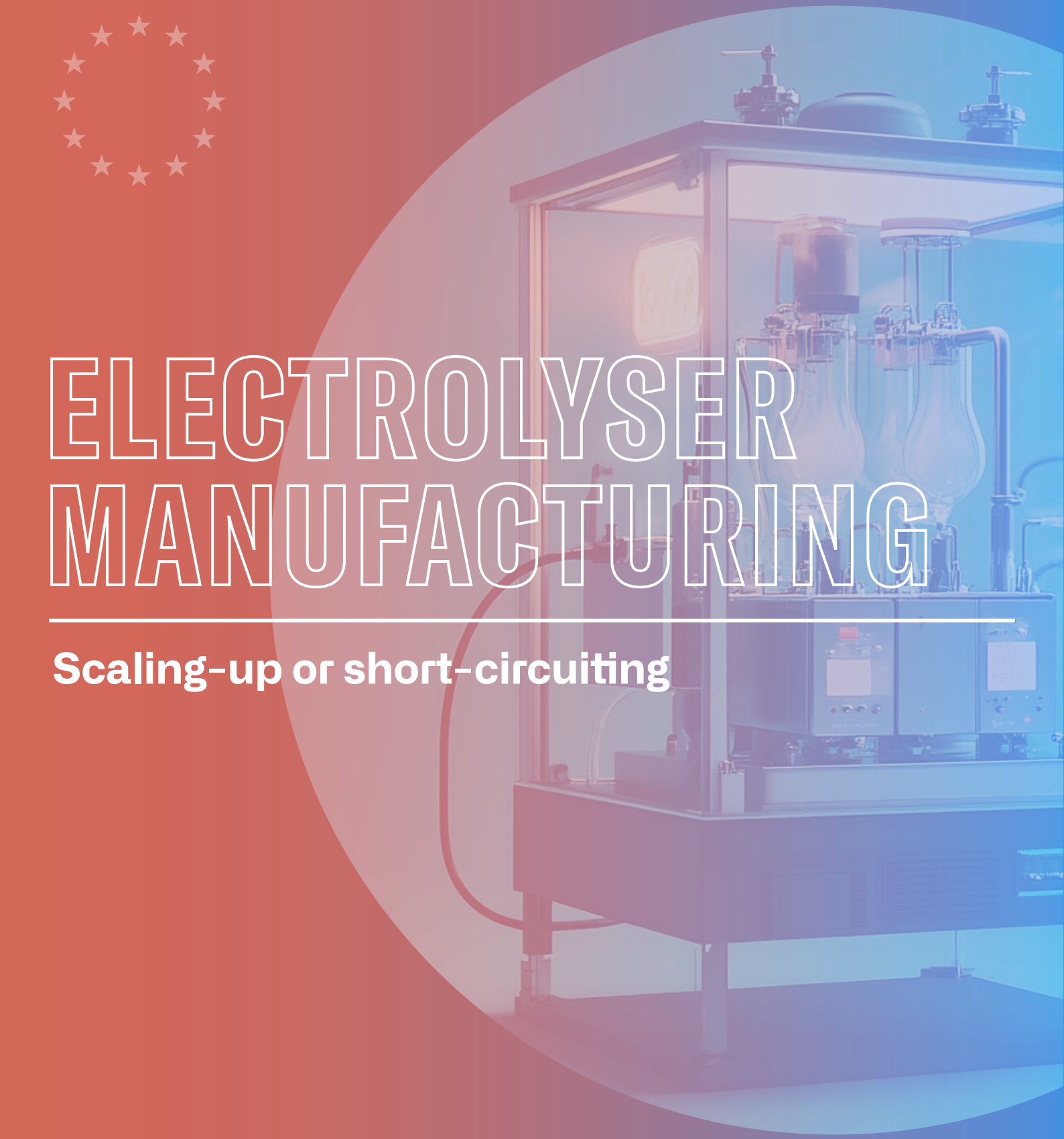
Breakthrough Energy

Cleantech for Europe

With analyses led by SYSTEMIQ

# CLEANTECH REALITY CHECK



# ELECTROLYSER MANUFACTURING

## Scaling-up or short-circuiting

Breakthrough Energy Cleantech for Europe

With analyses led by SYSTEMIQ

# CLEANTECH REALITY CHECK

# ELECTROLYSER MANUFACTURING

## Scaling-up or short-circuiting

### What are electrolysers?

Electrolysers are a cornerstone technology for the hydrogen economy. Their integration into renewable and low-carbon energy systems positions them as key enablers of decarbonisation across multiple sectors. Electrolysers produce hydrogen via water electrolysis, classified into four main types:

