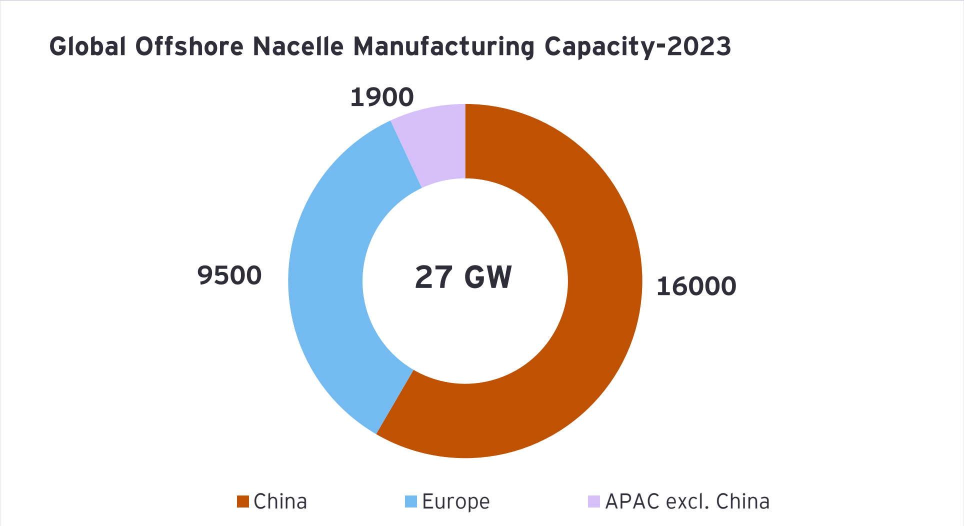


Source: Global Wind Report, GWEC 2023

Global wind turbine nacelle manufacturing ecosystem



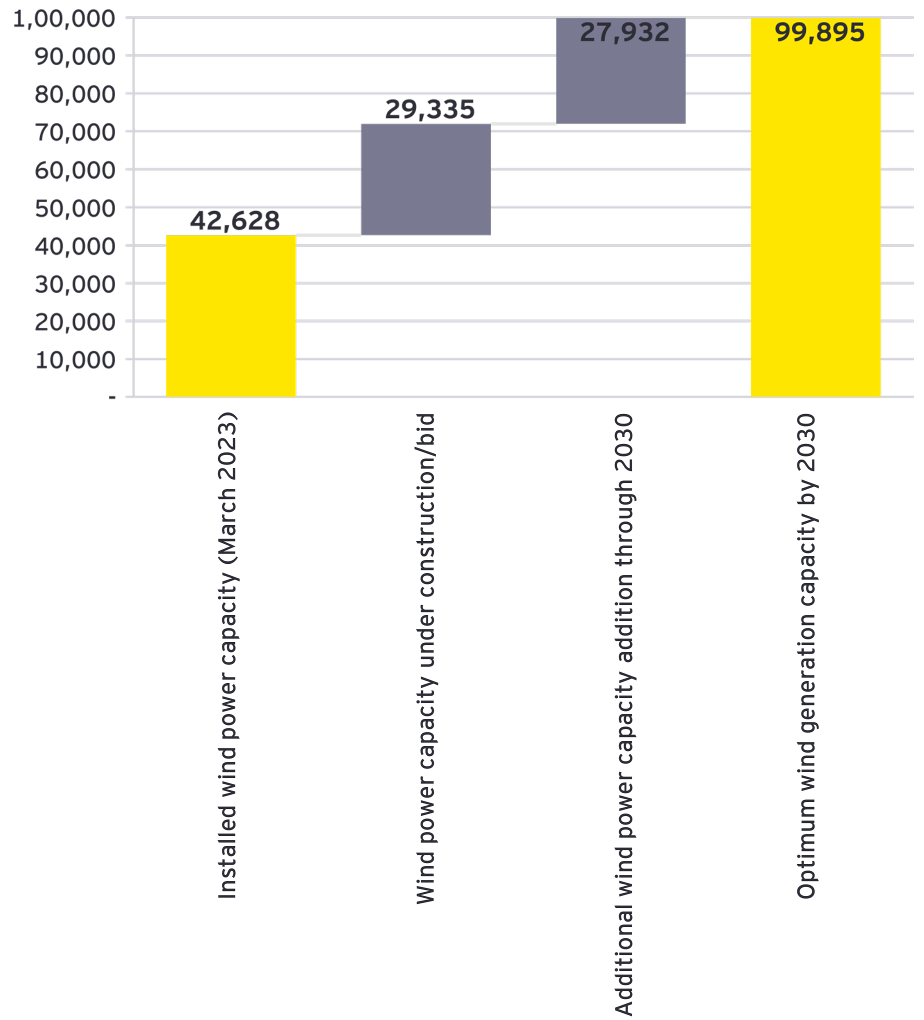




Source: Global Wind Report, GWEC 2023

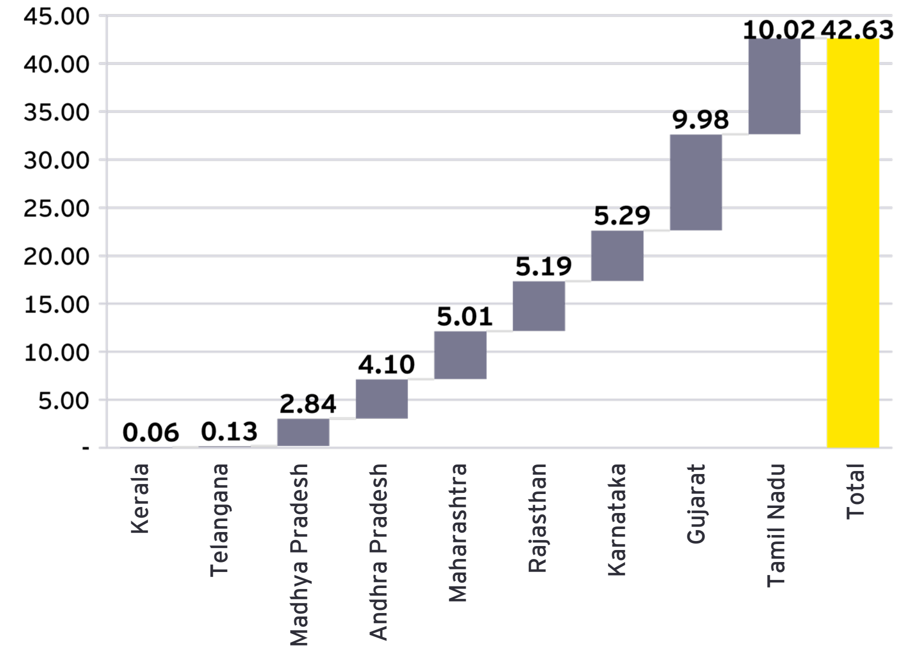
India's wind power generation capacity is likely to double through 2030 and may even surpass ~150 GW for achieving the green hydrogen production targets

Demand for wind power generation through 2030 (MW)



Source: Power Sector Dashboard CEA March 2023, EY Research, CEA Optimal Energy Mix report 2023

State-wise wind power Installed Capacity as of March 2023 (GW)



By 2030, an estimated 5 million tons of green hydrogen production capacity is expected to be created, resulting in approximately 125 GW of renewable energy (RE) capacity. Out of which, wind power is likely to be a major contributor. Round-the-clock RE power generation systems typically required for electrolytic production of green hydrogen is best achieved with a high share of wind power generation as compared to solar PV and energy storage systems. Moreover, a substantial wind power generation potential of approximately 696 GW exists at a hub height of 120 meters.

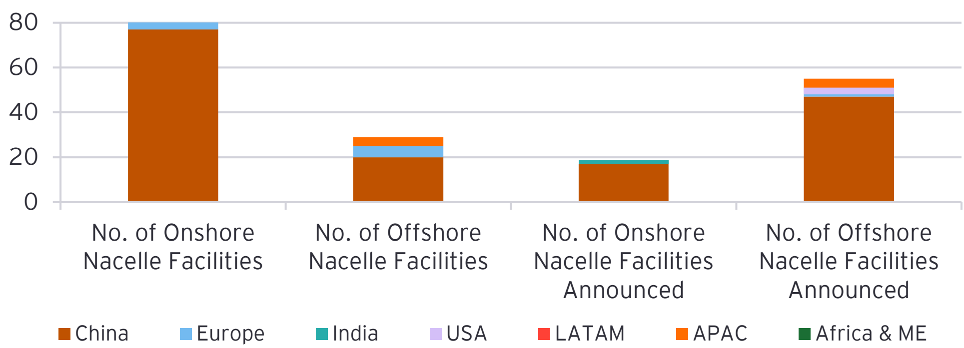
Given India's abundant wind power potential and its commitment to expand renewable energy, the production of green hydrogen presents a significant market opportunity for the wind turbine manufacturing industry in the near future.

Source: Power Sector Dashboard CEA March 2023

Indian wind turbine production contributes only 7% of global production

- On 9 January 2023, MNRE released an office memorandum that revised the competitive bidding mechanism for procurement of power from Wind Power Projects (WPPs). This transitioned from reverse auction bidding to a single-stage two-envelope approach, involving technical and financial aspects, with several other changes. The bidders meeting the technical requirements will be considered for the financial bid and subsequently, the lowest bidder will be awarded the project. It was also proposed that the cumulative bid capacity would be 8 GW each year until 2030, with a cap of 2 GW for each state. In cases where there was only one bidder, the remaining capacity would be rolled over to the next tender. This would be facilitated through composite state-specific bids for all eight windy states (comprising eight sub-bids), with independent selection of bidders for each state.
- There are also provisions to penalize the qualified bidders in case of delay in project execution. Finally, the tariffs from all the bids will be pooled as per the notified Electricity (Amendments) Rules, 2022, and will be offered to DISCOMs. This move aims to increase the pace of deployment of wind power capacity and achieve the wind potential estimated by NIWE. The annual target was set at 8 GW for onshore wind tenders every year between 2023 and 2030, using a single-stage two-envelope bid system. MNRE published a strategy paper outlining a tender trajectory of 37 GW of offshore wind by 2030.

Global Nacelle Manufacturing Facilities-2023

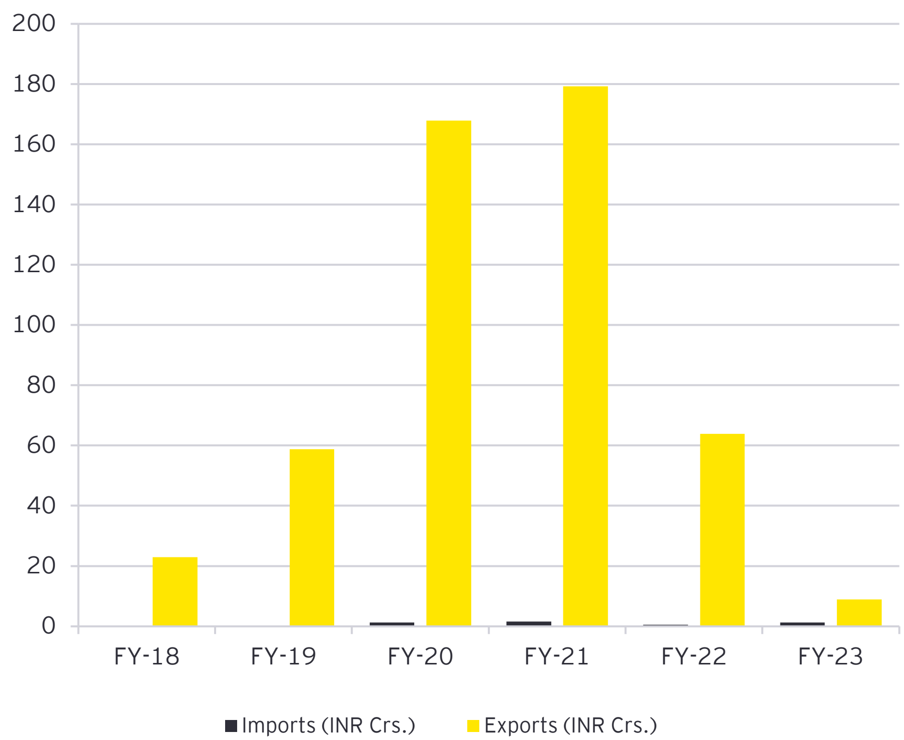


Source: Global Wind Report, GWEC 2023

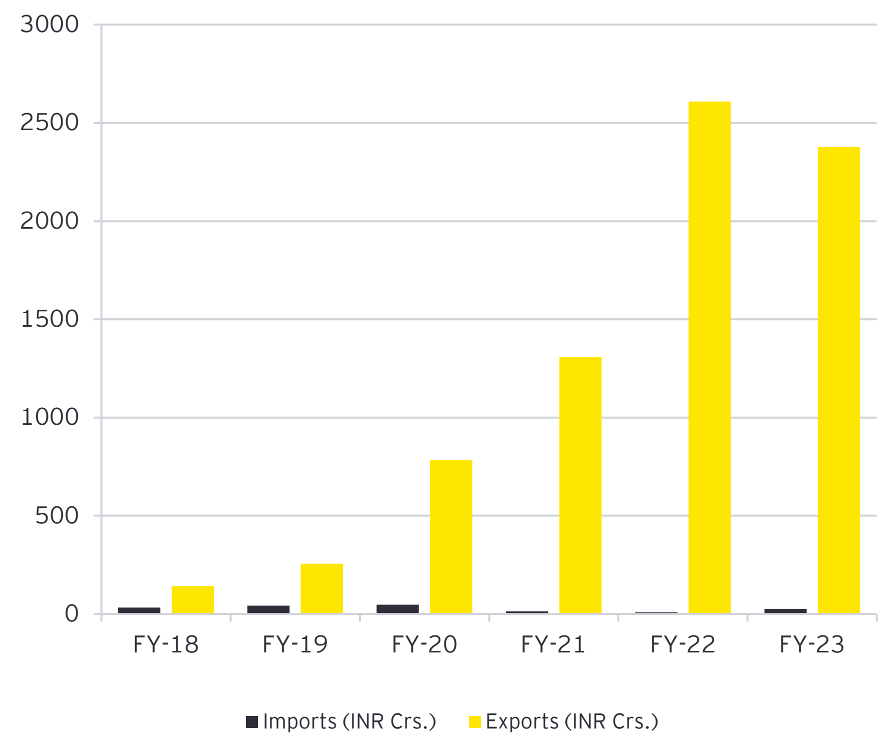
- India has established itself as a major player in wind turbine manufacturing with a total capacity of around 12 GW. As of June 2023, the Ministry of New and Renewable Energy (MNRE) has approved 33 wind turbine models from 14 OEMs, featuring advanced specifications such as rotor diameters up to 156 meters and hub heights up to 160 meters. Additionally, there is a growing emphasis on indigenization, with multiple OEMs achieving 70-80% localization and turbine units rated at 3.6 MW. These efforts not only create opportunities for investment, technology development, job creation but also contribute to fostering a green and sustainable energy sector in India.
- India holds the distinction of being the second-largest market for gearboxes worldwide and the second-largest manufacturer of blades in the Asia-Pacific (APAC) region. According to the Global Wind Energy Council Report 2023, India accounts for approximately 11% of the global blade manufacturing capacity, equivalent to 14.3 GW. Similarly, India contributes around 7% to the global wind generator manufacturing capacity, amounting to 8.75 GW, and holds a significant 12% share in global gearbox manufacturing, equivalent to 19.2 GW.
- As per the Global Wind Energy Council (GWEC) global wind report 2023, India contributes only 7% of the global wind turbine manufacturing capacity, translating to approximately 12 GW. The combination of favorable pricing and the shifting dynamics in supply chains in Europe presents a significant opportunity for India in the global wind energy supply chain. With a domestic manufacturing capacity of 10-12 GW for wind turbine generators and a strong presence in gearbox manufacturing, blades, and generators in the APAC region, India is well-positioned in the wind manufacturing sector.
- To strengthen its position as a leading exporter, India needs to establish a resilient supply chain for raw materials, including rare earth metals and non-standard steel, and focus on specific value chain components such as casting and forging. It is imperative to continue providing import duty relief on certain equipment and components that cannot be produced locally, such as balsa wood and pultruded carbon fiber.

India's trade scenario in wind turbines and generators

Wind turbine HS Code: 84128004



Wind generator HS Code: 850231



Source: www.dgft.gov.in

MNRE has announced a strategy roadmap to install 37 GW of offshore wind power by 2030

The Ministry of New and Renewable Energy (MNRE) in India has announced a strategy roadmap to install 37 GW of offshore wind power by 2030. This signifies a significant focus on harnessing wind resources from the seas and oceans surrounding the country. Offshore wind farms have the potential to generate large amounts of clean energy and contribute to meeting India's renewable energy goals. The roadmap set by the MNRE emphasizes the government's dedication to exploring and utilizing offshore wind resources to further enhance the country's renewable energy capacity.

By setting these targets and implementing strategic plans for onshore and offshore wind power development, India aims to strengthen its position as a global leader in renewable energy. The government's focus on wind energy expansion aligns with its commitment to combat climate change, reduce greenhouse gas emissions, and achieve sustainable development. Keeping in view the requirement of the holistic development of offshore wind farms in the country and to fast-track the process, the MNRE proposed three models:

Model - A

Proposed for B3 zone (365 sq. km) off the coast of Gujarat. Lease agreement for 35 years. A two-stage-single bid process would be followed e-RA by SECI and PPA will be signed with SECI as the off-taker.

Viability Gap Funding may be considered by Govt.

OWPD shall commission the project within four years

MNRE conducted following studies that would enable the bidders to bid for the projects

- Lidar-based offshore wind resource assessment for two years and data published on the NIWE website. Geophysical investigation and Geotechnical investigation for 3nos of representative boreholes up to 60m soil depth.
- Rapid EIA study
- Oceanographic (Wave, Tide & current) for one month

Model - B

Exclusivity for seabed during the study period of two years.

No studies have been carried out by MNRE/NIWE

Projects under EEZ of India

NIWE will act as a single window for clearances

Developer to conduct studies

After studies and clearances, SECI will invite tenders for offshore wind energy

OWPD need to submit DPR and enter into concession agreement and lease agreement (for a period of 35 years) for project development and sale of power under open access/captive/third party sale regime. Government may also call for bids for procurement of power for DISCOMs on the basis of tariff after two years.

OWPD shall commission the project within three years

Model - C

Sea bed will be allocated to bidders through a competitive bidding process.

The Government will come up with a bid for project development/allocation of the seabed. The bidding may include any of the following methods; Bidding on lease/allocation fee or revenue sharing in case of projects for captive consumption/third party sale/sale through exchange under an open access mechanism. Tariff-based competitive bidding in case of power procurement by DISCOMs or Central Govt. or State Govts. Any other transparent bidding mechanism identified by the Government.

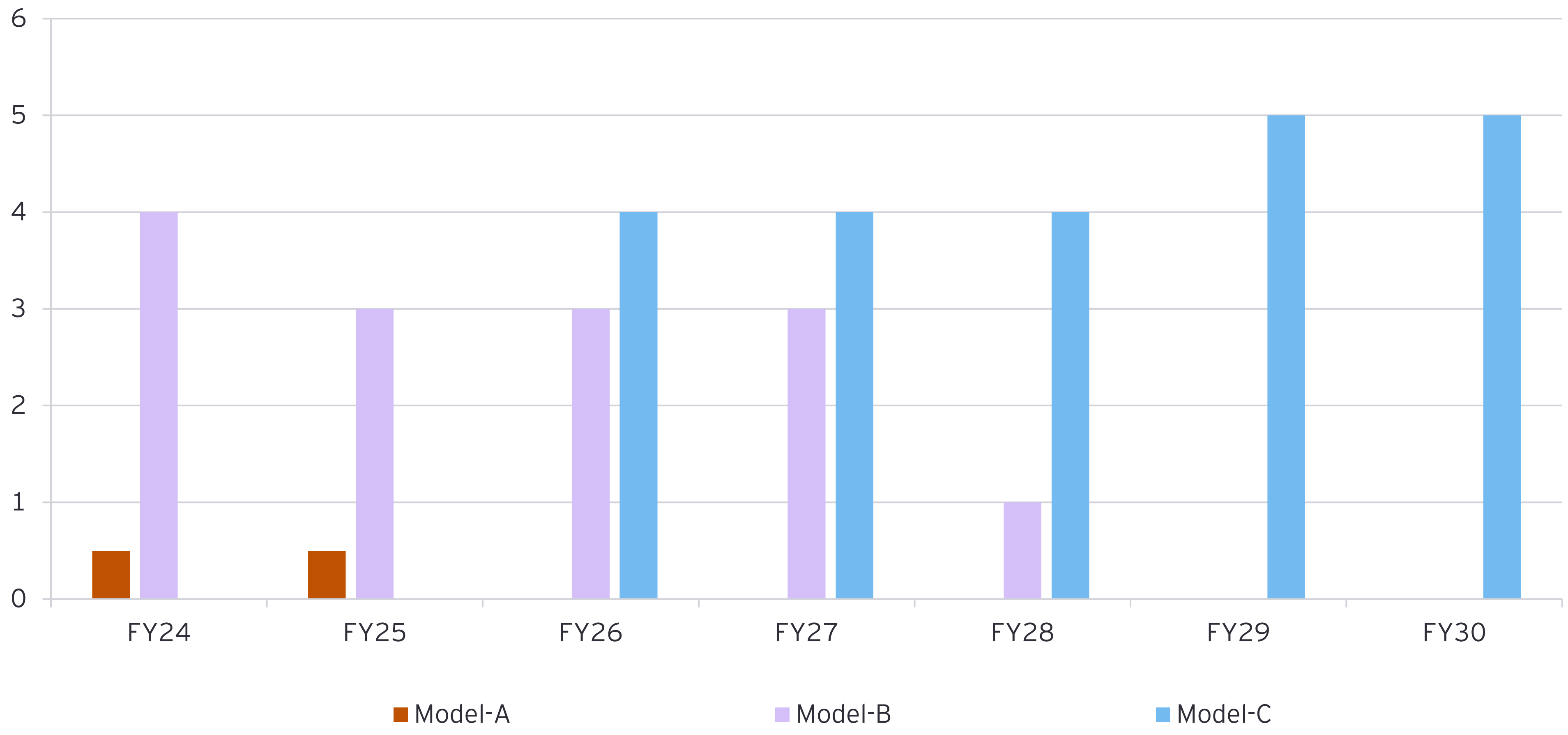
MNRE or its designated agency will enter into the concession agreement and 'Lease Agreement' for 35 years with the successful bidders.

