European Commission

SCIENCE FOR POLICY BRIEF

European Climate Neutral Industry Competitiveness Scoreboard 2021

HIGHLIGHTS

- → The Competitiveness Scoreboard (Figure 10) provides a snapshot of EU progress on 20 climate-neutral solutions measured against that of major global competitors.
- → The EU performs strongly in innovation-related indicators, especially high-value patents, public R&D investment and early-stage venture capital investment.
- → As a result of the pandemic, in 2020, there was a reduction in EU production and an increase in imports for many solutions.

The European Green Deal [1] and the new Industrial Strategy for Europe [2] give industry a leading role in delivering the transformational change needed to achieve climate neutrality. Faced with the challenge of energy dependence and rising energy prices, REPowerEU [3] has accelerated the urgency of this change. In order to succeed, EU industry needs to remain competitive and continue to innovate. This new scoreboard measures EU progress on climate neutral solutions key to achieving these goals.

EU INDUSTRY COMPETITIVENESS SCOREBOARD

Approach and scope

The scoreboard builds on a framework of competitiveness indicators that monitor EU progress in key climate neutral solutions [4 and 5]. It provides a snapshot of the EU's progress measured against that of major global competitors. The 2021 scoreboard (Figure 10) includes 20 climate-neutral solutions, considered to be of strategic importance to decarbonisation in the most relevant EU industrial ecosystems: renewable energy, mobility-transport-automotive, energy-intensive industries and construction.

The solutions are chosen based on their potential to contribute to the EU climate neutrality goal, their market relevance for EU industry, and their prominence in the Member States' plans for investment under the National Energy and Climate Plans [6] and the Recovery and Resilience Plans [7].

The assessment framework builds on JRC work monitoring competitiveness in low-carbon energy industries. The framework is based on ten key indicators: public R&D[1] investment; early and later stage investment (venture capital); patenting activity; innovating companies; employment; production; turnover; imports & exports; and trade balance. Technology experts were consulted to address issues related to the availability and granularity of the dataset and to validate the selection of companies. Information on the framework and background data is available in the methodology report [8]. Box 1 and Table 1 contain a summary of the ranking criteria.

[1] Research and development.

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Joint Research Centre

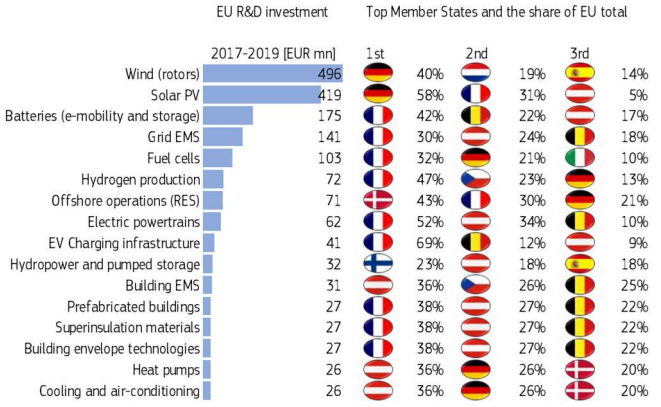
Investment is largely increasing

Public R&D investment

In 13 climate-neutral solutions, EU Member States public R&D investment increased in 2015-2019. **In 8 of these solutions, public R&D investment grew faster than EU GDP**. Public R&D investment increased most in offshore operations and batteries, in which investment grew by an average of 30% annually (2015-2019). For hydrogen production, heat pumps, cooling & air-conditioning and EV charging infrastructure the average growth rate was about 20% (2015-2019). However, public investment in R&D decreased in building energy management systems (EMS), grid EMS and electric powertrains.

In absolute terms, for the period 2017-2019, wind and solar PV received the most public R&D investment: nearly EUR 500 million and just above EUR 400 million respectively. Germany is the biggest EU investor in both, followed by the Netherlands and Spain for wind, and France and Austria for solar PV. As seen in Figure 1, there is a mix of Member States scoring highest across the 20 solutions.

