Shortage of electrolyzers for green hydrogen

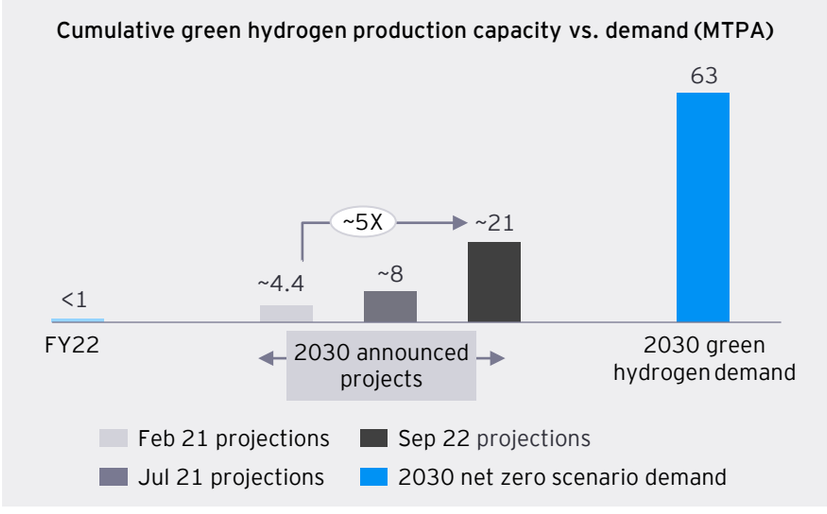
February 2023

EY Parthenon
Building a better working world

Green hydrogen has the potential to become the cogwheel of India's decarbonization strategy. However, there is a need to build a robust manufacturing ecosystem for green hydrogen electrolyzers in the country. Although the government has been taking steps to accelerate the uptake of green hydrogen, a more forward-looking policy framework for investors, PLI subsidies for manufacturers, innovative financing mechanisms, and creation of demand through purchase obligations can provide the necessary boost to the sector.

Kiran Malla
Partner, EY Parthenon
Strategy Leader for Energy transition and decarbonization

Green hydrogen capacity addition projections have reached 21MTPA by 2030, pipeline projects have grown 5x over the last 24 months



Source: Hydrogen council, IEA, EY analysis

- The growing focus on hydrogen applications, coupled with net zero ambitions, has driven the production capacity for green hydrogen to increase five times of the 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. In that scenario, 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.

India has recently announced the National Hydrogen Mission with an initial outlay of US$2.5 billion

National Hydrogen Mission

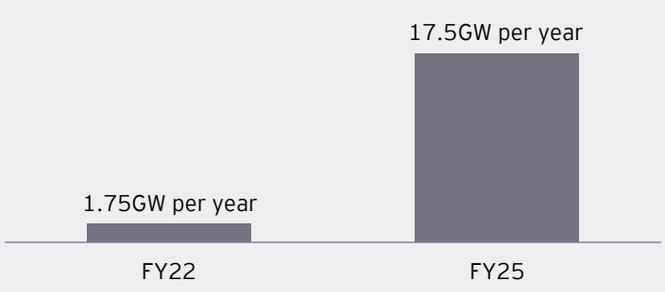
- In January 2023, the Union Cabinet has approved the National Green Hydrogen Mission with a target to achieve green hydrogen production of 5 MTPA by 2030 and to become net zero by 2070.
- The government has approved a capital outlay of US$2.5 billion to support green hydrogen initiatives, including setting up of electrolyzer manufacturing capacity of 60 to 100GW and RE capacity of 125 GW toward green hydrogen production.

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

REPowerEU

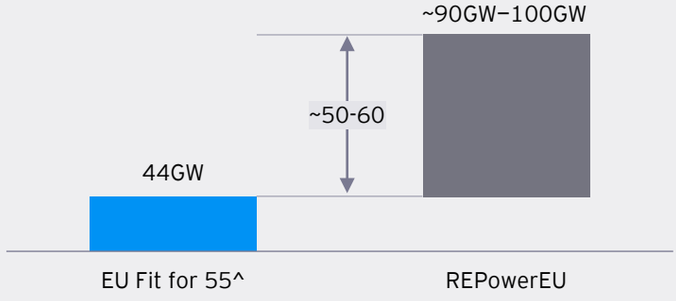
- February 2022: Russia's military aggression against Ukraine disrupted the world's energy system.
- In March 2022, the European Commission (EC) published the 'REPowerEU' plan to phase out Europe's dependency on Russian energy imports by developing strategies, such as diversifying energy imports and 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 electrolyzer, in addition to the 44GW already required for the 5 million tons in Fit for 55.

