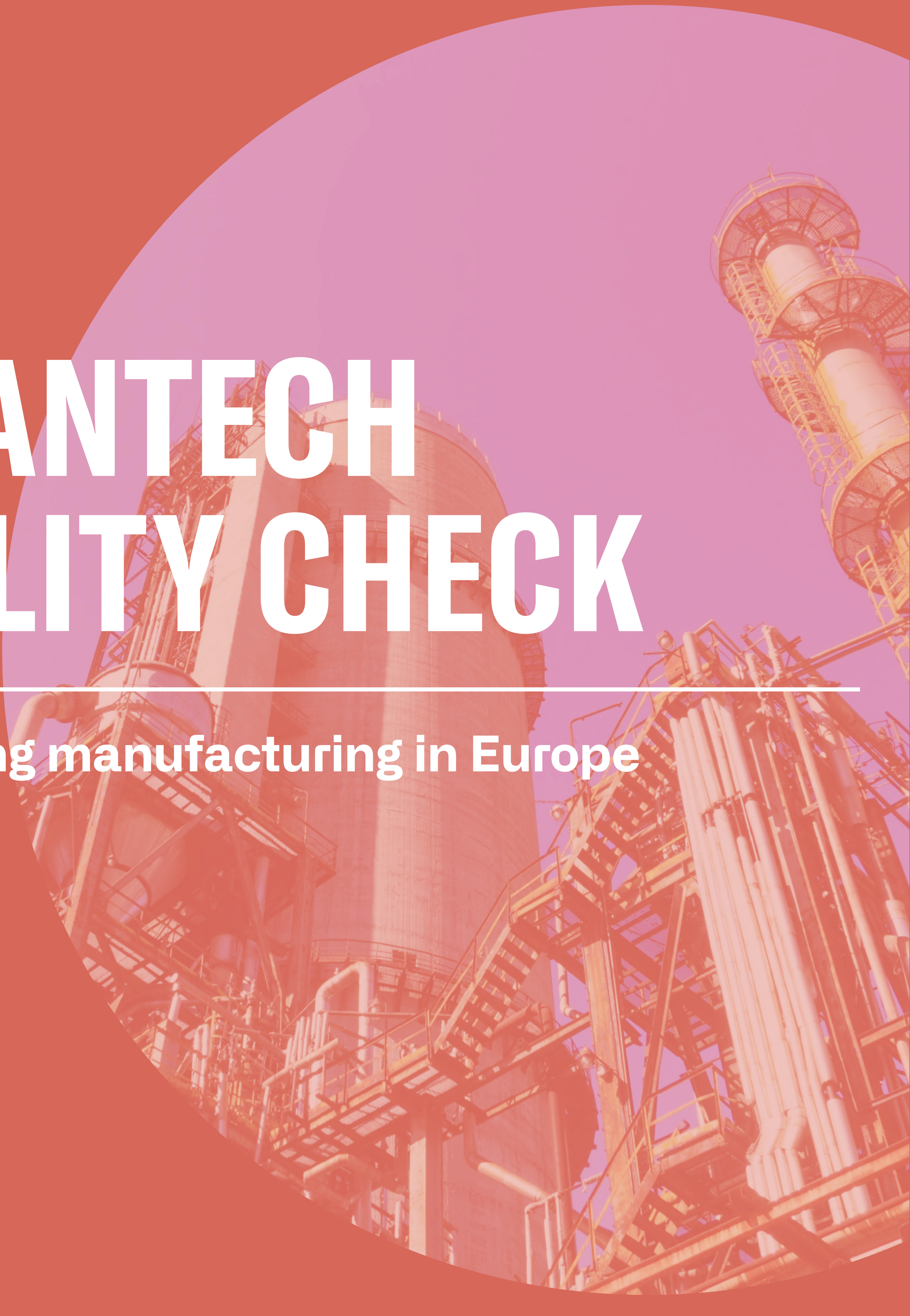
Breakthrough Energy

Cleantech for Europe

With analyses led by SYSTEMIQ



CLEANTECH REALITY CHECK

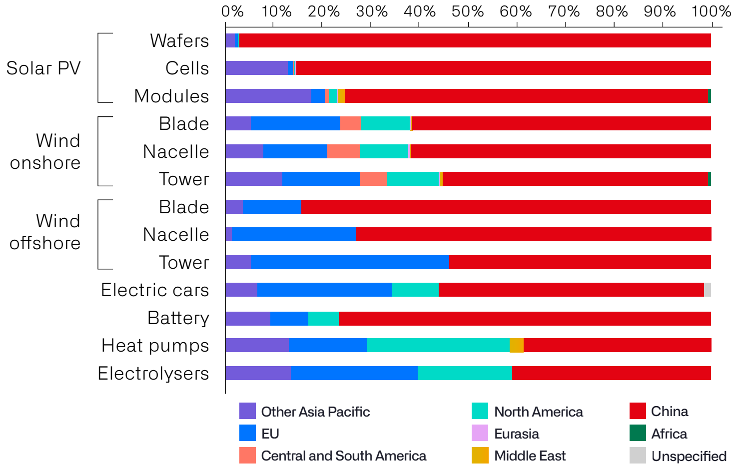
Revitalising manufacturing in Europe

AVERTING INDUSTRIAL DECLINE: REVITALISING MANUFACTURING IN EUROPE

By **Ann Mettler,** Vice President - Europe and **Julia Reinaud**, Senior Director - Europe, **Breakthrough Energy**

- Europe is at a crossroads. In his analysis published in September 2024, Mario Draghi highlighted an "existential risk" and forecast Europe's "slow agony" if it doesn't radically change course to reverse declining productivity, investment, and innovation. Recent announcements only seem to confirm this dire prediction: industries are reducing production across Europe (Volkswagen[1], thyssenkrupp Steel[2]); announced investments are being cancelled or put on hold (Northvolt[3], ACC Gigafactories[4]), and industrial output in Europe's four largest economies is declining, with Germany, France, Italy and Spain having recorded a year-on-year drop in the production of capital goods and consumer durables.[5]
- There is no denying it: Europe is in crisis, one in which its established industrial base is eroding while new sectors fail to get off the ground. This is particularly concerning for cleantech where Europe's ambitions are high, but the economic realities are sobering. As the recent bankruptcy of Northvolt reminds us, even with solid industrial policy in place, it is hard to scale up in Europe. Turning this situation around will be one of the overriding priorities of the new European Commission, which has recently unveiled the Competitiveness Compass and will soon produce the Clean Industrial Deal, two new (long overdue) economic and industrial policy programs. In a volatile security and fractured geopolitical environment, with looming threats of trade wars and deepening systemic competition, European policymakers have their work cut out for them.

Clean technology manufacturing by region[7]
GW, %, 2021



- While the multitude of threats can seem overwhelming, they make sustaining the current manufacturing base and building out new capacity all the more important. The good news is that Europe has inherent strengths which it must now quickly capitalise on: one of the world's most highly skilled workforces, supported by strong education systems and a robust healthcare infrastructure that fuels innovation and resilience. The EU and other European countries excel in the early stages of green innovation, together accounting for almost 27% of global cleantech patents between 2017–2021, ahead of Japan (21%), the US (20%) and China (15%).[6] The key now will be to finally turn these assets into tangible economic outcomes, reasserting technology leadership and demonstrating that a resource-poor geography with now structurally higher energy prices as a result of the war in Ukraine can be the perfect springboard for clean, innovative manufacturing at scale.

- In this third series of our Cleantech Reality Check, we home in on three sectors of critical importance for Europe's – old and new – industrial base. In the former camp, we analyse steelmaking, long a pillar of Europe's industrial heritage, which faces a dual challenge: enhancing productivity in an intensely competitive global market that suffers from overcapacity, while also cutting emissions. In the latter category, we examine batteries and electrolysers, two pivotal clean technologies vital to the world's green transition and Europe's competitiveness agenda, both of which are scaling far too slowly to meet ambitious targets and build out global market share.

- As we outlined in the first part of this Cleantech Reality Check series, our objective is to provide fact-based, real-time analysis of key technology and policy areas. This data-driven approach is complemented with key recommendations on how to improve performance and accelerate progress. As the following analysis indicates, while Europe faces formidable challenges in steel, batteries and electrolyers, decisive action now can lead to a future turnaround in fortune.

1: Source: VW's announcement: https://www.carexpert.com.au/car-news/volkswagen-announces-future-layoffs-production-changes-to-cut-costs
2: Source: Thyssenkrupp Steel announcement: https://www.reuters.com/markets/commodities/thyssenkrupp-steel-reduce-production-capacity-cut-jobs-2024-04-11
3: Source: Northvolt announcement: https://www.reuters.com/markets/deals/northvolt-subsidiary-files-bankruptcy-2024-10-08/
4: Source: ACC Gigafactory announcement: https://www.automotivelogistics.media/battery-supply-chain/acc-halts-construction-of-two-european-gigafactories/45724.article
5: Source: Industrial production down by 0.3% in the euro area and by 0.1% in the EU (2024), Eurostat
6: Source: Financing and commercialisation of cleantech innovation (2024), European Patent Office and European Investment Bank
7: Source: The future of European competitiveness – A competitiveness strategy for Europe (2024), Mario Draghi, based on data from IEA and Bruegel

The Cleantech Reality Check is published jointly by Breakthrough Energy and Cleantech for Europe, with analytical support provided by Systemiq

CLEANTECH REALITY CHECK

REVITALISING MANUFACTURING IN EUROPE

As highlighted in the Draghi report[1] (2024), maintaining growth and productivity is an "existential challenge" for the EU. This reality check assesses five dimensions of EU industry competitiveness, before going in more depth in three key sectors from traditional industry (steel) and new clean technologies (batteries and electrolysers).

