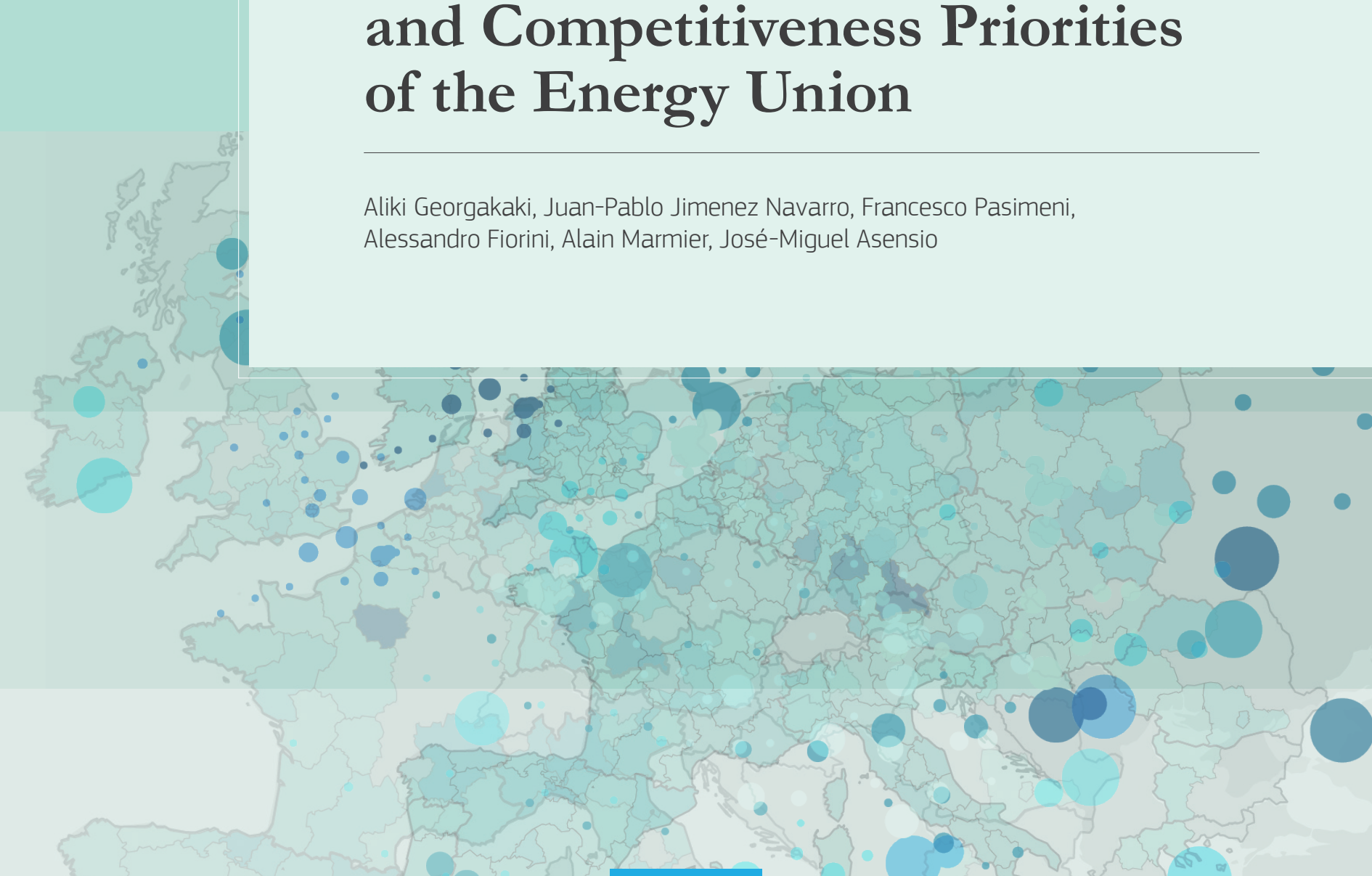
European Commission

Socio-economic regional microscope series

Regional performance in the Research, Innovation and Competitiveness Priorities of the Energy Union

Aliki Georgakaki, Juan-Pablo Jimenez Navarro, Francesco Pasimeni, Alessandro Fiorini, Alain Marmier, José-Miguel Asensio



Joint Research Centre

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Regional performance in the Research, Innovation and Competitiveness Priorities of the Energy Union

The Energy Union is one of the 10 political priorities of the current Commission; and comprises five closely interlinked dimensions, the fifth of which addresses research, innovation and competitiveness (RIC). Trends in patents are among the key performance indicators monitored annually to evaluate the contribution of the European Strategic Energy Technology Plan (SET Plan) to the objectives of the Energy Union in a quantifiable way, as part of the reporting on the State of the Energy Union. At regional level, the Commission has called on the relevant authorities to develop smart specialisation strategies for research and innovation, encouraging all European regions to identify their areas of competitive advantage, where research and innovation investment under cohesion policy could be prioritised. This document provides an overview of regional performance in the Research, Innovation and Competitiveness Priorities of the Energy Union through maps.

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The Socio-economic regional microscope series

The current political and economic challenges faced by the European Union and its Member States call even more for evidence-informed policies. They also require tailor-made policies, developed using highly sophisticated analyses based not only on country-level data, but rather on regional and sub-regional knowledge.

National averages, in particular, bear the risk to present a misleading picture in countries with significant disparities between different regions and areas.

Looking only at national averages can also limit and delay understanding of the differences between regions and cities – identifying leaders and laggards –, as well as prevent the identification of emerging trends in certain socio-economic indicators. Only a detailed analysis of data at regional and local level can bring these insights.

The Joint Research Centre (JRC) of the European Commission has developed the *Socio-economic regional microscope*. It is a new series of short periodical publications which aims to open-up new areas of analysis, and present the stories which can only be told using regional socio-economic data.

Each report presents EU socio-economic indicators according to a data storytelling principle, using a combination of three key elements: data, visuals (maps), and narrative. Each indicator will therefore be represented through maps at regional level (NUTS2), and in some cases even at the NUTS3 and local level.

The *Socio-economic regional microscope* will also show the breadth of the JRC regional analysis in a wide range of research areas: culture, economics, education, energy, healthcare, research and innovation, tourism, etc.

The reports, data and maps are also available on the Territorial Dashboard website of the JRC Knowledge Centre for Territorial Policies, in the *Thematic Analyses* section: *http://urban.jrc.ec.europa.eu/t-board/index.html#/thematic-analyses*.

Introduction

The Energy Union is one of the 10 political priorities of the current European Commission. It comprises five closely interlinked dimensions, the fifth of which addresses research, innovation and competitiveness (RIC)[1]. The Clean Energy for All Europeans[2] Communication of the European Commission identifies innovation as one of the key areas that should be strengthened in the short term, to support jobs, growth and investment in Europe. Similarly, the strategy presented in the Communication on 'Accelerating Clean Energy Innovation'[3] aims to boost research and innovation in clean energy solutions in European companies. To accelerate energy system transformation the European approach to energy RIC should comprise an updated Strategic Energy Technology Plan (SET Plan)[4] and be grouped around four core and two additional priorities, described briefly under the headlines: renewables, smart system, efficient systems, sustainable transport, carbon capture utilisation and storage (CCUS) and nuclear safety[5].

Trends in patents are among the key performance indicators monitored annually to evaluate the contribution of the SET Plan to the objectives of the Energy Union in a quantifiable way, as part of the reporting on the State of the Energy Union[6]. The European Commission's Joint Research Centre has developed a methodology that uses data from the European Patent Office (EPO)[7] to monitor trends in patents in the Energy Union RIC priorities as part of the set of indicators in support of the State of the Energy Union Report.

At regional level, the European Commission has called on the relevant authorities to develop Smart Specialisation Strategies for research and innovation. All European regions have been encouraged to identify their areas of competitive advantage, enabling the prioritisation of research and innovation investment under cohesion policy[8]. This is in line with the Smart Specialisation concept of cooperation across territories with common interests; it enables accelerated learning and the implementation of strategies in a number of policy areas, including Energy[9].

[1] COM(2017) 53 final
[2] COM(2016) 860
[3] COM(2016) 763
[4] *https://ec.europa.eu/energy/en/topics/technology-and-innovation/strategic-energy-technology-plan*
[5] COM(2015) 80 final
[6] C(2015) 6317 final
[7] PATSTAT - EPO Worldwide Patent Statistical Database, European Patent Office
[8] COM(2010) 553 final
[9] *http://s3platform.jrc.ec.europa.eu/s3p-energy*