Figure 1 - EU Member States public R&D investment and top Member States based on the available data

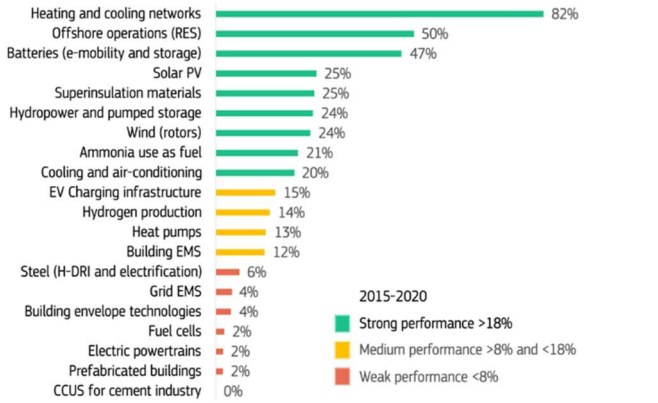


Source: JRC based on IEA data

Early and later stage investment

Investment in climate and clean energy solutions is increasing overall. The EU captured a significant share of all early stage investment in heating & cooling networks, offshore operations, batteries, solar PV, superinsulation materials, hydropower, wind, ammonia use as fuel and cooling & air-conditioning (Figure 2). In absolute terms, batteries, at EUR 0.6 billion, received the largest investment in the EU during the 2015-2020 period.

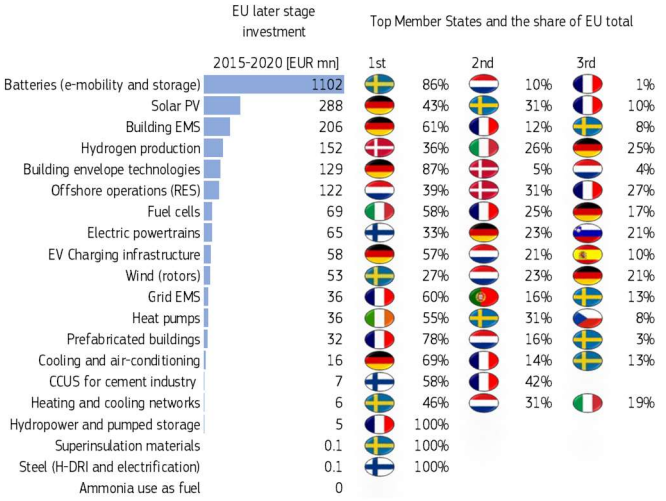
Figure 2 – EU share in global disclosed early stage investment



Source: JRC based on Pitchbook data

The EU also captured a significant share of all later stage investment in hydrogen production, heating & cooling networks, offshore operations, heat pumps, batteries, wind, building EMS and superinsulation materials. Again, batteries, at EUR 1.1 billion, received the most later stage investment in the EU during the 2015-2020 period. Solar PV and building EMS followed. Venture capital companies in different Member States performed strongly across different solutions, as seen in Figure 3. In 11 solutions, the EU captured less than 8% of global total later stage investment, indicating weak performance. This confirms that while the EU does better at financing start-ups at early stages, it more often lags behind in financing scale-ups at later stages [9].

Figure 3 – EU later stage investment and top Member States



Source: JRC based on Pitchbook data

QUICK GUIDE – The European Climate Neutral Industry Competitiveness Scoreboard is a project carried out by the Joint Research Centre in partnership with the Directorate General Internal Market, Industry, Entrepreneurship and SMEs.

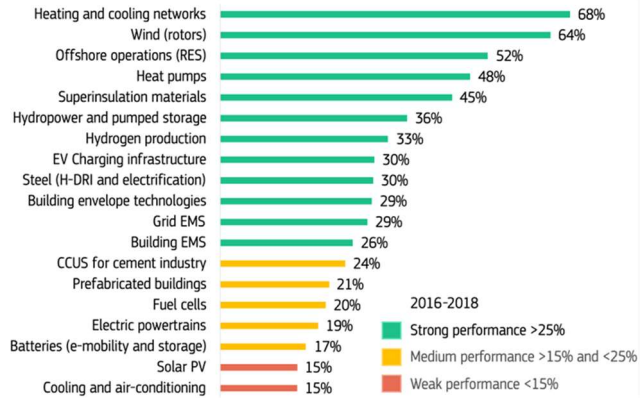
For more information and extended analysis, please see European Climate Neutral Industry Competitiveness Scoreboard (CIndECS) – Annual Report 2021 [10].