STAGNATING COMPETITIVENESS AND PRODUCTIVITY

EU competitiveness and productivity have **stagnated over time**, and the **EU is falling behind** the U.S. and China. High energy prices, slower labour productivity growth, and a deteriorating trade balance, particularly in high-tech and energy-intensive sectors, underscore the EU's challenges in maintaining its global economic position.

Energy prices[2]

2022

Industrial power prices

2-3x

v USA and china

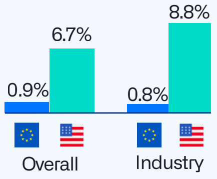
Industrial gas prices

4-5x

v USA

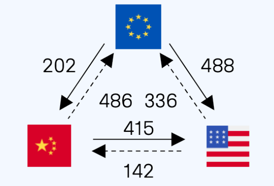
Labor productivity growth[3]

% between Q4-2019 and Q2-2024



Trade balance[4]

€ billion, 2023, goods only



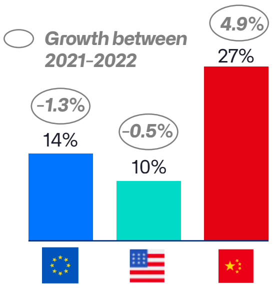
EU runs a negative trade balance with China, but a positive trade balance with the US

CONCERNING SIGNS OF MANUFACTURING DEINDUSTRIALISATION

Looking at the manufacturing sector, the EU shows **concerning signs of deindustrialisation** with a slowly declining manufacturing share of GDP, reduced employment in the sector, as well as increased site closures and relatively lower foreign direct investment (FDI) in its industry compared to the U.S. and China, which have fostered stronger industrial policies and attracted more investment in advanced manufacturing.

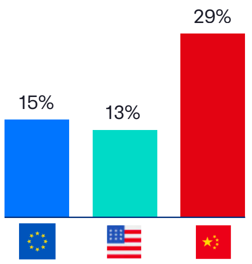
Manufacturing share of GDP[5]

% of GDP, 2022



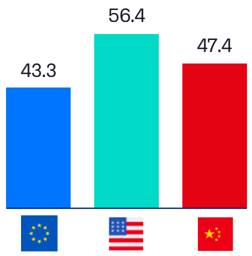
Employment in manufacturing[6]

% of total workforce, 2023



Foreign Direct Investment (FDI)[7]

FDI inflow directed toward manufacturing, € billions, 2023



BEST-IN-CLASS CARBON INTENSITY AND ENERGY EFFICIENCY OF INDUSTRY

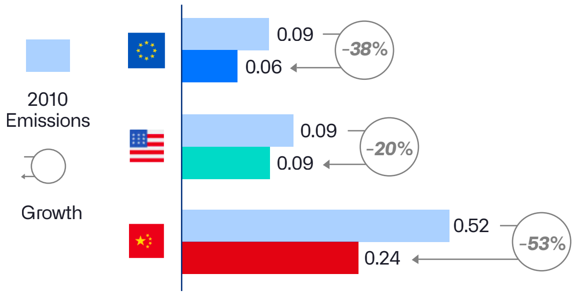
The EU has made **progress in reducing the carbon and energy intensity of its manufacturing and industry**, becoming less carbon intensive than the USA and China.

The reduction in carbon intensity is driven not only by a decrease in industrial activity but also by improvements in energy efficiency and production methods across Europe.

However, China is decarbonising and becoming energy efficient at a faster rate than the EU, aided by the very rapid rate of electrification in the past couple of years.

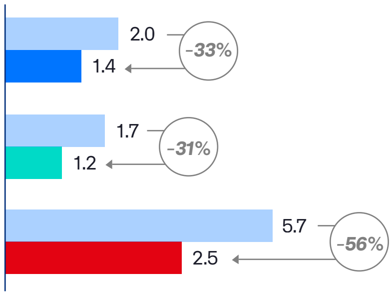
Carbon intensity of industry[8]

tons of CO_2 per € million, 2010 vs 2022

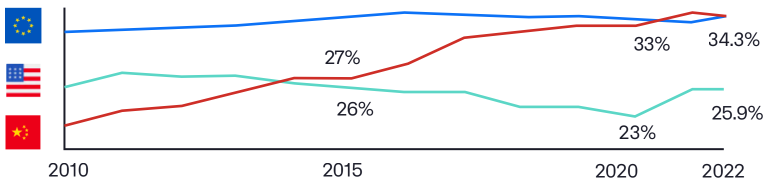


Energy intensity[8,9]

tons of CO_2 per € million, 2010 vs 2022



Rate of electrification in industry[10]



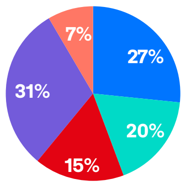
CLEANTECH REALITY CHECK

REVITALISING MANUFACTURING IN EUROPE

EXCELLENCE IN CLEAN TECHNOLOGY INNOVATION DESPITE TRAILING IN STRATEGIC AREAS

Cumulative cleantech international patent family filings[11]

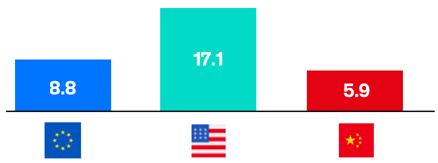
2017-2021



While Europe is one of the leaders in filing of patents, it is also the region that makes less use of them in real world applications

Venture capital investment in clean technologies

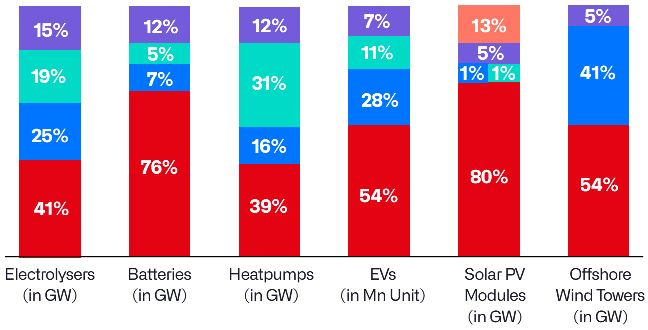
€ Billions, 2024[12]



China's investement might be underrepresented due to lack of publicly available data

Clean technology manufacturing capacity

Operational capacity, % of total, 2021[13]



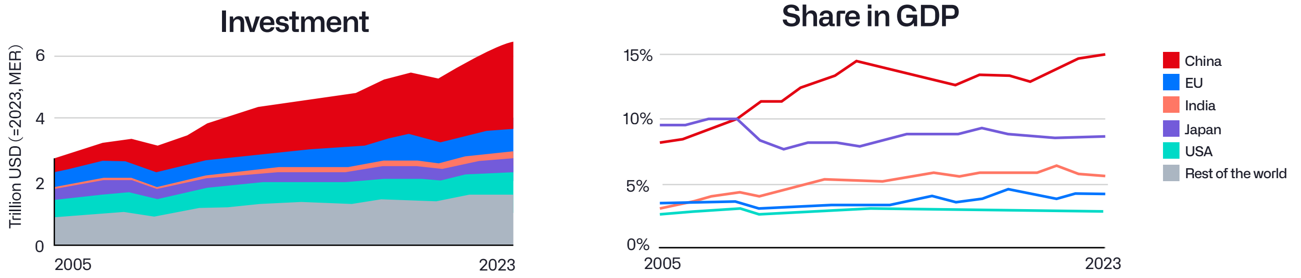
🟩 USA 🟦 EU 🟥 China 🟪 Other Asia Pacific 🟧 Rest of the world

In terms of **clean technology innovation,** the EU has **held on to its firm share of technology manufacturing** in several areas, excelling most in the wind industry. However, the EU is trailing behind or facing a risk of losing position for several technologies (batteries, heat pumps, solar PV), even to regions other than China, due to uncertainty regarding financing, demand and Europe's inability to scale.

EU'S LAGGING INVESTMENT SHARE

Despite absolute growth in manufacturing investment, the EU's share of global manufacturing investment has dwindled compared to China's explosive growth. While the EU and US have maintained a relatively constant manufacturing investment share of GDP (around 3-4%), China's share has more than doubled to nearly 15%, and Japan, even after a contraction, maintains a higher share at around 9%.

Manufacturing sector investment by country/region, 2005-2023.[14]



This disparity is particularly evident in clean technology, where China's dominance has been growing.

In the rest of this Cleantech Reality Check series, we will take a closer look at three key sectors that are among the most important for Europe's decarbonisation efforts: primary steelmaking, battery manufacturing, and electrolyser production.