OWPD to shall commission the project within four years

Source: Strategy Paper for Offshore Wind Energy In India, MNRE August, 2023

MNRE indicative auction trajectory for offshore wind

MNRE indicative offshore wind auction trajectory (GW)



Source: Strategy Paper for Offshore Wind Energy In India, MNRE August, 2023

Policy enablers

Production-linked incentives for wind turbine grade ancillary manufacturers and rare earth mineral processing

Casting and forging is a critical process in wind turbine manufacturing, especially for components such as turbine hubs, rotor blades, and gearboxes. Challenges related to casting can include quality control issues, casting defects, and delays in production. Ensuring the availability of skilled personnel and modern casting facilities is essential for maintaining the desired quality and efficiency in the manufacturing process. Any shortcomings in the casting process can lead to rework, production delays, and increased costs for wind turbine manufacturers.

Considering the continuous upgradation in the unit size of wind turbine, it is worth investing in advanced casting and forging facilities that can accommodate rapid upgrades in unit size, design and technology of multiple OEMs and cater to the demand for multiple OEMs together. Implement rigorous quality control measures to minimize casting defects and ensure consistent production. Collaborate with casting/forging experts or seek partnerships with specialized casting/forging companies to optimize these operations. Providing necessary financial incentives to these industries could ramp up the production and reduce the bottlenecks in overall manufacturing process of wind turbines.

Additionally, fluctuations in raw material prices can pose challenges for wind turbine manufacturers. The cost of materials such as steel, aluminum, zinc, copper, and composites can significantly impact the overall manufacturing cost of wind turbines. Sudden increases in raw material prices can squeeze profit margins, making it difficult for manufacturers to maintain cost competitiveness. Various raw materials to manufacture wind turbine are creating a stress on wind turbine manufacturing capacity in India. Several critical raw materials are imported such as Balsa- as essential material used as reinforcement in blades. Rare earths to manufacture permanent magnets for generator, fiberglass/resin, etc. Domestic value addition in wind turbine manufacturing is currently only ~25%. Price volatility can also affect procurement planning and inventory management requiring manufacturers to closely monitor market trends and engage in strategic sourcing to mitigate these challenges.

Rare earth elements (REEs) are critical to produce permanent magnets used in wind turbine generators. The prices of REEs, such as neodymium and dysprosium have experienced wide fluctuations due to factors like global supply and demand dynamics, export restrictions, and geopolitical factors. Wind turbine OEMs closely monitor the prices of REEs as they impact the cost and availability of magnets.

Strengthening transportation and logistics for wind turbine installations

Essential infrastructure such as approach roads, robust cranes, and efficient power evacuation systems, needs to be put in place. By collectively establishing shared facilities, spearheaded by Special Economic Zones (SEZs) and government entities, there is potential to lower power generation costs and alleviate financial strain on Original Equipment Manufacturers (OEMs) and Independent Power Producers (IPPs). Enhancing the efficiency of transportation routes and schedules is imperative to mitigate delays and ensure punctual delivery of wind turbine components. Strategic investments in appropriate handling equipment and infrastructure at both manufacturing plants and project sites are essential to streamline transportation and facilitate seamless installation processes.

Promote export-oriented incentives

In the global market, Indian wind turbines encounter fierce competition from their Chinese counterparts, which often have cost advantages. To address this situation and bolster the global competitiveness of Indian wind turbine manufacturers, the government could contemplate implementing export-oriented incentives.

By offering incentives tailored toward exports, the government would provide Indian wind turbine manufacturers with a competitive edge in international markets. These incentives could encompass various forms, such as financial support, tax benefits, streamlined export procedures, or even research and development grants, incentivizing manufacturers to enhance the quality, efficiency, and affordability of Indian modules for the global market.

Setting up shared testing facilities for wind turbine components on PPP mode

Testing wind turbines in India is a complex endeavor hampered by multiple challenges. The limited availability of advanced testing infrastructure and specialized technical expertise for intricate components like gearboxes, blades, and control systems contributes to delays and increased costs in wind energy projects. Additionally, the inadequacy of standardized testing protocols and regulatory frameworks specific to wind turbines complicates the validation process. As a result, the lack of comprehensive testing mechanisms extend project timelines.

In India, most of the turbines/components are shipped to Denmark, the Netherlands, China etc. for testing. In partnership with academic and research institutions, the government could explore the establishment of an advanced shared testing facility for wind turbines within the country. This initiative would serve to assess turbine performance domestically, leading to a reduction in both lead time and associated expenses.

Access to round-the-clock affordable electricity

Manufacturing wind turbines involves various energy-intensive processes, such as casting, machining, welding, and assembly. These processes require a significant amount of electricity to power the machinery and equipment used in the production line. The power requirements can put a strain on the electrical infrastructure, especially if the manufacturing facility is located with limited or unreliable power supply. Power outages or interruptions can disrupt the manufacturing process and lead to production delays, lower productivity, and increased costs. Inconsistent power supply can result in equipment downtime, material waste, and reduced efficiency.

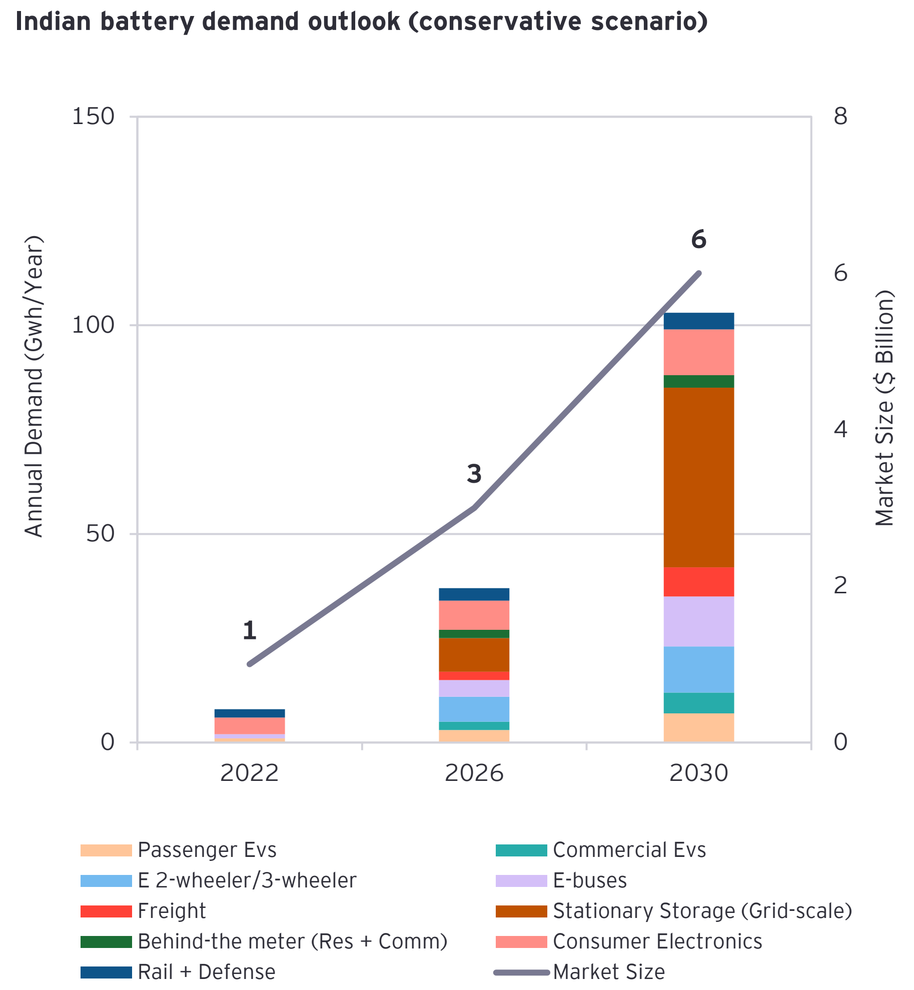
Wind turbine OEMs rely on a continuous and stable electricity supply to maintain seamless operations throughout the manufacturing process. The cost of electricity is an important factor for wind turbine OEMs, as it directly impacts their operational expenses and overall cost competitiveness. If the electricity rates are high, it can increase the manufacturing cost of wind turbines, which may affect the OEM's ability to offer competitive pricing to customers. The cost of electricity can also influence investment decisions related to expanding manufacturing facilities or setting up new production units.

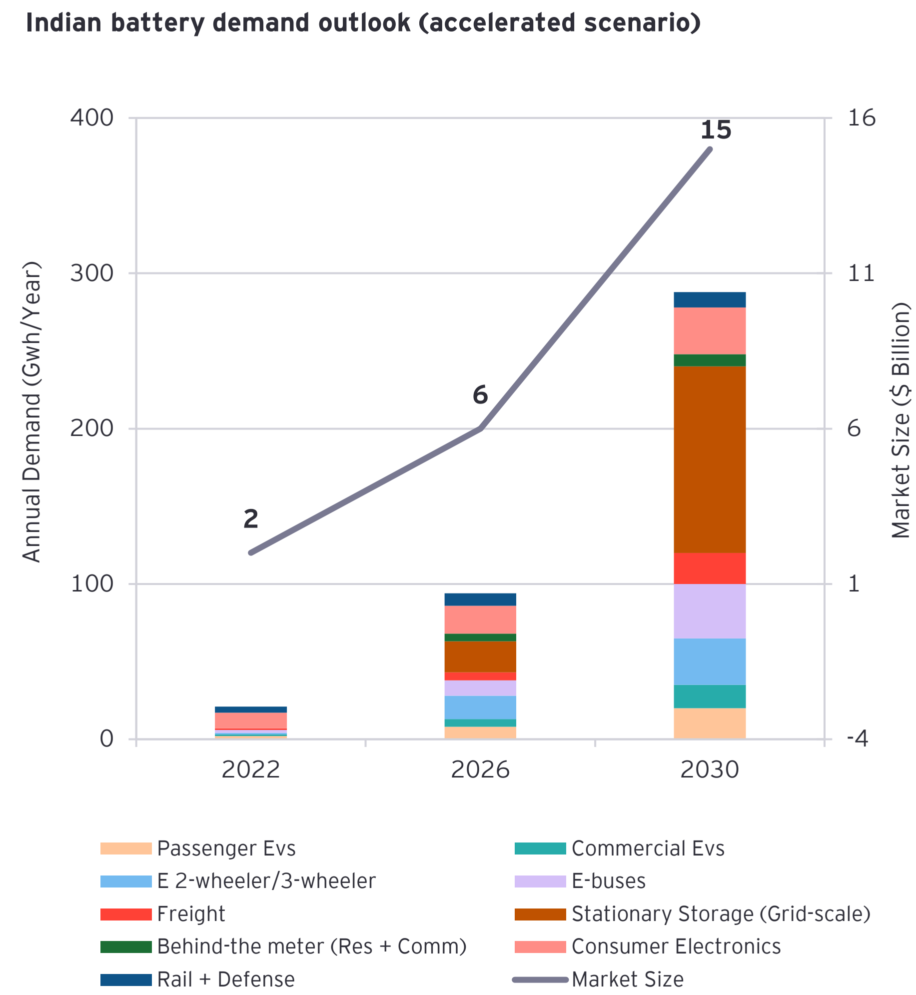
Access to round-the-clock reliable and affordable electricity is essential for upstream components in the value chain. The financial health of state power utilities and electoral promises of free power supply do not leave fiscal room for accommodating affordable industrial tariffs. A National scheme to incentivize/compensate state utilities for reducing industrial tariffs or promoting green energy open access transactions for round-the-clock supply can be explored. Implementing policies that enable longer duration of banking would allow manufacturers to store excess energy and utilize it when needed, ensuring a continuous and uninterrupted power supply from DISCOMs.

05

Domestic value addition in advanced chemistry cell (ACC) battery manufacturing

India's ACC battery market has potential to exceed US$~15 billion/annum by 2030





Source: Need for ACC energy storage in India, NITI Aayog, 2022

Stationary BESS market alone is ~208 GWh by 2030,– a massive opportunity for the domestic manufacturing industry

According to the Central Electricity Authority's Optimal Energy Mix report for 2030, the region-wise estimated battery energy storage system (BESS) during 2029-30 is 30.5 GW/152.5 GWh for Northern region and 11.1 GW/55.5 GWh for Southern region.

The energy storage capacity required for 2029-30 is likely to be 60.63 GW (18.98 GW PSP and 41.65 GW BESS) with storage of 336.4 GWh (128.15 GWh from PSP and 208.25 GWh from BESS). As on 31.03.2023, PSP based capacity of 4746 MW exists in the country. PSP projects totalling 2780 MW are under construction.

In addition, PSP capacity of 11,460 MW is required till 2030 to meet the electricity storage requirements of the country. Many PSP plants are likely to yield benefits by 2030 in the southern region, thereby making it a cost-effective storage alternative and thus reducing the need of additional BESS requirement in that region.

In the case of BESS resource, the investment is preferably in a northern region as compared to other regions due to steeper evening peaks. Therefore, BESS resource is found to be most cost effective and optimally utilized if installed locally in the northern region.

Stationary BESS applications for grid

Ancillary services (short duration)

- **Voltage support**: maintain grid voltage within specified limits, to help manage reactive power.
- **Frequency regulation**: correcting frequency deviations and maintaining frequency within limits.
- **Spinning reserves**: Standby generation stations utilized during unexpected power shortages. ESS with longer discharge durations can be used as spinning reserves.
- **Black start**: energizing part of the grid during unplanned blackouts.
- **Balancing**: fast-response time creates a balance between load and generation when the load changes rapidly. This helps to maintain the stability of the grid.

Bulk energy services (long duration)

- **Energy arbitrage**: This stores energy when the price is low and sells energy during peak demand when the price is high. Round-trip efficiency and operating cost play a key role when ESS is involved in arbitrage.
- **RE integration**: ESS should be able to absorb fluctuations to make the power system more flexible when a large share of intermittent renewables integrates into the grid.
- **Seasonal storage:** ESS with the capability to discharge for days, weeks, or months can supply the seasonal mismatches in the power system.

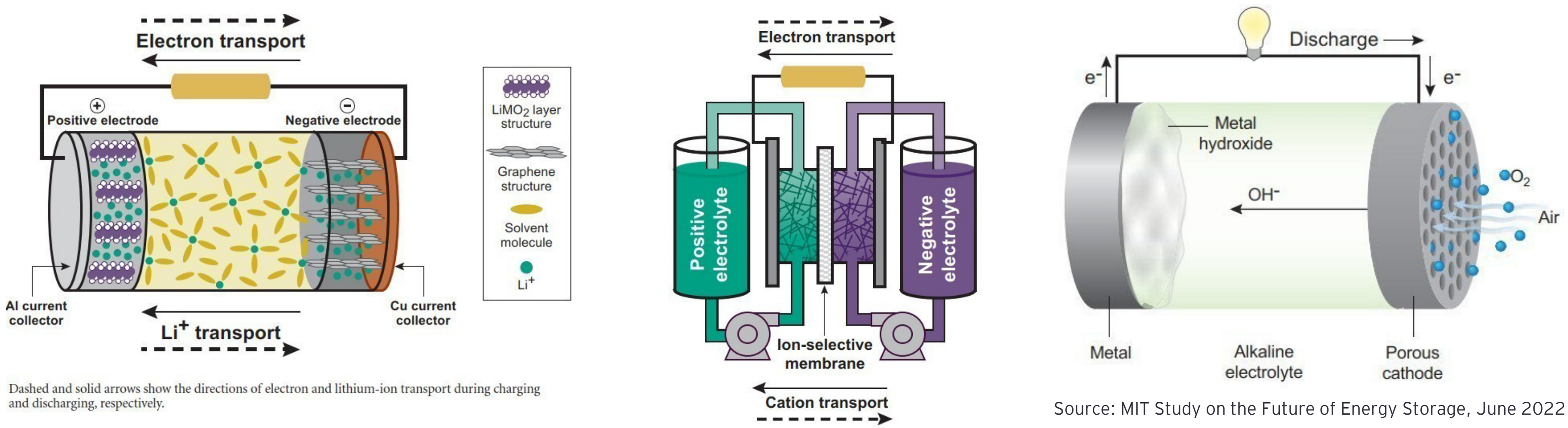
T&D infrastructure services

- **T&D upgrade deferral:** This involves using ESS to either defer or avoid the need of a T&D equipment upgrade to meet demand growth.
- **T&D congestion relief:** ESS charging during off-peak hours and discharging during peak load helps in reducing the congestion in the transmission network.

Customer energy management services

- **Power quality**: ESS will help in protecting consumers from high variations in voltage.
- **Power reliability**: The ESS installed close to consumer load aids customer during an unplanned interruption from the utility.
- **Demand shifting and peak reduction:** ESS supports by reducing peak demand and shifting the demand to non-peak hours.

Advanced chemistry cell battery technologies and key performance metrics for market transformation



Dashed and solid arrows show the directions of electron and lithium-ion transport during charging and discharging, respectively.

Source: MIT Study on the Future of Energy Storage, June 2022

- High energy density batteries > 350 wh/kg, 1000 wh/L
- Extended battery life > 10,000 cycles
- C-rating for fast charging (>= 5C)
- Cost of active materials < 20 US$/kWh
- Safety with inorganic / solid state / non-oxidizable active materials
- Real-time sensing of battery health condition
- Atomic layer deposition of active materials onto current collector foils

Source: EY analysis

ACC battery manufacturing value chain: a snapshot

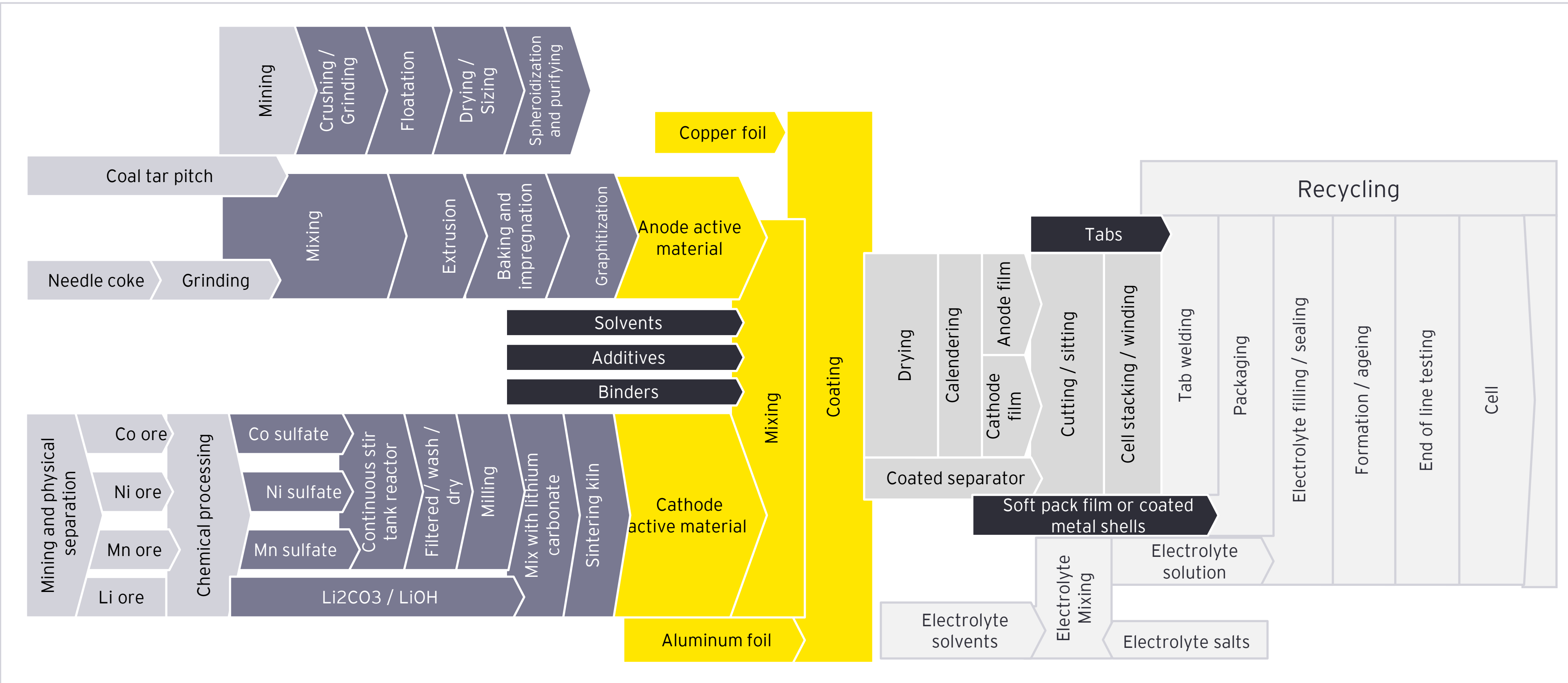
Mining
Extraction of raw materials, such as Li, Co, Ni, Mn and graphite

Chemical processing
Conversion of raw materials into intermediate compounds

Active material production
Manufacturing of electrode materials, such as NMC, LFP, etc.

