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Chapter 2.5 Resilience and the clean energy transition

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Chapter 2.5
Resilience and the clean energy transition

2.5.1. Introduction

The European Union's high reliance on external energy supplies has weakened its international competitiveness, as high and volatile energy prices have increased the costs and exposed the EU to unstable supply conditions (European Commission, 2025l). The impact of this was most recently illustrated by the disruption of energy flows through the Strait of Hormuz. In 2024, the EU produced 43% of its own energy. Oil and petroleum products still accounted for the largest share of energy sources (38%), with almost all of these products (96%) imported from outside the EU (Eurostat, 2026a). Similarly high levels of dependency on external suppliers are observed for natural gas, with 12% still being imported from Russia in 2025. ([108])

In response to these vulnerabilities, the European Union adopted, among other initiatives, the Competitiveness Compass, which identifies the shift to clean and affordable energy as one of the transformational imperatives for boosting competitiveness ([109]) (European Commission, 2025b). The 2026 European Semester Spring Communication highlights that this transition will simultaneously improve energy security by reducing the EU's dependence on external suppliers, while also making the EU economy more competitive by lowering energy-related production costs. The transition will also reduce the impact of geopolitical tensions on the internal energy market. Moreover, greater deployment of renewable energy could reduce water use in the energy sector and mitigate air pollution with positive effects for human health.

2.5.2. Energy autonomy for a more competitive economy

2.5.2.1. Electrification as a key to energy autonomy

The roll-out of the renewable energy sources, alongside the electrification of industrial processes, remains a key means of reducing the exposure of people and businesses to energy price volatility (European Commission, 2025c). The EU has already made substantial progress in rolling out renewable energy sources. ([110]) In 2024, renewables accounted for 25.2% of the EU's gross final energy consumption and 47.5% of gross final electricity consumption. ([111]) Compared with a decade earlier, this represents a major structural shift. Solar photovoltaic (PV) and wind technologies have evolved from being marginal energy sources to become defining components of the energy system with deployment accelerating across a wide range of Member States. The newly installed renewable energy capacity in 2024 is estimated at around 77 GW, which is a 17% increase on 2023. (European Commission, 2025k)

In 2024, the proportion of renewable energy in final energy consumption still differed greatly among Member States, reflecting their varying starting points in the transition to clean energy. Sweden recorded the highest proportion (63%), followed by Finland (52%), Denmark (46%), Latvia (46%) and Austria (43%). By contrast, Belgium, Luxembourg, Ireland, Malta and Poland recorded the lowest shares, all below 18%. ([112]) Reaching the EU 2030 target of 42.5% renewable energy consumption in the EU's energy mix ([113]) will require a much faster uptake of renewables

([108]) The import of gas from Russia dropped from 45% in 2021 to 12% in 2025. See REPowerEU - 4 years on.

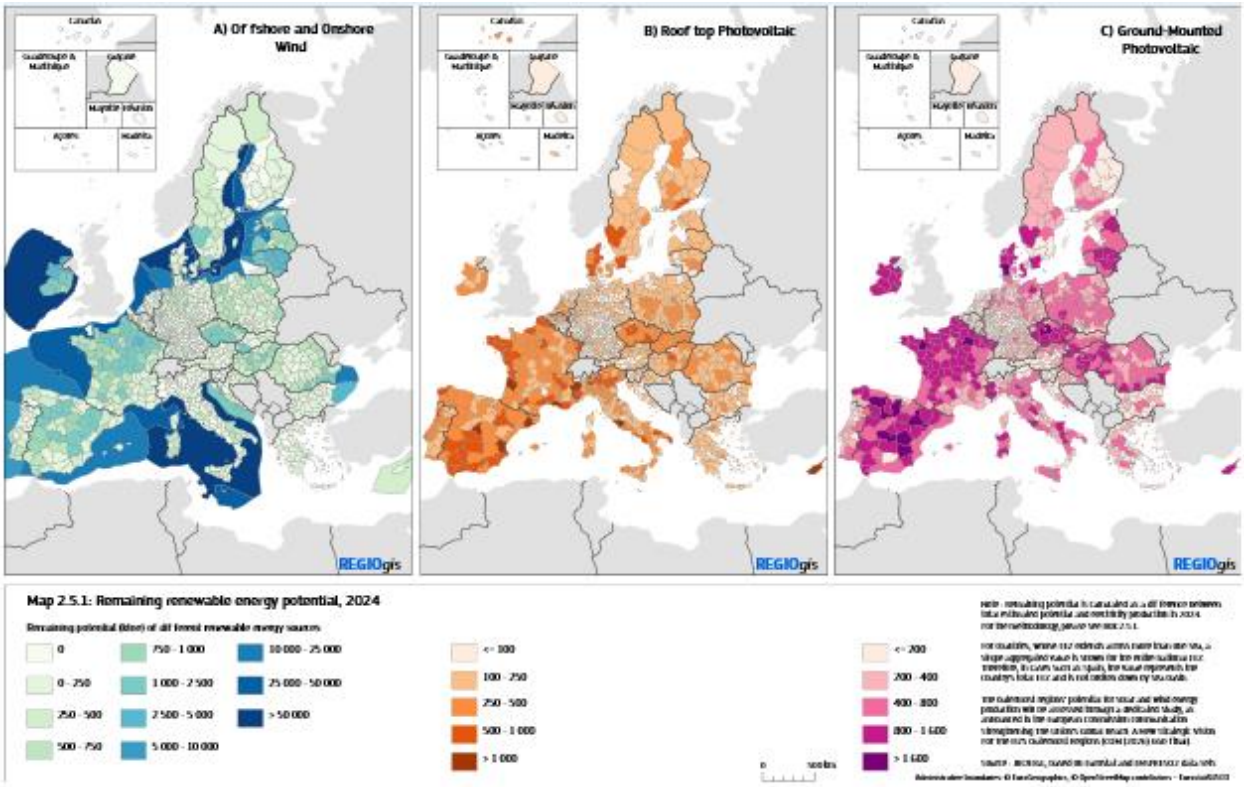
([109]) Other enablers of decarbonisation and competitiveness identified in the Competitiveness Compass include shifting of the economy to cleaner production, improving resource efficiency and increasing the circular use of materials in line with the forthcoming Circular Economy Act.

([110]) Renewable energy sources include hydropower, wind and solar energy, gaseous and liquid biofuels, renewable municipal waste, geothermal energy, and tide, wave and ocean energy. See Eurostat – Reference metadata: Share of energy from renewable sources [nrg_ind_share].

([111]) Eurostat datasets: Main indicator - share of renewable energy [nrg_ind_ren].

([112]) Eurostat dataset: Main indicator - share of renewable energy [nrg_ind_ren].

([113]) Target laid down in (Directive (EU) 2023/2413, 2023)



in the coming years (European Commission, 2025k). Progress in countries such as Estonia and Lithuania, where the energy mix has shifted significantly towards renewables in recent years, should not obscure the scale of the challenge facing the EU. This challenge is even greater as the EU simultaneously decarbonises power generation and attempts to electrify a much larger share of the economy while preserving affordability and security of supply. Efforts to increase the share of renewable energy must also be accompanied by measures to reduce energy demand through improved energy efficiency.

Electricity still constitutes only a small proportion of final energy consumption in most Member States. The lowest shares are found in central and eastern Europe (at an average of 20%) ([114]) and remain considerably below the 2040 indicative target of 46% (European Commission, 2026e). The 2026 European Semester (European Commission, 2026a) notes that, to incentivise electrification several Member States, including Belgium, Greece and Poland, would benefit from reducing the relatively high taxation of electricity compared with fossil fuels.

Analysis shows that the EU has substantial renewable energy potential, which is distributed across regions in highly differentiated ways. Solar PV potential alone could generate roughly 7 800 TWh annually, while onshore wind could generate around 3 400 TWh and offshore wind around 8 500 TWh ([115]). Taken together, this implies that the EU's renewable potential could cover around twice the current energy demand. ([116])

According to model estimates covering both ground-mounted and rooftop PV, more than 90% of PV potential remains untapped in most Member States. In absolute terms ground-mounted PV can deliver twice as much energy as rooftop PV (see Map 2.5.1, panels C and B, respectively). The remaining PV potential depends on solar resources, land or roof availability, and the size of the region. For ground-mounted PV, the highest absolute potential is estimated to be in large regions with available land, such as those in Ireland, and in areas with favourable solar conditions, such as Cyprus and the Spanish regions of Castilla-La Mancha and Aragon. Similar factors influence the remaining potential of

([114]) Eurostat dataset - Final energy consumption by product [ten00123].

([115]) Estimates based on (JRC, forthcoming), (Elsner, Collaer and Uihlein, 2026a), (Uihlein, Elsner and Collaer, 2026)

([116]) Eurostat - Energy Balances: Final consumption – energy use in 2024 was used as to estimate energy demand.

Box 2.5.1: How to calculate remaining renewable energy potential?