Notes: 1. EU competitiveness: Looking ahead - European Commission (Draghi, 2024), 2. Data derived from average spot market price in relevant countries from 2022-2024, 3. Sourced from Labour productivity growth in the Euro area and the United States: short and long-term developments, labour productivity in $ per hour, from 2019 to mid 2024 (ECB Economic Bulletin, 2024) 4. For goods only, including non-industrial goods. Sourced from EuroStat, EU-US Trade Data by Consilium, USA Census Data for Trade. 5. Data sourced from latest data available for Share of manufacturing in gross domestic product (GDP) from Our World in Data by Global Change Data Lab 6. Data sourced from latest data available for Manufacturing jobs as a share of total employment from Our World in Data by Global Change Data Lab. 7. FDI is derived for manufacturing sector, including non-industrial goods. Data is derived from multiple sources, including EUR-Lex and US Bureau of Economic Affairs. 8. Carbon intensity is derived from Greenhouse Gas Emissions from Industry from International Energy Agency and GDP contribution from manufacturing data from Our World in Data by Global Change Data Lab. 9. Energy intensity is derived from Energy Consumption in Industry from International Energy Agency and GDP contribution from manufacturing data from Our World in Data by Global Change Data Lab. 10. Rate of Electrification is derived from electricity portion in final power consumption in Industry, from International Energy Agency. 11. Sourced from European Patent Offices' Financing and Commercialisation of Cleantech Innovation report (2024). 12. A Cleantech Investment Plan for European Competitiveness: How the EU can become the industrial and climate leader of the next decades (Cleantech for Europe, 2023). 13. Based on available data from Draghi Report and European Commission, 2024, which are based on IEA, Bruegel, 2024. 14. IEA (2024), Energy Technology Perspectives 2024

CLEANTECH REALITY CHECK

REVITALISING MANUFACTURING IN EUROPE

- The EU's industrial leadership faces a critical juncture. Steel, the backbone of its industrial base, is losing its global edge due to supply constraints, project cancellations, and reduced capacity, all while navigating an increasingly uncertain and volatile international trade environment. Meanwhile, batteries and electrolysers—essential technologies for the energy transition with multi-billion-dollar market potential—struggle to compete with cost leaders like China.
- This Cleantech Reality Check outlines the urgent steps needed to safeguard the EU's position in industrial manufacturing, particularly in clean technology. It emphasises ensuring that the EU's leadership in research and development translates into tangible industrial success, preserving its competitiveness in the global race for innovation.

OFF-TRACK **ON-TRACK**

	IRON & STEEL	BATTERY MANUFACTURING	ELECTROLYSER MANUFACTURING
	Off Track: Decarbonising European steel is crucial for reducing emissions, preserving jobs, and maintaining technological leadership. European governments have provided unprecedented public support to the sector for capital expenditures, but operational costs (especially energy) remain a serious concern. Decisions on first-of-a-kind (FoaK) projects are facing delays, with project developers citing low confidence in the current CBAM design to level the playing field and insufficient premiums for low-emissions production as challenges to investment decisions. Currently ~50% of the 10Mt H2-DRI capacity at FID is at risk of delays and cancellation following statements from project developers.	**At Risk:** With planned capacity expansions, the European battery manufacturing sector demonstrates potential to achieve the Net Zero Industry Act's 400 GWh/yr domestic demand target by 2030. However, realising this potential requires a doubling of manufacturing capacity from the 200GWh/yr operational today and addressing significant challenges that are reversing momentum: project cancellations and delays, a persistent cost gap with China and the US, a technological disadvantage, and slowing demand from the automotive sector all threaten EU competitiveness.	**At Risk:** Electrolyser manufacturing is crucial for Europe's energy security, industrial decarbonisation, and technological leadership. While major support has been mobilised through initiatives such as the Innovation Fund, IPCEI, and European Hydrogen, 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 capacity by 2030	**15-20 Mt** **of low-carbon primary steel**	**400 -550 GWh** **of battery production capacity**	**15-20 GW/yr** **of electrolyser production capacity**
Projects reaching announcements and FID	<1 Mt operational, 10 Mt H2-DRI capacity has reached FID, however 50% are at risk of delays or cancellation.	~200 GWh/yr operational ~350-400GWh/yr total operational expected by 2026 1,500–1,800 TWh announced by 2030	9 GW/yr operational in 2025 4 GW/yr reached FID and under construction
Required additions to 2030	Additional 5-10 Mt capacity in addition to projects with FID secured	Completing existing planned capacity	up to 7-11 GW additional production capacity added, depending on demand realisation
Cost premium and cost competitiveness	**20-40% gap** (cost increase over conventional European primary steel production) **550-600 €/t** for conventional route **700-850 €/t** cost for green route	**20-30% gap** (cost in €/kWh) 🇪🇺 vs 🇨🇳 LFP **65-75** vs **40-50** NMC **71-86** vs **60-70**	**70-80% gap** (cost in €/kW) SYSTEM PRICE / STACK PRICE 🇨🇳 ALK 400-750 €/kW 100-150 €/kW 🇪🇺 🇺🇸 ALK 1,900+ €/kW 300-500 €/kW 🇪🇺 🇺🇸 PEM 2,000+ €/kW 550-750 €/kW
What has been working well	Carbon pricing set to close the cost premium gap Initial demand signals and advanced market commitments Foundations for low-carbon technology are in place	Targets for phase out of ICE car sales Offtake commitments from the automotive industry Strong EU-level support for the sector	Strong EU technological leadership Comprehensive policy framework established Significant manufacturing capacity in place
What is has not been working well	High electricity and low-carbon electrolytic hydrogen prices undermine EU competitiveness Slow progress of retrofit projects compared to greenfield builds Insufficient demand from key steel-intensive sectors	Loss of momentum in EV registrations and project cancellations Cost gap with chinese manufactured batteries Reliance on imported battery minerals	Slower than anticipated low-carbon electrolytic hydrogen demand Overcapacity and heavy subsidies from international competitors Risks in raw materials supply

Notes: All sources for data points are provided in the three sectoral briefs for Series 3.

CLEANTECH REALITY CHECK

REVITALISING MANUFACTURING IN EUROPE

ARE THE ENABLING CONDITIONS FOR RAPID SCALE UP IN PLACE?

🟩 In place and sufficient
🟧 In place and insufficient
🟥 Missing
⬛ No applicable

DEMAND ENVIRONMENT ENCOURAGES EARLY OFFTAKE

🟥	🟧	🟧	Lead markets are fostered with targets and financial support (i.e., tax breaks, auction mechanisms)
🟥	🟩	🟧	Sufficient GHG reduction targets and technology phase out dates for downstream markets
🟥	🟧	🟧	Minimum EU content requirements for manufacturers and product buyers

SUPPLY ENVIRONMENT ENABLES ECONOMIES OF SCALE

🟥	🟩	🟧	Credible production targets are legislated, setting an ambitious but feasible horizon
🟧	🟧	🟧	Financial support with preferential planning & permitting adequately levels the playing field
🟥	🟩	🟩	Technology, skills and enabling infrastructure (e.g., grid capacity, EV charging) is mature to meet required scale up

MARKET IS FACILITATED AND COORDINATED

🟥	🟥	🟩	Uniform EU-wide green product definitions, standards and regulation
🟥	🟧	🟩	Non-price sustainability and resilience criteria defined for downstream markets
🟧	🟩	🟥	Voluntary market instruments and mechanisms are established

ACTION AGENDA

Key actions and interventions areas to develop the EU manufacturing in key sectors

	IRON & STEEL	BATTERIES	ELECTROLYSERS
1	Ensure policy ambition and continuity for investor confidence	De-risk strategic battery manufacturing investments	Strengthen domestic demand certainty for low-carbon electrolytic hydrogen via creation of lead markets and de-risking mechanisms
2	Accelerate affordable low-carbon energy access	Incentivise local battery demand and prioritise EU content	Further Europe's technological lead
3	Develop solutions to improve market financing conditions by earmarking ETS revenues	Strengthen raw material supply resilience through domestic sourcing, diversification and recycling infrastructure.	Level the playing field against imports
4	Stimulate demand through green product standards and public procurement		Bridge the cost gap

Breakthrough Energy

Cleantech *for* Europe

With analyses led by

SYSTEMIQ

CLEANTECH REALITY CHECK

MANUFACTURING - STEEL

Forging a Competitive Future

Breakthrough Energy

Cleantech *for* Europe

With analyses led by

SYSTEMIQ

CLEANTECH REALITY CHECK

MANUFACTURING - STEEL

Forging a Competitive Future

What is green steel ?

Steel production accounts for 4-6% of annual CO_2 emissions in the EU, 80% of which originates from primary steel or iron-making processes.

The blast furnace-basic oxygen furnace (BF-BOF) route accounts for ~60% of EU crude steel production, relying on metallurgical coal as a reducing agent, sintered iron ore feedstocks, scrap steel, limestone flux, and hot-air blast injected at temperatures exceeding 1,200°C. This integrated steelmaking process emits 1.8–2.2 tCO_2 per tonne of steel, contributing to the sector's 25% share of EU industrial emissions.

The remaining 40% is produced through secondary steelmaking, utilising scrap steel and other ore-bearing metallics in electric arc furnaces (EAF), emitting ~0.5 tCO_2 per tonne of steel.

