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Monitoring progress towards the Energy Union objectives - Concept and first analysis of key indicators

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1. INTRODUCTION

The Energy Union aims to ensure that European consumers – households and businesses – have secure, affordable, competitive and sustainable energy. It is made up of five closely related and mutually reinforcing dimensions, progress against which should also be measured through key indicators.

This Staff Working Document presents a concept, methodological approach and first analysis for setting up such key indicators for the Energy Union. It includes a proposal as regards concrete indicators to monitor and assess progress towards meeting the Energy Union objectives.

This Staff Working Document will be the basis for further exchanges, which will be taken forward over the next months. The selection of indicators can therefore further evolve in the future to take account of new or better indicators being made available or suggested to address the issues at hand.

In its Communication on the 2030 Climate and Energy Framework, the European Commission proposed to develop a set of key indicators in order to measure progress towards a more competitive and secure energy system in a 2030 perspective and get a facts base for policy action over time.

A meaningful specification of these indicators is crucial for their policy relevance and future development of potential accompanying measures. Discussions with Member States in the Energy Council showed that the list of indicators made in the 2030 Climate and Energy Framework would benefit from selected amendments and from being extended by further key objectives in the context of the Energy Union.

The March European Council provided a first orientation by Member States regarding a possible prioritisation among the indicators. According to the Council conclusions, affordable energy prices and industrial competitiveness, security of supply and the development of interconnections are key parameters for ensuring a coherent European energy and climate policy until 2030.

The Annual State of the Energy Union is an opportunity to monitor and assess progress as regards Energy Union targets and objectives. In fact, systematic monitoring with key indicators is needed to assess progress over time and to provide a factual base for potential policy response.

The indicators should form the basis (i) for assessing the specific impacts of the 2030 climate and energy policy targets and (ii) for a more holistic assessment of progress towards a competitive and secure energy system, as enshrined in the Energy Union Strategy objectives.

This need was confirmed by the European Council conclusions, stating that the governance system should step up the role and rights of consumers, transparency and predictability for investors, inter alia by systematic monitoring of key indicators.

2. METHODOLOGY

2.1. Overall approach

The selected key indicators aim to transparently inform on past developments, including potential discrepancies with Energy Union objectives, while allowing for the anticipation of future trends and potential impacts of policy options. This way, inconsistencies between market and policy developments and overall objectives can be detected at an early stage, allowing for swift implementation of response measures at EU and Member State level.

As part of the kick-start of the implementation phase of the Energy Union Strategy, country factsheets have been prepared, relying on a series of indicators available at Member State level for each dimension of the Energy Union.

Building on this initial work, this Staff Working Document complements the Member State specific analysis by providing a cross-country assessment approach. For each Energy Union dimension, a factual snapshot of the situation across the EU and its Member States is provided.

Given the wide array of issues to be considered, the analysis combines a specific focus on some key indicators, summarised in a scoreboard, together with complementary indicators or analysis along the five dimensions of the Energy Union, as well as considerations on the macroeconomic relevance of the energy sector and on the use of EU funds towards Energy Union objectives. The proposed indicators allow assessing progress vis-à-vis:

1. **Energy security:** monitoring the relative dependency of EU Member States to specific energy sources and/or trading partners as well as the overall reliability of the energy system (i.e. its overall ability to supply energy without interruption).
2. **Internal energy market:** monitoring progress of developing the EU internal energy market in terms of competition, cross-border trade and consumer empowerment.
3. **Energy efficiency:** monitoring progress in terms of energy savings and energy intensity improvements at macroeconomic and sectoral level, including for transport.
4. **Decarbonisation:** monitoring progress towards greenhouse gas emission reductions, renewable energy and greenhouse gas intensity developments.
5. **Research, innovation and competitiveness:** monitoring research, development and innovation activity; monitoring EU energy prices and costs differentials with main trading partners.

No scoreboard can on its own provide a comprehensive assessment of progress made towards Energy Union targets and objectives. Some issues, such as market integration or interconnections, are pan-European by nature and must rely on data and information at regional or even EU level. In addition, some policy goals do not easily translate into quantitative objectives and, as such, require additional qualitative assessment. Finally, there are areas with some data constraints where additional indicators will need to be developed over time.

Therefore, this Staff Working Document highlights, where relevant, areas where: i/ regional or EU-wide indicators and analysis is needed; ii/ qualitative assessment is essential in addition to quantitative indicators; and iii/ additional indicators would need to be developed and/or more systematically collected across EU Member States.

2.2. Definition and rationale for the selected indicators

The objective is to present in a synthetic manner latest data and recent changes for most relevant issues in each one of the five dimensions of the Energy Union. For each dimension, a limited number of indicators are selected for inclusion in the overall scoreboard. In addition, complementary indicators are also presented to provide a more comprehensive assessment for each Energy Union dimension. Beyond the Energy Union dimensions as presented in the Energy Union Strategy, information is also collected on the macroeconomic relevance of the energy sector, and on the use of EU funds for Energy Union objectives.

2.2.1. Macroeconomic relevance of the energy sector

The Energy Union is calling for a significant transformation of the energy sector¹ over the next decades that will impact the European economy as a whole and for which proper monitoring at macro-economic level is required.

On its own, the energy sector is a sizeable industrial sector and source of wealth and employment. Significant investments are expected in the context of the decarbonisation of the energy sector not only to replace the ageing EU energy infrastructure by low carbon technologies and smart and efficient appliances, but also to develop new energy services that will transform the energy market. These investments are expected to create economic value and jobs, while re-structuring the current energy sector. To monitor these effects, the Value Added and Employment of the energy sector indicators are used, as they measure the wealth creation triggered by capital expenditure in the energy market both in monetary and labour terms.

The Value Added of the energy sector calculates the value added generated by the supply of electricity, gas, steam and air conditioning² over the total value added of the economy. Value added refers to the value of goods and services produced, less the value of consumption of intermediate inputs.

The Employment in the energy sector indicator covers all persons engaged in the supply of electricity, gas, steam and air conditioning. Employed persons are either employees or self-employed.

In addition, energy prices are a significant cost element for businesses³, and energy bills represent an important item of the household budget. In this context, the Consumer Prices Index is used to give an indication of the relative contribution of energy to price increases. The Harmonised Indices of Consumer Prices (HICPs) indicator measures the change over a year of the prices of consumer goods and services acquired by households. In this exercise, it measures the relative contribution of energy to inflation for the countries and country groups for which it is produced.

¹ Mining and refineries are not included in the scope of the definition of the energy sector used for this section.

² This includes electric power generation, transmission and distribution, manufacture of gas, distribution of gaseous fuels, steam and air conditioning supply, and is based on Eurostat terminology.

³ See below indicators on competitiveness.

This set of indicators provides only a high level overview of the place of the energy sector in the economy. It is based on traditional sectoral classification which does not include equipment manufacturing and does not always capture the emergence of new sectors in energy equipment and energy services. It will need to be complemented in the future by more detailed indicators that monitor the macro-economic variables at the level of the main components of the energy value chain and that are able to capture the heterogeneity of the impact of the energy transition across the EU economy and continent. In particular, there is a need to better assess the impacts of renewable and energy efficiency policies on net employment and the distributional effects of the energy transition across sectors and countries. For the time being, additional information is presented in the next chapter on the (direct and indirect) employment and turnover in the renewables energy sector.

A specific focus is also put on the energy and transport related taxes. The ratio between energy and transport taxation and GDP is often used to provide indication on whether and to which extent tax instruments are used to incentivise economic operators to decrease energy consumption and reduce emissions.

2.2.2. *Energy security, solidarity and trust*

Much progress has been made in the last few years to enhance Europe's energy security. Despite these achievements, Europe remains vulnerable to energy supply shocks. Energy security is therefore a permanent priority and at the centre of the Energy Union strategy.

In particular, the 2030 Climate and Energy Framework referred to the need to monitor the diversification of energy imports and the share of indigenous energy sources used in energy consumption over the period up to 2030.

S1: Net import dependency⁴: this indicator measures the level of net imports divided by gross inland consumption and bunkers (i.e. what is consumed and stored in a country or region over a year).

This indicator on its own cannot capture all determinants of the vulnerability of Member States and the EU to energy supply shocks. In particular, it does not provide information on the degree of diversification of import sources, as well as on the relative significance of various import and fuel sources in the energy mix.

Therefore, a country specific supplier concentration index (SCI) is used in this Staff Working Document to complement the analysis on energy security across the EU and its Member States⁵. A country-specific supplier concentration index by fuel is computed as the sum of squares of the quotient of net positive imports from a partner to an importing country (numerator) and the gross inland consumption of that fuel in the importing country (denominator). Smaller values of SCI indicate larger diversification and hence can be seen as a proxy for lower risk to energy supply shocks. All else equal, SCIs will be lower in countries where net imports form a smaller part of energy consumption. They will also be lower in a country using a well-balanced source of imports. Hence, even if SCIs are often correlated with the commonly used metric of net import dependency, they also provide additional insight on the level of diversification in import sources and the

⁴ Net import dependency as it is defined above may reach values above 100% in certain cases. This indicator is taken from Eurostat database, table [tsdcc310].

⁵ This indicator was notably used in the in-depth study accompanying the European Energy Security Strategy, COM(2014)330

relative importance of a given fossil fuel in the country's energy mix. For each country, the following index is presented:

S2: Aggregate country-specific Supplier Concentration Index looking at total fossil fuel imports to a country from outside of the European Economic Area (EEA), thus disregarding flows within the EEA area in the volume of imports of a Member State⁶.

Imports of uranium and nuclear fuels are not included in the energy imports statistics used to compute the above-mentioned indicators. Hence, complementary information is provided in the next chapter on import routes for uranium and nuclear fuels. Similarly, aggregated information is provided on trade patterns of petroleum products.

In addition to indicators measuring the relative imports of a country as compared to gross inland energy consumption, it is useful to add an assessment of the impacts of energy import bills in a macroeconomic perspective. An indicator is therefore used which measures net import energy bills divided by the GDP of a given country. As such, the lower the indicator (in absolute terms), the less vulnerable the economy of a country is to energy price shocks.

The Energy Union Strategy also calls for specific attention to security of gas and electricity supply. Regarding gas, an important element to consider is how robust and resilient the gas system is in the event of a disruption of the largest infrastructure (e.g. pipeline, storage, production facility).

S3: N-1 rule for gas infrastructure: The so-called N-1 is an indicator of infrastructure adequacy as it tests the resilience of the system ensuring that gas demand on extremely cold days can be covered even if the largest infrastructure fails⁷.

Regarding electricity, attention should be paid to the overall resilience of the electricity system. This means looking into the following aspects:

- Adequacy, i.e. the ability of the electricity system to supply the aggregate electricity demand;
- Security, i.e. the ability of the electricity system to withstand external perturbations (due to natural/accidental and malicious events)
- Quality, i.e. the ability of the electricity system to ensure continuity of supply, both in the technical sense (by ensuring voltage quality) and in the commercial sense (which relates to the speed and accuracy with which commercial requests are being dealt with).

At this stage, there are no commonly agreed standards or indicator which would allow for a monitoring of the overall resilience of the electricity systems throughout Europe on a comparable basis. This issue is therefore not further investigated in this Staff Working Document⁸.

⁶ Norway is the only EEA country exporting significant volumes of gas and oil to the EU.

⁷ Regulation (EU) No. 994/2010 obligates Member States to fulfil the N-1 standard.

⁸ Section 2.3.2 presents a summary assessment of indicator's availability and potential additional needs for each Energy Union dimension.

Regarding the specific issue of generation adequacy however, the European Network of transmission system operators for electricity (ENTSO-E) is mandated under EU legislation to publish a yearly pan-European seasonal and a long term adequacy assessment. These are known as the Summer/Winter Outlook Reports, and the Scenario Outlook and Adequacy Forecast (SO&AF) respectively. Although there is a need to further improve the existing methodology used by ENTSO-E, with in particular in mind the design of a common set or menu of indicators to measure generation adequacy, it is still possible at this stage to report on some of these considerations.

Finally, security of supply considerations also relate to emergency oil stocks, as the main instrument to be used in case of a supply disruption. A statistical summary of Member States' oil stocks is presented in the Staff Working Document: "Overview of emergency oil stock in the European Union"⁹.

2.2.3. *A fully integrated internal energy market*

The 2030 Climate and Energy Framework mentioned the need to monitor:

- Deployment of smart grids and interconnections between Member States, with particular urgency between those that are further away from meeting the already agreed objective for Member States to ensure a level of electricity interconnections equivalent to or beyond 10% of their installed production capacity. This includes the electricity interconnection target of 15% between Member States for 2030.
- Intra-EU coupling of energy markets, building on the liberalisation of gas and electricity markets achieved already by EU legislation.
- Competition and market concentration on wholesale and retail energy markets both at the national and (for regions with functioning coupling) at the regional level.

Regarding interconnections, the selected indicator measures the electricity interconnection capacity, as % of installed capacity. No specific indicator is used in this Staff Working Document as regards gas interconnections, but the N-1 rule for gas infrastructure presented above offers a good proxy. In addition, the state of implementation of Projects of Common Interest (for gas as well as for electricity) remains highly relevant and important to monitor. Regarding deployment of smart grids, no readily available indicator could be identified and this will therefore require additional work.

S4: Electricity interconnection capacity: this indicator divides the electricity interconnection capacity of a given Member State by its total generation capacity.

This indicator could be complemented with additional or more refined analysis, for instance taking account of peak capacity rather than overall capacity, or also better capturing the impact of intermittent renewable energy on the need for interconnections.

Competition and market concentration on wholesale energy markets can be monitored at Member State level. The following indicators are considered:

⁹ SWD(2015)405

S5: Market concentration index for power generation: this indicator is based on the Herfindahl Hirschman Index (HHI) and is defined as the sum of the squared market shares of the three largest electricity generation companies measured in percentages of total installed capacity, with 10,000 corresponding to a monopoly.

S6: Market concentration index for wholesale gas supply: this indicator is based on the Herfindahl Hirschman Index (HHI) and is defined as the sum of the squared market shares of the wholesale gas supply companies measured in percentages of total wholesale gas supply, with 10,000 corresponding to a monopoly.

The above two indicators provide indications as regards the degree of competition on wholesale energy markets. The lower the values, the higher the degree of potential competition is.

Implementing the internal energy market objectives of the Energy Union also means considering additional elements than market concentration at Member State level. It is for instance important to monitor wholesale gas and electricity price developments across Member States.

S7: Wholesale electricity prices: this indicator presents electricity prices as available on wholesale markets, based on data and methodology developed in the European Commission's Quarterly Reports on European electricity markets.

S8: Wholesale gas prices: this indicator presents an average of annual gas prices for a country, based on data and methodology developed in the European Commission's Quarterly Reports on European gas markets¹⁰.

However, there are some limitations with the use of such prices as part of the monitoring exercise. As regards gas, available price data are not fully comparable across Member States, as for some, hub prices can be used while for most of the others, estimates of average import prices are used. Moreover, beyond individual price developments, it is also essential to monitor potential convergence across European prices. This is why an additional analysis is provided on the intra-EU coupling of energy markets. Hence, evidence is presented in the next chapter on energy price convergence and on energy flows across borders. Still, there is a need to reflect on the potential need for additional indicators and/or analysis on regional integration.

Regarding retail energy markets, the two indicators below are good proxies to assess the degree of empowerment of consumers on retail energy markets, and whether they have the option of switching retailers and/or exercise this option in order to benefit from better conditions.

S9: Annual switching rates on electricity retail markets: this indicator measures the percentage of final electricity consumers changing suppliers in a given year.

S10: Annual switching rates on gas retail markets: this indicator measures the percentage of final gas consumers changing suppliers in a given year.

¹⁰ The European Commission's Quarterly Reports on European gas and electricity markets are available here: <https://ec.europa.eu/energy/en/statistics/market-analysis>

The next chapter's analysis also includes more specific considerations on competition at retail level. In addition, some information is also collected and presented as regards smart metering. Smart metering can positively affect consumers' engagement with the market and ultimate energy consumption. More specifically, two indicators are used measuring the percentage of final electricity and gas household consumers equipped with a smart meter.

A broader set of indicators could also be considered to monitor energy retail market functioning¹¹, in areas such as customer satisfaction, market condition or distribution system operator services. Many national regulators are indeed analysing these various areas but no source could be identified covering in a consistent manner such indicators and analysis across all EU Member States.

Developing the Energy Union also means better protecting vulnerable consumers against energy poverty risk. Estimating energy poverty depends on the definition given. As there is no single agreed definition at EU level, it is difficult to identify the most appropriate indicator. Still, a variety of factors contribute to energy poverty, which includes high energy bills, low income and poor energy efficiency of the building envelope¹². A composite indicator is used to cover these various factors. It is based on the only indicators currently available across the EU:

S11: Energy poverty index: this indicator calculates the average of the percentage of households in a given year: i/ facing arrears on utility bills; ii/ who are unable to keep their home adequately warm; iii/ and/or living in dwellings with leakages and damp walls¹³. It is based on the information collected by Eurostat in the EU Statistics on Income and Living Conditions¹⁴. The share of population with arrears in accounts provides some insights into energy affordability. The ability to keep the home adequately warm can inform on the need to constrain spending on heating. Dwellings with leakages and damp walls provide some indication of building quality. The higher the value of the indicator, the most significant energy poverty issues are expected to be in a given Member State.

In addition to the energy poverty index, information is presented in the next chapter on the estimated share of energy products in total households' expenditures, as used by central banks to calculate inflation. This is useful additional information as regards potential vulnerabilities to e.g. energy price shocks.

¹¹ See for instance suggestions by the Council for European Energy Regulators: http://www.ceer.eu/portal/page/portal/EstoniaR_HOME/EstoniaR_CONSULithuania/CLOSwedenD%20PUBLIC%20CONSULithuaniaAustriaIONS/CUSTOMERS/GGP%20retail%20market%20monitoring

¹² A more detailed discussion on energy poverty and relevant proxies to measure it can be found here: https://ec.europa.eu/energy/sites/ener/files/documents/INSloveniaGHT_E_Energy%20Poverty%20-%20Main%20Report_FinlandNAL.pdf.

¹³ Some studies argue on the need to include an additional indicator, on the ability to keep comfortably cool. See: https://ec.europa.eu/energy/sites/ener/files/documents/INSloveniaGHT_E_Energy%20Poverty%20-%20Main%20Report_FinlandNAL.pdf

¹⁴ For more information, see here: <http://ec.europa.eu/eurostat/web/microdata/european-union-statistics-on-income-and-living-conditions>

2.2.4. Energy efficiency and moderation of demand

The first element to monitor concerns primary energy consumption at Member State level.

S12: Primary energy consumption (2005 = 100): this indicator monitors the evolution of primary energy consumption¹⁵ in EU Member States, using 2005 as the base year.

In addition, information is also provided on final energy consumption developments. Measuring progress in terms of energy efficiency also requires monitoring energy intensity developments. It allows assessing energy consumption in view of other macroeconomic considerations, such as GDP, value added changes or population growth. Energy efficiency must also be considered at sectoral level, and therefore indicators monitoring energy intensity developments in the residential and industrial sectors are taken into account. The following indicators are selected:

S13: Primary energy intensity of the economy: this indicator divides primary energy consumption by GDP at constant 2010 prices in a given year. It measures the energy intensity of the economy and can capture changes over time in terms of decoupling energy consumption from economic growth. The lower the value, the more energy efficient the overall economy is. This indicator does not make corrections for differences in climate conditions.

S14: Final energy intensity in industry: this indicator divides final energy consumption¹⁶ in the industry (including construction) sector by total gross value added for industry, buildings and construction sectors (at constant 2010 prices). It measures the energy intensity of the industrial sector and therefore can reflect both potential specialisation in energy intensity sectors and effort in decoupling industrial growth from energy consumption. All else equal, the lower the value, the most energy efficient the industrial sector is. However, this indicator could also be refined by also measuring final energy consumption per amount of physical output, so as to e.g. capture potential changes in the industrial value chain which are not easily observable by comparing energy consumption to value added.

S15: Final energy consumption per square meter in residential sector, climate corrected: this indicator measures energy consumption in buildings, and can inform on the relative efficiency of the buildings stock and of energy equipment. When the value of the indicator decreases, it can be considered that the buildings sector becomes more energy efficient.

In addition to the above-mentioned indicators, it might also be relevant to monitor the uptake of energy efficient equipment. However, indicators on e.g. market diffusion of efficient heating or efficient appliances remain scarce¹⁷ and could not be compiled in the context of this Staff Working Document.

Regarding transport-related issues, which are covered under the same heading than energy efficiency in the Energy Union Strategy, specific energy intensity for passenger

¹⁵ Primary energy corresponds to the Gross Inland consumption minus final non-energy consumption

¹⁶ Final energy consumption covers all energy supplied to the final consumer for all energy uses.

¹⁷ See for instance <http://www.indicators.odyssee-mure.eu/market-diffusion.html>

and freight transport would be necessary to provide an in-depth analysis of the evolution of energy efficiency in transport. These two indicators correspond, respectively, to the energy used (expressed in ton of oil equivalent) per passengers- kilometres and tonnes-kilometres travelled within a Member State. Therefore the lower the value, the more energy efficient the transport sector is. Currently, Member States do not provide Eurostat with the split of final energy by passenger and freight transport and the traffic activity expressed in passenger-kilometres and tonne-kilometres cannot be aggregated. In addition, it is problematic to calculate intensities due to the fact that final energy consumption in transport is based on fuel sold rather than on fuel used within a Member State. Also, the methodology followed for reporting the traffic activity for passenger and freight transport does not always follow the territoriality principle, which renders the calculation of the intensity indicators even more difficult.

Furthermore, in addition to pure energy efficiency considerations, information is also collected as regards decarbonisation in the transport sector. The following indicator is proposed.

S16: Average CO₂ emissions from new passengers cars: this indicator measures the average CO₂ emissions from new passenger cars sold in a country in a given year, in order to observe progress towards an energy-efficient, decarbonised transport sector. As such, it provides indications as regards developments of a low-carbon fleet of passenger cars. The lower the value, the less carbon intensive new sold cars are, leading to a general improvement of the fuel economy. It could also be complemented with an additional indicator on the average CO₂ emissions from new light commercial vehicles (vans). A long-term target of 95 g CO₂/km to apply to the average new fleet from 2021 and of 147 g CO₂/km applicable from 2020 has been set for passenger cars and for light commercial vehicles respectively.

More indicators on e-mobility and deployment of hybrid cars, as well as on the availability of alternative fuels and related infrastructure should be included in this analysis. However, at the current state, the data available is very fragmented across community-based websites and data observatories, some important data is missing or there are concerns regarding its reliability.

2.2.5. Decarbonisation

The decarbonisation dimension of the Energy Union is very much driven by efforts towards meeting the EU and Member States greenhouse gas emissions reduction and renewable energy objectives. In particular, the EU Emission Trading System (ETS) constitutes the key instrument for limiting greenhouse gas (GHG) emissions in the power sector, energy intensive industries and aviation in the EU. While the EU ETS provides an EU-wide cap, the Effort Sharing Decision (ESD) sets national binding targets to be met through mitigation action in the non-ETS sectors (transport, buildings, small businesses and services, agriculture and waste). The following indicators are used to monitor progress in the sectors not covered by the EU-ETS:

S17: Gap between greenhouse gas emissions projections and target in 2020 in the non-Emission Trading System sectors. This indicator monitors progress of each Member State towards its EU-2020 GHG emission target. The projections for the year 2020 in the non-ETS sectors are estimated by the Member States taking into account existing measures. The EU-2020 target is set by the Effort Sharing Decision (ESD), which provides national binding targets from 2013 to

2020 for each Member State. The gap is expressed as a percentage of base year emissions (2005).

S18: Gap between latest proxy inventory of non-Emission Trading System greenhouse gas emissions and targets. This indicator measures the gap between the latest approximated inventory emissions available and its respective non-ETS target expressed as a percentage of base year emissions (2005).

S19: Share of renewable energy in percentage of gross final energy consumption: this indicator monitors progress towards renewable energy developments.

The overall renewable energy (RES) share indicator is complemented with information regarding RES share developments at sectoral level, namely in electricity, transport and heating and cooling sectors. Analysis is also provided on RES initiatives and developments at local level. Additional indicators on regional integration of renewable energy could be developed in the future.

Beyond the information provided on GHG emissions in the non-ETS sector and on RES developments, data is also collected on other variables related to decarbonisation. In particular:

S20: Greenhouse gas intensity of the economy: this indicator represents Member States' emissions relative to Gross Domestic Product. A lower value indicates that a particular economy is less carbon intensive.

Additional information is also provided regarding GHG emissions per capita, share of GHG emissions for the different sectors, and share of emissions covered by the EU ETS with respect to the total GHG emissions in each Member State. Further analysis is also provided on key sectorial aspects of the decarbonisation agenda, such as transport-related emissions under the section on energy efficiency and transport.

2.2.6. Research, innovation and competitiveness

2.2.6.1. Research and innovation

The 2030 Climate and Energy Framework refers to the need to monitor technological innovation (R&D expenditure, EU patents, competitive situation on technologies compared to third countries). In addition, the Energy Union Strategy recalls the objective of the EU to become the world's number one in renewable energy.

The transition to a low-carbon economy requires the development and implementation of new technologies. Such technologies will emerge via an innovation process, starting with R&D spending followed by innovation and deployment. Unfortunately, lack of available data does not yet allow properly monitoring all dimensions of the innovation process

In the coming years, more accurate data and analysis will be channelled through the monitoring mechanisms embedded in the Integrated Strategic Energy Technology (SET) Plan¹⁸, where it is proposed to monitor annually on the level of investment in research and innovation (both private and public sector), trends in patents, and the number of researchers active in the energy sector. Participation of Member States in joint actions

¹⁸ C(2015) 6317 final

will also be monitored, including through contractual Public Private Partnerships (cPPPs) or Joint Technology Initiatives.

For now, some indicators are provided, based on available data, mostly focusing on public R&D spending and patent applications. They are complemented with additional analysis as accessible and relevant, but some important gaps remain. In particular, it would be interesting to closely monitor energy investment and deployment across the world, to assess in detail the competitive position of the EU in this area. Various indicators could be considered, including e.g. the share of world's renewable energy patents held by EU companies¹⁹, the EU share in operational and service business (e.g. assembling, maintenance, repairs) in RES installations worldwide, renewable energy finance flows or the comparative advantage of EU RES technologies worldwide.

S21: Share of energy and environment in total public civil R&D spending: this indicator divides public R&D spending in the field of energy and environment by the total public R&D spending in civil research (therefore excluding military public R&D spending).

Whilst R&D spending does not always translate in the use of new technologies, it can be assumed that the latter will benefit from such spending. Yet, the choice of this indicator has some drawbacks. First, it does not cover corporate (or private) R&D spending, which is an essential component of overall R&D efforts in a given country. This is because no readily available data could be identified at Member State level on private R&D efforts in the field of energy. Some evidence is provided in the next chapter as regards private R&D in the field of low-carbon technologies, but information is still quite scarce. Second, this indicator does not indicate the overall effort of a given country towards energy and environment. To close this gap, some information is therefore presented in the next section about the public R&D intensity of Member States in the energy field²⁰. Comparison is also provided with R&D intensity in the energy field for main EU trading partners.

Third, complementary indicators are presented to identify specialisation in R&D efforts within the energy field (e.g. between energy efficiency, nuclear or renewable energy) in the EU and EU trading partners.

S22: Low-carbon technology patents application per million inhabitants: this indicator divides the number of patent applications in the field of low carbon technologies by the number of inhabitants in a given country. It provides information regarding the level of low-carbon technology innovation in a given country, adjusting absolute levels by taking account of the size (number of inhabitants) of the country.

Regarding deployment of innovative technologies, information on investments in renewable energy generation is presented in the next chapter, putting recent developments in the EU in perspective with developments in the rest of the world. Estimates on the evolution of costs for fossil fuel and renewable energy technologies are also presented.

¹⁹ Although information exists on patent applications, in many cases, data is still lacking as regards who effectively holds the patent.

²⁰ This analysis is based on data from the International Energy Agency and as such does not cover all 28 Member States.

2.2.6.2. Competitiveness: EU and major trading partners' energy prices and costs developments

On the issue of competitiveness, the 2030 Climate and Energy Framework recalled the need to monitor energy price differentials between the EU and major trading partners, building on the report on energy prices and costs²¹. Due to statistical issues, identifying relevant indicators that can be compared across (including non-EU) countries is difficult. In addition, broad variations exist within the industrial sector, with energy prices and costs having significantly different impacts depending on the sub-sector considered, even within a single Member State. Analysis of competitiveness should be complemented with additional and more detailed considerations.

Indicators on wholesale price differentials between EU Member States and main trading partners are considered²² in a first step. Wholesale prices are considered for two reasons: first, comparability is much easier as differences with trading partners often happen due to different statistical treatments of transmission and distribution costs; second, wholesale prices are usually considered a relatively good proxy of the price actually paid by large industrial users, that is, typically consumers most affected by international competition. Wholesale price indicators are complemented with information on final energy prices paid by a range of industrial users²³, combining data from Eurostat for EU Member States and from the International Energy Agency (IEA) for trading partners and for the EU Member States who are also members of the IEA.

When monitoring the impacts of energy prices on competitiveness, it is also important to consider a more holistic approach, which takes account of overall energy costs. Therefore, the following indicator is being proposed.

S23: Real unit energy costs: This indicator measures the amount of money spent on energy sources needed to obtain one unit of value added for the manufacturing sector, excluding the refinery sector. As such, it provides a more comprehensive approach regarding competitiveness issues related to energy costs, as it combines the impact of energy prices and of energy intensity level, when comparing to value added. The higher the value of this indicator, the higher the energy cost component is in the overall cost structure of the manufacturing sector of a given Member State.

There are some drawbacks with the choice of this indicator. The most significant one is that data is outdated, since information is only available up to 2011. Therefore, the Commission is working on updating this indicator in view of future monitoring of real unit energy costs across the EU and main trading partners.

2.2.7. Cohesion Policy investments supporting the Energy Union

EU Cohesion Policy makes a key contribution for delivering the Energy Union objectives on the ground, including significant financial allocations from the European Regional Development Fund (ERDF) and the Cohesion Fund (CF), totalling EUR 68.9 billion over 2014-2020 for investments related to all five dimensions of the Energy Union.

²¹ COM(2014) 21 /2, SWD(2014) 20 final/2

²² Regarding gas, US hub prices (Henry Hub) and LNG import prices for Japan, South Korea, China and India are used. Regarding electricity, wholesale price information is collected for some trading partners, in comparison to the European composite average of wholesale electricity prices.

²³ Eurostat data is reported for the median consumption bands, as well as minimum and maximum prices. It is however difficult to interpret to which specific industrial users each price applies to.

With the strategic policy framework and the important financial allocations which will be complemented by national public and private co-financing, and also with the technical assistance and capacity building provided, the conditions are there to use the full potential of the funding for investing in the Energy Union in Europe's regions and cities. To make this a reality, the development and implementation of high quality projects is crucial.

Therefore, it is important to monitor progress in Cohesion Policy investments supporting the Energy Union. This can be done by dividing the amount of ERDF and CF allocations allocated to specific projects by the end of each year, or a certain cut-off date, by the total amount of planned allocations 2014-2020 for ERDF and CF investments supporting the Energy Union in a given country, i.e. the project selection rate. It provides information regarding progress in Cohesion Policy investments supporting the Energy Union in a given country, controlling for the size of the allocation. This information will be provided from autumn 2016 onwards and will be included as part of the scoreboard indicators.

2.3. Summary

2.3.1. The selected scoreboard indicators

An overview of the selected main indicators included in the scoreboard is presented in Annex to this Staff Working Document, including latest available data per Member State regarding each selected indicator.

Energy security, solidarity and trust	S1: Net import dependency
	S2: Aggregate country-specific Supplier Concentration Index
	S3: N-1 rule for gas infrastructure
A fully integrated internal energy market	S4: Electricity interconnection capacity
	S5: Market concentration index for power generation
	S6: Market concentration index for wholesale gas supply
	S7: Wholesale electricity prices
	S8: Wholesale gas prices
	S9: Annual switching rates on electricity retail markets
	S10: Annual switching rates on gas retail markets
	S11: Energy poverty index
Energy efficiency and moderation of demand	S12: Primary energy consumption
	S13: Primary intensity of the economy
	S14: Final energy intensity in industry
	S15: Final energy consumption per m2 in residential sector, climate corrected
	S16: Average CO ₂ emissions from new passenger cars
Decarbonisation	S17: Gap between non-Emissions Trading System greenhouse gas emissions projections and target in 2020
	S18: Gap between latest proxy inventory of greenhouse gas emissions in the non-Emissions Trading System sector and targets
	S19: Share of renewable energy in percentage of gross final energy consumption
	S20: Greenhouse gas intensity of the economy
Research, innovation and competitiveness	S21: Share of energy and environment in total public civil R&D spending
	S22: Low-carbon technology patents application per million inhabitants
	S23: Real unit energy costs

2.3.2. Areas for additional work in preparing and selecting key indicators

The following table summarises the coverage limitations identified so far. It can help identify areas where additional indicators could be developed, and/or when a regional focus would seem appropriate to complement the Member State specific analysis.

Dimension	Main area of relevance	Identified needs
Macroeconomic relevance of energy sector	Contribution to economic growth	Need for additional focus on distributional effects across sectors and countries
	Contribution to employment	Need to better assess impacts of renewable and energy efficiency policies on net employment
Energy security, solidarity and trust	Security of electricity supply	Need for harmonised indicators across EU MS
A fully integrated internal energy market	Electricity interconnections	Additional information could be added in the future on implementation of PCI projects and on the uptake of smart grids considering for instance the extent of smart metering deployment as a first quantification of developments in smart grids related infrastructure
	Gas interconnections	
	Energy market coupling	Need for deeper analysis based on additional indicators as regards intra-EU market coupling and energy trade flows
	Retail market functioning	Need for additional and more comprehensive indicators across EU Member States.
	Vulnerable consumers	Additional indicators/analysis could be developed for a pan-EU assessment of energy poverty
Energy efficiency and moderation of demand	Energy intensity - transport	Need to develop robust indicators on energy and carbon intensity developments in the transport sector
	Energy intensity – residential	Need to work on the comparability of available indicators across Member States
	Transport	Additional data and information is needed to better assess energy intensity and decarbonisation trends in the transport sector.
Decarbonisation	Greenhouse gas emissions	Additional sectoral and cross-country related indicators could complement and improve a comparability analysis
	Renewable energy	Indicators on the cross-border integration of renewable energy could be further developed Indicators on local deployment of renewables and self-consumption could be further developed Indicators on the sustainability of biomass for energy use (incl. impacts inside and outside the EU) to be further used
Research, innovation and competitiveness	Public R&D	Need to collect more up to date information on public R&D investments from all Member States
	Private R&D	Limited consistent data regarding corporate investments in R&D for low-carbon technologies. Need to expand coverage so that it is comparable to that available for public sector R&D
	Researchers	Need to work on data collection on the number of researchers active in the energy sector
	Innovation deployment	Lack of indicators, including regional or EU-wide ones, on the deployment of innovation in low-carbon sectors and competitive position of such sectors on global markets
	Competitiveness	Need to update data on real unit energy costs

3. DESCRIPTIVE ANALYSIS

This chapter presents a cross-country descriptive analysis of the current situation and recent trends for the five dimensions of the Energy Union, complemented by information and analysis on the macroeconomic relevance of the energy sector and on the use of EU funds to meet Energy Union objectives. It builds on the selected indicators included in the scoreboard, complemented with other relevant information when possible and necessary²⁴.