The remaining renewable energy potential is calculated as a difference between the total estimated renewable energy potential (ENSPRESO2 dataset) and the energy produced from renewable sources in 2024 (Eurostat energy balances). ENSPRESO2 provides a so-called feasible technical potential. This goes beyond purely theoretical potential by applying additional criteria that reflect real-world constraints. Therefore, for each renewable energy source, the theoretical potential determined by the overall wind or solar resource is used as a starting point. The modelling then uses a set of constraints, such as, for example, land cover, distance to settlements, terrain suitability, and exclusion of conservation areas (see Elsner at al., 2026). It should be noted that some of those criteria are subject to political decisions of Member States. Examples are changes in setback distance regulations or the expansion of marine space declared to be military area which would directly impact on the estimated potential for onshore and offshore wind, respectively. For energy production, disaggregation from MS level to NUTS 3 is performed using information on currently operating power plants. If the plant or installation location is known, energy produced can be attributed to specific NUTS 3 region. If location data is unavailable, the produced energy is allocated across NUTS 3 regions according to the ENSPRESO2 potential. A mapping of this potential is provided in Map 2.5.1.([1])

([1]) For countries whose exclusive economic zone extends across more than one sea, a single aggregated value is shown for the entire national EEZ. Therefore, in cases such as Spain, the value represents the country's total EEZ and is not broken down by sea basin. The assessment of the outermost regions' potential for solar and wind energy production will be developed through the dedicated study as outlined in (European Commission, 2026).

rooftop PV: solar resource availability is relevant for urban regions such as Bouches-du-Rhône in France and Barcelona and Valencia in Spain, while the absolute size of the region shapes the remaining potential in regions such as Pohjois-Pohjanmaa in Finland. ([117])

The remaining potential for wind energy deployment in the EU is also very significant and its roll-out needs to be accelerated. The highest absolute remaining potential for onshore wind is found in northern and western Ireland, across parts of Lithuania and Estonia, and the northernmost regions of France (see Map 2.5.1, panel A). More than 90% of this onshore wind potential is unrealised.

Likewise, the unrealised potential of floating offshore wind is close to 100% across exclusive economic zones (EEZ) in the Atlantic, the Mediterranean Sea and the Black Sea. Only in some parts of the North Sea EEZ has the potential for bottom-fixed offshore wind been almost fully exploited. Analysis also indicates that in a number of regions, mainly in western Europe (for example, Niederösterreich and Steiermark in Austria and the urban regions of Vlaams Gewest in Belgium) onshore wind potential appears to be nearly fully utilised. ([118]) However, it is important to keep in mind that the estimated onshore wind potential is highly influenced by regulations on setback distances to settlements, which can be overly strict in some regions and are subject to change. In addition, there may still be potential in these regions to repower existing wind farms and increase their output.

The need to use the full potential of renewable energy sources is also reflected in the 2026 country-specific recommendations. These highlight the importance of providing incentives to support the roll-out of large-scale wind capacity in countries such as Bulgaria, Czechia, Greece, and Slovakia (Council of the European Union, 2026). The recommendations emphasise the urgent need to reduce reliance on fossil fuels and diversify the energy supply by expanding domestically generated power. To foster public acceptance and minimise environmental impacts, it is important to recognise and limit potential adverse effects of renewable energy sources. Measures include limiting noise and vibrations from wind turbines, reducing emissions of particulate matter from the combustion of solid biomass and combining land use for ground-

([117]) Estimates based on (Elsner et al., 2026b)

([118]) These results reflect a conservative approach to estimating potential (see Box 2.5.1).

mounted PV installations with agricultural land use and biodiversity conservation.

2.5.2.2. Grids and infrastructure as key enablers of the green transition

The high potential for renewable energy is not yet matched by sufficient energy infrastructure. EU regions face challenges in scaling up investments to provide sufficient grid capacity and smart grid infrastructure. Projects and investments already announced by Member States do not fully match the estimated investment needs required for the energy transition. According to recent study estimates (European Commission, 2025h) energy infrastructure investment is expected to peak between 2027 and 2029, with average annual EU investment needs estimated at over EUR 100 billion from 2024 to 2040. At the time of data collection, the highest absolute committed energy infrastructure investments were planned in Germany, France, and the Netherlands. Data on planned investment were less complete for central and eastern Europe, which may reflect economic constraints or less advanced planning for the energy transition. It should be noted that the available data represent a snapshot of the situation in 2024 and are subject to change as national planning progresses across Member States.

Grid bottlenecks are already slowing the deployment of renewables, delaying electrification and constraining the absorption of new clean generation (European Commission, 2023). Alongside grid expansion, EU battery energy storage capacity needs to increase to support grid stability and integrate higher shares of renewable energy (European Commission, 2025k). In addition, a shortage of skilled workers needed to deploy renewable energy installations and carry out grid maintenance is emerging as a further constraint on the green transition. ([119])

At the same time, expanding the grid is a lengthy process. Distribution grids can take up to 7.5 years to complete, while transmission infrastructure projects can take up to 10 years, with planning and permitting accounting for half of these timelines (European Court of Auditors, 2025). This is reflected in some key regional and national challenges identified in the 2026 European Semester Spring package (European Commission, 2026a), which have led to country-specific recommendations for almost all Member States (Council of the European Union, 2026). For example, the Council recommended that Belgium '[a]ccelerate the upgrade of grid infrastructure and the roll-out of renewable energies, by further streamlining permitting procedures, while addressing regional challenges'. For Croatia, the recommendation was to '[s]treamline permitting and grid connection procedures for renewables and energy communities'. For Italy, the recommendation was to '[a]ccelerate electrification and intensify efforts for the deployment of renewable energy and storage, including by fully implementing permitting reforms, particularly at sub-national level, and investing in the electricity grid'.

Both transmission and distribution infrastructure play a key role in delivering the energy transition, since renewable energy sources are often located far from areas where demand is concentrated, as is case with offshore wind. This is also why the energy transition must be understood as a place-based process.

2.5.2.3. The path to a climate-neutral economy

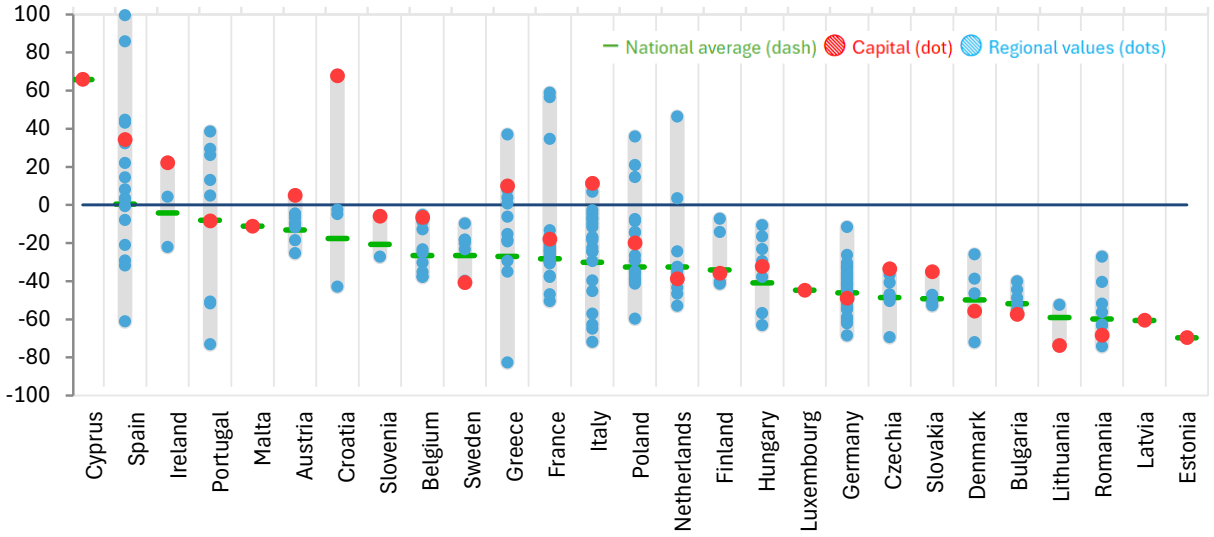
As electricity generation shifts towards renewable energy sources, whose potential remains largely untapped across EU regions, and as industrial processes become increasingly electrified, fossil fuel consumption is expected to decline. This will pave the way for a further reduction in greenhouse gas (GHG) emissions. While the EU has made considerable progress in reducing overall GHG emissions, a nuanced understanding of regional and sectoral variations is crucial to implementing effective policies and ensuring a just transition.

The EU's GHG emissions fell by 37% between 1990 and 2024 (European Commission, 2025e). ([120]) In absolute terms, emissions decreased from 4.9 gigatonnes of CO2 equivalent (Gt CO2eq) in 1990 to 2.9 Gt CO2eq in 2024. The EU is making progress towards becoming a climate-neutral economy by 2050 and achieving its target of

([119]) See for example (European Labour Authority, 2026); (Galanakis, Lopez Cobo and Vergote, 2026)

([120]) Data from the 2025 EU Climate Action Progress Report are used when EU targets are mentioned (European Commission, 2025e), while EDGAR database is used for regional emissions (Crippa et al., 2025).