Innovation trends

Patenting activity

The EU performs at medium or high level in patenting activity across nearly all climate neutral solutions assessed, as shown in Figure 4. In heating & cooling networks, wind and offshore operations, the EU accounts for over half of all high-value filings. The weakest performance is in solar PV and cooling & air-conditioning, where Chinese and South Korean patenting activity has surged ahead of the EU in recent years. While the EU captures less than a 15% share globally, its patent portfolio in solar PV is one of the biggest among the solutions assessed. The biggest portfolio of high value filings, the EU holds in batteries, followed by solar PV, fuel cells and EV charging infrastructure.

Figure 4 – EU global share of high-value inventions (2016-2018)



Source: JRC based on EPO Patstat data

EU corporates are leading in patenting activity related to superinsulation materials, heat pumps, wind, offshore operations, and decarbonising the cement industry through CCUS[2]. In these areas, at least five EU corporates are among the global top 10.

Innovating companies

An ecosystem of patenting corporates and venture capital companies facilitates innovation and growth in future markets. The EU hosts over 35% - the threshold of strong performance – of identified innovating companies globally in heating & cooling networks, superinsulation materials, heat pumps, steel decarbonisation (H-DRI[3] & electrification), offshore operations for renewables, and wind (rotors).

The EU score is low for CCUS for the cement industry, cooling & air-conditioning, solar PV, fuel cells, batteries and prefabricated buildings, as it hosts less than a quarter of all innovating companies. Despite this, the EU still has a strong innovation landscape in these solutions, with the largest number of innovating companies, among the solutions assessed, in batteries, solar PV and EV charging infrastructure (Figure 5).

[2] Carbon capture, utilisation and storage.
[3] Renewable hydrogen-based direct reduction of iron.

Box 1: Scoreboard ranking criteria

The scoring criteria are based on:

- EU aggregated trends in public R&D, employment, production, turnover and trade balance;
- EU share of global total in early and later stage investment, patents, innovating companies and imports & exports.

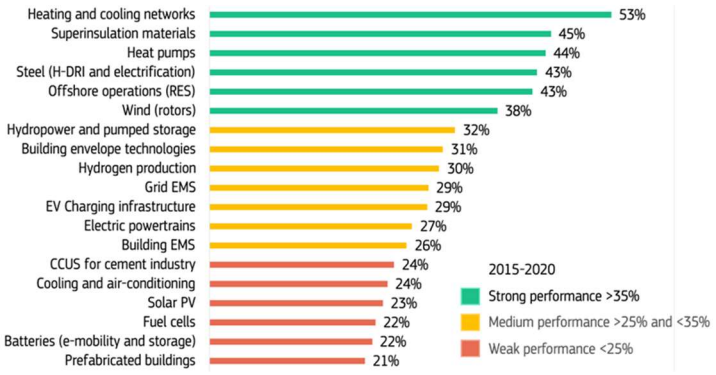
EU GDP growth is used as a benchmark for public R&D investment, production and turnover. Employment growth in the overall economy is used as a benchmark for the employment indicator.

For global comparison, the EU share (18%) of the global economy is used as a benchmark in early and later stage investment, patents, and extra-EU exports. In addition, objectives identified by the European Roundtable for Industry [11] are used to define the threshold of strong performance in venture capital investment, patents, and exports. Due to a vibrant venture capital market, the US is used as a benchmark for strong performance in (innovating) companies. All thresholds are shown in Table 1.

Table 1 – Scoring thresholds for 2021 assessment

Legend	High	Medium	Low
Summary of criteria			
Public R&D	>3%	0< and <3%	<0%
Early Stage	>18%	8%< and <18%	<8%
Later Stage	>18%	8%< and <18%	<8%
Patents	>25%	15%< and <25%	<15%
Companies	>35%	25%< and <35%	<25%
Employment	>1%	0%< and <1%	<0%
Production	>2%	0%< and <2%	<0%
Turnover	>2%	0%< and <2%	<0%
Imports & Exports	>25%	15%< and <25%	<15%
Trade Balance	positive / improving		negative / deteriorating

Figure 5 – EU share of innovating companies (2015-2020)