Direct Reduced Iron (DRI) is Europe's foremost decarbonisation pathway, offering a scalable transition from natural gas to green hydrogen while leveraging existing infrastructure. With at least 5 Mt of hydrogen-DRI capacity already funded, it outperforms alternatives like CCS and electrolysis in technical readiness, job retention, and export competitiveness

Key take-aways

- The EU steel industry has the potential to service the growing global demand for steel products as a market leader in low-carbon technologies, such as hydrogen-based direct reduced iron (H2-DRI) technology and electric arc furnaces. Yet, the sector faces major challenges despite more than €10 billion in public funding and 10 Mt of H2-DRI capacity reaching Final Investment Decision as of December 2024.
- The steel industry is a cornerstone of the European economy, directly employing 310,000 individuals while indirectly supporting 2.2 million jobs across various sectors. Beyond its economic contributions, the industry is pivotal in bolstering Europe's industrial autonomy, particularly within critical supply chains, including defence.
- Low-carbon primary steel currently carries a 20-40% cost premium, and projects face potential delays due to concerns about policy inconsistency, demand for low-emissions products, and falling profitability.
- To accelerate green steel adoption, the EU must maintain robust carbon pricing policies, simplify and expedite permitting, target public funding to FoaK deployments, ensure competitive low-carbon electricity and low-carbon electrolytic hydrogen prices, and stimulate demand through green product standards and procurement mandates, such as the ones covered in the Net Zero Industrial Act (NZIA), in key sectors like automotive and construction.

PRIMARY STEELMAKING

FORGING A COMPETITIVE FUTURE

STRATEGIC IMPORTANCE FOR EUROPE

- Steel decarbonisation is crucial for Europe to achieve its 2030 and 2050 climate goals, accounting for 4-6% of total CO2 emissions and 25% of industrial CO2 emissions annually.[1,2]
- Transitioning to green steel production is vital for maintaining Europe's economic competitiveness, preserving 2.6 million jobs, and safeguarding the €152 billion annual contribution to the EU economy against global overcapacity and rising production costs.[1]
- Low-carbon steel is fundamental to enabling clean technology value chains in Europe, supporting the expansion of renewable energy infrastructure and meeting the growing demand for green materials in the automotive and construction sectors. It is also essential to non-energy sectors, including defence, where strategic autonomy is valued.

CURRENT PROGRESS OF IRON & STEEL IN THE EU

STATUS : OFF TRACK Decarbonising European steel is crucial for reducing emissions, preserving jobs, and maintaining technological leadership. European governments have provided unprecedented public support to the sector for capital expenditures, but operational costs (especially energy) remain a serious concern. Decisions on first-of-a-kind (FoaK) projects are facing delays, with project developers citing low confidence in the current CBAM design to level the playing field and insufficient premiums for low-emissions production as challenges to investment decisions. Currently ~50% of the 10Mt H2-DRI capacity at FID is at risk of delays and cancellation following statements from project developers.

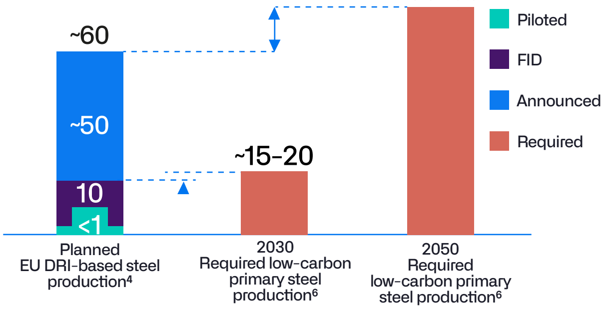
REQUIRED : **15-20 Mt** of low-carbon primary steel required by 2030[3]

PROGRESS : **~10 Mt** H2-DRI steel capacity has reached FID.[4,5] However, **~50%** of this capacity is at risk of delays and cancellation following statements from project developers[5]

POLICY UNCERTAINTY, LOW CONSUMER WILLINGNESS-TO-PAY AND FALLING MILL PROFITABILITY ARE DELAYING FIRST-OF-A-KIND (FOAK) PROJECT DECISIONS

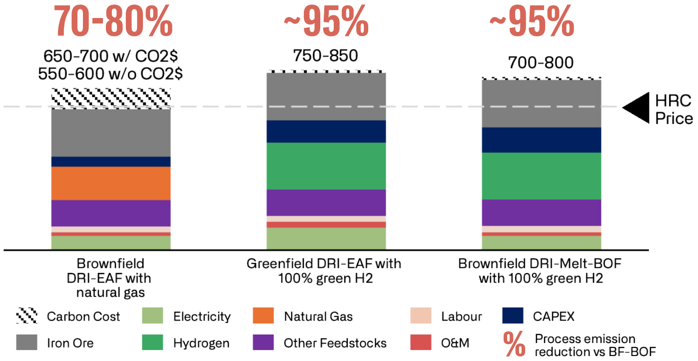
- The EU hosts >50% of global low-carbon steel projects (60+ initiatives as of 2024), with 10 Mt of hydrogen-DRI (H_2-DRI) capacity reaching Final Investment Decision (FID).[4] However, ~50% of approved projects face delays or cancellations, driven by high hydrogen costs (€5–6/kg vs target of €3/kg) and potentially limited scrap availability. Scrap supply constraints could limit both primary and secondary steelmaking growth.
- European governments allocated >€10 billion in public grants to accelerate steel decarbonisation projects.[6] However, only 12% of EU blast furnaces have approved retrofit plans, in contrast to over 40 greenfield DRI projects.

Low-carbon primary steel production capacity in the EU, Mt



BRIDGING THE COST PREMIUM FOR LOW-CARBON STEEL IS CHALLENGING, WITH ELECTRICITY PRICE AND CARBON PRICING BEING THE MAIN LEVERS TO SOLVE THE BUSINESS CASE

Levelised Cost of Steel (LCOS) by production technology in 2030[7], €/tonne crude steel



HRC: Hot-rolled coil steel

- The planned phase-out of "free allocation" of allowances in the ETS could increase the cost of steel produced via conventional BF-BOF technology by ~€120–200/tonne of steel, narrowing this cost premium within the EU.
- Trade measures, such as the CBAM, can provide some protection against the import of cheaper, more emissive steel products from outside the EU.
- Improving the competitiveness of EU industrial power prices is critical to closing the remaining cost premium and competing with low-carbon producers internationally.
- Additional supply and demand-side policy support (e.g., guarantees, mandates, etc) will be needed to bolster the investment case for new projects in the near term.

PRIMARY STEELMAKING

FORGING A COMPETITIVE FUTURE

ENABLERS – WHAT IS GOING WELL

CARBON PRICING SET TO CLOSE THE COST PREMIUM GAP

The ETS's declining cap is driving carbon prices up, and the withdrawal of free allowances will reduce the premium gap between low-carbon and existing production routes. Carbon pricing within the ETS and the upcoming Carbon Border Adjustment Mechanism (CBAM) will provide protection from cheaper imported higher emissivity steel if the agreed timeline is adhered to.

INITIAL DEMAND SIGNALS AND ADVANCED MARKET COMMITMENTS

Voluntary commitments and long-term offtake agreements from companies in steel-intensive end use markets have seeded initial demand signals for steel companies to invest in low-carbon technologies. These signals provide rising (though insufficient) confidence of durable demand for deeply decarbonised primary steel for project developers.

FOUNDATIONS FOR LOW-CARBON TECHNOLOGY ARE IN PLACE

The EU is a leader in low-carbon steel innovation and pioneer projects, accounting for the majority of announced projects worldwide. Although many DRI-based projects will initially operate using natural gas, the commitment to DRI-based technology is the first step in the transition to low-carbon feedstocks, processes and steelmaking when deployed in combination with EAF steelmaking and in parallel to scrap-based EAF technology.[8]

BARRIERS – WHAT IS NOT GOING WELL

HIGH ELECTRICITY AND LOW-CARBON HYDROGEN PRICES UNDERMINE EU COMPETITIVENESS

Electricity costs (~35–50% of H_2-DRI production costs) average €66/MWh in the EU—significantly higher than competing regions like China and the US (€43–50/MWh), challenging the competitiveness of EU EAF production. Low-carbon hydrogen costs remain prohibitively high at €5–6/kg, far exceeding the target of €2–3/kg needed for H_2-DRI to compete with BF-BOF production routes.[7] Long lead times for permitting and grid connections also add cost. Without substantial reductions in electricity taxes, grid fees, or expanded renewable and nuclear capacity, low-carbon steelmaking will struggle to achieve cost parity by 2030.

SLOW PROGRESS OF RETROFIT PROJECTS COMPARED TO GREENFIELD BUILDS

Despite receiving over €10 billion in public subsidies,[8] only 12% of EU blast furnaces have approved retrofit plans for carbon capture and storage (CCS), compared to over 40 greenfield DRI projects. Retrofitting existing assets faces significant barriers, including high upfront costs (€1.2–2 billion per plant) and declining steel consumption across Europe is calling these investment into question.[9]

INSUFFICIENT DEMAND FROM KEY STEEL-INTENSIVE SECTORS

Demand for green steel remains insufficient across key sectors such as construction, automotive, appliances, and heavy machinery—(collectively ~ 80% of EU steel consumption). Ongoing economic slowdowns and the influx of cheap imports (up by 12% in 2024) threaten the business case for green steel. Without stronger policy mandates or public procurement reforms, the market risks stagnating before reaching critical mass.

