

Clean tech in the energy sector

SUMMARY

Clean technologies are at the forefront of the EU's ambition to pursue both decarbonisation and industrial competitiveness. The global clean tech market is expected to triple by 2035, covering sectors such as solar, wind, batteries, heat pumps and electrolyzers for the production of hydrogen. While the roll-out of clean technologies is increasing in the EU, its global market share is falling and manufacturing is lagging behind. This is due to a combination of factors, such as high energy prices, import dependency on raw materials and key components, skills shortages and fierce international competition, fuelled by robust public support policies adopted by the EU's main global competitors, such as China and the United States.

The EU has already taken some steps to boost manufacturing of clean technologies. The Net-Zero Industry Act of June 2024 seeks to enhance the manufacturing capacity of strategic net-zero technologies by streamlining administrative procedures, boosting investment and improving skills. It sets a target for domestic manufacturing capacity of strategic net-zero technologies to reach 40% of EU annual deployment needs by 2030 and 15% of global production by 2040. The Critical Raw Materials Act of April 2024 addresses the issue of import dependencies by seeking to diversify supplies and boost domestic capacity in mining, processing and recycling of critical raw materials.

However, some challenges remain for EU clean tech. These include ensuring adequate private and public funding, swiftly implementing the recently adopted legislative framework and reinforcing a favourable regulatory environment for investment. The Clean Industrial Deal to be announced in February 2025 by the new European Commission, together with the Competitiveness Fund under the future multiannual EU budget, are expected to provide an additional boost to clean technologies in Europe.



IN THIS BRIEFING

- Introduction
- Clean technologies: State of play
- EU legislative framework
- EU funding
- Outlook



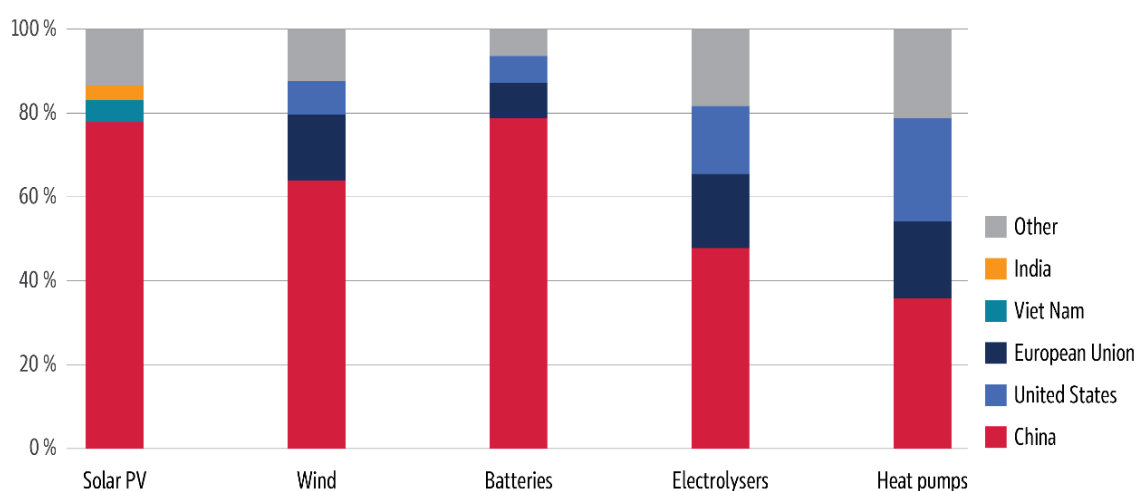
Introduction

Clean technologies play a key role in the green transition and economic competitiveness. The 2023 International Energy Agency (IEA) [report](#) on 'The State of Clean Technology Manufacturing' highlights the following five key technologies: wind, solar, batteries, heat pumps and electrolysers used for the production of hydrogen. These technologies are also analysed under the 'clean tech' heading in the 2024 Draghi [report](#) on European competitiveness. The 2023 European Commission [report](#) on the competitiveness of clean energy technologies additionally includes power grids, biogas and CCUS (carbon capture, utilisation and storage). The Cleantech for Europe platform [proposes](#) much broader coverage, including sectors such as agriculture and food, energy, materials and chemicals, transport and logistics, resources and environment, and enabling technologies such as quantum computing and artificial intelligence.