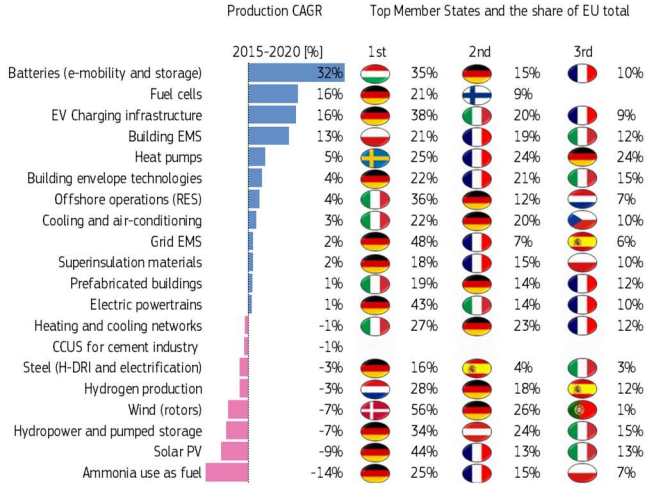
Source: JRC compilation of sources

The EU in today's markets

EU production

Production values provide an indication of EU manufacturing capacity in key components of the solutions in question. EU production grew fastest in batteries, fuel cells, EV charging infrastructure and building EMS, for which the average growth rate reached double digits in the 2015-2020 period (Figure 6). The production of heat pumps, and components for building envelope technologies, offshore operations for renewable energy (RES) and cooling & air-conditioning, also grew faster than EU GDP in the same period. Figure 6 shows the largest EU producers as a share of the EU total disclosed production value.

Figure 6 – EU production average growth rate and top Member States



Source: JRC based on Prodcom data

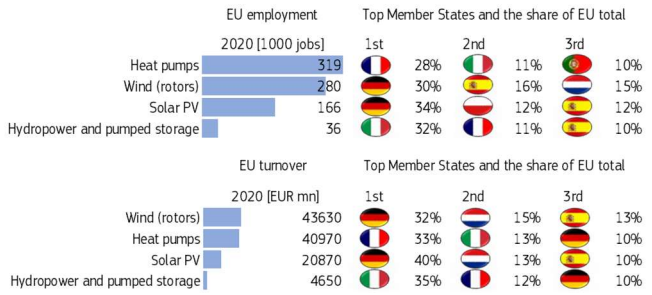
The production of ammonia has halved since 2015, and the production of solar PV has been decreasing throughout the 2011-2020 period. The production of wind generating sets experienced a drop in 2020, whereas hydropower is dependent on large and lengthy projects, therefore hydroturbines are susceptible to volatile production statistics. For steel (H-DRI), the decrease can be traced to the production of graphite electrodes that are used in electric arc furnaces in steel manufacturing. The production of solvents for CCUS in the cement industry, and of heat exchangers for heating & cooling networks, fluctuates but remains largely stable.

Employment and Turnover

In the 2015-2020 period, **employment and turnover in solar PV and heat pumps increased** faster than EU employment and GDP overall. Growth has been particularly strong in solar PV, with a compound annual growth rate of 17% in employment and 18% in turnover. In heat pumps, the growth was 6% and 7% respectively. By contrast, wind experienced no employment growth, but still generated a 4% increase in turnover. Wind's biggest EU market, Germany, seems to have reversed the previously declining trend. As hydropower is largely mature as a technology, with most of its potential capacity already deployed, employment and turnover figures continue to decline after peaking in 2018.

Figure 7 shows the employment and turnover figures in 2020 and the top Member States for solutions where comparable data is available. **There are significant difficulties in consolidating employment and turnover figures,** and data is therefore unavailable for most solutions.

Figure 7 – EU employment & turnover and top Member States



Source: JRC based on EurObserv'ER

As **decarbonisation solutions in energy-intensive industries are still at development stage**, there are no specific employment and turnover figures available. Direct employment in the EU steel industry, at 314 000[4], has remained largely stable, whereas turnover, based on Eurostat data[5], has increased by 8% in the 2015-2018 period – significantly faster than EU GDP. The turnover of the cement industry has also grown fast, with a 10% compound annual growth rate. The figures indicate **the size of affected industries,** that will need to apply decarbonisation solutions to remain competitive.

EU imports and exports

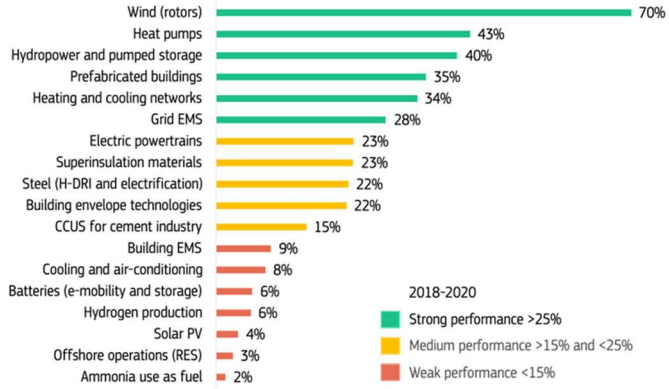
EU external trade provides an indication of EU presence in the global market. Simultaneously, EU internal trade illustrates the strength of the European single market.