The EU on the global stage

Patent families normalised by population - International comparison

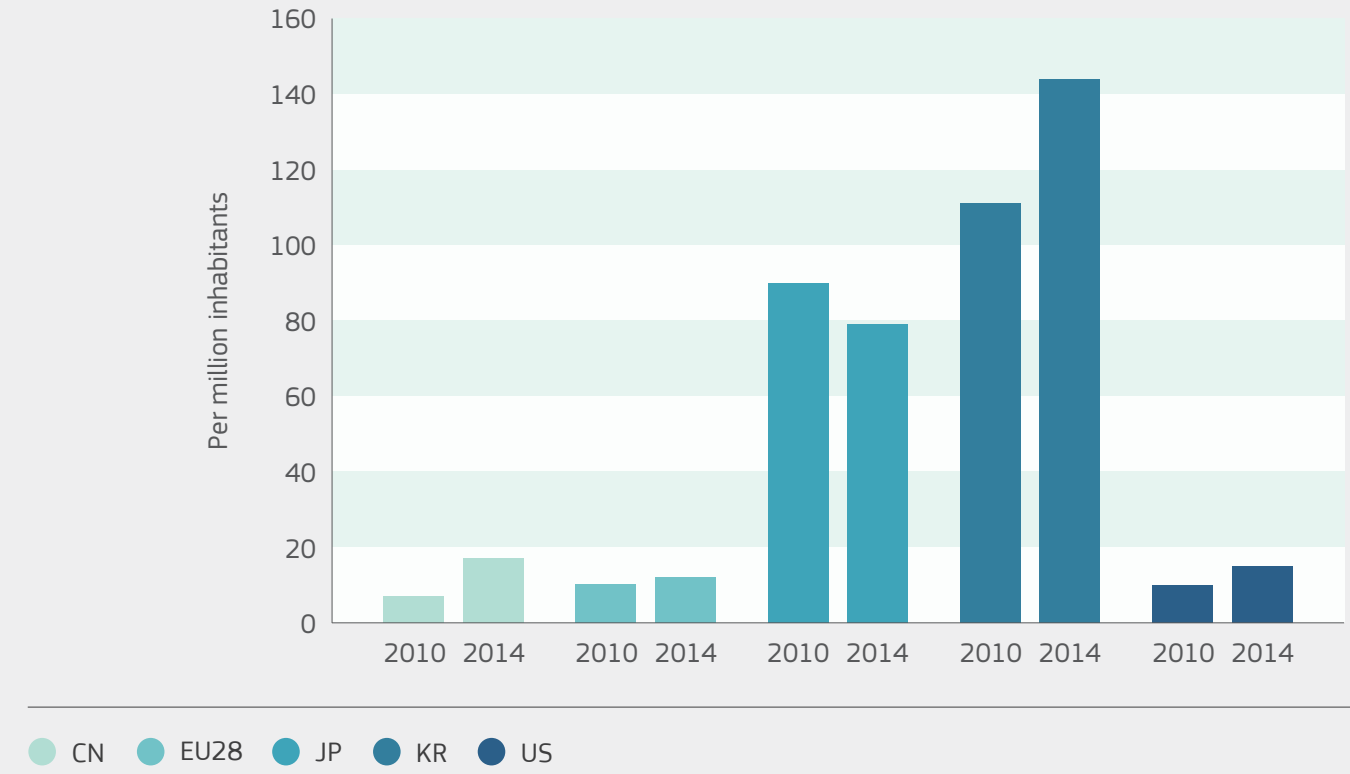


Figure 1. Patenting activity normalised by population. International comparison of patent families, monitoring inventions in the Energy Union RIC priorities, per million inhabitants for the EU and selected major economies. Source: JRC based on EPO data.

Patent families normalised by population - EU and Members States. 2014

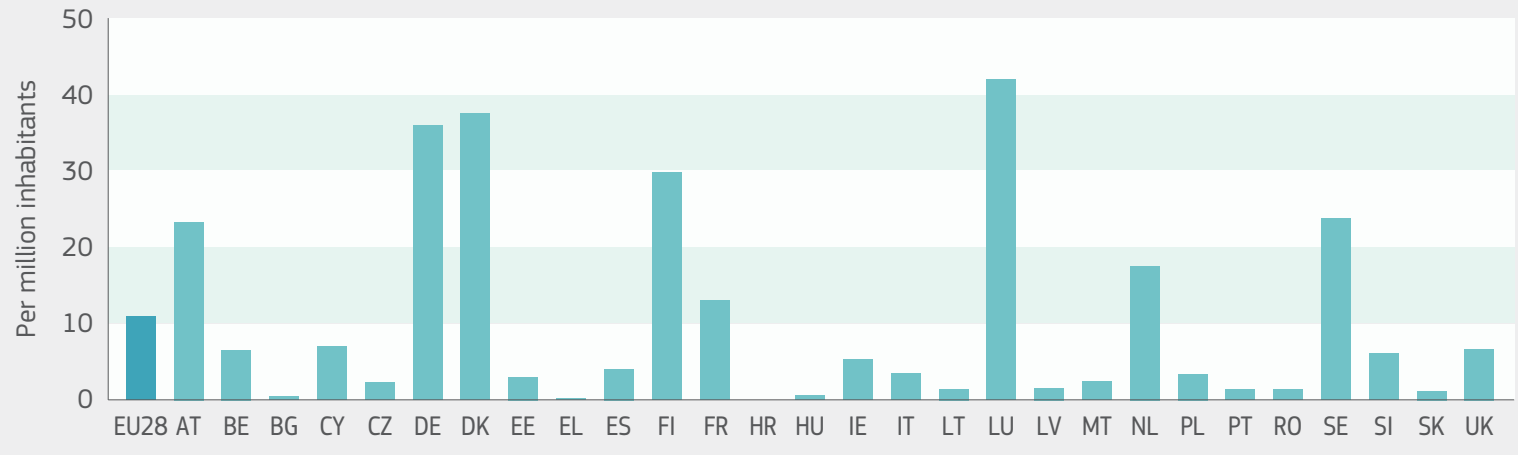


Figure 2. Patenting activity normalised by population. Patent families, monitoring inventions in the Energy Union RIC priorities, per million inhabitants for the EU Member States and EU average. Source: JRC based on EPO data.

Patenting[10] activity in Energy Union RIC priorities has generally been increasing both in the EU and worldwide (Figure 1). The EU performance, when normalised by population, is comparable with the United States (US) and China, but far below the world leaders, Japan and South Korea. Nonetheless, the EU is among the world leaders in specific technological areas, such as wind energy technologies. Furthermore, individual Member States, such as Denmark and Germany, are far above the EU average in all priorities (Figure 2), as well as in the case of specific technologies, where they are often placed among the world leaders[11]. The specialisation index (Figure 3) compares the share of patents in the Energy Union RIC priorities over the total innovative activity for the EU against the respective share for the World. The EU is clearly gaining ground internationally in Sustainable Transport technologies. At the same time the advantage for EU companies in Renewables has been diminishing over time.

Specialisation Index - EU vs the World

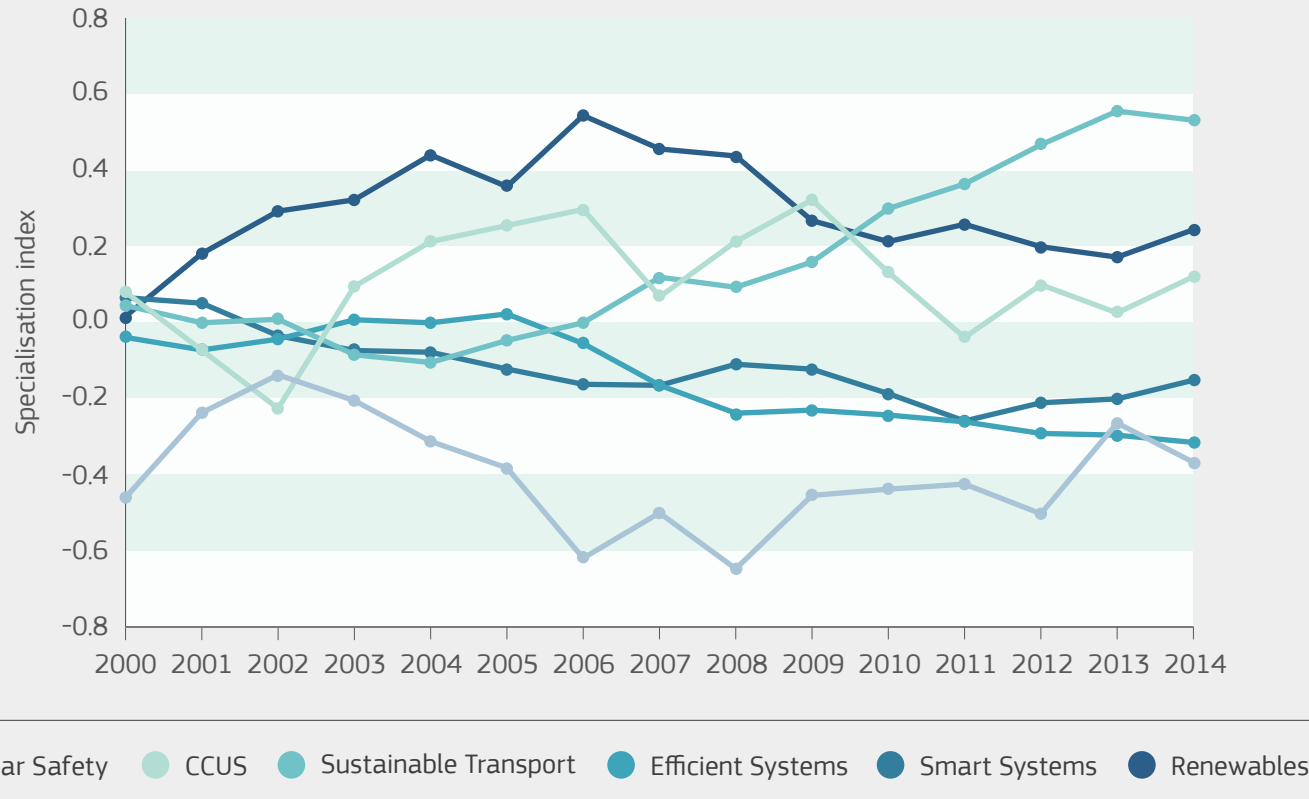


Figure 3. Specialisation Index of the EU versus the World for each of the Energy Union RIC priorities. Source: JRC based on EPO data.

[10] In the context of this document, the term 'patent' refers to patent families, rather than applications, as a measure of innovative activity. Patent families include all documents relevant to a distinct invention (e.g. applications to multiple authorities), thus preventing multiple counting. A fraction of the family is allocated to each applicant and relevant technology.

[11] Luxembourg is the place of registration of a large number of corporate headquarters, relative to the size of the country and the economy; as a result indicators are skewed and do not allow for direct comparison with other Member States.

