EUROPEAN
COMMISSION

Brussels, 1.2.2017
SWD(2017) 32 final

Second Report on the State of the Energy Union

COMMISSION STAFF WORKING DOCUMENT

Monitoring progress towards the Energy Union objectives – key indicators

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Contents

1. INTRODUCTION

The aim of the Energy Union[1] is to ensure that European consumers – households and businesses – have secure, affordable, competitive and sustainable energy. It consists of five closely related and mutually reinforcing dimensions, progress against which is to be measured through key indicators.

In October 2014, the European Council[2] concluded that a reliable and transparent governance system, without any unnecessary administrative burden, should be developed to help ensure that the Union meets its energy policy goals. It emphasised that this governance should involve systematic monitoring of key indicators of an affordable, safe, competitive, secure and sustainable energy system, facilitate the coordination of national energy policies and foster regional cooperation between Member States.

The proposal for a Regulation on the Energy Union governance[3] takes account of the Council conclusions from October 2014. The proposed Regulation provides that every second year thereafter the Commission shall assess progress at Union level towards meeting the Energy Union objectives, in particular on the basis of the integrated national energy and climate progress reports, other information reported under the governance, the indicators and European statistics.

As part of the first State of the Energy Union package from November 2015[4], the Commission produced a staff working document (SWD)[5] proposing an overall monitoring approach and methodology, supported by initial analysis. The document also put forward a first set of specific indicators to monitor and assess progress on meeting the Energy Union objectives.

This SWD is an update of the one presented in 2015, building on exchanges with and feedback from the Member States and taking account of stakeholder opinions collected from related reports and events. The current set of indicators may be refined in the years to come depending on the availability of data for new, more suitable indicators, and on the development of new indicators able to provide more accurate evidence on particular policy lines or sub-sectors.

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1 *Energy Union package – a framework strategy for a resilient Energy Union with a forward-looking climate change policy* (COM(2015) 80 final); http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015DC0080&from=EN

2 EUCO 169/14, Brussels, 24 October 2014

3 COM(2016) 759 final

4 https://ec.europa.eu/priorities/energy-union-and-climate/state-energy-union_en

5 Monitoring progress towards the Energy Union objectives - Concept and first analysis of key indicators (SWD(2015) 243 final); http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1449767808781&uri=CELEX:52015SC0243

2. OVERALL APPROACH AND METHODOLOGY

Key points

- The purpose of defining a set of energy and climate indicators and reflecting them in a scoreboard is threefold:
  - to streamline the monitoring process and ensure coherence in the assessment of energy and climate policies;
  - to provide a commonly-agreed metric to support policy-making process by monitoring progress on EU energy and climate objectives;
  - to summarise, on a scoreboard, latest data and recent changes affecting the most relevant aspects of the five dimensions of the Energy Union.
- This SWD updates the 2015 SWD on *Monitoring progress towards the Energy Union objectives*, published as part of the first *State of the Energy Union* package.
- The overall aim of this SWD and the selected key indicators is to develop a sound, robust monitoring tool that provides a factual snapshot of the situation across the EU and in the Member States and identifies potential discrepancies *vis-à-vis* the achievement of Energy Union objectives. More specifically, this is intended as a practical tool for use by the Commission and Member States in the assessement of the implementation of future national integrated energy and climate plans.
- A revised scoreboard approach has been taken. For each Energy Union dimension, the scoreboard summarises key indicators for the EU and each Member State, showing the indicator values in the most recent year for which data is available and changes over a set period of time.

In 2015, the Commission produced country factsheets and a SWD on monitoring progress towards the Energy Union objectives and included these in the first *State of the Energy Union* package. These documents presented indicators and statistical data relating to each dimension of the Energy Union. This was a first attempt to aggregate a set of relevant key indicators to quantify and measure progress on EU energy and climate objectives and targets.