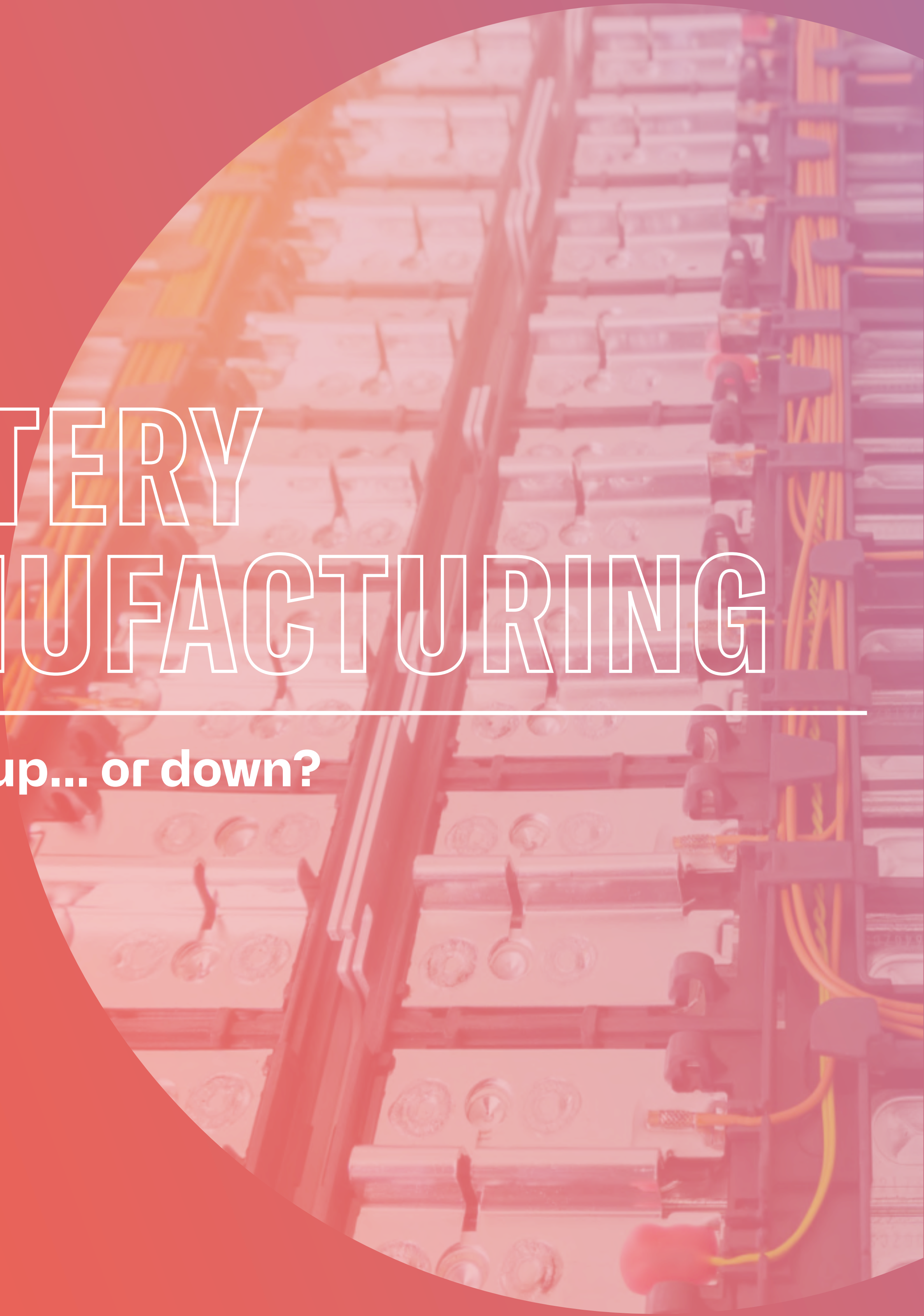
ACTION AGENDA – WHAT NEEDS TO BE DONE

1. **Ensure policy ambition and continuity for investor confidence.** If implemented consistently, the EU ETS and CBAM are projected to close the green cost premium by the early 2030s. However, exports will remain uncompetitive without an export rebate, and potential circumvention loopholes must be addressed. Delays or dilution would put already-announced projects at risk.
2. **Accelerate affordable low-carbon energy access.** Fast-track permitting, prioritising grid access for lower-carbon steel plants and related low-carbon power and expanding the use of guarantees and risk-reduction instruments to facilitate long-term power purchase agreements (PPAs) to provide low-carbon energy access. Reduce electricity taxes and grid fees, alongside accelerated investments in renewable energy infrastructure. Consider options to incentivise industrial customers to provide voluntary demand flexibility services and explore EU-wide indirect CO_2 cost compensation. Target low-carbon electrolytic hydrogen cost reduction via the European Hydrogen Bank and infrastructure scaling through coordination of the Connecting Europe Facility, IPCEI Hy2Infra, and REPowerEU Hydrogen Backbone.
3. **Develop solutions to improve market financing conditions by earmarking ETS revenues.** Expand financial mechanisms such as Contracts for Difference (CfDs), financial guarantees, and credit-linked guarantees to de-risk investments in decarbonisation technologies. Leverage ETS revenues—expected to exceed €200 billion by 2030—to provide targeted support for both capital expenditure (CAPEX) and operational expenditure (OPEX) for FoaK green steel projects.
4. **Stimulate demand through green product standards and public procurement.** Introduce standardised low-carbon criteria for public procurement under the NZIA and the forthcoming Clean Industrial Deal (CID) to mobilise demand. Create lead markets targeting a proportion of green steel use in automotive manufacturing and construction projects before 2030, supported by transparent labelling systems, tax incentives for product purchase and harmonised standards.

> "The technology for green steel is here and investments in decarbonisation are taking place. To secure these ongoing and future industrial investments, the EU must maintain its course with the Green Deal and the enacted Fit for 55 package. We welcome the Clean Industrial Deal as a complement to the Green Deal and see the potential to increase Europe's competitiveness, innovation and number of investments"
>
> **Maria Persson Gulda,** Chief Technology Officer, **Stegra**

References

[1]Based on EUROFER's 2024 Annual Report
[2] Based on the Future of Steelmaking, Roland Berger (2021)
[3] World Steel in Figures 2024 – World Steel Association
[4] Based on Mission Possible Partnership's Green Project Tracker and Global Energy Monitor's Global Steel Plant Tracker (2024).
[5] 3-5 Mt (50% of 10 that reached Final Investment Decision) are considered at risk is based on ThysenKrupp and ArcellorMittal's organizational announcements on company performance the impact towards sustainability commitments.
[6] Based on EU's portion of required low-carbon steel supply-demand projection in a Carbon Cost scenario, which is aligned with 1.5°C Scenario, from Mission Possible Partnership's Steel Sectoral Transition Strategy and the assuming 30% of this low-carbon steel production route is achieved via H^2-DRI by 2030 as per required to reach 2050 90% decarbonisation target in EUROFER's Low Carbon Roadmap Pathways to a CO^2 neutral European Steel Industry report, assuming BF-BOF route produces 1.9 to 2.3 MtCO^2e per tonne of steel produced.
[7] Majority of the 50 Mt projects announced will use natural gas as a short-term energy/feedstock source before transitioning to Green H^2 based production, based on expert interviews
[8] Based on EU State Aid given to steel producing companies in 2023-2024, from GMK Center European countries granted €10.5 bln for decarbonization of the steel sector in 2023-2024 — GMK Center.
[9] Cost of production is based on Agora Industry, Wuppertal Institute and Lund University (2024): Low-carbon technologies for the global steel transformation. A guide to the most effective ways to cut emissions in steelmaking.
[10] Based on 2030 Landed Cost of Hydrogen (LCOH) calculation from multiple low-carbon electrolytic hydrogen producing regions to Germany by Aurora Energy Research (2023) Aurora Energy Research publishes study on the cost of imported hydrogen: Bayern Innovative



BATTERY MANUFACTURING

Powering up… or down?

Breakthrough Energy

Cleantech for Europe

With analyses led by

SYSTEMIQ

CLEANTECH REALITY CHECK

BATTERY MANUFACTURING

Powering up... or down?

What are batteries?

Batteries are essential for storing electricity (particularly from intermittent renewable energy sources) and powering an electrified economy. Batteries are anticipated to be deployed mostly for the mobility sector (~70% of demand) and grid balancing (~25% of demand), with the remainder for consumer electronics and industrial applications. There are several affordable battery chemistries on the market. Each serves a different purpose:

- Lithium iron phosphate battery (LFP) has a lower energy density (Wh per kilogram) but is made from more abundant materials, making it the affordable choice in the market. It is mainly used in affordable electric vehicles (EVs) and stationary storage.
- Lithium nickel manganese cobalt oxide (NMC) offers higher energy density but at a higher cost than LFP as it requires more expensive materials that carry higher supply chain risks.
- Other chemistries, such as sodium-ion and flow batteries, are emerging as a low-cost option for stationery storage. For EVs, novel battery technologies such as solid-state batteries show promise with higher energy density and safety.

For this series we focus on the main commercial volume lithium-ion battery chemistries, LFP and NMC.