- Proton Exchange Membrane (PEM): Operates at 70°–90°C, uses solid polymer electrolytes, and offers rapid response to variable renewable energy inputs.
- Alkaline (ALK): Operates below 100°C, uses liquid alkaline solutions (e.g., potassium hydroxide) and is a mature, cost-effective technology.
- Solid Oxide: Operates at 500°–800°C, utilises heat to improve efficiency, and is suited for industrial integration.
- Anion Exchange Membrane (AEM): A newer technology operating at 50°–60°C, combining advantages of both alkaline and PEM systems.

Hydrogen from electrolysers is used in various sectors:

- Transportation: Synthetic fuels and fuel cell vehicle niches.
- Industry: Chemical manufacturing and low-carbon steel production.
- Energy storage: Long-term storage of rewable energy
- Heat: Industrial processes and residential heating.

### Key take-aways

- The EU's REPowerEU approach targets renewable hydrogen to replace ~5% of natural gas consumption by 2030, translating to ~5-7% emissions cuts in hard-to-abate sectors. It is estimated that in the region of 150,000 jobs for manufacturing and maintenance of electrolyser capacity could be created by 2030, with further realised in the wider value chain.[1]
- Europe currently has ~9 GW of manufacturing capacity as of the end of 2024, majority being alkaline and proton exchange membrane. The EU leads in proton exchange membrane and pressurised alkaline electrolyser technology but faces competition from cheaper Chinese alkaline electrolysers.
- To support a resilient and domestic supply chain, the EU must establish a level playing field between European producers and importers, provide de-risking support for projects using EU-manufactured electrolysers, and encourage the deployment of diverse EU-manufactured electrolyser technologies.

# ELECTROLYSER MANUFACTURING

## SCALING-UP OR SHORT-CIRCUITING

## STRATEGIC IMPORTANCE FOR EUROPE

- Electrolysers enable large-scale low-carbon electrolytic hydrogen, which is critical for decarbonising hard-to-abate sectors, supporting energy security through long duration energy storage and achieving the REPowerEU's 2030 target of 10 Mt/year of domestic renewable hydrogen.
- The EU hosts nine (9) of the world's top 15 electrolyser manufacturers,[3] driving a projected €50billion global market by 2030. Combined industry and European-led initiatives aim to scale annual production capacity, securing high-value jobs and export opportunities.
- Electrolysers are key to the EU's Clean Industrial Deal, enabling decarbonisation of steel, chemicals, and refining industries whilst reducing dependence on imported natural gas as a feedstock for industry.

## CURRENT PROGRESS OF ELECTROLYSERS MANUFACTURING IN THE EU

**OFF-TRACK** — **ON-TRACK**

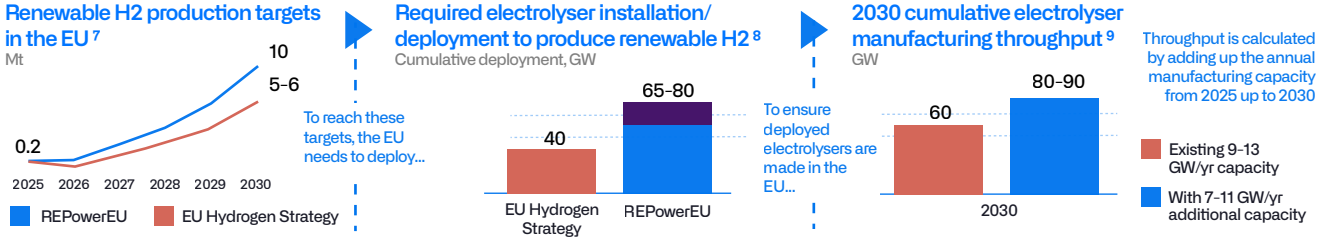
**STATUS : AT RISK** Electrolyser manufacturing is crucial for Europe's energy security, industrial decarbonisation, and technological leadership. While major support has been mobilised through initiatives like the Innovation Fund, IPCEI, and European Hydrogen Bank, underutilisation risks loom as low-carbon electrolytic hydrogen projects lag behind manufacturing capacity growth.