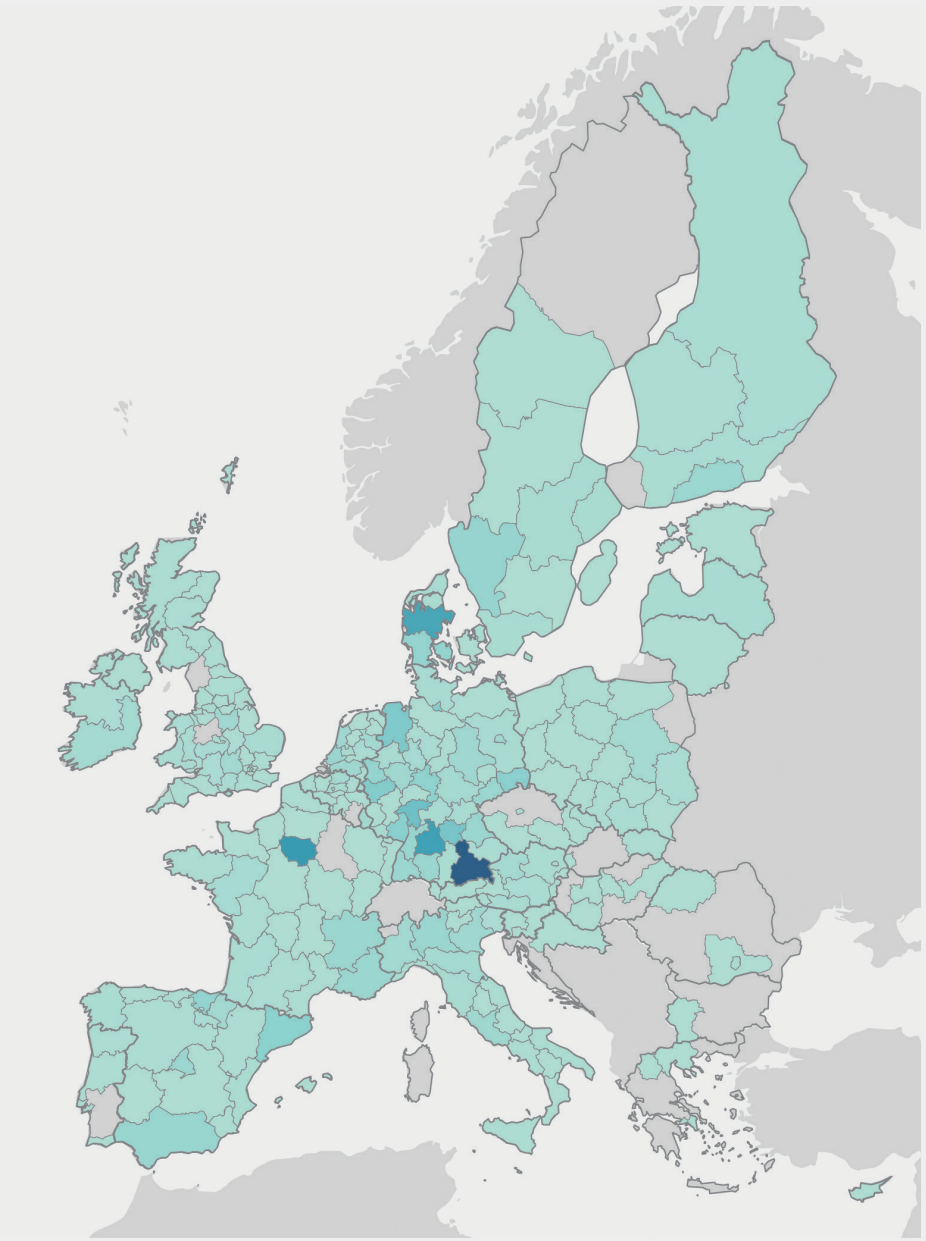
Energy Union RIC priorities in the regions

The following maps present the intensity of research, innovation and competitiveness activities across European regions, quantified by the number of inventions of companies or research organisations. The maps focus on the six Energy Union RIC priorities, and enable the identification of leading regions, and the presence of clusters of innovative entities within a given geographical area. The geographical analysis explores the relevance of a region in terms of innovative performance, mapping how the patenting activity is distributed over each country. The maps show the balance between public and private actors across Europe, by displaying the number of public and private entities with certain patenting activity, while also identifying innovation hubs that could attract knowledge and expertise in specific areas. Special attention is given to the Renewables Energy Union RIC priority. In particular, indicators for wind and solar photovoltaic technologies, which are those with both the highest patenting activity and number of entities, are presented. Finally, the relevance of investment flows in low-carbon energy technology research and innovation by multinational corporations at the national level is discussed.

The information provided in the maps is produced using the European Commission's Joint Research Centre methodology, based on data from the European Patent Office (EPO).

Renewables

Smart Systems



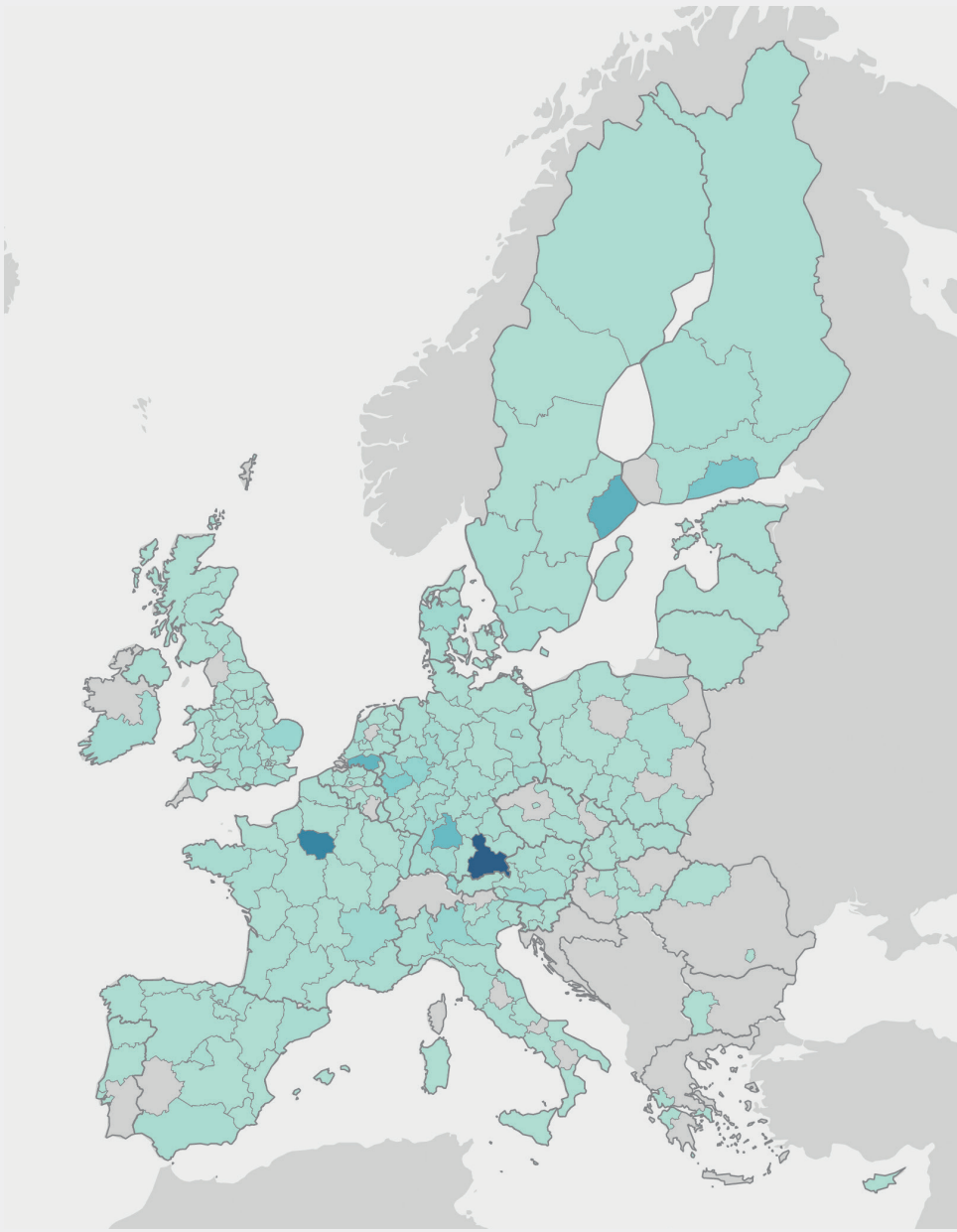


Figure 4a. Patent families, monitoring inventions in each of the six Energy Union RIC priorities (Renewables, Smart Systems), in the EU regions (2010-2014).
Source: JRC based on EPO data.