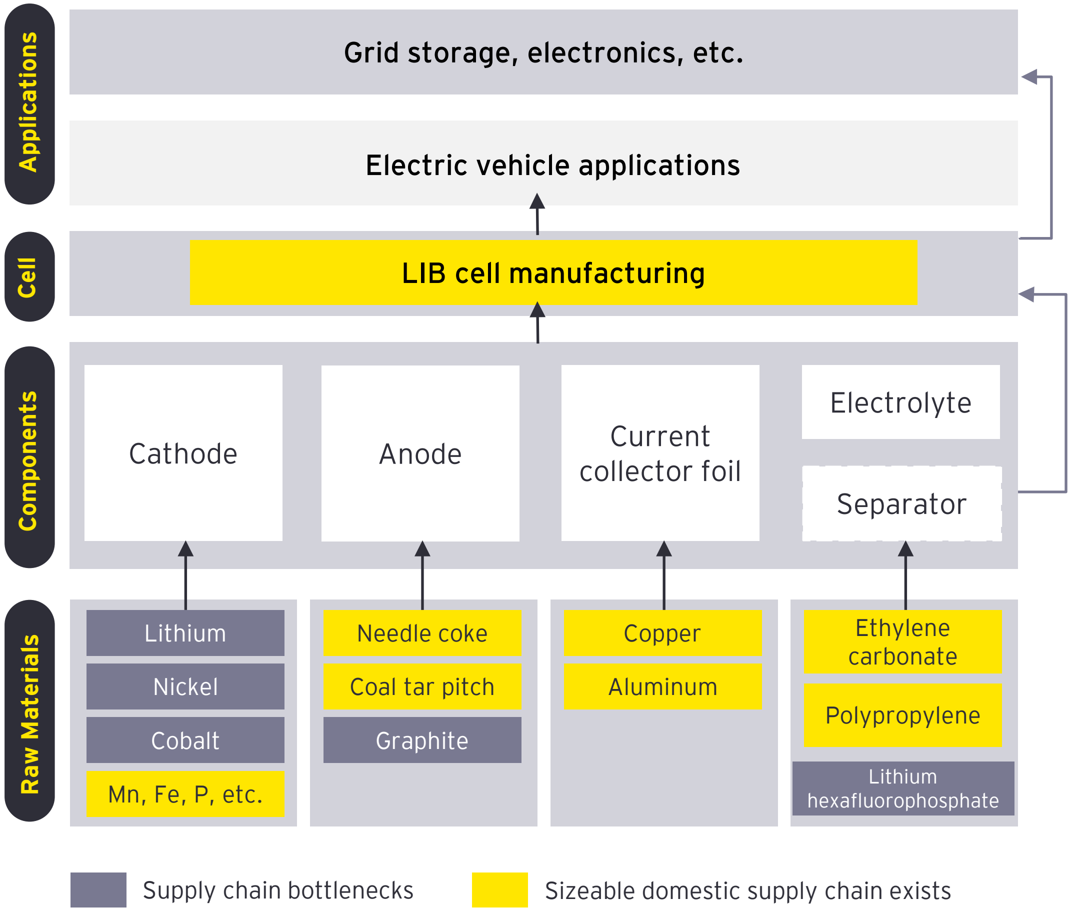
Cell production
Integration of electrodes, electrolytes and separators into a sealed unit

Recycling
Reclamation of valuable materials from used batteries



Source: EY analysis

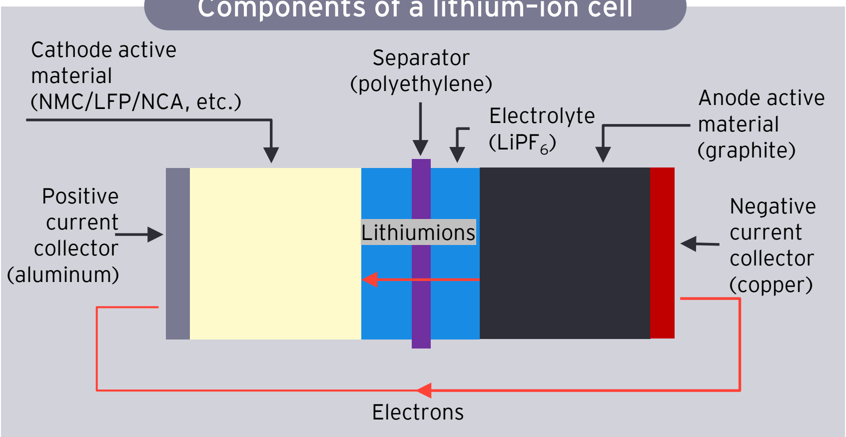
Key components and materials for manufacturing lithium-ion batteries (LIBs)



Source: EY analysis

- Commercially available LIB cell cathode and anode production will need active materials, such as NMC, LFP, NCA, LCO, LMO, spherical graphite, for different types of electrode chemistry. Active material synthesis will require battery grade processed chemical precursors of critical mineral commodities (e.g., lithium carbonate, nickel and cobalt sulfates).
- Moreover, Li-ion cells use polyolefin as ion exchange separators. This material has excellent mechanical properties, decent chemical stability and low-cost. Polyolefins are a class of polymer derived from olefins (alkenes) through the polymerization of ethylene, which is sourced from petrochemicals. Polyolefins can be manufactured using polyethylene, polypropylene, or a combination of both materials in the form of laminates. The separator must be permeable with pore size ranging from 30 nm to 100 nm. The recommended porosity is 30% to 50%.

Components of a lithium-ion cell



Source: how-can-india-scale-lithium-ion-battery-manufacturing-sector-and-supply-chain.pdf (ceew.in)

ACC battery applications and policy initiatives for domestic value addition

The Government of India's Production Linked Incentive (PLI) Scheme for Advance Chemistry Cells (ACC) will help in the local manufacturing of 50 GWh capacity of LIB cells and reduce dependency on imports. The scheme mandates 60% domestic value addition within five years of commercial operations. Additionally, approx. 95 GWh of battery manufacturing capacity announced by private players is under various stages of development.

G2G dialogues are advancing with friendly countries (e.g., Australia, Chile, Argentina, Bolivia, etc.) for joint exploration and mining. Government of India has set up KABIL to ensure a consistent supply of critical and strategic minerals through G2G negotiations and acquiring mining assets abroad. Most importantly, India has recently become the newest partner in the US led Mineral Security Partnership (MSP) to bolster critical mineral supply chains. The partnership aims to accelerate the development of diverse and sustainable critical mineral supply chains.

In the case of lithium, a handful of countries (viz. Australia, Chile and China) make up more than 90% of mine production of lithium bearing ores in the current scenario. Most of the refining of lithium ore into useful chemicals (Li2CO3 and LiOH) to make battery components is concentrated in Chile and China. In 2022-23, India imported INR 2262 crores of lithium-ion (HS code: 85076000) as per trade statistics from the department of commerce.

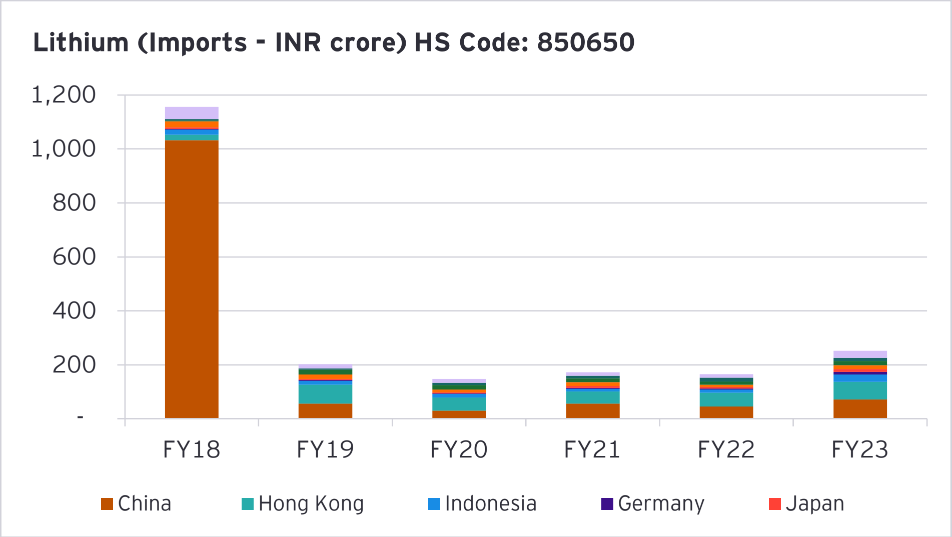
More research is needed to determine which minerals can be extracted economically from the recently discovered lithium resources (G3) in India. Lithium grades / concentrations are typically measured in parts per million (ppm) and weight percentage. A typical run of mine spodumene ore (commonly found hard rock lithium bearing mineral) can contain ~0.5 to 1% of Li2O (eq. 10,000 ppm).

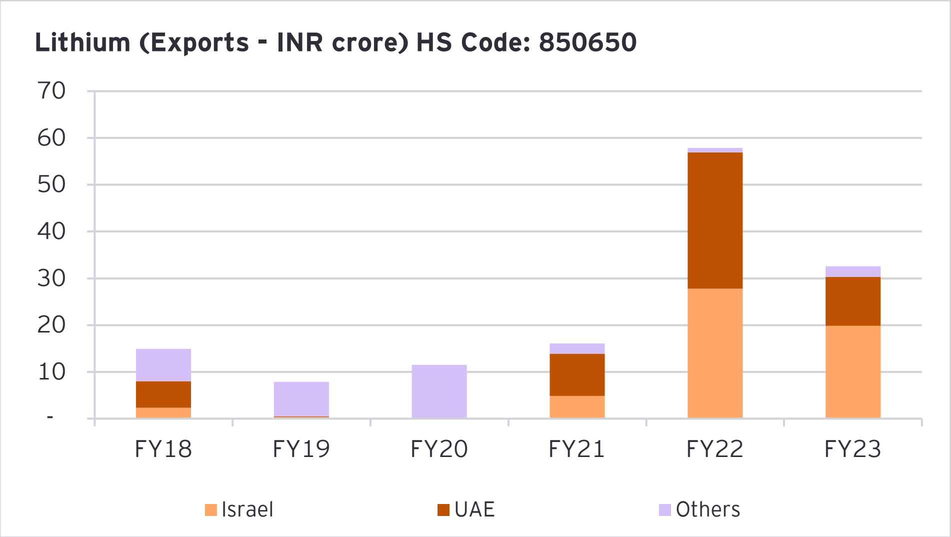
Battery storage market attractiveness

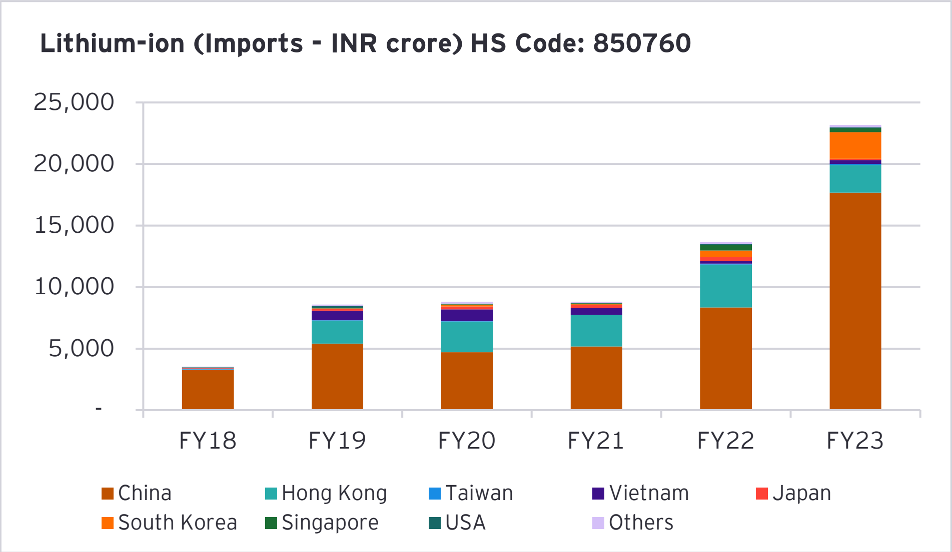
Mobile Applications	2020	2025	2030
Personal 4W- EVs	Low	Medium	High
Commercial 4W-EVs	High		
Personal 2W-EVs	Medium	High	
Commercial 2&3W-EVs	Medium	High	
Electric Buses	Medium	High	
Stationary Applications			
Microgrid Applications/Diesel Replacement	High	Medium	Low
Grid support/Ancillary Services	High		
Renewable Integration	Medium	High	High
T&D Upgrade Deferral	Medium		High
C&I Behind the Meter	Medium	High	
Residential Behind the Meter	Low	Medium	

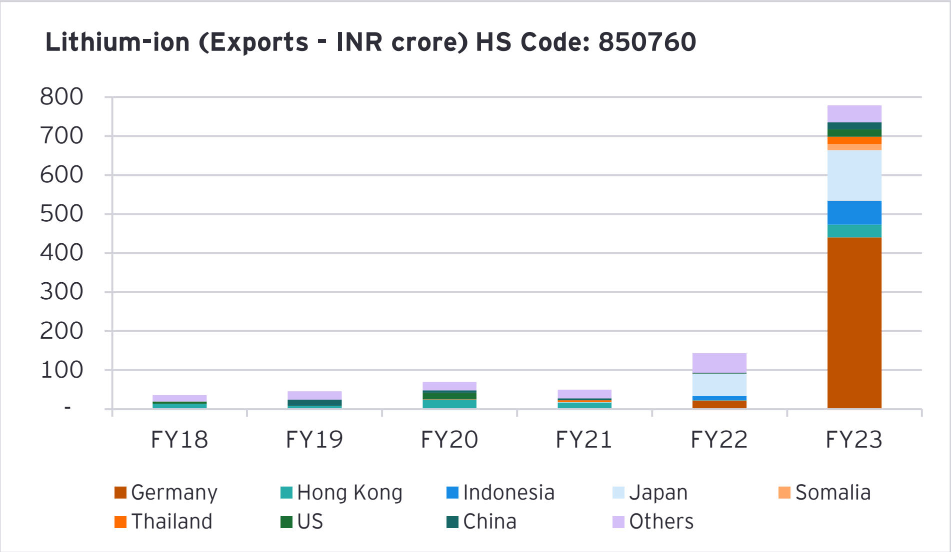
Source: Need for ACC energy storage in India, NITI Aayog, 2022

India's trade scenario in lithium and lithium-ion





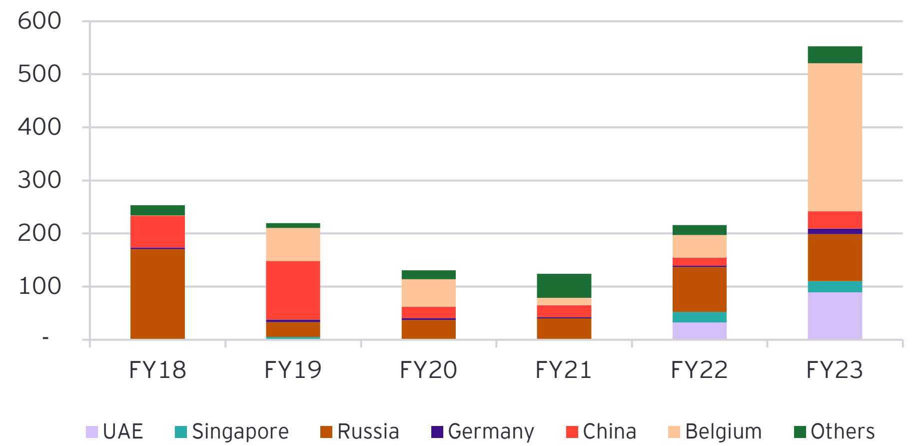




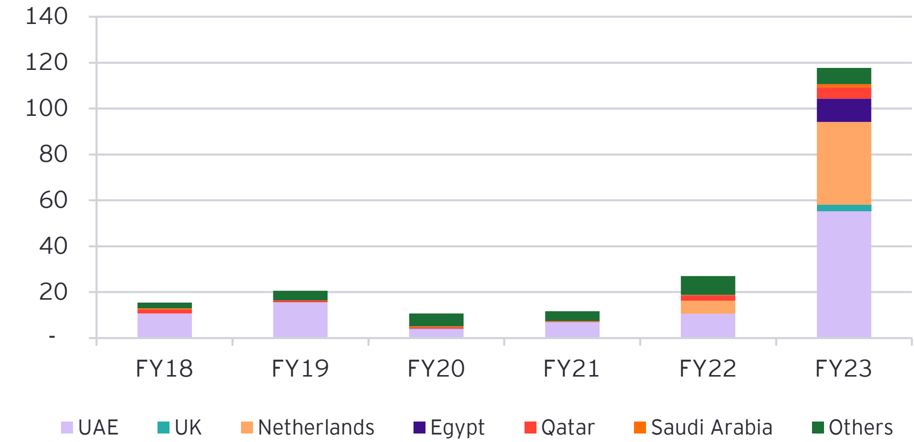
Source: www.dgft.gov.in

India's trade scenario in lithium derivatives

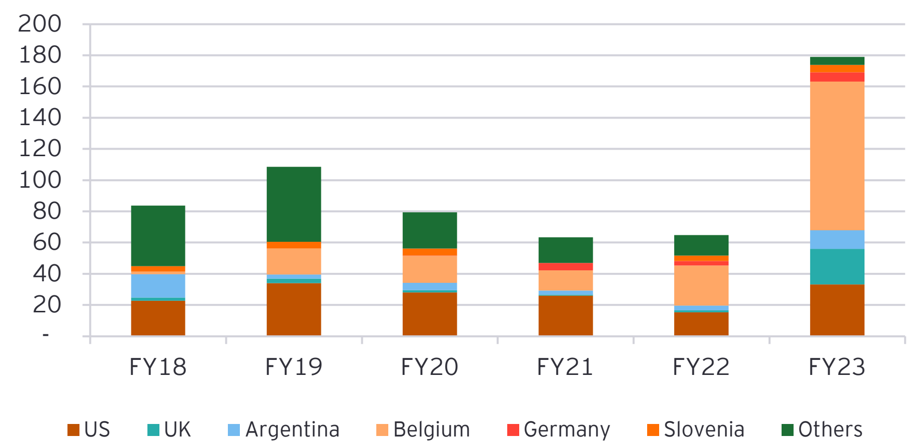
Lithium Oxide/Hydroxide (Imports - INR crore) HS Code: 282520



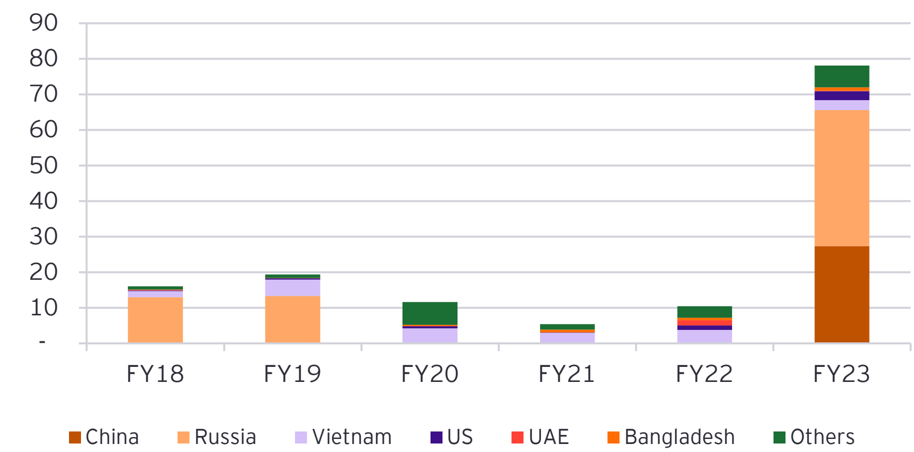
Lithium Oxide/Hydroxide (Exports - INR crore) HS Code: 282520



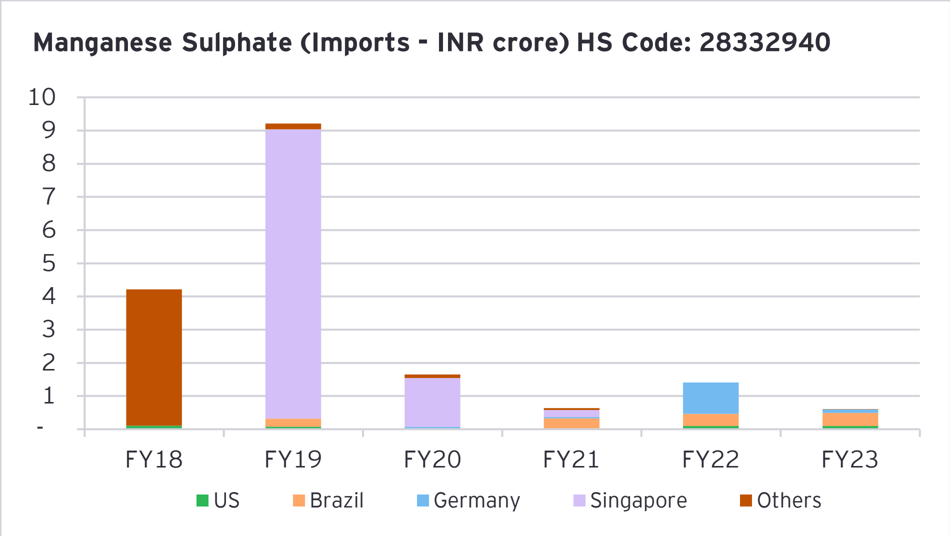
Lithium Carbonate (Imports - INR crore) HS Code: 283691