Given the wide range of issues to be covered, the methodology combines a focus on some key indicators, summarised in a scoreboard, with additional supporting indicators or analysis relating to the five dimensions. The proposed indicators assess progress on:

1. **energy security**: monitoring the relative dependency of the Member States and the EU as a whole on net imports of main energy carriers and on specific trade partners, and the overall reliability of the energy system (i.e. its overall ability to supply energy without interruption);
2. **the internal energy market**: monitoring progress towards an EU internal energy market in terms of competition, cross-border trade and consumer empowerment;
3. **energy efficiency**: monitoring progress on the 2020 and 2030 targets for moderating primary and final energy demand and in terms of energy savings and energy intensities in various sectors, including transport;
4. **decarbonisation**: monitoring progress on the 2020 and 2030 targets on greenhouse gas (GHG) emission reductions, renewable energy share in gross final energy consumption and changes in GHG intensity; and
5. **research, innovation and competitiveness**: monitoring research, innovation and development activities relating to the European Strategic Energy Technology Plan (SET-Plan)[6] and Energy Union priorities; monitoring energy prices and cost differentials between the EU and its major trading partners.

The 2015 SWD and the key indicators were intended to form the basis of a commonly agreed monitoring tool, using credible, publicly available data sources and methodology, and providing a factual snapshot of the situation across the EU and potential discrepancies vis-à-vis Energy Union objectives.

This SWD builds on those initial steps, takes account of suggestions from Member States and other stakeholders, and gives an update on the basis of new data. The changes as compared with the previous SWD can be summarised as follows:

- The list of the key indicators is slightly modified; a few key indicators are replaced by new ones, while a few others are downgraded as supporting indicators and/or relocated in another Energy Union dimension. Besides, some other indicators are based on different data inputs.

[6] https://ec.europa.eu/energy/en/topics/technology-and-innovation/strategic-energy-technology-plan

- the list of key indicators has been amended slightly; a few have been replaced by new ones, some have been downgraded to supporting indicators and/or relocated to another dimension and others are based on different data inputs;
- where possible, the indicators have been better adjusted to metrics and data sources already used for monitoring in specific policy areas;
- some indicators are provisional, pending the search for better solutions based on credible, publicly available data. The Commission services are already redrafting some of these (see below), but we have included them here as the best currently available options and in view of the relevance of the topic in question to the overall Energy Union strategy;
- where a key indicator relates to an EU or Member State target, it is presented and assessed in terms of progress towards that target and no longer in terms of progress in previous years;
- although included for one particular dimension, many indicators have an impact on or influence another dimension, so their cross-dimensional contribution is also considered in the analysis, including by means of additional supporting indicators;
- the assessment of the indicators focuses more on how they have changed over time for each Member State and the values in the most recent year for which they are available;
- changes in a specific indicator over a set period of time are assessed in several ways: relative or absolute change, average annual change or average value over the period. The approach has been tailored to the needs of each indicator and relevance for policy-making; and
- the scoreboard summarises key indicators by dimension for the EU and each Member State, showing the most recent available value of the indicator and changes over a set period of time.

Obviously, no set of indicators or scoreboard can on its own provide a comprehensive assessment of progress on the Energy Union targets and objectives. This is due to several well-known challenges in properly reflecting reality Europe-wide, policy objectives that cannot easily be pursued at country level, policies that cannot easily be assessed in quantitative terms and areas in which data availability is currently an issue.

Acknowledging these challenges, this SWD also highlights where there is a need for new indicators, better statistical data collection and additional qualitative assessment.

2.1. RATIONALE FOR THE SELECTED INDICATORS

The purpose of defining a set of energy and climate indicators and reflecting them in a scoreboard is threefold:

- to streamline the monitoring process and ensure coherence in the assessment of energy and climate policies;
- to provide a common metric for monitoring progress on EU energy and climate objectives; and

- to summarise latest data and recent changes affecting the most relevant aspects of the five dimensions of the Energy Union.