3.1. Macroeconomic relevance of the energy sector

3.1.1. Value Added and Employment

In 2012, the energy sector accounted for 2.01% of the total value added of the economy in EU27 (Figure 1). These shares vary significantly across countries, with relative shares generally higher in Eastern Member States. Over the period 2005-2012, these shares grew the most in Ireland, Spain, Cyprus, Latvia, Romania and United Kingdom, while they decreased in Denmark, Greece, France, Lithuania, Luxembourg, Austria and Slovakia.

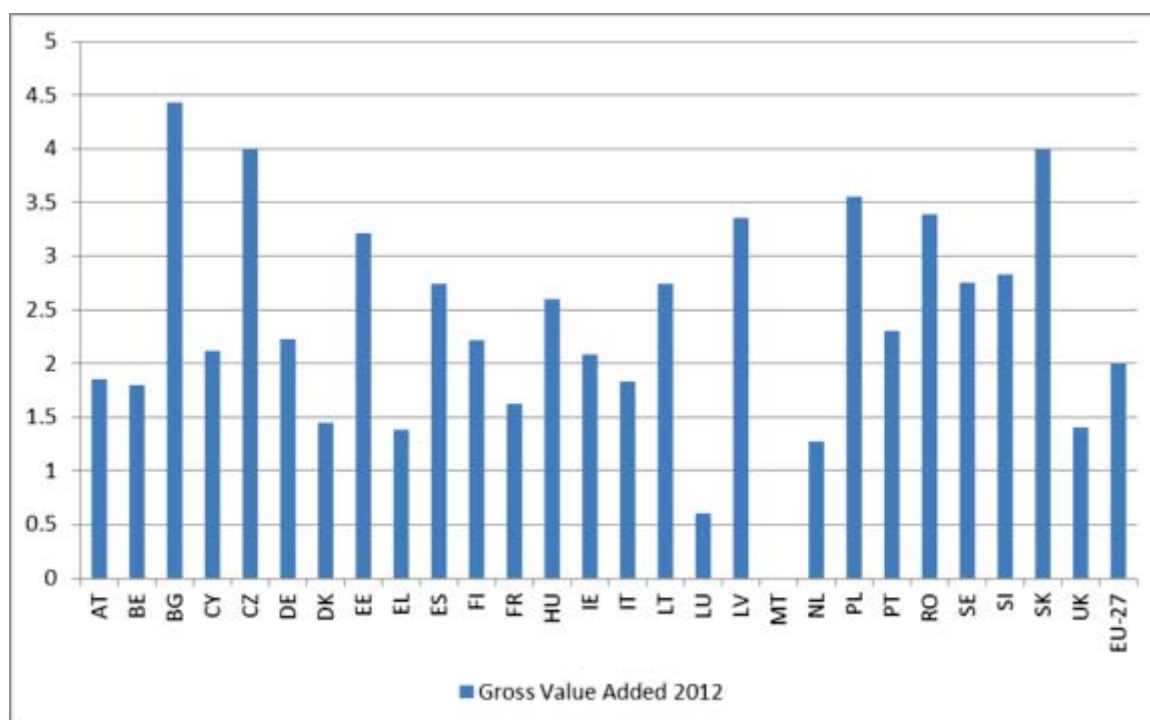


Figure 1: Value added of the energy sector - percentage of gross value added (total economy) in 2012

Source: Eurostat – National Accounts

The EU is in the lead when it comes to turnover of renewable energy companies. In 2013, the RES sector has generated a 138 billion€ turnover, with a 6% increase compared to the previous year.

²⁴ Note that for data collected from Eurostat, the extraction of the data was performed by September 2015. As such, there might be some discrepancies with the current Eurostat dissemination database.

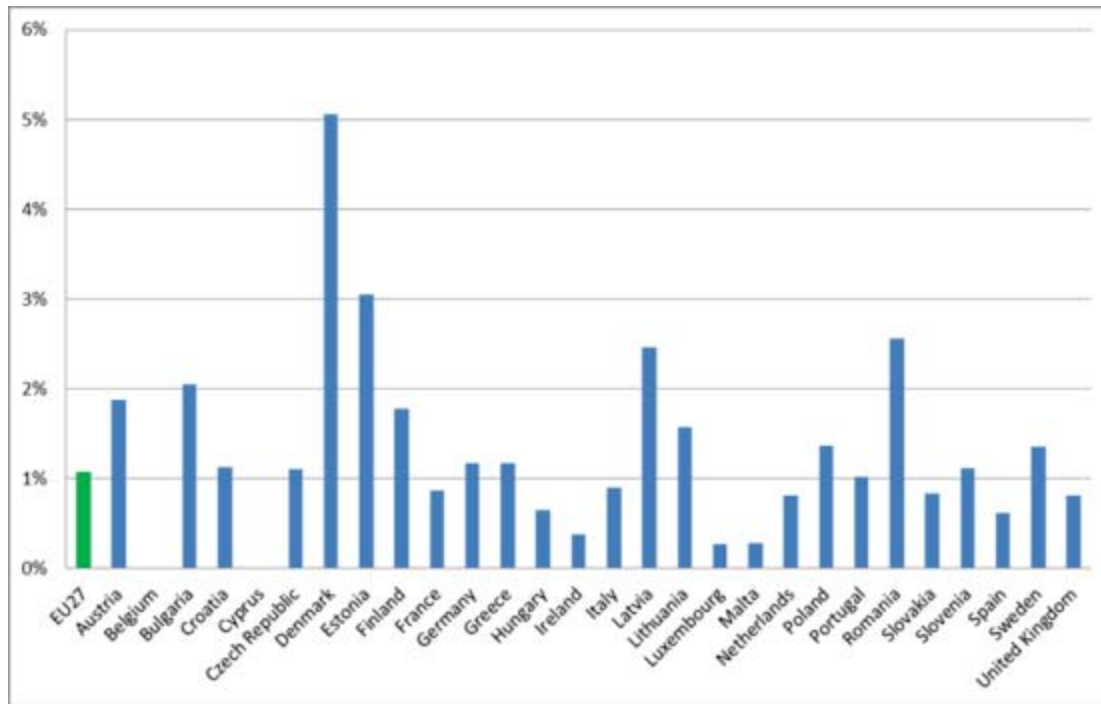


Figure 2: Turnover of all renewable energy sectors (% GDP 2013)

Source: EurObserv'ER

In terms of employment, the energy sector represented 0.56% of the total employment in EU-27 in 2012. It has remained broadly stable at EU level over the period 2005-2012, although the share increased in Belgium, Denmark, Spain, Cyprus, Slovenia, Sweden and the United Kingdom. The share in employment decreased the most in Bulgaria, Czech Republic, Lithuania, Luxembourg, Poland, Romania and Slovakia.

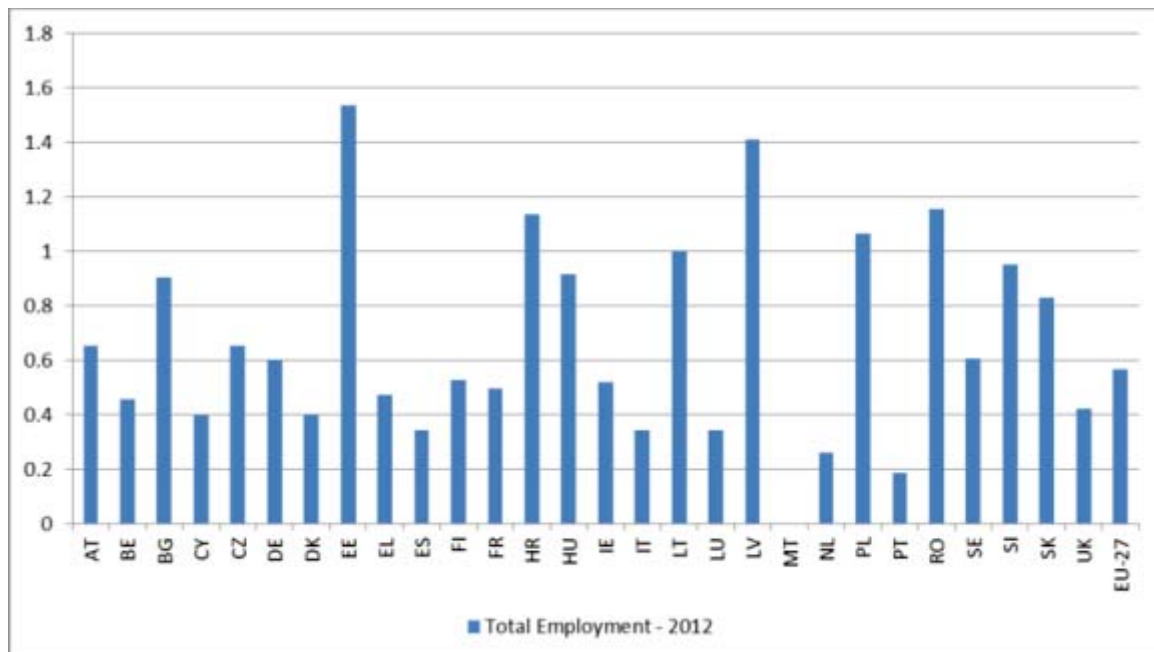


Figure 3: Employment in the energy sector – percentage of total employment in 2012

Source: Eurostat – National Accounts

European renewable energy employs over a million people, i.e. more than 2 renewable jobs per 1000 capita, which is twice the world average. Despite the financial and economic crisis, employment has grown in the renewable energy sector, with almost half a million additional jobs in EU-27 between 2008 and 2013²⁵.

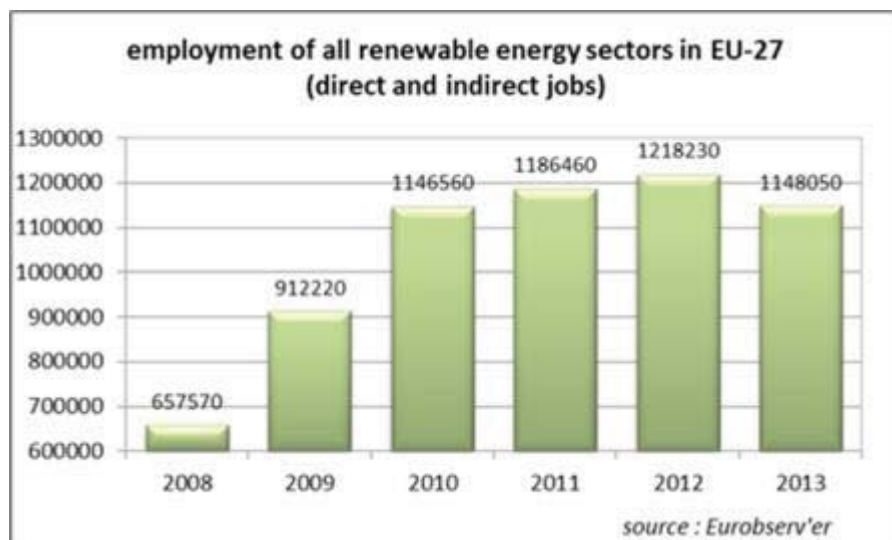


Figure 4: Evolution of employment of all renewable energy sectors in the EU, 2008-2013

Source: EurObserv'ER

A growing trend can also be observed worldwide, with a 17% increase in renewable employment in 2013. In Europe, new momentum for job creation might emerge from exports towards rapidly expanding markets like Asia, South America and Africa.

²⁵ Source : EurObserv'ER database

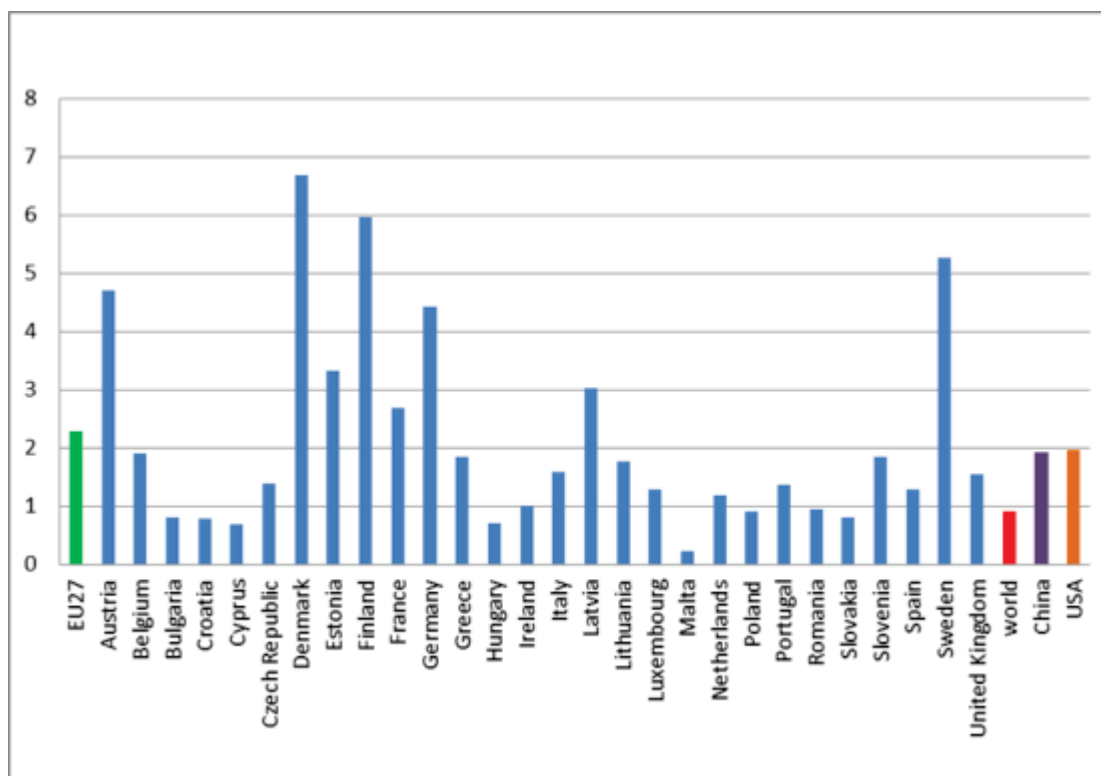


Figure 5: Employment of all renewable energy sources sectors - 2013 (per 1000 inhabitants)

Source: EurObserv'ER, REN21

Renewable energy technologies are, in general, more labour-intensive than conventional energy technologies. Therefore, increased implementation of renewable energy technologies is likely to lead to increased employment in the future, at least in the sectors directly connected to the manufacture and operation of such technologies. However, expansion of renewable energy technologies is also expected to lead to new types of jobs and skill requirements, especially in the power sector²⁶. The transition thus needs to be met with training and education, notably in positions related to research and engineering²⁷.

3.1.2. Consumer Prices

Consumer price inflation has decreased on average by five times since 2011 at EU level. Energy products have contributed significantly to this trend, notably in 2014 through the sharp drop in oil prices.

²⁶ Cambridge Econometrics, Employment Effects of selected scenarios from the Energy roadmap 2050, 2013

²⁷ Cambridge Econometrics, Studies on Sustainability Issues – Green Jobs; Trade and Labour, 2011

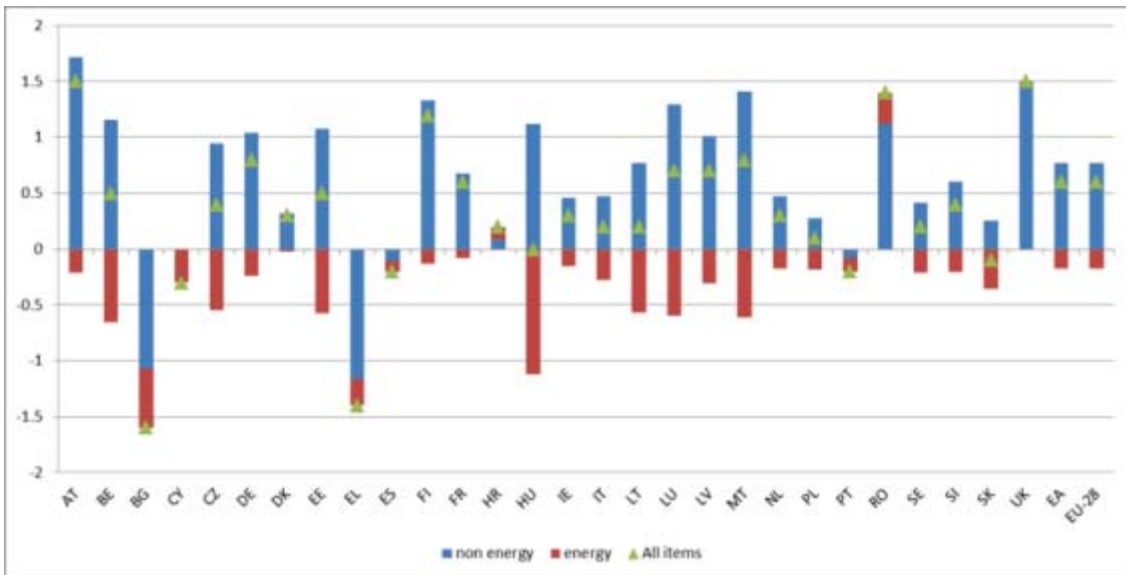


Figure 6: Consumer Price inflation (%) across the EU in 2014

Source: Eurostat – National Accounts

Since 2011, energy inflation has experienced a significant reduction. Overall at EU level, this decrease has led to a price reduction in 2014 for transport and other liquid fuels and to a lesser extent for gas. For electricity, prices have overall continued to increase although at a slower pace. These trends vary strongly across Member States as it depends on their economic outlook, the electricity and overall energy mix, the share of the transport and petrochemical industries in the economy. For instance in 2014, electricity prices have decreased in 16 Member States (Belgium, Bulgaria, Czech Republic, Estonia, Croatia, Cyprus, Lithuania, Luxembourg, Hungary, Malta, the Netherlands, Poland, Romania, Slovenia, Slovakia, Sweden), while gas increased in 10 Member States (Ireland, Spain, Croatia, Malta, Poland, Portugal, Romania, Slovenia, Sweden and United Kingdom).

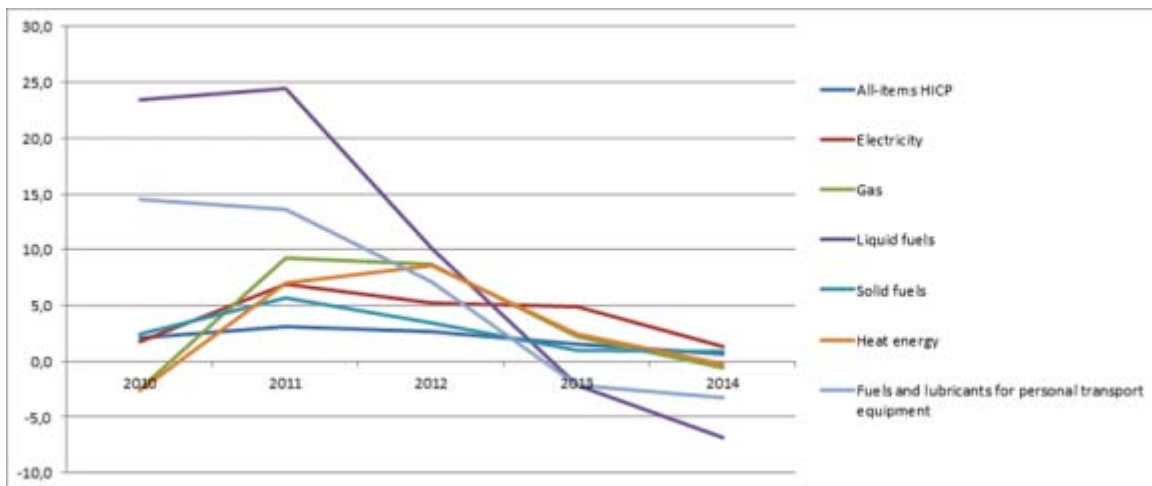


Figure 7: Harmonised Indices of Consumer Prices (HICP) in EU28 and its energy components' evolution, 2010-2014 (%)

Source: Eurostat – National Accounts

3.1.3. Energy and transport related taxes

Environmentally related taxes, including taxes on energy and transport, serve both a fiscal and an environmental objective. By targeting different sources of pollution, taxation provides incentives to reduce emissions and enhance efficiency. Despite some challenges in terms of political economy, experience has proven that environmental taxes can be effective and efficient instruments for achieving environmental policy objectives. Environmentally related taxes are also among the taxes considered to be least detrimental to growth, and could thus be a source of revenue that can be used to improve public finances or to facilitate a tax shift away from labour taxation.

Taxation of energy, both in the form of taxes on carbon and energy products, currently generate the most revenue of these taxes. Transport related taxes excluding fuels include registration taxes (levied on the purchase of a car) and circulation taxes (levied most often annually on car ownership). Both these forms of vehicle taxation can be used by Member States to encourage fuel efficiency and emissions reduction by making the tax rate dependent on the carbon dioxide emissions of the vehicle.

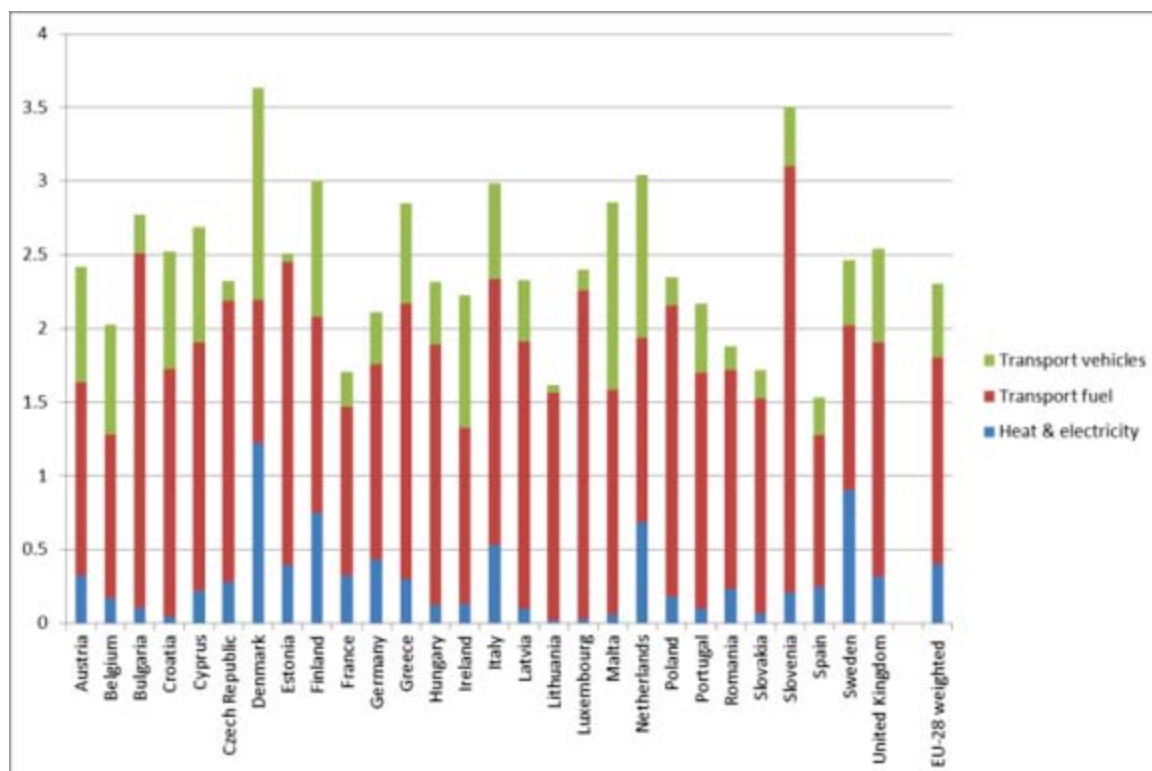


Figure 8: Energy and transport related taxes in the EU, % of GDP, 2012

Source: DG TAXUD, Taxation Trends in the EU annex A

In 2012, energy and transport related taxation amounted on average to 2.3% of GDP in the EU28. This revenue ratio to GDP has fallen slightly since 2005, when it amounted to 2.4% for the EU28. This decrease can be attributed to revenue from transport fuel taxation. Energy taxes on motor fuels, including carbon taxes where relevant, account for the greatest share of these revenues, i.e. 61% corresponding to 1.4% of GDP on average in 2012. In several Member States, notably Slovenia, Luxembourg, Bulgaria and Estonia, fuel taxation actually account for more than 2% of GDP. The tax revenues from heat and electricity taxes amount on average to 0.4% of GDP. Denmark, Sweden, Finland and the Netherlands tax electricity and heating as part of their climate and energy policies, which

results in revenue shares at or above 0.7% of GDP. Finally, Member States differ greatly in their use of vehicle taxation as a revenue and policy instrument. The tax burden on vehicles in Denmark, Malta and the Netherlands amount to more than 1% of GDP, while it is 0.1% or below in Lithuania, Estonia, the Czech Republic and Luxembourg. This data indicate that there is scope for several Member States to make better use of tax instruments in their energy and climate policies, in particular to achieve better energy and carbon efficiency²⁸.

3.2. Energy security, solidarity and trust

3.2.1. Import dependency

The EU imports about 53% of its fossil fuel needs from the rest of the world. This value slightly increased over the 2005-2013 period, notably due to the depletion of EU fossil fuel reserves. Figure 9 illustrates the net import dependency levels in 2005 and 2013 across EU Member States (% of net fossil fuel imports in gross inland consumption and bunkers, based on tonnes of oil equivalent).

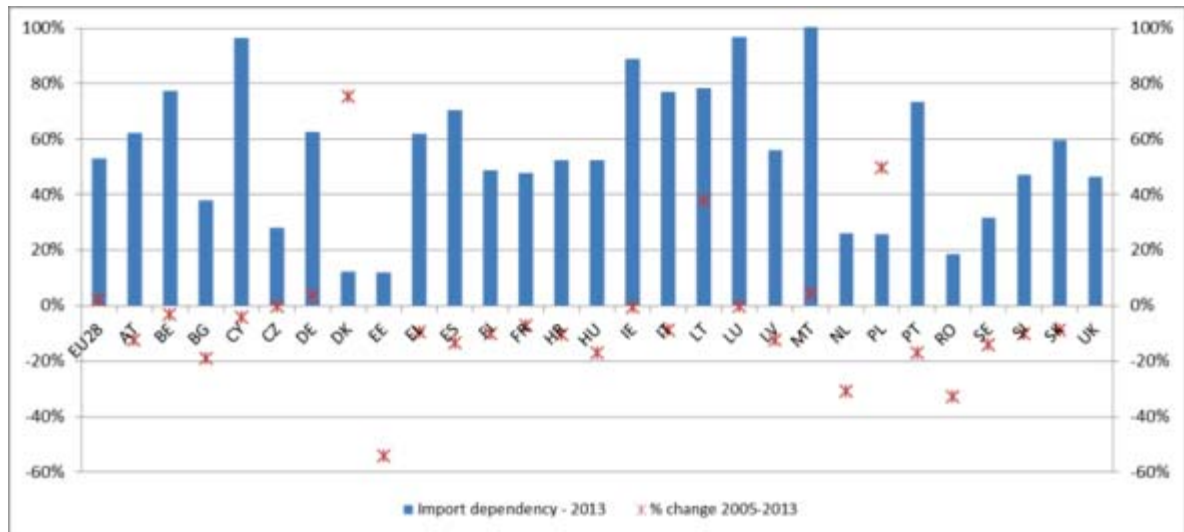


Figure 9: Net import dependency for EU Member States²⁹

Source - Eurostat

Import dependency greatly varies across EU Member States, some countries being almost exclusively dependent on imports while others can rely on national resources. Over the 2005-2013 period, import dependency increased most in Denmark, Lithuania, Poland and United Kingdom. In the case of Denmark and the United Kingdom, it is notably due to depleting national fossil fuel resources. Conversely, import dependency significantly decreased in Estonia, the Netherlands and Romania.

Moreover, the EU imports 40% of its uranium and other nuclear fuels. In 2013, it imported more than 17 000 tU. Out of it, 45% came from Russia and Kazakhstan.

²⁸ For further discussion see also "Tax Reforms in the EU Member States 2015", European Economy, Institutional Paper, 8/2015, and previous editions of this report.

²⁹ For the United Kingdom, import dependency increased by more than 200%. Results are not visible on the graph for scale reasons.

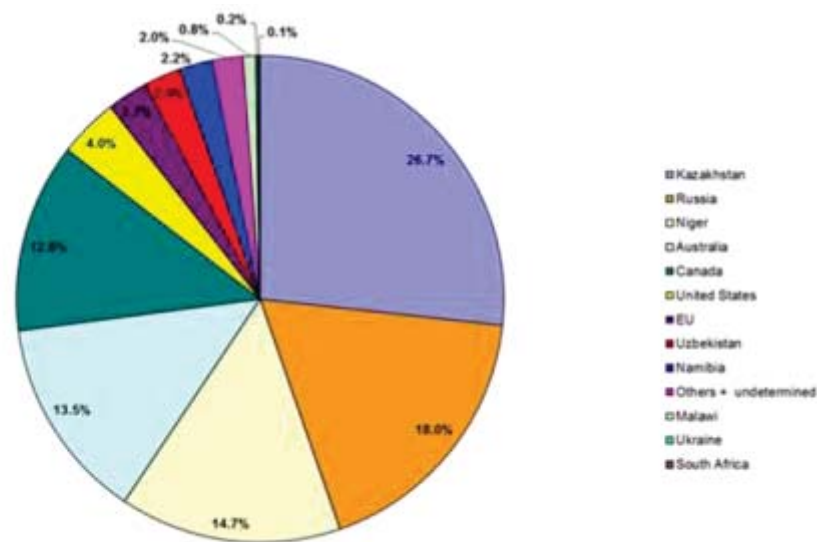


Figure 10: Share of purchases of natural uranium by EU utilities by origin, 2013 (%)

Source: Euratom Supply Agency

Regarding trade patterns for petroleum products, although the EU has enough and even excess gasoline production capacity, it is at the same time unable to meet the demand for gas/diesel oil. Therefore, the majority of the refined products import in 2013 was gas/diesel oil: 44 million tonnes from extra-EU countries, a figure which almost tripled from 2000 (16 million tonnes). The total amount of gasoline exported extra-EU in 2013 was 44 million tonnes which is more than double compared to 2000 when the export amounted to 19 million tonnes. In 2013 most exports, more than 13 million tonnes, went to the United States.

3.2.2. Supplier concentration index

Only focusing on import dependency own does not provide enough information on the degree of diversification in import sources, as well as on the relative significance of various import sources in the energy mix. Therefore, the analysis of the previous section is complemented with information on energy import supplier concentration.

In the in-depth study accompanying the European Energy Security Strategy³⁰, a country-specific supplier concentration index (SCI) by fuel was computed as the sum of squares of the quotient of net positive imports from an extra European Economic Area (EEA) country to an importing Member State (numerator) and the gross inland consumption of that fuel in the importing Member State (denominator). Smaller values of SCI indicate larger diversification and hence lower risk.

An aggregated indicator, combining information on SCI for oil, gas and coal³¹, is used in this Staff Working Document. The value of this indicator is influenced by two factors: the share of non-EEA country sources in a Member State's energy mix, as well as the degree of diversification of the Member State's energy mix. As such, it combines information regarding import dependency, the number of countries from which such

³⁰ SWD(2014) 330

³¹ Regarding coal, information on other bituminous products is used

imports come and the relative balance in a Member State's energy mix between various energy sources.

A Member State importing most of its fossil fuel sources, but from a wide range of countries, such as Spain, shows relatively low levels of supplier concentration. In addition, all else equal, a Member State in which fossil fuels represent a limited share of the overall energy mix, such as France, also shows relatively lower values for this indicator than a Member State solely relying on energy imports.

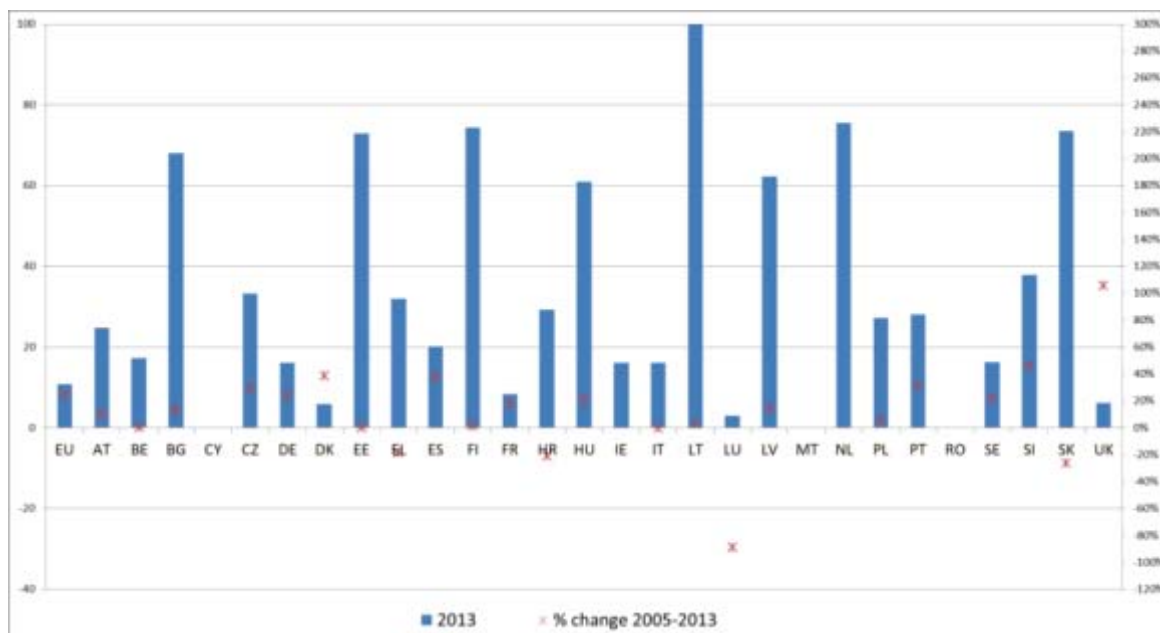


Figure 11: Aggregate (gas, oil, and coal) country specific concentration index³²

Source: European Commission services calculations, based on Eurostat

At EU level, the indicator is low, showing a good degree of diversification of import sources and a balanced energy mix when considering the EU as a whole. However, the indicator has slightly increased over the 2005-2013 period, a sign of small additional concentration in import sources.

Concentration in fossil fuel import sources is particularly high in Bulgaria, Estonia, Finland, Lithuania, the Netherlands and Slovakia. Regarding changes over the 2005-2013 period, it can be noted that concentration increased in most countries over the period, a potential sign of increased vulnerability to single supplier or fuel source. The aggregate concentration index however hides more encouraging signs when focusing on specific fuels, such as gas, as this specific supplier concentration index has decreased over the period for a majority of Member States.