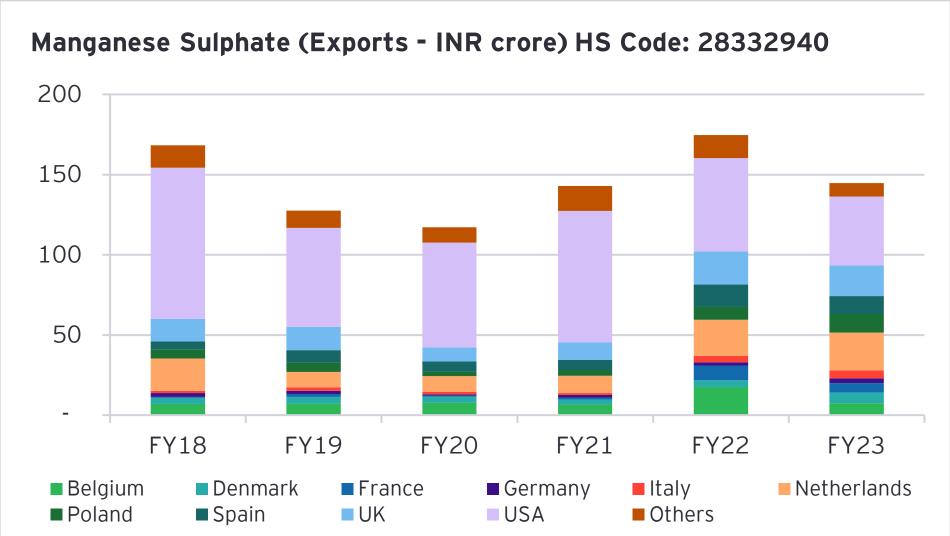


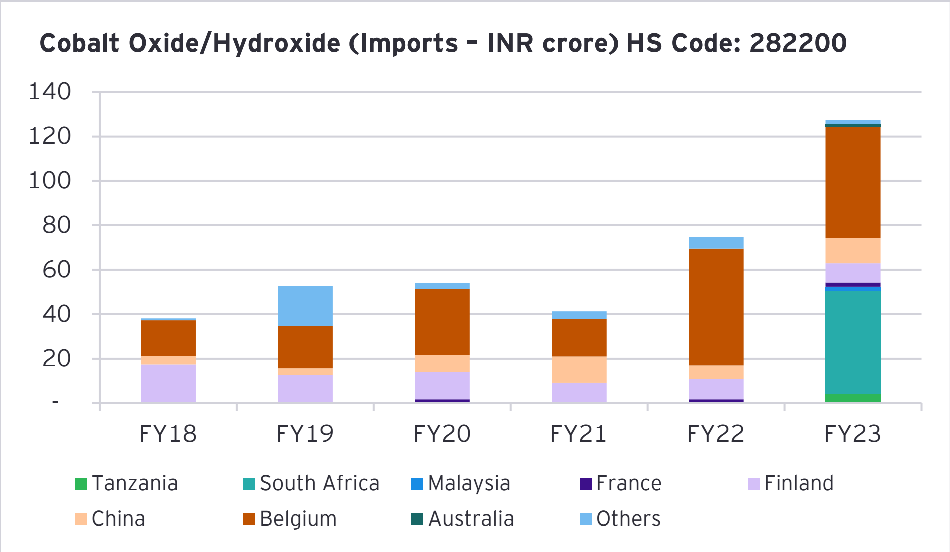
Lithium Carbonate (Exports - INR crore) HS Code: 283691

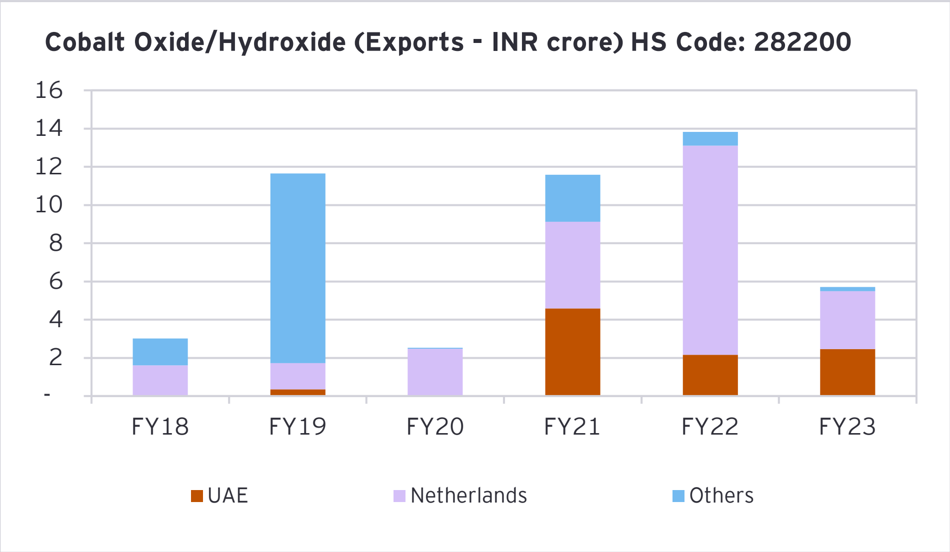


Source: www.dgft.gov.in

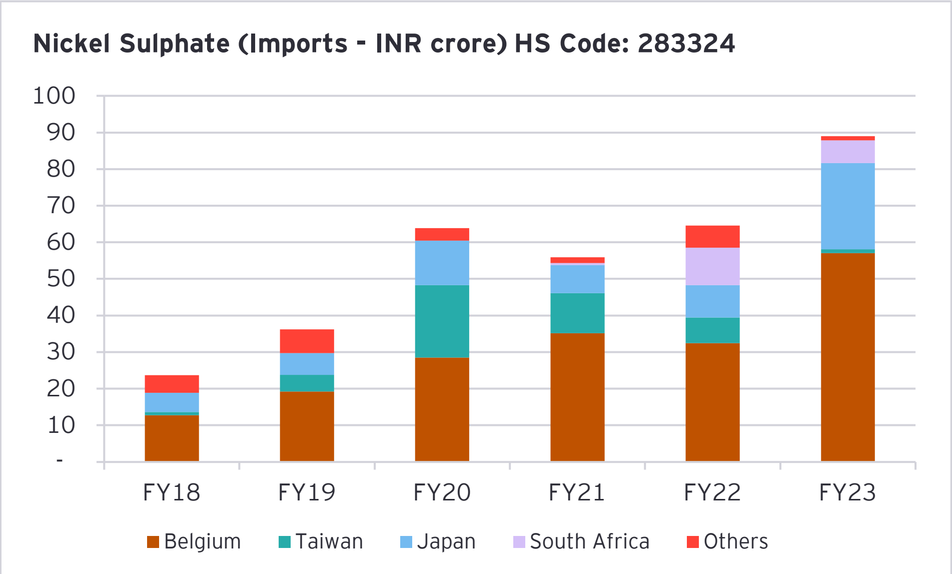


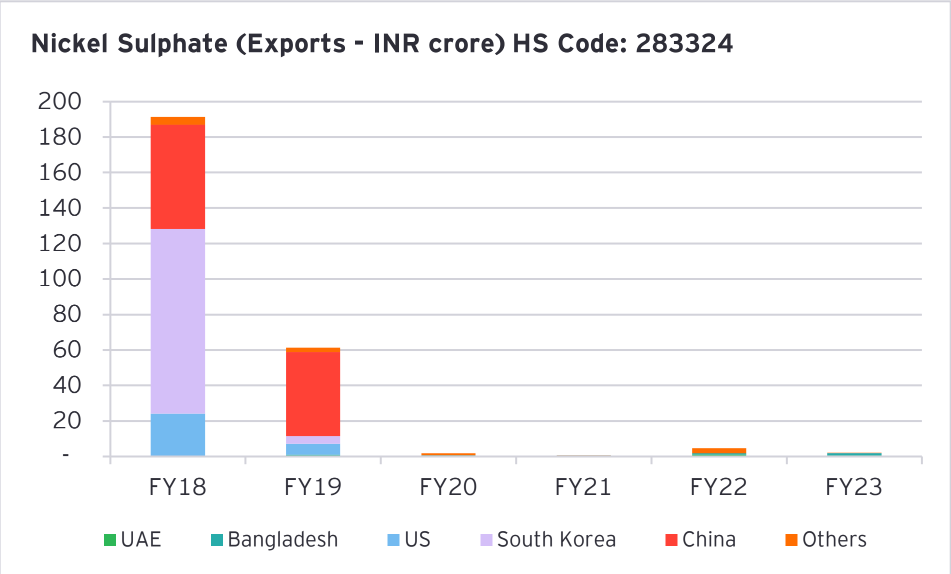


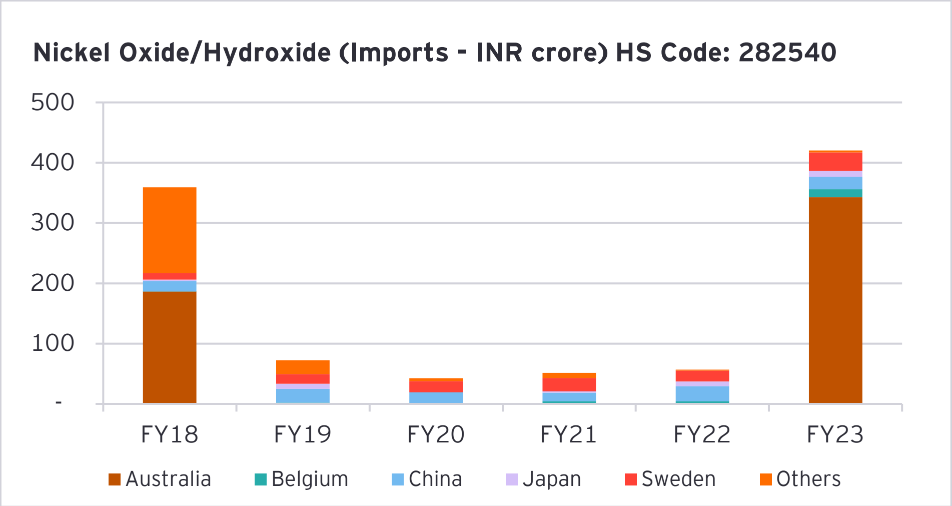


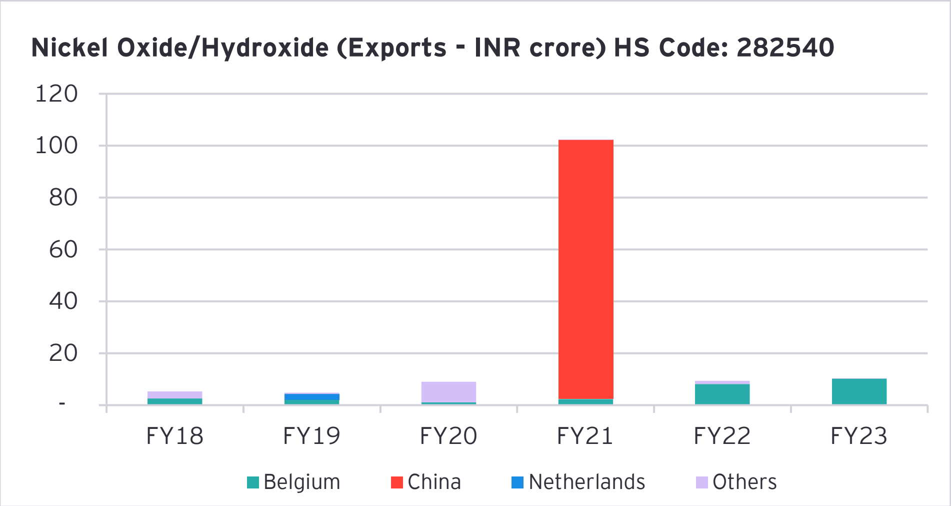


Source: www.dgft.gov.in





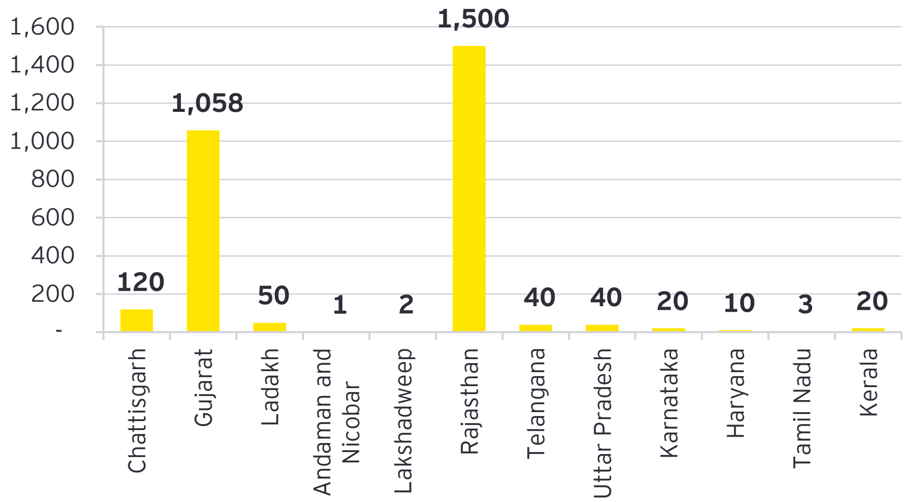




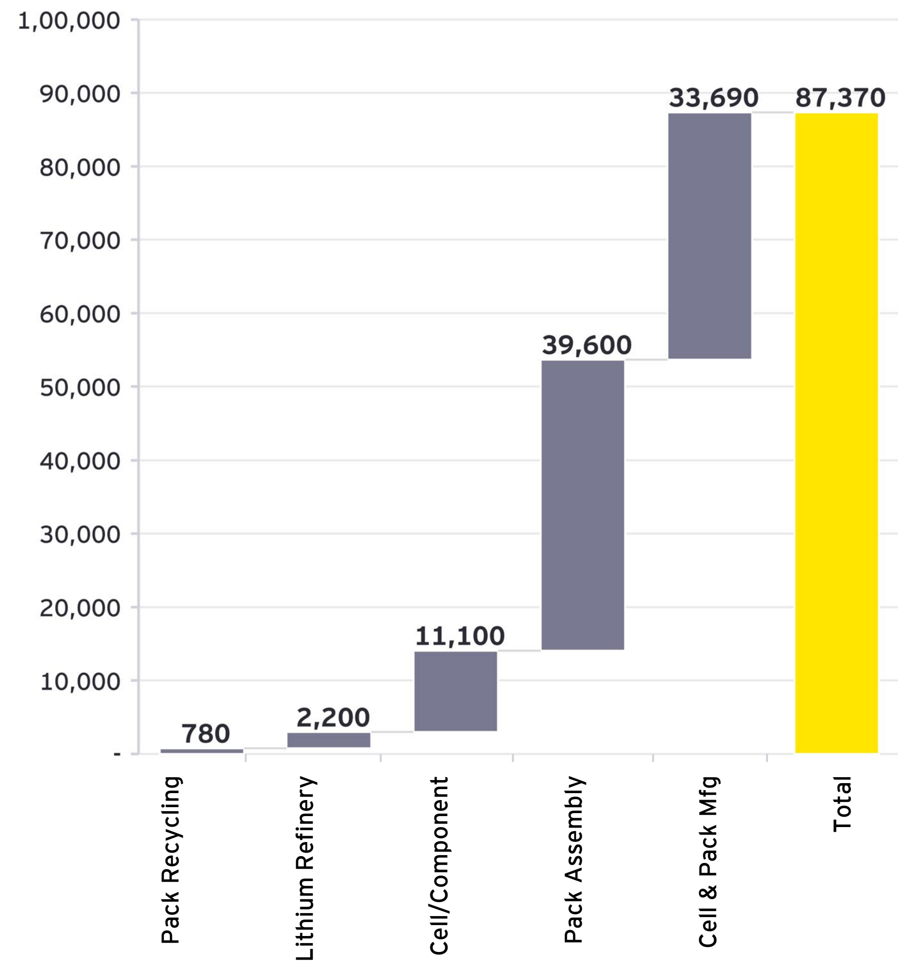
Source: www.dgft.gov.in

India's pipeline for ACC battery manufacturing projects announced, under permitting and construction, exceeds a capacity of 96 GWh per annum, with an investment potential of INR 87 thousand crores

Pipeline of BESS projects (MWh)



Total pipeline of ACC battery manufacturing investment (INR. crore)



Pipeline of ACC battery manufacturing/treatment in India

State	Pack Assembly (MWh)	Cell &Pack Mfg (MWh)	Cell/Component (MWh)	Pack Recycling (Ton/Year)	Lithium Refinery (Ton/Year)
Tamil Nadu	20,500	20,000	10,000		
Karnataka	5,000		17,000		
Gujarat	20,000	5,000		28,500	20,000
Telangana	1,200	16,500		15,000	
Others	1,400		100	30,000	
Total	28,100	41,500	27,100	73,500	20,000

Source: EY Research

Policy ecosystem (existing) for scaling up ACC battery storage investments in grid storage and mobility applications

Guidelines for Procurement and Utilization of BESS as part of GT&D assets along with Ancillary Services	▸ For intra-state projects: Minimum individual project size of power rating of 1MW and above ▸ For inter-state projects: Minimum individual project capacity of 50 MW and above ▸ Not applicable for business cases involving RE supply with BESS in hybrids
Energy Storage Purchase Obligations	▸ Progressive increase from 1% in 2023-24 to 4% of total electricity mix by 2029-30; At least 85% of energy stored must be sourced from renewables
Viability gap funding for BESS projects	▸ Support for ~4000 MWh capacity addition; Guidelines under development
GST and Standard customs duty	▸ Li-ion batteries @ 18% GST ▸ Other batteries @ 28% GST ▸ Li-ion batteries @ 20%* standard duty (HSN: 85076000) ▸ Total effective tax rate including GST is ~43.96%
PLI scheme for niche chemistry batteries	▸ PLI ~5 GWh manufacturing capacities under development
Faster Adoption and Manufacturing of Hybrid & Electric Vehicles in India (FAME)	▸ Phase-II of FAME India Scheme is being implemented for a period of five years w.e.f. 1 April 2019 with a total budgetary support of INR10,000 crore for demand side incentives ▸ Phased Manufacturing Programme (PMP) for EV parts for eligibility under Fame II incentive claims by OEMs requires only traction battery packs to be assembled in India with cells and associated thermal, battery management systems allowed to be imported.
PLI scheme for manufacturing of ACC batteries	▸ Local manufacturing of 50 GWh capacity of LIB cells and reduce dependency on imports. ▸ The scheme mandates 60% domestic value addition within five years of commercial operations
GST	▸ GST on electric vehicles has been reduced from 12% to 5% ▸ GST on chargers/ charging stations for electric vehicles has been reduced from 18% to 5%

Policy enablers

Mandate a gradual, time-bound increase of domestic content requirements for demand-side incentives in mobility and stationary grid applications

Advanced Chemistry Cell (ACC) batteries represent the cornerstone of future low-carbon transportation and energy systems. India's domestic ACC battery manufacturing industry is rapidly emerging with support from government initiatives on both demand and supply side. As global demand for lithium-ion batteries continues to rise, India has a unique opportunity to support resilient supply chains of ACC battery active materials refined from critical minerals, cells, modules, pack assembly, and aim to establish self-reliance and reduce imports.

Some developed countries have integrated demand side incentives for consumers and businesses to purchase clean vehicles with programs to expand domestic manufacturing and sourcing of critical minerals and battery components. In these countries, specific requirements must be met regarding the sourcing or processing of the battery's critical minerals to qualify for EV demand-side incentives. For example, according to the US Inflation Reduction Act Guidebook, consumers purchasing new qualifying clean vehicles, including battery electric, plug-in hybrid, or fuel cell electric vehicles, are eligible for a Clean Vehicle Credit. To qualify for the maximum US$7,500 credit, the vehicle must meet certain standards for North American assembly. Additionally, the battery's components must meet certain standards for manufacturing or assembly; and the battery's critical minerals must meet certain requirements for sourcing or processing in the United States or from trusted trade partners. US$3,750 credit for vehicles meeting critical minerals requirement, with the vehicle required to contain a threshold percentage of critical minerals extracted or processed in the United States or in a country with which the United States has a free trade agreement or be recycled in North America. An additional US$3,750 credit is offered for vehicles meeting the requirement that a threshold percentage of battery components be manufactured or assembled in North America.

Vehicles must fulfill other criteria, including final assembly in North America and MSRP limits (generally US$55,000; for vans, SUVs, and pickups US$80,000). Starting in 2024, qualifying vehicles cannot have battery components manufactured or assembled by a foreign entity of concern. Starting in 2025, qualifying vehicles' batteries cannot contain critical minerals extracted, processed, or recycled by a foreign entity of concern.

India's policy could explore integration of demand side incentives under FAME initiative for the purchase of clean vehicles (EVs and hybrids) beyond 2024. This integration could be coupled with stringent domestic value addition norms that promotes local manufacturing of critical LIB components, active materials and sourcing of refined critical minerals including lithium.

Currently, the Phased Manufacturing Programme (PMP) for EV parts, as eligibility criteria under Fame II incentive claims by OEMs requires only traction battery packs to be assembled in India with cells and associated thermal, battery management systems allowed to be imported. Government led policy could focus on providing a clear roadmap and timeline for revising the PMP norms to include local manufacturing of LIB cells, active materials and sourcing of critical minerals including Lithium. Additionally, the quantum of incentive under FAME scheme can be allocated differently (graded incentive) for vehicles that meet localization norms for LIB cells and sourcing of critical minerals.