For each dimension, a limited number of indicators is selected for inclusion in the overall scoreboard. In addition, supporting indicators are presented to provide a more comprehensive assessment for each dimension or to reveal cross-dimensional impacts.

2.2. An overview of selected indicators to monitor progress towards the Energy Union objectives

We have identified a set of 24 main indicators that address all Energy Union dimensions and provide a solid basis for monitoring progress on the commonly agreed objectives. These are supported by additional indicators and information intended to provide a fuller and more detailed picture of the energy sector and how it is changing.

Table 2.1 maps the main and supporting indicators. Detailed definitions of each main indicator are presented in section 2.3, while details on data sources and formulas used to build the set of indicators are presented in Annex 1. The assessment on the basis of selected indicators is presented in chapter 3.

Table 2.1. Main and supporting indicators for monitoring progress towards Energy Union objectives

Energy Union dimension	Main Indicators	Supporting indicators
Energy security, solidarity and trust	**SoS1: Net import dependency**	Net import dependency - natural gas Net import dependency -crude oil and NGL[7] Net import dependency - hard coal Nuclear imports and dependency
	SoS2: Aggregate supplier concentration index	Supplier concentration index - Natural gas Supplier concentration index - Crude oil and NGL Supplier concentration index - Hard coal
	SoS3: N-1 rule for gas infrastructure	
A fully integrated internal energy market	**IM1: Electricity interconnection capacity**	
	IM2: Market concentration index for power generation	Cumulative market share in power generation, main entities Cumulative market share in power capacities, main entities
	IM3: Market concentration index for wholesale gas supply	Cumulative market share of main entities bringing gas in the country
	IM4: Wholesale electricity prices	
	IM5: Wholesale gas prices	

[7] Natural gas liquids

	IM6: Annual switching rates - electricity (household customers)	Market performance indicator (MPI), retail electricity services Share of household customers with smart electricity meters
	IM7: Annual switching rates - gas (household customers)	Market performance indicator (MPI), retail gas services Share of household customers with smart gas meters
	IM8: Energy affordability - energy expenditure share in final consumption expenditure for the lowest quintile	Harmonised index of consumer prices - weight of electricity, gas and other fuels in total household expenditure Inability to keep home adequately warm (share in total population at risk of poverty) Household electricity prices Household gas prices
Energy efficiency and moderation of demand	**EE1: Primary energy consumption**	Primary energy intensity
	EE2: Final energy consumption	Final energy consumption of main economic sectors, i.e. industry, transport, households and services
	EE3: Final energy intensity in industry	
	EE4: Final energy consumption per square meter in residential sector, climate corrected	Final energy consumption of households (per capita)
	EE5: Final energy consumption in transport	Share of collective transport in all passengers' transport Final consumption in transport vs. passengers and freight activity
	EE6: Final energy intensity in services sector	
Decarbonisation of economy	**DE1: GHG emissions reductions (base year=1990)**	Share of ETS and ESD emissions Land use, land-use change and forestry (LULUCF) Sectorial share of GHG emissions
	DE2: Gap between GHG emissions projections and 2020 target in Effort Sharing sectors	
	DE3: Gap between latest (proxy) inventory of Effort Sharing emissions and interim targets	
	DE4: GHG intensity	GHG per capita GHG intensity of power & heat generation Average CO2 emissions from new cars
	DE5: Renewable energy share	RES share transport RES share electricity RES share heating & cooling Fossil fuels avoidance by RES GHG emissions avoided due to RES
Research, innovation and competitiveness	**RIC1: Public investments on Energy Union related R&I (%GDP)**	Public investments on Energy Union related R&I (% GBAORD) Estimates of total (public and private) and private investments on Energy Union related R&I Patents in Energy Union R&I priorities (also normalised by GDP) Levelised cost of renewable electricity Turnover of the EU renewable energy industry Worldwide investments in renewable energy Cohesion policy investments supporting the Energy Union
	RIC2: patents related to Energy Union R&I priorities (per inhabitant)	
	RIC3: Real unit energy costs in the manufacturing sector (excl. refining)	

		Covenant of Mayors: signatories and GHG emission reductions Electricity and gas wholesale and retail prices for industrial customers – comparison with main international players

2.2.1. ENERGY SECURITY, SOLIDARITY AND TRUST

Despite the considerable progress made in recent years to enhance Europe's energy security, there are still serious vulnerabilities to potential energy supply shocks.