3.2.3. Contribution of renewables to energy security

The European Energy Security Strategy (EESS) has already underlined the significant cost-effective potential for a fuel-switch to indigenous renewable electricity and heating sources to further reduce the use of natural gas in a number of sectors by the end of this decade. For this purpose, renewable heating and cooling is highly prioritised and can

³² For Ireland and the Netherlands, partial lack of data does not allow presenting 2005-2013 trends. For Romania, Cyprus and Malta, incomplete data does not allow presenting results.

displace significant amounts of imported fuels. At present, almost 17% of the heating and cooling demand in the European Union is covered by renewable energy sources³³.

Currently, renewables in Europe are already playing a key role for energy security. The increased consumption of renewable energy compared to the 2005-level has enabled the EU to cut its demand for fossil fuels by 98MToe, the equivalent of the energy consumption of Poland. In 2012, the EU's gross inland consumption of fossil fuels would have been 7% higher³⁴ without the introduction of large amounts of RES. Coal was the fuel most substituted by renewables across Europe (consumption would have been 13% higher without the introduction of a large amount of RES), followed by gas (7% higher without RES)³⁵. At country level in 2012, 12 Member States saw reductions of their gross inland consumption of fossil fuels of 7% or more, in response to RES increases since 2005 (Austria, Belgium, Denmark, Estonia, Germany, Finland, Italy, Latvia, Portugal, Slovenia, Spain and Sweden).

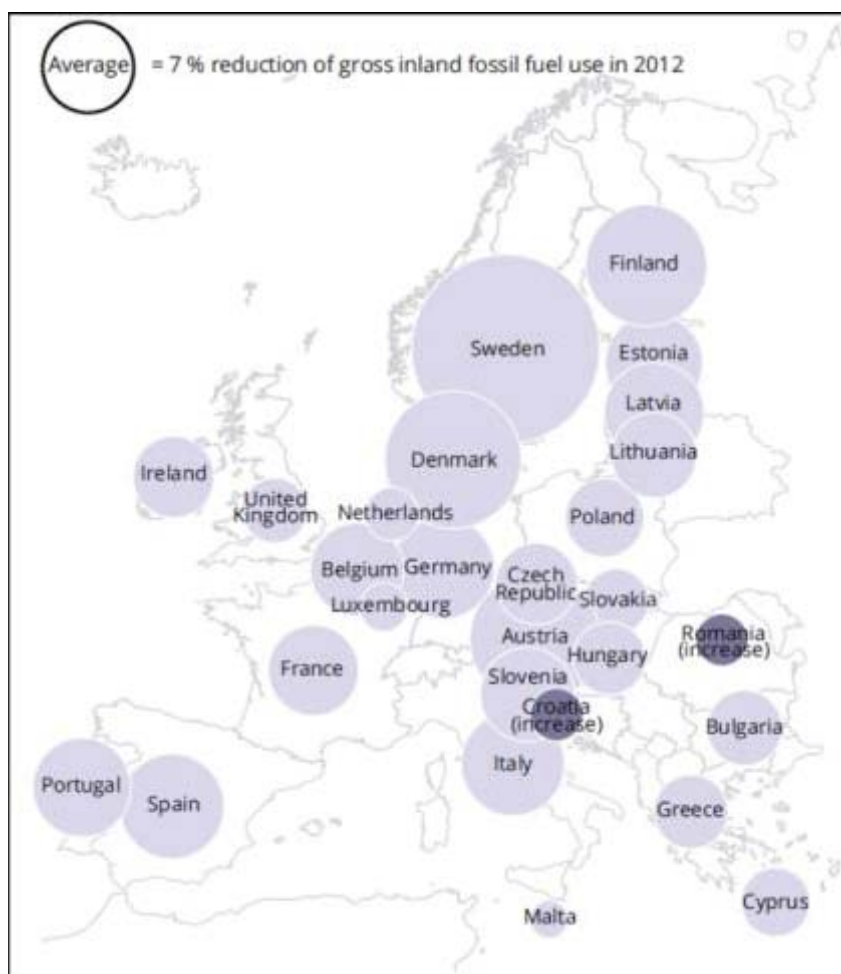


Figure 12: Relative reduction of gross inland consumption of fossil fuel use due to deployment of renewable energy

Source : EEA, Renewable energy in Europe - approximated recent growth and knock-on effects, 2015

³³ RES Progress Report, EC, 2015

³⁴ EEA, Renewable energy in Europe - approximated recent growth and knock-on effects, 2015. 2012 figures see technical report : <http://www.eea.europa.eu/publications/renewable-energy-in-europe-approximated>

³⁵ Renewable energy in Europe - approximated recent growth and knock-on effects. European Environment Agency technical report No1/2015

3.2.4. Net trade balance of energy products

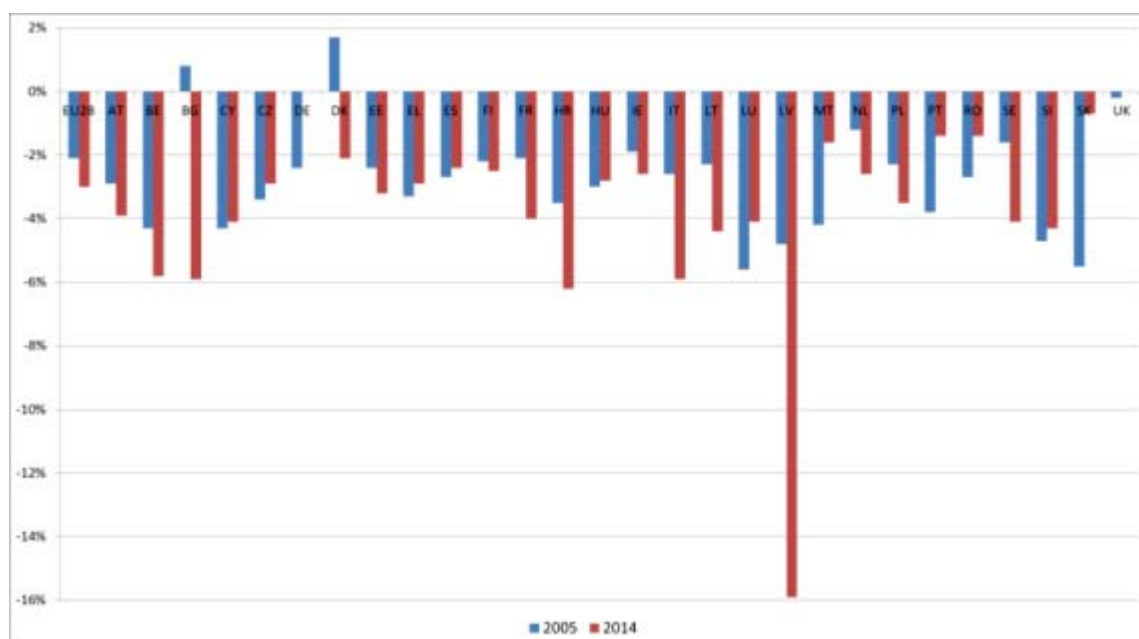


Figure 13: Net trade balance of energy products - % of GDP

Source: Eurostat

The above indicator shows the influence of energy import bills from a macroeconomic perspective. It is one of the indicators that can provide additional information as regards the potential vulnerability of Member States to energy price shocks, including via negative implications on external macroeconomic imbalances. Since 2005, the situation has deteriorated for many Member States, in particular for Bulgaria, Croatia, Italy, or Latvia. However, the decrease in international fossil fuel prices in the second half of 2014 have reduced energy trade deficits of most Member States, in particular when compared to 2013 data.

3.2.5. Security of gas supply

Regulation 994/2010 aims to safeguard the gas supply to the customers in the event of a supply disruption (e.g. interruption of external gas supplies, failure of infrastructure) or exceptionally high gas demand. The Regulation defines an EU-wide infrastructure standard that all Member States should fulfil, the so called "N-1". The N-1 standard aims at ensuring a certain redundancy in the system so that in the event of a disruption of the single largest gas infrastructure, the capacity of the remaining infrastructure is able to satisfy the total gas demand during a day of exceptionally high gas demand occurring with a statistical probability of once in 20 years.

It is also possible to fulfil the N-1 rule on a regional level if relevant Member States establish a joint Risk Assessment and a joint Preventive Action and Emergency Plan and define "the single largest gas infrastructure of common interest" for the region.

The number of Member States who comply with the N-1 rule has been increasing over the years and currently stands at 20³⁶.

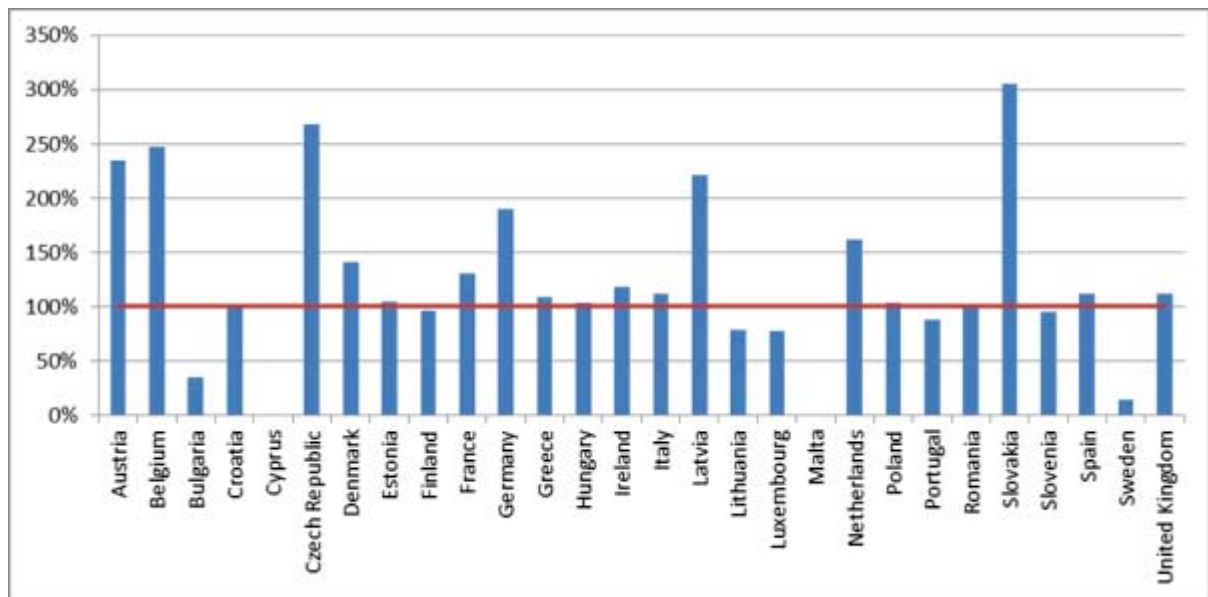


Figure 14: Member States' position as regards the N-1 criteria (2015)

- (1) FI: Fulfils the N-1 using demand-side measures
- (2) IE: Fulfils the N-1 at regional level (UK-IE)
- (3) SE, SI, LU: Exempted from the N-1 rule

Source: Member States' Risk Assessments and Preventive Action Plans

3.2.6. Security of electricity supply

In addition to fossil fuel trade patterns, security of energy supply considerations also need to pay attention to the quality of electricity supply and of potential generation adequacy issues. Such issues are usually addressed by energy regulators or transmission system operators (TSOs).

The ENTSO-E Winter Review 2014/15 highlighted that during the winter 2014/2015 temperatures across the whole of Europe were near average. As a result, demand was around seasonal average in most countries. In Greece, Croatia and Serbia, snow, ice and strong wind caused some difficulties and damages to the transmission network. However, no critical situation related to system adequacy occurred in Europe last winter. The ENTSO-E Winter Review 2015/16 will be published on 1 December 2015.

The Scenario Outlook and Adequacy Forecast (SO&AF) report aims at providing stakeholders in the European electricity market with a Pan-European overview of generation adequacy with a five to ten year time frame. In the latest report, the regional analysis shows that from a Pan-European system point of view, the level of imports necessary to maintain adequacy is feasible and within the level of forecast cross-border interconnectivity for the period 2016–2025.

³⁶ Additional information can be found in the "Report on the implementation of Regulation (EU) 994/2010 and its contribution to solidarity and preparedness for gas disruptions in the EU". Available at: <https://ec.europa.eu/energy/sites/ener/files/documents/SWD%202014%20325%20Implementation%20of%20the%20Gas%20SoS%20Regulation%20en.pdf>

3.3. A fully integrated internal energy market

3.3.1. Electricity interconnection capacity

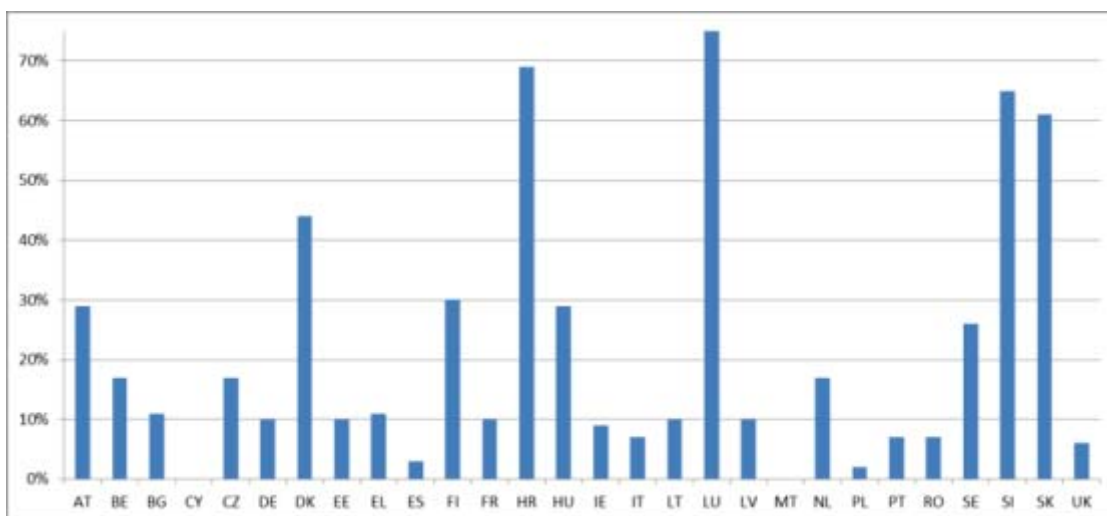


Figure 15: Electricity interconnection capacity (% of total generation capacity) - 2014³⁷

Source: European Commission based on ENTSO-E scenario outlook and adequacy forecast 2014

Being aware of the benefits of energy interconnections, Member States have increased their interconnection capacities during the last decades. For instance, the launch of the Estlink2 interconnection has increased remarkably Baltic States' connectivity with the Nordic power market. However, currently eight Member States remain below the 10% electricity interconnection target and by increasing interconnections would further benefit from the internal electricity market.

In this context, the EU has gradually been equipping itself with the right policy tools to enable necessary investments in grid infrastructure, investments in interconnection being paramount among those. As underlined by the European Council, the interconnection target should mainly be reached through implementation of the Projects of Common Interest.

³⁷ Due to scale reasons, the graph does not properly reflect the level of interconnection capacity in Luxembourg, which is much higher than suggested on this graph (i.e. at 245%).

3.3.2. Concentration on wholesale markets

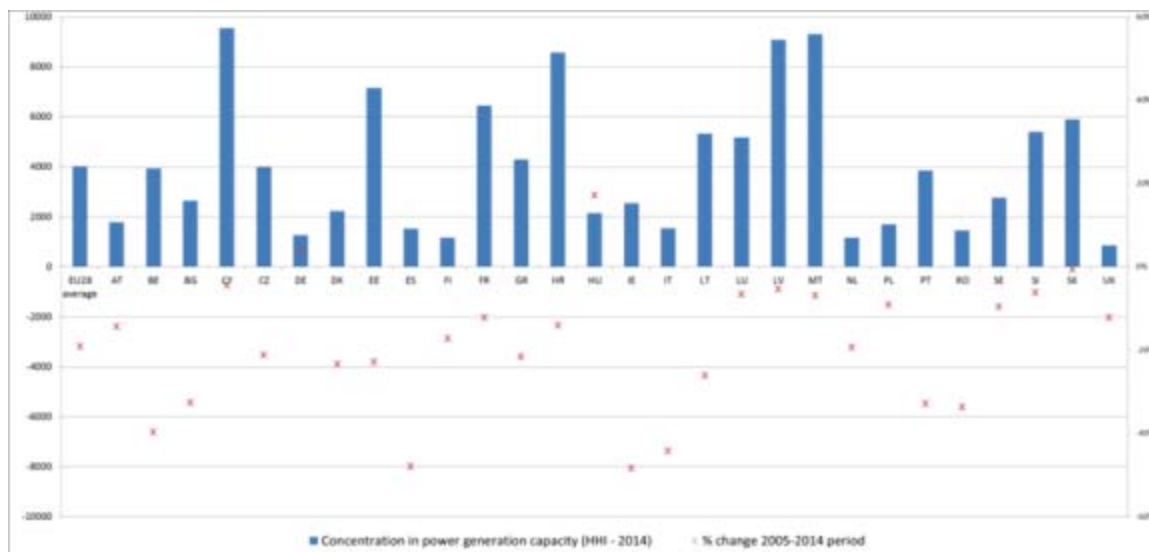


Figure 16: Market concentration in power generation capacity in EU Member States

Source: Commission services calculations, based on Platts data

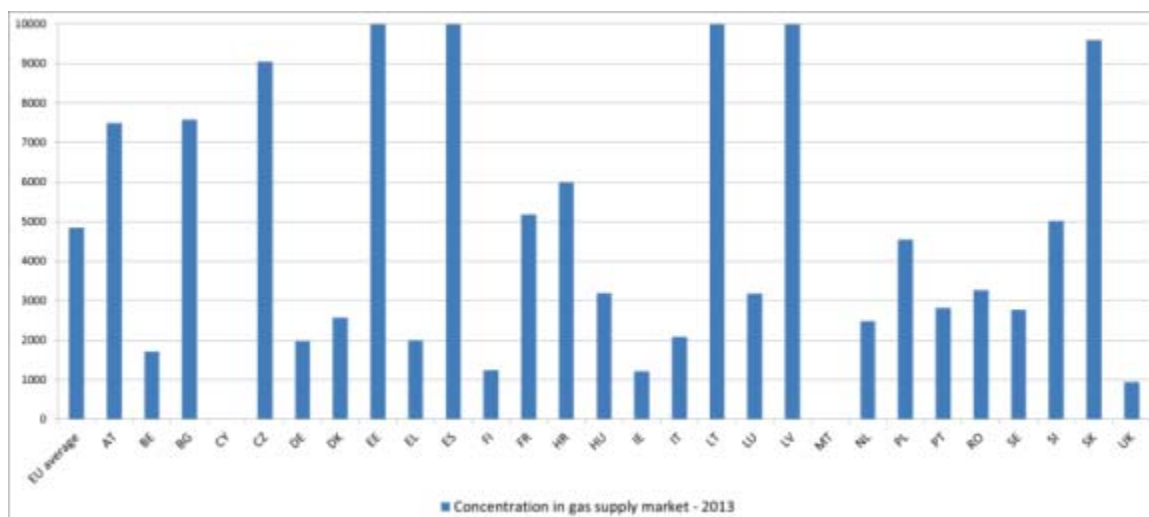


Figure 17: Market concentration in Member States' wholesale gas markets

Source: ACER

At EU level, market concentration remains significant both on electricity and gas markets³⁸. However, at least for electricity, Concentration levels have decreased in wholesale electricity markets over the last 10 years, on average by 19%, a sign of greater competition.

Concentration levels also vary across Member States. Most concentrated markets for electricity can be found in Cyprus, Estonia, Croatia, Latvia and Malta, while for gas, it is

³⁸ The Herfindahl-Hirschman index (HHI) describes market concentration. It is the sum of squared market shares of individual companies. The HHI assumes values between zero and 10,000, with high values indicating high market concentration. An HHI of 10,000 is a monopoly, an HHI of 5,000 represents two market participants of 50% market share each, five equal market participants yield an HHI of 2,000.

in Estonia, Spain, Lithuania, Latvia and Slovakia. Most significant decreases in concentration levels were observed in Greece, Italy, Ireland, Belgium, Spain or Romania.

3.3.3. EU energy market coupling and convergence in wholesale prices

3.3.3.1. Prices developments on EU electricity markets

As can be seen in Figure 18, wholesale electricity prices showed signs of convergence during the last few years, as the difference between the cheapest and most expensive wholesale electricity market prices decreased in the EU. However, differences between the price levels still remain and temporary price divergences may occur in the future, as a consequence of sudden shifts in local power demand and supply, owing to changes in electricity mixes in different markets or availability of infrastructure and interconnection capacities.

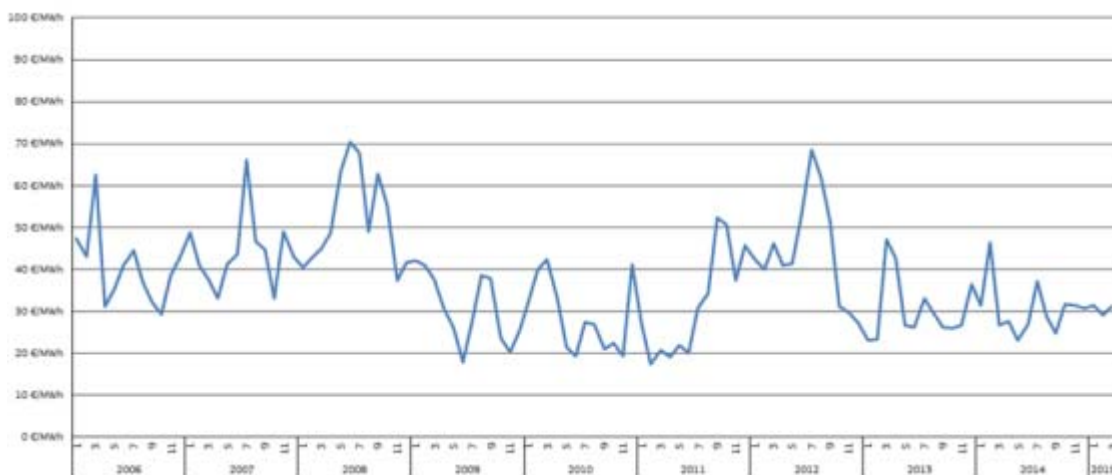


Figure 18: Difference between the highest and the lowest regional wholesale electricity price

Source: European power exchanges, own computations

More specifically, when observing latest trends, Figure 19 shows there were significant price differences in the wholesale electricity prices across the EU in the first quarter of 2015, ranging from 28-29€/MWh in Denmark and Sweden to 58 €/MWh in Greece.

Local market prices may significantly differ from each other even in a coupled region, as the Central Western Europe (CWE) region gave a good example for this in the first semester of 2015. Due to record high wind power generation in Germany local prices were lower than in France, Belgium and the Netherlands, where local particularities of the fuel mixes (the availability of nuclear generation and gas-fired plants) significantly impacted wholesale prices. In the Nordic region and in Spain and Portugal the availability of hydro reserves can impact the wholesale electricity price level and can result in price volatility across different seasons of the year. Besides domestic generation mixes, the existence of sufficient level of interconnection capacities also exert significant influence on the local price level.



Figure 19: Comparison of average wholesale baseload electricity prices, first quarter of 2015

Source: European wholesale power exchanges

As the market integration moves forward, expectations rise towards full price convergence. However, it must be noted that the existence of fully converged prices over time is not a precondition to a well-functioning internal electricity market in the EU as regional differences stemming from the aforementioned reasons will probably result in temporary divergences in the future, even if the market integration is complete and all necessary interconnection infrastructure is built. A better measure for a good functioning internal market is the disappearance of the non-economic power flows (when electricity flows from the higher-priced area to the lower-priced one), as these non-economic power flows result in welfare losses in cross-border electricity trade.

Market coupling is the main tool for achieving the elimination of non-economic power flows through implementing implicit cross border electricity trade auctions. By mid-2015 most of the EU electricity markets are coupled to one or several of their neighbours; the most significant coupling area is the North West European coupled area, stretching from the Iberian-peninsula to the Nordic and Baltic markets, including seventeen EU markets plus Norway that cover about three quarters of the total EU electricity trade volume. Between 2009 and 2014 four markets in Central and Eastern Europe (Czech Republic, Slovakia, Hungary and Romania) have been gradually coupled, and as of February 2015 Italy has been coupled with Austria, France and Slovenia.

3.3.3.2. Price developments on EU gas markets

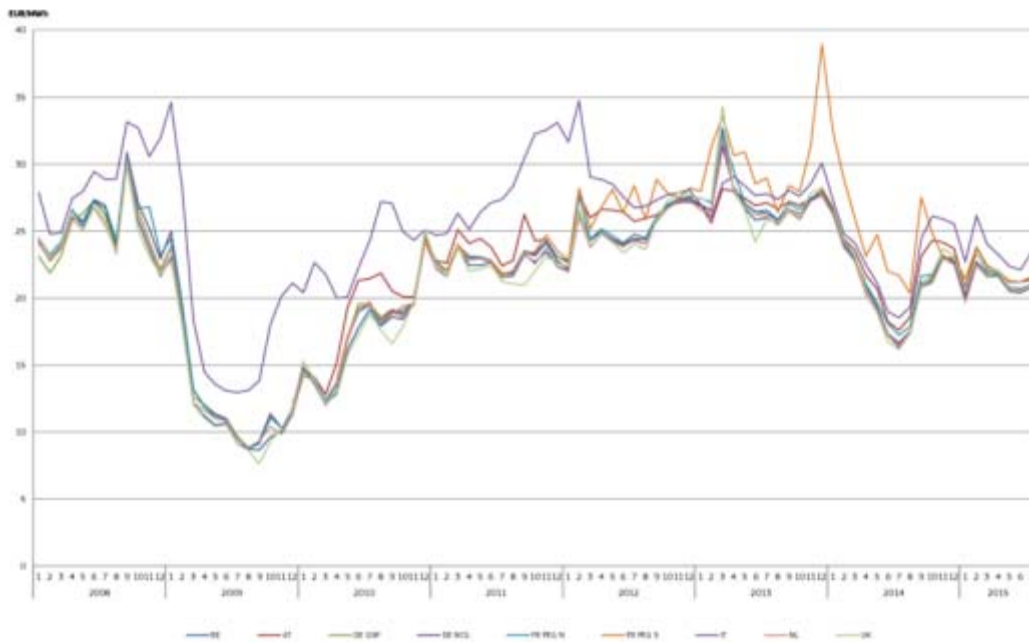


Figure 20: Wholesale day-ahead gas prices on gas hubs in the EU

Source: Platts

Regarding gas, the situation is more contrasted. Figure 20 presents the evolution of European hub day-ahead natural gas prices in the period from January 2009 until July 2015, showing the convergence in the day-ahead price on major European gas hubs. Nevertheless, in spite of the convergence, some differences remain, often caused by infrastructure bottlenecks, e.g. between Northern and Southern France.

However, not all gas consumed in Europe is traded on day-ahead markets. In particular, taking account of gas imported via pipelines, the signs of price convergence are less obvious. The price of gas imports under long term contracts, especially from Russia, is often linked to the price of oil products (usually with a 6-9 month time lag). The level and dynamics of such "oil-indexed" prices can be quite different to that of hub prices.

A comparison of a selection of estimated border prices of gas deliveries from the main exporters to the EU – Norway, Russia and Algeria – shows significant variations in price levels and, to a smaller extent, in price dynamics. After the increasing price divergence in 2014, prices converged again in the first half of 2015 as oil-indexed prices started to decline. With the continuing weakness of oil prices, oil-indexed prices are set to decrease further, projecting a continuation of price convergence in the coming months.



Figure 21: Comparison of EU wholesale gas price estimations

Source: Eurostat COMEXT and European Commission estimations, BAFA, Platts³⁹

Estimated prices of most of the contracts reported on Figure 21 decreased in the first half of 2014 but bounced back in the second half of the year. Hub-based prices were relatively stable in the first half of 2015 while oil-indexed prices clearly decreased. The estimated price levels of Russian gas to Lithuania and Algerian gas to Italy remained the highest but their premium to the other – mainly hub-based – prices has shrunk. The other contracts more or less followed the movement of the NBP price, albeit in some cases with a delay.

³⁹ Note: Border prices are estimations of prices of piped gas imports paid at the border of the importing country, based on information collected by customs agencies, and are deemed to be representative of long-term contracts.

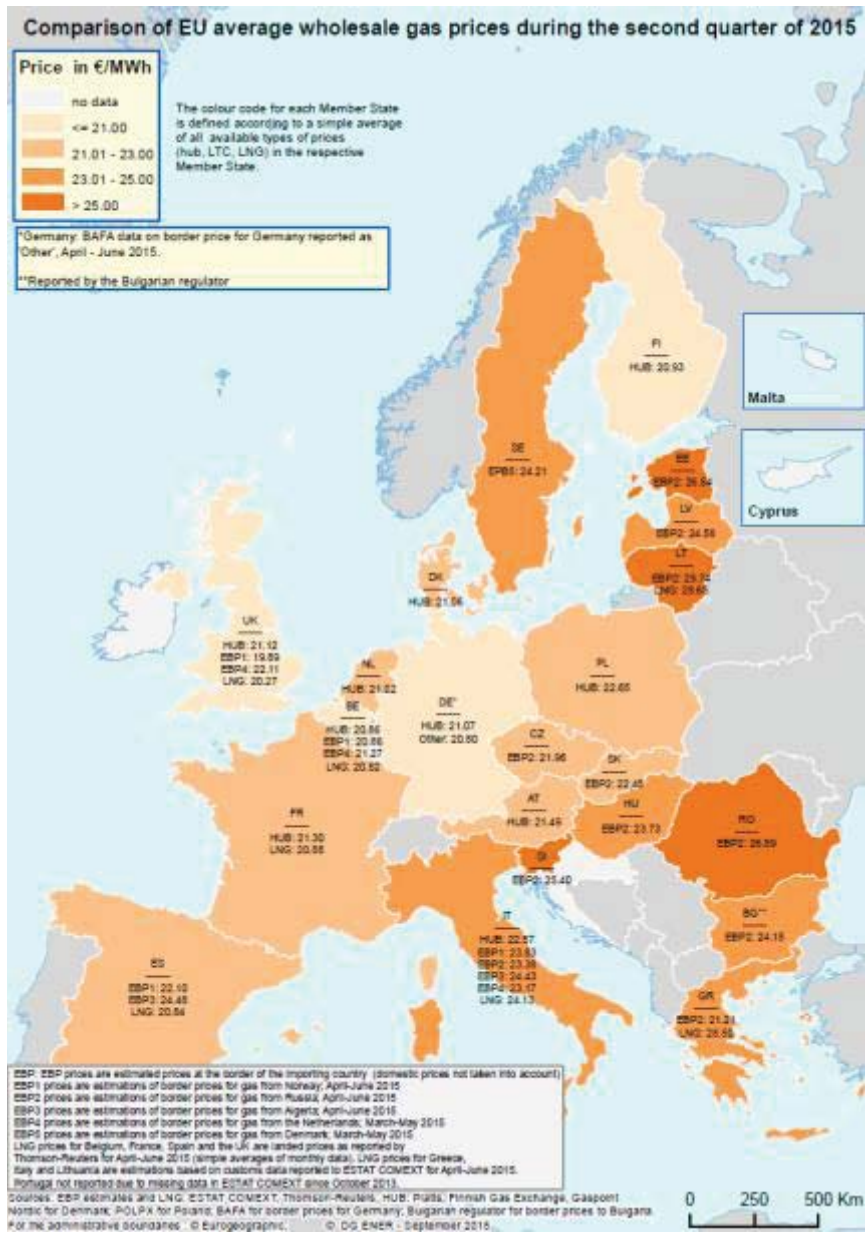


Figure 22: Comparison of EU wholesale gas prices in the second quarter of 2015

Source: European Commission estimations⁴⁰

3.3.4. Retail market functioning

Retail market functioning is described below by looking first at switching rates, before briefly mentioning the use of end-user regulated prices, and then describing competition levels on retail markets. Finally, some information is provided on the deployment of smart meters.

⁴⁰ Note: Border prices are estimations of prices of piped gas imports paid at the border of the importing country, based on information collected by customs agencies, and are deemed to be representative of long-term gas contracts.

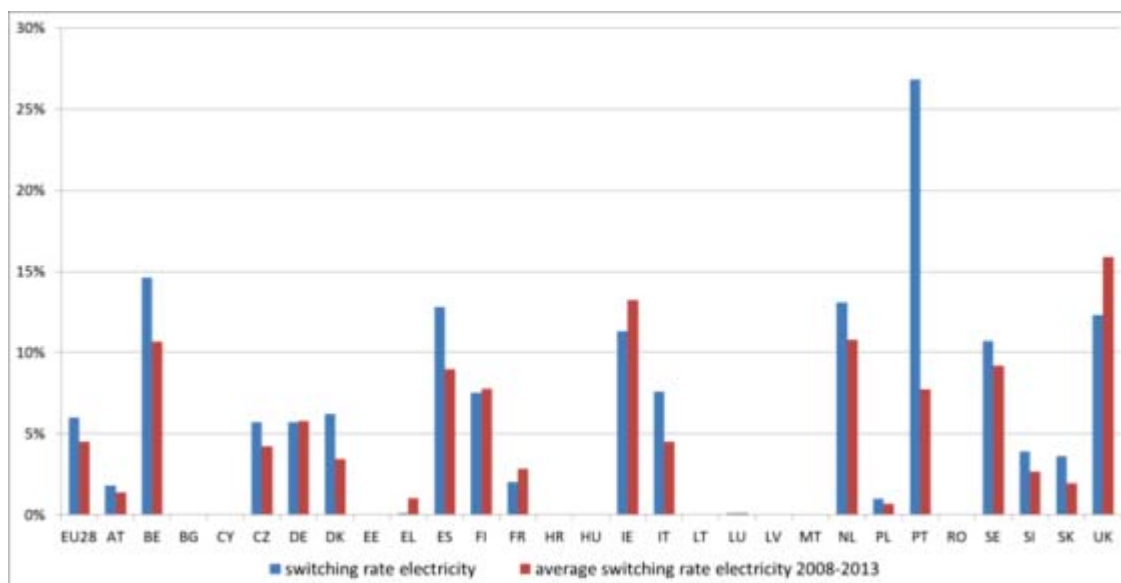


Figure 23: Annual switching rates for households on retail electricity markets - 2013 and average 2008-2013

Source: ACER

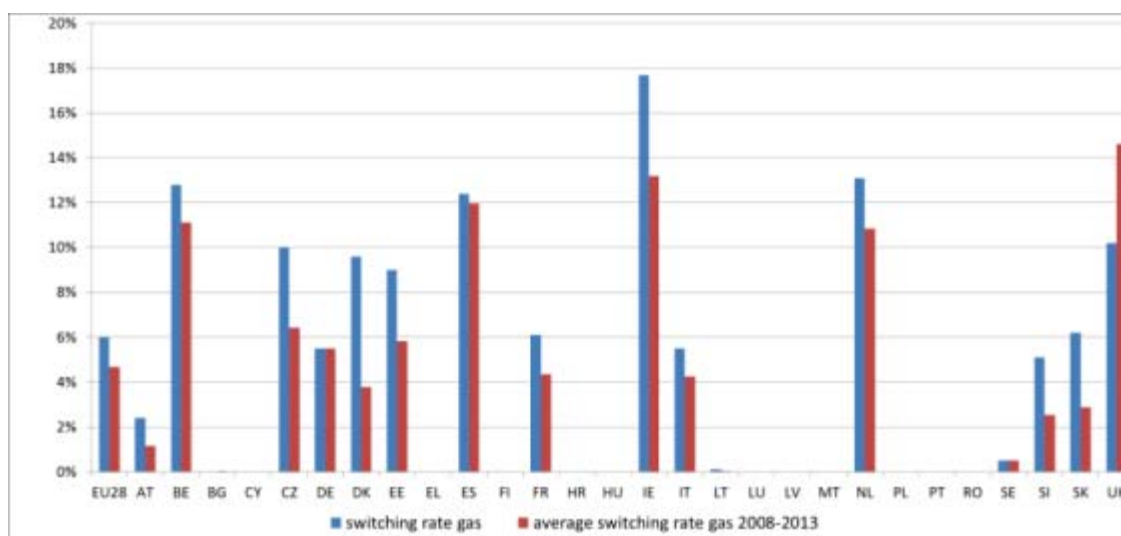


Figure 24: Annual switching rates for households on gas retail markets - 2013 and average 2008-2013

Source: ACER

An available proxy indicator to assess retail market functioning is the annual switching rates on retail gas and electricity markets. At the EU level, the switching rate for households is above 5% for both electricity and the gas markets. In addition, switching rates in 2013 were above the 2008-2013 average, a sign of additional competition and consumer empowerment on retail markets. Large discrepancies are still observed between Member States. In many cases, switching rates are equal to 0%, meaning that consumers do not have the right to switch retailers or do not exercise it.