Expedite mining and exploration activities of critical minerals used in ACC batteries

The supply chain for critical minerals, especially lithium, cobalt, nickel and spherical graphite, and their refining for active materials are vital to achieving domestic value addition in the manufacturing of ACC battery electrode materials. By localizing the mining and refining value chain of critical minerals, India can reduce its reliance on imports and help build resilience in global supply chains.

India has become the newest partner in the US led Mineral Security Partnership (MSP) to bolster critical mineral supply chains. The partnership aims to accelerate the development of diverse and sustainable critical mineral supply chains. Apart from this, G2G dialogues are advancing with friendly countries for joint exploration and mining. Government of India has set up KABIL to ensure a consistent supply of critical and strategic minerals through G2G negotiations and acquiring mining assets abroad. Recently, the Indian Parliament Passed Mines and Minerals (Development & Regulation) Amendment Bill, 2023, with focus on Critical Minerals. The amendment introduces major reforms in the mining sector, six minerals have been omitted from the list of twelve atomic minerals, central government to exclusively auction mineral concessions for critical minerals and the state governments to get revenue, introduces exploration license for deep-seated and critical minerals. All these amendments expected to provide a conducive legal environment for attracting FDI and mining companies.

Uniform GST @5% application on all ACC batteries used in mobility and grid storage applications with renewable energy

Li-ion batteries attract 18% GST and 20% standard customs duty (HSN: 85076000), while other batteries attract 28% GST. The total effective tax rate including GST, is approximately 43.96% for Li-ion batteries made from imported cells. These taxes make ACC battery storage services less competitive in the present scenario, hampering domestic manufacturing and hindering the achievement of India's renewable energy goals.

Implementing a temporary reduction or waiver of custom duty would have far-reaching benefits for the grid scale energy storage sector in India. Moreover, a favorable duty structure would make ACC battery pack assembling in India more cost-effective and competitive, attracting both domestic and foreign investments. Similarly, establishing a uniform GST rate of 5% on all ACC batteries used in mobility and stationary applications would bring much-needed clarity and simplicity to the tax regime. A uniform GST rate would level the playing field for manufacturers, facilitating their decision-making processes and encouraging long-term investments. It would also streamline tax compliance, reducing administrative burdens and promoting a more conducive business environment.

By providing certainty in the duration and applicability of these taxes and duties, the government can offer stability to manufacturers operating in the renewable energy sector. This stability allows manufacturers to accurately assess costs, plan their operations, and make informed investment decisions. It also enables them to develop strategies to navigate changing market dynamics and to remain resilient in the face of uncertainties. Ultimately, these policy measures would not only bolster the growth of the renewable energy sector but also contribute to India's self-sufficiency in clean energy production and enhance its competitiveness in the global market.

Production linked incentives for active material extraction from recycled ACC batteries

The policy should focus on scaling up LIB recycling infrastructure to complement direct extraction efforts and support the domestic critical mineral requirements including lithium.

This will also aid in promoting environmentally sustainable battery disposal and waste management practices. To promote efficient lithium-ion battery recycling in India, it is essential to establish a robust recycling infrastructure with advanced technologies for dismantling, material separation, and metal extraction. This can be achieved by setting up well-equipped recycling centers tailored specifically for lithium-ion batteries. Additionally, investing in research and development is crucial to advance recycling technologies, encourage innovation, and minimize environmental impact. Collaboration between academia, industry, and research institutions can drive the development of cost-effective and innovative recycling methods.

Implementing an Extended Producer Responsibility (EPR) framework will hold battery manufacturers accountable for the end-of-life management of their products, including collection mechanisms, tracking systems, and proper disposal. Awareness campaigns and educational programs should be conducted to educate stakeholders about the importance of recycling lithium-ion batteries, responsible disposal practices, and potential environmental hazards. Collaborating with international partners will provide access to global best practices and expertise, facilitating the development of recycling capabilities within India.

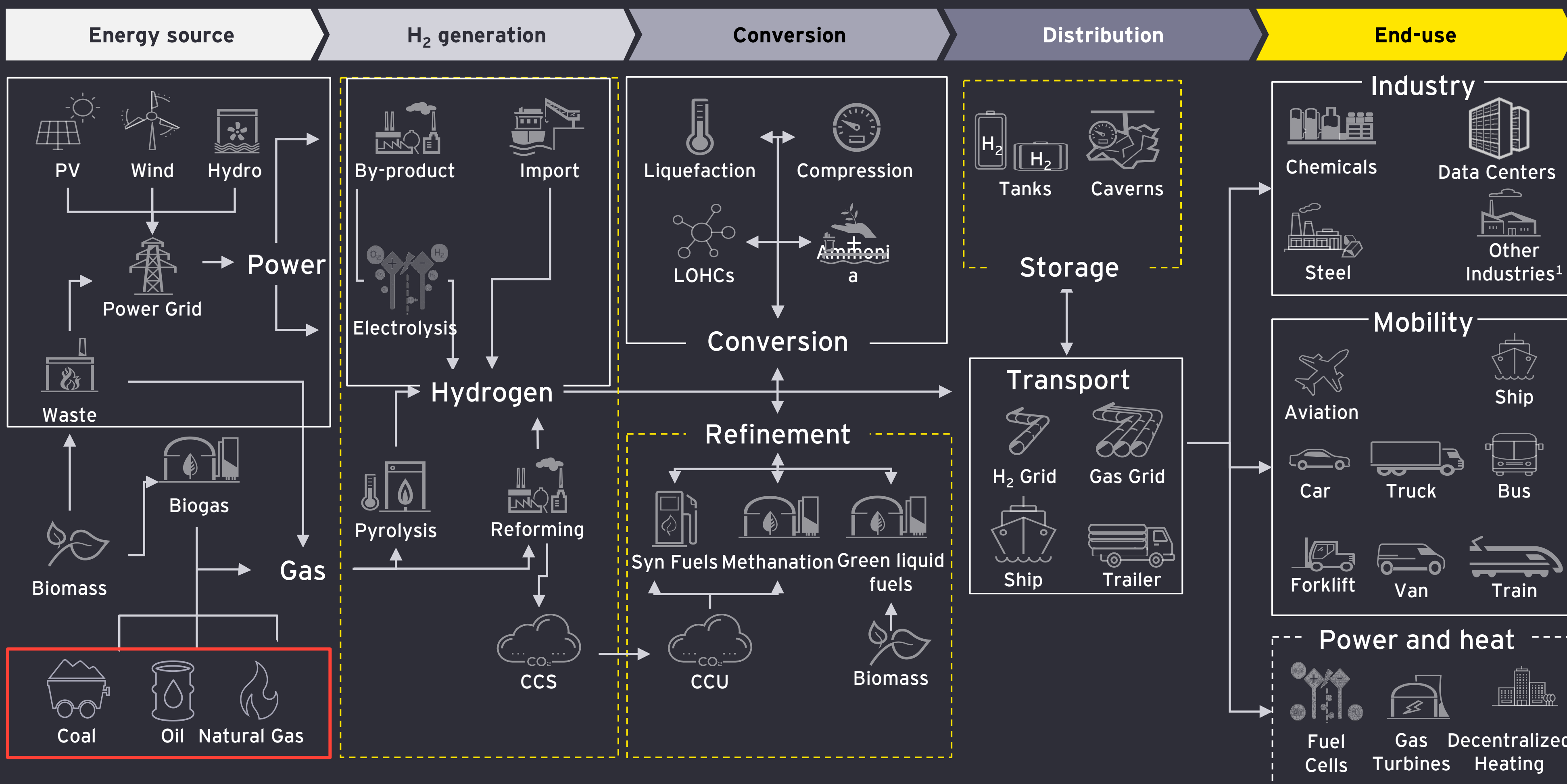
Boost the availability of skilled workers and professionals

Addressing the shortage of skilled workforce is essential for efficient manufacturing operations. The manufacturing and assembly processes of lithium-ion batteries require specialized skills and knowledge. The availability of a skilled workforce with expertise in battery technology, electrochemistry, materials science, and manufacturing processes is limited in India. Bridging this skill gap through training programs and educational initiatives is essential. To address the skilled labor needs in the lithium-ion battery industry in India, it is recommended to establish skill development programs in collaboration with vocational training institutes, universities, and industry stakeholders. This should be complemented by fostering industry-academia collaboration, government support, continuous learning opportunities, and the introduction of industry-recognized certifications. These measures will help bridge the skills gap, provide practical training, encourage ongoing professional development, and ensure a qualified workforce capable of driving innovation and meeting industry demands.

06

Green hydrogen and electrolyser manufacturing ecosystem for domestic production and exports

The global hydrogen ecosystem is a complex value chain with multiple technologies evolving for low carbon transition



Source: EY analysis

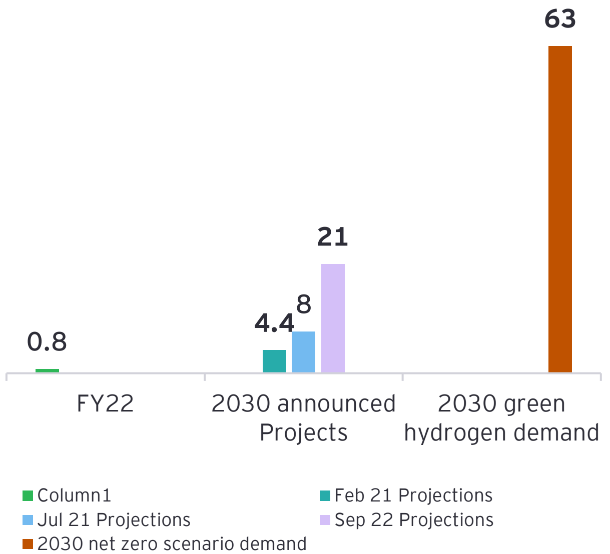
Global green hydrogen capacity addition projections to reach ~21MTPA by 2030

- The growing focus on hydrogen applications, coupled with net zero ambitions, has driven the production capacity for green hydrogen to increase five times compared 2021 projections.
- The global demand for hydrogen was 94 million tons in 2021 and is expected to reach 185 million tons by 2030 in the net zero scenario. Similarly, green hydrogen demand is expected to reach 63 million tons by 2030.
- With the pipeline of announced projects until Sep 2022, green hydrogen production is expected to reach 21MTPA by 2030.
- The number of countries with policies that directly support investment in hydrogen technologies is increasing, along with the number of sectors they target.

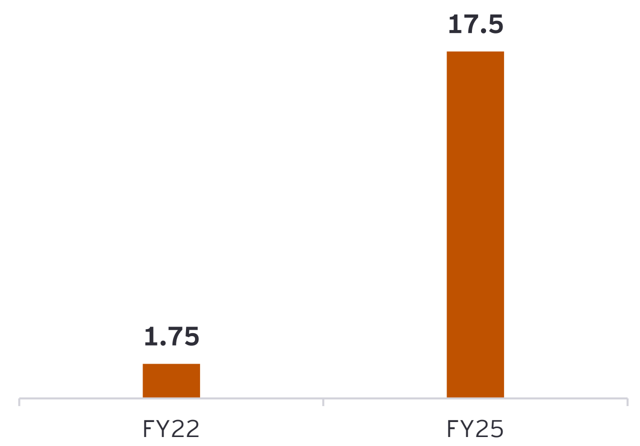
EU's decision to shift away from Russian gas dependency is one of the primary triggers

- In March 2022, the European Commission (EC) published the 'REPowerEU' plan to phase out Europe's dependency on Russian energy imports by developing strategies, such as diversifying energy imports and boosting renewable energy.
- It has set a target of producing 10 million tons of green hydrogen domestically and importing 10 million tons by 2030.
- 5 million tons of additional production target from REPowerEu would require approximately 50GW–60GW of electrolyser, in addition to the 44GW already required for the 5 million tons.

Cumulative green hydrogen production capacity vs. demand (MTPA)

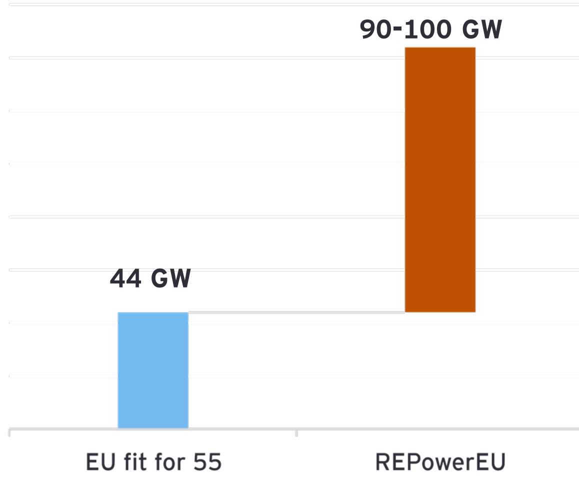


EU electrolyser manufacturing capacity target (GW/year)



EC has signed a joint declaration with major European electrolyser manufacturers to increase the manufacturing capacity 10 times the current capacity

EU installed electrolyser capacity 2030



Meeting REPowerEU's target of producing 10MTPA, to increase installed electrolyser capacity by FY30

Source: Hydrogen Council, IEA

Source: European Commission, https://ec.europa.eu/commission/presscorner/detail/en/IP_22_2829

North America is expected to see a significant increase in green hydrogen production due to incentives provided by the US Inflation Reduction Act

- The IRA encouraged investments in power generation from renewables, emissions reduction technology, and others. The act will provide investment tax credits (ITCs) and production tax credits (PTCs) for clean energy generation. It is estimated that the IRA will create a demand for 10 million tons of clean hydrogen by 2030.
- PTC: Tax credits are provided to low-carbon hydrogen producers based on the quantity of carbon they emit during production. Producers are eligible for a credit of up to US$3 per kg of hydrogen, making green hydrogen to be produced in the US one of the most economical options in the world (as low as US$0.73 per kg).
- ITC: IRA to create a 30% credit for energy storage technology constructed before January 2025 (applicable only to hydrogen-related ITC storage).
- The clean hydrogen credit is a 10-yr Production Tax Credit (PTC) for facilities that commence construction by 31 Dec 2032. Along with the additional credits across the value chain (for example, renewable credits), it will enable a credit of more than $3/kg. As an alternative to the PTC, taxpayers may elect for the ITC (Investment Tax Credit) with respect to clean hydrogen production facilities, receiving an ITC of up to 30% depending on the carbon intensity of the production process. Further, a multiplier mechanism would be triggered if producers build new facilities within a certain period and if they meet certain wage and labor requirements for the project.
- With IRA incentives, green hydrogen is expected to be competitive across the US by 2030. Considering that tax credit is for the first 10 years while H2 projects are for 20 years or so, about 60 to 65% of tax credit would reflect in LCOH (Levelized Cost of Hydrogen). So, a $3/kg tax credit will lower LCOH by approximately $1.9/kg.
- It is expected that clean hydrogen's cost reductions will drive its use as a low-carbon fuel for energy and transport, and as a feedstock to decarbonize industrial production.

Hydrogen tax credit mechanism under the IRA, 2022

H2 Source	Carbon Intensity kg-CO2e/kg-H2	Tax Credit Amount PTC value/kg of H2	Tax Credit Amount ITC value (% of facility cost)	Wage/Other Benefits 5x multiplier
SMR + CCUS	2.5-4	US$0.12	1.20%	$0.60
SMR + CCUS	1.5-2.5	US$0.15	1.50%	$0.75
Nuclear + Electrolysis	0.45-1.5	US$0.20	2%	$1.00
RE Electrolysis	0-0.45	US$0.60	6%	$3.00
PTC: Production Tax Credit; ITC: Investment Tax Credit				

Source: EY analysis from US IRA Guidebook

Green hydrogen standards for availing policy incentives

Global Scenario

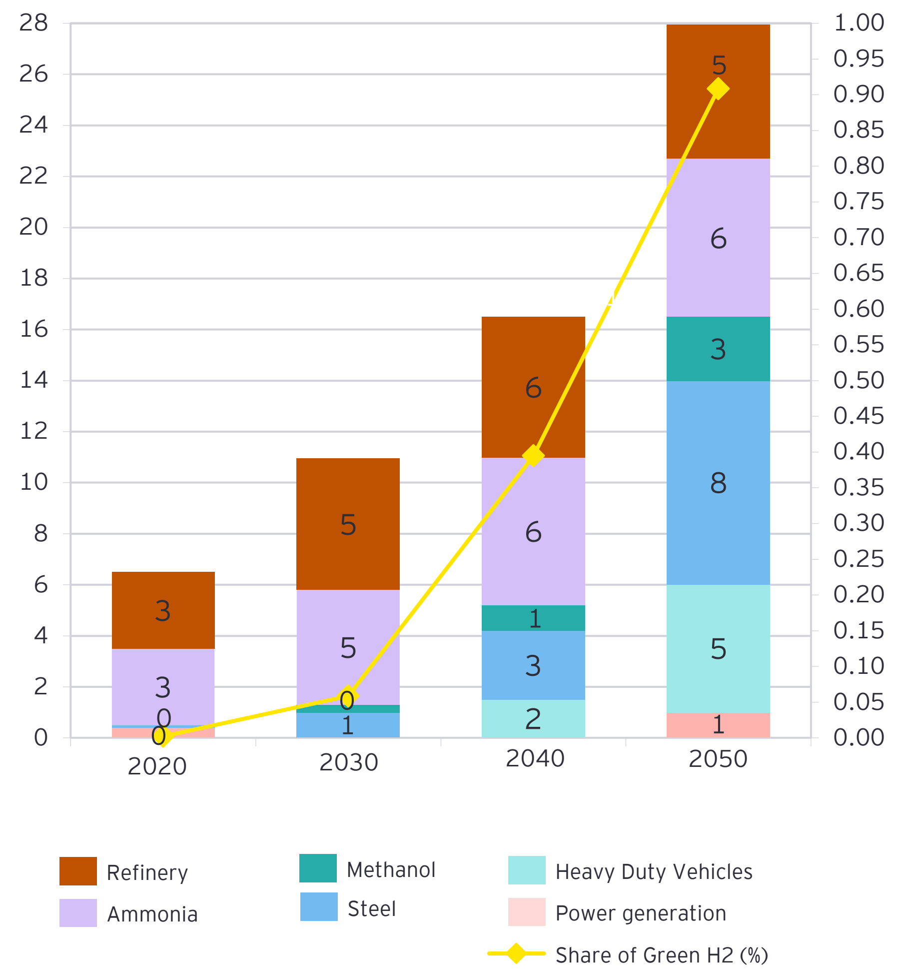
- The 2022 Breakthrough Agenda report authored by the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), and the UN Climate Change High-Level Champions recommended that "production routes will need to achieve verifiable low-carbon intensities that trend towards near zero by 2030".
- The Climate Bonds Initiative Hydrogen Production Standard, which also covers emissions associated with transportation to the point of use requires hydrogen to be produced with no more than **1.5 kg of CO2e per kg by 2030; 0.6 kgCO2e/kgH2 by 2040** and then zero by 2050.
- The Green Hydrogen Organization's standard for Green Hydrogen, requires that hydrogen made with renewables emits no more than **1.0 kg of CO2e per kg hydrogen** up to the point of production. This is a 91% reduction compared to grey hydrogen made from fossil fuels.
- The Hydrogen Science Coalition's Clean Hydrogen Definition also states that blue hydrogen made from fossil gas should emit a maximum of **1.0 kg of CO2e per kg hydrogen**.
- The US Inflation Reduction Act provides tax credits to hydrogen produced with emissions up to 4kg CO2e/kg H2.
- Canada's recently published Clean Hydrogen Investment Tax Credit (CHITC) mentions government subsidies will be available for hydrogen produced with **4.0 kg CO2e per kg hydrogen.**
- The EU rules for renewable green hydrogen and blue hydrogen require a **70% reduction (3.4kg CO2e/kg H2)** including transportation of the hydrogen up to the point of use, and the UK's Low Carbon Hydrogen Standard requires a **78% reduction (2.4kg CO2e/kg H2)** up to the point of production.

Indian Scenario

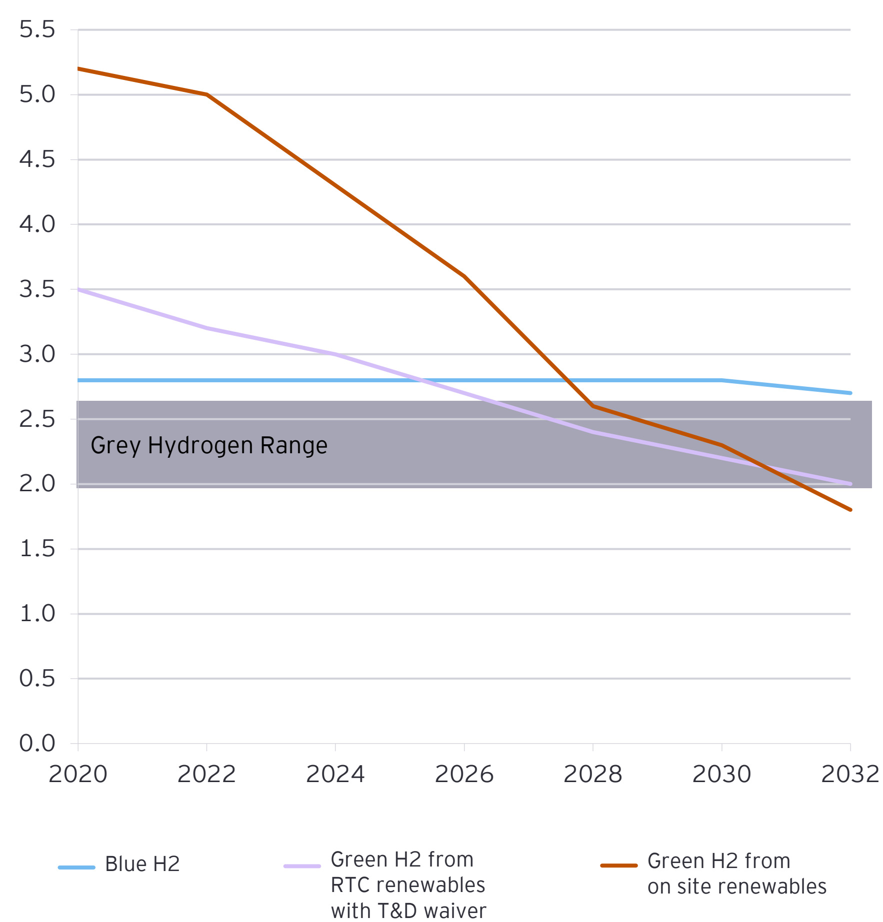
- The MNRE National Green Hydrogen Standard mandates the renewable character of energy input for any production pathway including but not limited to electrolysis and conversion of biomass.
- Additionally, the standard specifies that renewable energy used in the production of green hydrogen includes electricity generation from renewable sources stored in energy storage systems or banked with the grid in accordance with applicable regulations.
- For green hydrogen produced through electrolysis, the non-biogenic greenhouse gas emissions arising from water treatment, gas purification, drying and compression of hydrogen shall not be greater than 2kg CO2e / kg H2.
- For green hydrogen produced through biomass conversion, the non-biogenic green house gas emissions arising from biomass treatment, heat generation, conversion, gas purification, drying and compression of hydrogen shall not be greater than 2kg CO2e / kg H2.