REPowerEU targets 10 Mt/yr while the EU Hydrogen Strategy set the ambition of 40GW, ~5-6Mt/yr of domestic renewable hydrogen by 2030. REPowerEU is unobtainable with current capacity. Yet, today's ~9GW/yr production capacity and pipeline could put us on the path to meet the 40GW target if we see a seismic ramp up in demand to overturn low utilisation rates.

**REQUIRED : 10-20 GW** by 2030, depending on the achievement of EU Hydrogen Strategy or REPowerEU targets[4]

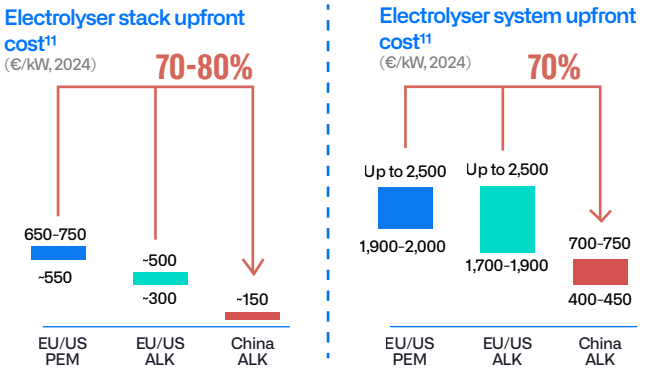
**PROGRESS :**
Operational (at end of 2024) **9 GW**[2]
Beyond FID **4GW**[6]

## SYNCHRONISATION OF EU ELECTROLYER MANUFACTURING AND DEPLOYMENT IS NEEDED




- Operational + FID manufacturing capacity: The potential ~13 GW/yr renewable capacity by the end of 2025 is enough to put Europe on track to meet the EU Hydrogen Strategy target for 40GW deployment and ~5-6 Mt low-carbon electrolytic hydrogen by 2030. by 2030.[4]
- REPowerEU gap: Over 10 GW/yr of additional low-carbon electrolytic hydrogen capacity is required (beyond the 9-13GW/yr operational by the end of 2025) by 2030, with FID in 2027/28 to ensure a minimum of 65-80 GW cumulative deployed electrolysers to meet the 10Mt REPowerEU 2030 target.[5]
- Demand is critical: Only 0.9Mt of low-carbon hydrogen supply to EU buyers is under binding contracts. Equating to just 4.5% of the overall REPowerEU target for 20Mt low-carbon electrolytic hydrogen (10Mt domestic production, plus 10Mt imported).[10]

## EU'S HIGHER UPFRONT ELECTROLYSER COSTS ARE PARTIALLY COMPENSATED BY HIGHER PERFORMANCE




System cost includes balance of plant costs such as, electricity grid connection, water treatment systems, piping, compressors, storage tanks, cooling systems, control systems etc.

- While Chinese electrolysers are 50–70% cheaper upfront than Western equivalents, their lower efficiency (60–70% vs. 75–85% for EU PEM systems) is reflected in total system costs.[12]
- This lower efficiency of Chinese electrolysers results in additional costs incurred from +10–15% power consumption, larger BoP (balance-of-plant) infrastructure, and higher maintenance, all eroding the initial capital savings.[13]
- 60–80% of the production cost of low-carbon electrolytic hydrogen is attributable to the cost of electricity to run an electrolyser, therefore, reducing clean power costs is critical and more impactful than subsidising electrolyser manufacturing CAPEX alone.[14]

# ELECTROLYSER MANUFACTURING

## SCALING-UP OR SHORT-CIRCUITING

## ENABLERS – WHAT IS GOING WELL

### STRONG EU TECHNOLOGICAL LEADERSHIP

EU electrolyser producers lead in proton exchange membrane manufacturing (60% of new projects) and in pressurised alkaline technology, innovation with new patents, and are advancing SOEC and AEM technologies (e.g., completion of the world's first 500MW SOEC factory in Denmark).[15] Beyond electrolyser stacks, there are opportunities in balance-of-plant systems (e.g., BoP designs) and AI-driven control software (e.g., optimisation tools).