Key take-aways

- The EU battery demand is expected to reach ~1,000 GWh by 2030. Currently only ~200 GWh of battery manufacturing capacity is operational and the EU relies heavily on Chinese imports of materials to support the capacity.
- To meet the Net Zero Industry Act (NZIA) goal of fulfilling 40% of EU demand domestically, an additional 200 GWh/year of manufacturing capacity must be operational by 2030[1].
- Achieving the European Battery Alliance (EBA) target of 550 GWh/year will require an even larger increase—around 350 GWh/year in additional capacity.
- The announced project pipeline suggests that meeting these targets is feasible, as the low-risk projects far exceed the required capacity. However, a significant portion of this pipeline is under non-EU ownership, indicating a need for an onshoring strategy.
- European plants face intense cost competition, with Chinese battery cells expected to remain materially lower cost.[2] Over half of Europe's operational and planned battery cell assembly still depends on imported materials, highlighting a vulnerability in the supply chain.
- The lack of a circular value chain for recycling materials exacerbates this issue. Production scrap during factory ramp-up is often exported to Asia, missing opportunities to recover critical materials within Europe.

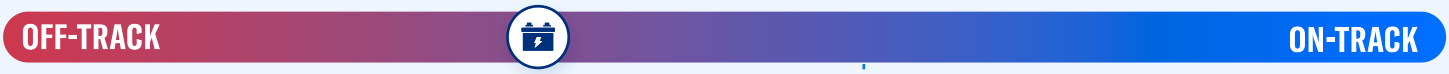
BATTERY MANUFACTURING

POWERING UP... OR DOWN?

STRATEGIC IMPORTANCE FOR EUROPE

- **Enable the transition.** Increasing battery manufacturing capacity is crucial to enable a clean energy system that can achieve the EU's net-zero goals. The sectors with the greatest demand for batteries, power and mobility, currently account for ~35-40% of the region's total GHG emissions.[3]
- **Reduce the EU's reliance on battery imports.** The EU currently imports 10-15% of its annual demand.[4] Battery imports expose the automotive industry to supply chain risks (as demonstrated during COVID), reduce opportunities for regional value creation, and threaten long-term competitiveness, as batteries account for ~15–30% of an EV's total cost.[5]
- **Increase EU green jobs.** The battery sector is projected to grow from employing ~500,000 people today to ~1.5 million in 2030, potentially reaching ~5 million by 2050. This will be driven by growth in EV manufacturing, recycling, and raw materials.[6]
- Capture the €40–60 billion economic opportunity that the battery manufacturing value chain represents for the EU.[7]

CURRENT PROGRESS OF ELECTROLYSERS MANUFACTURING IN THE EU



STATUS : AT RISK With planned capacity expansions, the European battery manufacturing sector demonstrates potential to achieve the Net Zero Industry Act's 400GWh/yr domestic demand target by 2030. However, realising this potential requires a doubling of manufacturing capacity from the 200GWh/yr operational today and addressing significant challenges that are reversing momentum: project cancellations and delays, a persistent cost gap with China and the US, a technological disadvantage, and slowing demand from the automotive sector all threaten EU competitiveness.

REQUIRED :

400-550 GWh/yr production capacity by 2030[1]

PROGRESS :

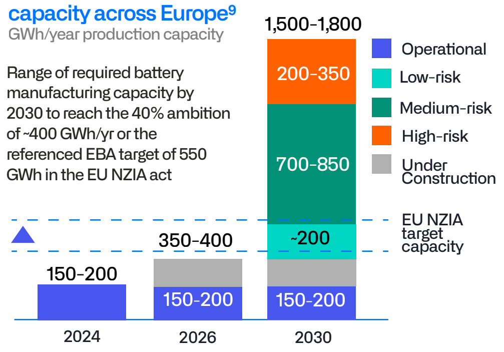
150-200 GWh/yr operational today[8]

350-400 GWh/yr expected total to be online by 2026

1,500-1,800 GWh/yr total capacity inc. announced to be operational by 2030[8]

THE EU BATTERY MANUFACTURING SECTOR FACES SIGNIFICANT CHALLENGES, COMPOUNDED BY A LIMITED DOMESTIC RECYCLING VALUE CHAIN.

Risk classification of planned battery manufacturing capacity across Europe[9]



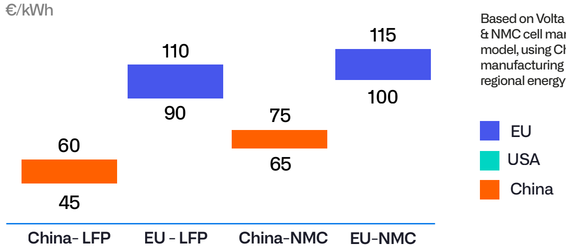
Range of required battery manufacturing capacity by 2030 to reach the 40% ambition of ~400 GWh/yr or the referenced EBA target of 550 GWh in the EU NZIA act

Risk classification based on assessment of key factors such as secured funding, secured location, construction status & permits, investments from EU OEMs /support from EU institutions, planned projects in the US, cooperation with the US OEMs.

- The EU Net Zero Industrial Act (NZIA) has stated two targets for batteries: EBA's 550 GWh/yr target that was set in 2022, and an ambition of meeting 40% of EU battery demand in 2030, equivalent to ~400 GWh/year, with domestic manufacturing capacity.[1]
- To meet the stated ambition and target in the NZIA, only ~15-25% of the additional 1,300-1,600 GWh/year manufacturing pipeline must be operational by 2030. More than 90% of this capacity is based on NMC technology, while the rest focuses on LFP chemistry.[10]
- Although the EU is on track to meet the conservative ambition of 400 GWh/yr, there are ongoing headwinds when considering factory building challenges (for example for Northvolt, ACC) and weakening demand (e.g., BMW cancelling a €2.1bn offtake deal).[11] [12] [13]
- The EU recycling infrastructure is inadequate to harness the material potential and must be scaled up to improve the recovery rate of domestic critical raw materials.[14] Gigafactories experience a 15-30% scrap rate during ramp-up, producing "black mass" containing recoverable critical raw materials. This valuable scrap is often exported to Asia, representing a missed opportunity for domestic material recovery.[15] Acting now would enable the EU to benefit from the imminent ramp-up of factory capacity.

TO COMPETE EFFECTIVELY IN BATTERY MANUFACTURING WITH CHINA AND THE US, THE EU MUST CLOSE THE GAP ACROSS PUBLIC FUNDING, SCALE AND SUPPLY CHAIN INTEGRATION.

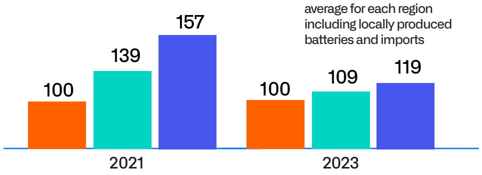
Regional battery cell cost comparison[16]



Based on Volta Foundation's LFP & NMC cell manufacturing cost model, using Chinese manufacturing technology and regional energy price

Regional battery prices and average pack costs [17]

Battery Prices. Indexed, China = 100



Battery prices refer to the average for each region including locally produced batteries and imports

Average battery pack costs

$94/kWh CHINA ↑ +31% US ↑ +48% EU

Average across multiple battery end-uses, including different types of electric vehicles and stationary storage projects

- EU battery cell production costs are significantly higher than in China (e.g., LFP: €90-110/kWh vs. €45-60/kWh). On average, cells make up 75-85% of the total battery pack cost structure. [16]
- The regional price gap for batteries has converged in recent years, highlighting how batteries are an increasingly globalised product. EU battery pack costs are, on average, 48% higher than in China.[17]
- China benefits from economies of scale, lower energy and labour costs, and a well-integrated value chain.
- The EU's cathode active material (CAM) manufacturing capacity lags significantly behind China (50 GWh/year vs. 200 GWh/year in 2024). Although this ratio is expected to improve by 2030 (700 GWh/year CAM vs. 1,500-1,800 GWh/year cell capacity), the EU's fragmented supply chain remains a disadvantage.[18]

BATTERY MANUFACTURING

POWERING UP... OR DOWN?

ENABLERS – WHAT IS GOING WELL

TARGETS FOR PHASE OUT OF ICE CAR SALES

Mandates are accelerating EV adoption, surpassing 20% of total new car sales across Europe in 2023 despite a slowdown in the automotive sector. Leading countries include Sweden (60% EV share) and the Netherlands (43%), though reduced incentives have tempered growth.[20]

OFFTAKE COMMITMENT FROM AUTOMOTIVE INDUSTRY

Long-term offtake agreements from automakers provide critical stability for battery manufacturers during market volatility. These agreements ensure predictable cashflows and meet financing requirements for greenfield projects and scale-ups.[21]

STRONG EU-LEVEL SUPPORT FOR THE SECTOR

The EU has implemented robust support mechanisms for battery manufacturing under the Green Deal Industrial Plan, allocating €3 billion annually to green manufacturing and attracting investments like CATL’s plant in Hungary.[22] Initiatives such as InvestEU, the European Battery Alliance (EBA), and Important Projects of Common European Interest (IPCEI) aim to unlock additional funding.[23] The Battery Regulation further strengthens the EU’s leadership position, though enhancements are needed to support the sector fully.