The rapid growth of the clean technology market offers many opportunities in terms of investment and job creation. According to the IEA, the global market for key clean technologies is set to [triple](#) to almost US\$2 trillion by 2035. Currently, China [leads](#) as the largest manufacturer in all of the key technologies (see Figure 1). The EU and US are also major players in all these sectors except for solar. While public support policies for clean tech are expected to continue in China, the future of the main US funding programme (the Inflation Reduction Act – see box) is currently uncertain in light of the election campaign pledges by President-elect Trump to repeal it. However, analysts [point out](#) that a full repeal is unlikely and changes will probably target individual provisions, such as incentives for electric vehicles and offshore wind power.

The EU is one of the world's [largest](#) markets for clean technologies and has a strong position in terms of high-value inventions (e.g. in wind and heat pump technologies, electrolysers, solar photovoltaics (PV), batteries and CCUS). However, domestic manufacturing is lagging behind in many sectors. In solar PV, it has a negligible global presence, while its once high market share in wind turbine components is also [declining](#) (from 58 % in 2017 to 30 % in 2022). Although an [estimated](#) 60–70 % of demand is met domestically, the EU is currently a net importer of heat pumps. In terms of battery cell production, the EU is projected to achieve self-reliance in the coming years (although the recent bankruptcy of the Swedish battery manufacturer Northvolt might [suggest](#) this view is too optimistic). Moreover, the EU has technological leadership in electrolysers, although it does not yet produce at a large scale (giga scale). It is also a frontrunner in carbon capture technologies. The IEA [estimates](#) in its Announced Pledges Scenario that the EU has a chance to fulfil its domestic needs for batteries, electrolysers and heat pumps by 2030, if all announced projects are completed.

Figure 1 – Geographical concentration of manufacturing capacity, 2022



Source: IEA, [The State of Clean Technology Manufacturing](#), 2023.

However, higher demand for clean tech also entails increased demand for resources and [raw materials](#), such as lithium, cobalt, nickel, copper and rare earth elements. The EU is currently heavily import-reliant on both raw materials and components for clean technologies.

Domestically produced clean energy technologies are a foundation for achieving the EU climate targets by replacing fossil fuels in end-use sectors and reducing the EU's dependence on imports of energy, raw materials and components, thereby improving energy security and affordability.

Inflation Reduction Act (United States)

Adopted in August 2022, the Inflation Reduction Act (IRA) provides subsidies, loans and tax incentives to accelerate investment in domestic manufacturing of clean technologies. The funding is estimated at US\$400 billion over 10 years, though the total amount will depend on the actual take-up (tax credits are not capped). Projects can acquire a bonus if they meet a domestic content requirement, i.e. when a percentage of products used in manufacturing is produced in the US. Examples of supported projects include wind, solar, battery storage, electric vehicles, nuclear, hydroelectricity, biomass and geothermal projects.

According to the Draghi report, EU financial support is comparable in terms of climate measures overall but less targeted in terms of clean tech support and less generous for clean tech manufacturing than the IRA. Moreover, access to EU funds is more complex ('long time to money') due to lengthy approval procedures and state aid authorisation schemes. EU support is also more fragmented (different programmes for R&D, manufacturing and deployment), while the IRA is a single programme based on simple procedures, fast clearance and more certainty when it comes to accessing funding. In October 2022, an EU-US [Task Force](#) on the IRA was launched to enhance collaboration on sustainable supply chains and address some international competition concerns.

Source: [European Commission](#), 2023; [The White House](#), 2023; Draghi [report](#), 2024.

Clean technologies: State of play

Since 2020, the European Commission has been publishing annual progress reports on the competitiveness of clean energy technologies. The latest [report](#) from 2023 highlights the main drivers of competitiveness in the clean energy and net-zero technology sectors, along with opportunities and challenges (the latter include energy and material costs, value chain resilience, labour shortages and innovation). Separate sections are dedicated to assessing the competitiveness of strategic energy technologies outlined in the Net-Zero Industry Act, i.e. solar PV, solar thermal, onshore and offshore wind, ocean energy, batteries, heat pumps, geothermal energy, water electrolysis to produce renewable hydrogen, sustainable biogas and biomethane, carbon capture and storage, and grid technologies.