Efficient Systems

Sustainable Transport

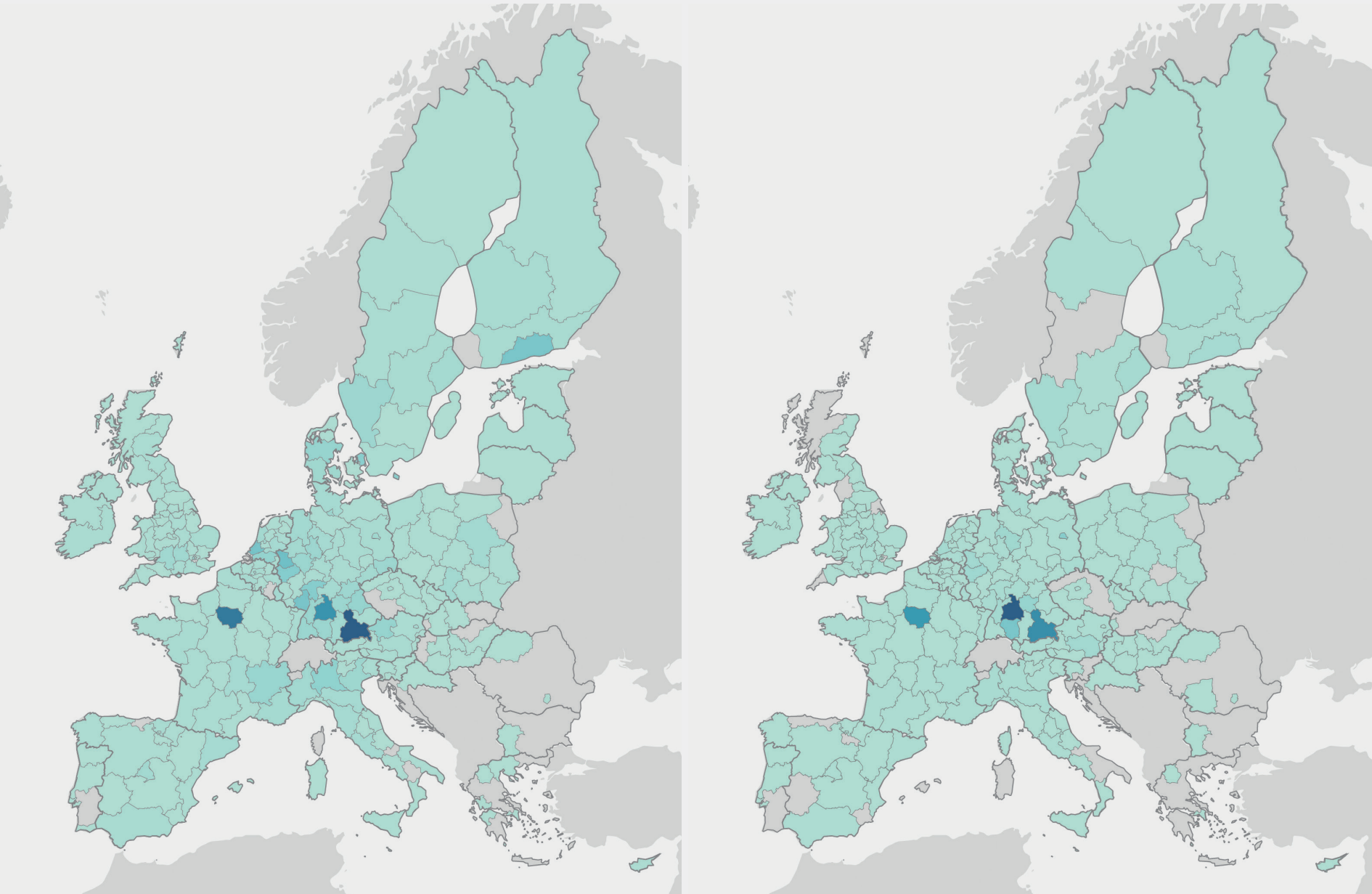
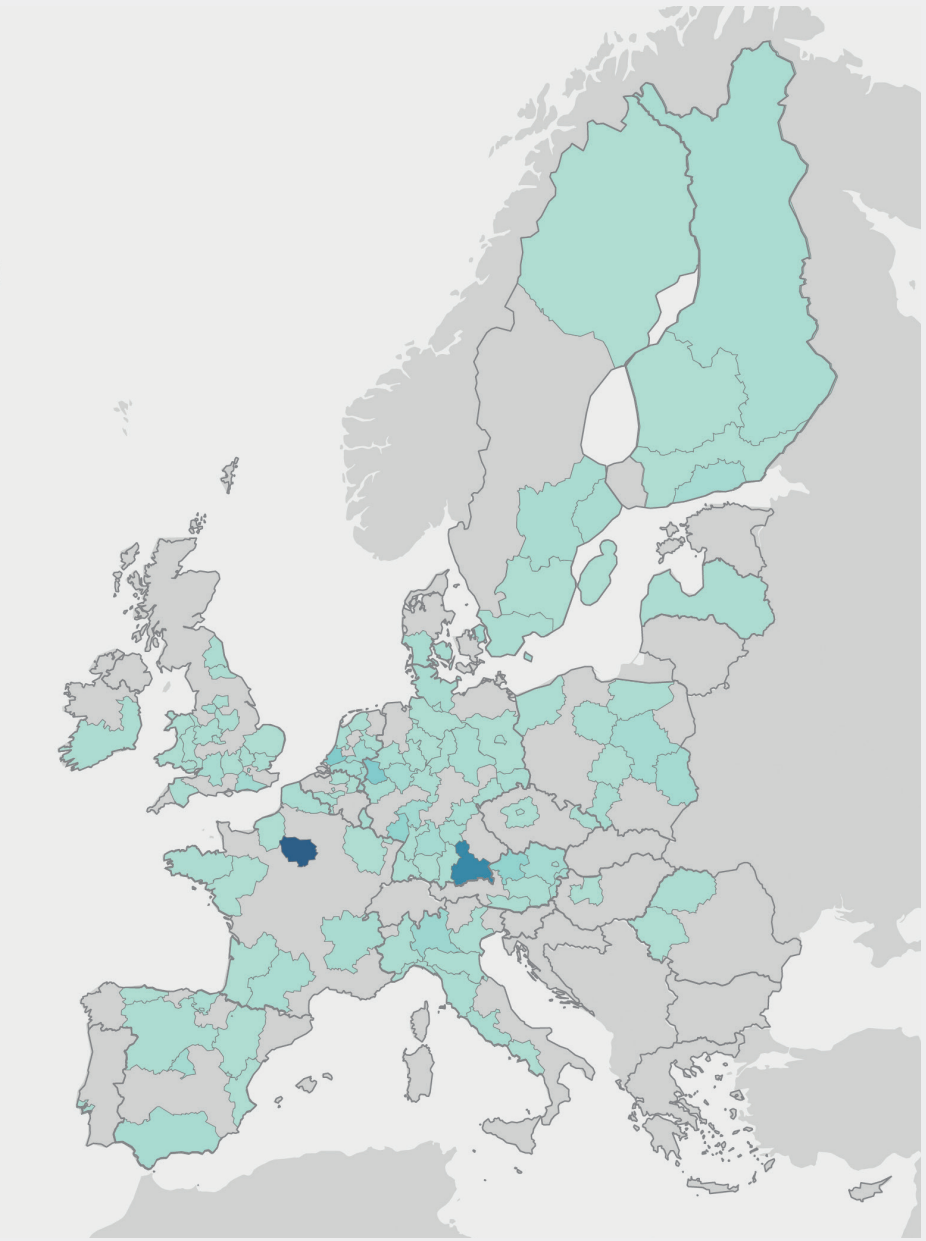


Figure 4b. Patent families, monitoring inventions in each of the six Energy Union RIC priorities (Efficiency Systems, Sustainable Transport), in the EU regions (2010-2014).
Source: JRC based on EPO data.

CCUS

Nuclear Safety



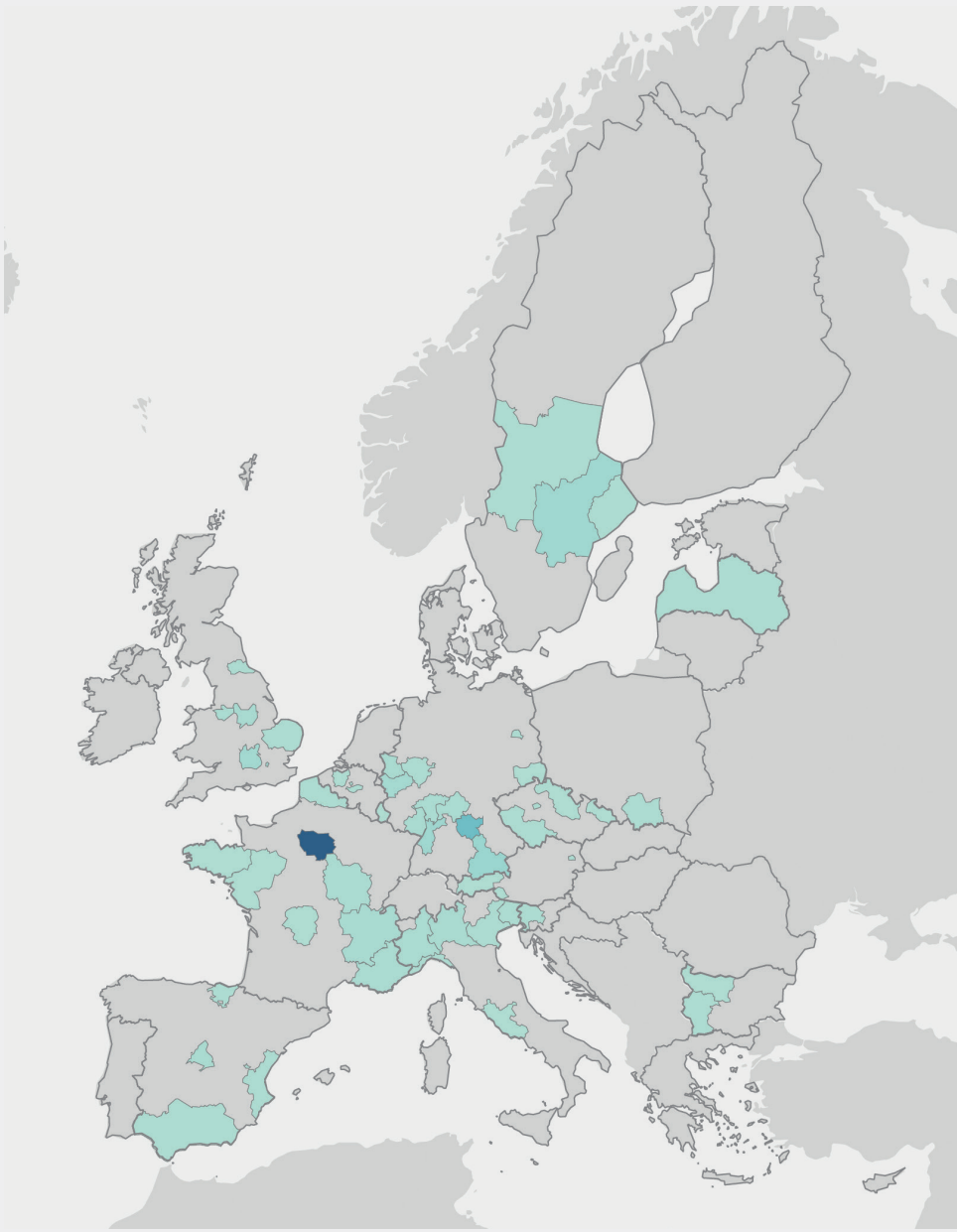
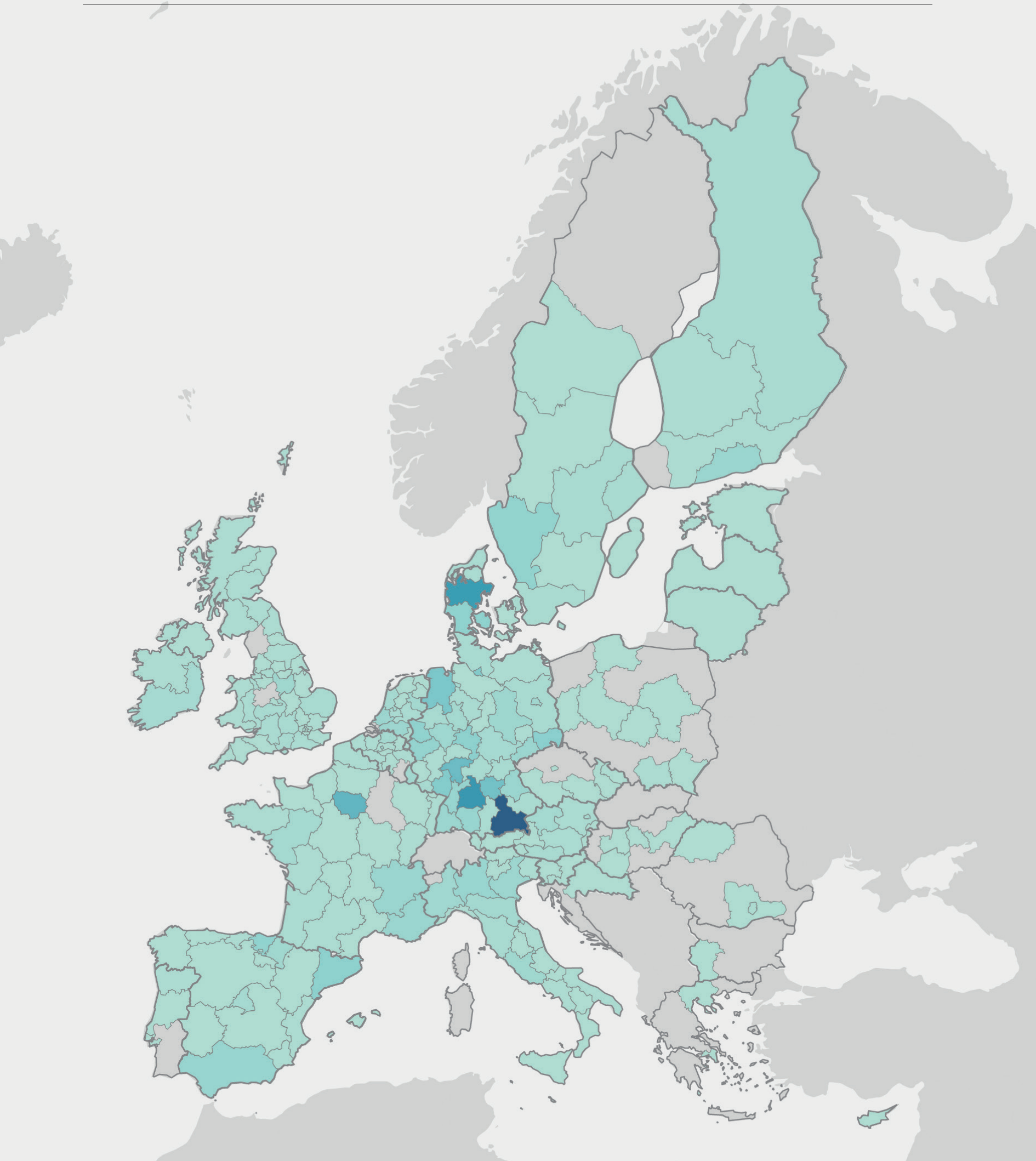