Figure 2.5.1: Change in total GHG emissions in 2025 compared with 1990 levels



The chart does not contain data for the following NUTS2 regions: Ceuta (ES), Melilla (ES), Mayotte (FR) and La Réunion (FR). However, Member State-level data include changes recorded by these NUTS2 regions. Reductions recorded by Member States might differ slightly from those reported in the EU Climate Action Progress Report.

Source: Emissions database for global atmospheric research (EDGAR).

reducing its GHG emissions by 55% by 2030. ([121]) The downward trend in absolute GHG emissions has also been accompanied by a decline in the carbon intensity of the EU economy. ([122]) GHG emissions per unit of GDP have dropped by more than 50% since 1990, indicating that emissions have declined even as GDP has increased ((Crippa et al., 2025); (European Environment Agency, 2026c)). Despite progress in reducing emissions, greater efforts are needed to achieve the 2050 objective of a climate-neutral economy (European Environment Agency, 2025b).

The decline in emissions is largely due to reductions recorded in energy and manufacturing sectors, while emissions from transport, notably domestic aviation, have increased considerably over last three decades (European Environment Agency, 2025b). Between 1990 and 2024, total EU transport emissions – including international aviation and maritime – rose by 28%, with road transport emissions alone increasing by 24% (European Commission, 2026) despite transport reducing its emissions by 5% since 2005 (Crippa et al., 2025).

The main factors contributing to the reduction in GHG emissions have been the lower carbon intensity of the energy system and the improved energy intensity of the EU economy (European Environment Agency, 2026b). Power generation and industry have achieved sustained reductions, supported by a 47% renewable share in net electricity generation in 2024 and a 40% reduction in emissions from energy-intensive industries between 2010 and 2024 (European Commission, 2026).

In 2024, manufacturing produced 26% of all GHG emissions, followed by transport (25%) and energy (19%). This marks a change in the sectoral mix compared with 1990. Since 1990, transport has almost doubled its share to become the second-largest emitting sector, while energy has reduced its share by 9 percentage points (Crippa et al., 2025). These shifts may be linked to structural changes in the EU economy in recent decades, namely the growing importance of the services sector and the declining share of more energy-intensive industries (European Environment Agency, 2026b).

While nearly all EU Member States have reduced their GHG emissions to some extent, progress remains uneven, and there are sharp disparities both within and between Member States (see Figure 2.5.1). In some Member States, such as Portugal, Spain, and Poland, considerable reductions in GHG emissions in certain regions

([121]) Target laid down in Regulation (EU) 2021/1119, European Climate Law.

([122]) Carbon intensity is calculated as the tonnes of GHG emitted to produce EUR 1000 of GDP expressed in purchasing power standards (PPS).

have been accompanied by increases in others. ([123]) However, these regional divergences do not necessarily prevent the EU from meeting its climate targets.

All Member States need to contribute to the transition to climate neutrality in line with their capacities. For greenhouse gas emissions covered by the Effort Sharing Regulation, a national target for reducing emissions by 2030 has been laid down for each EU Member State, ranging from -10% to -50% compared with 2005 levels.([124]) While total GHG emissions have dropped over the last three decades across EU Member States, Cyprus stands out as a particular case with emissions having increased by almost 60% across all sectors. ([125]) Economic growth in Cyprus, accompanied by limited investments in clean technologies, high reliance on oil-based energy, limited public transport and the presence of carbon-intensive buildings, have contributed to increasing emissions. ([126])

The sectoral distribution of GHG emissions across EU regions in 2025 reflects differences in local economic structures and the challenges that regions face reducing emissions. Transport is the main contributor to regional GHG emissions in almost 40% of EU regions, particularly in Austria, Greece and Italy. Agriculture-related emissions predominate in Ireland and in certain regions of Denmark (Midtjylland and Syddanmark), France (Bretagne and Pays-de-la-Loire) and the Netherlands (Noord-Brabant and Overijssel).

In contrast, GHG emissions from buildings, including those associated with the use of gas boilers and water heaters in residential and commercial buildings, account for the largest share in the highly urbanised capital regions of Belgium, Germany, and Romania, and in the predominantly urban regions of Utrecht (NL) and Hamburg (DE). Industrial manufacturing generates the highest GHG emissions across regions in northern and western Europe. This pattern is evident in regions where industrial activity accounts for a significant proportion of regional gross-value added such as those in northern Italy (e.g., Emilia-Romagna, Lombardia, and Veneto) and southern Germany (e.g. Freiburg and Rheinhessen-Pfalz). Industrial emissions also predominate across regions with high employment in industrial manufacturing in central and eastern Europe, such as Východné Slovensko (SK), Centru (RO), and Yuzhen tsentralen (BG).

Energy-related emissions continue to constitute a major proportion of total GHG emissions across Germany and Poland and in specific regions where energy is produced such as Groningen (NL) and Severozapad (CZ). The sectoral challenges that Member States face are reflected in the 2026 country-specific recommendations, including Ireland '[i]ncentivise further sustainable agricultural policies and practices that reduce nutrient losses and emissions', Spain '[f]oster the decarbonisation of industry, buildings and the electrification of transport' or France '[a]ccelerate electrification of end uses focusing on high emitting sectors'. (Council of the European Union, 2026)

Industrial activities and power generation are geographically concentrated in most Member States. As a result, a relatively small number of regions account for a disproportionately large share of EU emissions. Only seven out of 244 NUTS2 regions, i.e. Lombardia (IT), Andalucía (ES), Düsseldorf, Brandenburg and Sachsen-Anhalt (DE), and Mazowiecki and Śląskie (PL) produce just over 10% of all the EU's GHG emissions. These regions host much of the EU's energy production and heavy industry.

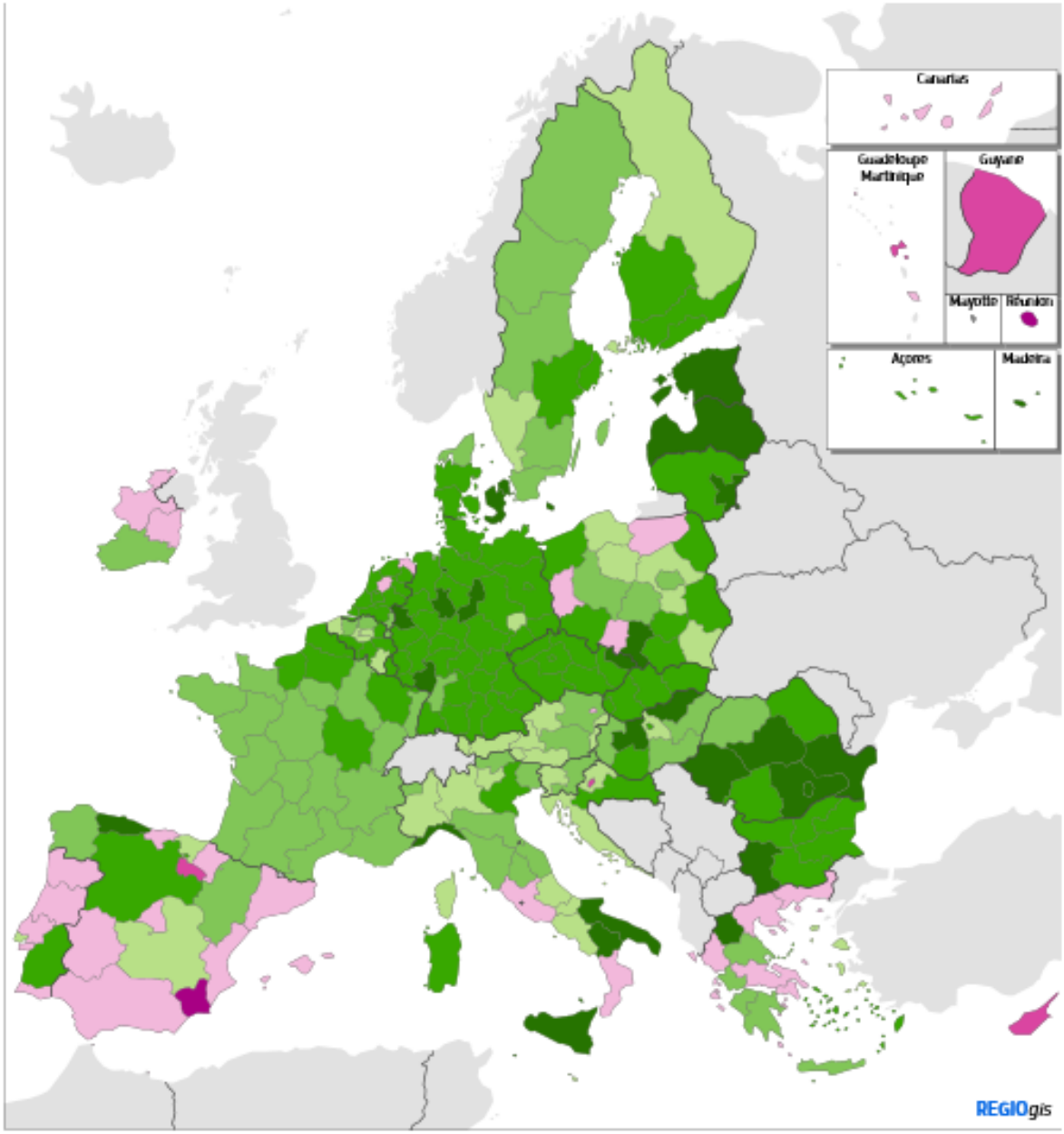
At the same time, their sectoral profiles mean that they have great potential for emission reductions. Recent EDGAR estimates show that two of these regions, Düsseldorf (DE) and Śląskie (PL), have reduced their emissions by 60% compared with 1990 levels (see Map 2.5.2). However, as proposed in the 2026 country-specific recommendations, further support should be provided to regions undergoing industrial and energy transitions. Poland, for example, should '[e]nable clean industrial transformation and foster innovation-oriented transition strategies for coal-dependent regions' (Council of the European Union, 2026).