In addition to information on switching rates, it can be added that at the end of 2013, household end-user price regulation existed in 15 countries for electricity and in 15 countries for gas⁴¹.

Monitoring retail market functioning also requires considering competition levels, and in particular the cumulative market shares of main electricity and gas retailers⁴². The graphs below show the cumulative market shares and the number of main retailers on each market.

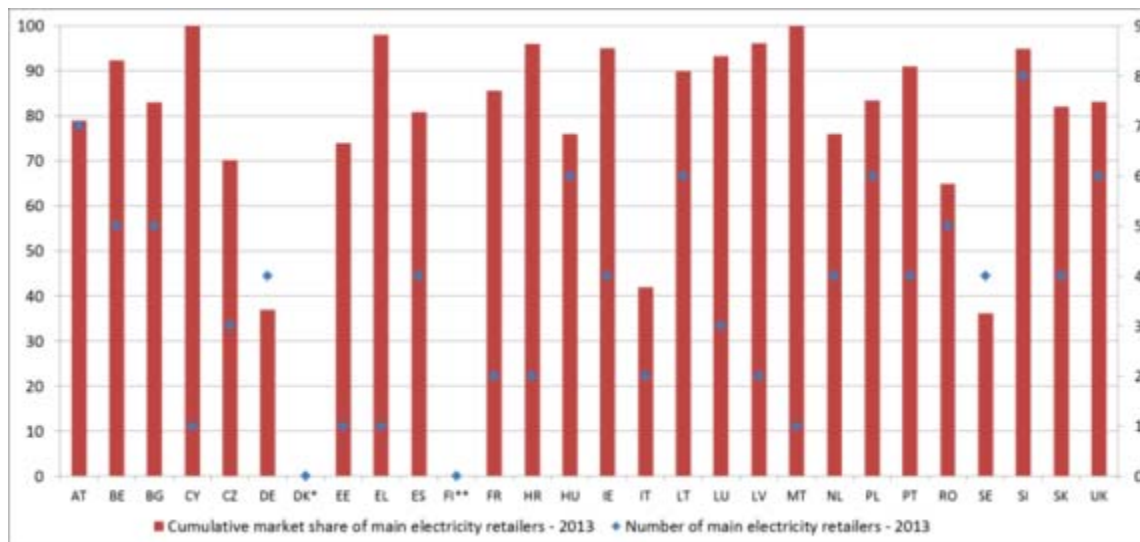


Figure 25: Concentration on retail electricity markets, 2013

Source: Eurostat

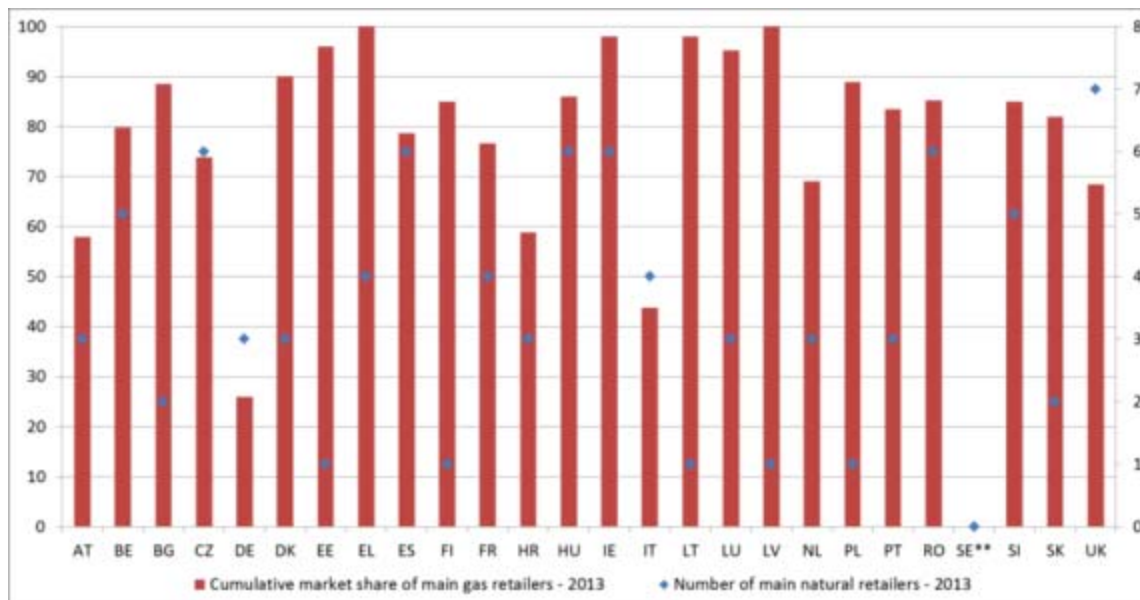


Figure 26: Concentration on retail gas markets, 2013

Source: Eurostat

⁴¹ Source: ACER Market Monitoring report 2014

⁴² Retailers are considered as "main" if they sell at least 5% of the total national electricity consumption.

Regarding electricity markets, in Cyprus, Estonia, Greece, Bulgaria, Slovakia and Malta, there are only one or two main actors on the market, which cumulate a very high market share between them. Conversely, there are at least 6 main companies active on retail electricity markets in Austria, Hungary, Lithuania, Poland, Slovakia and United Kingdom.

Regarding gas markets, there are at most 2 major companies active on the market in Bulgaria, Estonia, Finland, Finland, Lithuania, Latvia, Poland and Slovakia. Conversely, there are at least 6 major companies active in the Czech Republic, Spain, Hungary, Ireland, Romania and the United Kingdom.

To facilitate the integration of distributed generation, the deployment of smart metering solutions is crucial. Some information based on available data is presented below regarding the penetration rate of smart electricity and gas meters in households. Information is only available for 15 Member States as regards electricity and 4 Member States as regards gas.

On this basis, it can be seen that some countries, such as Sweden, Finland or Italy, have already achieved a full roll-out of electricity smart meters. This corresponds to close to 45 million smart meters already installed in these three Member States⁴³. Other Member States, such as Denmark, Estonia or Malta are close to or above a 50% roll-out. Conversely, deployment rates are much lower, and well below 10%, in other Member States.

Information is even patchier as regards penetration rates for gas smart meters. Denmark, the United Kingdom, Italy and the Netherlands have begun a roll-out for a small share of consumers, but only in the Netherlands does it seem that deployment of gas smart meters has made some significant progress.

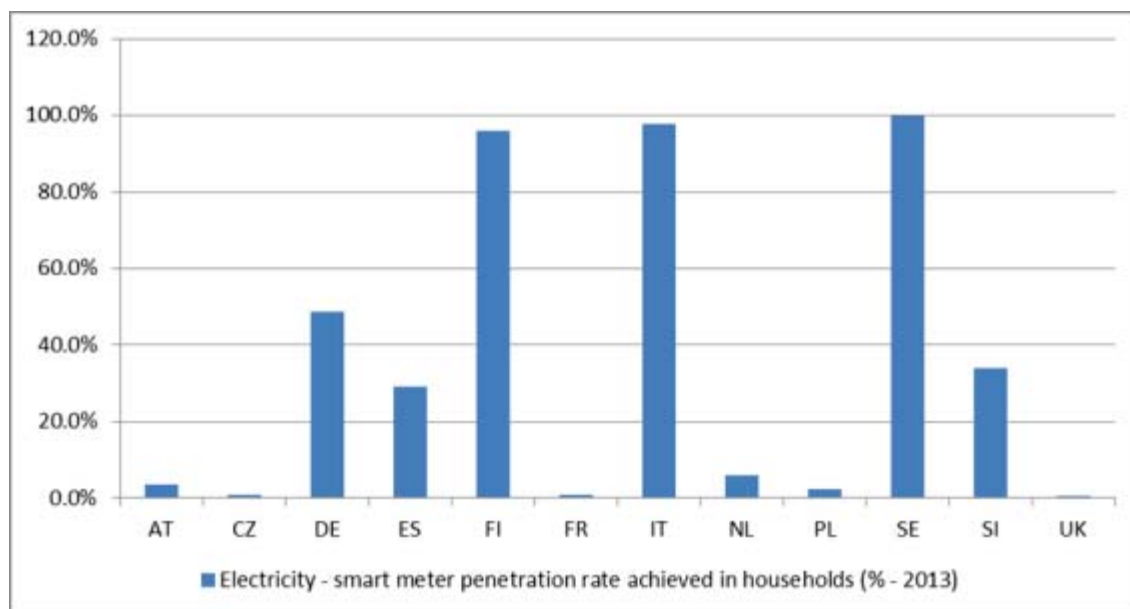


Figure 27: Electricity smart meter Penetration rate achieved in households (%), 2013

Source: ACER/CEER market monitoring report 2014

⁴³ Benchmarking smart metering deployment in the EU-27 {SWD(2014) 188 final}

A final dimension for which additional information will be needed in the future concerns self-consumption of renewable energy. It will be important to monitor the pace of deployment of small scale renewable energy projects so as to better understand and anticipate their implications on the electricity market functioning.

3.3.5. *Electricity tariff deficits*

An electricity tariff deficit can be defined as a shortfall of revenues in the electricity system. It emerges when tariffs covering the regulated components of the retail electricity price are set below the corresponding costs of the energy companies. In general, it has been driven by both macroeconomic and energy market related factors⁴⁴. Over the recent years, electricity tariff deficit has emerged in some Member States. In 2007, only four countries displayed a tariff deficit, while in 2013 there were 12 countries⁴⁵.

Tariff deficits differ in scope and size among the respective Member States. In some (e.g. Germany and Italy), the tariff deficits were temporary and caused by a mismatch between forecasted and actual costs for the renewable electricity production. In both cases, subsidies to renewables have increased substantially during 2010-2012 and were not matched by a sufficient increase in tariffs. Similarly, in other Member States where the economic crisis was particularly severe (Spain and Portugal), cumulative deficits turned into tariff debts, which reached 2 to 3% of GDP in 2013, while the tariff debts of France and Greece (0.2-0.4% of GDP) were much lower. In Bulgaria, Malta and Hungary tariff deficits emerged as a result of low regulated end-user prices (especially for households), while in Romania, Latvia and Belgium the grid tariffs were not sufficient to cover the corresponding costs.

In some cases the tariff deficit has been recognized by the authorities (e.g. Spain, Portugal, Greece, France, Italy, Germany, Belgium). When it is not recognised, it risks leading to accumulated losses for the electricity companies, usually electricity suppliers or distributors. Where the tariff deficit has been acknowledged, reforms have normally been undertaken to address it, but the policy context differs across countries. Most of the reforms have aimed at reducing and controlling the cost of support schemes to renewable energy and co-generation. For example, Spain, Portugal, Greece, Italy and Germany tried, among other things, to reduce the level of remuneration (i.e. feed-in tariffs) and the period of support, as well as to allocate various revenue sources (tariff increases, various levies etc.) to finance the deficits. In addition, Spain and Portugal have also securitised the accumulated tariff debt.

As a result, Germany and Italy had managed to address their deficit by early 2014. Spain and Greece are considered to have control of their tariff debts and are avoiding new deficits. Based on current projections, they are expected to achieve balanced systems from a revenue-cost perspective in 2015⁴⁶. France and Portugal have defined policy roadmaps with the aim to eliminate the tariff debt and achieve tariff sufficiency.

⁴⁴ Macroeconomic factors concern the economic growth and budgetary imbalances, while the energy related factors are associated with increasing regulation of retail prices, cost of support schemes and crude oil prices, as well as with highly concentrated electricity retail markets. Electricity Tariff Deficit: Temporary or Permanent problem in the EU?, Economic Papers 534, October 2014, http://ec.europa.eu/economy_finance/publications/economic_paper/2014/pdf/ecp534_en.pdf

⁴⁵ Belgium, Bulgaria, France, Germany, Greece, Hungary, Italy, Latvia, Malta, Portugal, Romania, Spain.

⁴⁶ Provisional data from the national regulatory authorities for energy in Spain (CNMC) and Greece (RAE).

3.3.6. Vulnerable consumers

Developing the Energy Union also means better protecting vulnerable consumers against energy poverty risk. There is no EU-wide agreed definition and/or measure to assess energy poverty issues and the vulnerability of consumers to energy price shocks⁴⁷. Still, a variety of factors contribute to energy poverty, which includes high energy bills, low income and poor energy efficiency of the building envelope. A composite indicator is used to cover these various factors. It is based on the currently only available indicators across the EU, which relate to the percentage of households in a given year: i/ facing arrears on utility bills; ii/ who are unable to keep their home adequately warm; and/or iii/ living in dwellings with leakages and damp walls⁴⁸. The indicator is calculated on the basis of the information collected by Eurostat in the EU Statistics on Income and Living Conditions. The share of population with arrears in accounts provides some insights into energy affordability. The ability to keep the home adequately warm can inform on the need to constrain spending on heating. Dwellings with leakages and damp walls provide some indication of building quality. The higher the value of the indicator, the most significant energy poverty issues are expected to be in a given Member State.

On average, based on the proxy indicators considered for this analysis, 12% of EU households can be considered at risk of energy poverty⁴⁹. Energy poverty issues seem particularly relevant in Bulgaria, Greece, Cyprus, Latvia, Lithuania, Hungary and Portugal. Comparing trends since 2005, it must be noted that the situation deteriorated in Austria, Denmark, Malta, Greece, Slovenia, Ireland and Italy, as well as in the United Kingdom.

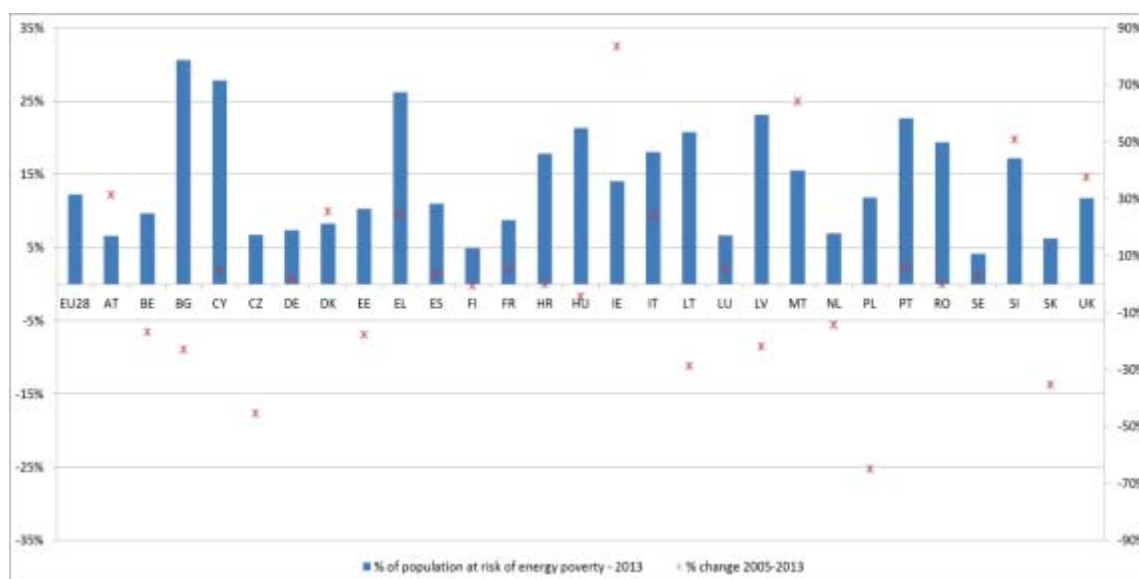


Figure 28: percentage of population at risk of energy poverty

⁴⁷ There are definitions for fuel and/or energy poverty and vulnerable consumers in several EU Member States and by some international organisations. Fuel and energy poverty are mainly related to the unaffordability of energy services.

⁴⁸ Some studies argue on the need to include an additional indicator, on the ability to keep comfortably cool. See: https://ec.europa.eu/energy/sites/ener/files/documents/INSloveniaGHT_E_Energy%20Poverty%20-%20Main%20Report_FinlandNAL.pdf

⁴⁹ Note that based on the available data, it is not possible to establish whether the same or different households face similarly the three issues identified in the survey (arrears on utility bills, inability to keep home adequately warm, and/or living in dwellings with leakages and damp walls). Therefore, the value obtained for the composite indicator should be interpreted with caution.

Source: European Commission calculations, based on Eurostat

There is no readily available indicator on the share of energy products in households' expenditure. However, the weights used to calculate the Harmonised Index of Consumer Prices (HICP) can be used as proxy. The information used to calculate the weight of each product group is collected mainly by means of household budget surveys and cross-checked and updated with information from other sources (e.g. VAT revenue statistics and national accounts). The product group weights are representative for the average household consumption expenditure at national level. As such, for each country they capture national consumption habits, which may depend on climate, product taxes, lifestyles, cultural traditions and other factors (e.g. product availability). It is important to note that the HICP takes into account the consumption expenditure of all the households in a country and not some "typical" household. This indicator does not allow either to isolate the share of energy expenditures for low-income households.

Considering all energy products together (electricity, gas and other fuels, as well as fuel and lubricants for personal transport equipment), they represent more than 10% of average households' expenditure in the EU. The higher the share, the more vulnerable consumers become to energy price hikes. Furthermore, this share increased at EU level by more than 20% since 2005. The share is highest in Poland, Latvia, Slovakia, Croatia and Hungary. It has increased for most Member States since 2005, except in Denmark, Poland, Portugal, Romania, Slovakia and Sweden.

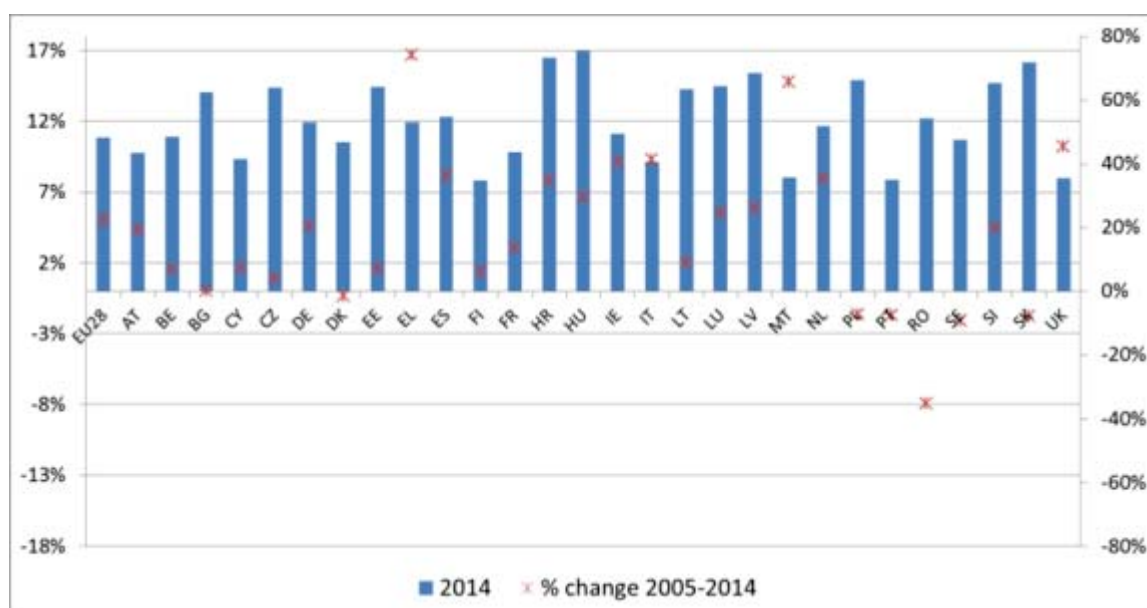


Figure 29: Share of energy products in households' expenditure, as used for the calculation of HICP

Source: Eurostat

3.4. Energy efficiency and moderation of demand

3.4.1. Evolution of primary and final energy consumption

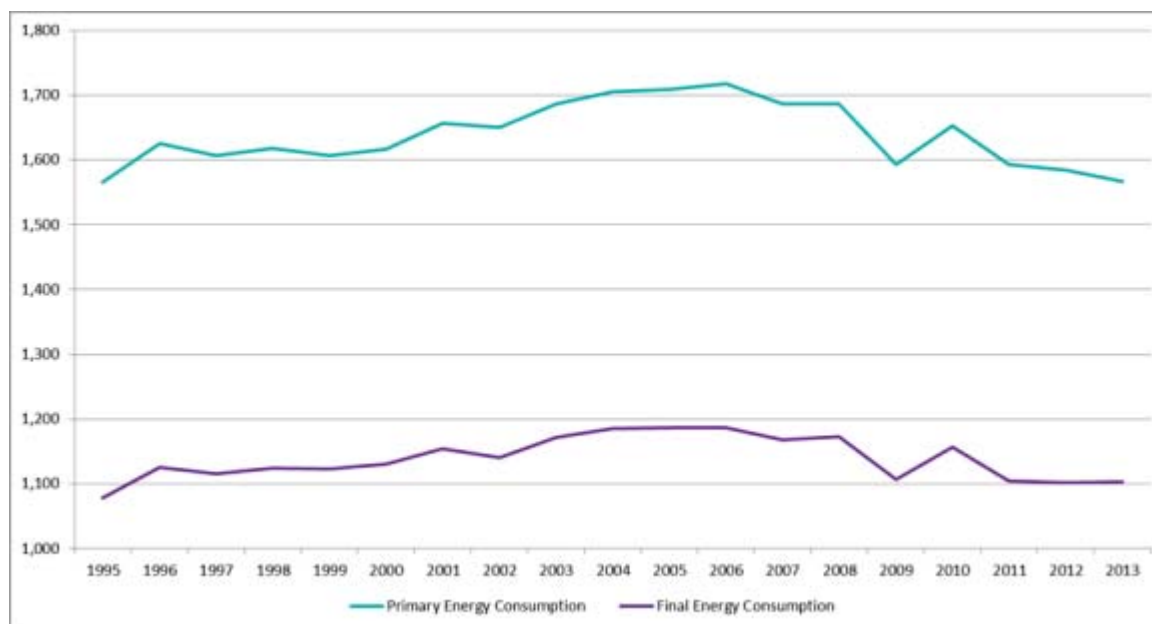


Figure 30: Evolution of EU28 Primary and Final energy consumption

Source: Eurostat

The long term evolution of primary and final energy consumption at EU level shows similar trends⁵⁰. Consumption peaked around 2006 before declining in the past few years, under the influence of both the economic crisis, which decreased economic growth and therefore the need for energy, and of more efficient and ambitious energy efficiency policies.

Final energy consumption (FEC) of EU28 dropped from 1186 Mtoe in 2005⁵¹ to 1105 Mtoe in 2013. This equals a reduction of final energy consumption by 18.6% compared to 2020 projections. The absolute final energy consumption of all Member States except Estonia, Germany, Lithuania, Malta and Poland has declined since 2005. Looking at the short term trends, final energy consumption increased from 1102 Mtoe in 2012 to 1105 Mtoe in 2013. There were increases in Austria, Belgium, Czech Republic, France, Germany, Hungary, Ireland, the Netherlands, Slovakia and the United Kingdom.

Primary energy consumption (PEC) of EU28 dropped from 1709 Mtoe in 2005 to 1567 Mtoe in 2013. This equals a reduction of primary energy consumption by 15.5% compared to 2020 projections. The absolute primary energy consumption of all Member States except Estonia and Poland has declined since 2005. The average reduction was more pronounced compared to EU28 in Bulgaria, Ireland, Greece, Spain, Croatia, Italy, Cyprus, Lithuania, Luxembourg, Hungary, Malta, Portugal, Romania and the United Kingdom.

⁵⁰ More details on energy efficiency developments can be found in COM(2015)574 "Assessment of the progress made by Member States towards the national energy Directive 2012/27/EU as required by Article 24 (3) of Energy Efficiency Directive"

⁵¹ 2013 is the most recent year for which data are available from Eurostat. 2005 was chosen because it allows consistency with the EU energy and climate framework where both the GHG and RES targets are set against 2005 as the base year.

Between 2012 and 2013, the latest years for which data are available, most Member States lowered their primary energy consumption to close their gap towards the 2020 target. However Belgium, Denmark, Germany, Estonia, France, Poland, Portugal and Slovakia increased their primary energy consumption in 2013 compared to 2012.

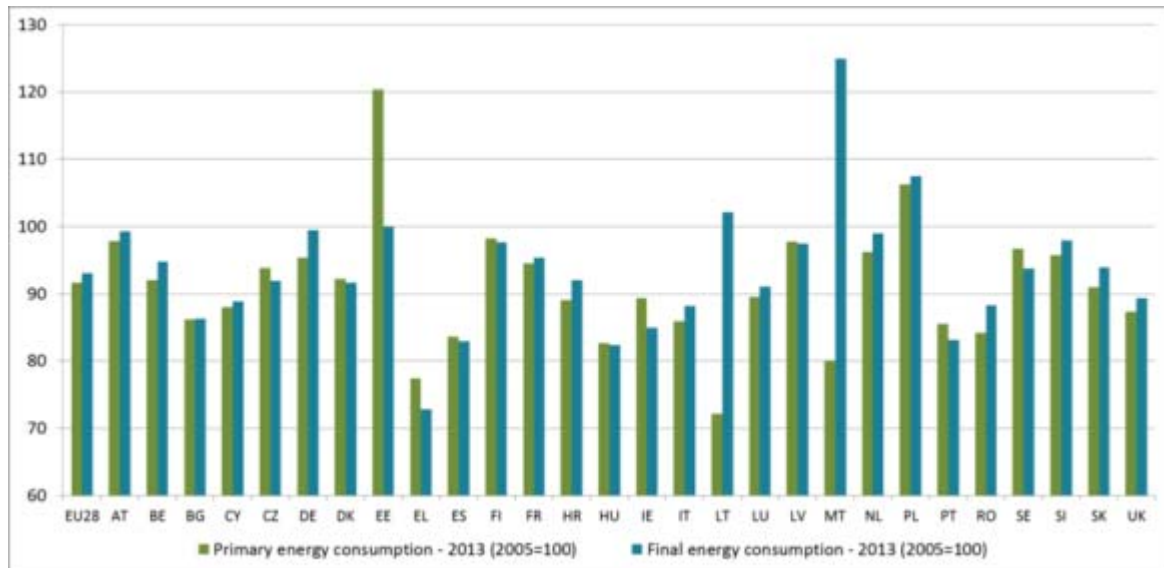


Figure 31: Primary and final energy consumption per Member State in 2013 (2005 = 100)

Source: Eurostat

3.4.2. Primary energy intensity of the economy

When describing efficiency trends it is meaningful to compare absolute trends with trends in terms of economic output, not only because energy consumption and economic growth are correlated, but also because a decoupling of these two indicators can be considered as a proxy for increasing energy efficiency. As shown in Figure 32, many Member States significantly reduced on average their energy consumption from 2005 to 2013, while at the same time increasing their economic output.

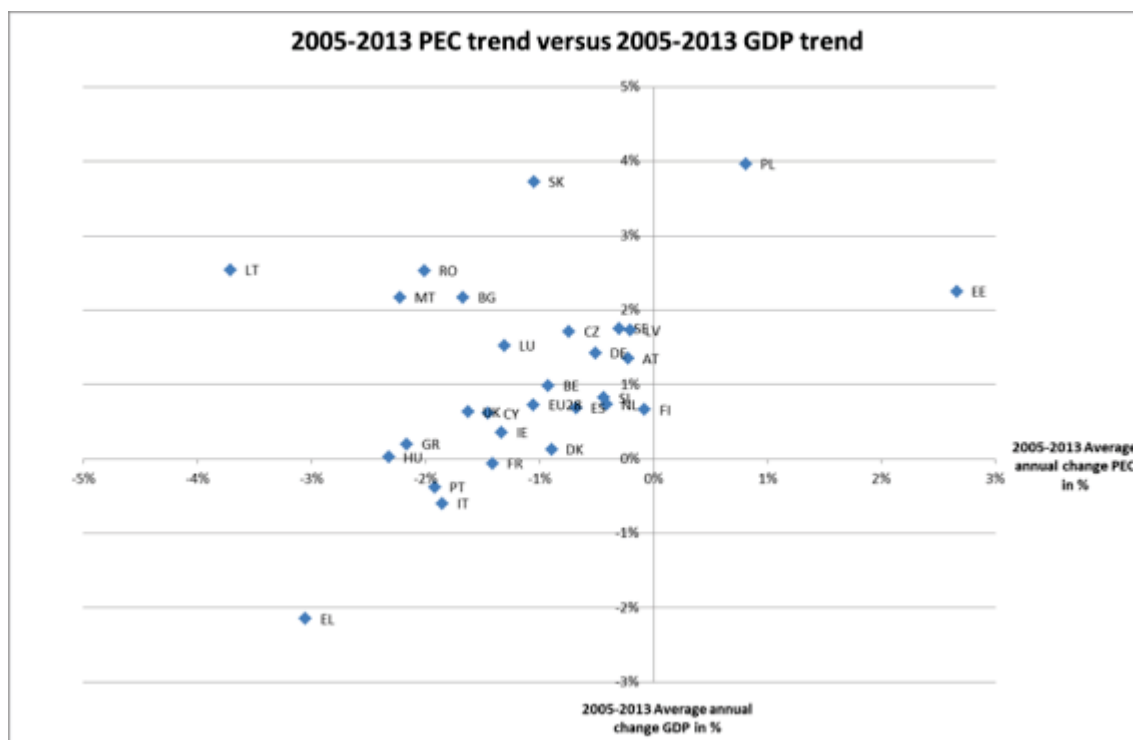


Figure 32: Average annual growth of GDP and average primary energy consumption developments in % in the period 2005-2013

Source: Eurostat

Estonia is the only Member State where average primary energy consumption increased more than the average increase of GDP from 2005 to 2013. Thus, the primary energy intensity for the whole economy of Estonia grew on average over the period between 2005 and 2013, whereas it decreased in all other Member States. Bulgaria, Czech Republic, Cyprus, Greece, Hungary, Lithuania, Luxembourg, Malta, Poland, Romania, Slovakia, Spain, Sweden and the United Kingdom reduced their intensity on average by more than 2% in this period.

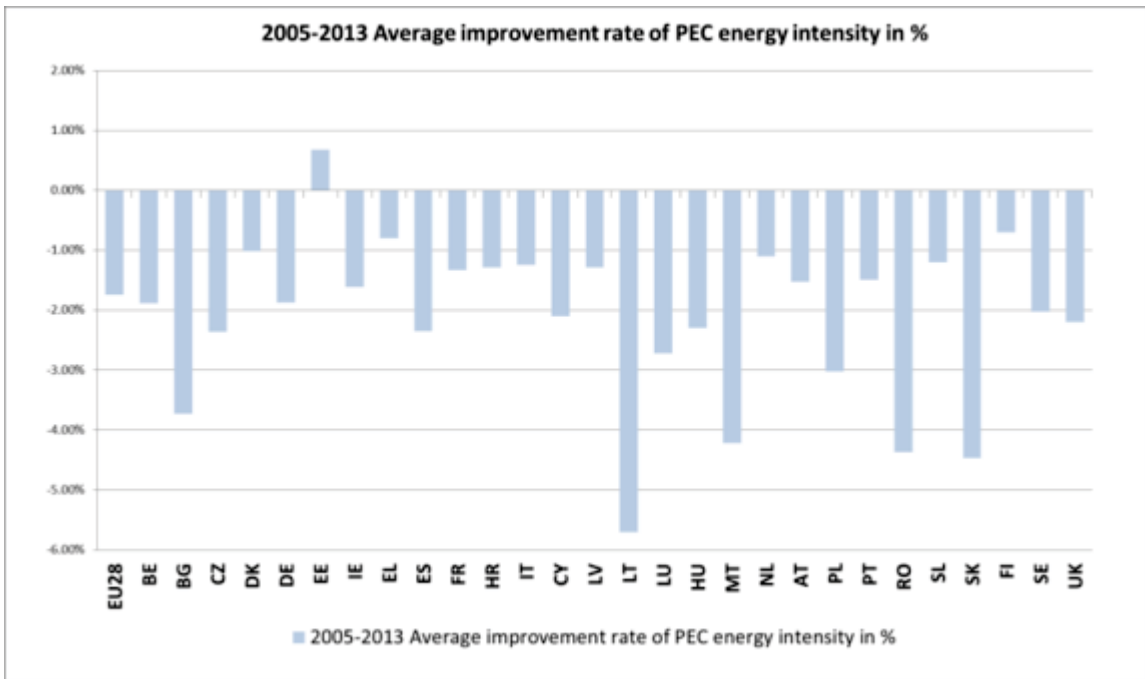


Figure 33: 2005-2013 Average improvement rate of primary energy intensity in %
Source: Eurostat

3.4.3. Energy intensity of industry

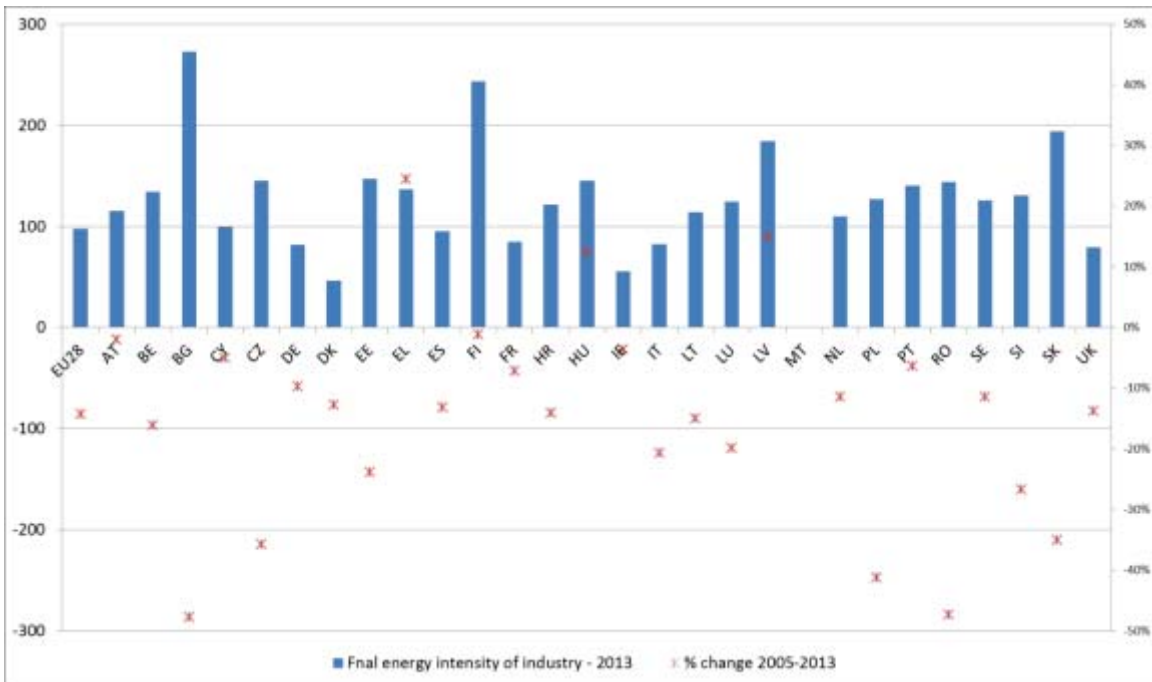


Figure 34: Energy intensity for industry
Source: Eurostat

Measuring energy intensity of the industry can help to see if the value added in industry has been produced with less final energy over time, which was the case for the EU28 from 2005 to 2013.