BARRIERS – WHAT IS NOT GOING WELL

LOSS OF MOMENTUM IN EV REGISTRATIONS AND PROJECT CANCELLATIONS

The EU is experiencing a slowdown in EV adoption, with a 5% year-on-year decline in registrations.[18] This has led to weakened automotive battery offtake commitments, contributing to gigafactory project cancellations and downsizing. These trends reflect a fiercely competitive market and declining demand for EVs across key regions.

COST GAP WITH CHINESE MANUFACTURED BATTERIES

European battery production costs remain materially higher than China's due to limited manufacturing scale, higher labour and energy costs, and expensive raw materials. Additionally, tax credits in the Inflation Reduction Act (IRA) for U.S. manufacturers make EU cell costs 10-15% higher than those in the US.[24] This lack of cost competitiveness, coupled with disparities in subsidies and scale, puts European manufacturers at a disadvantage against global competitors.

RELIANCE ON IMPORTED BATTERY MINERALS

Europe remains heavily dependent on imports for key battery minerals including lithium and cobalt, primarily sourced from China, exposing it to geopolitical risks and supply chain disruptions. Gaps in cathode active material (CAM) production and limited domestic R&D for recycling technologies exacerbate this reliance.

ACTION AGENDA – WHAT NEEDS TO BE DONE

1. **De-risk strategic battery manufacturing investments**
Establish a dedicated fund to provide loan guarantees, insurance, and equity investments for projects that demonstrably reduce the EU's reliance on imported battery components and materials. Focus "Net-Zero Acceleration Valleys" on vertically integrated manufacturing clusters that incorporate raw material processing, cell production, and recycling, offering incentives for companies to co-locate and share infrastructure. Implement accelerated permitting processes specifically for projects that align with EU circular economy goals and utilize sustainable manufacturing practices.

2. **Implement EU-wide EV subsidy schemes and procurement policies** that prioritise EU-made batteries with low-carbon footprints and high recycled content, aligning with the EU's Battery Regulation. Develop a robust EU-backed incentive scheme, similar to France's conditional incentives for EU-made batteries, to sustain demand from the automotive sector.

3. **Strengthen raw material supply resilience through domestic sourcing, diversification and recycling infrastructure**
Enhance raw material supply resilience by supporting domestic sourcing, building local black mass processing capabilities, securing end-of-life batteries within Europe, and establishing strategic reserves of critical raw materials. Prioritise the expansion of recycling infrastructure to meet the Critical Raw Materials Act benchmarks, targeting 25% of domestic mineral needs through recycling by 2030 in parallel with domestic extraction, processing, and diversification.

> “Europe has immense potential to build a competitive and sustainable battery and circular recycling ecosystem by leveraging its strengths in R&D and high-tech capabilities. To unlock this, policymakers must ensure strict implementation of key regulations like the battery regulation or the critical raw materials act, robust financial support for scaling innovative ventures, and a balanced focus on advancing critical technologies. Trust in the long-term viability of the ecosystem is essential to secure Europe's position in the global energy transition”

Dr. Lilian Schwich, CEO & Co-Founder, **Cylib**

References

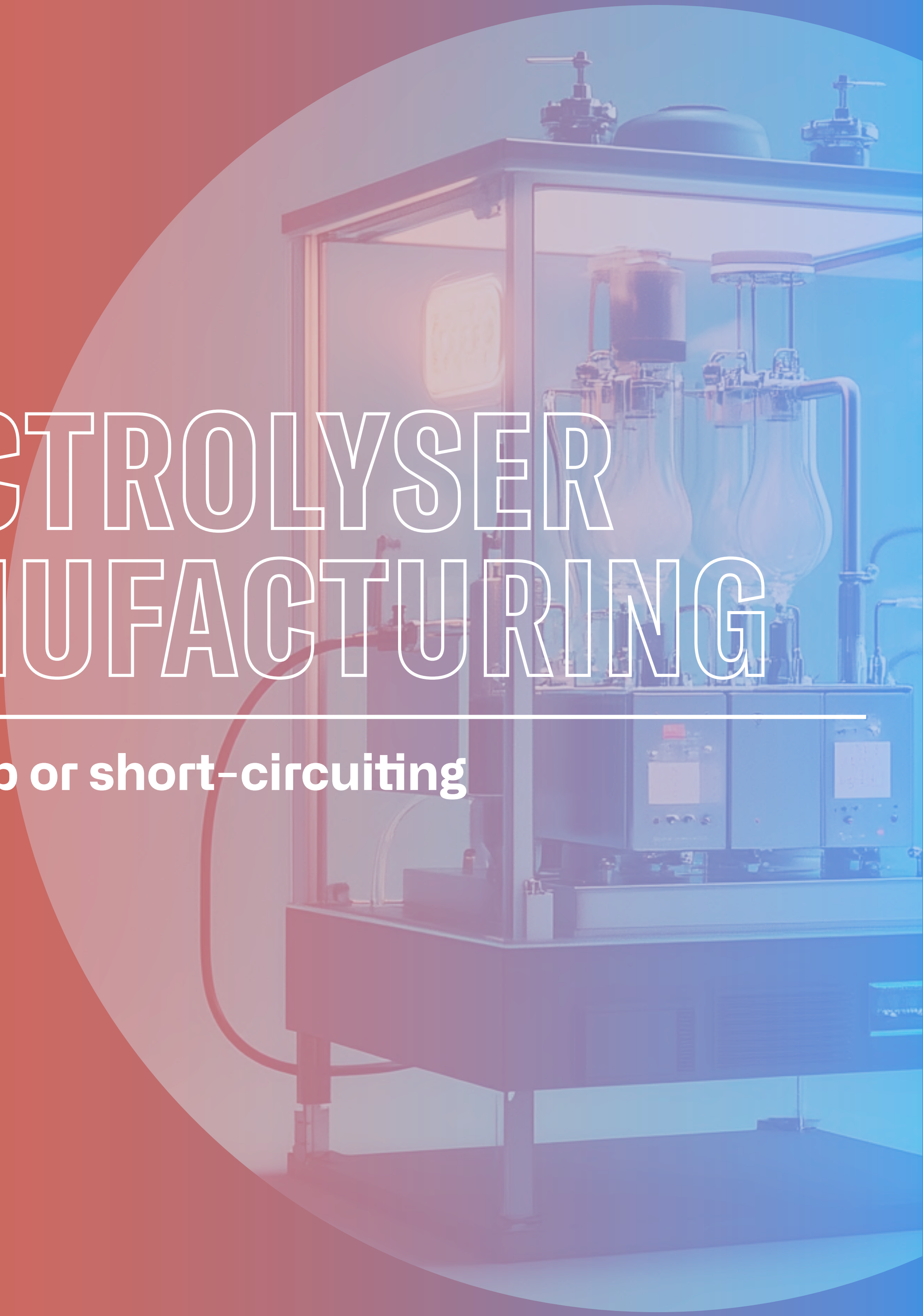
[1] 550 GWh was a target that NZIA referenced, based on European Battery Alliance's 90% target and demand projections made in 2022, as per line (16) of the NZIA act: "...For battery technologies this would mean contributing to the objectives of the European Battery Alliance and aim at almost 90% of the Union's battery annual demand being met by the Union's battery manufacturers, translating into a Union manufacturing capacity of at least 550 GWh in 2030..." However, the NZIA also stated an ambition that 40% of battery annual deployment needs by 2030 to be manufactured in the EU should be adopted considering supply chain and manufacturing capacity, as per line (17) in the NZIA act: "Considering those objectives together, while also taking into account that for certain elements of the supply chain, such as inverters, as well as solar cells, wafers, and ingots for PV or cathodes and anodes for batteries, the Union manufacturing capacity is low. In order to help tackle import dependency and vulnerability concerns and to ensure that the Union's climate and energy targets are met, while striving towards a similar benchmark for net-zero technologies. The Union net-zero technologies annual capacity should aim to approach or reach an overall annual manufacturing benchmark of at least 40 % of annual deployment needs by 2030 for net-zero technologies considered as a whole." For this ambition, we used McKinsey's analysis on 2030 battery demand in EU, totaling at ~1,000 GWh annually. This means the 40% ambition in the EU will need to supply 40% of that annual demand, at 400 GWh/yr.
[2] Cell cost average is derived from Fastmarket's cell-cost-teardown model, not a price survey cost from manufacturers.
[3] EU emissions are based on Power sector emissions are projected to be around 500-600 MtCO2e in 2023, based on Amber Energy (2023) and road mobility (e.g., cars) are responsible for 13% of EU emissions in 2022, and 59% of overall road transport emissions (Transport & Environment, 2023).
[4] EU imported 1.1bn USD worth of battery cells. Assuming cost of production of battery cells are at 40-50 $/kWh, EU imported ~25 GWh of batteries. Using EU's 2023 production capacity at 100-150 GWh, around 15% of EU's full annual Battery production capacity was imported. Data from from TrendEconomy's Open Data Portal and T&E Battery risk report and from IEA: Global EV Outlook 2024, which highlights that imports supply over 20% of Europe's EV battery demand due to insufficient local production.
[5] Based on average battery capacity (78 kWh), range of global battery price (110-160 $/kWh), and average price of EV in EU for 2023, from Electric vehicle model statistics | European Alternative Fuels Observatory
[6] Based on the Centre for Research on Multinational Corporations and projected from announced capacity by 2030.
[7] Derived from 215 billion USD global market revenue pool, with 30-40% of demand coming from EU region, the battery cell component opportunity in Europe and North America (McKinsey, 2024).
[8] Based on Volta Foundation's 2024 Battery Report in "EU battery manufacturing capacity", there are 1,500 GWh of announced manufacturing capacity by 2030 in the EU, of which 50-60% are fully owned by European-based company, and 40-50% having partial or full ownership from international battery manufacturers, as well as Market Analysis Update Q2 2024 - Battery Cell Production In Europe: Status Quo And Outlook (IPCEI, 2024) and Powering the EU's future: Strengthening the EU battery industry from European Parliamentary Research Service (2025)
[9] Transport & Environment: An Industrial Blueprint for Batteries in Europe. The T&E methodology assigns a risk category (low, medium, high) for each announced gigafactory plant. The risk category is calculated based on a scoring system that factors in six factors, each with a rating of 0 to 2 (0 is low risk, 2 is high risk). A cumulative project scoring of 0-4 total points gets a low-risk rating, while 8-12 points are considered high- risk. The risk factors considered by T&E are: Secured funding, Secured location, Construction status & permits, Investments from EU OEMs or support from EU institutions, Planned projects in the US, Cooperation with the US OEMs.
[10] Based on IEA analysis on battery chemistry market per region, NMC batteries are more common in the European and American electric car markets, while LFP is the most prevalent chemistry in the Chinese electric car market. IEA: Global EV Outlook 2024
[11] Based on 'Huge losses': Sweden fears for future of batterymaker Northvolt (The Guardian, 2024).
[12] In June '24, ACC paused battery plant construction in Germany and Italy to consider transitioning to cost-effective LFP chemistries. Based on "ACC Puts work on battery factories in Kaiserlautern and Termoli on hold" (Elective, 2024) https://www.electrive.com/2024/06/05/acc-puts-work-on-battery-factories-in-kaiserslautern-and-termoli-on-hold/
[13] Based on BMW cancelling $2bn cells contract with Northvolt (Reuters, 2024) (BMW cancels $2 bln battery cells contract with Northvolt (Reuters)
[14] Based on Payables for NCM Black Mass in South Korea pick up in March (Fastmarkets, 2024) Payables for NCM black mass in South Korea pick up in March - Fastmarkets
[15] Battery recycling in Europe – a reality check (Circular Energy Storage Online, 2024)
[16] Volta Foundation's 2024 Battery Report
[17]Based on indexed global battery pack cost comparison with China as index (China=100) from Global EV Outlook (IEA, 2024) and Lithium-Ion Battery Pack Prices See Largest Drop Since 2017, Falling to $115 per Kilowatt-Hour: BloombergNEF (BNEF, 2024)
[18] Q42024 Market update: Weakening European Electric Vehicle Market - Challenges and Opportunities for the Battery Industry (IPCEI, 2024)
[20] Transport&Environment's EV market watch dashboard and New registrations of electric vehicles in from European Environment Agency, data as per November 2024
[21] Based on company media release from Verkor: Renault Group and Verkor: a long-term commercial partnership for high-performance, low-carbon batteries (Verkor, 2023)
[22] Making a Success of the Clean Industrial Deal (Institute 4 Climate Economics, 2023
[23] European Commission and EIB announce new partnership to support investments in the European battery manufacturing value chain at the end of 2024 https://www.eib.org/en/press/all/2024-484-european-commission-and-eib-announce-new-partnership-to-support-investments-in-the-european-battery-manufacturing-value-chain?utm_
[24] $369 billion in investment incentives to address energy security and climate change, UN Trade and Development (UNTAD) Investment Policy Monitor (2022)