([123]) (Crippa et al., 2025b) GHG emissions based on EDGAR excluding emissions from shipping, aviation, offshore installations and land use, land-use change, and forestry.

([124]) (Regulation (EU) 2023/857, 2023)

([125]) (European Commission, 2025f) Country profile – Cyprus.

([126]) (European Commission, 2025b)



Map 2.5.2: Change in greenhouse gas (GHG) emissions between 1990 and 2025

Total emissions by NUTS 2 region

Change between 1990-2025 (%)

- <= -55
- -55 - -30
- -30 - -15
- -15 - 0
- 0 - 55
- 55 - 100
- > 100

Note : Emissions of GHG were calculated using Global Warming Potential Values(GWP-100) from IPCC AR5 and they include fossil CO2 only, CH4, N2O and F-gases. Emissions from international shipping and aviation are excluded from the calculation due to their international feature. Domestic shipping, domestic aviation and of f-shore fuel exploitation emissions are reported at the NUTS0 (country level) and therefore excluded from this NUTS2 calculation.

Sources: REGIO-GIS, Emissions Database for Global Atmospheric Research (EDGAR) 2025

0 500km

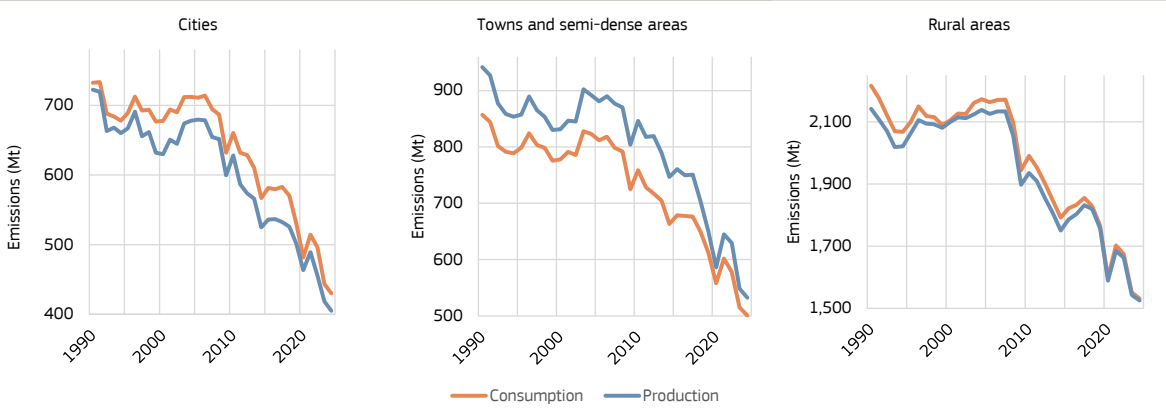
© EuroGeographics Association for the administrative boundaries

Box 2.5.2: Consumption-based approach to estimate emissions

To complement the production-based approach to estimate emissions, a consumption-based approach reallocates emissions from electricity and heat production to end-users. It provides additional insight into distribution of energy demand across human activities by attributing emissions to the sectors that ultimately consume the energy rather than to those that produce it. When switching to a consumption-based approach for CO_2 emissions the residential sector receives the largest share of these reallocated emissions (15%), followed by industry (9%), while smaller shares are attributed to fuel exploitation activities, and to transportation (mainly non-road) (Ciarlantini et al., 2026) (Crippa et al., 2026a).

The shift from production- to consumption-based approach also reveals the differences between urban and rural environments. Cities emerge as net importers of energy-related emissions: their high demand for electricity and heat leads to emissions that are largely generated in other areas. In contrast, towns and semi-dense areas act as net exporters, since they host a significant share of energy production infrastructure and therefore generate emissions associated with energy consumed in other areas, although this gap has narrowed since 1990. Rural regions show a more balanced profile. Their production and consumption-based emissions are broadly aligned, suggesting closer correspondence between local energy production and use (Crippa et al., 2026b).

CO2 emissions in the EU27 (1990–2024) by degree of urbanisation: comparison between production- and consumption-based approaches



Source: (Crippa et al., 2026b).

The analysis presented in this chapter so far used emissions calculated according to their place of production, which is known as the territorial or production-based approach. While this approach is essential for monitoring emissions, it can obscure the extent to which end-use sectors drive emissions and efforts undertaken by energy consumers to reduce emissions. Emissions from the EU energy sector have declined significantly over time, but this sector remains a major source of emissions under a production-based approach (Crippa et al., 2025). Under switching to a consumption-based approach, these energy-related emissions are redistributed across end-use sectors based on how energy demand is distributed across activities (Box 2.5.2).

2.5.2.4. Regional transition pathways

The green transition challenges in the EU are not uniform. Next to differences per sector, as shown by the EU Climate Law-aligned sectoral decarbonisation pathways (CLIMACT, 2025), transition pathways vary according to the combination of local economic structure and energy source found in each region. In other words, the constraints and opportunities associated with the clean energy transition depend on the extent to which each region's energy base relies on fossil fuels. They also depend on which end-use sectors drive energy demand, highlighting the need of a place-based transition policy (see Box 2.5.3). National and sub-national sectoral decarbonisation pathways could provide valuable and appropriate reference points for actors aiming to decarbonise or fund decarbonisation projects.

In fossil-dependent regions (i.e. regions where more than 50% of energy demand and/or supply comes from solid fossil fuels, crude oil or petroleum products) in which the highest share of energy is consumed by industrial processes and electricity generation (see the dark red regions in Map 2.5.4) the challenge is to reduce dependence on fossil fuel-intensive energy while maintaining competitiveness. These include coal-dependent areas of countries with a long history of coal extraction, such as Stara Zagora in Bulgaria and Rybnicki in Poland; regions that have committed to phasing out other fossil fuels such as oil shale in Kirde-Eesti in Estonia; and individual regions in Member States with otherwise clean energy systems that have met their national renewable energy targets such as Sydjylland in Denmark and Helsinki-Uusimaa in Finland.

In contrast, in fossil-dependent regions where the main energy demand comes from the transport, residential and commercial sectors, the transition to clean energy should focus on reducing fossil dependence in residential heating. It will also require investments in energy-efficient building renovation and low-carbon mobility as highlighted in the 2026 European Semester Spring package (European Commission, 2026a) and the 2026 country-specific recommendations. This profile is broadly exemplified by regions in central and eastern Europe (see the dark blue regions in Map 2.5.4 such as Csongrád-Csanád and Békés in south-eastern Hungary and Gorzowski, Zielonogórski and Jeleniogórski in western Poland). ([127])

Although fossil-dependent regions face challenges, they do not constitute a majority of EU regions. Most regions, especially those where sectors other than energy and industry are the main energy consumers, already have a share of clean energy of at least 50% on either the demand or the supply side. ([128]) Latvia stands out as a particularly strong example of an advanced clean energy transition, with all its regions recording more than 50% carbon-free energy on both the demand and supply sides.