Solar photovoltaic (PV)

Solar PV is the [fastest](#) growing power generation technology in the EU; according to a 2024 SolarPower Europe [report](#), the EU reached a solar PV capacity of 269 gigawatts (GW) in 2023. The EU [solar energy strategy](#) of 2022 set a non-binding target for solar PV capacity of 320 GW by 2025 and almost 600 GW by 2030.

The [European Solar PV Industry Alliance](#), launched by the European Commission in 2022, pursues a target of scaling-up annual solar PV manufacturing capacity in Europe to 30 GW by 2025. The [European Solar Charter](#) signed in April 2024 sets out voluntary actions in support of the EU photovoltaic sector, such as promoting innovative forms of solar energy deployment and creating favourable framework conditions for manufacturing facilities for PV products.

While the solar PV value chain is dominated by China (with a share of over [80%](#) in all the manufacturing stages of solar panels), EU companies are especially [active](#) in producing inverters and polysilicon. However, the EU has recently been importing [84%](#) of its installed solar PV modules.

Wind

According to the European Commission [report](#), the EU wind sector is still one of the strongest global players (despite its decline), with EU manufacturers accounting for 85 % of the EU wind energy market and 30% of the global market share in 2022. The 2024 Wind Europe [report](#) states that the total installed wind power capacity in the EU reached 220 GW (201 GW onshore and 19 GW offshore) in 2023.

A non-binding EU target for offshore wind and ocean energy is 111 GW by 2030 and 317 GW by 2050, in line with the Member States' [pledge](#) of 2023. This pledge partially raises the ambition previously set out in the [offshore renewable energy strategy](#) of 2020, i.e. 60 GW of offshore wind and 1 GW of ocean energy by 2030, and 300 GW of offshore wind and 40 GW of ocean energy by 2050.

The [European wind power action plan](#) adopted in October 2023 sets out actions to accelerate permitting, improve auction systems and facilitate access to finance. The [European Wind Charter](#) of December 2023 includes voluntary commitments aimed at supporting the development of the EU wind sector.

Batteries

Batteries play a crucial role both for transport (electric vehicles) and stationary applications, especially balancing the electricity grid. According to the European Commission, battery production in the EU is [expected](#) to reach 458 gigawatt hours (GWh) by 2025 and 1 083 GWh by 2030. While most batteries are used in the automotive sector (in 2023, 40 % of all new cars sold in China were electric, 20 % in the EU and 10 % in the US), stationary storage is also increasing. China currently [dominates](#) the battery supply chain (85 % of global battery cell production capacity), although battery [factories](#) are increasingly present in Europe.

The [European Battery Alliance](#) launched in 2017 by the European Commission brings together stakeholders in this sector. [Eurobat](#) is an association of European automotive and industrial battery manufacturers, while [Batteries Europe](#) provides a platform bringing together stakeholders in the area of research and innovation. Two Important Projects of Common European Interest ([IPCEIs](#)) in the batteries value chain were [launched](#) in 2019 and 2021, bringing together 59 companies in 12 Member States.

Heat pumps

Heat pumps are an [efficient](#) and fossil-free technology that can be used for heating, hot water and cooling. According to the [European Heat Pump Association](#), 24 million heat pumps were installed in Europe at the end of 2023. There are over 250 manufacturing sites in Europe and the sector employs around 168 000 people directly.

According to the [REPowerEU](#) plan, 41.5 million installed heat pumps in residential units and services are needed by 2030 to reach the plan's objectives. While a [planned](#) EU heat pump action plan has not been published yet, a [Heat Pump Accelerator Platform](#) was launched in November 2024 to speed up the deployment of heat pumps.

Electrolysers and hydrogen

Renewable [hydrogen](#) can be used to replace coal in iron and steel production, as an energy carrier (especially for heavy goods transport and energy storage), and as a feedstock for producing chemicals, fertilisers and sustainable fuels. According to the [Clean Hydrogen Observatory](#), EU hydrogen consumption was estimated at 7.3 million tonnes in 2023. In 2022, most hydrogen in the EU (96 %) was produced with natural gas, involving significant greenhouse gas emissions. Water [electrolysis](#) in combination with renewable electricity is a key technology for the production of renewable hydrogen, while [low-carbon](#) hydrogen (blue hydrogen) is produced from natural gas coupled with carbon capture and storage.