### COMPREHENSIVE POLICY FRAMEWORK ESTABLISHED

The Renewable Energy Directive (RED) sets ambitious targets, including 42% renewable hydrogen use for industrial feedstock and 1% Renewable Fuels of Non-Biological Origin (RFNBOs) in the transport sector by 2030. Delegated acts on renewable hydrogen, including additionality rules and a high-integrity RFNBO definition offer crucial clarity for project developers. The EU Hydrogen Bank is a powerful demand instrument with the first auction securing 1.5 GW of capacity, and winning bids for subsidies at €0.37–€0.48/kg of hydrogen.[16]

### SIGNIFICANT MANUFACTURING CAPACITY IN PLACE

Expected European manufacturing capacity of up to 13 GW/year by 2025 is sufficient to fulfil the EU Hydrogen Strategy 2030 target of 40GW of hydrogen and ~60–70% of REPowerEU target of 10Mt domestic production. This capacity reflects Europe's readiness to scale but highlights the need for continued focus on downstream project delivery to bring demand certainty, and solve system integration challenges.

## BARRIERS – WHAT IS NOT GOING WELL

### SLOWER THAN ANTICIPATED LOW-CARBON ELECTROLYTIC HYDROGEN DEMAND

Downstream demand for low-carbon electrolytic hydrogen in sectors like H2-DRI-EAF steelmaking, SAF, and fertiliser production is not materialising. The lack of widely available affordable, clean electricity remains a significant challenge to investment cases, insufficient implementation of EU demand incentives in Member States (RED II & III, REFuel etc) and uncertain penalties by Member States for buyers missing quotas e.g., under REFuelEU and FuelEU Maritime leaves willingness to pay a premium low (see CRC Series 1).

### OVERCAPACITY AND HEAVY SUBSIDIES FROM INTERNATIONAL COMPETITORS

Europe's initial competitive advantage from electrolyser R&D leadership is at risk due to the rapid production ramp-up in China, where cheaper electrolysers captured 25% of Europe's market share in 2024 (up from 5% in 2022). Subsidy auction caps (25% Chinese electrolyser stacks per project) have been introduced in the European Hydrogen Bank, but enforcement gaps remain.[17]

### RISKS IN RAW MATERIAL SUPPLY

The limited availability of critical raw materials, such as platinum and iridium for PEM electrolysers and nickel for SOEC electrolysers, may lead to potential bottlenecks in the technology where the EU currently holds a competitive edge.

SAF - Sustainable Aviation Fuel
DRI - Direct Reduced Iron
EAF - Electric Arc Furnace

## ACTION AGENDA – WHAT NEEDS TO BE DONE

1. **Strengthen domestic demand certainty for low-carbon electrolytic hydrogen via creation of lead markets and de-risking mechanisms.** Incentivise the creation of "green lead markets" for sustainable products made with low-carbon electrolytic hydrogen and derivatives to help deliver the adopted RFNBO targets and increase the proportion of projects at FID. Enforce RED III quotas at the national level and ensure long-term legal certainty for production rules. Extend EIB's counter-guarantee scheme to allow electrolyser manufacturing to access private loans for their manufacturing plants.
2. **Further Europe's technological lead.** Double down on Europe's innovation advantage with direct financial support and policy interventions to advance R&D in nascent technologies (SOEC and AEM), while simultaneously targeting PEM and innovative ALK scale-up production. Additionally, leverage learnings from ALK-based projects that can help drive down system costs (e.g., from balance of plant) to future projects using PEM or SOEC technologies.
3. **Level the playing field against imports.** Maintain the 25% Chinese stack cap in the European Hydrogen Bank auctions and expand "resilience criteria" to mandate EU/EEA assembly. Strict local content rules may raise costs, conflicting with REPowerEU's domestic hydrogen target; a phased approach balancing cost and resilience is critical.
4. **Bridge the cost gap.** Increase the European Hydrogen Bank's budget with clear auction timeline, drive Member States' support for low-carbon electrolytic hydrogen projects through the the European Hydrogen Bank, and introduce demand-side CfD (Contract for Difference) support in combination with harmonised implementation of the adopted sectoral targets for REDIII. Simplify and speed up application processes and access to public funding and prioritise demand side financial support for offtakers.