The EU performs strongly, accounting for over 25% of extra-EU exports, in wind, heat pumps, hydropower, prefabricated buildings, heating & cooling networks and grid EMS. In electric powertrains, superinsulation materials, steel H-DRI & electrification, building envelope technologies, and CCUS for

[4] Based on Eurofer data.
[5] Eurostat SBS_NA_IND_R2, for steel NACE 24.1 and for cement NACE 23.51 codes were used.

the cement industry, the EU holds less than 25% but above a 15% global share of extra-EU exports. In the remaining solutions, the EU share in global exports is less than 10%, which is considered weak, as it is significantly lower than the EU's economic weight globally (Figure 8).

Figure 8 – EU share of extra-EU exports (2018-2020)



Source: JRC based on Comext and Comtrade data

A big share of EU imports in nearly all solutions, ranging from 98% in hydrogen production and 90% in wind to 56% in EV charging infrastructure, are EU internal trade, illustrating the importance and strength of the European single market. The largest share of imports coming from outside the EU is seen in solar PV, at 64%, and batteries, at 55%. For these solutions, the high dependence on imports can be seen in the negative trade balance.

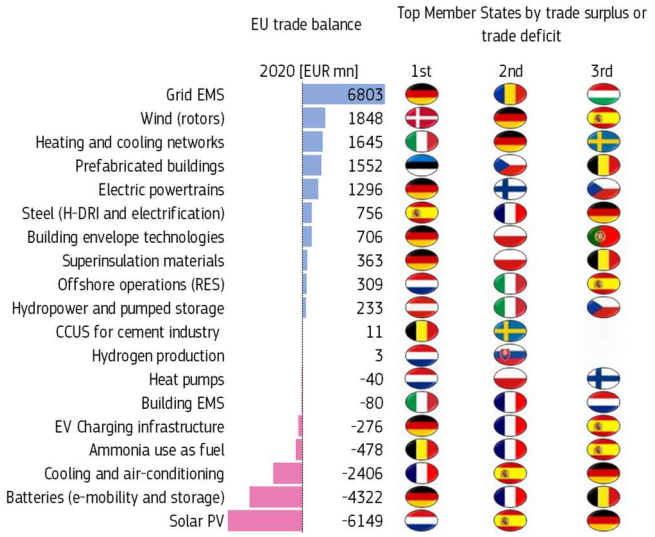
EU trade balance

The EU has a positive trade balance in 11 solutions. The biggest trade surplus is in grid EMS (EUR 7 billion), wind (EUR 2 billion), heating & cooling networks (EUR 2 billion), prefabricated buildings (EUR 2 billion) and electric powertrains (EUR 1 billion). Germany has the biggest trade surplus in grid EMS and electric powertrains, Denmark in wind generating sets, Italy in components for heating & cooling networks and Estonia in prefabricated buildings (Figure 9).

In the areas of electric powertrains, grid EMS, hydrogen, building envelope technologies, steel H-DRI & electrification technologies, and solvents used in CCUS, the positive trade balance is increasing, indicating a strong performance for the EU.

The EU has the biggest trade deficit in solar PV (EUR 6 billion), **batteries** (EUR 4 billion), and cooling & air-conditioning (EUR 2 billion). At Member State level, the Netherlands has the biggest trade deficit in solar PV, Germany in Batteries and EV charging infrastructure, and France in cooling & air-conditioning. The latter reflects a booming French market for reverse heat pumps used mainly for cooling. In all four, the trade deficit is increasing. In addition, 2020 was the first year in which the EU trade surplus in heat pumps turned into a deficit, due to increasing imports from China. In all solutions, where the EU has negative trade balance, China is the main exporter to the EU, with the exception of ammonia, which is primarily imported from Russia.