EU electrolyzer manufacturing capacity target



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

EU installed electrolyzer capacity - 2030



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

^EC plans to reduce greenhouse gas emissions in 2021

Source: European Commission, EY analysis

US incentives are expected to create an exponential increase in hydrogen production

Inflation Reduction Act (IRA), 2022

August 2022: 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 emitted during production. Producers are to be eligible for a credit of up to US$3 per kg of hydrogen, making green hydrogen produced in the US to become 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 storage).

Source: US Department of Energy, Secondary Sources, EY analysis

Europe's new REPowerEU targets and IRA incentives in the US will provide big push to the hydrogen market and we may be within the reach of meeting the green hydrogen demand of 63 MTPA by 2030, equivalent to 700 GW of electrolyzer demand

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

Manufacturers	Headquarters	Technology	Capacity (MW)		
			Current	Expansion plans	Growth
ITM Power	UK	PEM	1,000	5,000 (by 2024)	5x
McPhy	France	PEM, Alkaline	100	1,300 (by 2024)	13x
Nel	Norway	PEM, Alkaline	500	10,000 (by 2025)	20x
John Cockerill	Belgium	Alkaline	350	8,000 (by 2025)	22x
Plug Power	US	PEM	75	3,000 (by 2025)	40x
Thyssenkrupp	Germany	Alkaline	1,000	5,000 (by 2030)	5x
Sunfire	Germany	Alkaline, Solid oxide	40	500 (by 2023)^	12x
Siemens Energy	Germany	PEM	125	1,000 (by 2030)	8x
Cummins	US	PEM, Alkaline, Solid oxide	38	3,500 (by 2025)	92x
Topsoe	Denmark	Solid oxide	75	5,000 (by 2030)	66x
Ohmium	US	PEM	500	2,000 (by 2022)	4x
Enapter	Italy	AEM	30	300 (by 2023)	10x
Bloomenergy	US	Solid oxide	500	1,000 (by 2023)	2x
Green Hydrogen Systems	Denmark	Alkaline	75	400 (by 2023)	5x
Hydrogen Pro	Norway	Alkaline	100	1,000 (by 2030)	10x
Elogen	France	PEM	160	1,000 (by 2025)	6x
Other manufacturers		PEM, Alkaline, Solid oxide	1,000E	12,000E (by 2030)	
Total			**5,600**	**37,000 (by 2025)** **60,000 (next 10 years)**	**6x** **10x**

Source: EY analysis, Company press releases, Secondary sources
^1,000 MW, eventually | PEM: proton exchange membrane | AEM: anion exchange membrane

The sudden increase in hydrogen capacity announcements is resulting in an overflow of orders for electrolyzers

All values in MW

Manufacturers	Tie-ups	Current capacity	Order size	Manufacturers	Tie-ups	Current capacity	Order size
Plug Power	H2 Energy	75	1,000	Topsoe	First Ammonia	75	5,000
Thyssenkrupp	Air Products	1,000	2,000	Siemens Energy	Air Liquide	125	3,000

Source: EY analysis, company releases

The sudden increase in hydrogen capacity announcements is resulting in an overflow of orders for electrolyzers

NA: not applicable

Manufacturers	Current capacity (MW)	Announcements
h2e Power	NA	To set up a solid oxide electrolyzer manufacturing plant in Maharashtra by 2023
Ohmium	500	To increase manufacturing capacity to 2GW at its factory in Bangalore
Hydrogen Pro and Larsen & Toubro	NA	MoU signed for GW-scale manufacturing of alkaline water electrolyzers
John Cockerill and Greenko	NA	To set up two alkaline electrolyzer factories of 1GW each over the next 1.5 years
Stiesdal and Reliance	NA	Formed a partnership to develop and manufacture hydrogen electrolyzers