"We both need to look at the full value chain approach and create the necessary incentives to improve domestic low-carbon hydrogen demand from key downstream industries, and to keep investing in new technologies as they could drive major improvements on overall efficiency and total cost of ownership, and therefore help accelerate a wider adoption of electrolysers by industrial players"

**Khouloud Karam,** Chief Operating Officer, **Genvia**

Breakthrough Energy

Cleantech for Europe

With analyses led by

SYSTEMIQ

## References


[1] Hydrogen Europe (2020), Green Hydrogen for a European Green Deal A 2x40 GW Initiative. 140,000-170,000 jobs estimated to be created for a 80GW installed electorlyser capacity by 2030 is manufactured and maintained in the EU.
[2] European Hydrogen Observatory (data as of Dec 2024), Current and planned water electrolyser manufacturing capacity in the EU27, EFTA and UK countries by 2026 (in GW/year).
[3] Resilience criteria in European public funding instruments; Hydrogen Europe Position Paper (Hydrogen Europe, 2024).
[4] European Courts of Auditors (2024), Special Report: The EU's industrial policy on renewable hydrogen. Based on Commission staff working document accompanying the REPowerEU plan(SWD(2022) 230, page 16 and 30).
[5] Depending on electrolyser efficiency and utilization rates up to 140GW of electrolyser capacity is estimated to be required to meet the 10MT 2030 RePowerEU target, with lower estimates of 65-80GW.
[6] European Hydrogen Observatory (data as of Dec 2024), Current and planned water electrolyser manufacturing capacity in the EU27, EFTA and UK countries by 2026 (in GW/year).
[7] European Courts of Auditors (2024), Special Report: The EU's industrial policy on renewable hydrogen. Based on Commission staff working document accompanying the REPowerEU plan(SWD(2022) 230, page 16 and 30). 5-6Mt relates to the approximate production from 40GW electorlysers. 5-6MT is also representative of the current renewable hydrogen commitments made by 16 Member States in respective national hydrogen strategies, collectively amounting to 40GW of capacity targeted for 2030 or 5.6MT of renewable hydrogen.
[8] Minimum cumulative deployment of electrolysers by 2030 required to meet the EU targets. Estimates expect up to 140GW of installed capacity of electorlysers will be required to meet the 10Mt RePowerEU target.
[9] Cumulative manufacturing throughput is derived from using 9-13 GW/yr manufacturing capacity by 2026 and assuming a phased ramp up to reach 2030 annual manufacturing capacity requirements of up to 20 GW to reach REPowerEU targets, and 80% utilisation factors in electrolyser manufacturing capacity annually.
[10] The Oxford Institute for Energy Studies (2024), 2024 State of the European Hydrogen Market Report.
[11] Electrolyser cost estimates compiled from IEA (2024), Global Hydrogen Review 2024; Electric Hydrogen (2024), PEM vs. Alkaline: Re-examining market perceptions of electrolyzer technologies in an evolving landscape; The Oxford Institute for Energy Studies (2024) 2024 State of the European Hydrogen Market Report; Hydrogen Europe (2024) CLEAN HYDROGEN PRODUCTION PATHWAYS; PV Magazine (2024) Electrolyzer prices – what to expect based on BNEF insights, alongside Systemiq sectoral expert input. Based on Hydrogen Insight article, referencing multiple studies that electrolysers developed by Chinese manufacturers overestimated efficiency.
[12] Based on Hydrogen Insight article, referencing multiple studies that electrolysers developed by Chinese manufacturers overestimated efficiency.
[13] Balance of Plant, or BoP, are all the components and subsystems that support the electrolyser's main hydrogen production process. BoP consists of power supply, water management system, instrumentation and control, pumps, separator, tanks for electrolyte and hydrogen.
[14] Hydrogen Europe, Clean Hydrogen Production Pathways: 2024 LCOH from low-temperature electrolysis of a theoretical 100 MWel project in Europe.
[15] European Hydrogen Observatory (data as of Dec 2024), Breakdown of current and planned water electrolyser manufacturing capacity by technology type in the EU27, EFTA and UK countries (in GW/year).
[16] European Hydrogen Bank pilot auction results spark renewable hydrogen competitiveness.
[17] European Commission, DG Clima, Innovation Fund IF24 Auction, Terms and Conditions v0.2 (Accessed Feb 2025)