Hydrogen demand and price trajectory trends in Indian markets

Hydrogen Demand Forecasts (Million Tons) [1]



Projected price trajectory of hydrogen production (US$ / kg)



Source: Harnessing Green Hydrogen Report 2022, NITI Aayog

India has approved a budgetary outlay of US$2.5 billion to support green hydrogen initiatives, including setting up of electrolyser manufacturing capacity of 60 to 100GW

Particulars	Component I: Incentive scheme for electrolyser manufacturing	Component II: Incentive scheme for green hydrogen production
Outlay for incentive scheme	INR 4,440 Crores	INR 13,050 Crores
Implementing agency	SECI	SECI
Principles of incentive	1. Support will be provided for electrolyser manufacturing, in terms of Rs/kW corresponding to manufacturing capacity 2. Base incentive as follows a. Year 1 - INR 4,440 per kW b. Year 2 – INR 3,700 per kW c. Year 3 – INR 2,960 per kW d. Year 4 – INR 2,220 per kW e. Year 5 – INR 1,480 per kW	1. Direct incentive in terms of INR/kg on green hydrogen production for a period of 3 years 2. Beneficiaries under the scheme to be selected through competitive selection process 3. Incentives will be capped at INR 50/kg – Year 1, INR 40/kg – Year 2 and INR 30/kg – Year 3 of production
Bid selection parameter	Sum of products of quoted Local value Addition Factor (LVA) and Performance Quotient over 5-year period	Incentive demanded by bidder per kg of green hydrogen production
Selection process	Bidders will be ranked in the decreasing order of the selection parameter for allocation of admissible bid capacity	In the order of **Least Average Incentive demanded** (in Rs/kg) taken as simple average of the incentive demanded for each of the three years
Capacities available for bidding	Under first tranche of 1500 MW the following buckets available 1. Bucket 1 – Electrolyser manufacturing capacity based on any stack technology (1200MW) 2. Bucket 2 - Electrolyser manufacturing capacity based on indigenously developed stack technology (300MW)	1. Technology agnostic pathways (Bucket I) – 410,000 MT/annum of green hydrogen 2. Biomass based pathways (Bucket II) – 40,000 MT/annum of green hydrogen
Capacity allocation	1. Maximum capacity allottable under Bucket 1 will be 300MW and minimum capacity 100MW 2. Maximum capacity allottable under Bucket 2 will be 300MW	1. Under Tranche 1 of Mode 1 – 450,000 MT per annum of green hydrogen. 2. Under BUCKET 1, maximum capacity to be allotted per bidder will be 90,000MT per annum and minimum capacity is 10,000 MT p.a 3. Under BUCKET 2, maximum capacity to be allotted per bidder will be 4,000MT per annum and minimum capacity is 500 MT p.a

Source: SIGHT program, MNRE

Review of state wise green hydrogen policies addressing land and water allocation

	Uttar Pradesh Green Hydrogen Policy (draft)	Rajasthan Investment Scheme 2022	Andhra Pradesh GH & GA Policy 2023	Maharashtra Green Hydrogen Policy 2023
Stamp duty exemption	100%	100%	100%	100%
Land conversion charges exemption	100%	100%	100%	100%
Land tax exemption	0%	100%	0%	100%
Land lease rate (INR/acre/year)	15,000 Only for captive solar parks		31,000 5% increase every 2 years	-
Industrial water charges exemption	50%	0%	0%	0%

UP Policy – https://upneda.org.in/MediaGallery/UPGH2_policy_II.pdf
AP Policy – https://www.nredcap.in/PDFs/2023/GO_Ms_No_14_Dt_20_06_2023.pdf.
Maharashtra Policy – Maharashtra introduces Hydrogen policy, a first in the country | Mumbai News - The Indian Express
Rajasthan Policy – https://www.invest.rajasthan.gov.in/policies/rajasthan-investment-promotion-scheme-rips-2022.pdf

Gujarat's Policy 2023 for leasing out government fallow land for green hydrogen production using non-conventional energy sources such as solar, wind, and solar hybrid energy

Incentives

40 years lease period
For setting up solar, wind, wind-solar hybrid energy plants

0.1 to 3 million MTPA
Min. capacity of annual green hydrogen production for setting up captive RE plants

1 lakh acres land
Reserved for expansion of existing salt base chemical industry in Kutch

1 lakh hectares land
For state government companies to develop renewable energy sources

INR 15,000 /hectare/year
Annual rent of land allotted by government for RE power plant

15% increase every three years
Increase in land lease rate

Eligibility

8 years
For achieving 100% of committed green hydrogen capacity

50% in 5 yrs, 100% in 8 yrs
Green hydrogen production capacity to be achieved

INR 50 Cr per 0.1 million ton
Security to be deposited to state government

Source: New-GR-for-Green-Hydrogen-08-05-2023-English_compressed.pdf (eqmagpro.com)

Review of state wise green hydrogen policies addressing captive open access charges

	Uttar Pradesh Green Hydrogen Policy (draft)	Rajasthan Investment Scheme 2022	Andhra Pradesh GH & GA Policy 2023	Maharashtra Green Hydrogen Policy 2023
Intra-state transmission charges exemption	50%	100% for first 3 captive power plants	25% 5 yrs, max INR 10 Lakhs/MW/yr of electrolyser	50%
Wheeling charges exemption	50%	100% for first 3 captive power plants	50%	50%
CSS exemption	100%	0%	100% reimbursed for 5 years	100%
Distribution charges exemption	100%	0%	0%	0%
Additional surcharges exemption	0%	0%	0%	100%
Grid support charges exemption	0%	0%	0%	0%
Electricity duty exemption	0%	100% for 7 years	100% for 5 years	100%
Banking provisions	Quarterly banking with 6% charge. Drawl cannot be more than injected during peak hours.	10% banking charge with drawl not allowed during peak hours as notified by DISCOM	100% monthly banking with 5% charge. Drawl not allowed from February to June	Monthly Banking with 2% banking charge with energy banked during off-peak ToD can't be withdrawn during peak

UP Policy – https://upneda.org.in/MediaGallery/UPGH2_policy_II.pdf
AP Policy – https://www.nredcap.in/PDFs/2023/GO_Ms_No_14_Dt_20_06_2023.pdf
Maharashtra Policy – Maharashtra introduces Hydrogen policy, a first in the country | Mumbai News - The Indian Express
Rajasthan Policy – https://www.invest.rajasthan.gov.in/policies/rajasthan-investment-promotion-scheme-rips-2022.pdf

Review of state wise green hydrogen policies giving capex and production linked subsidies

	Uttar Pradesh Green Hydrogen Policy (draft)	Rajasthan Investment Scheme 2022	Andhra Pradesh GH & GA Policy 2023	Maharashtra Green Hydrogen Policy 2023
SGST Exemption	100%	75%	100% reimbursement for 5 years	-
Production linked incentives	**Green urea production** **INR 3500/ton** of urea with >10% blending share	-	-	**Green hydrogen blending in gas INR 50/kg** subsidy for 5 years
Electrolyser CAPEX incentives	**For capacity >50MW:** 2023-60%, 2024-55% 2025-45%, 2026-35% 2027-20%, 2028-00%	-	-	-
Other monetary Incentives	Technology acquisition 30% of CAPEX or INR 5 Cr **EPF Reimbursement** 50% of employer's contribution to EPF and ESI	-	-	**Green hydrogen refueling stations** 30% CAPEX subsidy, max. INR 4.50 Cr for the first 20 stations **Green hydrogen-based passenger vehicle** 30% CAPEX subsidy, max. INR 60 lakhs for the first 500 vehicles

UP Policy – https://upneda.org.in/MediaGallery/UPGH2_policy_II.pdf
AP Policy – https://www.nredcap.in/PDFs/2023/GO_Ms_No_14_Dt_20_06_2023.pdf.
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Rajasthan Policy – https://www.invest.rajasthan.gov.in/policies/rajasthan-investment-promotion-scheme-rips-2022.pdf

Opportunity for Indian OEMs to create world-class manufacturing facilities

- In India, the existing capacity of alkaline electrolysers is estimated to be less than 1GW, which is mainly used for chlor-alkali process.
- **Choice of technology and access to technology partners**
- Alkaline electrolysers dominate the market today and are expected to continue being the most preferred technology. Of the other technologies, PEM is emerging to be a promising electrolysis technology.
- Today, alkaline technology is cheaper, with an average cost of US$700 to US$1,100 per kW and has an efficiency of ~70% (producing 0.021kg H2 per kWh). PEM technology costs between ~US$1,200 and US$2,000 per kW, having an efficiency of ~60% (producing 0.018kg H2 per kWh). As the PEM technology advances, it is expected to achieve parity with alkaline (~US$500 per kW) by FY2030.
- Players look forward to technology diversification. For instance, NEL has exposure to both alkaline and PEM technologies, which offers an edge in case one of the technologies prevails in the future.
- Solid oxide and AEM technologies are at a nascent stage today with some players like Bloom Energy (US) and H2e Power (IN), developing electrolysers based on solid oxide, while Enapter (IT) and Hydrolit (IL) are a few players that are developing AEM.

Source: EY Report on shortage of electrolyzers for green Hydrogen, 2023

Electrolyser manufacturers are gearing up to increase the green hydrogen production capacity

Manufacturer	Headquarters	Technology	Capacity (MW)		Growth
			Current	Expansion plans	
ITM Power	UK	PEM	1,000	5000 by 2024	5x
McPhy	France	PEM, Alkaline	100	1300 by 2024	13x
Nel	Norway	PEM, Alkaline	500	10000 by 2025	20x
John Cockerill	Belgium	Alkaline	350	8000 by 2025	23x
Plug Power	US	PEM	75	3000 by 2025	40x
Thyssenkrupp	Germany	Alkaline	1,000	5000 by 2030	5x
Sunfire	Germany	Alkaline, Solid Oxide	40	500 by 2024	13x
Siemens Energy	Germany	PEM	125	1000 by 2030	8x
Cummins	US	PEM, Alkaline, Solid Oxide	38	3500 by 2025	92x
Topsoe	Denmark	Solid Oxide	75	5000 by 2030	67x
Ohmium	US	PEM	500	2000 by 2024	4x
Enapter	Italy	AEM	30	300 by 2024	10x
Bloomenergy	US	Solid Oxide	500	1000 by 2024	2x
Green Hydrogen Systems	Denmark	Alkaline	75	400 by 2024	5x
Hydrogen Pro	Norway	Alkaline	100	1000 by 2030	10x
Elogen	France	PEM	160	1000 by 2025	6x
Others		PEM, Alkaline, Solid Oxide	1,000	12000 by 2030	12x
Total			5,668	37,000 by 2025 60,000 by 2030	6x 10x

Source: EY analysis, company press releases, secondary research

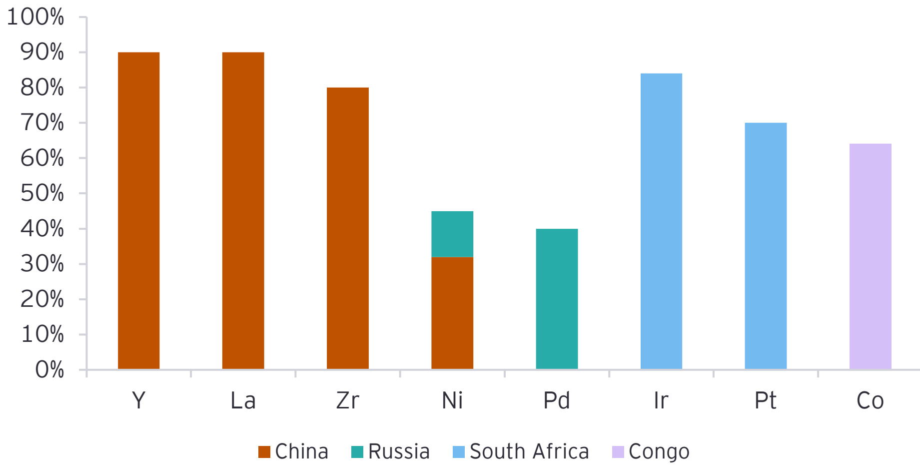
Efficiency and competitiveness for Indian manufacturers require securing raw materials and planning large scale investments

As the demand for electrolysers increases in the next few years, the players look forward to strategic tie-ups with key hydrogen producers across different industry segments. These partnerships are expected to support the development of a green hydrogen ecosystem. Many electrolyser manufacturers are forming partnerships with energy and utility players as renewable power hubs are inferred to be better suited for green hydrogen production due to access to renewable electricity. Policy push in the US and Europe is expected to fast-track green hydrogen adoption and thereby accelerate the energy transition. This will translate to multibillion-dollar opportunity for electrolyser manufacturers, and India should target to become a global hub for manufacturing.

Key minerals and metals for electrolysers

Solid Oxide	Alkaline	PEM
Zirconium, Nickel, Yttrium, Lanthanu	Nickel, Zirconium, Palladium	Iridium, Platinum, Palladium

Key Suppliers of critical minerals for Electrolysers



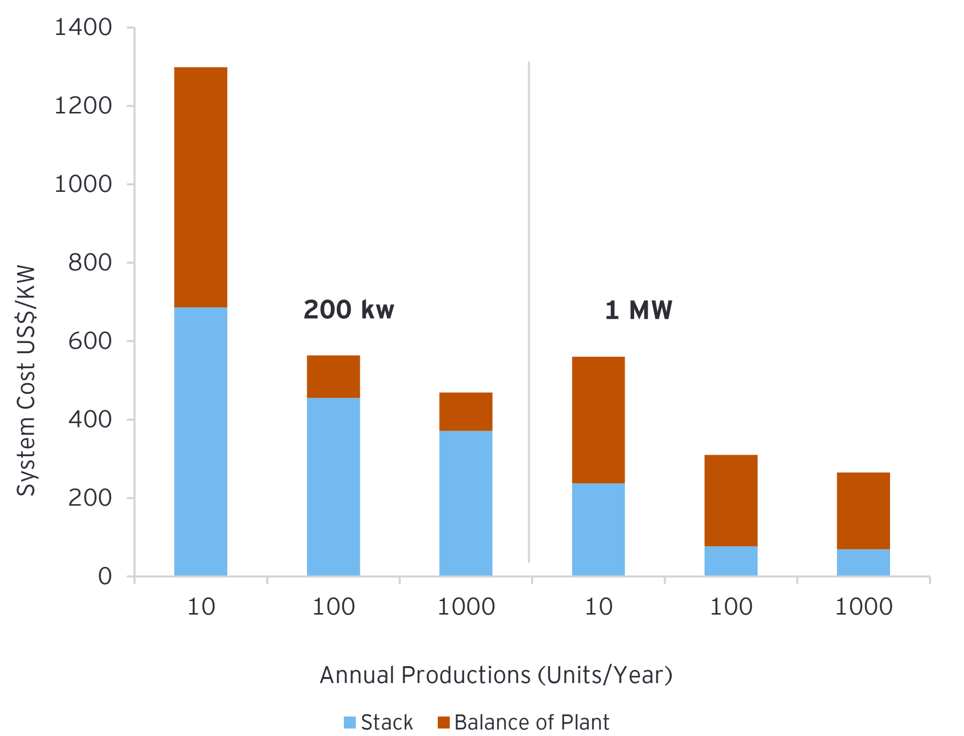
Source: European Commission, USGS

- Many minerals and metals required for electrolysers are highly concentrated in specific geographies, presenting a supply chain risk to manufacturers.
- Critical raw material supply for PEM is highly concentrated, with South Africa supplying over 70% of platinum and over 85% of iridium required globally.
- Solid oxide electrolysers are produced at a lab scale today; however, they show future potential. They face a larger concentration of supply as more than 90% of the critical materials come from China.
- There will be a need for electrolyser manufacturers globally to work with key stakeholders on raw material dependency issues, such as strategic sourcing and forming strong partnerships.

Source: EY Report on shortage of electrolyzers for green Hydrogen, 2023

Plan for large-scale investments and boost efficiency with economies of scale

Economies of scale impact: potential cost reductions in PEM electrolysers



Source: NREL, IRENA, EY Analysis

Key factors driving cost competitiveness	
Electrolyser cost	↓
Electrolyser efficiency	↑
Renewable electricity cost	↓
Lifetime of electrolysers	↑
Full load hours	↑
Weighted average cost of capital	↓

↓ Reduction ↑ Increase

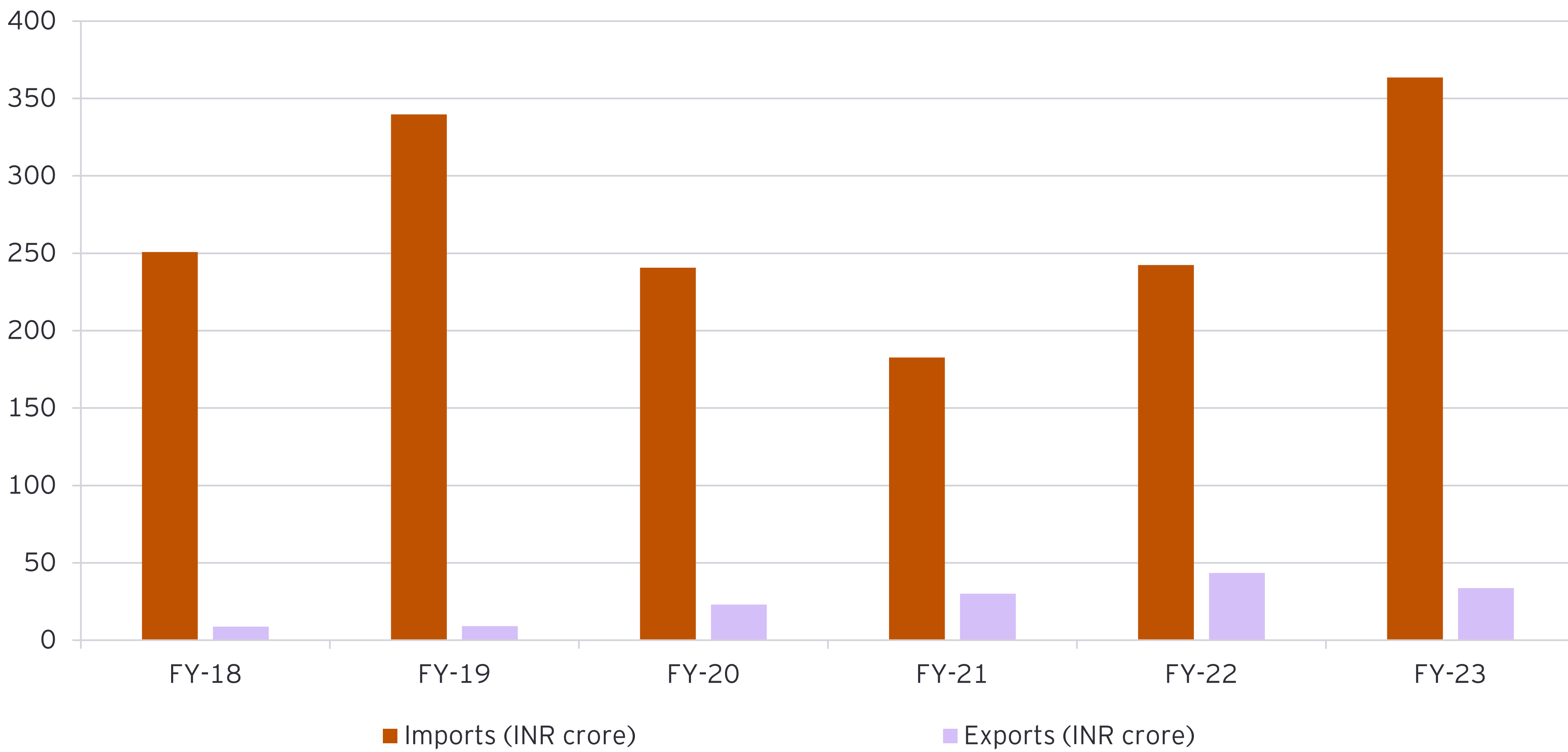
Economies of scale can be achieved by increasing the size of electrolyser facilities.