Source: EY analysis, Company press releases, other secondary sources

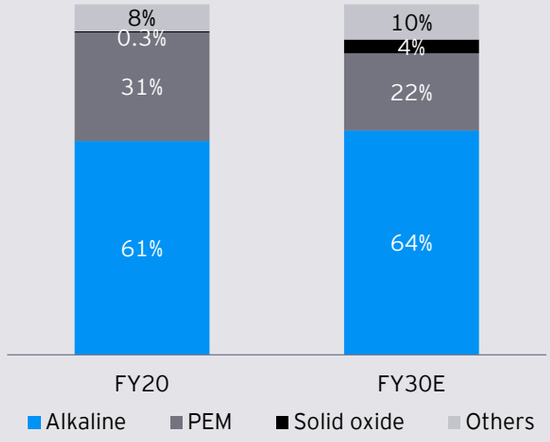
In India, the existing capacity of alkaline electrolyzers is estimated to be less than 1GW, which is mainly used for the chlor-alkali process

Indian manufacturers should grab this opportunity and create world-class facilities Key points to consider are:

1 Choice of technology and access to technology partners

- Alkaline electrolyzers 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 electrolyzers based on solid oxide, while Enapter (IT) and Hydrolit (IL) are a few players that are developing AEM.

Major technologies - current share and future outlook

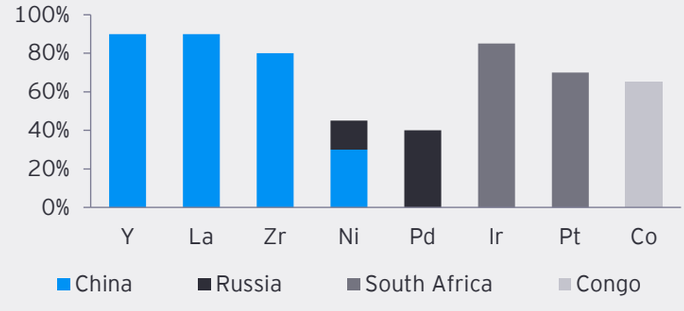


Source: IEA

2 Secure raw material supply to prevent bottlenecks

Key minerals and metals for electrolyzers									
Solid oxide				Alkaline			PEM		
Zirconium	Nickel	Yttrium	Lanthanum	Nickel	Zirconium	Palladium	Iridium	Platinum	Palladium

Key suppliers of critical materials for electrolyzers

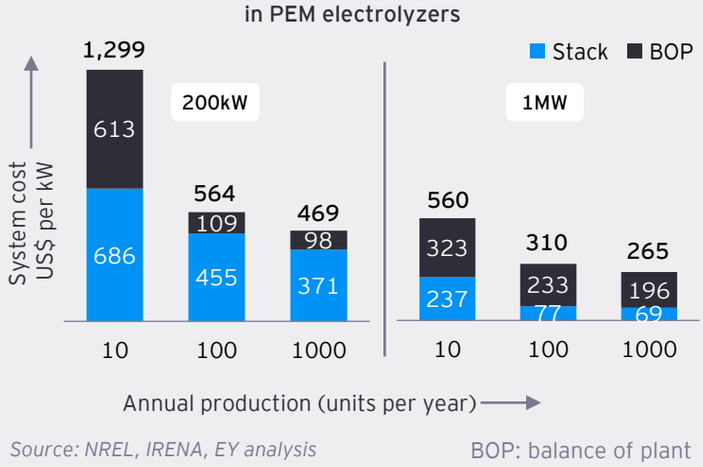


Source: European Commission, USGS

- Many minerals and metals required for electrolyzers 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 electrolyzers 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 electrolyzer manufacturers globally to work with key stakeholders on raw material dependency issues, such as strategic sourcing and forming strong partnerships.

3 Plan for large-scale investments and bring efficiency with large-scale projects

Economies of scale impact: potential cost reductions in PEM electrolyzers



Source: NREL, IRENA, EY analysis

BOP: balance of plant

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

↓ Reduction ↑ Increase

- Economies of scale can be achieved by increasing the size of electrolyzer facilities.
- In stack manufacturing, as more units of electrolyzers are produced, the shared cost from 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.