Figure 4c. Patent families, monitoring inventions in each of the six Energy Union RIC priorities (CCUS, Nuclear Safety), in the EU regions (2010-2014).
Source: JRC based on EPO data.

Similarly to the variation across EU Member States, patenting trends in Energy Union RIC priorities also vary significantly across the EU regions (Figure 4). There are high levels of activity across a large number of regions in Sustainable Transport, an area where the EU is gaining ground internationally. The topics of Smart and Efficient Systems and Renewables are also widely pursued across the board, in contrast to Carbon Capture Utilisation and Storage, and Nuclear Safety, where the efforts are concentrated in fewer regions.

Patenting activity can be further distinguished on whether it is driven by public (university or research organisation) or private (industry) actors (Figure 5). Public funding is often necessary to support fledging technologies through the early stages of development associated with high risk, but the involvement of industry is crucial to successfully bring them to market. For example, at regional level, patenting activity in Renewables is concentrated in Central and Western Europe and driven mostly by the private sector, although a number of regions also host public research entities with a notable performance. Between 2010 and 2014, Île-de-France is by far the leading region in publicly funded activities, containing 18 organisations which filed for 218 patent families; Köln in Germany is the second region with 9 organisations and 70 inventions. Oberbayern (Upper Bavaria) is the leading region in patents from private organisations, being home to 65 companies with 768 patents between them. Another German region, Stuttgart, is second with 436 patents from 70 companies, followed by the Danish region of Midtjylland, with 408 patents also from 23 companies. Patenting activity in Renewables in Denmark is almost entirely industry driven.

Disaggregating the Renewables priority further, the mapping shows whether the regions identified above are home to clusters of entities active in research and innovation in specific technologies, and whether the competencies are spread across one or multiple Energy Union RIC priorities.



Private sector

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Figure 5a. Patent families, monitoring inventions in the Renewables Energy Union RIC priority, in the EU regions split by applicant sector (Private, 2010-2014).
Source: JRC based on EPO data.

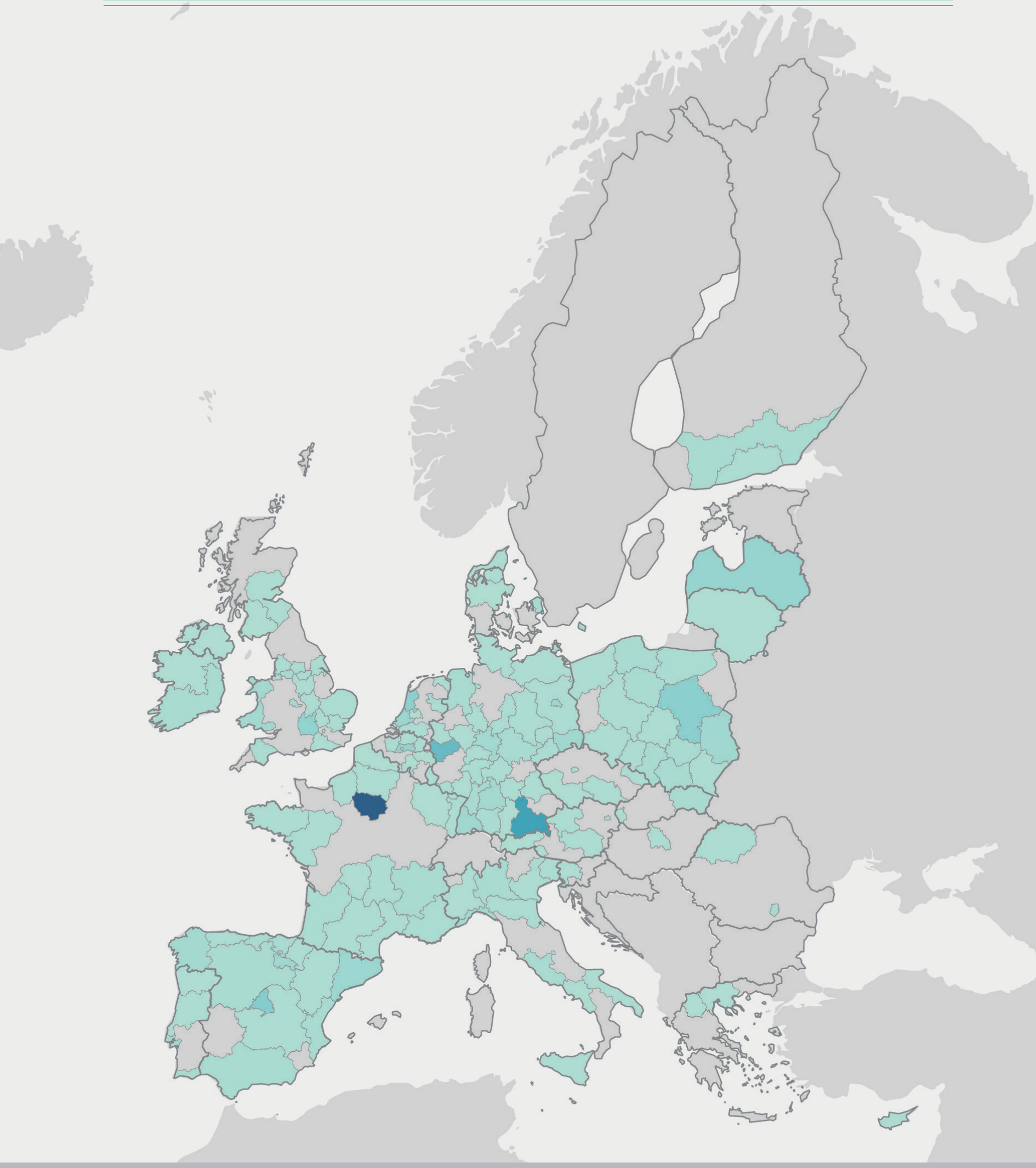


Figure 5b. Patent families, monitoring inventions in the Renewables Energy Union RIC priority, in the EU regions split by applicant sector (Public, 2010-2014).
Source: JRC based on EPO data.

Using Renewables again as an example, Figure 6 shows the patent output in two prominent technologies, solar photovoltaics (PV) and wind energy across the EU regions. Île-de-France stands out as the host of the largest number of entities (both public and private), active in research and innovation for solar PV technologies followed by the regions of Oberbayern and Stuttgart in Germany and Lombardy in Italy. Similarly, entities patenting in wind technology are clustered in Île-de-France, followed by Stuttgart and Oberbayern in Germany.