Breakthrough Energy

Cleantech for Europe

With analyses led by SYSTEMIQ

CLEANTECH REALITY CHECK



ELECTROLYSER MANUFACTURING

Scaling-up or short-circuiting

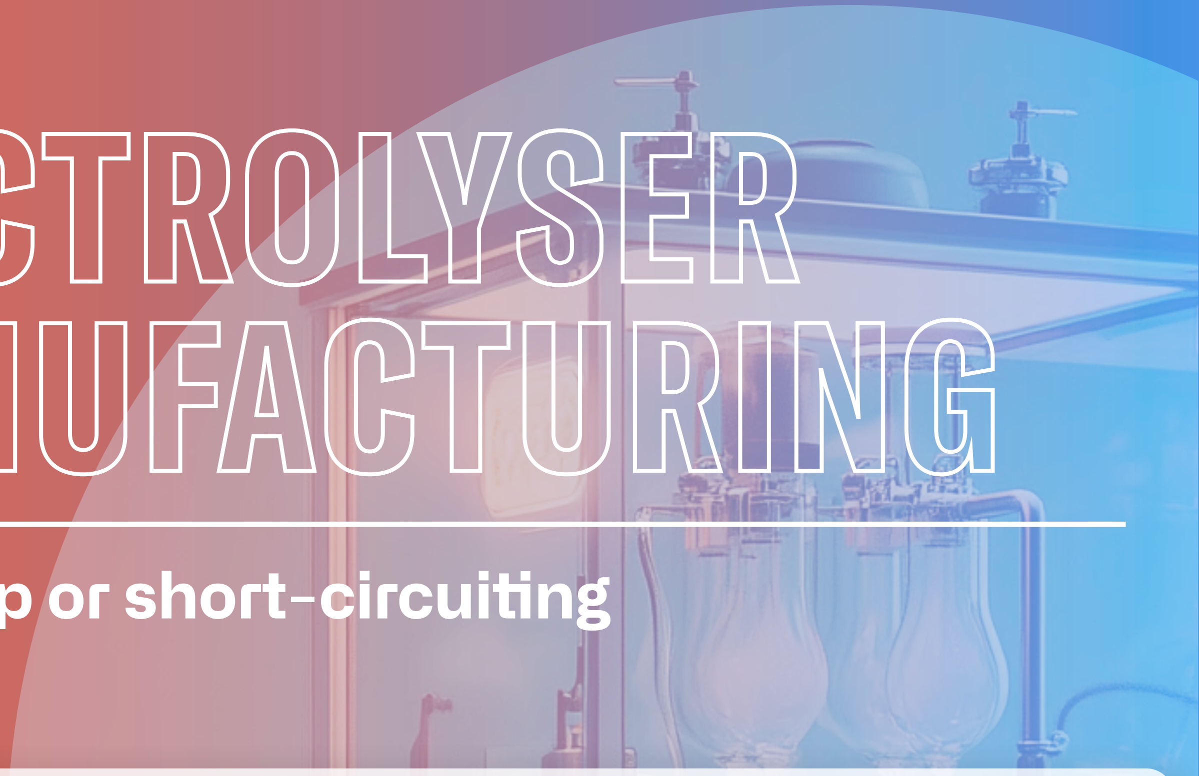
Breakthrough Energy

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 100ºC, 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.

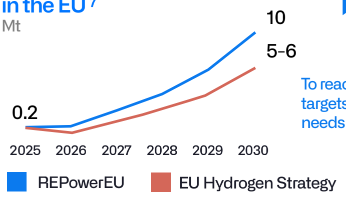
REPowerEU targets 10 Mt/yr while the EU Hydrogen Strategy set the ambition of 40GW, ~5-6Mt/yr of domestic renewable hydrogen by 2030. REPowerEU is unobtainable with current capacity. Yet, today's ~9GW/yr production capacity and pipeline could put us on the path to meet the 40GW target if we see a seismic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

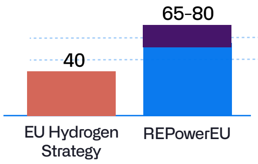
Renewable H2 production targets in the EU [7]



To reach these targets, the EU needs to deploy...

Required electrolyser installation/ deployment to produce renewable H2 [8]

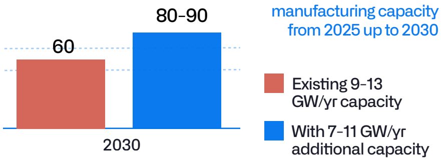
Cumulative deployment, GW



To ensure deployed electrolysers are made in the EU...

2030 cumulative electrolyser manufacturing throughput [9]

GW



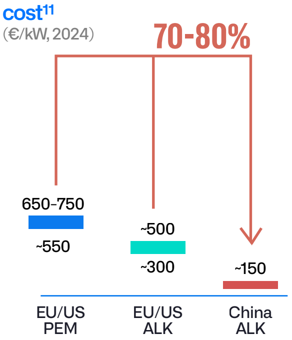
Throughput is calculated by adding up the annual manufacturing capacity from 2025 up to 2030

- 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

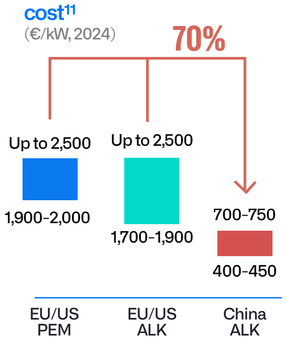
Electrolyser stack upfront cost[11]

(€/kW, 2024)



Electrolyser system upfront cost[11]

(€/kW, 2024)



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)