The EU target for renewable hydrogen set out in REPowerEU ([Hydrogen Accelerator](#)) amounts to 10 million tonnes of domestic production and 10 million tonnes of imports by 2030. According to the [REPowerEU](#) plan, 65 GW of installed electrolyser capacity for hydrogen is needed by 2030 to reach the plan's objectives. China is currently the [leader](#) in terms of electrolyser capacity (750 MW under construction in 2023, compared with the EU's capacity addition of about 80 MW in 2022), while its manufacturing capacity for electrolysers accounts for [60%](#) of global capacity.

The EU [hydrogen strategy](#) of 2020 establishes actions to boost investment, demand for and scaling-up of hydrogen production in Europe. The [European Clean Hydrogen Alliance](#) was launched alongside the EU hydrogen strategy in 2020 to bring together stakeholders. The [Hydrogen Bank](#), created in 2022, is a financing instrument aimed at improving investment opportunities. Moreover, four [IPCEIs](#) in the hydrogen value chain have been launched up to now, covering 99 companies in 16 Member States. The EU has also adopted [rules](#) for renewable hydrogen production and a [methodology](#) for evaluating low-carbon hydrogen is under way.

Carbon capture, utilisation and storage (CCUS)

The European Commission [estimates](#) that achieving climate neutrality by 2050 will require capturing up to 550 million tonnes of CO₂ annually by 2050. The EU currently has a [target](#) of at least 50 million tonnes of CO₂ injection capacity per year by 2030. According to the 2023 [Commission report](#), CCUS technologies are mature, proven and readily available. However, they are also costly, ridden with commercial and regulatory uncertainties, and need to be deployed at scale to reach the EU's long-term goals.

The [industrial carbon management strategy](#) adopted in February 2024 outlines a comprehensive approach for the EU to scale-up carbon management, improve investment opportunities and take action to establish a single market for CO₂ in Europe.

EU legislative framework

The [Green Deal Industrial Plan for the Net-Zero Age](#) of February 2023 outlined a vision for a net-zero industrial transformation in Europe. It proposed a number of steps to improve the EU regulatory environment in order to boost industrial competitiveness, including a plan to adopt a Net-Zero Industry Act and a Critical Raw Materials Act. Moreover, the [Renewable Energy Directive](#) adopted as part of the 'Fit for 55' package includes provisions boosting the roll-out of clean energy technologies such as solar, wind, heat pumps and batteries. The [Batteries Regulation](#) of 2023 sets rules to enhance the circularity of battery use and increase security of supply for raw materials.

Net-Zero Industry Act

Adopted in June 2024, the [Net-Zero Industry Act](#) (NZIA) establishes a framework for scaling-up the manufacturing capacity of 19 strategic net-zero technologies in the EU. These technologies include: solar PV and solar thermal technologies; onshore wind and offshore renewable technologies; battery and storage technologies; heat pumps and geothermal energy technologies; hydrogen technologies (including electrolysers and fuel cells); sustainable biogas and biomethane technologies; carbon capture and storage technologies; electricity grid technologies; nuclear fission; sustainable alternative fuels; renewable fuels of non-biological origin (RFNBO), hydropower and several other technologies (Article 4 of the NZIA).

The Act sets a benchmark for at least 40 % of the EU's annual deployment needs to be covered by EU manufacturing capacity by 2030, with a view to reaching 15 % of world production by 2040. It also sets an EU-level target of ensuring an annual injection capacity of at least 50 million tonnes of CO₂ in storage sites, to be achieved by 2030.