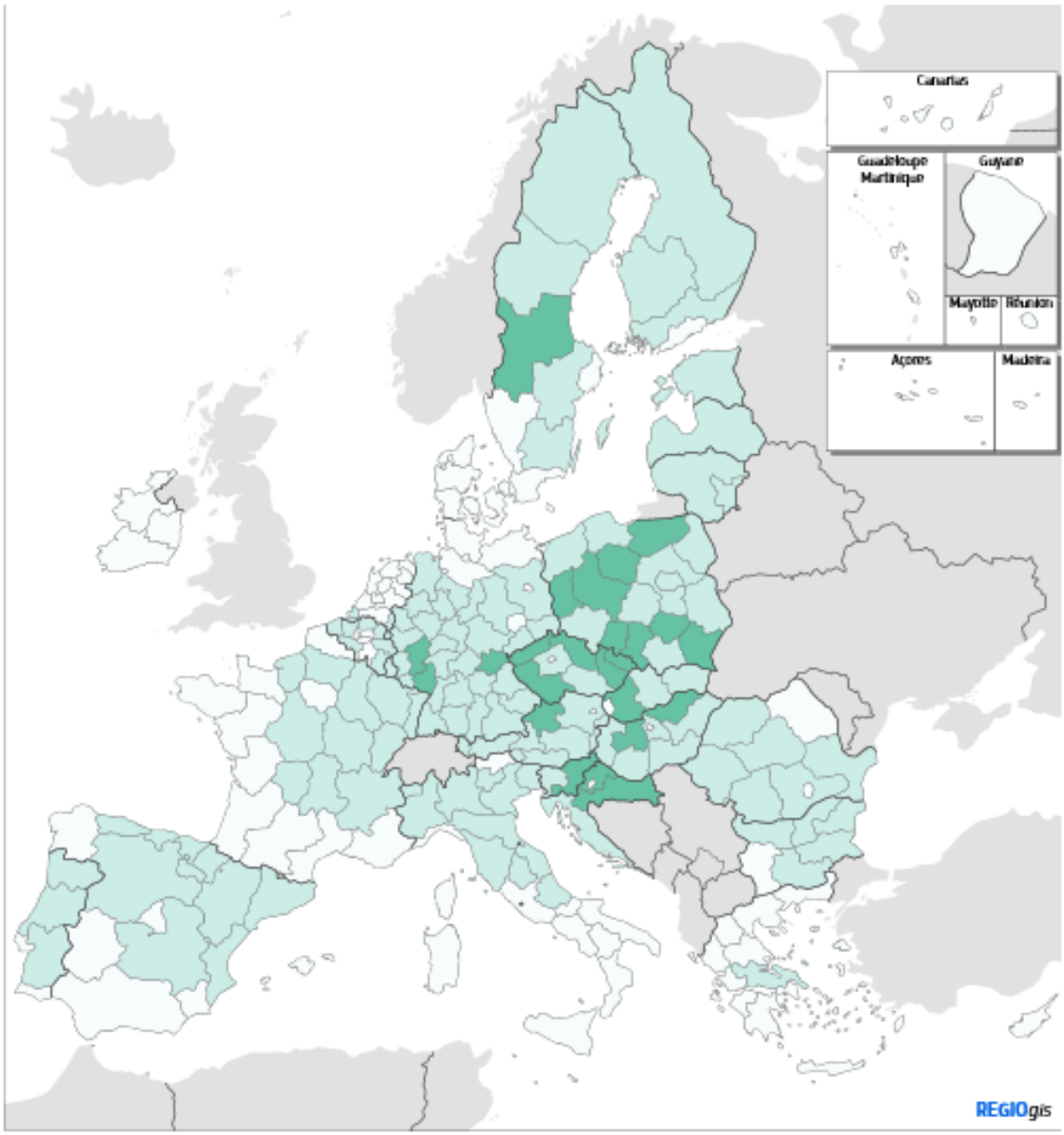
In regions where both energy demand and supply are already largely carbon-free, such as Albacete and Cuenca in Spain (see the light red and light blue regions in Map 2.5.4), the policy priorities could focus on expanding the grid and ensuring system stability. This is reflected in the 2026 country-specific recommendations for Spain ('[i]nvest in energy storage, electricity transmission and distribution and cross-border electricity interconnections.') (Council of the European Union, 2026).

Overall, different regions will contribute to the clean energy transition in different ways. Southern and many continental regions are well placed to expand solar power generation, while northern coastal and maritime regions have strong offshore wind advantages. Inland areas can support energy generation through onshore wind. Mountainous areas can contribute through hydropower and energy storage. Urban regions can scale up rooftop solar installations and energy storage. Industrial regions can accelerate the electrification of industrial processes and drive demand for clean power, among others.

The clean energy transition will generate new jobs in renewable energy and clean technologies, but these employment gains will not be evenly distributed across regions with projected job losses in areas dependent on fossil-fuel industries, see Map 2.5.3 (Cedefop, 2026). Therefore, the relevant question for cohesion policy is not whether all regions can follow the same decarbonisation model, but how each

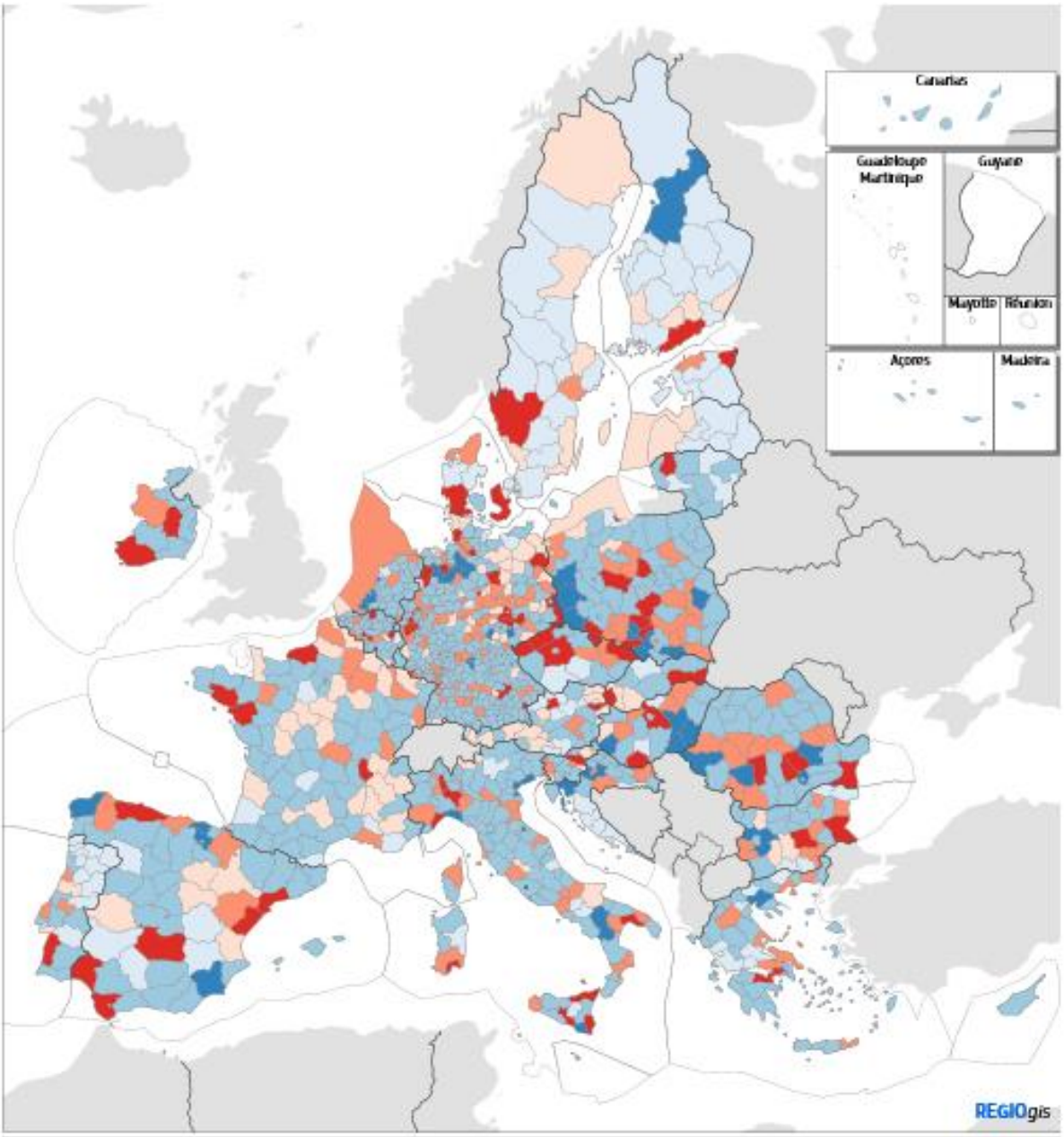
([127]) Analysis based on JRC – Energy and Industry Geography Lab.

([128]) The 50% threshold is used here only as a statistical threshold for classification purposes.; It is not an EU policy target.



Map 2.5.3: Regional distribution of employment in energy intensive industries, 2023

region can identify its role within an integrated European clean-energy system while ensuring a just transition so that no territory is left behind.



Map 2.5.4: Sectoral energy demand vs fuel mix in supply and demand, 2024

0 500km

- Energy and industry – clean demand and supply (both > 50% carbon-free)
- Energy and industry – fossil demand or supply (one > 50% fossil-dependent)
- Energy and industry – fossil demand and supply (both > 50% fossil-dependent)
- Others – clean demand and supply (both > 50% carbon-free)
- Others – fossil demand or supply (one > 50% fossil-dependent)
- Others – fossil demand and supply (both > 50% fossil-dependent)
- No demand

Source : JRC/EIGL, 2026, based on EUROSTAT energy balances

Note : This map shows for each NUTS3 region the main energy consuming activities, and whether most of the energy supplied and consumed in those regions is carbon-free (electricity, heat, nuclear heat, non-electric renewable energy products) or fossil (solid fossil fuels, crude oil, petroleum products. The energy consuming activities are "energy and industry" (red hues, including electricity generation, fossil fuel extraction, oil refining and industrial manufacturing) or "others" (blue hues, including transportation, commercial and public sector, residential, agriculture and fisheries). The map also incudes of fshore EEZs where there is significant energy supply or demand.