4 Tie-up anchor capacity with reliable hydrogen producers

Energy and utility		Oil and gas	Industrial gas
► John Cockerill ► Greenko (Alkaline)	► Cummins ► Iberdrola (PEM)	► Cummins ► Sinopec Group (PEM)	► ITM Power ► Linde (PEM)
► McPhy ► EDF Energy (NA)	► Stiesdal ► Reliance (Alkaline)	► Ohmium ► Shell India (PEM)	► Siemens Energy ► Air Liquide (PEM)

Source: Economic Times, Business Standard, Company press releases

(Indicates the technology)
List is indicative and not exhaustive

- As the demand for electrolyzers 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 electrolyzer 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 multi billion-dollar opportunity for electrolyzer manufacturers, and India should target to become a global hub for manufacturing.

India can become a global hub for electrolyzers by taking the following proactive steps on the policy and regulatory front:

1. PLI policy for manufacturing of electrolyzers

A favorable PLI policy for electrolyzers, similar to incentives announced for solar modules and storage, will enable Indian players to gain scale in this emerging sector and achieve overall cost competitiveness for green hydrogen.

2. Mandatory purchase obligations

Green hydrogen will have higher cost compared to gray hydrogen and the value of Certified Emissions Reductions (CERs) is not likely to offset the premium in the near term. While the US and European markets will spearhead the overall demand for green hydrogen, it will be equally important to create a local demand for green hydrogen. This will help electrolyzer manufacturers to tie up with domestic hydrogen producers and build additional capacity for exports. Similar to renewable purchase obligations that apply for utilities and captive generators, the government can consider purchase obligations for petroleum refining and fertilizer sectors to use green hydrogen as a certain proportion of their requirements in a phased manner.

3. Efficient hydrogen contracting framework

The current framework that exists for molecules, such as hydrogen, will not be conducive to accelerate the green hydrogen consumption. The government should set up an intermediary, which can facilitate long-term offtake of green hydrogen and develop an efficient contracting framework for subsidizing green hydrogen until cost parity with gray hydrogen is achieved.

Source: MNRE, NITI Aayog, EY Analysis

Policy support from the government such as long-term contracts, mandatory purchase obligations and incentives to mitigate the challenges of high cost is expected to boost the green hydrogen market and provide India with a unique opportunity to become a global electrolyzer manufacturing hub

Ernst & Young LLP

EY | Building a better working world

EY exists to build a better working world, helping to create long-term value for clients, people and society and build trust in the capital markets.

Enabled by data and technology, diverse EY teams in over 150 countries provide trust through assurance and help clients grow, transform and operate.

Working across assurance, consulting, law, strategy, tax and transactions, EY teams ask better questions to find new answers for the complex issues facing our world today.

EY refers to the global organization, and may refer to one or more, of the member firms of Ernst & Young Global Limited, each of which is a separate legal entity. Ernst & Young Global Limited, a UK company limited by guarantee, does not provide services to clients. Information about how EY collects and uses personal data and a description of the rights individuals have under data protection legislation are available via ey.com/privacy. EYG member firms do not practice law where prohibited by local laws. For more information about our organization, please visit ey.com.

About EY-Parthenon

EY-Parthenon teams work with clients to navigate complexity by helping them to reimagine their eco-systems, reshape their portfolios and reinvent themselves for a better future. With global connectivity and scale, EY-Parthenon teams focus on Strategy Realized – helping CEOs design and deliver strategies to better manage challenges while maximizing opportunities as they look to transform their businesses. From idea to implementation, EY-Parthenon teams help organizations to build a better working world by fostering long-term value. EY-Parthenon is a brand under which a number of EY member firms across the globe provide strategy consulting services. For more information, please visit ey.com/parthenon.

Ernst & Young LLP is one of the Indian client serving member firms of EYGM Limited. For more information about our organization, please visit www.ey.com/en_in.

Ernst & Young LLP is a Limited Liability Partnership, registered under the Limited Liability Partnership Act, 2008 in India, having its registered office at 9th Floor, Golf View Corporate Tower B, Sector 42, Golf Course Road, Gurgaon Haryana 122002

ED None
EYIN2302-001

Contacts

Kiran Malla
Partner, EY Parthenon
Strategy Leader for Energy transition and decarbonization
kiran.malla@parthenon.ey.com

Anirban Mitra
Director, EY Parthenon - Strategy
anirban1.mitra@parthenon.ey.com

Kamal Suri
Associate Director, Strategy and Transactions Research
kamal.suri@in.ey.com

Ankit Dutta
Assistant Manager, Strategy and Transactions Research
ankit.dutta1@in.ey.com