The NZIA establishes enabling conditions for domestic production of net-zero technologies, for instance through streamlined administrative procedures and facilitated access to market. It grants 'priority status' to net-zero strategic projects and sets rules for 'Net-zero Acceleration Valleys'

hosting clusters of industrial activity and regulatory sandboxes to test innovative net-zero technologies. It also establishes mechanisms to support skills development (European net-zero industry academies). While the Act itself does not provide additional funding sources, it encourages Member States to use 25 % of their annual ETS revenues to support clean tech manufacturing. The [Net-Zero Europe Platform](#) assists with the implementation of the NZIA, including advice on obtaining private and public funding.

Critical Raw Materials Act

Adopted in April 2024, the [Critical Raw Materials Act](#) (CRMA) aims to ensure the EU's access to a secure and sustainable supply of critical raw materials. It strengthens the extraction, processing and recycling capacity within the EU, diversifies imports of raw materials, promotes their substitution, facilitates monitoring and risk mitigation, and improves sustainability and circularity of critical raw materials. The CRMA establishes a list of 17 strategic raw materials (Annex I) and 34 critical raw materials (Annex II).

[Strategic projects](#) under the CRMA can benefit from streamlined permitting procedures and easier access to finance. Furthermore, it introduces benchmarks for EU domestic capacities in extraction (at least 10 % of EU annual consumption), processing (at least 40 % of EU annual consumption), and recycling (at least 25 % of EU annual consumption); no more than 65 % of the EU's annual consumption shall come from a single third country. A [European Critical Raw Materials Board](#), composed of EU country representatives and the Commission, was set up to coordinate the implementation of the Act.

Strategic Technologies for Europe Platform (STEP)

Adopted in February 2024, the [STEP Regulation](#) creates an EU framework to boost investment in the development and manufacturing of critical technologies. These include digital technologies and deep-tech innovation, clean and resource-efficient technologies (including net-zero technologies as defined in the NZIA), and biotechnologies.

The Platform enables reprogramming of EU funds to support the STEP sectors. It establishes a STEP portal that brings together funding opportunities and creates a one-stop shop for questions from industry and relevant authorities. It also creates a STEP Seal, which is a label for high-quality projects that facilitates their access to funding.

Source: European Commission, [Strategic Technologies for Europe Platform](#).

Renewable Energy Directive

The [Renewable Energy Directive](#), revised in 2023, sets a target of 42.5 % renewables in EU gross final energy consumption by 2030; this number stood at [23 %](#) in 2023. The Directive promotes the deployment of clean energy technologies – such as solar, wind, heat pumps, storage and hydrogen – by accelerating permitting procedures and granting renewable installations a status of overriding public interest. It establishes common rules for the use of renewables in electricity, heating and cooling, and transport. It also includes provisions allowing consumers to produce their own electricity and rules for promoting the roll-out of batteries.

Batteries Regulation

The [Batteries Regulation](#) of 2023 covers various kinds of batteries including portable batteries, electric vehicle batteries, industrial batteries, and batteries for light means of transport such as e-bikes and e-scooters. It sets waste collection targets for producers (e.g. 73 % by 2030 for portable batteries), targets for recovery of chemical elements from batteries (e.g. 80 % for lithium by 2031 and 95 % for copper by 2031), minimum levels of recycled content in batteries (e.g. 85 % for lead from August 2031) and recycling efficiency targets (e.g. 65 % for lithium-based batteries by 2025). It also introduces rules for labelling, end-of-life management and due diligence obligations as regards sourcing of raw materials.

Taxonomy Regulation

The 2020 [regulation](#) on the establishment of a framework to facilitate [sustainable investment](#) (Taxonomy Regulation) sets out common EU-wide criteria for environmentally sustainable investment. Such investments have to contribute to one or more environmental objectives, such as climate change mitigation and adaptation, sustainable use of water, transition to a circular economy, pollution prevention and protection of biodiversity.

The Regulation requires the Commission to propose a list of environmentally sustainable [activities](#). These include manufacturing of renewable energy technologies, manufacturing of hydrogen, batteries and other low carbon technologies, electricity generation from clean sources, etc.

EU funding

According to the European Commission [assessment](#) of investment needs, boosting EU manufacturing in line with NZIA objectives (the NZIA policy scenario) would require an accumulated investment of €92 billion to €119 billion over the period 2023–2030 just for six selected technologies (solar PV, wind, batteries, heat pumps, electrolysers and CCS). According to the same assessment, in the 2021–2027 period the majority of EU funding is dedicated to the deployment of net-zero technologies (up to €124 billion), followed by R&D (€36 billion), while up to €8 billion could be available to support production. [Public resources](#) from the EU and Member States are considered to be an important catalyst to attract additional private funding needed to close the funding gap.