In stack manufacturing, as more units of electrolysers are produced, the shared cost of assembly lines, buildings, and staff comes down, achieving economies of scale.

Manufacturing more units of stack assembly is expected to result in cost reduction of 90% by shifting from a manual to a semi-automated process at a volume of about 1GW per year.

Machines and apparatus for electro-plating, electrolysis and electrophoresis

HS Code: 854330

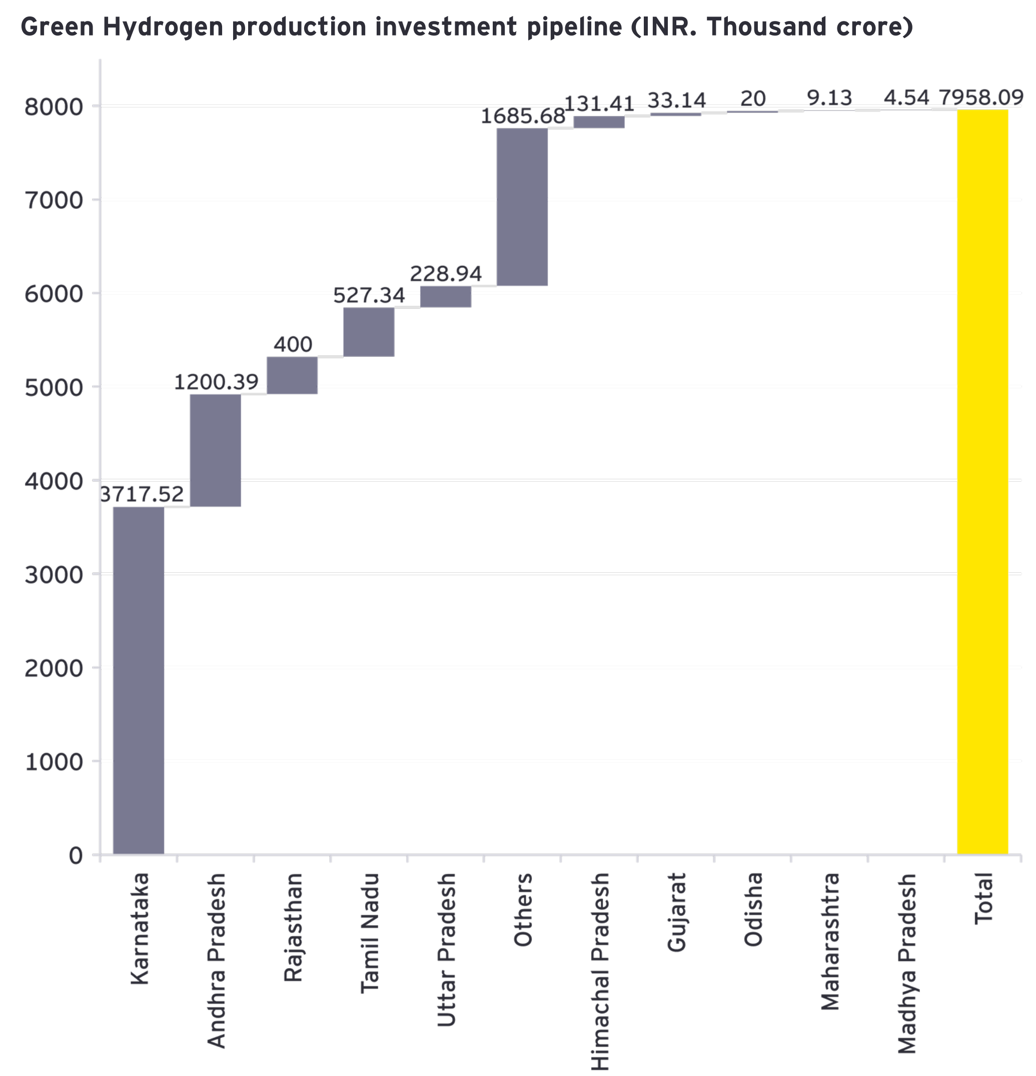


Source: www.dgft.gov.in

India's pipeline of green hydrogen and ammonia projects exceeds ~10 million tons/annum, with over ~10 GW of electrolyser manufacturing projects

Location of the facility	Electrolyser manufacturing (MW/Year)	Green hydrogen/Ammonia production (Tons/year)
Madhya Pradesh		5,767
Andhra Pradesh		10,00,388
Haryana		2,075
Ladakh		30
Uttar Pradesh	100	5,05,052
Karnataka	1,500	59,00,025
Himachal Pradesh		1,09,516
Maharashtra	1,500	906
Rajasthan		10,00,000
Odisha		1,20,000
Kerala		338
Tamil Nadu		11,03,000
Gujarat		42,493
Facility location not reported	7,250	2,26,738
Total	10,350	1,00,16,328

Source: EY Analysis



Source: EY Analysis

Policy enablers

National program to incentivize and compensate state utilities for implementing annual grid banking facility for captive open access RE power supply

RE power input contributes 40% to 50% of green hydrogen production costs. To manage RE intermittency during a time when storage is relatively expensive, industry will need annual grid banking facility for round-the-clock RE power supply to achieve global cost competitiveness.

Government policy and budgetary outlay should focus on incentivizing and compensating states to implement annual grid banking facilities for green energy open access captive transactions.

Blended innovative low-cost financing instruments

Robust risk-mitigation instruments, deployed at scale by IFIs (International Financial Institutions) and MDBs (Multilateral Development Banks), along with institutional capacity and reforms in the development finance and banking sector, involving private sector stakeholders, can help create investment platforms for accessing low-cost capital. At the crux of this initiative lies the acknowledgment that the cost of capital significantly influences the viability of manufacturing endeavours, particularly in an infrastructure-intensive sector like green hydrogen production.The financial burden imposed by high-interest debt can amplify the overall cost of production, rendering domestically manufactured products less competitive against their imported counterparts. To rectify this, the government may consider mechanisms to provide domestic manufacturers with access to low-cost debt.

Promote export-oriented incentives

The US IRA led incentives for their green hydrogen production renders exports to that market less competitive. EU is another major export market for Indian companies, which often face cost disadvantages because of the geographical distance. To address this situation and bolster the global competitiveness of Indian green hydrogen industry, the government could consider implementing export-oriented incentives. By offering incentives tailored toward exports, the government would provide Indian RE players and green hydrogen producers a competitive edge in international markets. These incentives could present itself in various forms, such as financial support, tax benefits, streamlined export procedures, or even research and development grants, incentivizing manufacturers to enhance the quality, efficiency, and affordability of Indian green hydrogen and its derivatives for the global market.

Setting up shared desalination facilities in emerging green hydrogen clusters

Establish shared / common sea water and groundwater desalination plants powered by renewable energy to produce demineralized (DM) water for green hydrogen production. Green hydrogen production requires approximately 9 to10 liters of demineralized water per kg of H2 production meaning 20 to 25 liters of raw water per kg of H2 depending on the source of raw water. Public private partnerships can be envisaged to set up these facilities.

India faces water scarcity in many regions because of exacerbated climate change and the demand for DM water requires advanced treatment processes, which further strain water resources. The establishment of such desalination plants requires significant investments and careful water resource and waste management to balance the needs of various sectors. Encouraging the development of renewable energy-powered desalination plants can enhance water availability for green hydrogen projects and support water resource management.

Boost the availability of skilled workers and professionals

Building a skilled workforce capable of designing, operating, and maintaining green hydrogen infrastructure is crucial. Adequate training programs and educational initiatives need to be implemented to develop a skilled workforce for the growing green hydrogen sector. Encouraging knowledge sharing, collaboration, and partnerships among industry players, research institutions, and academia can accelerate technological advancements and knowledge dissemination.

Addressing the shortage of skilled workforce is essential for maintaining efficient manufacturing operations. The manufacturing and assembly processes of electrolysers require specialized skills and knowledge. The availability of a skilled workforce with expertise in electrochemistry, materials science, and manufacturing processes is limited in India. Bridging this skill gap through training programs and educational initiatives is essential. To address the skilled labor needs in the green hydrogen value chain, it is recommended to establish skill development programs in collaboration with vocational training institutes, universities, and industry stakeholders. This should be complemented by fostering industry-academia collaboration, government support, continuous learning opportunities, and the introduction of industry recognized certifications. These measures will help bridge the skills gap, provide practical training, encourage ongoing professional development, and ensure a qualified workforce capable of driving innovation and meeting industry demands.

07

Corporate renewable energy procurement market in India

Improved policy outlook and net zero transition goals are driving corporate RE demand

The Commercial and industrial (C&I) renewable energy open access market is growing in almost all key renewables-rich states. Nearly two-thirds of the current renewable energy OA capacity came online in the last five years. Increasing awareness and demand from Commercial and industrial (C&I) customers was a key driver of growth. The central government's Green OA Policy in 2022 was a significant positive regulatory development for the renewable energy OA market. Timely implementation of the green energy OA Policy by the states will help further growth in the years to come. C&I consumers account for 51% of total power consumption in the country. Grid tariffs for these consumers are inflated due to cross-subsidization of other consumer categories. Direct renewable power procurement accounts for less than 10% of total C&I power consumption. Many consumers are keen to procure renewable power to reduce costs and meet renewable purchase obligations or decarbonization targets. Increased focus on net zero emissions are key drivers for growth in renewable power procurement among corporate consumers. The introduction of a single window application process for open access with increased oversight from central government is expected to improve capacity additions. Interstate transmission charge waiver is expected to spur the market significantly over the next few years driven by demand from large industrial consumers. Despite increasing restrictions on net metering, many states now offer multiple grid connectivity options for rooftop systems in line with central government guidelines. Group captive and behind the meter are the preferred models for adoption by the C&I market. The group captive model remains the most preferred model for large-scale procurement as it offers the highest savings and faces relatively low regulatory barriers. Behind-the-meter systems have gained market share as consumers look to maximize installation size despite net metering policy constraints.

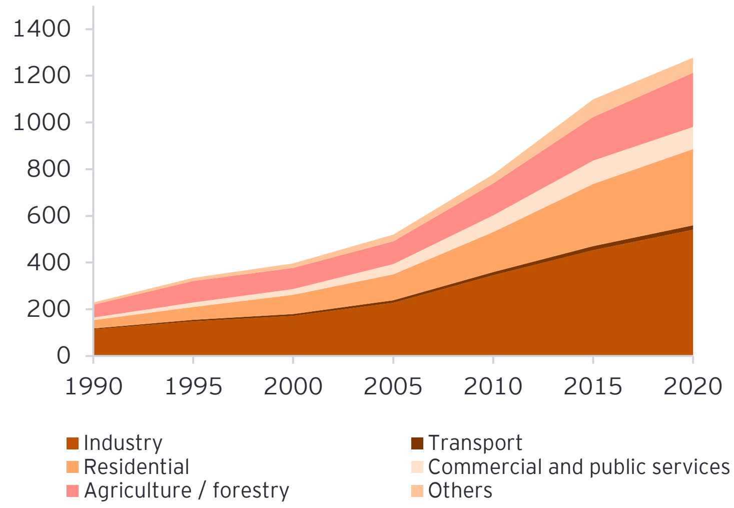
Wind and Solar remain the dominant renewable technologies, but the market is increasingly adopting wind-solar hybrid route to increase renewable penetration. Green hydrogen and storage technologies are yet to take off due to low commercial viability. However, some large consumers are procuring pumped storage power to consume round-the-clock (RTC) renewable power. OA project development business has become increasingly fragmented due to increasing investment interest. Utility scale IPPs are bullish on the OA market, primarily to diversify offtake risk away from state DISCOMs. The rooftop solar CAPEX market is also highly fragmented, whereas the OPEX market is more concentrated. Bridge to India analysis expects a total capacity addition of 47 GW over the next five years, entailing a CAGR of 23%. Capacity addition is expected to remain geographically concentrated in RE rich states such as Maharashtra, Tamil Nadu and Karnataka, which remain the most attractive markets. Under-penetrated markets in Uttar Pradesh, Gujarat, Odisha, and Chhattisgarh are also expected to see more growth.

Source: Corporate RE brief, Q2-2023, Bridge to India research, EY Analysis

Total corporate renewable capacity by June 2023, MW

Source: Corporate RE brief, Q2-2023, Bridge to India research

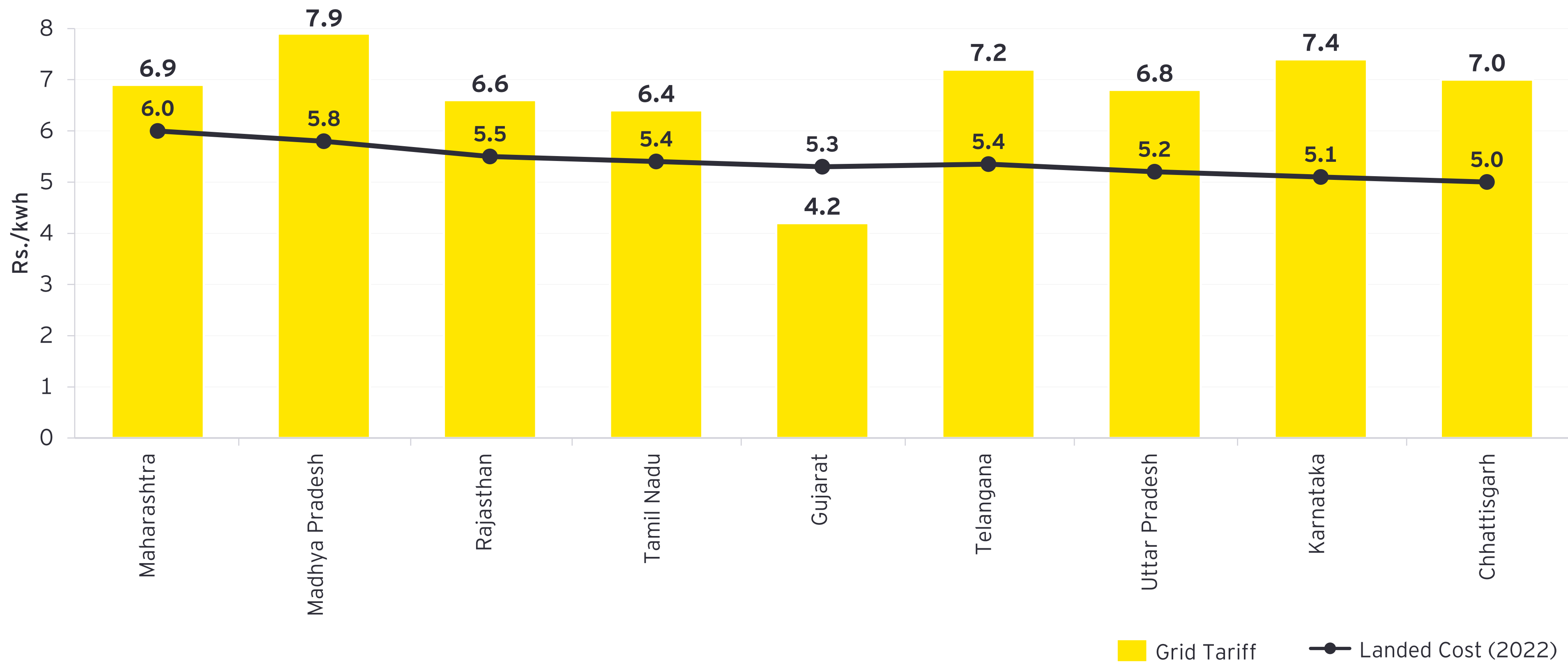
India Electricity consumption by sector in BU



Source: IEA, 2021

The competitiveness of open access captive RE transactions for C&I consumers is likely to sustain through 2030 and witness high levels of growth

As per Bridge to India analysis, India added a record 2,205 MW corporate renewable capacity in Q2 2023, up 35% QOQ. Total corporate renewable capacity is estimated to have reached 32,303 MW. The jump in capacity addition was driven by ALMM waiver, rush to complete projects before expiry of Gujarat's wind-solar hybrid (WSH) policy incentives and falling solar equipment prices.



1. Gujarat has the Fuel surcharge recovery being done separately and currently levies INR 2.60 p.u over and above the grid tariff for all consumers excluding agriculture.
Source: JMK Research & Analytics

Policy enablers

Harmonized adoption of green energy open access rules at state level

It is crucial for all states in India to either adopt the Green Energy Open Access rules mandated by the Government of India or formulate their own state-specific open access rules that address the challenges faced by open access consumers. By doing so, states can establish a standardized framework that ensures consistency and clarity for businesses seeking to transition to open-access arrangements. These rules should clearly outline the timelines and guidelines for granting approvals, providing businesses with a transparent process and enabling them to plan their renewable energy procurement effectively.

Moreover, the open-access rules should incorporate comprehensive provisions regarding the reasons for rejection of open access applications. By explicitly mentioning the grounds for rejections, businesses can have a better understanding of the requirements and take necessary measures to meet them. Additionally, it is essential for these rules to include all relevant technical information related to grid stability. This information should cover aspects such as grid capacity, load forecasting, and other grid parameters that impact the feasibility of open access arrangements. By providing detailed technical information, the rules can ensure that businesses have a clear understanding of the grid stability requirements and can make informed decisions regarding their renewable energy procurement strategies.

Long-term predictability and consistency of open access charges

Forum of Regulators (FoR) plays a crucial role in developing a transparent methodology to calculate the open access charges to be imposed by Distribution Companies (DISCOMs) in accordance with the Green Energy Open Access rules. This methodology is of utmost importance as it determines the financial implications for businesses opting for open access and procuring renewable energy directly.

By establishing a standardized and fair approach, the FoR can contribute to creating an enabling environment for the decarbonization of industrial growth in India.

Rationalizing the charges associated with open access is essential for fostering the transition towards a low-carbon economy. The current charges levied by DISCOMs can often be prohibitive, acting as a disincentive for commercial and industrial consumers to adopt renewable energy and reduce their carbon footprint. The FoR's methodology should take into account various factors such as grid infrastructure investments, balancing and settlement costs, and system losses to arrive at charges that are reasonable and reflective of the actual costs incurred.

Policy enablers

Compliance and enforcement of RPO and ESO on obligated entities

The Government of India, along with state governments, has a critical responsibility to ensure the effective implementation of Renewable Purchase Obligation (RPO) targets and establish clear consequences for non-compliance. RPO targets are essential mechanisms that drive the adoption of renewable energy sources and facilitate the transition to a cleaner and more sustainable energy landscape.

To ensure the success of RPO targets, it is crucial for the government at both the central and state levels to provide a robust framework for enforcement. Additionally, there should be a well-defined mechanism to monitor and assess compliance with these targets, ensuring transparency and accountability.

Equally important is the need to clearly define the consequences of non-compliance with RPO targets. These consequences should be proportionate and designed to incentivize compliance while also addressing any potential challenges or limitations faced by obligated entities. It is essential that the consequences are adequately communicated to all stakeholders, emphasizing the importance of meeting RPO targets and the benefits of transitioning to renewable energy sources.

Demand aggregation services for RE RTC supply to OA consumers

A more cost-effective approach to reduce the overall energy storage cost could involve government bodies like the Solar Energy Corporation of India (SECI) soliciting bids and establishing grid-level storage facilities. By providing a steady stream of renewable energy to energy-intensive industries, this strategy not only mitigates storage-related expenses but also supports these industries in attaining their decarbonization objectives.

Predictable grid banking regulations for OA consumers

To facilitate the transition to clean energy, the government should consider introducing more lenient banking guidelines, particularly tailored to the requirements of energy-intensive industries.

08

Biofuels and circular economy pathways for energy security

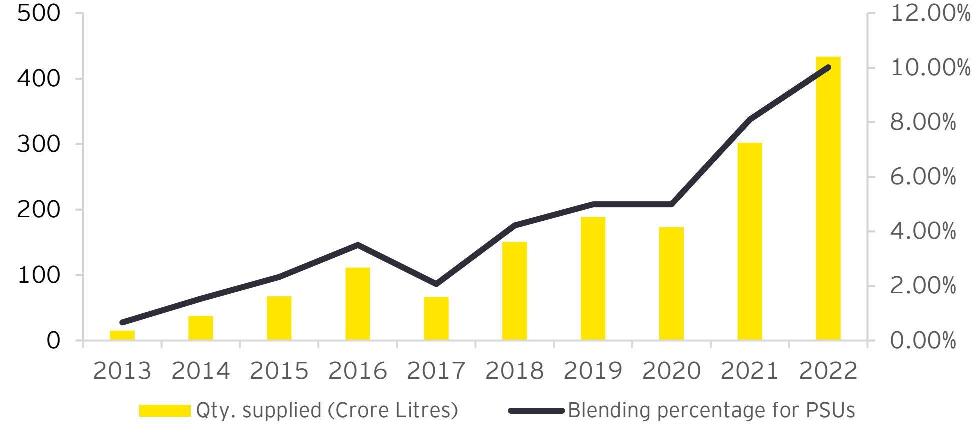
Bioethanol demand supply scenario in India

- By 2018, ethanol blending rates reached around 4%, followed by a faster uptake in the subsequent years. As of 2021, the Government of India reported a blending rate of 8.1%. From Aug 2021 to Jan 2022, Expression of Interest (EOI) for signing Long Term Offtake Agreements (LTOA) with Dedicated Ethanol Plants for ethanol supply saw oil marketing companies (OMCs) sign 131 LTOAs. India achieved the targeted 10% ethanol blending in May 2022, much ahead of the target date of Nov 2022, and has gone on to prepone the timeline by five years to 2025 for an ambitious blending target of 20%.
- India's present approach to biofuel production is dominated by 1G feedstocks (e.g., sugarcane, rice, and maize) and has to overcome challenges from a lifecycle perspective. The low yield for sugarcane and maize will require land use change, which necessitates the exploration of new production pathways.