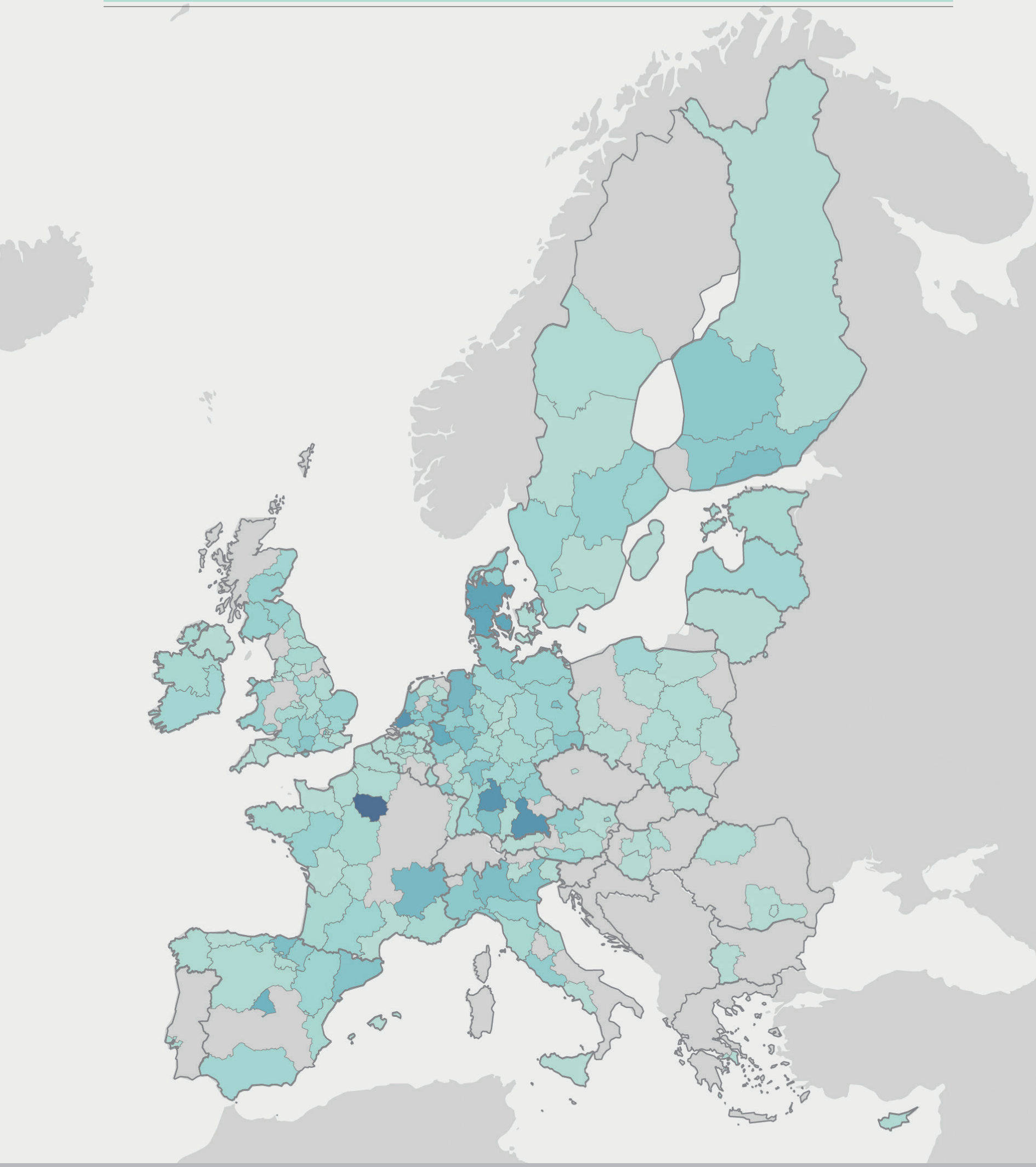
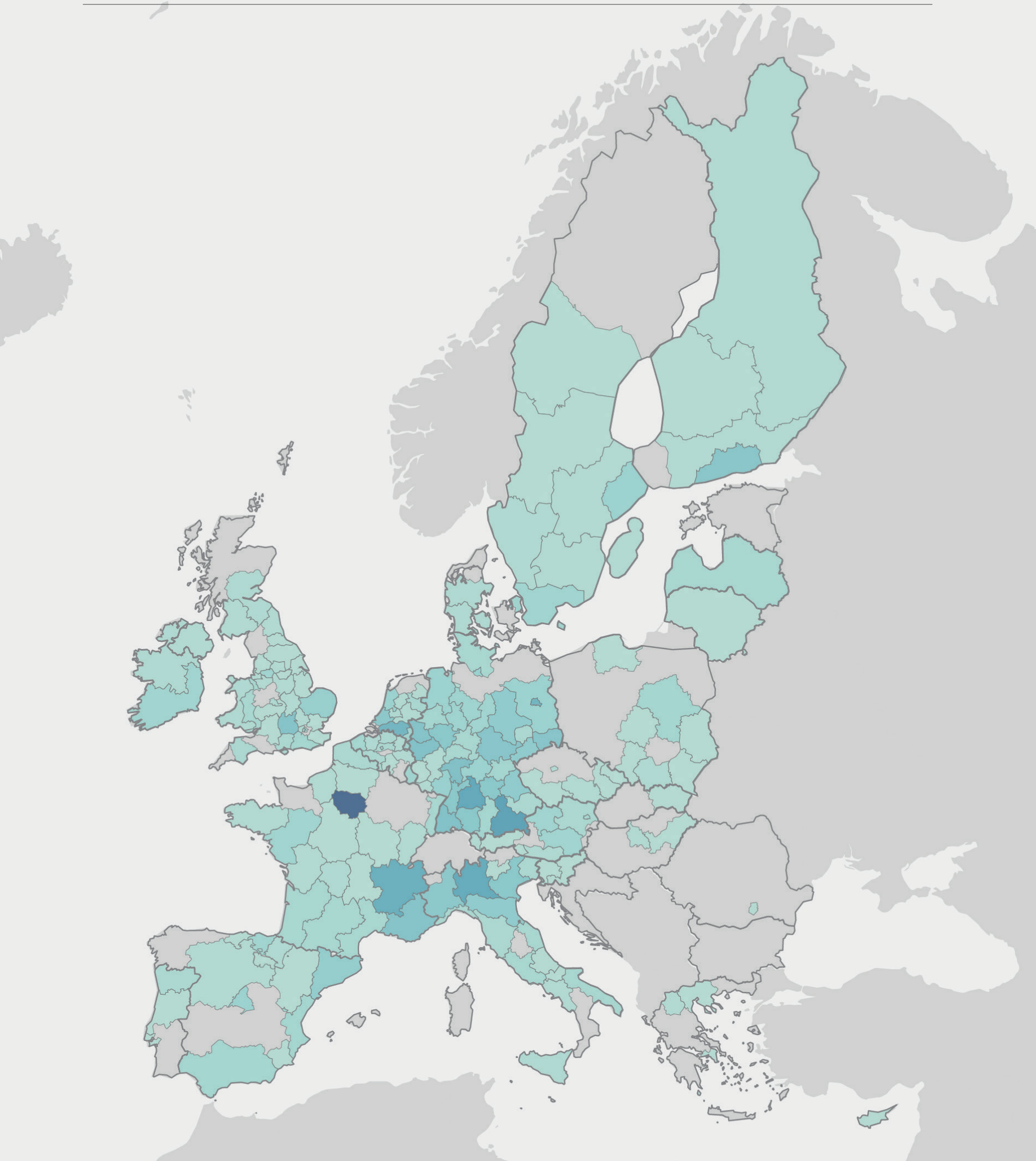


Figure 6a. Number of innovators (companies or research organisations applying for a patent) in the EU regions for two prominent renewable technologies (Wind, 2010-2014). Source: JRC based on EPO data.



Solar PV

1 66

Figure 6b. Number of innovators (companies or research organisations applying for a patent) in the EU regions for two prominent renewable technologies (Solar PV, 2010-2014). Source: JRC based on EPO data.

Patent intensity in the six Energy Union RIC priorities varies across European regions (map on the left in Figure 7). In the period 2010-2014, companies in the Oberbayern region in Germany have produced on average 19 inventions each, followed by Stuttgart with 17 inventions per company. Midtjylland in Denmark has a patent intensity equal to 10, while the Île-de-France region ranks sixth with 8 patent families per company, despite the high number of innovators. Three regions in Poland have more than 7 patents per company.

Regional differences in each Member State provide insights on the national and regional systems of innovation (Figure 7). In France, innovation activity is concentrated in the Île-de-France region (71 %), while other countries show a more heterogonous innovation environment. The Italian innovation system shows clear differences between Northern and Southern regions, compared to Spain where the inventive outcomes are more balanced. In Germany, although the highest concentration remains in the Oberbayern and Stuttgart regions (57 % in total), all other regions also have notable activity. In the United Kingdom, regional output gradually increases from North to South, with the highest concentration occurring near London.