Figure 9 – EU trade balance and top Member States



Source: JRC based on Comext data

Impact of the pandemic

Venture capital investment was practically unaffected by the pandemic, with investments continuing to rise in 2020. By contrast, the production of most solutions experienced some contraction in 2020, amounting to a 4% overall decline on 2019 values. The biggest decline was seen in wind, where production dropped by 30%. At the same time, **the production of batteries and fuel cells was unaffected**, and continued to grow by 52% and 64% respectively in 2020 compared to 2019. Extra-EU exports declined by 3% in 2020 compared to 2019, whereas EU imports from outside the EU increased by 3%. Imports increased the most, by 20-30%, in offshore operations (RES), wind generating sets, heat pumps and batteries.

EU industry champions and challengers

Areas of strength

The EU continues to perform well in the majority of indicators for **wind (rotors). The EU scores high in all innovation-related indicators for this solution**, being well-placed to capture future growing markets and maintain technological leadership. However, circularity may require further R&I

efforts. **The EU also performs well globally**, as it captures 70% of all extra-EU exports, reaching 84% if intra-EU trade is included. EU Member States host a substantial proportion of the global wind energy supply chain and are the leading suppliers for the EU onshore and offshore wind rotor market. The previously declining trend in wind sector employment and turnover seems to be reversed. However, permitting and skills bottlenecks pose a concern if EU installation targets are to be met.

The EU continues to **perform well in all innovation-related indicators for heat pumps** (mainly for heating), with the exception of early stage investments, where the EU only captures a 13% share, trailing behind the US. However, EU imports have increased significantly in recent years, while exports have stagnated, resulting in a trade deficit in 2020. There is a risk that large Asian manufacturers of air conditioners could saturate European markets with less efficient products.

The EU shows a **strong performance in all innovation-related indicators for offshore operations for renewable installations**. The EU plays host to over 40% of all innovating companies, thanks to being a first mover, especially in offshore wind, but also in ocean energy. The EU has a strong production base of offshore vessels and infrastructures, and European offshore operators are well represented globally, e.g. in the Asia-Pacific region. However, **rapid developments in turbine sizes are causing bottlenecks for operators** in terms of up-to-date vessels and overcapacity. **Ports will require major upgrades** to meet the offshore renewable energy targets, while action is needed to avoid an imminent shortage of skilled workers, as well as large investments in fuel infrastructures to be able to supply zero-emission fuels for maritime transport.

In hydropower and pumped storage, EU public investment is growing and the EU captured a high share of early stage investment and patents globally. While EU exports have been decreasing, the EU still captures 40% of all extra-EU exports, indicating a **strong global presence for EU manufacturers of hydroturbines.**

In heating & cooling networks, the EU performs well on all indicators except for production, which is slightly decreasing. Moreover, there are several growing non-EU markets for the EU to capture. Operating using purely renewable energy sources and waste heat goes hand in hand with the development of smart management systems. **Next-generation networks, which are bi-directional, able to operate at lower temperatures and include thermal storage, facilitate system integration and provide demand-side flexibility**. However, retrofits of existing networks also require a retrofit of the buildings involved.

High expectations

There are signs of **improvement in batteries, solar PV and hydrogen production**. EU public R&D investment in batteries grew by nearly 30% annually in 2015-2019. Early stage investment grew from EUR 1 million in the 2009-2014 period to nearly EUR 600 million in the 2015-2020 period, while **later stage investment increased from EUR 45 million to EUR 1.1 billion** over the same period. Sweden is the top performing EU Member State, largely driven by mega-deals in Northvolt. Nevertheless, many other countries have attracted investments too, indicating that start-ups are emerging in various regions of the EU. The EU is also catching up with Japan and South Korea in patenting activity. While the EU is largely dependent on imports, its production of batteries is growing very fast, with many industry announcements. **In solar PV, EU companies are attracting more venture capital investment than before**, indicating that EU start-ups and scale-ups are becoming relatively more attractive than companies in other regions. New manufacturing facilities have also been announced by industry, which should reverse the decline in EU manufacturing capacity. Growing employment and turnover show that the EU deployment market is growing fast.

As one of the main pathways for decarbonisation, the renewable hydrogen production and electrolysers sector has a high potential for growth and is attracting increasing amounts of venture capital investment. The EU is strong on innovation aspects, performing well in terms of public R&D investment and patenting output. In addition, it has a number of policy initiatives and instruments in place, and a well-established community of stakeholders to facilitate collaboration and access to dedicated funding. As **host to 40% of global electrolyser capacity, and half of the manufacturers of large-scale electrolysers, the EU has a good industrial basis to take advantage of future market opportunities**. However, it could face competition, particularly from the deployment drive and cost reductions in China. Other issues to address include ensuring demand for green hydrogen, and a dependence on (critical) raw material imports, and thus supply disruption and price volatility.