In particular, the 2030 climate and energy framework referred to the need to monitor the diversification of energy imports and the share of indigenous sources used for energy consumption over the period to 2030.

Therefore, security of supply is a continuous priority of the Energy Union strategy and the following indicators are proposed to monitor it:

- **SoS1: Net import dependency** – this indicator measures the level of total net imports as a proportion of total gross inland consumption and the energy consumption of maritime bunkers (i.e. what is consumed in a country or region over a year). The indicator is based on Eurostat energy statistics. [8]

This main indicator is accompanied by three supporting indicators reflecting net import dependency for hard coal, crude oil and NGL and natural gas.

In the assessment of this dimension, we provide complementary information on patterns of trade in petroleum products.

As imports of uranium and nuclear fuels are not included in energy statistics as such, we provide complementary information on the relevant EU import routes, nuclear electricity production and operational and under-construction reactors in the Member States.

Net import dependency cannot on its own capture all determinants of Member States' and the EU's vulnerability to energy supply shocks. In particular, it does not tell us about the degree of diversification of import sources or the relative significance of import and fuel sources in the energy mix.

Therefore, we use a country-specific supplier concentration index (SCI) to complement the analysis on energy security.[9]

- **SoS2: Aggregate supplier concentration index –** this indicator measures the importance of total imports of main energy carriers to a Member State from suppliers outside the European Economic Area (EEA), thus disregarding flows within the EEA in the volume of a Member State's imports.[10] The indicator is based on Eurostat statistics on imports and exports by country of origin, and energy balances.

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8 Net import dependency as defined above may reach values above 100 % in certain cases. This indicator is taken from Eurostat database (Table [tsdcc310]).

9 This indicator was used in the in-depth study accompanying the European Energy Security Strategy (COM(2014) 330).

10 Norway is the only EEA country exporting significant volumes of energy (gas and oil) to the EU.

The aggregate SCI is accompanied by specific SCIs of the main energy carriers, i.e. hard coal, crude oil and NGL, and natural gas. The methodology for calculating SCIs is explained in section 3.1.2.

The SCIs take into account suppliers from outside the EEA only, because non-EU EEA countries are not a potential vulnerability from an energy security perspective, as they share common obligations within the internal market.

The quality of the input data from statistics is critical to the assessment of the SCIs. Currently, the relevant official statistics suffer from some limitations when it comes to identifying sources of imports, especially for natural gas. The exclusion of intra-EU transit is another challenge, especially for natural gas, but also for hard coal import/export statistics.

The Energy Union strategy calls for specific attention to be paid to the security of gas and electricity supply.

- **SoS3: N-1 rule for gas infrastructure** – N-1 is an indicator of infrastructure adequacy, as it tests the resilience of the system in ensuring that gas demand on extremely cold days can be covered even if the largest infrastructure fails.[11] It is calculated by the Member States.

As yet, there is no full agreement on what indicators to use to assess security of electricity supply; this makes it difficult to compare Member States' performance effectively[12]. Therefore, in order to ensure transparency and comparability across the EU, the Commission's recent proposal for a Regulation on risk preparedness[13] defines two harmonised security of supply indicators: 'expected energy non-served' (EENS – expressed in GWh/year) and 'loss of load expectation' (LoLE – expressed in hours/year). The European Network of Transmission System Operators for Electricity (ENTSO-E) will calculate the proposed indicators annually for all Member States on the basis of a common methodology. The Agency for the Cooperation of Energy Regulators (ACER) should use those indicators when reporting on Member States' performance in the area of security of supply in its yearly electricity market monitoring reports. These new indicators will be taken into account at future updates of this SWD.