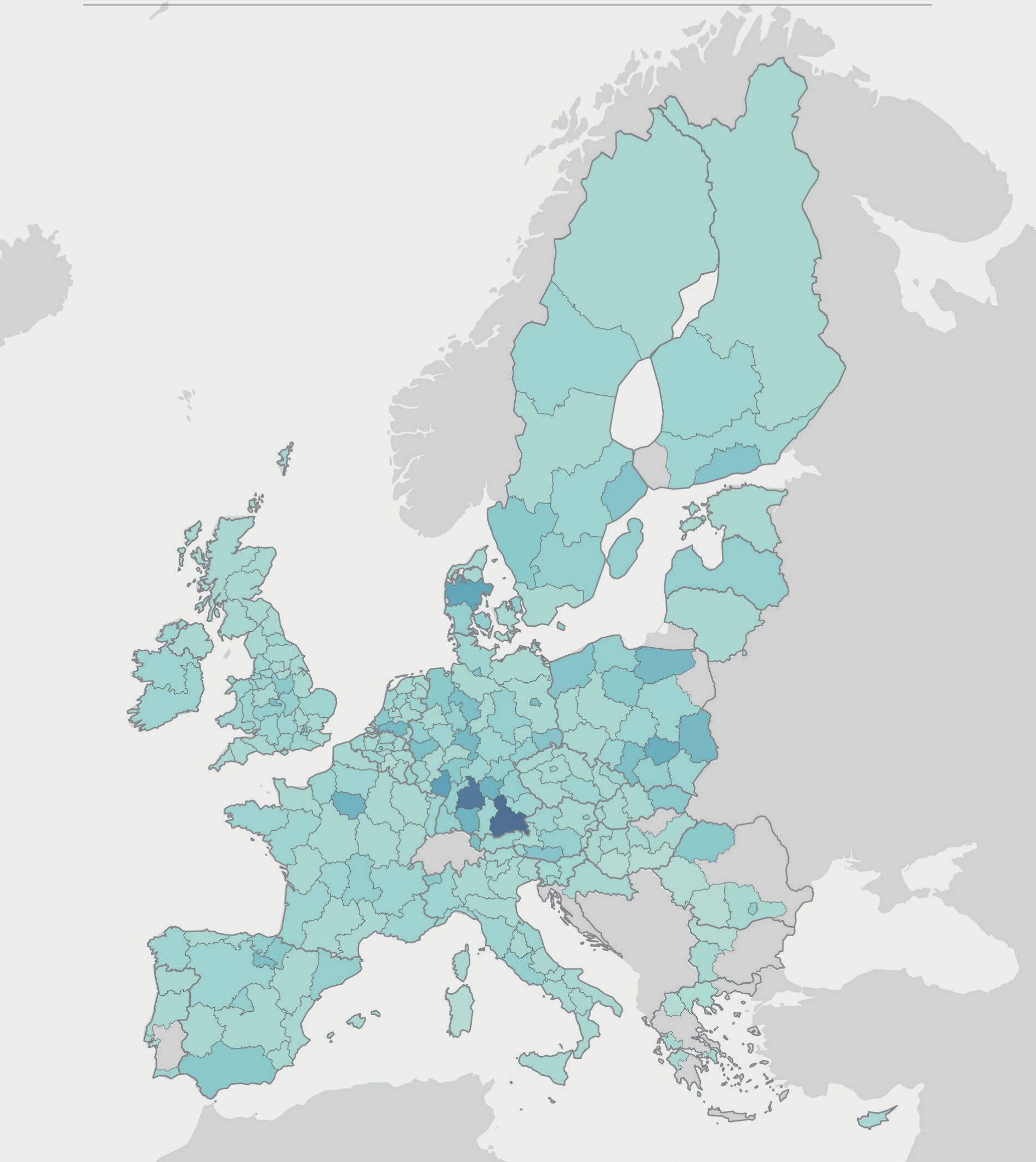


Figure 7a. Patenting intensity in Energy Union RIC priorities by the private sector in EU regions, 2010-2014.
Source: JRC based on EPO data.

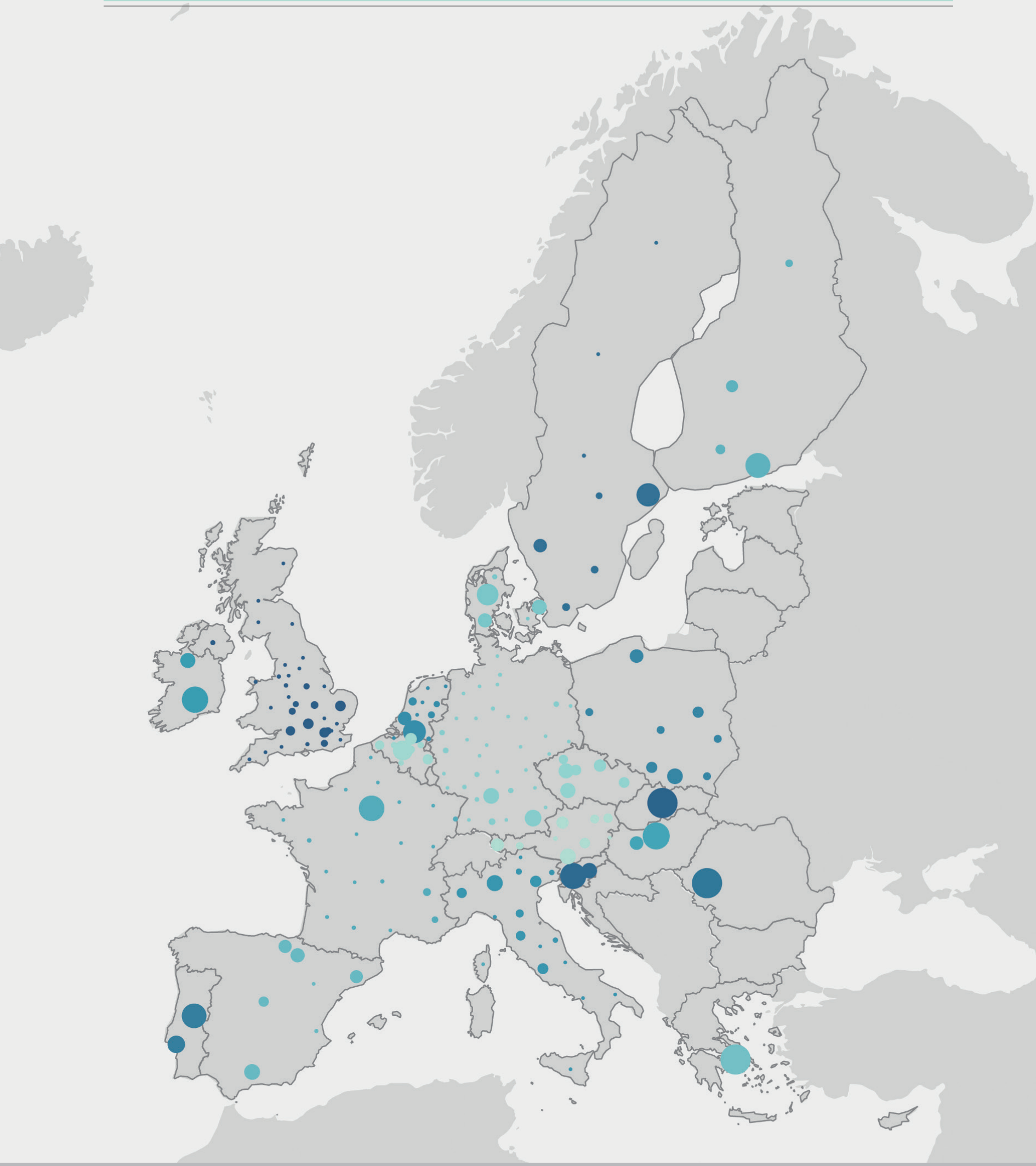


Figure 7b. Patenting intensity in Energy Union RIC priorities by share of inventions per region in EU Member States, 2014 (right). Countries with a single region are not shown: Cyprus, Estonia, Lithuania, Luxembourg, Latvia and Malta. Source: JRC based on EPO data.

Investment flow in Energy Union RIC priorities

Multinational Corporations (MNCs) trigger much of the new development in energy technologies by investing to energy-related research. The term 'energy exposure' measures the estimated share of R&I budget allocated by MNCs to low-carbon energy technologies over their total R&I investment[12]. Figure 8 shows the average energy exposure of MNCs registered in the EU. The energy exposure is less than 7 % in most countries, however corporations headquartered in Spain and Denmark allocate 23 % of their R&I budget to energy-related activities. This is explained by the fact that the core business of the largest MNCs based in these countries (such as Vestas AS and Dong Energy AS in Denmark, and Acciona SA and Abengoa SA in Spain) is more energy-oriented compared to other countries.