Green ammonia as a sustainable alternative fuel for maritime transport, while still at a very nascent stage, **represents a first mover opportunity for the EU**, provided the required investment is made across the whole value chain and along trade routes. 75% of pilots and demonstration projects currently identified are either located

in Europe or rely on solutions provided by leading EU corporate innovators.

Solutions in need of attention

There are **some trends of concern in transport-related solutions**, such as fuel cells, electric powertrains and EV charging infrastructure, particularly in innovation-related indicators. Investment in the EU, in both public R&D and attracted venture capital, seems to fall behind that of competitors, and the EU hosts a smaller share of innovating companies in these areas compared to the other solutions assessed. The exception is EV charging infrastructure, where EU public R&D investment is increasing and EU applicants account for a significant share of high-value inventions.

Public R&D investment by EU MS is growing at a lower rate than EU GDP for construction-related solutions (prefabricated buildings, superinsulation materials, and building envelope technologies) and is decreasing for building EMS. The level of venture capital investment in prefabricated buildings and building envelope technologies is also lower than the EU average and might indicate that the sector could do more to support the delivery and reap the benefits of building sector decarbonisation and the Renovation Wave. Nevertheless, the EU scores well on innovation outputs in terms of high-value patenting activity in all solutions, showing that the potential is there for innovation. Issues to address include the lack of skilled workers and the accessibility of user data in order to improve products and services.

In cooling & air-conditioning, the EU is falling behind on innovation, but capturing a significant share of early stage investment in 2015-2020. It is increasingly dependent on imports, the effects of which spill over to the closely-related heat pumps market.

In grid EMS, which includes smart control and communication systems enabling demand side flexibility and integration of renewables, the EU performs well in patenting activity, production, exports and trade balance, but investments in innovation need to increase in order to facilitate the development of future grid systems. The increasing integration of renewable energy systems pose a challenge to existing software and analytic solutions, while cybersecurity is also a concern. The EU relies on foreign digital components and assemblies for its digital technologies.

Emerging solutions for the decarbonisation of energy-intensive industries

The EU has the potential to take the lead in green hydrogen-based steelmaking. The EU is already a leader in energy- and CO_2-efficient steel production, and with a 30% share of high-value inventions globally, the EU leads in patenting activity in breakthrough technologies. **About two thirds of global steel decarbonisation projects via the H-DRI route are based in Europe**. Deep decarbonisation of steel production will, nevertheless, depend on the accelerated development and adoption of other technologies, such as electrolysers and hydrogen infrastructure, and the availability of abundant renewable energy.

In Europe, there are three CCUS projects in the cement industry expected to be operational in the mid-2020s, with two more announced recently. While there is clear momentum, some challenges, both economic and technological, remain. Moreover, the EU seems to be falling behind the US on innovation indicators.

Box 2: Connection to other work

This work builds on the report 'Climate neutral market opportunities and EU competitiveness' commissioned from ICF and Cleantech Group in 2020 [5].

It contributes to Clean Energy Competitiveness Progress Report which accompanies the annual State of the Energy Union Report [9].

The solutions chosen for assessment feature in Member States' National Climate and Energy Plans [6] as well as Recovery and Resilience Plans [7] and are aligned with the EU's long-term decarbonisation needs and with the targets of REPowerEU [3].

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Public R&D data is subject to Member States' reporting to the IEA. Production is reported as the value of production sold during the reported period. There is very limited information on the physical volumes of production, therefore, only the monetary value is tracked. Not all EU Member States disclose their data. In all solutions, production and trade aim to track those flows that are specific enough to the solution in question, e.g. electric furnaces and graphite electrodes are used as proxies in steel (H-DRI), and solvents used for CCUS are tracked in cement (CCUS). Employment and turnover are based on Eurobserv'ER investment-based modelling, which is sensitive to the input data. In addition, employment and turnover figures are allocated to the year when projects are commissioned, therefore causing statistical peaks.

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Figure 10 – European Climate Neutral Industry Competitiveness Scoreboard 2021

Source: JRC

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