Feedstock	Cost / MT of the feedstock (Rs.)	Quantity of ethanol per MT of feedstock	Ex-mill Ethanol Price (Rs./liter)
Sugarcane juice / Sugar / Sugar syrup	2850	70 litres	62.65
B Molasses	13,500	300 liters	57.61
C Molasses	7,123	225 liters	45.69
Damaged Food Grains (Broken Rice)	16,000	400 liters	51.55
Rice available with FCI	20,000	450 liters	56.87
Maize	15,000	380 liters	51.55

Source: NITI Aayog Roadmap for Ethanol Blending 2020-25

Ethanol supply trend



Source: Final Report: Energy Transition Advisory Committee, MoP&NG, 2023

The advancements in 2G bioethanol produced from lignocellulosic biomass, such as crop residues, woody crops or energy grasses, are gaining momentum. Though they still represent less than 3% of total bioethanol production globally, the GHG reduction potential is higher than for 1G bioethanol. The environmental impacts of bioethanol production are dependent on feedstock availability and conversion technology. The biochemical conversion route must overcome technological and economic challenges such as pre-treatment, fermentation, hydrolysis and separation. India has four operational advanced biofuel plants, including a pilot and a demonstration plant, with a cumulative annual production capacity of 1.75 million Liters of cellulosic ethanol. Consistent availability of feedstock from crop residues, and the establishment of a necessary infrastructure for aggregation, logistics, and handling of large amounts of biomass, all with the least carbon footprint, will be a step toward 2G ethanol production.

Compressed biogas demand supply scenario in India

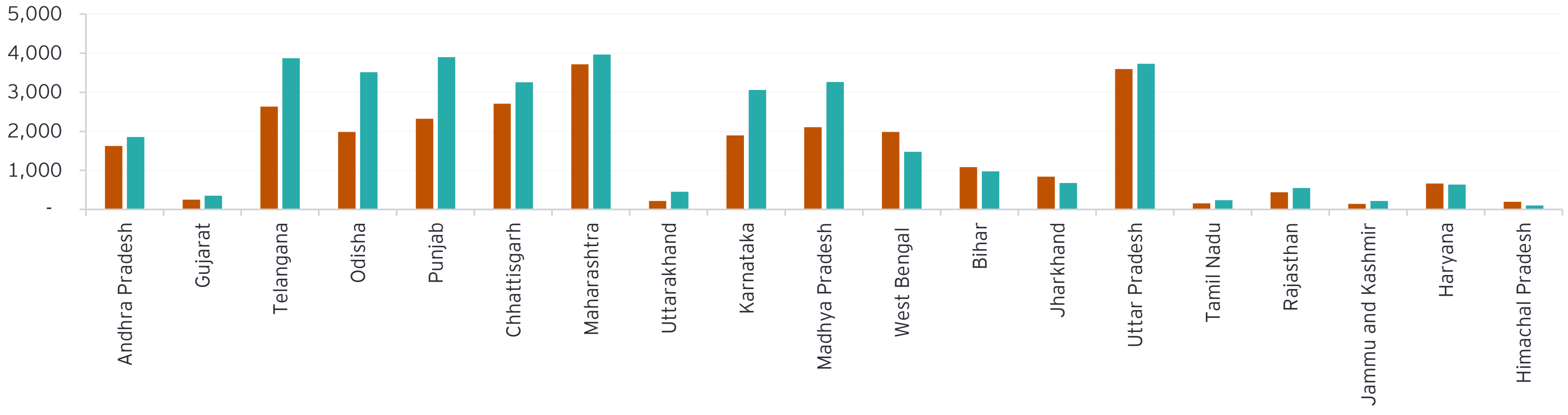
- Waste and bio-mass sources like agricultural residue, cattle dung, sugarcane press mud, distillery spent wash, municipal solid waste, sewage treatment plant waste, etc., produce biogas through the process of anaerobic decomposition. The biogas is purified to remove hydrogen sulphide (H2S), carbon dioxide (CO2), and water vapor, and compressed to form Compressed Biogas (CBG) or Bio-methane, which has methane (CH4) content of more than 90%. Biogas can serve as a suitable replacement for imported fossil natural gas with close to net zero emissions while boosting energy security supported by competitive economics.
- The Ministry of Road Transport and Highways, Government of India, vide the Gazette Notification no. 395 dated 16.6.2015, has permitted the usage of CBG for motor vehicles as an alternative to CNG. CBG can be used in vehicles using CNG fuel without making any modifications to the vehicle. CBG has a high potential to replace CNG in automotive, industrial as well as commercial areas, given the abundant biomass availability within the country. 'SATAT' (Sustainable Alternative Towards Affordable Transportation) initiative on CBG was launched by the Hon'ble Minister of Petroleum & Natural Gas on 1.10.2018. The scheme envisages the production of 15 MMT CBG and 50 MMT of manure from 5,000 plants. Under the SATAT scheme, Oil & Gas Marketing Companies (OGMCs) viz. IndianOil, HPCL, BPCL, GAIL and IGL have been inviting EOIs from potential investors/entrepreneurs to procure CBG.
- **Salient features of the SATAT scheme**

  Plant owner shall be responsible for the installation, operation and maintenance of the plant. Oil and gas marketing companies shall offtake CBG from the plant.
- Oil and gas marketing companies shall execute a Commercial Agreement of 15 years with the CBG Plant owner, to be extended on mutual consent.
- There are various technologies available for the production of CBG. Anaerobic Digestion is used for the production of biogas which includes technologies like continuous stirred tank reactor (CSTR), plug flow, 2-stage reactors, Upflow Anaerobic Sludge Blanket (UASB), etc. After the production of biogas, hydrogen sulfide is purified through ferric chloride, iron chelate, biological process, activated carbon, etc.
- Fermented Organic Manure (FOM) produced varies from 15% to 30% of the feedstock of the CBG plants. FOM is useful for maintaining soil health, particularly organic carbon, which helps microflora to flourish. It is a source of nitrogen (N), phosphorus (P), and potassium (K) and also has essential micro and macro nutrients that are vital for the balanced growth of plants. Creating an effective marketing strategy for FOM is critical for CBG Plants. The promotion of FOM can create an ecosystem of organic/natural farming in the country. Further, FOM can be enriched to Phosphate Rich Organic Manure (PROM), which can reduce India's import dependency on phosphate fertilizers.
- The various feedstocks of biogas are waste and bio-mass sources like agricultural residue, cattle dung, sugarcane press mud, municipal solid waste, etc. CBG production varies as per technology, feedstock quality, etc.
- The Government of India has set a target to increase the share of gas in the energy mix from the current levels of about 6.5% to 15% by 2030 to make India a gas-based economy. CBG can form a critical domestic supply source to contribute to this build-up.
- Production of CBG shall increase the green energy mix, reduce import dependence, create employment, especially in semi-urban and rural areas and reduce pollution. This will create value and employment in the rural economy across the supply chain, from biomass collection to plant operation.
- The minimum procurement price of CBG will not be lower than INR 46/kg + applicable taxes for the period up to 31.3.2029. The Retail Selling Price (RSP) of CBG in a market shall be at par with the RSP of CNG. Under MoP&NG policy guidelines on co-mingling of domestic gas for supply to CNG (Transport) and PNG (Domestic) of CGD, the biogas procurement price set by GAIL is INR 1,082/MMBTU (equivalent to INR 46/kg). Compression & CBG transportation charges of INR. 8/kg are provided additionally.

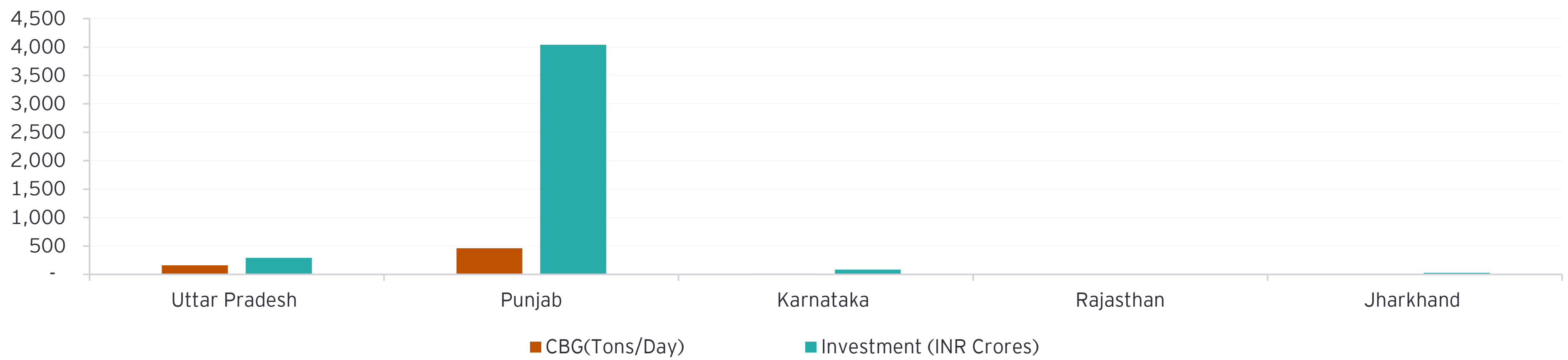
Source: Final Report: Energy Transition Advisory Committee, MoP&NG, 2023

Ethanol and compressed biogas production to attract investment of INR40,533 crores

Ethanol production pipeline in India



CBG production pipeline in India



Source: EY analysis

PM KUSUM Scheme extend till March 2026

Component – A: Setting up of 10,000 MW of Decentralized Grid Connected Renewable Energy Power Plants on barren land of capacity 500 kW to 2 MW will be setup by individual farmers/groups of farmers/ cooperatives etc. even on cultivable land on stilts where crops can also be grown below the solar panels within five km radius of the sub-stations in order to avoid high cost of sub-transmission lines and to reduce transmission losses. The power generated will be purchased by local DISCOM at pre-fixed tariff

CFA: Procurement Based Incentive (PBI) @ 40 paise/kWh or INR 6.60 lakhs/MW/year, whichever is less, will be provided for the first five years by MNRE to DISCOMs, for buying the power from farmers/developers

Component – B: Installation of 17.50 Lakh stand-alone solar agriculture pumps. Under this Component, individual farmers will be supported to install standalone solar Agriculture pumps of capacity up to 7.5 HP for replacement of existing diesel Agriculture pumps / irrigation systems in off-grid areas, where grid supply is not available. Pumps of capacity higher than 7.5 HP can also be installed, however, the financial support will be limited to a 7.5 HP capacity

Component – C: Solarization of 10 Lakh Grid Connected Agriculture Pumps. Under this Component, individual farmers having grid connected agriculture pump will be supported to solarize pumps. The farmer will be able to use the generated solar power to meet the irrigation needs and the excess solar power will be sold to DISCOMs at a pre-fixed tariff

CFA to Component B&C: CFA of 30% of the benchmark cost or the tender cost, whichever is lower. State Government subsidy 30%; Remaining 40% by the farmer. In north-eastern states, Sikkim, J&K, Himachal, Uttarakhand, Lakshadweep and A&N Islands, CFA of 50%, State Government subsidy 30%, Remaining 20% by the farmer.

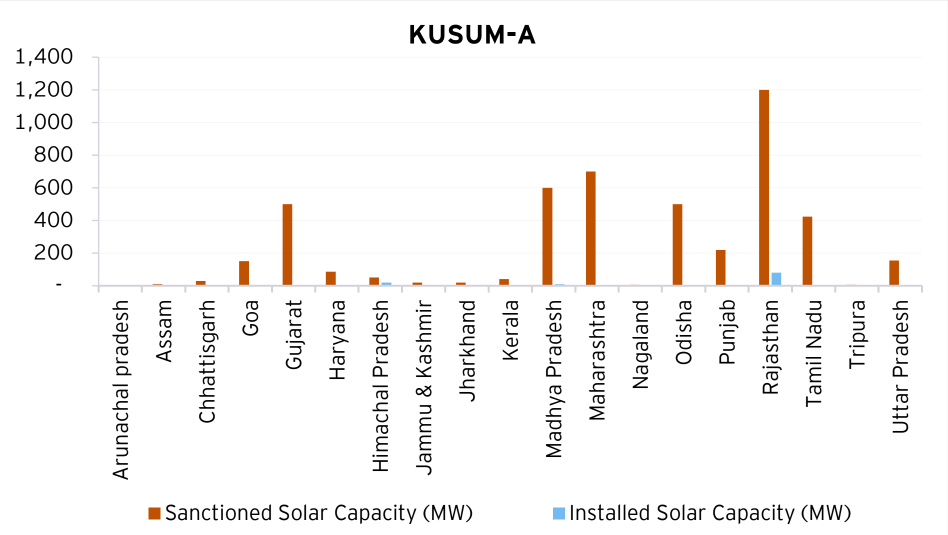
Considering the below reasons MNRE extended the PM KUSUM Scheme till March 2026.

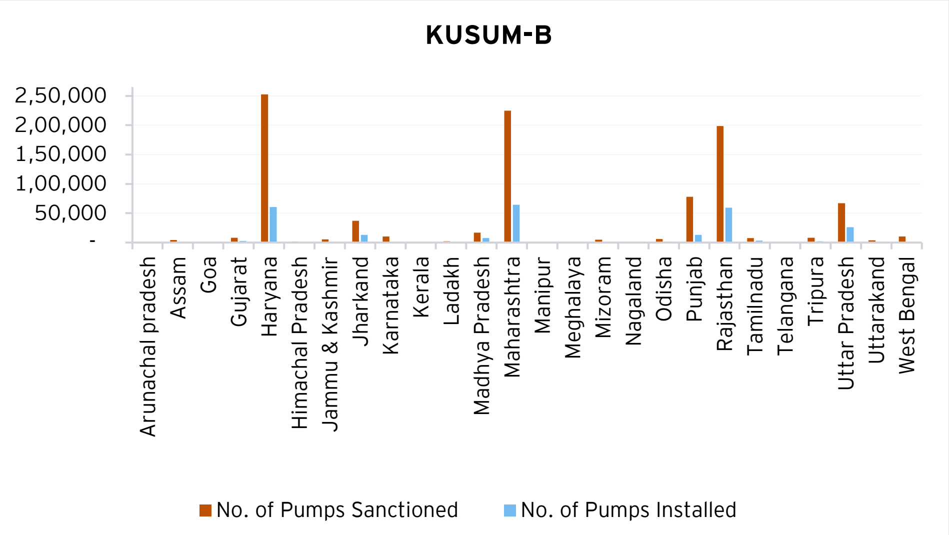
- Delay in State Government approval for the project
- Delay due to limited access to installation sites owing to COVID-19 pandemic
- States are to provide at least 30% subsidy for which matching state share is not available
- Increase in steel prices, GST and shortage in supply of glass affected implementation
- Slow Implementation by Banks to process loans under Component A
- Lack of availability of land for decentralized solar projects in few states
- Non-availability of metered connection in some states led to delay in implementation in some states.
- Farmers share not coming in under Component-C (IPS)

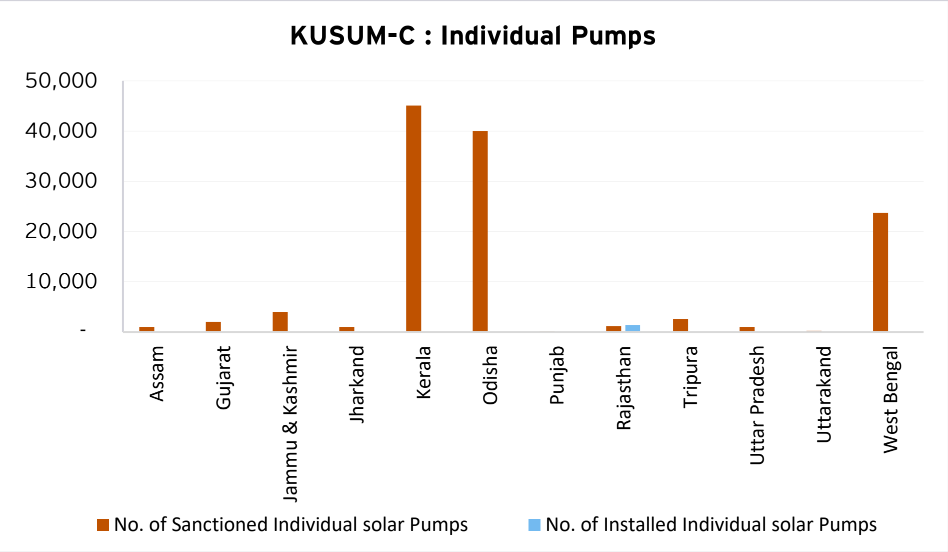
MNRE issued below major amendments to ease the implementation of KUSUM scheme

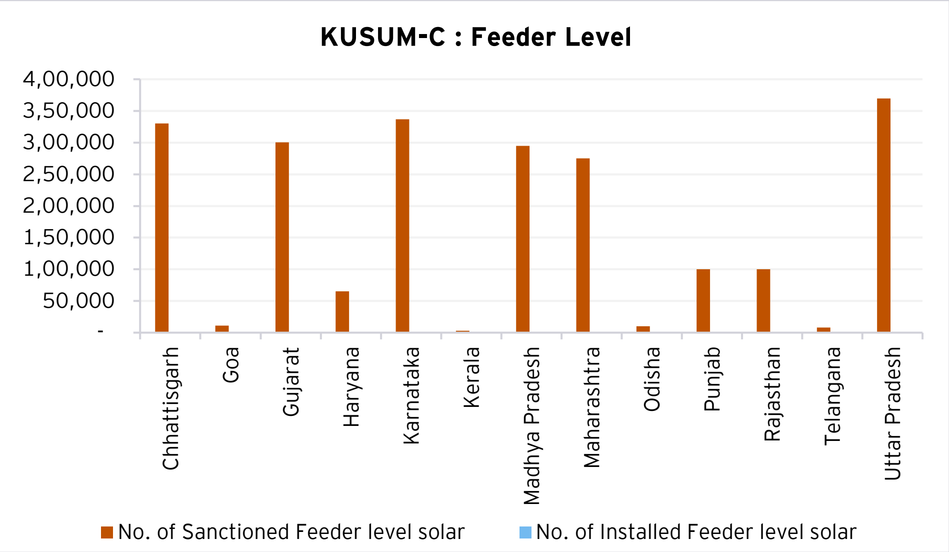
- DCR for solar cells waived off for feeder solarization projects for work awarded to the implementing company by 20.06.2023
- CFA is available for pump capacity up to 15 HP to the individual farmers in the north-eastern states, hill states and island UTs under Component-B & C
- No Requirement for PBG of INR 5 Lakh/MW under Comp. A of PM KUSUM
- Requirement of Bank Guarantee for the release of CFA under Comp. C of PM KUSUM has been removed
- State tender allowed under Component-B
- The time period extended for implementation to 24 months for all the Components
- Multiple extensions allowed to states to complete the sanctioned capacities

Source: https://pmkusum.mnre.gov.in/pdf/Progress%20Update%20of%20PM%20KUSUM%20Scheme.pdf









Source: https://pmkusum.mnre.gov.in/

Policy enablers

Promote biomass aggregation and storage

Government is providing subsidies on biomass aggregation and storage equipment under the SMAM and state-specific schemes. Presently, about 50% subsidy is available for biomass aggregation and storage equipment under the SMAM scheme.

State governments may provide an additional subsidy of a minimum of 30% to make the procurement of equipment more viable. The subsidy may be provided upfront during the procurement of equipment and may also be extended to set up CBG Plants. Promote engagement of FPOs/CHCs etc., for aggregation and storage of biomass. Create awareness and promote activities for biomass aggregation in the catchment area. Deploy biomass aggregation equipment (Cutter+Racker+Baler) in the catchment area of CBG plants by state governments.

Identify and notify biomass clusters for CBG plants and other biomass-based biofuel projects and grant of an exclusive area for a long tenure.

Provide incentives on operating expenses of biomass aggregation and storage equipment by state governments.

Local governments to allot land for a decentralized storage facility for the development of biomass depots.

Blending mandates

Provide CBG blending mandates to all City Gas Distribution (CGD) entities marketing CNG and PNG. Promotion of CBG and CNG vehicles in locations with upcoming CBG plants and convert existing vehicles and tractors to CNG based vehicles. Issue comprehensive guidelines on marketing of CBG through CNG outlets and vice versa. Dedicated "Green Hours" can be designated for undertaking sale of CBG through CNG outlets.

Creation of a market ecosystem for bio manure and promotion of Fermented Organic Manure (FOM)

Mandatory offtake arrangement of bio manure from CBG Plants @ Rs 5000-6000/ton by chemical fertilizer companies with minimum mandated offtake of bio manure as a percentage of chemical fertilizers in a 'Basket Approach.'

Exemption from retail license requirement for the sale of FOM in small quantities, including packages less than 5 Kg and stock less than 10 MT at any given time. Creation of natural farming and organic farming ecosystems. The Government may declare the vicinity of CBG Plants as 'Green Zones' where only FOM may be used for organic and natural farming. Creation of a national brand & certification for organic and natural food produced by FOM.

Production linked incentives

Extending Central Financial Assistance (CFA) for all commissioned CBG Plants as well as upcoming CBG Plants for the next 10 years. Providing Production Linked Incentive (PLI) @ Rs. 10/kg of CBG to encourage production. Financial incentives like access to credit, accelerated depreciation, long term land leases and tax holidays would help to attract private investment to the CBG sector.

Establish feedstock pricing mechanism

Design a feedstock pricing mechanism linked to bioethanol prices and the logistical set up at various collection points to avoid exploitation of feedstock suppliers by the biofuel producers.

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Notes

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