The current [EU budget for 2021–2027](#) actively supports green technologies, with 30 % of the funding earmarked for climate spending. In addition, at least 37 % of the expenditure under the [Recovery and Resilience Facility](#) (RRF) supports the green transition; the RRF also provides funding for the [REPowerEU](#) programme that promotes clean energy. The EU multiannual budget and Next Generation EU ([NGEU](#)) are projected to contribute [€658 billion](#) to climate spending (34.3 % overall).

The [Innovation Fund](#) is the main EU instrument containing funding that is earmarked specifically for clean tech. With an estimated budget of €40 billion for 2020–2030 (based on ETS auctioning revenues), it finances innovative technologies in areas such as energy-intensive industries, renewables, energy storage, net-zero mobility and buildings, hydrogen and CCUS.

Other possible EU funding sources for clean tech include: [cohesion policy funds](#), which support the transition towards a net zero carbon economy; [InvestEU](#) (with a €26.2 billion EU budget guarantee that is expected to attract €372 billion in additional investment), which supports the development of sustainable infrastructure and research and innovation; [Horizon Europe](#), which funds research and innovation in the area of clean tech (in collaboration with the European Innovation Council); the [Modernisation Fund](#) (with an estimated [budget](#) of €57 billion for 2021–2030, funded from ETS auctioning revenues), which supports energy modernisation investments in 13 lower-income countries; the [LIFE Clean Energy Transition](#) sub-programme, with almost €1 billion for 2021–2027; and the [Hydrogen Bank](#) ([€720 million](#) in the first and [€1.2 billion](#) in the second auction).

Moreover, the Member States are required to use all their ETS revenues for climate-related purposes, which can include innovation and manufacturing in low-carbon technologies. In 2023, the total ETS auction revenues amounted

Clean transition dialogues

In her [2023 State of the Union speech](#), Commission President Ursula von der Leyen announced the launch of 'clean transition dialogues' to discuss a reinforced industrial approach under the European Green Deal with European industry and social partners. Nine dialogues have taken place so far, covering topics such as hydrogen, energy-intensive industries, clean tech, energy infrastructure, critical raw materials, the forest-based bioeconomy, cities, clean mobility, and steel.

In April 2024, the Commission presented a [communication](#) taking stock of the dialogues. This revealed strong commitment by industry and social partners to implementing the EU's climate goals. It also presented stakeholders' concerns over the lack of a global playing field, the risks of carbon leakage and insufficient access to finance.

to [€43.6 billion](#), of which €33 billion went directly to the Member States. The [European Investment Bank](#) Group also provides funding for the green transition, with €49 billion for climate action and environmental sustainability, and €21 billion to support the goals of REPowerEU.

A supportive regulatory environment also plays a role in boosting investment. **State aid** policy provides possibilities to support clean investments at national level (including IPCEIs). The [Temporary Crisis and Transition Framework](#) adopted in March 2023 gives Member States the flexibility to accelerate investments in key sectors for the transition towards a net-zero economy, enabling investment support for the manufacturing of strategic equipment (such as batteries, solar panels, wind turbines, heat pumps, electrolysers and CCUS) and for the production of key components and the production and recycling of related critical raw materials.

Outlook

Strengthening the EU's capacity in the production and use of clean technologies is crucial to maintaining its competitiveness on the global clean tech market. While the EU has developed a number of funding sources and regulatory measures in support of clean tech, it still needs to address the growing international competition and solve internal challenges to ensure more affordable energy prices, sufficient availability of raw materials, a highly skilled workforce and a supportive business environment.

In her 2024-2029 [political guidelines](#), Ursula von der Leyen highlighted the need to boost EU competitiveness while continuing to decarbonise the economy. The new Clean Industrial Deal to be announced in February 2025, along with the European Competitiveness Fund to be proposed under the new multiannual financial framework, are expected to provide an additional boost for investment in clean and strategic technologies.

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