In Figure 34, it can be observed that there is a significant difference between the most energy intensive Member State, Bulgaria, and the least energy intensive ones, Denmark and Ireland. Whilst this is influenced by the share of energy-intensive industries, most Member States decreased energy intensity in industry from 2005 to 2013, the exceptions being Greece, Hungary, and Latvia.

Given the significant impact that the structure of industry has on the overall energy intensity, it is worth performing a decomposition analysis, which strips out the impact of three variables on the changes in energy consumption: changes in production activity (volume produced), changes in the structure of production, and energy efficiency improvements. The outcome of the decomposition analysis performed in 2014 shows that, in absolute terms, 45 Mtoe were saved in the industry sector across the EU28 in the period 2008-2012. The main reason was a decrease of industry activity, followed by the impact of energy efficiency improvements on the energy consumption of industry, which was almost three times bigger than the impact of changes in the structure of the industry⁵².

3.4.4. Energy intensity in the residential sector

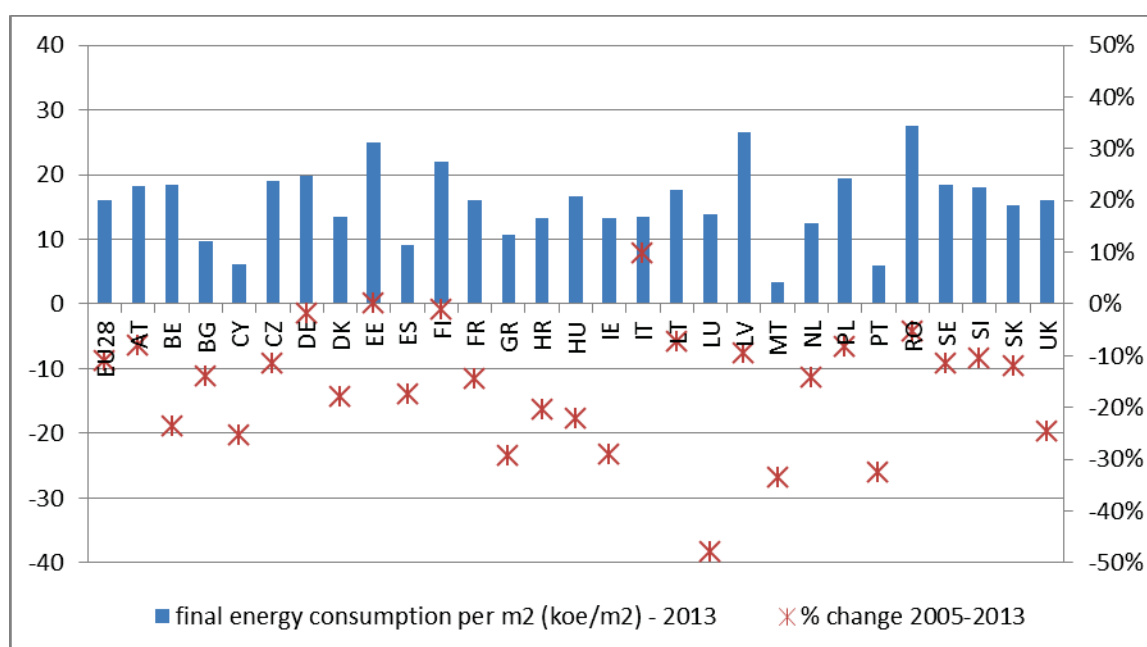


Figure 35: Final energy consumption per m2 (koe/m2)

Source: Odyssee-Mure

When looking at the residential sector different factors influencing energy consumption must be taken into account. For example, the climate variations over the years, changes in consumption in terms of comfort and a change in the size of dwellings. In addition, consumption might be driven by the economy, by demographics and by concrete

⁵² This analysis was performed in 2014 by an external contractor of the European Commission and is also undertaken by the Odyssee-Mure project which is co-financed by the Intelligent Energy Europe Programme. See PwC/Fraunhofer ISI/TU Wien (2014): Study evaluating the current energy efficiency policy framework in the EU and providing orientation on policy options for realising the cost-effective energy efficiency/ saving potential until 2020 and beyond, Figure 18 (https://ec.europa.eu/energy/sites/ener/files/documents/2014_report_2020-2030_eu_policy_framework.pdf)

efficiency measures, such as building renovation or the installation of efficient equipment or equipment assisting consumers in optimising their energy use.

The indicator above focuses on energy consumption per square meter of the residential sector. It is corrected for climate variations across Member States. As these data are not collected by Eurostat, findings from the Odyssee-Mure project are taken into account. The data from Odyssee-Mure show that between 2005 and 2013 energy consumption per square meter decreased in all Member States except in Italy where it grew by 10% and Estonia where the value remained constant⁵³.

Additional indicators or analysis can also be considered to assess energy consumption improvements in the residential sector, for instance to better capture changes in the fuels used for heating purposes. Some information is presented below when describing developments in the share of renewable energy for heating and cooling purposes.

3.4.5. Energy efficiency in transport

As explained in section 2.2.4, due to data availability and other methodological issues, it is not possible to provide sound indicators for monitoring the energy intensity trends in transport. However, some high level analysis is provided below drawing on the final energy consumption in transport and transport activity, while keeping in mind the caveats mentioned in section 2.2.4.

Final energy consumption in transport⁵⁴ in the EU28 decreased from 370 Mtoe in 2005 to 349 Mtoe in 2013 (decrease of 6%). When focusing on the first three years 2005-2007, final energy consumption in transport increased by 4% during this period, but has been decreasing quite rapidly since 2007 (-9% for 2007-2013). According to the findings of the Odyssee-Mure project, about 40% of the 2007-2013 reduction is estimated to be due to the economic crisis, with the stabilisation of passenger traffic and the decrease in freight traffic. The remaining 60% mostly originates from improvements in energy efficiency of passenger cars. Energy efficiency improvements for road freight have slowed down after 2007, driven by the fall in traffic and the less efficient operation of the vehicle fleet i.e. as shown by the lower load factors⁵⁵.

In relative terms, the highest reductions in final energy consumption in the transport sector were registered in Greece, Ireland and Spain in the period 2005-2013. Consumption increased slightly in Croatia, Finland and Germany and a considerable increase in relative terms was recorded in Lithuania, Malta, Poland, Romania, Slovakia and Slovenia. Most of the increase originated from road transport. Comparison between Member States can however be influenced by other factors as well. This is because final energy consumption is based on the fuels sold rather than on the fuels used on the territory of a country. Therefore, factors other than energy efficiency come into play e.g. the degree to which a given Member State is a 'transit country' for road transport or a hub for aviation.

⁵³ See Odyssee-Mure database: <http://www.indicators.odyssee-mure.eu/online-indicators.html>

⁵⁴ Eurostat data used with the code: tsdpc320.

⁵⁵ Odyssee-Mure (2015): Trends and policies for energy savings and emissions in transport (available at: <http://www.odyssee-mure.eu/publications/br/energy-efficiency-in-transport.html>)

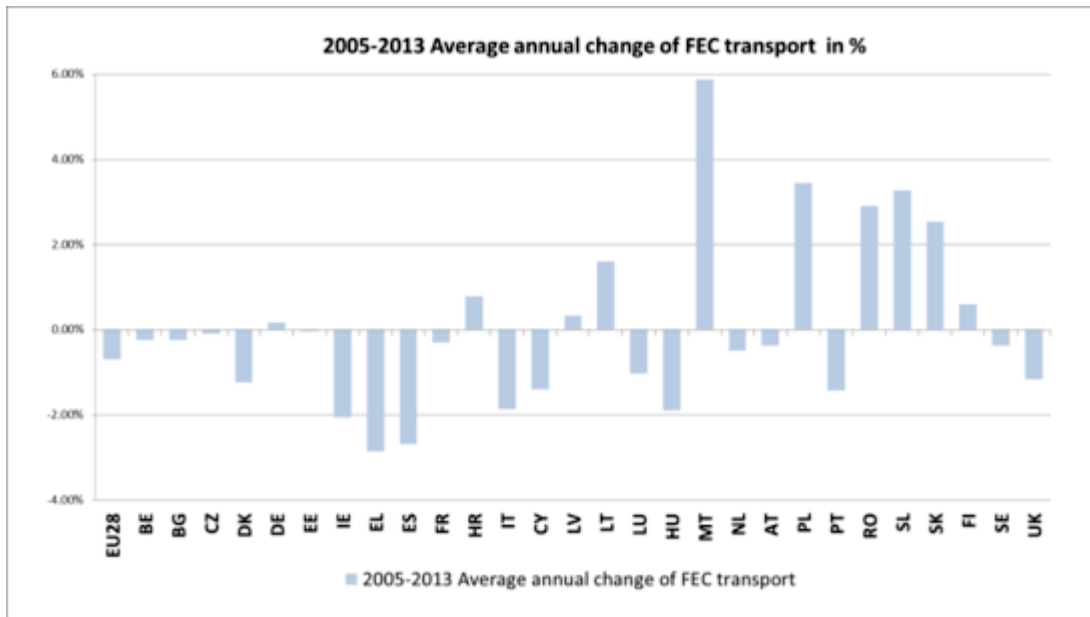


Figure 36: 2005-2013 Average annual change of final energy consumption in transport (%)

Source: Eurostat

Comparing 2012 and 2013 data, final energy consumption in transport increased in Austria, Croatia, Finland, Germany, Ireland, Latvia, Lithuania, Malta, Slovakia, and Sweden.

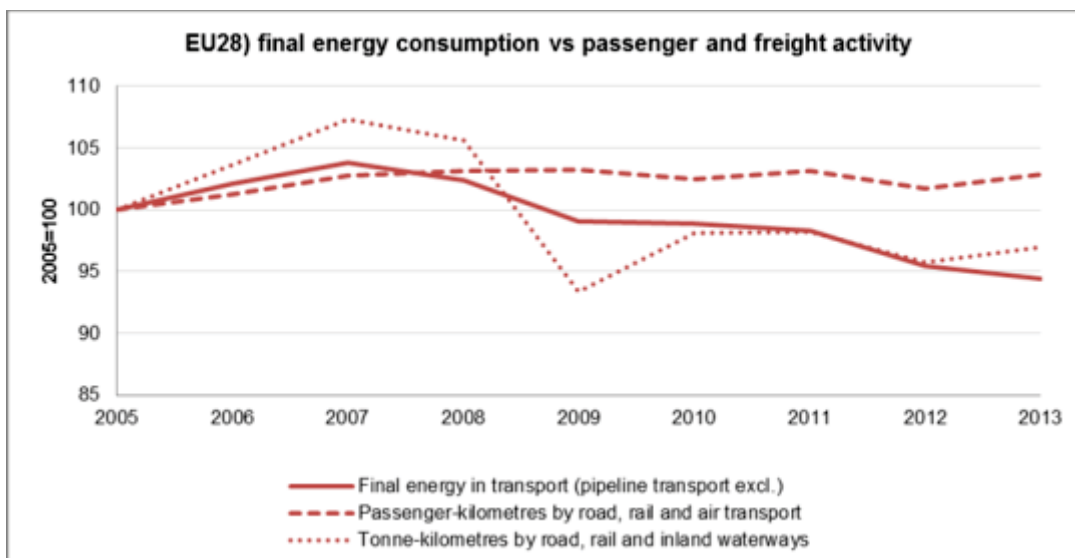


Figure 37: Evolution of final energy consumption in the transport sector of EU28

Source: Eurostat, DG MOVE Transport in Figures⁵⁶

Findings from the Odyssee-Mure project show that the majority of transport measures undertaken at Member State level concern the passenger modes. The energy efficiency improvements seem to be mainly related to three sets of measures, *i.e.* measures

⁵⁶ http://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2015_en.htm

concerning the energy and CO₂ standards for new cars, measures addressed to the renewal of the car fleet, and measures addressed to traffic management⁵⁷.

For road freight, significant energy efficiency improvements took place between 2000 and 2007, driven by an increase in the efficiency of vehicles and by a more efficient management of freight transport (e.g. higher load factors and a shift to larger trucks), according to the findings of the Odyssee-Mure project. However, since 2008, despite continuous improvements in vehicle efficiency, empty running increased and trucks were less loaded⁵⁸.

Focusing more specifically on CO₂ emissions in road transport, EU legislation sets mandatory emission reduction targets for new cars and vans leading to significant improvements in the fuel economy of light duty vehicles sold on the European market⁵⁹. The average emission level of a new car sold in 2014 was 123.4 g CO₂/km (provisional data), i.e. significantly below the 2015 target of 130 g CO₂/km, according to provisional data from the European Environment Agency. This is a 24% decrease compared to 2005. As a result of both EU and Member State level measures, the specific fuel consumption of passenger cars EU fleet average went down from about 7.4 l/100km in 2005 to 6.8 l/100km in 2012 according to the findings of the Odyssee-Mure project.

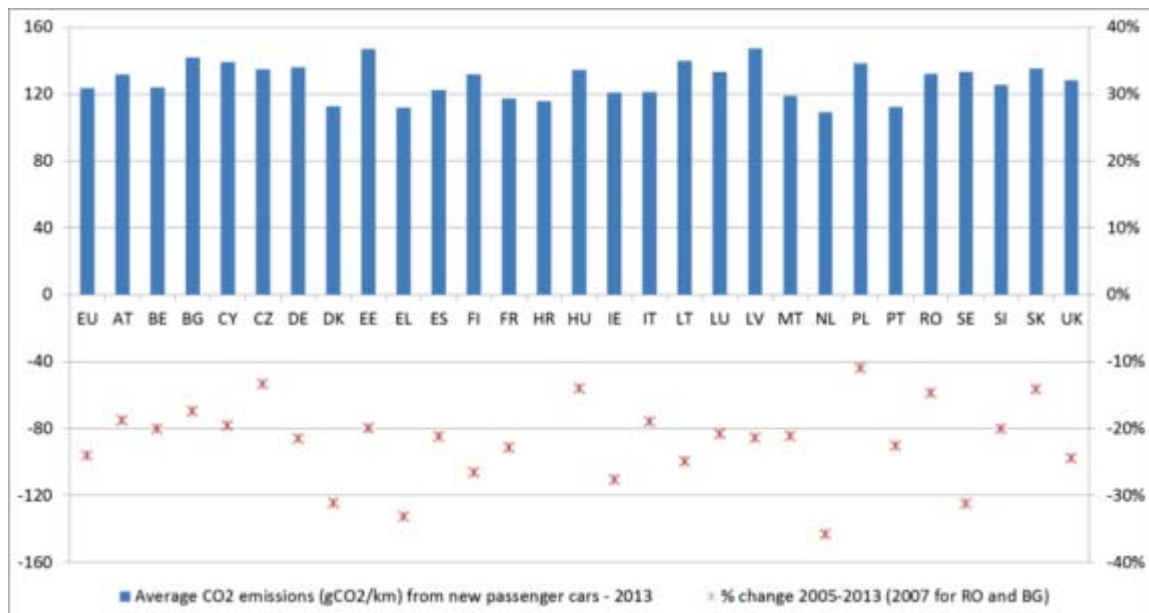


Figure 38: Average CO₂ emissions from new passenger cars

Source: European Environment Agency

The countries for which average CO₂ emissions from new passenger cars are highest include Bulgaria, Cyprus, Estonia, Lithuania and Latvia. Conversely, lowest emissions for new passenger cars are recorded in the Netherlands, Greece, Portugal and Denmark. The countries with the highest percentage reductions since 2005 are Denmark, Ireland, Greece, Sweden and the Netherlands.

⁵⁷ Odyssee-Mure (2015): Trends and policies for energy savings and emissions in transport.

⁵⁸ Odyssee-Mure (2015): Trends and policies for energy savings and emissions in transport

3.5. Decarbonisation

3.5.1. Monitoring greenhouse gas emission reductions in the non-Emission Trading Systems sectors⁶⁰

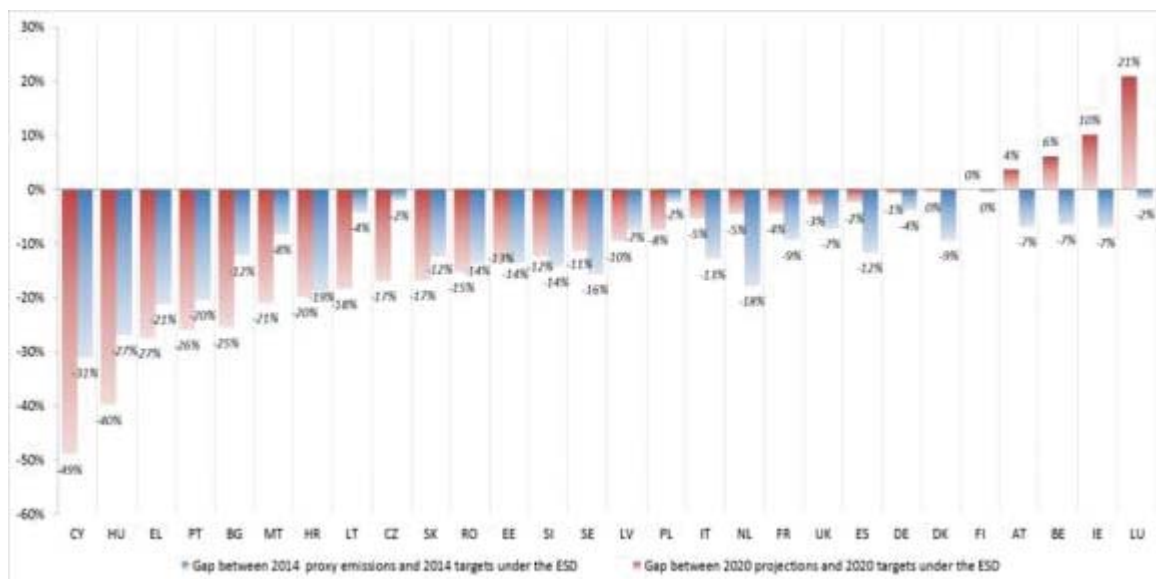


Figure 39: Gap between greenhouse gas emissions in the non-ETS sector and targets

According to the projections submitted by Member States, 24 Member States are projected to meet their 2020 targets in the non-ETS sectors with existing policies and measures. However, four Member States - Ireland, Luxembourg, Belgium and Austria - will need to make additional efforts to meet their 2020 targets for the non-ETS sectors at home or to make use of the flexible mechanisms provided for in the Effort-Sharing Decision (ESD). This includes transfers of unused emission allocations from one year to another, the use of international project credits or transfers of unused emission allocations between Member States.

For all Member States, 2013 emissions and estimates for 2014 are expected to be below their respective 2013 and 2014 targets under the ESD.

3.5.2. Monitoring other greenhouse gas emission reductions developments

3.5.2.1. Greenhouse gas intensity of the economy

The greenhouse gas (GHG) intensity of the economy is the ratio of greenhouse gas emissions to Gross Domestic Product (GDP). In the EU, real GDP increased by 46% between 1990 and 2014 while emissions decreased by 23%. Subsequently, the GHG intensity of the EU economy decreased by almost half during this period of time. The GHG intensity of all the Member States has also been decreasing since 1990.

⁶⁰ More detailed analysis on these developments can be found in the Climate Action Progress Report, COM(2015)576.

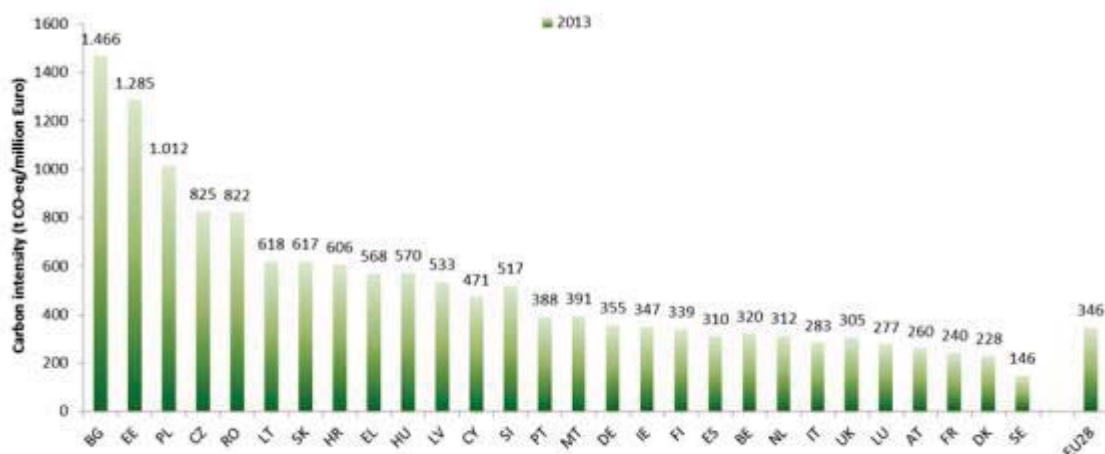


Figure 40: Greenhouse gas intensity of the economy, 2013

Bulgaria, Estonia, Poland, the Czech Republic and Romania are the five Member States with the largest greenhouse gas intensity of the economy. This reflects the large share of energy intensive industries in their economy and also for some of the Member States concerned the importance of coal in their energy mix, in particular in the power generation sector. With the exception of Luxembourg, which imports most of its electricity, the countries with the lowest greenhouse gas intensity (Luxembourg, Austria, France, Denmark and Sweden) have also a high share of low-carbon technologies (renewable and nuclear) in their electricity mix.

3.5.2.2. Greenhouse gas emissions per capita

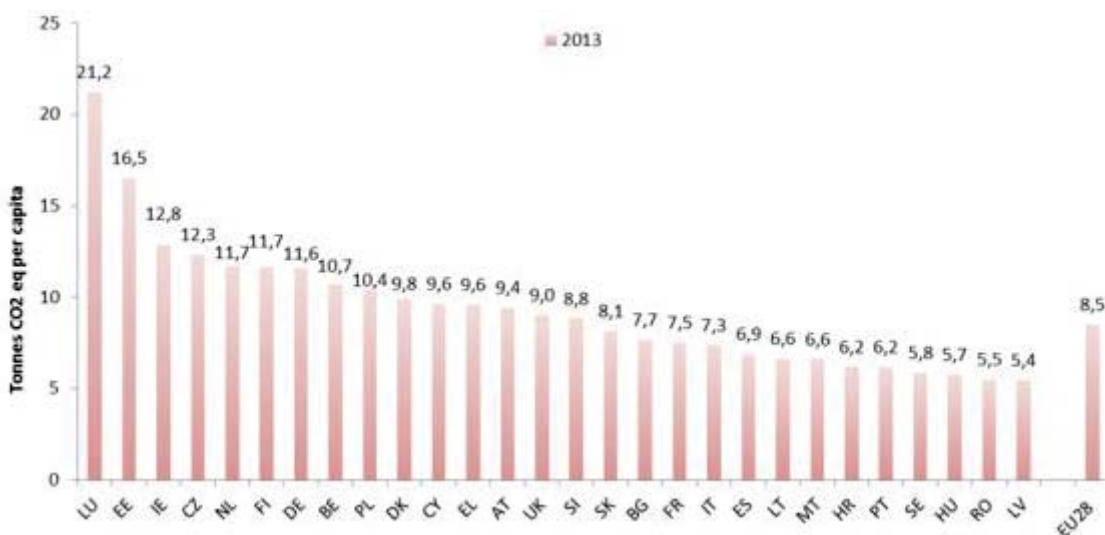


Figure 41: Greenhouse gas emissions per capita, 2013

The GHG emissions per capita indicator is the ratio between emissions and population. Croatia, Portugal, Sweden, Hungary, Romania and Latvia have the lowest emissions per capita in the EU while Luxembourg, Estonia, Ireland, Czech Republic, the Netherlands, Finland and Germany have the highest. Luxembourg's high per capita emissions are explained by the high level of road transport emissions (representing more than two-thirds of total non-ETS emissions) due to low excise duties on motor fuel as well as to a

large number of commuters and transit traffic. High per capita emissions in Estonia, Czech Republic, Finland and Germany reflect their industrial specialisation and the share of solid fuels in the energy mix of some of these countries. High per capita emissions in Ireland reflect the importance of the agricultural sector in the economy, but also the lack of public transport and the underutilisation of Ireland's renewable potential.

3.5.2.3. Sectoral share of greenhouse gas emissions

(% share of total emissions)	Transport	Manufacturing, industry & construction	Agriculture	Energy	Residential, Commercial & Institutional	Waste	Other
EU28	19,6%	19,0%	12,1%	32,8%	13,2%	3,1%	0,2%
Austria	27,0%	33,5%	10,5%	16,1%	10,8%	2,1%	0,1%
Belgium	21,4%	27,7%	9,8%	20,0%	19,7%	1,3%	0,0%
Bulgaria	13,7%	11,9%	11,5%	54,1%	2,9%	5,9%	0,0%
Croatia	21,6%	22,0%	15,4%	27,8%	9,0%	4,3%	0,0%
Cyprus	22,3%	14,1%	9,7%	38,4%	4,5%	10,8%	0,2%
Czech Republic	12,9%	22,2%	6,3%	46,8%	8,2%	2,9%	0,9%
Denmark	23,7%	12,1%	22,7%	33,1%	6,1%	2,1%	0,2%
Estonia	11,9%	7,6%	8,3%	68,6%	1,9%	1,6%	0,1%
Finland	20,8%	22,6%	11,9%	34,2%	4,5%	3,4%	2,6%
France	27,0%	20,5%	20,5%	11,7%	17,7%	2,6%	0,0%
Germany	16,6%	19,7%	8,1%	40,0%	14,1%	1,4%	0,1%
Greece	14,5%	13,9%	9,1%	50,7%	7,6%	4,3%	0,0%
Hungary	17,5%	13,9%	15,5%	30,3%	17,8%	5,1%	0,0%
Ireland	18,6%	11,6%	32,0%	21,9%	14,2%	1,7%	0,0%
Italy	23,0%	18,4%	9,3%	29,0%	16,8%	3,5%	0,1%
Latvia	25,4%	15,5%	25,5%	17,6%	10,5%	5,5%	0,1%
Lithuania	21,0%	23,0%	23,9%	21,6%	6,0%	4,5%	0,0%
Luxembourg	55,1%	16,1%	6,1%	9,1%	13,2%	0,4%	0,0%
Malta	17,6%	7,9%	3,3%	65,5%	3,7%	2,1%	0,0%
Netherlands	17,7%	18,8%	13,6%	32,4%	15,4%	1,9%	0,2%
Poland	11,7%	14,7%	11,9%	46,5%	11,4%	3,8%	0,0%
Portugal	24,7%	19,0%	12,1%	27,3%	4,9%	11,9%	0,1%
Romania	12,7%	23,5%	16,3%	34,0%	8,1%	4,9%	0,5%
Slovakia	15,2%	35,7%	7,8%	24,6%	9,2%	5,0%	2,4%
Slovenia	30,5%	14,3%	11,1%	33,5%	7,9%	2,6%	0,0%
Spain	23,7%	20,9%	14,3%	28,3%	9,1%	3,8%	0,0%
Sweden	33,2%	25,5%	16,0%	19,5%	2,8%	2,8%	0,3%
United Kingdom	19,7%	15,5%	9,7%	34,5%	16,1%	4,0%	0,4%

Figure 42: Share of greenhouse gas emissions by economic sector, 2012⁶¹

Note: Sectorial breakdown for 2013 emissions is not yet available.

⁶¹ Emissions from agriculture also include emissions from fuel combustion in this sector.

The share of emissions per economic sector is specific to the particular situation of Member States in the field of energy and climate.

3.5.2.4. Share of emissions within the Emissions Trading System in total greenhouse gas emissions

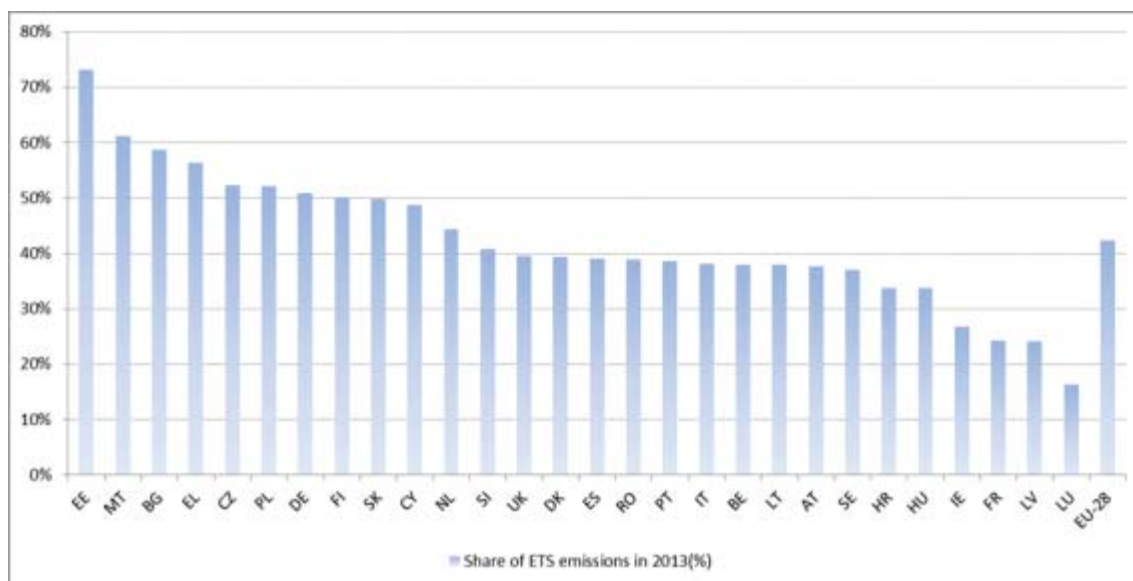


Figure 43: Share of emissions within the ETS in total GHG emissions, 2013

In 2013, 42% of the EU emissions were covered by the EU ETS. Figure 43 displays the share of ETS emissions by Member State. The share of ETS emissions is the highest in Estonia, Malta, Bulgaria, Greece and the Czech Republic. In most of these countries, the industrial sector is relatively important compared to the other sectors of the economy and solid fuel (or oil) are used predominantly in the electricity mix. Conversely, countries like Luxembourg, Latvia, France and Ireland have a limited share of emissions in the ETS due to relatively limited size of the industrial sectors in their economic specialisation. For the case of France, the predominance of nuclear in the electricity mix also explains the limited size of the ETS sector.

3.5.3. Renewable energy developments

Renewable energy offers a cost-effective solution for climate change mitigation. The increase in renewable energy use since 2005 resulted in approximately 326 Mton of gross avoided CO₂ emissions at EU level in 2012, the equivalent to the annual emissions of Spain. Renewable energy and energy efficiency policies have contributed to the decoupling of greenhouse gas emissions from economic growth.

3.5.3.1. Overall renewables developments

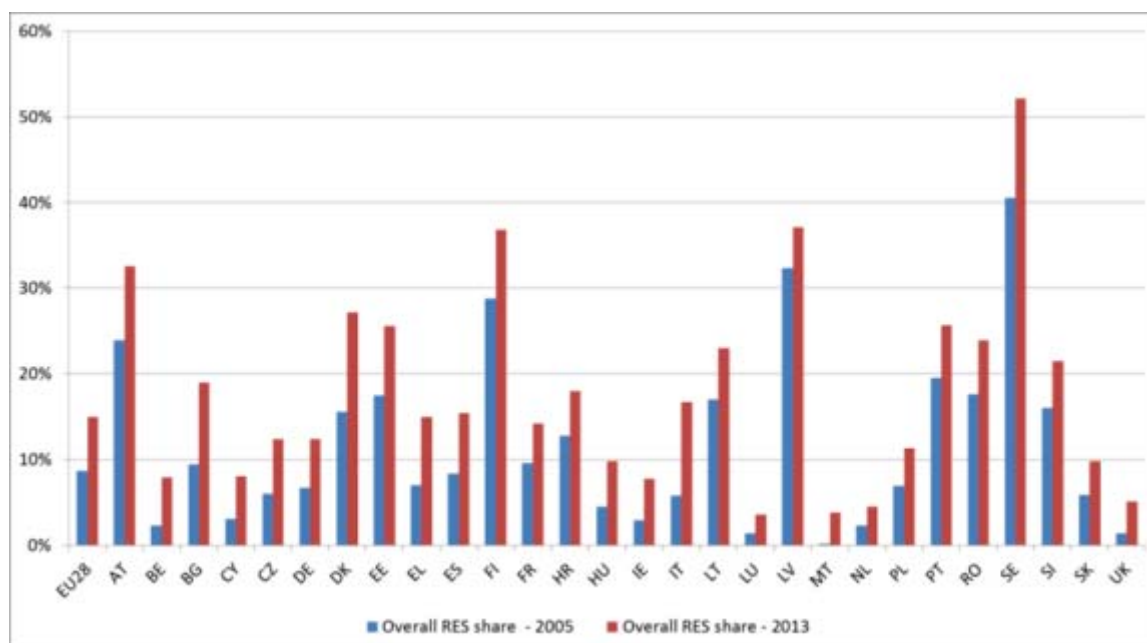


Figure 44: Share of energy from renewable energy sources in gross final energy consumption

Source: Eurostat

In 2013, the combined EU share of renewable energy reached 15% in gross final energy consumption and the estimate for 2014 indicates a 15.3% share⁶². In all Member States, the share of RES has increased between 2005 and 2013, notably because of a decrease in the overall energy consumption in several Member States. The most important increases in the RES shares took place in Austria, Bulgaria, Italy, Sweden and Denmark.

Nineteen Member States⁶³ may exceed, some even considerably, their 2020 renewable energy targets with implemented and planned renewable energy policies.

However, seven Member States, i.e. France, Luxembourg, Malta, the Netherlands and the United Kingdom, and to a lesser extent Belgium and Spain need to assess whether their policies and tools are sufficient and effective in meeting their renewable energy objectives. Achievement of the 2020 renewable energy targets is also not certain in the case of Hungary and Poland: it is only under optimistic assumptions related to the future development of energy demand and country-specific financing conditions that the 2020 renewable energy targets appear achievable⁶⁴.