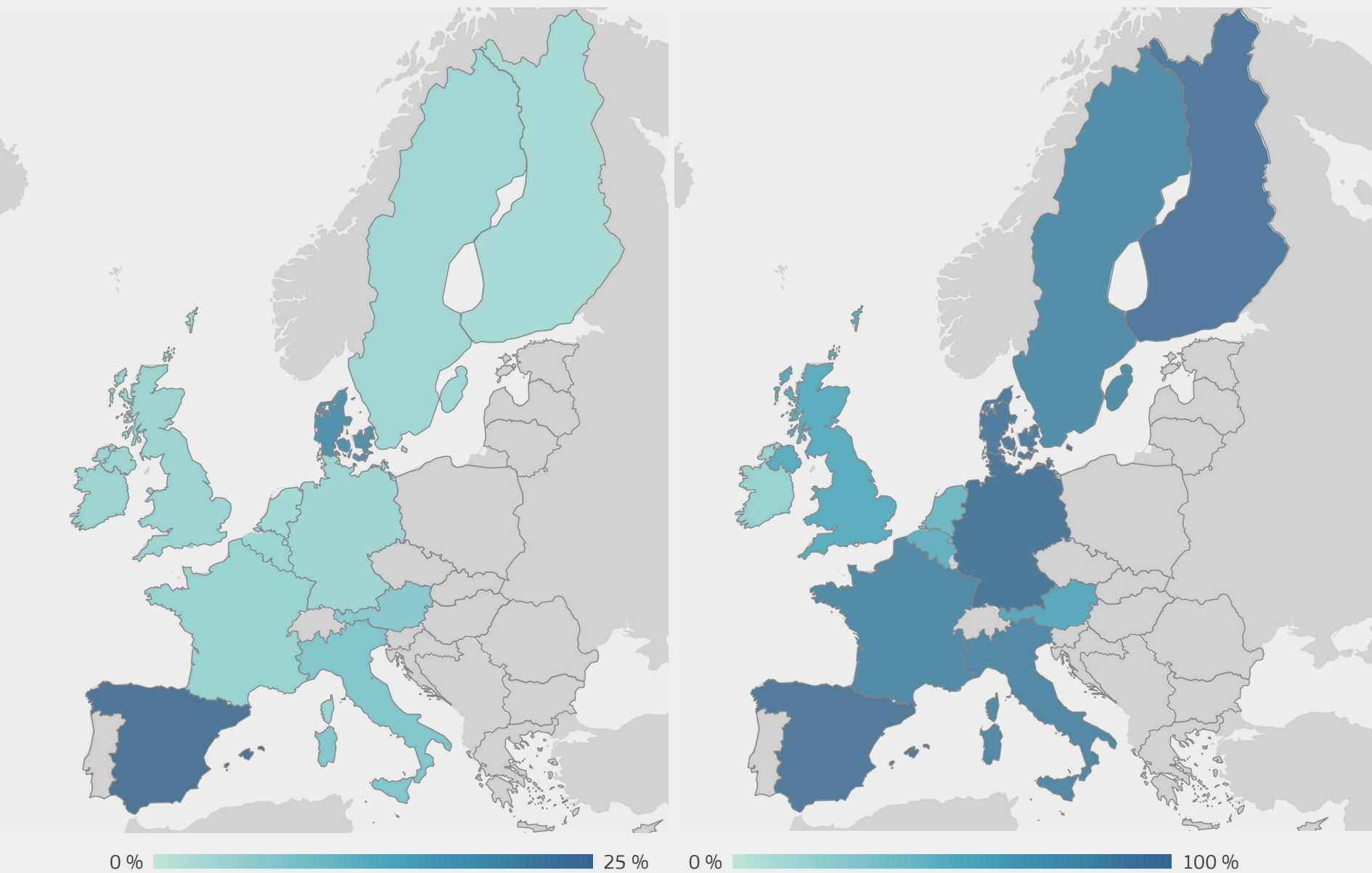


Figure 8. R&I exposure to low-carbon energy technologies (left) and energy R&I investment allocated to the home country (right) for Multi-National Corporations based in EU Member States. Source: JRC based on EPO data.

[12] Methodology: Pasimeni, F; Fiorini, A; Georgakaki, A. (2018). 'Patent-based Estimation Procedure of Private R&D: The Case of Climate Change and Mitigation Technologies in Europe', *SPRU Working Paper Series*: *www.sussex.ac.uk/spru/swps2018-06*

The energy R&I budget of a MNC can be directed to subsidiaries either within the same country or abroad. Figure 8 also shows the average share of the R&I budget remaining in the home country, i.e. allocated by the parent company to subsidiaries within the country of registration. Figure 9 (the Sankey diagram) shows the flow of R&I in energy technologies, from EU parent companies to foreign subsidiaries.

For the most part, EU corporations tend to allocate energy R&I budget to subsidiaries located within the same country. Exceptions are Ireland, the Netherlands and Belgium. Companies headquartered in the Netherlands also have the highest share of R&I budget directed to foreign subsidiaries. The above is explained by a favourable fiscal regime, in both Ireland and the Netherlands, which has motivated MNCs to locate their headquarters in these countries, while maintaining subsidiaries and R&I operations elsewhere.

Geographical and language proximity further explain the flows in Figure 9. The budget allocated to subsidiaries in Switzerland (CH) and in Belgium (BE) is provided, almost entirely, by French corporations. Corporations in the United Kingdom (UK) allocate about 60 % of their investment in energy research to subsidiaries in the United States (US). This is due to the historical relationship between the countries and to their language proximity; the latter also explains the connection between Ireland (IE) and the United States (US). Germany (DE) is both a major origin and destination country for R&I internationalisation; a confirmation of its central role in the energy industry. The strong connection between subsidiaries in Sweden (SE) and in Austria (AT) and German corporations is also due to the geographical proximity among these countries. Finally, R&I investment in Japanese (JP) subsidiaries comes from MNCs located either in Sweden or in Germany. This relationship is sector-dependent since EU subsidiaries in Japan are mostly active in the transport sector, which is also one of the most prominent sectors in the two origin countries.

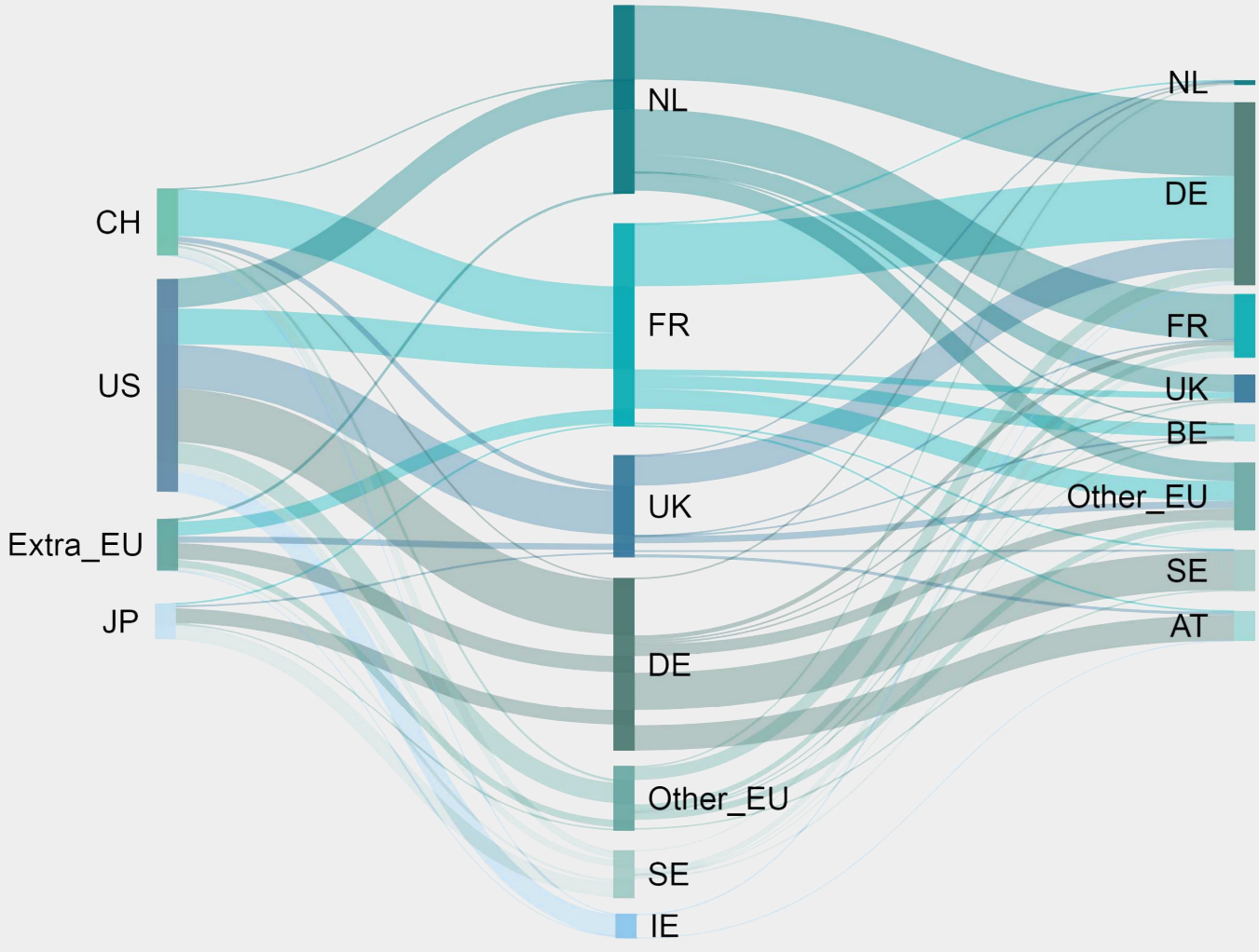


Figure 9. R&I flow from European MNCs to foreign subsidiaries. Average 2010-2014. Centre column: country of origin; left column: destinations outside the EU; right column: destinations within the EU. Source: JRC based on EPO data.

Strengthening Innovation in Europe's Regions

The EU is investing less in R&D as a share of GDP than other major international trading partners. Gross domestic expenditure on R&D per GDP[13] has been increasing, but has yet to reach the 3 % target of the Europe 2020 strategy[14] for smart, sustainable and inclusive growth. While Member States need to prioritise expenditure on R&D as a means of enhancing growth, there is in parallel, a need to monitor the efficiency and impact of these investments, including on leveraging funds from- and building networks with industry[15]. The Communication on 'Strengthening Innovation in Europe's Regions'[16] identifies the key challenges in boosting innovation-led growth, which include actions on energy, as kick-started in the context of the Communication on Clean Energy for all Europeans[17], and the smart specialisation thematic platform on energy. These actions include enhanced dialogue between stakeholders, as well as increased cooperation on research and innovation across regions. Monitoring research and innovation on the Energy Union RIC priorities at the regional level helps to identify competitive strengths and relevant stakeholders, and also provides a basis for better targeted EU support when needed.

[13] Eurostat. Research and development expenditure, by sectors of performance [tsc00001]
[14] COM(2010) 2020 final
[15] COM(2014) 339 final
[16] COM(2017) 376 final
[17] COM(2016) 860 final

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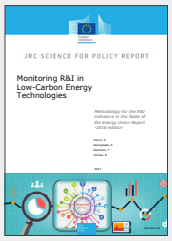

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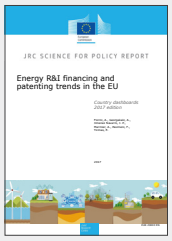

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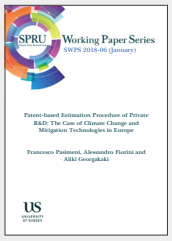

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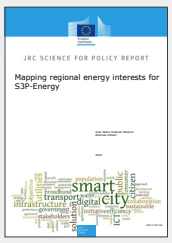
https://www.sussex.ac.uk/webteam/gateway/file.php?name=2018-06-swps-pasimeni-et-al.pdf&site=25



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