Administrative boundaries: © EuroGeographics, © OpenStreetMap contributors – EurostatGISCO

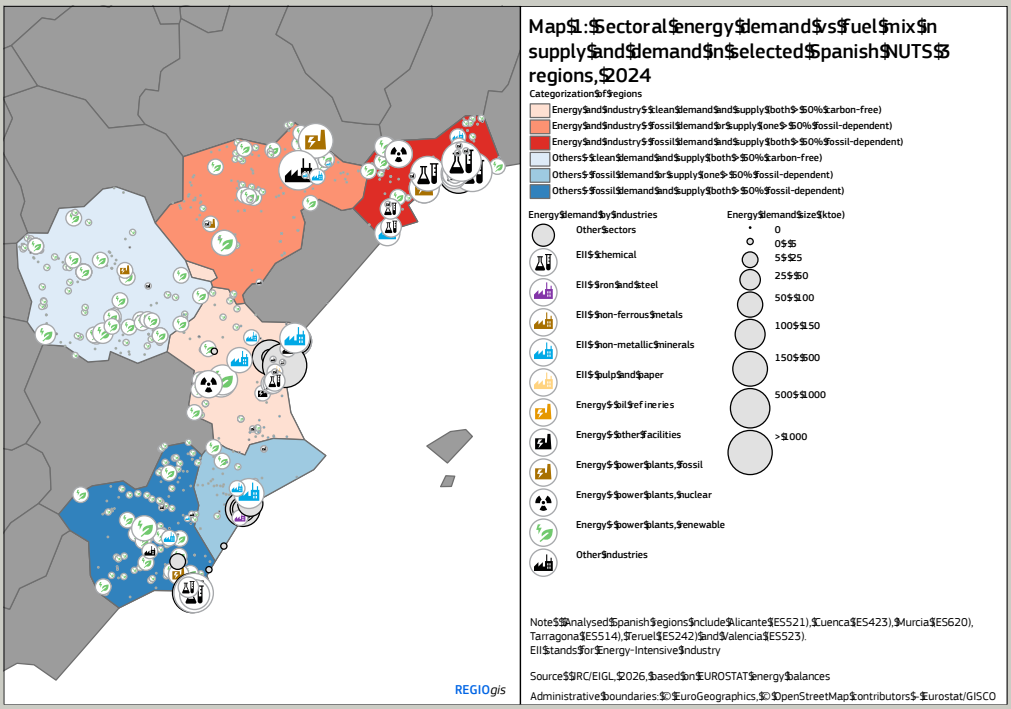
Box 2.5.3: Zooming in on how regional energy-transition profiles coexist in Spain

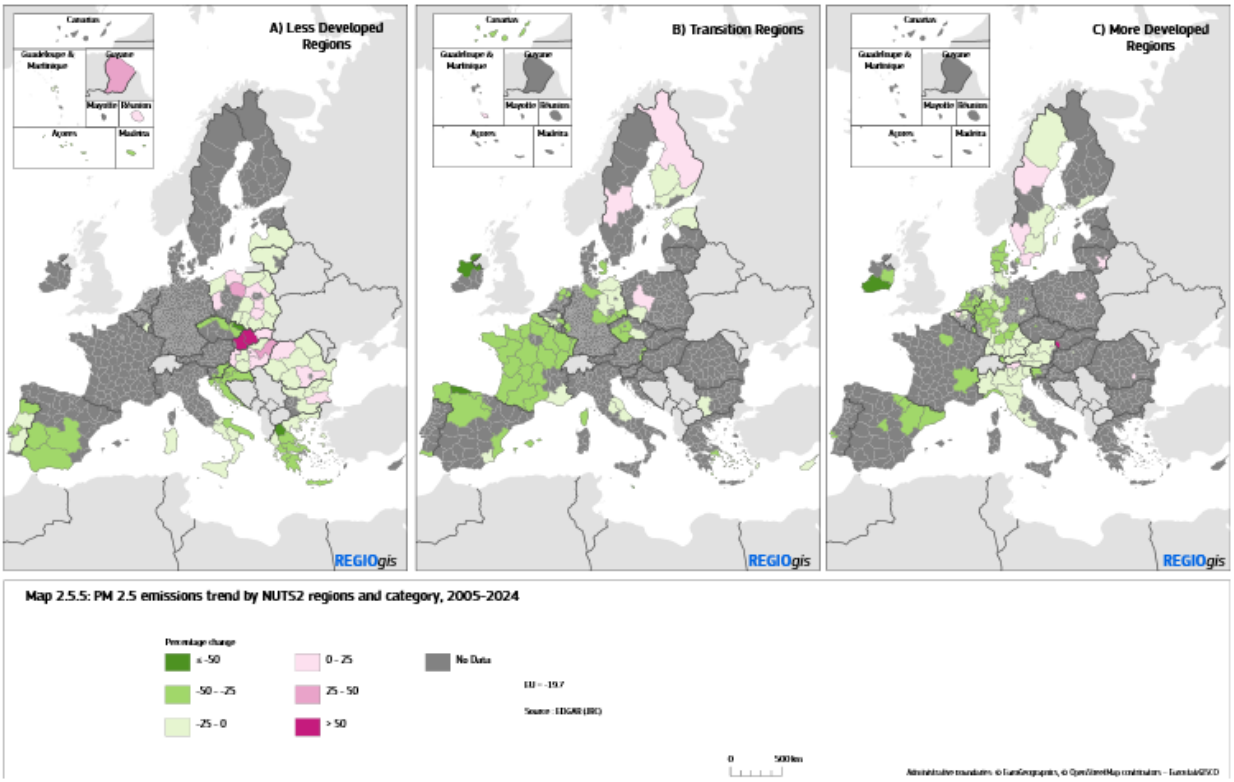
Spain illustrates well how all six energy-transition categories coexist within a single Member State. Regions such as Valencia (ES523) and Cuenca (ES423) combine clean demand with clean energy supply, as in both cases carbon-free energy exceeds 50%. In Cuenca, numerous renewable energy plants spread across the region provide carbon-free energy, whereas in Valencia carbon-free energy comes mainly from the Cofrentes nuclear plant. The regions' demand drivers also differ. In Valencia, industrial and energy demand dominate, with several energy-intensive industries sites, such as cement factories and glass manufacturing plant. By contrast, in Cuenca, transportation, residential and commercial sectors are the main sources of energy demand.

To the north of Valencia and Cuenca, in rural Teruel (ES242) and coastal Tarragona (ES514), the energy and industrial sectors are also the main drivers of the energy demand. In Tarragona, both energy demand and supply are largely fossil-dependent, with fossil-fired power plants and refineries in Tarragona petrochemical complex playing a major role. In Teruel, part of the energy system is still fossil dependent with fossil-fired power plants producing energy.

In contrast to Teruel, in coastal regions of Alicante (ES521) and Murcia (ES620), most energy demand comes from non-industrial sectors, as both are urban regions with large population requiring more energy to meet transport, residential and commercial sector needs. While Alicante has made progress in the roll-out of clean energy, with one side of the energy system becoming carbon-free, in Murcia both energy demand and supply remain mostly fossil-dependent, with fossil-fired power plants providing energy.

Spain's transition, as in many other EU Member States, is therefore marked by the parallel presence of locally clean and fossil-based energy systems, also shaped by sectoral composition.





2.5.3. Better Environment

Environmental factors and climate change impacts affect the competitiveness of companies, people's health and overall well-being. ([129]) These include pressures such as air and noise pollution, water scarcity, heatwaves, wildfires, droughts, floods, soil degradation and biodiversity loss. This section focuses in particular on air pollution and water scarcity, both of which could be mitigated by the green transition. Phasing out fossil fuels, electrifying heating, transport and industrial processes and switching to renewable energy sources such as wind and solar power can reduce GHG emissions and air pollution, demonstrating the broader benefits of the clean energy transition across the economy (European Environment Agency, 2026c). The impact on human health should not be overlooked either. Reduced air pollution could save lives across the EU (Romanello et al., 2025). The transition to renewable energy is also expected to reduce water use in the energy sector, easing pressure on water resources as water scarcity is becoming a systemic challenge across Europe. At the same time, other environmental and the climate risks also deserve attention. Although these are not examined in detail here, they are covered in the flagship *State of the Environment Report* (European Environment Agency, 2025c) and EU Climate Action Progress Report.