A decomposition analysis can be performed to better understand the determinants of an increase in the share of RES in gross final energy consumption. From the figure below, it can be seen that gross final energy consumption from renewable sources increased in all Member States over the 2005-2013 period. In addition, 25 Member States experienced a decline of gross final energy consumption, which amplifies the increase in the RES

⁶² More details can be found in the 2015 renewable energy progress report. http://eur-lex.europa.eu/resource.html?uri=cellar:4f8722ce-1347-11e5-8817-01aa75ed71a1.0001.02/DOC_1&format=PDF

⁶³ including for example Austria, Estonia, Denmark, Germany, Italy, Lithuania, Romania or Sweden,

⁶⁴ See the 2015 Renewable energy progress report (COM(2015) 293) for more details on developments across Member States and sectors

shares. Conversely, the increase in total gross final energy consumption observed in Estonia, Malta and Poland during this period somewhat mitigated the effect of the increase in RES use on the RES share⁶⁵.

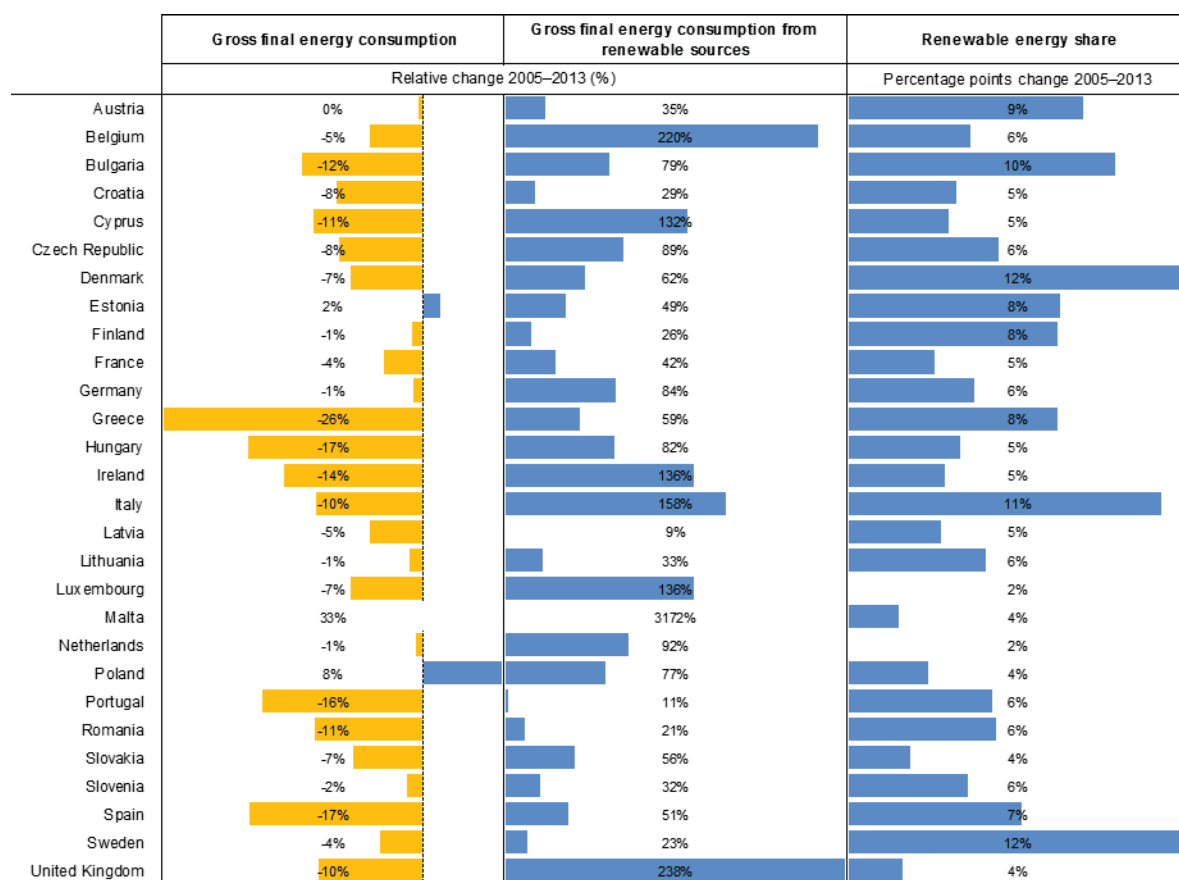


Figure 45: Member States' growth in total gross final energy consumption (total; RES) and RES Shares between 2005 and 2013⁶⁶

Source: Adapted from EEA Report No 4/2015 Trends and projections in Europe 2015 Tracking progress towards Europe's climate and energy targets for 2020, calculated from Eurostat

⁶⁵ See EEA Report No 4/2015 Trends and projections in Europe 2015 Tracking progress towards Europe's climate and energy targets for 2020 for more details

⁶⁶ Malta exhibits very strong growth in renewable gross final energy consumption (3 271 %). Due to its absolute small size however, the data may not be fully representative and is thus omitted above.

3.5.3.2. Renewable energy in electricity

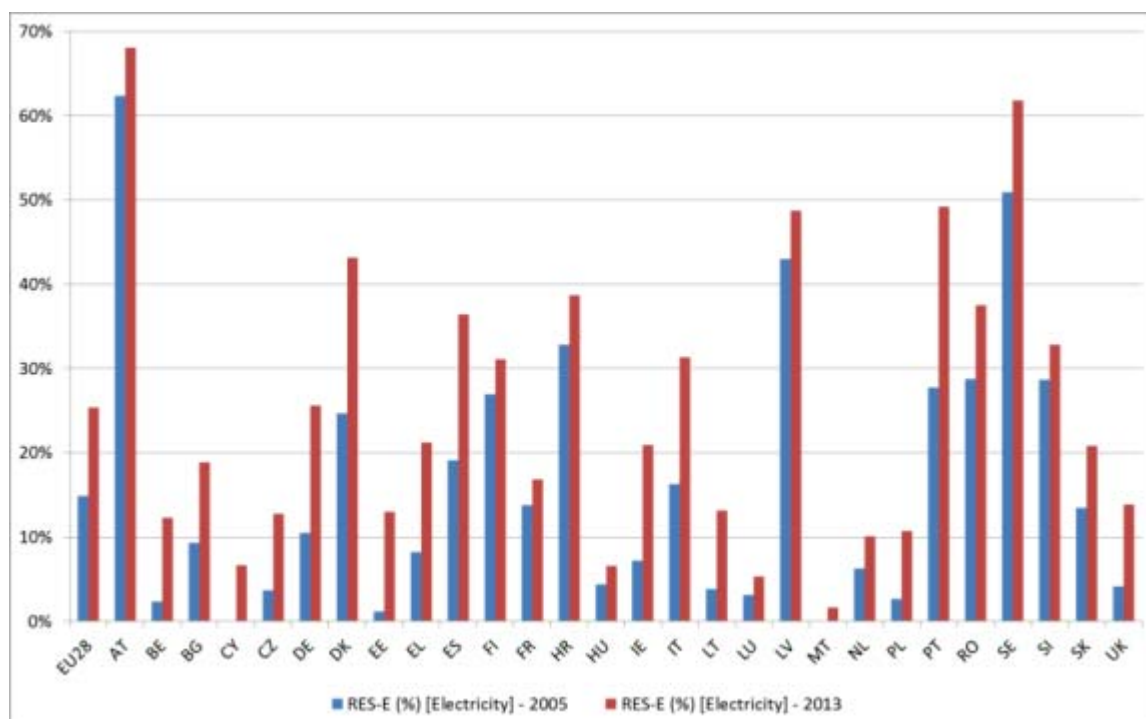


Figure 46: Share of energy from renewable energy sources in electricity generation

Source: Eurostat

In 2013, more than 25% of electricity was generated from renewable energy sources, a more than 10 percentage point increase since 2005. All Member States have seen the share of RES in electricity increase since 2005, ranging from 1 percentage point to more than 20 percentage points.

Total installed capacity of renewable electricity generation has increased significantly over the last 20 years, in particular through rapid growth of installed wind and PV capacity. To put into perspective, while electricity generation capacity from renewable sources in 2013 reached around 380 GW, the existing electricity generation capacity of fossil fuel plants in the EU was around 450 GW in 2013. Preliminary data indicate that the EU managed to set a new wind energy capacity installation record in 2014 with 12.4 GW newly installed capacity. By the end of 2014, the EU wind energy fleet had passed the 130 GW mark. The total capacity of installed offshore wind power reached 9.2 GW at the end of 2014, compared to 7 GW at the end of 2013)⁶⁷.

In the electricity sector, technology deployment and production rates in 2013 were generally in line with the trajectory foreseen in the National Renewable Energy Action Plans (NREAPs)⁶⁸. 15 Member States (Belgium, Bulgaria, Germany, Estonia, Spain, Croatia, Italy, Cyprus, Latvia, Lithuania, the Netherlands, Romania, Finland, Sweden and United Kingdom) were above their indicative trajectory for renewable electricity in 2013.

⁶⁷ Wind Energy Barometer, Eurobserv'ER (2015)

⁶⁸ Data sources: 2013 Eurostat data are used to assess Member State and sectorial performance, while renewable energy technology assessments are based on provisional 2013 data from Eurobserv'ER 2014

Hydropower plants generate by far the largest share of electricity from renewable energy sources, although their share of the total renewable electricity generation shrank from 94% to 43% over the 1990-2013 period.

Wind power generation more than tripled over the period 2005-2014 and it has become the second largest contributor to renewable electricity, taking over biomass⁶⁹. Solar electricity generation also increased rapidly and in 2013 accounted for 10% of all renewable electricity, the third most important contributor to the electricity production from renewable sources⁷⁰.

Solid renewables (wood and other solid biomass, excluding renewable wastes) are also used in conventional thermal generation power plants: their share in electricity from renewable sources grew from 3.5% in 1990 to 9.5% in 2013. Bioliquids and biogas, which were negligible in 1990, reached 6.7% in 2013⁷¹.

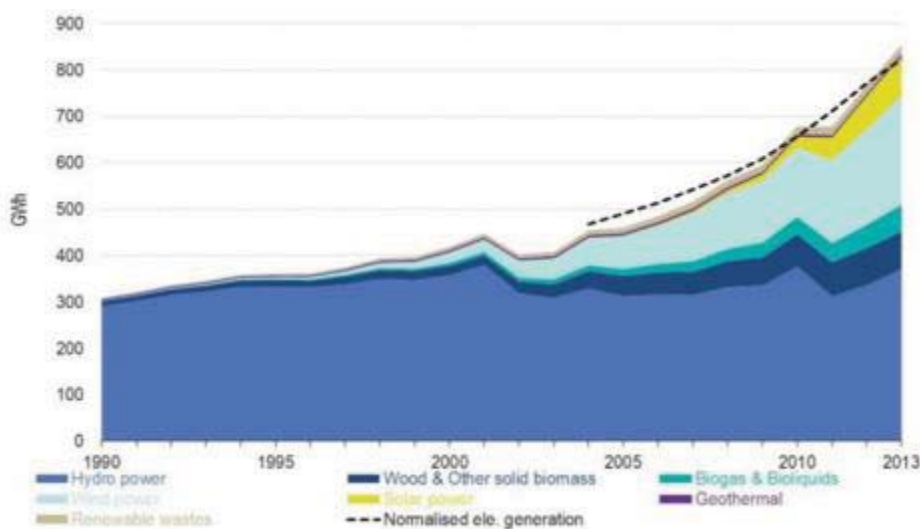


Figure 47: EU renewable electricity generation in 1990-2013

Source: Eurostat

⁶⁹ Eurostat statistics explained (March, 2015)

⁷⁰ Eurostat statistics explained (March, 2015)

⁷¹ Idem.

3.5.3.3. Renewable energy in heating and cooling

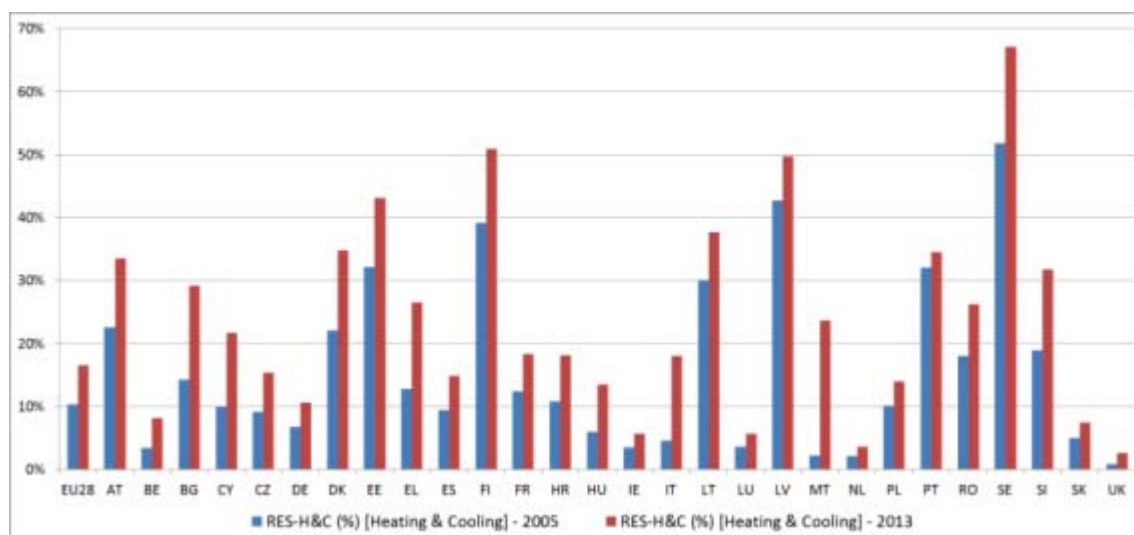


Figure 48: Share of energy from renewable energy sources in heating and cooling

Source: Eurostat

About half of final energy consumption in the EU is used for heating and cooling. At EU level, the renewable energy share in the heating and cooling sector was estimated to be 16.6% in 2014⁷², while it was 10.3% in 2005. The share increased in all Member States, ranging from 1 percentage point to more than 20 percentage points. Renewable heating is increasingly being used as a cost-efficient and secure alternative to fossil fuels in Member States in district heating and at local level.

Solid biomass was still the largest contributor to renewable heat production in 2013 with 73 Mtoe of renewable heat produced⁷³. In 2014, the European Commission published a report on the sustainability of solid and gaseous biomass for heat and electricity generation. Roughly one sixth of the biomass heat generation is based on grid connected applications, while the majority is still based on decentralised units. In absolute terms, decentralised heat generation from biomass also grows faster than biomass heat generation from grid connected systems. The largest biomass heat consumers were France with 10.2 Mtoe and Germany with 8 Mtoe⁷⁴. Heat pumps contributed 7.4 Mtoe to renewable energy heat and cooling production in 2013. In absolute figures, Italy stands out as a leader in heat pump use with 2.5 Mtoe, followed by France with 1.6 Mtoe and Sweden with 1.2 Mtoe production⁷⁵. Biogas plays a significantly smaller role among heating and cooling technologies. In 2013, 2.6 Mtoe of heat was produced from biogas.

Solar thermal heat production, with 1.9 Mtoe in 2013⁷⁶, still contributes relatively little to the renewable energy use in the heating and cooling sector.

3.5.3.4. Renewable energy in transport

Renewable energy use in transport has generally been lagging in most countries, except in Sweden, Finland, Austria, France and Germany. At EU level, the share in 2013 was

⁷² ECOFYS, 2014

⁷³ Eurobserv'ER 2014

⁷⁴ Eurobserv'ER 2014

⁷⁵ 2013 EUROSTAT.

⁷⁶ 2013 Eurostat

5.4%. Sweden is the only Member State that has already reached its renewable energy target for transport with the 2013 share reaching 16.7%, well above the binding 10% target for 2020⁷⁷.

Biodiesel remains the most widely used form of renewable energy in transport with 10.3 Mtoe in 2013, followed by bioethanol with 2.7 Mtoe⁷⁸. France, Germany and Italy are the top 3 biodiesel markets in the EU with 2.3 Mtoe, 1.9 Mtoe and 1.2 Mtoe consumption in 2013⁷⁹. Also for bioethanol the largest consumption was reported by Germany with 758 ktoe, followed by France with 392 ktoe and Denmark with 387 ktoe.

A consumption of 1484 ktoe of renewable electricity in transport was reported for 2013, the vast majority of it being consumed in non-road transport modes. In absolute terms, France was the biggest consumer with 239 ktoe, followed by Italy with 218 ktoe and Germany with 215 ktoe⁸⁰.

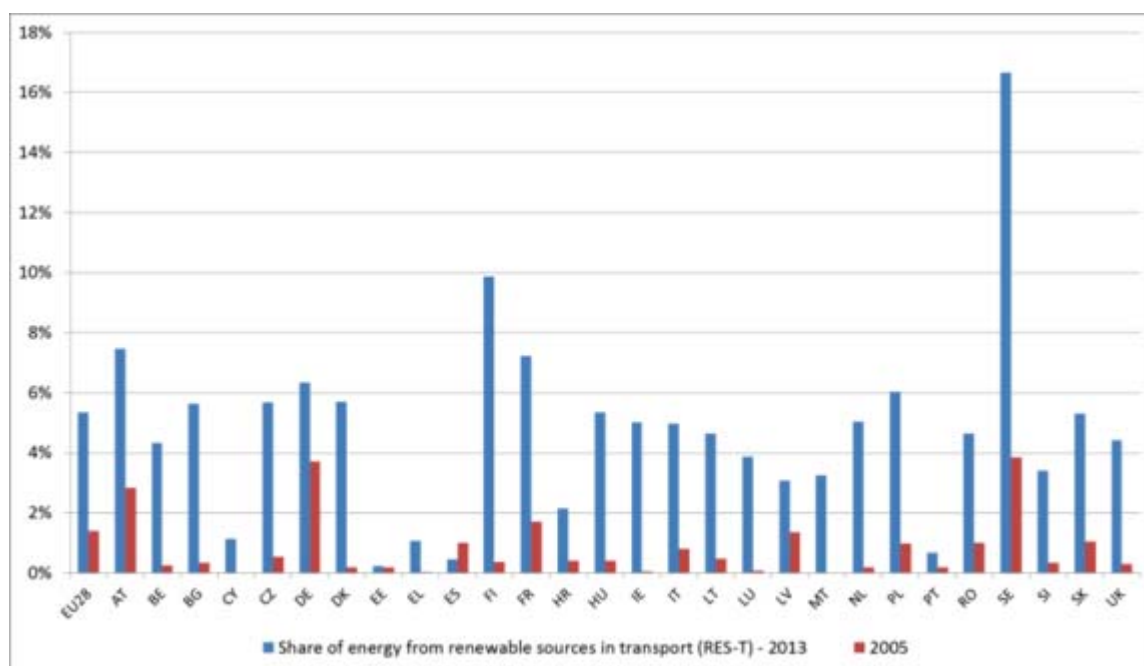


Figure 49: Share of energy from renewable energy sources in transport

Source: Eurostat

Currently, the vast majority of biofuels is produced from food crops. The share of advanced biofuels based on cellulosic material or wastes and residues is still small, due to technological challenges, feedstock availability, financing and political uncertainty. Given the move towards a low carbon electricity mix, both electrification of transport and the use of hydrogen produced from renewables could contribute to the decarbonisation of the transport sector. Around 38 000 electric vehicles were registered in the EU in 2014, up by 57% compared to 2013. The largest number of registrations was recorded in France (more than 10 700 vehicles), Germany (around 8 500 vehicles) and

⁷⁷ Eurostat

⁷⁸ Eurostat

⁷⁹ Eurostat.

⁸⁰ Eurostat

the UK (around 6 700 vehicles). Nevertheless, electric vehicles continue to constitute only a very small fraction of new registrations (0.3 %) ⁸¹.

3.5.3.5. Renewable energy deployment at local level

Deployment of distributed generation and self-consumption at household level is mostly driven by solar photo-voltaic (PV).

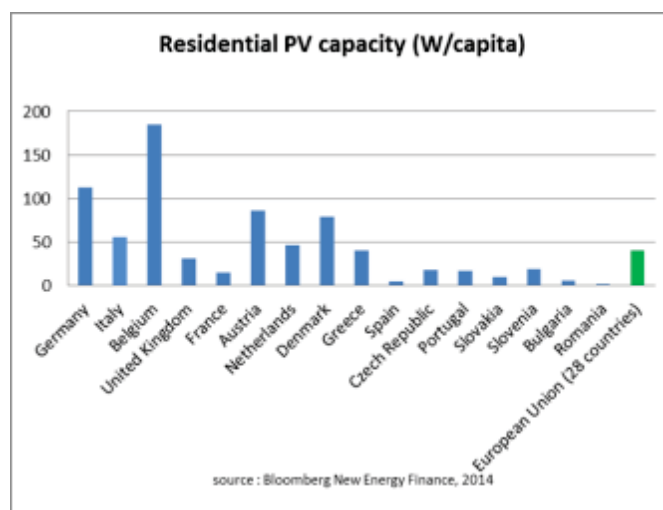


Figure 50: Residential PV capacity, 2014

Source: Bloomberg New Energy Finance

At local level, in October 2015, over 6500 cities representing over 40% of EU population are committed to fighting climate change and promoting renewable energy under the Covenant of Mayors ⁸² initiative. More than 3000 municipalities have committed themselves to implement sustainable energy action plans, already covering 9% of their energy needs with locally produced energy, of which at least 19% were renewables ⁸³

3.6. Research, innovation and competitiveness

3.6.1. Research and innovation

The analysis below focuses first on collected information on investments in research and development, before specifically considering innovation performance.

3.6.1.1. Investments in R&D

As mentioned in Section 2.2.6, the analysis of research and innovation efforts in the field of sustainable energy and other low-carbon technologies is made difficult by a certain lack of data, in particular when looking for recent trends and by the need to interpret with caution the situation across countries, given differences in size, population, economic development and national Smart Specialisation Strategies. Taking account of these methodological limitations, this section highlights:

⁸¹ Source: EEA <http://www.eea.europa.eu/highlights/new-cars2019-co2-emissions-well>

⁸² Source : COMO website

⁸³ JRC, The Covenant of Mayors in Figures and Performance Indicators, 2015 - Based on BEIs, excluding CHP, DH and *not specified*

- The degree of specialisation of public R&D investments in the fields of energy and environment across Member States, as compared to other sectors of public R&D investments.
- The public R&D intensity in the energy sector, that is, public R&D investments in the energy sector compared to GDP.
- Within the energy field, the degree of specialisation across areas (e.g. energy efficiency, renewables, nuclear) across some Member States and at EU level, compared to trading partners.
- Some information on absolute corporate R&D investments in the energy field across Member States, as well as the relative share of public vs. private investments.

(a) Public support to R&D

This first element to consider is the concentration of EU Member States' and some trading partners' public R&D support towards energy and environment, as opposed to other research fields.

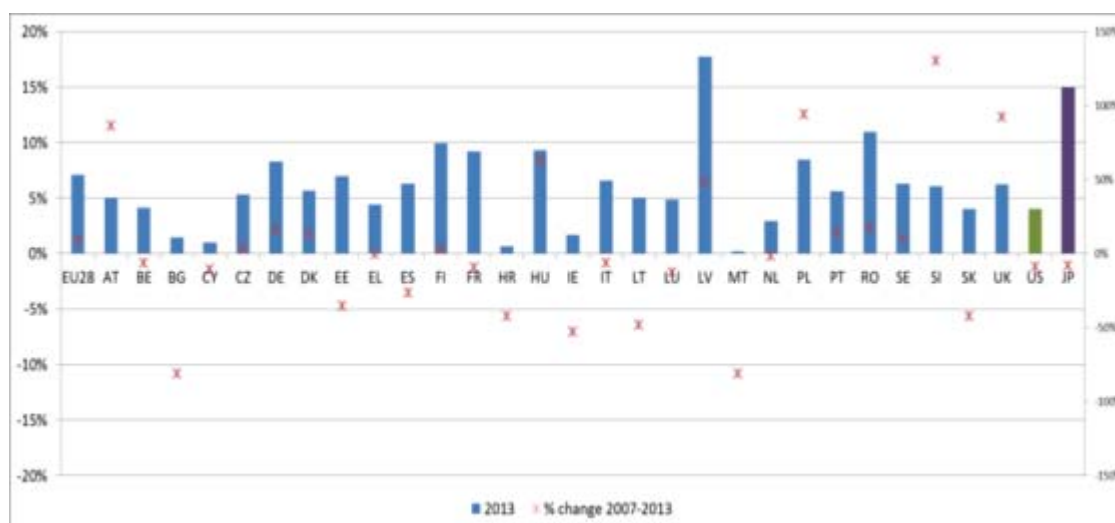


Figure 51: Share of energy and environment in total public civil R&D spending

Source: Eurostat

Overall, there is limited concentration of public support to R&D in the field of energy and environment (7.1% at EU level). However, this share has slightly increased over the 2007-2013 period, even if there are large discrepancies across Member States in terms of trends. Bulgaria, Cyprus, Croatia, Ireland and Malta are the countries showing the lowest share of public support to R&D in the field of energy and environment. Conversely, Finland, France, Hungary, Latvia and Romania concentrate a relatively high share of public R&D budget to these issues. In terms of growth rates, Slovenia, Poland and the United Kingdom register the highest increases between 2007 and 2013 while Bulgaria and Malta show important declining trends.

Another dimension to assess relates to the public R&D intensity in the field of energy, that is, public support to R&D in energy divided by GDP. This analysis is based on data from the International Energy Agency and therefore does not cover all EU Member

States⁸⁴. Overall, EU available data shows that public R&D intensity support to energy in Europe falls between R&D intensity in the US and in Japan. Between Member States, contrasted situations emerge, with relatively strong support in Denmark, Finland, France, Hungary or Luxembourg, while support intensity seems much lower in countries like Czech Republic, Estonia, Portugal, Ireland or Spain.

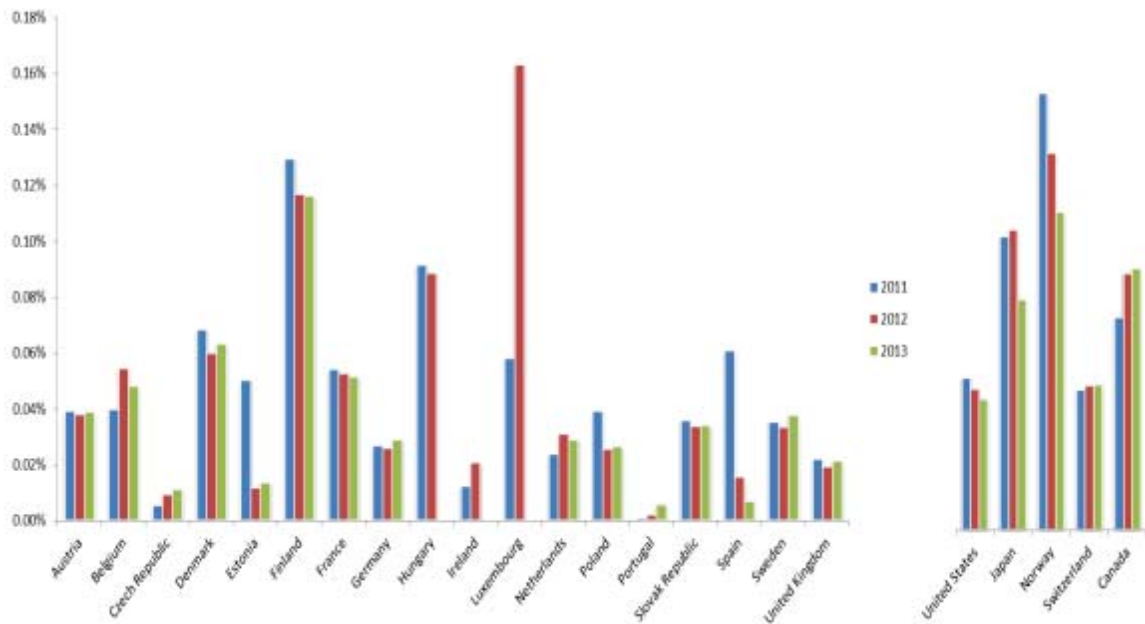


Figure 52: Public R&D intensity support to energy (R&D budget/ GDP, 2011-2013)

Source: IEA available EU MS and other countries]

In addition, it is possible to look at the split of public R&D investments in various energy fields. In 2013, EU available data shows that nuclear energy was energy field receiving the highest share of public investment in energy R&D, closely followed by energy efficiency and renewable energy. The share of public support to renewable energy R&D increased from 19% in 2005 to 25% in 2013. The share of public R&D support to nuclear decreased by 12 percentage points since 2005, when it represented about 39% of total public support to energy.

⁸⁴ The quality of the data reported with this indicator might vary across countries, for instance because of a different understanding of what should be included in the R&D and demonstration reports.

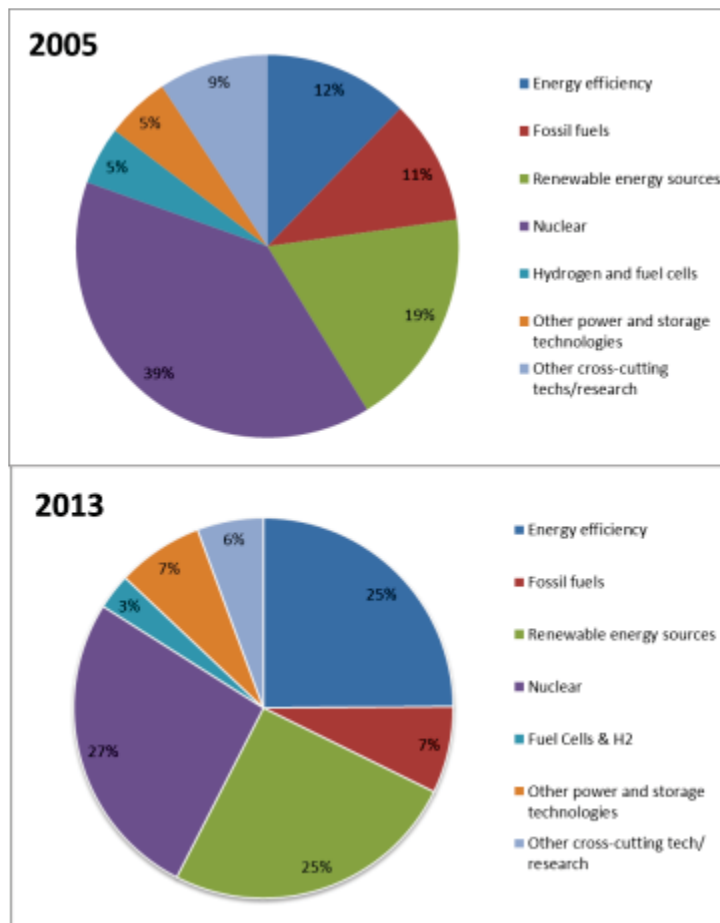


Figure 53: Split of public support to R&D in various energy fields - EU available data (2005 – 2013)

Source: IEA

Regarding the EU's trading partners, the focus in Canada and Norway is very much on fossil fuels, which can include also a significant share for CCS-related research, while in Japan, it was – at least until 2011 – on nuclear. Korea shows a very balanced public support to R&D in various energy fields. The situation is also quite balanced in the US, with cross-cutting technologies research receiving the highest share.

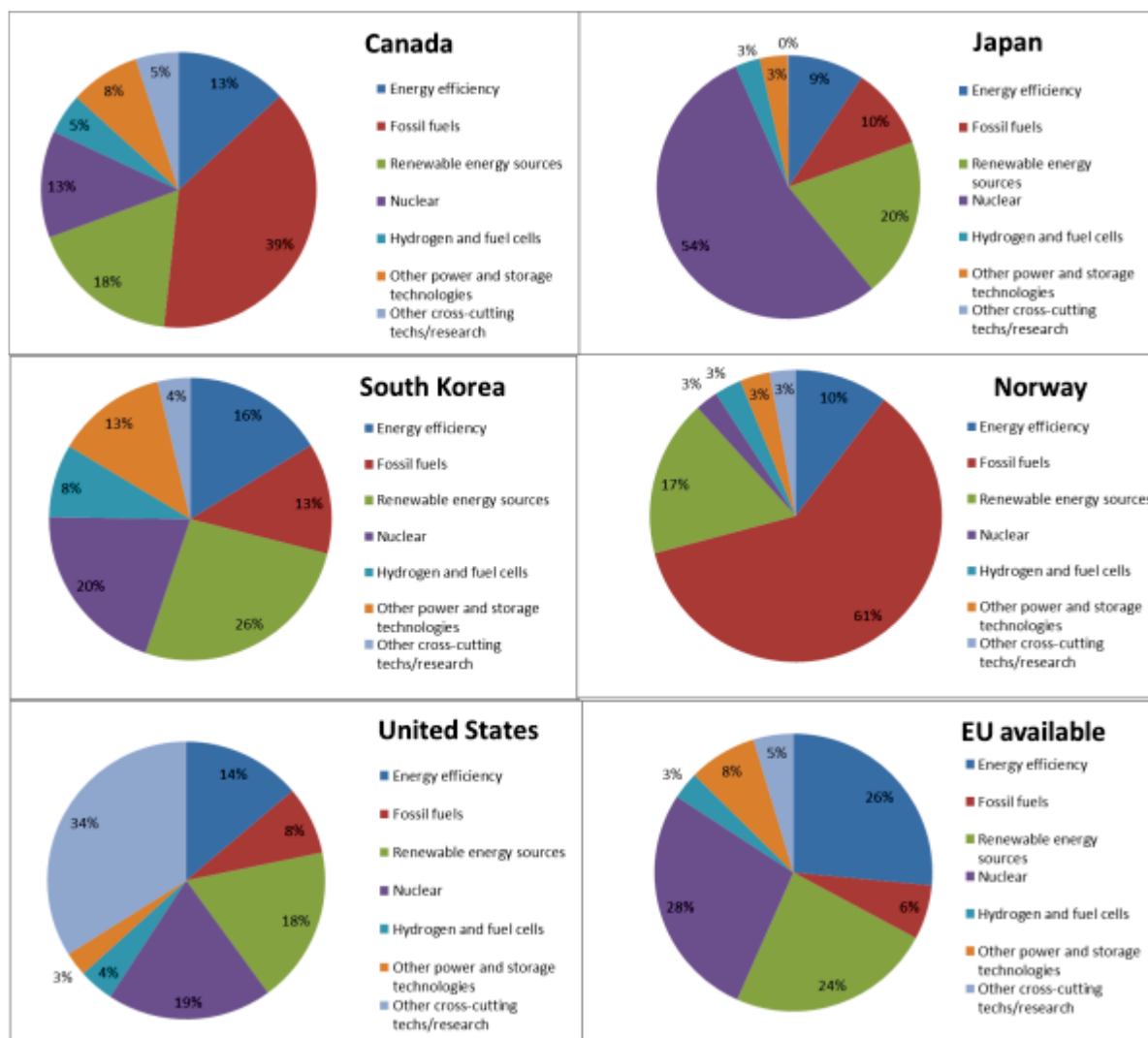


Figure 54: Split in public R&D support in various energy fields - international comparison, 2011

Source: IEA

(b) Corporate R&D in low-carbon technologies

In total, EUR 8.8 billion have been invested in 2011 in R&D from public (European and national level) and corporate sources in nine energy related technologies. Among those investments, the total investment in renewable energy technologies was around € 3,8 billion, with around € 1 billion from national funding⁸⁵, € 2,6 billion from corporate funding and € 146 million from EU funding⁸⁶.