2.2.2. A FULLY INTEGRATED INTERNAL ENERGY MARKET

The 2030 climate and energy framework referred to the need to monitor:

- the deployment of smart grids and interconnections between Member States against the agreed 2020 objective of electricity interconnections of at least 10 % of national installed production capacity, moving towards 15 % by 2030;

[11] Regulation (EU) No. 994/2010 requires Member States to comply with the N-1 standard.

[12] Annual report on the results of monitoring the internal electricity markets in 2015, ACER (September 2016); http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Market%20Monitoring%20Report%202015%20-%20ELECTRICITY.pdf.

[13] Proposal for a Regulation on risk preparedness in the electricity sector and repealing Directive 2005/89/EC (COM(2016) 862 final).

- intra-EU coupling of energy markets, building on the liberalisation of gas and electricity markets already achieved under EU legislation; and

- competition and market concentration on wholesale and retail energy markets at both national and (for regions with functioning coupling) regional level.

Regarding interconnections, the selected indicator measures electricity interconnection capacity as a percentage of installed capacity. No specific indicator is used in this SWD as regards gas interconnections, but the N-1 rule for gas infrastructure (see above) offers a good proxy. In addition, the implementation of projects of common interest (for gas and electricity) remains key and should be monitored carefully. No readily available indicator could be identified as regards the deployment of smart grids; this will require additional work.

- **IM1: Electricity interconnection** – this indicator uses the same approach as proposed last year, i.e. the interconnection capacity of a given Member State as a proportion of its total generation capacity. This is based on the agreed methodology for tracking progress towards the target of 10 % interconnection by 2020, as endorsed by the European Council.

However, differences between Member States in terms of geographical location and structure of energy mix and supply mean that a case-by-case approach based on a thorough assessment of bottlenecks, taking into account costs, is needed when looking at the 2030 perspective. Therefore, the Commission has set up an expert group[14] which will provide it and the regional cooperation structures[15] with technical advice on how best to translate the target of 15 % interconnection by 2030 into regional, country and/or border-level targets.

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

- **IM2: Market concentration index for power generation –** this indicator is based on the Herfindahl Hirschman Index (HHI) and 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; and

- **IM3: Market concentration index for wholesale gas supply –** this indicator is also based on the 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.

These indicators measure the degree of competition on wholesale energy markets: the lower the values, the higher the degree of potential competition.

Implementing the internal energy market objectives of the Energy Union requires us to take account of additional factors, e.g. it is important to monitor wholesale gas and electricity price developments across Member States.

[14] Commission Decision of 9 March 2016 setting-up a Commission expert group on electricity interconnection targets (C/2016/1406); http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.C_.2016.094.01.0002.01.ENG&toc=OJ:C:2016:094:TOC.

[15] Regional groups for electricity established under Regulation (EU) No 347/2013 (TEN-E Regulation) and the relevant high level groups for energy infrastructure.

- **IM4: Wholesale electricity prices –** this indicator presents the electricity prices available on wholesale markets, on the basis of data and methodology developed in the Commission's quarterly reports on European electricity markets.[16]

- **IM5: Wholesale gas prices –** this indicator presents annual average gas prices in wholesale markets in a country, on the basis of data and methodology developed in the Commission's quarterly reports on European gas markets.[17]

The use of such prices as part of the monitoring exercise is subject to some limitations. As regards gas, available price data are not fully comparable across Member States, as hub prices may be used for some while estimates of average import prices are used for most of the others. Moreover, beyond individual price developments, it is also essential to monitor potential convergence in European prices. A short assessment of energy price convergence and energy flows across borders is presented in the next chapter.

The two following indicators are good proxies to assess the degree to which consumers are empowered 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:

- **IM6: Annual switching rates on electricity retail markets –** this indicator measures the percentage of final electricity household consumers changing suppliers in a given year.