2.5.3.1. Air pollution and uneven health impacts across EU regions

Despite progress in reducing air pollution emissions, with 19 Member States meeting their 2020-2029 national emission reduction commitments for each of the five main air pollutants (European Environment Agency, 2025a), most of the EU urban population remains exposed to concentration of fine particle air pollution ($PM_{2.5}$) that exceed safety recommendations of the World Health Organization's (WHO). ([130])

Unsurprisingly, the negative health impact is also more severe in cities than in less populated areas (JRC, forthcoming). Higher concentrations of air pollution also reduce labour productivity through increased absenteeism and lower productivity among workers (Dechezleprêtre and Vienne,

([129]) See (Romanello et al., 2025) for more on health impacts in and (Ceglar et al., 2025) for economic impacts.

([130]) The five air pollutants are NO_x, NH_3, SO_2, $NMVOC_s$ and $PM_{2.5}$.

2025) and contribute to number of premature deaths in several EU regions (see Box 2.5.4).

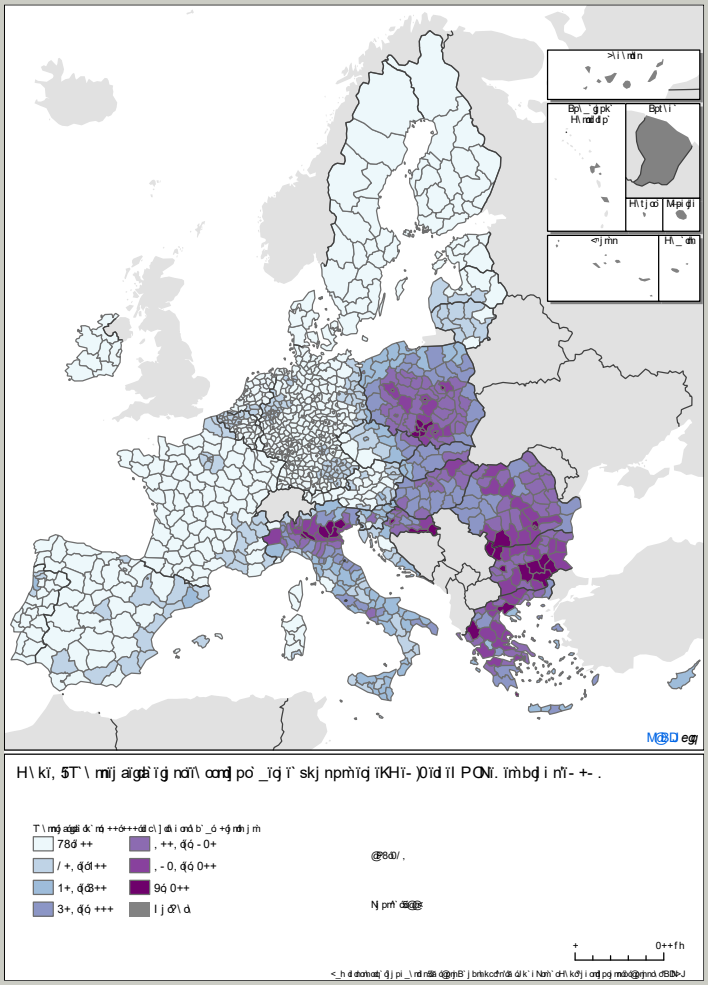
Box 2.5.4: Health cost of air pollution

Between 2005 and 2023, the number of premature deaths in the EU linked to exposure to fine particle air pollution (PM2.5) fell by 57%, achieving the target agreed for 2023. However, exposure to PM2.5 above recommended safety levels still led to 182 000 premature deaths and 1.9 million years of life lost across the EU (European Environment Agency, 2025) in 2023. The highest relative impact, measured in years of life lost per 100 000 inhabitants aged 30 years and over, was observed in Bulgaria, Greece and Romania.

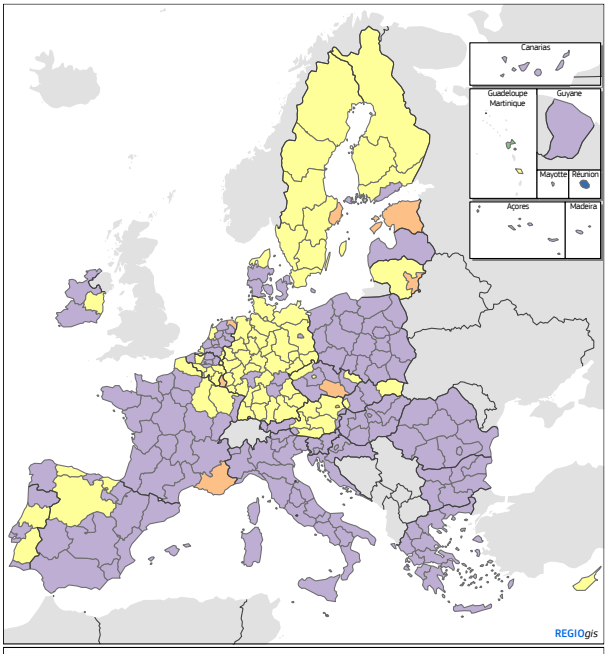
At regional level, a high impact, with more than 1 500 years of life lost per 100 000 inhabitants, was observed in Grad Zagreb and parts of Panonska Hrvatska in Croatia, in several territories in Veneto and Lombardia in northern Italy, and in large cities and Śląskie region in Poland (see Map 1).

At the other end of scale, Sweden and Finland experienced the lowest impact, with near-zero years of life lost per 100 000 inhabitants and the highest reduction of over 90% in PM2.5-attributable mortality per capita between 2005 and 2023. Recent estimates show that shift to clean energy with the reduced coal use has led to lower mortality attributable to PM2.5 coming from fossil fuel combustion (Romanello et al., 2025).

Despite the progress made, air pollution still imposes an economic cost, estimated at EUR 600 billion annually, equal to 4% of EU GDP, mostly in extra healthcare costs and damages to water bodies, crops and forests (European Environment Agency, 2025).



Although air pollution concentration is decreasing across the EU, environmental inequalities between the most and least disadvantaged regions persist. In 2022, the levels of fine particle air pollution ($PM_{2.5}$) in the EU's poorest regions were on average one-third higher than in the richest regions (European Environment Agency, 2025d). Over the last 20 years, the emissions of fine particle air pollution ($PM_{2.5}$) have decreased consistently across all types of cohesion regions in Portugal, Spain, France, and Greece. In contrast, progress in pollution reduction in Romania, Hungary, Finland and Sweden has been uneven across regions, while Slovakia has recorded an increase in air pollution emissions in every region (see Map 2.5.5).



Map 2.5.6: Most emitting sector by NUTS2 regions, 2024

The main sectors producing emissions of fine particle air pollution ($PM_{2.5}$) vary across regions. The residential sector remains the dominant source in most EU regions, especially in southern, central and eastern Europe. This highlights the need for increased efforts to improve insulation, upgrade heating systems, install low-emission boilers and switch from solid biomass and fossil fuels to cleaner fuel types (European Environment Agency, 2025a). In contrast, air industrial pollution dominates in western and northern Europe leaving scope for further reductions in the manufacturing and extractive industries (see Map 2.5.6).

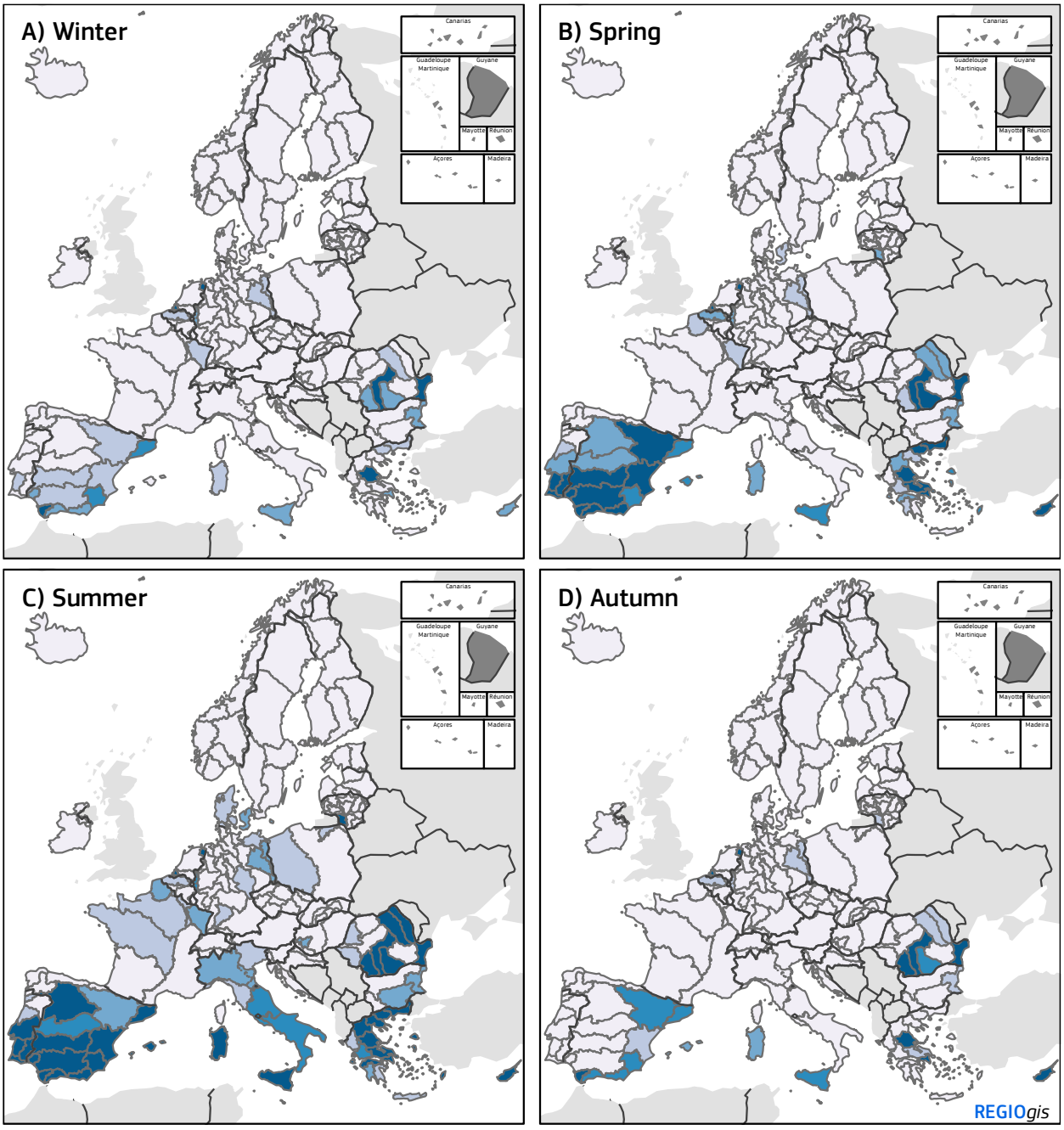
2.5.3.2. Uneven climate risks and growing water scarcity across EU regions