The figures below illustrate the level of investments from the corporate sector in different energy technologies and across countries. In the EU, Germany, France, Denmark, the United Kingdom and Spain are the Member States in which corporate R&D spending was the highest.

⁸⁵ As a comparison, the US national funding for RES research and innovation was € 668 mi

⁸⁶ Source : JRC, capacities map, 2015. Figure for 2011 (latest data available)

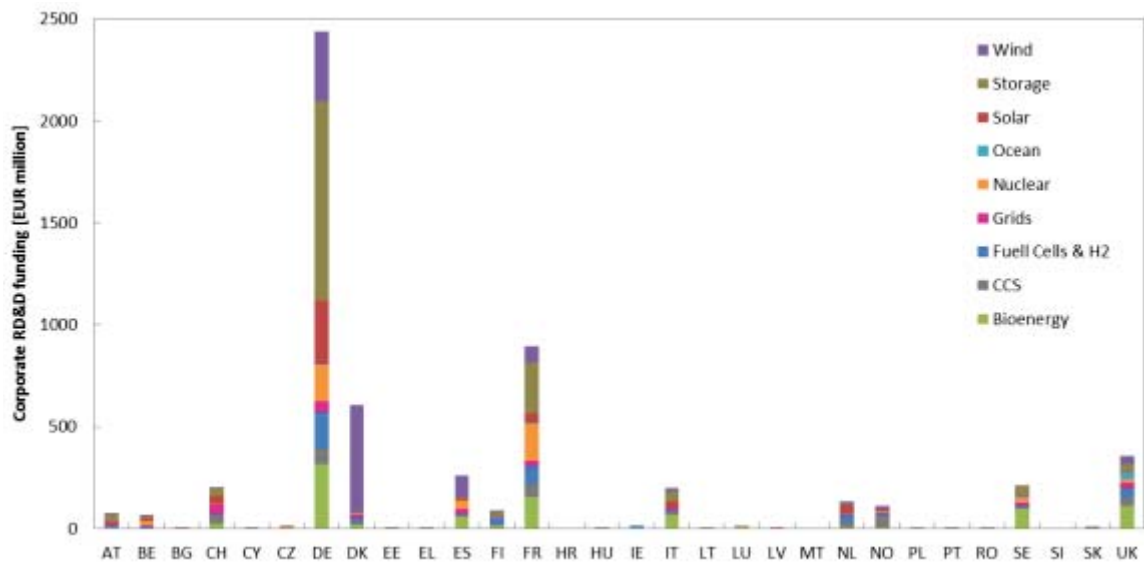


Figure 55: Absolute investment from the corporate sector in R&D per technology and country for 2011.

Source: JRC Capacities Map

In the EU, in 2011, energy storage, wind and bioenergy received the biggest investment from corporate sources, both in absolute and relative terms. Conversely, areas like nuclear, CCS, or electricity grids show a more than 50% contribution from public (EU and national) sources.

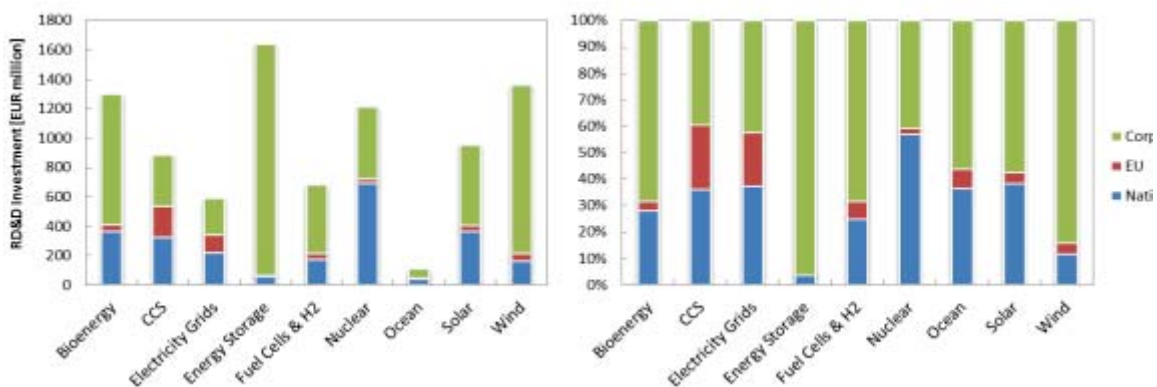


Figure 56: Absolute figures and relative contribution of national, EU and corporate funding to R&D for the nine technologies examined in the year 2011.

Source: JRC Capacities Map

3.6.1.2. Innovation trends in low-carbon and sustainable energy sectors

In addition to R&D investments, it is also important to monitor developments at other, more downstream phases of the innovation process. Here again, data constraints do not yet allow for a comprehensive assessment of all relevant dimensions. However, it is possible to monitor innovation activities and their diffusion by looking at:

- Developments in low-carbon technology, and more specifically renewable energy, patent applications across Member States and trading partners;
- Global trends in energy innovation, by main world region;

- Recent and projected trends, at EU level, in power generation investment costs; and
- Global trends in renewable energy investments.

First, regarding patent applications, EU levels fare well compared to major trading partners, standing above US or Canada levels but below Japan or South Korea.

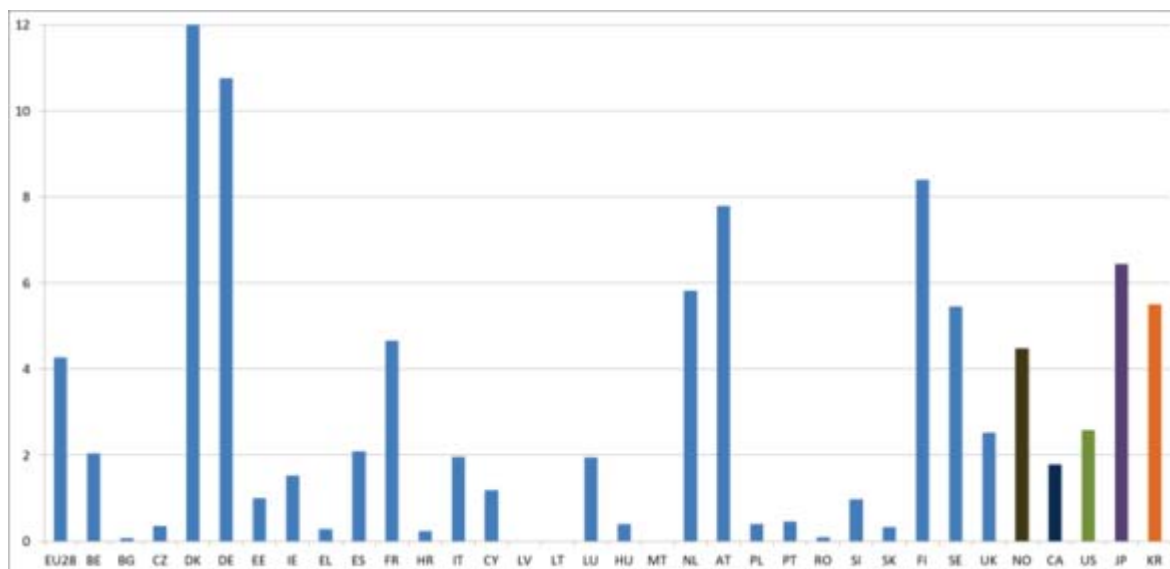


Figure 57: Number of low-carbon technology patent applications, per million inhabitants, 2011⁸⁷,

Source: Eurostat

Austria, Germany, Denmark, Finland and the Netherlands are the countries with the highest number of patent applications in low-carbon technologies, per million inhabitants. Conversely, Bulgaria, Greece, Croatia, Romania and Slovakia show very low numbers of patents applications.

Beyond patent applications, European companies today hold 40% of all patents for renewable technologies. The EU is leading in key sectors such as:

- Wind turbine manufacture, with 78% of all wind turbines installed in the world except China produced by European manufacturers⁸⁸
- Offshore wind, with 92% of the global offshore wind capacity installed in Europe;
- Concentrated Solar Panels, with EU entities involved in all projects developed so far worldwide;
- and pioneering the integration of large shares of renewables through smart grid technologies, storage systems or demand response.

⁸⁷ Denmark numbers are actually much higher than suggested by the graph, being at 48 patents per million inhabitants.

⁸⁸ 2014 JRC wind status report

Second, in order to obtain information on the trends concerning global energy innovation, the geographical distribution of the main academic and industrial players in 100 energy priority areas was identified, as presented in the relevant KIC report⁸⁹.

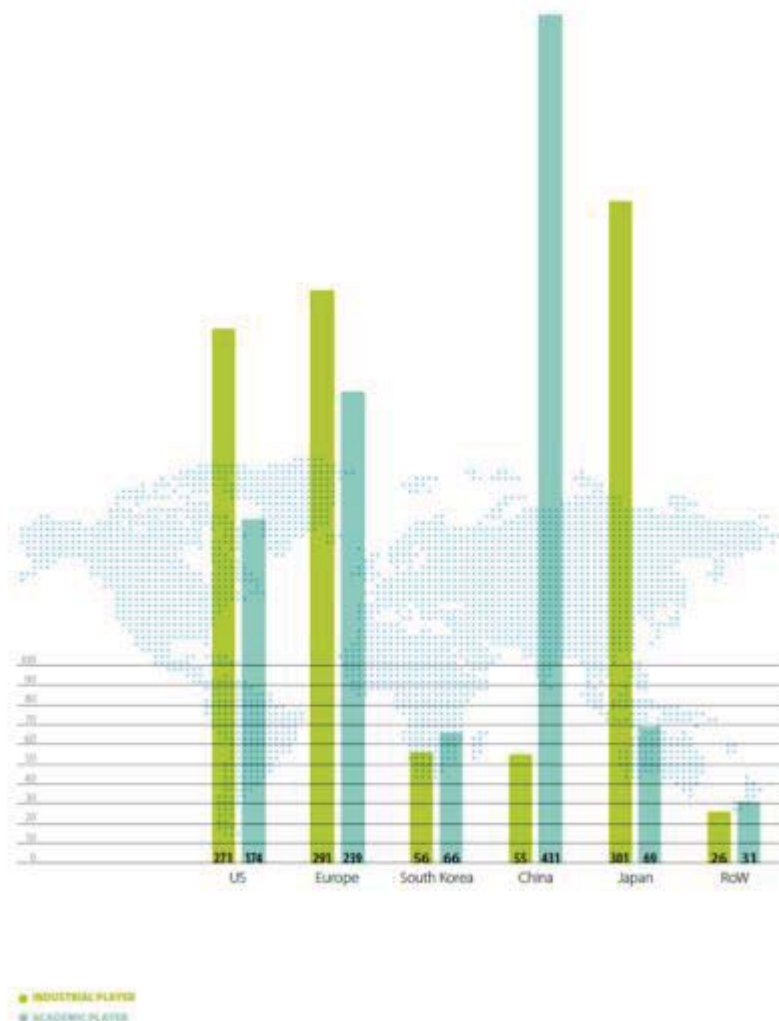


Figure 58: Geographic distribution of the top 10 most prominent industry and academic players and the frequency that they appear in 100 energy priorities

Source: KIC InnoEnergy & Questel Consulting

Each figure displays the number of times a country is represented by a top innovative player covering all priorities. 80% of innovative leaders in industry come from Japan, Europe and North America. European industrial and academic innovative players are well positioned overall in the global energy landscape (coming second in both cases behind Japan and China respectively). We observe a strong presence of Chinese academic players in all 100 energy priorities, with a 40% frequency of occurrence in the top 10 rankings. 3 energy thematic fields regroup 70% of the top 30 academic players: clean coal technologies, renewable energy convergence and solar PV. None of the top 30 innovative players appear to be wind energy; this may be because of a lack of appropriate data. On the other hand, Chinese industries are almost absent from the rankings concerning the industrial players.

⁸⁹ KIC InnoEnergy & Questel Consulting, "Top 10 Energy Innovators in 100 Energy Priorities: A unique report mapping industrial and academic players in global competition", January 2015

Third, the following graph presents a comparison of the levelized costs of electricity generation (LCOE)⁹⁰ for a range of representative technologies across both a historical and future time horizon. Such costs are based on economic conditions at the time of the investments, and are projected for future years based on current estimates⁹¹. It is important to note that these cost estimates are on the conservative side, as markets for new technologies develop fast and experts have been constantly revising their cost estimates downwards. In addition, estimates for 2030 are based on current energy and climate policy trends and meeting 2020 targets. LCOEs are also influenced by the economic lifetime of the project, the number of full load operating hours per year, and the net efficiency of the power generation technology.

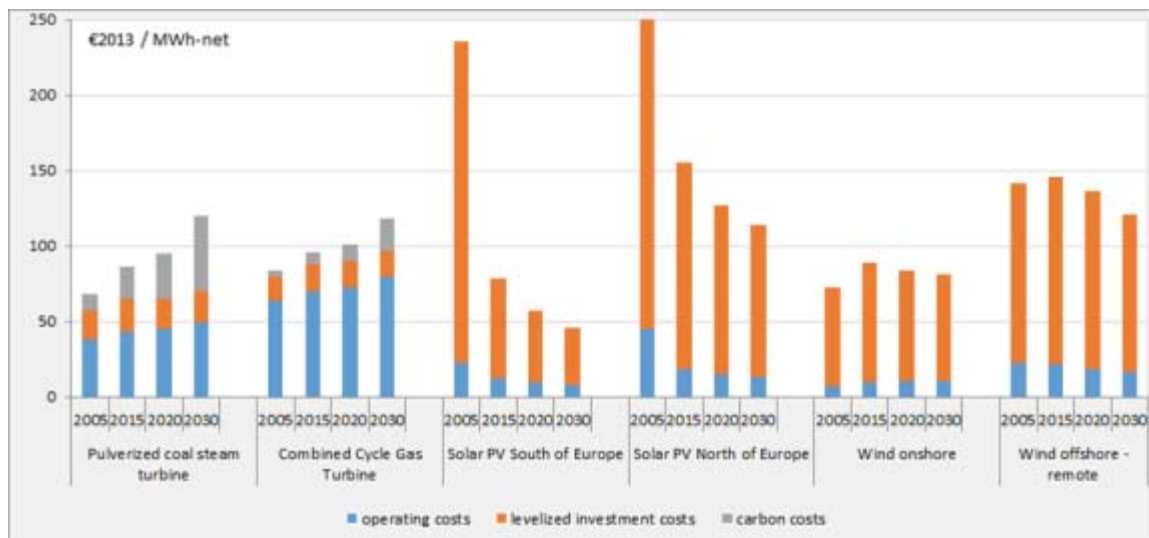


Figure 59: Evolution of levelized costs of electricity generation broken down by key cost components for selected representative technologies for the past, present and future⁹²

Source: European Commission services calculations, based on NTUA

In 2005, the comparative advantage for traditional fossil fuel technologies was evident, as the LCOE for such technologies was significantly lower than those for renewable electricity technologies. However, such cost disparities have decreased considerably in favour of new low-carbon technologies in the last ten years. Policy-induced technological progress has led to a rapid decrease in investment costs for solar and wind technologies. For instance, the LCOE for solar PV decreased by 71% (Northern Europe) and by 66% (Southern Europe) over the last ten years, something unexpected even five years ago. Wind investment costs are estimated to have slightly increased between 2005 and 2015, mostly due to additional raw material costs that came with the development of more advanced, taller and more efficient and powerful wind turbines. Nonetheless, wind technology costs are projected to decrease in the next 15 years.

⁹⁰ LCOE estimates are calculated by accounting for the power generation technology's expected lifetime costs (including e.g. construction, fuel, maintenance, carbon prices), which are then divided by the technology's lifetime expected power output (kWh). All cost and benefit estimates are discounted to account for the private time-value of money using the same WACC (weighted average capital cost) of 8.5%.

⁹¹ CO2 prices used for the estimates of the carbon costs are those available in the 2013 EU energy, transport and GHG emissions trends to 2050

⁹² In 2005, the LCOE for solar PV in Northern Europe was more than 500 €2013/MWh-net. However, the Y-axis in the chart above has been set to a maximum of 250€/MWh-net to better visualize changes in cost estimates for the rest of technologies and years

Finally, the analysis below is an attempt at comparing energy investment across main regions. Figure 60 compares renewable energy investments across world regions from 2004 to 2014. It can be seen that up to 2012, Europe represented the main region in terms of renewable energy investments. However, since 2013, China is the area with the most important investments in renewable energy.

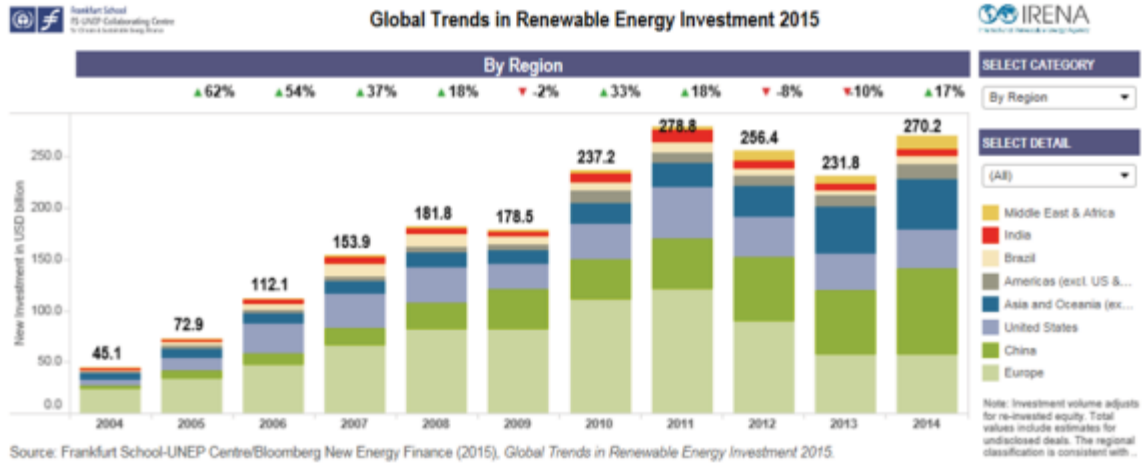


Figure 60: Global trends in renewable energy investments, by region

Source: IRENA

When observing these trends per sector, solar and wind remain the most important contributors to renewable energy investments at global level.

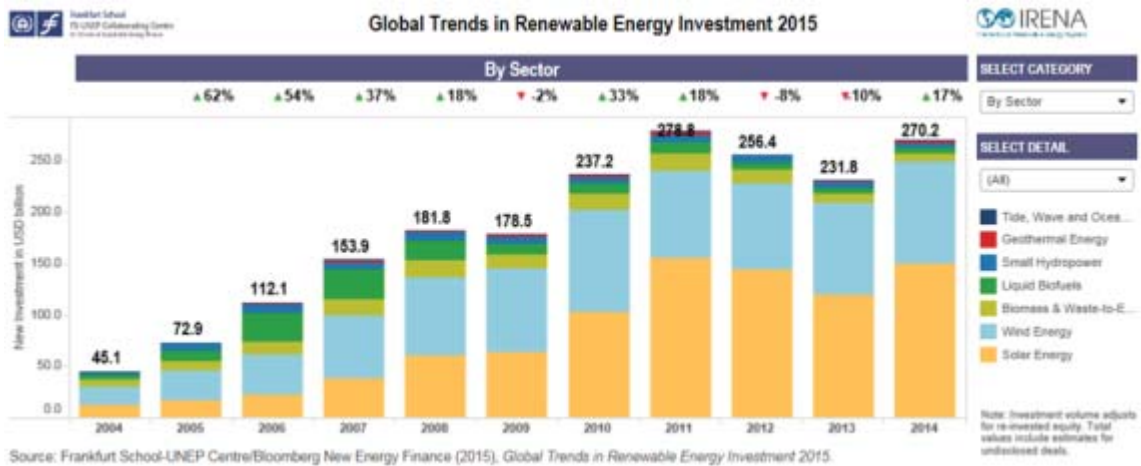


Figure 61: Global trends in renewable energy investments, by sector

Source: IRENA

3.6.2. Energy prices and costs in a global perspective

3.6.2.1.EU and major trading partners energy price developments

(a) Wholesale electricity prices

The Energy Union Strategy noted that the competitiveness of the European economy is affected by energy price and cost differentials across the world, especially in the case of energy intensive industries exposed to intensive international trade. From this perspective it is worthwhile to compare European electricity prices against some of the main global trading partners of the EU.

Regional wholesale electricity prices in the US were generally below the European power benchmark, the PEP index. However, US power prices are more volatile than their peers in Europe, primarily owing to dependence on gas-fired generation as gas prices are sensitive to changes in weather conditions. Low gas prices in the US tended to partly squeeze out coal from the local power generation mix during the last few years, which also impacted the global coal market, assuring export opportunities for US coal and decreasing global coal prices, resulting in decreasing coal-fired power generation costs in many countries, especially in Europe.

Looking at Japan, over the last few years, wholesale electricity prices have consistently been higher than in the EU. The price differential to the EU power prices has become even greater in consequence of the Fukushima nuclear power plant accident, as nuclear generation has been replaced by gas-fired plants. However, during the last few months as LNG import prices became lower, power generation costs also decreased and it had beneficial impact on wholesale electricity prices in Japan. By the end of the first half of 2015, the Japanese wholesale electricity price levels returned to the pre-Fukushima ranges.

In Australia, the average wholesale electricity price level used to be lower by a magnitude of two-to-three compared to the EU average; in the first half of 2015 the average price level was 40% below the PEP index in the EU. Wholesale electricity prices in the US and Australia have been of comparable magnitude during most of the time between 2010 and 2015, being significantly lower than in Japan and the EU.

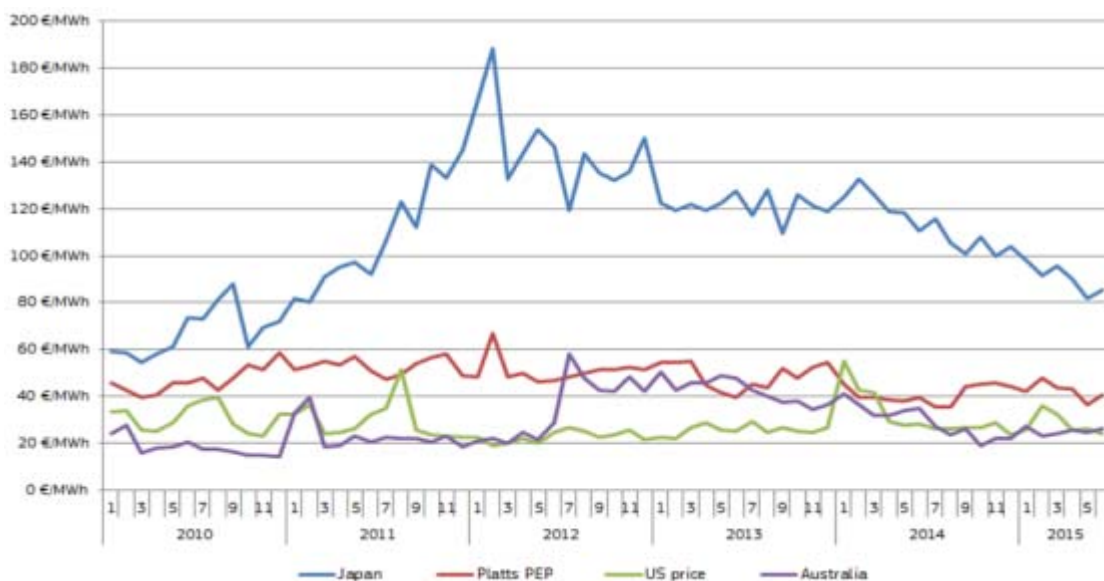


Figure 62: Wholesale electricity prices in the US, Japan, in comparison to the European composite average (PEP)

Source: Platts

(b) Wholesale gas prices

Figure 63 shows an international comparison of wholesale gas prices. Over 2014, wholesale prices decreased in all regions and the trend continued in early 2015. Since March 2015, prices have remained relatively stable.

The Fukushima accident in March 2011 and the ensuing increase of Japanese gas demand set LNG prices on an upward trajectory. In 2014, however, LNG prices showcased a big decrease, with Japanese landed prices decreasing by 65% between February 2014 and February 2015. LNG prices started to fall at the end of the 2013/2014 winter, mainly because of weak demand in Asia, the biggest LNG market, coupled with the commissioning of the Papua New Guinea LNG plant. Unlike in previous years, the 2014/2015 winter failed to reverse the downward trend and after a rebound in September-October 2014 prices continued to fall.

By February 2015, Asian spot LNG prices were on a par with the price at NBP, the United Kingdom gas hub. This was a major change compared to previous years when the LNG price had a premium of 3-10 USD/mmbtu over the NBP price. During summer 2015, Asian LNG prices slightly increased and in July traded 1 USD/mmbtu above the NBP price.

European prices significantly decreased in the first half of 2014. After a partial recovery in the autumn months, prices remained relatively stable in spite of the onset of winter. In the first half of 2015, NBP averaged about 7 USD/mmbtu (22 €/MWh). German border prices remained above NBP for most of 2014, with the premium exceeding 5 EUR/MWh in June, but this premium has practically disappeared in the first half of 2015.

Since 2010, with the onset of the shale gas boom, US gas prices have been consistently lower than European and Asian prices. The average monthly Henry Hub price remained below 3 USD/mmbtu in the first half of 2015, the lowest level since mid-2012. While the fall of the oil price cut the production of associated gas from oil shale plays, the resulting cost deflation helps the gas producers as they focus on gas-rich fields.

International gas prices have significantly converged in 2014 and the beginning of 2015. The ratio of the Japanese LNG price and US Henry Hub has fallen to 2.5 in February while in 2013 this indicator was in the 4-5 range. The NBP/Henry Hub ratio slightly increased in early 2015 (to about 2.5) but remained below 2012-2013 levels. The price convergence was partly driven by exchange rate developments: the Euro weakened by 12% compared to the US dollar during 2014 and by a further 11% in the first three months of 2015, thereby lowering European prices expressed in dollars.

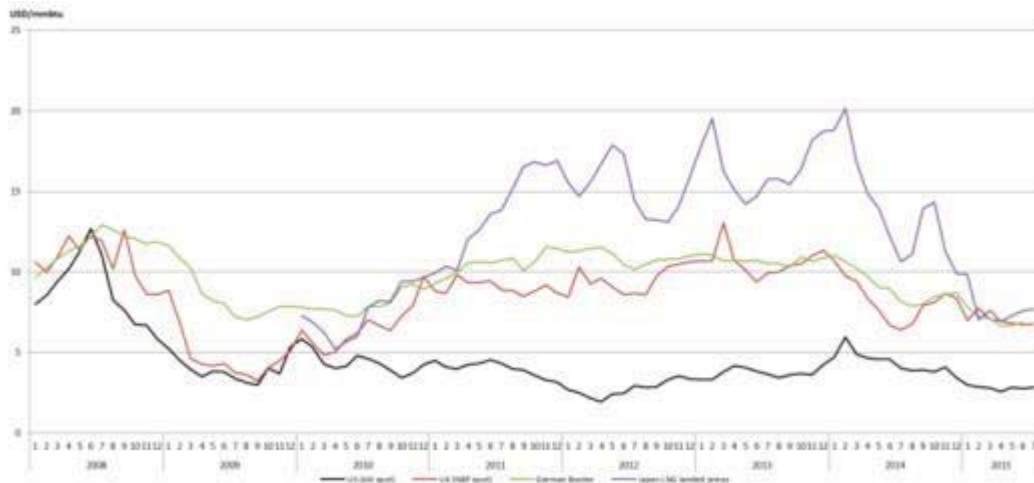


Figure 63: International comparison of wholesale gas prices

Sources: Platts, Thomson-Reuters, BAFA

(c) Retail prices paid by industrial users

Despite the importance and utility to look at wholesale prices as a proxy for prices paid by large industrial users, it is also essential when studying economic and industrial competitiveness to consider the final price paid by end consumers. Therefore, Figure 64 and Figure 65 compare final electricity and gas prices paid by industrial users.

There are large discrepancies in the prices paid by industrial users within countries, depending on the consumption band considered. At the same time, averages for the whole industrial sector hide a huge variation of situations across the wide spectrum of industrial sectors and sub-sectors. Besides, methodological limitations make international comparisons difficult. As such, the information presented below can only be indicative at this stage. It still shows that, in line with comparisons made on wholesale markets, prices paid by industrial users in the US are lower than in most EU Member States. However, EU prices fare better when compared to Japan.

In order to address some of the identified methodological limitations, the European Commission will publish in 2016 a new energy prices and costs report to provide an analysis of the cost of energy, including network costs, taxes and levies. It will also perform international comparisons, trying to overcome some of the identified data limitations when trying to compare EU energy prices with the ones of key trading partners.

In addition to this strand of work, additional information on trends in terms of new investments, installed capacity, used capacity and market shares could be added, when available, to more broadly assess the EU competitiveness strengths and weaknesses, in particular for key energy intensive industries.

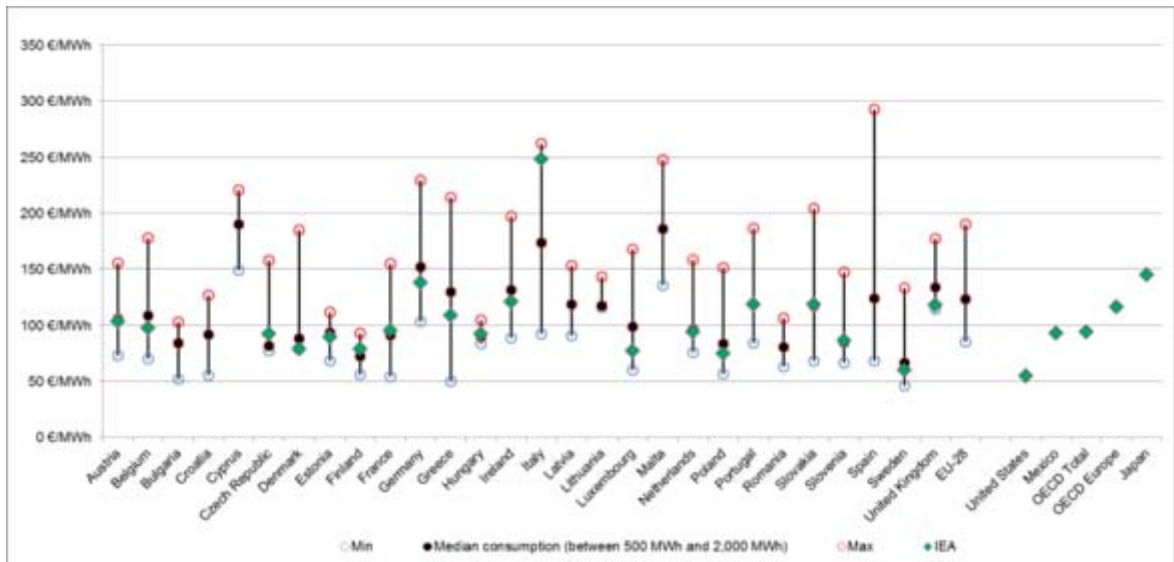


Figure 64: Electricity end-user prices paid by industrial customers (without VAT and rec. taxes, second half of 2014)

Source: European Commission services calculations, based on Eurostat and IEA

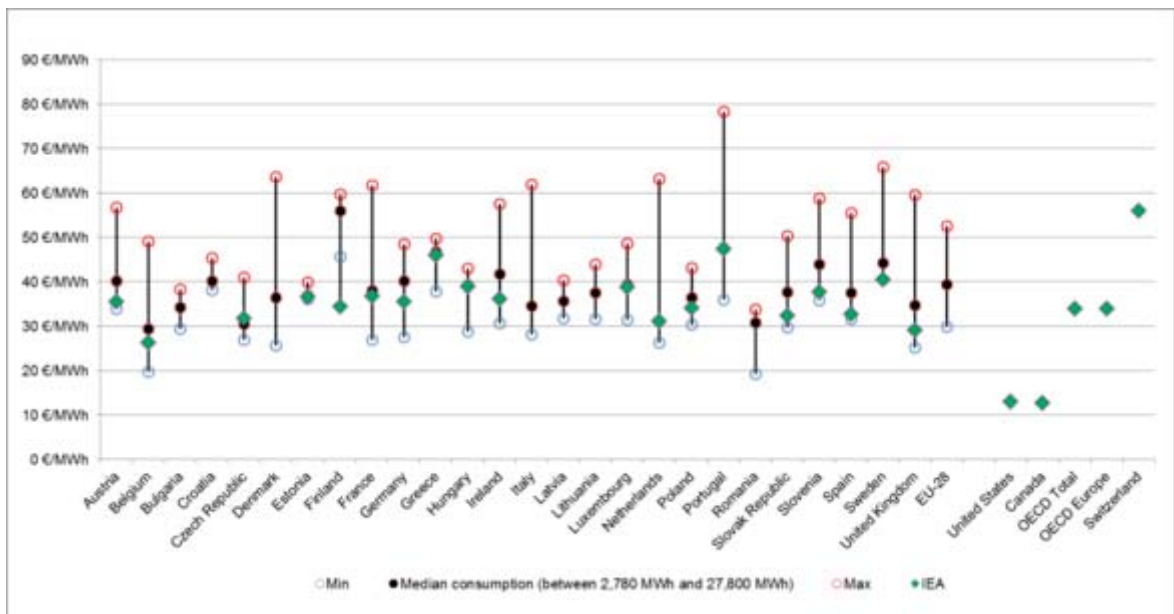


Figure 65: Gas end-user prices paid by industrial customers (without VAT and rec. taxes, second half of 2014)

Source: European Commission services calculations, based on Eurostat and IEA

3.6.2.2. EU and major trading partners energy cost developments

Looking at prices only is not sufficient to assess competitiveness considerations, as energy efficiency may have an impact on the energy costs faced by the manufacturing sector. Therefore, the emphasis is put below on an indicator – the real unit energy costs (RUEC) – combining energy prices and energy intensity to assess the significance of

energy costs in the manufacturing sector⁹³. Results are presented as percentage of value added.

Compared to its main economic partners, the EU manufacturing industry had in 2011 the second lowest RUEC⁹⁴ in terms of value added. China, Russia and other major economies such as Brazil and Indonesia show substantially higher values than the EU. The good performances of Japan and the EU are mostly explained by the low levels of energy intensity of their manufacturing sector which has helped to compensate the high real energy prices.

In the EU, the evolution of RUEC for Member States between 2000 and 2009 is in general characterised by an upward trend. The heterogeneity in levels is rather wide. For some Member States the RUECs are sensibly lower than the EU average while others on the contrary display levels that are significantly higher, not only than the average but also than the levels of their main international competitors.

In 2011, the Member States for which the RUEC were the highest were Bulgaria, Lithuania and to a lesser extent Slovakia, Poland and Latvia. This can be explained by a certain concentration of the industrial sector in energy intensive industries for some of these countries. Over the 2000-2011 period, real unit energy costs increased in most Member States by a very significant amount and by 45% at EU level. This means that during the years 2000s, despite continued efficiency improvements, specialization in higher-value added productions and potentially because of more limited economically and technically-feasible options than in the past, the energy intensity improvements in the EU's manufacturing sector were not sufficient to compensate for the increase in energy prices. Having said this, the EU manufacturing sector has enjoyed some of the lowest Real Unit Energy Costs (lower RUEC than in Russia or China, at similar levels than in Japan, but however now higher than in the US)⁹⁵.

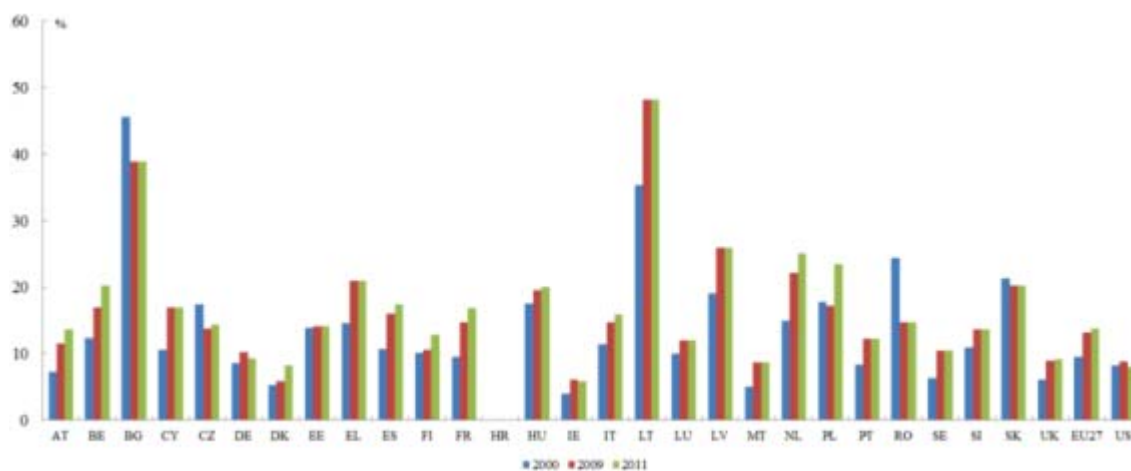


Figure 66: Real unit energy costs (% of value added) in the manufacturing sector (excl. refining)

⁹³ See http://ec.europa.eu/economy_finance/publications/european_economy/2014/pdf/ee1_en.pdf for a more comprehensive assessment

⁹⁴ Large differences of real unit energy costs are explained by refineries. For this reason, excluding refineries from the real unit energy costs is better to analysis the energy cost competitiveness of manufacturing sectors.

⁹⁵ See http://ec.europa.eu/economy_finance/publications/european_economy/2014/pdf/ee1_en.pdf for a more comprehensive assessment

Source: European Commission calculations, based on WIOD

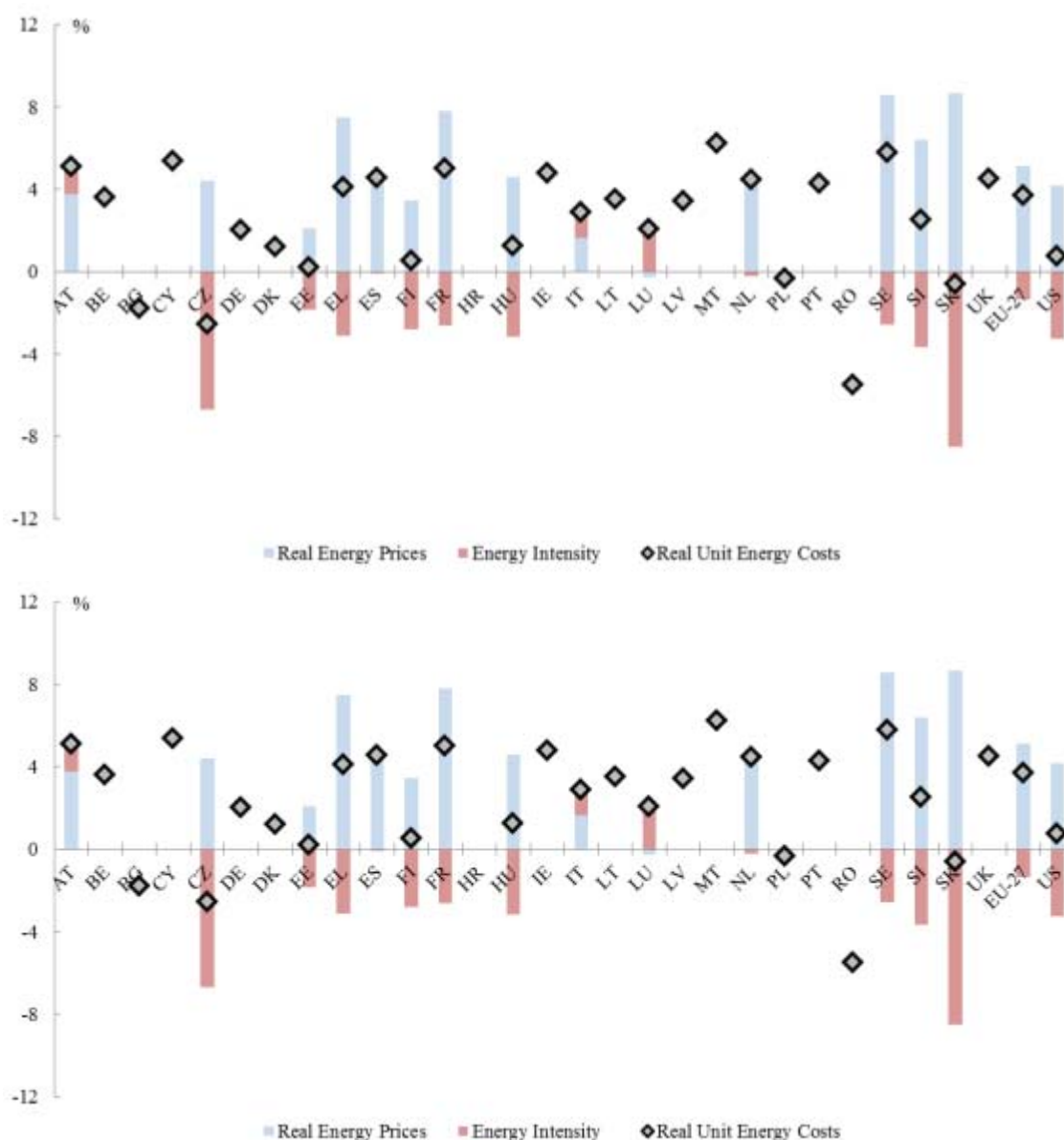


Figure 67: Contribution to annual growth rate 2000-2009 – Manufacturing excl. refining)

Source: European Commission calculations, based on WIOD

3.7. Cohesion Policy investments supporting the Energy Union

EU Cohesion Policy makes a key contribution for delivering the Energy Union objectives on the ground, including significant financial allocations from the European Regional Development Fund (ERDF) and the Cohesion Fund (CF), totalling EUR 68.9 billion, which will be complemented by national public and private co-financing, over 2014-2020 for investments related to all five dimensions of the Energy Union:

- EUR 13.3 billion for energy efficiency in public and residential buildings;
- EUR 3.4 billion for energy efficiency in enterprises, with a focus on SMEs;
- EUR 1.7 billion for high-efficiency cogeneration;
- EUR 4.9 billion for renewable energy;

- EUR 2.6 billion from the ERDF currently allocated to research and innovation and adoption of low-carbon technologies, with possible increases in the future in line with evolving smart specialisation strategies.
- EUR 3.4 billion for smart energy infrastructure, including EUR 1.1 billion for smart distribution grids and EUR 2.3 billion for infrastructure for smart electricity and gas distribution, storage and transmission systems, the latter mainly in less developed regions (six Member States currently foresee to use ERDF support for energy infrastructure investments of this kind: Bulgaria, Czech Republic, Greece, Lithuania, Poland, Romania).
- EUR 39.7 billion for supporting the move towards an energy-efficient, decarbonised transport sector, including EUR 16.0 billion for sustainable urban mobility (clean urban transport infrastructure, intelligent transport systems, cycle tracks and footpaths), and EUR 23.7 billion for other low-carbon transport (e.g. rail, seaports and inland waterways).

Figure 68 and Figure 69 below illustrates how different Energy Union-related measures are prioritized within the ERDF and CF allocations by the Member States.

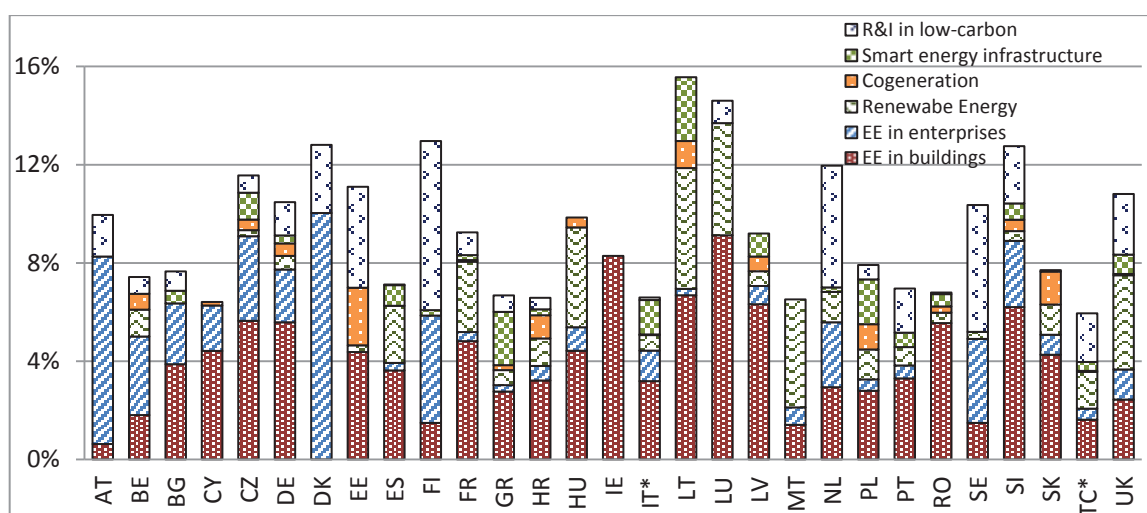


Figure 68: Share of the national ERDF and CF allocations to energy-related Energy Union areas out of the total Cohesion Policy allocations for the 2014-2020 period

* – not all operational programmes adopted
 TC – territorial cooperation

Source: European Commission calculations, based on operational programmes (data as of November 2015)

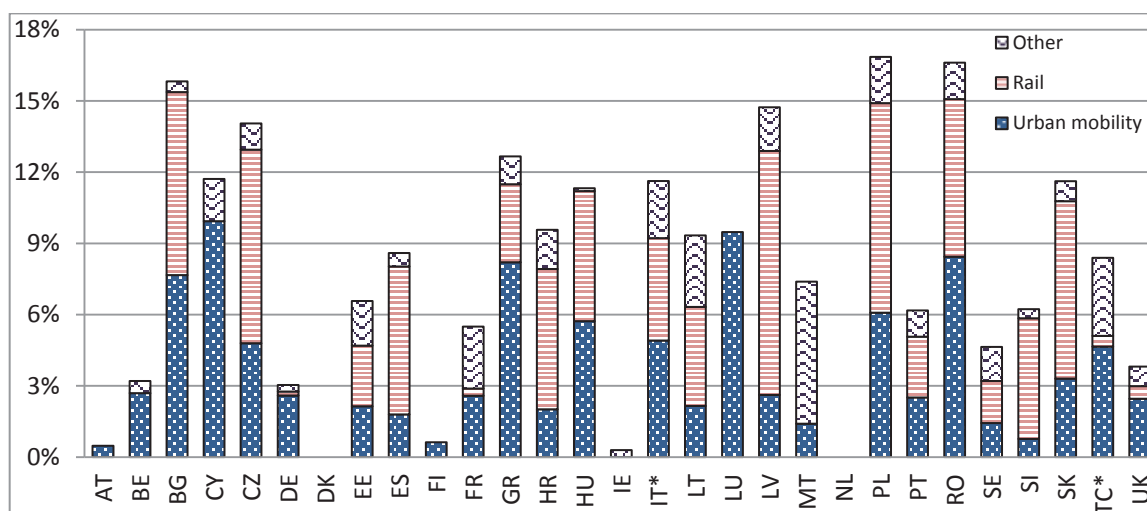


Figure 69: Share of the national ERDF and CF allocations to transport-related Energy Union areas out of the total Cohesion Policy allocations for the 2014-2020 period

* – not all operational programmes adopted
 TC – territorial cooperation

Source: European Commission calculations, based on operational programmes (data as of November 2015)

The figures also show that Energy Union investments receives a significant part – 20% on average – of the Cohesion Policy funding – ranging in the individual Member States from about 9% to 26%.

Following the adoption of the programmes, all efforts must now be focused on their implementation. The development and implementation of high quality projects is crucial to the success in delivering on the policy objectives. In order to assess such developments, from 2016 onwards, progress in Cohesion Policy investments supporting the Energy Union should be monitored, e.g. by dividing the amount of ERDF and CF allocations allocated to specific projects by the end of each year, or a certain cut-off date, by the total amount of planned allocations 2014-2020 for ERDF and CF investments supporting the Energy Union in a given country, i.e. the project selection rate. It can provide information regarding progress in Cohesion Policy investments supporting the Energy Union in a given country, controlling for the size of the allocation.

4. ANNEX:

4.1. Scoreboard of selected indicators

The tables below present the indicator values per Member State and at EU level for the selected indicators in the scoreboard. Highlighted in green (respectively red) are the values of the top 5 (respectively bottom 5) Member States for a specific indicator.

		Energy Security, solidarity and trust					Internal energy market				
Indicators	S1 - Net import dependency	S2 - Aggregated supplier concentration index	S3 - N-1 rule for gas infrastructure	S4 - Electricity interconnection capacity	S5 - Market concentration index - power generation	S6 - Market concentration index - wholesale gas supply	S7 - Wholesale electricity prices	S8 - Wholesale gas prices	S9 - Annual switching rates - electricity retail markets	S10 - Annual switching rates - gas retail markets	S11 - Energy poverty index
Source	Eurostat	Commission services, based on Eurostat	IHS , Gas coordination group	ENSTO-E	Platts	ACER/CEER	European Commission	European Commission	ACER/CEER	ACER/CEER	Commission services, based on Eurostat
Unit	net imports - % of gross inland consumption	0-100 (100 means maximum concentration)	% of total demand that can be satisfied if disruption of largest gas infrastructure	% of installed capacity	0-10000 (10000 means a single supplier)	0-10000 (10000 means a single supplier)	EURO/MWh	EURO/MWh	% of total consumers	% of total consumers	% of households
Year	2013	2013	2015	2014	2014	2013	2014	2014	2013	2013	2013
EU	53%	11			4031	4845	40.9	25.5	6.0%	6.0%	12%
Austria	62%	25	235%	29%	1793	7500	33	22	1.8%	2.4%	7%
Belgium	78%	17	247%	17%	3932	1709	41	21	14.6%	12.8%	10%
Bulgaria	38%	68	35%	11%	2650	7587		29	0.0%	0.0%	31%
Croatia	52%	29	101%	69%	8568				0.0%	0.0%	18%
Cyprus	96%			0%	9556				0.0%	0.0%	28%
Czech Republic	28%	33	268%	17%	4008	9051	33	22	5.7%	10.0%	7%
Denmark	12%	6	141%	44%	2240	2570	31	21	6.2%	9.6%	8%
Estonia	12%	73	105%	10%	7167	10000	38	32	0.0%	9.0%	10%
Finland	49%	74	96%	30%	6453	1240	36	28	7.5%	0.0%	5%
France	48%	8	131%	10%	4294	5181	35	26	2.0%	6.1%	9%
Germany	63%	16	190%	10%	1261	1982	33	22	5.7%	5.5%	7%
Greece	62%	32	109%	11%	1523	2000	58	30	0.1%	0.0%	26%
Hungary	52%	61	104%	29%	2150	5987	41	24	0.0%	0.0%	21%
Ireland	89%	16	118%	9%	2541	3198	57	26	11.3%	17.7%	14%
Italy	77%	16	112%	7%	1541	1215	52	26	7.6%	5.5%	18%
Latvia	56%	62	221%	10%	9097	3185	50	30	0.0%	0.0%	23%
Lithuania	78%	100	79%	10%	5343	2093	50	36	0.0%	0.1%	21%
Luxembourg	97%	3	78%	245%	5185	10000	33		0.0%	0.0%	7%
Malta	104%			0%	9310	10000			0.0%	0.0%	16%
Netherlands	26%	75	162%	17%	1160	2488	41	21	13.1%	13.1%	7%
Poland	26%	27	104%	2%	1693	4850	44	24	1.0%	0.0%	12%
Portugal	74%	28	88%	7%	3848	3883	42	26	26.8%	0.0%	23%
Romania	19%		101%	7%	1460	3270	35	26	0.0%	0.0%	19%
Slovakia	60%	73	305%	61%	5900	9595	34	23	3.6%	6.2%	6%
Slovenia	47%	38	96%	65%	5403	5027	40	30	3.9%	5.1%	17%
Spain	70%	20	112%	3%	1164	10000	43	26	12.8%	12.4%	11%
Sweden	32%	16	14%	26%	2769	2766	32	24	10.7%	0.5%	4%
United Kingdom	46%	6	112%	6%	850	950	53	20	12.3%	10.2%	12%

Indicators	Energy efficiency and transport					Decarbonisation of the economy				Research, innovation and competitiveness			
	S12 - Primary energy consumption	S13 - Primary energy intensity of the economy	S14 - Final energy intensity in industry	S15 - Final energy consumption per m2 in residential sector	S16 - Average CO2 emissions from new passenger cars	S17 - Gap between non-ETS GHG emissions projections and target in 2020	S18 - Gap between latest proxy inventory of GHG emissions in the non-ETS sector and targets	S19 - RES share	S20 - GHG intensity of the economy	S21 - Share of energy and environment in total public civil R&D spending	S22 - Low-carbon technologies patents	S23 - Real unit energy costs in manufacturing sector (excl. Refining)	Source
Unit	2005 = 100	toe/M€10	final energy consumption (industry)/GVA (industry)	Final energy consumption per m2 in residential sector, climate corrected	g CO2/km	(% of 2005 base year emissions)	(% of 2005 base year emissions)	percentage share of gross final energy consumption	tons per million euro	%	number per million inhabitants	% of value added	
Year	2013	2013	2013	2013	2013	gap 2020	2014 proxy	2013	2013	2013	2011	2011	
EU	91.7	121	97	16	127	-	-	15%	346	7.1%	4.3	13.7%	Eurostat
Austria	98	104	115	18	132	4%	-7%	33%	260	5.0%	7.8	14%	Eurostat
Belgium	92	127	134	18	124	6%	-7%	8%	320	4.1%	2.0	20%	Eurostat
Bulgaria	86	428	272	10	142	-25%	-12%	19%	1466	1.4%	0.1	39%	Eurostat
Croatia	89	168	121	13	116	-20%	-19%	18%	606	0.6%	0.2		Eurostat
Cyprus	88	122	99	6	139	-49%	-31%	8%	471	1.0%	1.2	17%	Eurostat
Czech Republic	94	252	145	19	135	-17%	-2%	12%	825	5.3%	0.4	14%	Eurostat
Denmark	92	74	47	14	113	0%	-9%	8%	228	5.6%	48.3	8%	Eurostat
Estonia	120	386	147	25	147	-13%	-14%	26%	1285	7.0%	1.0	14%	Eurostat
Finland	98	176	243	16	132	0%	0%	37%	339	10.0%	8.4	13%	Eurostat
France	95	120	85	11	117	-4%	-9%	14%	240	9.2%	4.7	17%	Eurostat
Germany	95	113	82	20	136	-1%	-4%	12%	355	8.3%	10.8	9%	Eurostat
Greece	77	128	137	9	112	-27%	-21%	15%	568	4.4%	0.3	21%	Eurostat
Hungary	83	211	145	17	134	-40%	-27%	10%	570	9.3%	0.4	20%	Eurostat
Ireland	89	79	55	13	121	10%	-7%	8%	347	1.7%	1.5	6%	Eurostat
Italy	86	100	83	13	121	-5%	-13%	17%	283	6.6%	2.0	16%	Eurostat
Latvia	98	211	184	27	147	-10%	-7%	37%	533	17.7%		26%	Eurostat
Lithuania	72	178	114	18	140	-18%	-4%	23%	618	5.0%		48%	Eurostat
Luxembourg	90	105	125	14	133	21%	-2%	4%	277	4.9%	2.0	12%	Eurostat
Malta	80	117		3	119	-21%	-8%	4%	391	0.2%		9%	Eurostat
Netherlands	96	105	110	12	109	-5%	-18%	5%	312	2.9%	5.8	25%	Eurostat
Poland	106	239	127	19	138	-8%	-2%	11%	1012	8.5%	0.4	23%	Eurostat
Portugal	86	127	140	6	112	-26%	-20%	26%	388	5.6%	0.5	12%	Eurostat
Romania	84	232	144	28	132	-15%	-14%	24%	822	11.0%	0.1	15%	Eurostat
Slovakia	91	228	194	15	135	-17%	-12%	10%	617	4.0%	0.3	20%	Eurostat
Slovenia	96	192	130	18	126	-12%	-14%	22%	517	6.1%	1.0	14%	Eurostat
Spain	84	110	95	22	122	-2%	-12%	15%	310	6.3%	2.1	17%	Eurostat
Sweden	97	123	126	18	133	-11%	-16%	52%	146	6.3%	5.5	10%	Eurostat
United Kingdom	87	103	79	16	128	-3%	-7%	5%	305	6.3%	2.5	9%	Eurostat

4.2. Definition and sources for selected indicators

4.2.1. Macroeconomic relevance of energy sector

- *The Value Added of the energy sector:*
 - Definition: It calculates the value added generated by the supply of electricity, gas, steam and air conditioning over the total value added of the economy. Value added refers to the value of goods and services produced, less the value of consumption of intermediate inputs.
 - Source: Eurostat
- *The Employment in the energy sector*
 - Definition: the indicator covers all persons engaged in the supply of electricity, gas, steam and air conditioning. Employed persons are either employees or self-employed.
 - Source: Eurostat
- *Employment and turnover in the renewables energy sector*
 - Definition: it measures total direct and indirect employment in the renewable energy sector, as well as turnover.
 - Source: Euroserv'er, REN21
- *Consumer Prices Index:*
 - Definition: The Harmonised Indices of Consumer Prices (HICPs) indicator measures the change over a year of the prices of consumer goods and services acquired by households. In this exercise, it measures the relative contribution of energy to inflation for the countries and country groups for which it is produced. It is used to give an indication of the relative contribution of energy to price increases.
 - Source: Eurostat
- *Energy and transport related taxes, % of GDP*
 - It measures the amount of energy transport related taxes collected in each Member State, divided by GDP
 - Source: Commission services
 - Used in: Tax Reforms in the EU Member States 2015", European Economy, Institutional Paper, 8/2015,

4.2.2. Energy Security, solidarity and trust

- *Import dependency:*
 - Definition: Energy import dependency shows the extent to which a country relies upon imports in order to meet its energy needs. It is calculated based on the following formula also used by statistics institutes such as EUROSTAT: $\text{net imports} / (\text{gross inland consumption} + \text{bunkers})$. A negative dependency rate indicates a net exporter of energy, while a dependency rate in excess of 100% indicates that energy products have been stocked.
 - Source: Eurostat database, complete energy balances, annual data (nrg_110a)

- Link:
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_110a&lang=en
- *Country-specific supplier concentration index*
 - Definition: weighted average of the sum of the square of net imports of gas, oil, and other bituminous products divided by gross inland consumption)
 - Source: Eurostat
 - Used in: Commission Staff Working Document on an in-depth study of European Energy Security
 - Link:
http://ec.europa.eu/energy/sites/ener/files/documents/20140528_energy_security_study_0.pdf
- *Net imports of energy products as % of GDP*
 - Source: Eurostat [tipsen10]
 - Used as part of the auxiliary scoreboard under the macroeconomic imbalances procedure
 - Link:
http://ec.europa.eu/economy_finance/indicators/economic_reforms/eip/index.html#/auxiliary/
- *Member States' position as regards the N-1 criteria (2015)*
 - Definition: % of total demand that can be satisfied with the remaining infrastructure in the event of a disruption of the single largest gas infrastructure.
 - Source: Member States' Risk Assessments and Preventive Action Plans, JRC calculations.

4.2.3. *A fully-integrated internal energy market*

- *Interconnection capacity for electricity in 2014*
 - Source: European Commission based on ENTSO-E scenario outlook and adequacy forecast 2014
 - Used in Communication "Achieving the 10% electricity interconnection target"
 - Link: http://ec.europa.eu/priorities/energy-union/docs/interconnectors_en.pdf (page 5)
- *Market concentration index for power generation:*
 - Definition: sum of the square of the market shares of the three largest companies in the electricity sector, as measured by total generation capacity installed.
 - Source: European Commission calculations, based on Platts data
- *Market concentration index for wholesale gas supply:*
 - Source: ACER
 - Used in ACER/CEER monitoring on the internal electricity and gas markets

- Link: <http://www.acer.europa.eu/Events/Launch-of-the-ACERCEER-Monitoring-report-on-the-internal-electricity-and-gas-markets-/Documents/Public%20data%20underlying%20the%20figures%20published%20on%20ACER%20CEER%20Annual%20Market%20Monitoring%20Report%202013.pdf> (page 67)
- *Wholesale gas prices*
 - Definition: simple average of annual gas prices for a country, based on data and methodology developed in Quarterly report on European gas markets
 - Source: European Commission
 - Used in Quarterly gas markets report
 - Link to quarterly reports: <https://ec.europa.eu/energy/en/statistics/market-analysis>
- *Wholesale electricity prices:*
 - Source: European Commission
 - Used in Quarterly gas markets report
 - Link to quarterly reports: <https://ec.europa.eu/energy/en/statistics/market-analysis>
- *Electricity switching rates:*
 - Definition: Switching rates for electricity household consumers in Europe.
 - Source: ACER
 - Used in *ACER/CEER monitoring on the internal electricity and gas markets*
 - Link: <http://www.acer.europa.eu/Events/Launch-of-the-ACERCEER-Monitoring-report-on-the-internal-electricity-and-gas-markets-/Documents/Public%20data%20underlying%20the%20figures%20published%20on%20ACER%20CEER%20Annual%20Market%20Monitoring%20Report%202013.pdf> page 31
- *Gas switching rates:*
 - Definition: Switching rates for gas household consumers in Europe.
 - Source: ACER
 - Used in *ACER/CEER monitoring on the internal electricity and gas markets*
 - Link: <http://www.acer.europa.eu/Events/Launch-of-the-ACERCEER-Monitoring-report-on-the-internal-electricity-and-gas-markets-/Documents/Public%20data%20underlying%20the%20figures%20published%20on%20ACER%20CEER%20Annual%20Market%20Monitoring%20Report%202013.pdf> page 32
- *Cumulative market share of main electricity retailers*
 - Source: Eurostat
 - Link: http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_market_indicators
- *Cumulative market share of main gas retailers*
 - Source: Eurostat

- Link: http://ec.europa.eu/eurostat/statistics-explained/index.php/Natural_gas_market_indicators
- *Arrears on utility bills:*
 - Definition: Share of total population with arrears on utility bills
 - Source: SILC survey [ilc_mdcs07]
 - Link: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_mdcs07&lang=en
- *Inability to keep home adequately warm.*
 - Definition: Share of total population with inability to keep home adequately warm
 - Source: SILC [ilc_mdcs01]
 - Link: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_mdcs01&lang=en
- *Dwellings with leakages and damp walls:*
 - Definition: Share of total population living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames of floor
 - Source: SILC [ilc_mdho01]
 - Link: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_mdho01&lang=en
- *Energy poverty meter:*
 - Definition: average of share of population with arrears on utility bills, inability to keep home adequately warm, or living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames of floor.
 - Sources: SILC: [ilc_mdcs07, ilc_mdcs01, and ilc_mdho01]
- Share of energy in households' expenditures
 - Definition: Share of energy products in households' expenditure, as used for the calculation of HICP
 - Source: Eurostat [prc_hicp_inw]

4.2.4. Energy Efficiency and moderation of energy demand

- *Primary energy consumption:*
 - Definition: Primary energy corresponds to the Gross Inland consumption minus final non-energy consumption.
 - Source: based on EUROSTAT database and from DG ENER country datasheets released annually at: <https://ec.europa.eu/energy/en/statistics/country>
- *Final energy consumption:*
 - Source: Eurostat database, complete energy balances, annual data (nrg_110a)
- *Primary energy intensity of the economy:*

- Definition: Primary energy intensity gives an indication of the effectiveness with which primary energy consumption produces added value. It is defined as the ratio of Primary Energy Consumption to Gross Domestic Product.
- Sources: primary energy consumption from the above mentioned country datasheets. GDP data in euro, chain linked volumes 2010 from AMECO/ECFIN database
- *Final energy intensity in industry:*
 - Definition: final energy consumption of industry (including construction sector) divided by gross value added for industry, buildings and construction sectors
 - Sources: final energy consumption of industry (Eurostat [tsdpc320]) , gross value added (chain linked volumes 2010): AMECO data base of DG ECFIN
(http://ec.europa.eu/economy_finance/db_indicators/ameco/zipped_en.htm).
- *Final energy consumption per m2 in residential sector, at normal climate*
 - Definition (as in Odyssee): It is obtained by dividing the unit consumption per dwelling by the average size of dwellings (floor area). To avoid climatic variations, this unit consumption can also be calculated at normal climate, i.e. taking into account the energy consumption with climatic corrected using heating degree-days.
 - Source: Odyssee project, from the online database at below link or early updates through direct communication between Commission and ENERDATA, technical coordinator of the project.
<http://www.indicators.odyssee-mure.eu/energy-efficiency-database.html>
- *Average CO₂ emissions of new passenger cars*
 - Source: European Environment Agency
 - Used in: EEA publications: Monitoring CO₂ emissions from passenger cars and vans, progress towards achieving the Kyoto and EU2020 objectives
 - Link: <http://www.eea.europa.eu/highlights/new-cars2019-co2-emissions-well>

4.2.5. Decarbonisation

- *Gap between greenhouse gas emissions in the non-ETS sector and targets (GHG emission inventory data and projections)*
 - Source: EEA, European Commission
 - Used in Climate Action Progress Report
 - Link: http://ec.europa.eu/clima/policies/strategies/progress/documentation_en.htm
- *Renewable Energy Share (total, electricity, transport, heating and cooling)*
 - Source: Eurostat
 - Used in SHARES tool
 - Link: <http://ec.europa.eu/eurostat/web/energy/data/shares>
- *Greenhouse gas intensity of the economy*
 - Source: EEA, European Commission

- Used in Climate Action Progress Report; Staff Working Document.
- Link:http://ec.europa.eu/clima/policies/strategies/progress/documentation_en.htm
- *Greenhouse gas emissions per capita*
 - Source: EEA, European Commission, Eurostat
 - Used in Climate Action Progress Report; Staff Working Document.
 - Link:http://ec.europa.eu/clima/policies/strategies/progress/documentation_en.htm
- *Sectoral share of greenhouse gas emissions (2014 inventory)*
 - Source: EEA, European Commission,
 - Used in Climate Action Progress Report, Staff Working Document.
 - Link:http://ec.europa.eu/clima/policies/strategies/progress/documentation_en.htm
- *Share of ETS in total GHG emissions*
 - Source: EEA, European Commission,
 - Used in Climate Action Progress Report, Staff Working Document.
 - Link:http://ec.europa.eu/clima/policies/strategies/progress/documentation_en.htm

4.2.6. *Research, innovation and competitiveness*

- *Share of public energy and environment R&D expenditures in total public civil R&D:*
 - Source: Eurostat: Total GBAORD by NABS 2007 socio-economic objectives [gba_nabsfin07] (energy + environment / total civil)
 - Link: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=gba_nabsfin07&lang=en
- *Public R&D intensity support to energy*
 - Source: International Energy Agency
 - Link: <http://www.iea.org/statistics/RDDonlinedataservice/>
- *Split of public support to R&D in various energy fields*
 - Source: International Energy Agency
 - Link: <http://www.iea.org/statistics/RDDonlinedataservice/>
- *Absolute investment from the corporate sector in R&D per technology and country for 2011.*
 - Source: JRC Capacities Map
- *Low-carbon technologies patents applications (patents per million inhabitants):*
 - Source Eurostat: Energy technologies patent applications to the EPO by priority year [pat_ep_nrg] (Technologies or applications for mitigation or adaptation against climate change)
 - Link: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=pat_ep_nrg&lang=en
- *Levelised costs of electricity*

- Source: Based on cost estimates received from the National Technical University of Athens, E3MLab.
- Cost estimates are calculated using similar assumptions as regards fossil fuel prices, weighted average capital cost (WACC), and carbon prices. Assumptions on the projected evolution of investment costs and fossil fuel prices are in line with the ones considered in the context of the on-going update of the EU energy, transport and greenhouse gas emission trends Reference scenario that uses the PRIMES model managed at the National Technical University of Athens, E3MLab. The carbon price trajectory is the one derived from the 2013 EU Reference scenario.
- Link: http://ec.europa.eu/energy/sites/ener/files/documents/trends_to_2050_update_2013.pdf
- *Share of European manufacturers in annual world RE installations (wind):*
 - Source: Joint Research Centre (JRC) of the European Commission and Global Wind Energy Council (GWEC)
 - Sum of global installations by European manufacturers (JRC) divided by annual global installations (GWEC)
 - Source: JRC annual wind status report
- *Energy industrial prices:*
 - Source: Eurostat and IEA
 - Electricity prices for industrial consumers - bi-annual data (from 2007 onwards) [nrg_pc_205] and gas prices for industrial consumers - bi-annual data (from 2007 onwards) [nrg_pc_203]: data reported on the various consumption bands;
 - Link: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_pc_205&lang=en and http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_pc_203&lang=en
 - IEA Energy end-use prices: Electricity and gas prices for industry, Total prices, including excise taxes but excluding VAT
 - Link: http://data.iea.org/ieastore/product.asp?dept_id=101&pf_id=401
- *Real Unit energy costs:*
 - Definition: This indicator measures the amount of money spent on energy sources needed to obtain one unit of value added for the manufacturing sector, excluding the refinery sector.
 - Source: European Commission
 - Used in Energy Economic Developments in Europe 2014
 - Link: http://ec.europa.eu/economy_finance/publications/european_economy/2014/pdf/ee1_en.pdf page 24

4.2.7 Cohesion Policy investments supporting the Energy Union

- *Progress in Cohesion Policy investments supporting the Energy Union:*

- Definition: This indicator, to be provided from autumn 2016 onwards, will divide the amount of ERDF and CF allocations allocated to specific projects by the end of each year, or a certain cut-off date, by the total amount of planned allocations 2014-2020 for ERDF and CF investments supporting the Energy Union in a given country, i.e. the project selection rate.
- Source: European Commission, based on Annual Implementation Reports from Member States
- Link: <https://cohesiondata.ec.europa.eu/>