Maintaining progress towards climate objectives is essential to reduce the frequency and severity of extreme weather events, such as floods, droughts, and wildfires (European Environment Agency, 2024b). Member States and regions are not equally exposed to these climate risks and neither they face equal impacts of climate change on hydrological systems (European Environment Agency, 2025b). Modelling the regional distribution of expected economic losses in Europe in 2050 due to various climate impact categories suggests that northern European regions are more vulnerable to economic losses from river and coastal flooding, while southern, central and eastern European regions are disproportionately affected by droughts and coastal flooding (European Commission, 2025i).

Although water resilience is a matter of security and crisis preparedness for the EU (European Environment Agency, 2025d), one third of the EU population was affected by seasonal water scarcity in 2023 and it was prevalent all-year round in southern Europe (European Environment Agency, 2025h) (see Map 2.5.7). Cyprus and Malta, in particular, face chronic annual water scarcity. ([131]) The situation in Romania has also deteriorated in recent years, with data for 2023 suggesting severe annual water scarcity conditions across the country. ([132]) However, water scarcity in Romania is predominantly seasonal and geographically concentrated, particularly the Danube Delta and the basins of three of the Danube's tributaries - the Olt, Argeș and Vedea rivers – during the summer months.

([131]) Water scarcity means that the water exploitation index plus (WEI+), which is a measure of water consumption as a percentage of renewable freshwater resources available, is above 20%.

([132]) The latest available data at the river basin level are from 2023.



Map 2.5.7: Seasonal water scarcity conditions for European river basin sub -units (sub-basins) for 2023, as measured by water exploitation index plus (WEI+)

Percentage
- <= 10
- 10 - 20
- 20 - 30
- 30 - 40
- > 40
- No data

Note : The seasonal water exploitation index plus (WEI+) provides a measure of total water consumption as a percentage of the renewable freshwater resources available for the European river basins at subunit level. Each season is def ined as a calendar quarter on the map : winter (January-March), spring (April-June), summer (July-September), and autumn (October-December).

Source : EEA

0 500 km

Administrative boundaries: © EuroGeographics, © OpenStreetMap contributors – Eurostat/GISCO

Seasonal water scarcity in summer 2023 affected more than 25% of the river basins in the European Union, mainly in Italy, Greece, Spain and Portugal, but also in areas further north. These included the Havel river basin in northeastern Germany, the islands of Zealand and Bornholm in Denmark, the Šešupė river basin in southern Lithuania and the basin surrounding Lake Balaton in Hungary (European Environment Agency, 2025h).

To address these challenges, the 2026 country-specific recommendations call on Member States to prevent excessive water use and strengthen water management through investment and reform (see more in Section 3.3). For example, the recommendation for Cyprus is to '[i]mprove water, wastewater and waste management by stepping up investments in infrastructure, increasing administrative capacity of local authorities, promoting sustainable water use practices, and expanding the separate collection of municipal and packaging waste'. Italy is encouraged to '[t]ackle remaining inefficiencies in water and waste management by reducing infrastructural gaps in particular in southern regions'. Malta is urged to '[e]nhance sustainable water management and quality by increasing investments in water collection and reuse, while tackling pollution in surface water and groundwater' (Council of the European Union, 2026).

Sustainable water use is essential to mitigating the impact of water scarcity. Between 2000 and 2023, total freshwater abstraction in the EU, including surface water and groundwater, fell by 14%. One of the main reasons for this was a 30% decline in water abstraction for electricity generation cooling, linked to the transition to renewable energy sources (European Environment Agency, 2025f). Despite this progress, the electricity sector still recorded the largest water abstraction in western, central and eastern Europe accounting for over 50% of annual freshwater use in Bulgaria, Estonia, France, Poland and Slovenia in 2022. ([133])

At the same time, growing water scarcity is putting pressure on energy infrastructure. Concurrent droughts and heatwaves led to reduced electricity generation from thermoelectric and nuclear power plants in France, Germany, Hungary and Romania. ([134]) A further shift to wind and solar power is expected to reduce total water use in the EU energy sector by another 25% by 2050 (Hidalgo González, Medarac and Magagna, 2020). With additional technological innovations, such as reusing waste heat from power plants in industrial processes and district heating, water use could fall by a further 45% to 95% (European Environment Agency, 2025g), thereby easing pressure on local water resources.

The contribution of different economic sectors to water use changes when considering net water consumption, which refers to the amount of water used but not returned to the environment. In the EU, agriculture is the largest net water consumer, primarily due to water-intensive irrigation practices used to sustain crops (European Environment Agency, 2024a). This is particularly evident in southern Europe, where extensive irrigated areas are located and account for a substantial proportion of water abstraction (Wolters et al., 2025), (Zajac et al., 2022). As a result, seasonal water scarcity during the growing season particularly affects the Mediterranean region, which highlights the need to promote water reuse practices and curb water losses (European Environment Agency, 2025g) (see Map 2.5.7

Drought conditions impacts can also propagate to the financial system via financing of affected firms: in the EU about 27.9% of long-term debt of SMEs is emitted by firms that are highly dependent on surface water, and 48.1% of this amount is emitted by firms that are located in regions that are highly exposed to drought conditions (Fatica et al., 2024).

A new challenge is the growing competition from emerging sectors, especially data centres. This will affect conventional water consuming sectors, such as energy production and agriculture. Water consumption by data centres is projected to increase by more than 50% by 2030. Much of this demand is for high-quality drinking water, with the projected required volume equivalent to the water needs of 40% of the EU population facing water scarcity (Water Europe, 2024). As

([133]) Eurostat [env_wat_abs]. No data available for BE, EL, ES, IT, CY, HU, AT, PT, SK, FI, SE.

([134]) See ,for example, (Bednar-Friedl et al., 2022), (European Environment Agency, 2025f); (European Environment Agency, 2026a), (OECD and Nuclear Energy Agency, 2021).

these challenges grow, coordinated policies will be essential to ensure sustainable water use for all EU regions. ([135])

2.5.4. Conclusion

As environmental challenges intensify and increasingly affect economic stability, the EU's transition to clean, affordable and domestically generated energy is no longer only an environmental necessity. It has become a strategic imperative for strengthening competitiveness, energy security and social equity in the EU. High energy costs and geopolitical instability highlight the risks of fossil fuel dependence. However, shifting to domestically generated energy from renewable sources presents an opportunity to reduce GHG emissions, lower energy prices and create future-proof industries. Renewables already account for almost a quarter of energy consumption in the EU, while GHG emissions have declined by 39% since 1990, reflecting the substantial progress already made by EU's Member States and regions. The transition to clean energy promises further broader gains, including reduced air pollution and alleviated water scarcity. Future progress will depend on place-based interventions ranging from investments in grid capacity to improving resilience of economic sectors to climate change. Water resilience must also be prioritised as an existential challenge, given that drought and heatwaves pose fundamental threats to the EU's future water availability - this needs to be addressed through improved water retention and resources management at local and regional levels. Moving forward energy independence, environmental and climate resilience should be treated as interconnected goals, ensuring that no region or sector is left behind in the transition towards a more competitive, sustainable and resilient EU economy.

([135]) More information on planned policy actions regulating the use of resources of data centres can be found here: Commission enhances energy efficiency and sustainability of data centres in the EU.