- **IM7: Annual switching rates on gas retail markets –** this indicator measures the percentage of final gas household consumers changing suppliers in a given year.

Both indicators are based on data from ACER's annual market monitoring reports.[18]

A broader set of indicators could be considered for the monitoring of energy retail market functioning[19] in areas such as customer satisfaction, market condition or distribution system operator services. Many national regulators are analysing these areas, but no source could be identified that covers such indicators in a consistent manner so as to allow analysis across all Member States.

The Commission services have developed two composite indicators assessing the overall market performance of gas and retail markets and these will be presented in the next chapter as supporting information. They are used for consumer market monitoring surveys[20] as composite indices taking into account key aspects of consumer experience.

In addition, the analysis in the next chapter includes more specific considerations around smart metering deployment. Smart metering can positively affect consumer engagement with the market and ultimate energy consumption. Its deployment is measured as the

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16 https://ec.europa.eu/energy/en/statistics/market-analysis
17 Idem 16
18 http://www.acer.europa.eu/en/electricity/market%20monitoring/pages/default.aspx
19 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
20 Surveys by the Commission's Directorate-General for Justice and Consumers (DG JUST); http://ec.europa.eu/consumers/consumer_evidence/consumer_scoreboards/market_monitoring/index_en.htm

percentage of final electricity and gas household consumers equipped with a smart meter, as reflected in ACER's annual market monitoring reports.

Developing the Energy Union also means protecting vulnerable consumers better and addressing energy poverty. Given the importance of these issues, in 2007 the Commission established the Citizens' Energy Forum, under which a working group on vulnerable consumers has been established[21].

Estimates of energy poverty vary according to how it is defined. Since there is no single agreed definition at EU level, it is currently not possible to produce an appropriate single indicator. Also, energy poverty is driven by a variety of factors (low income, high energy bills relative to income, poor energy efficiency of the building envelope, etc.), so it is a complex, multi-faceted concept which can be adequately captured only using a set of indicators covering economic, social and technical aspects. Currently, countries take two main approaches to measuring energy poverty:

- expenditure-based: metrics that capture the affordability of (adequate) energy services or inadequate consumption using financial information; and

- consensual: self-reported indicators provide an effective way of understanding perceived energy poverty and more explicit insights than quantitative metrics.

In May 2016, the Commission released a study proposing a set of indicators aiming to provide better quantitative assessment of energy poverty in the EU.[22] These require more refined statistical data collection than is currently available in a uniform way across the Member States.

In *Clean energy for all Europeans*[23], a recently released package of energy measures, the Commission proposed a new approach to protecting vulnerable consumers which includes helping Member States to reduce the costs of energy for consumers by supporting energy efficiency investments. In line with its efforts to empower and protect consumers, the Commission also proposes certain procedural safeguards before a consumer can be disconnected. In addition, as part of the Energy Union governance process, Member States will have to monitor and report on energy poverty, while the Commission will facilitate the exchange of best practices[24].

In order to develop energy poverty metrics further and increase awareness and debate, the Commission will set up an EU Observatory on Energy Poverty by the end of 2017.

The 2015 SWD proposed a consensual energy poverty index, compiled by averaging three indicators collected for Eurostat's annual survey of statistics on income and living conditions (SILC)[25]:

- the proportion of the population with arrears on energy bills;

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21 For more information on the Citizens' Energy Forum and the working group on vulnerable consumers, see https://ec.europa.eu/energy/en/events/citizens-energy-forum-london

22 Selecting indicators to measure energy poverty, final report (May 2016); http://ec.europa.eu/energy/en/studies

23 https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition

24 COM(2016) 860 final

25 http://ec.europa.eu/eurostat/web/microdata/european-union-statistics-on-income-and-living-conditions

- ability to keep the home adequately warm; and
- population living in dwellings with leakages and damp walls.

Following feedback from Member States and other stakeholders, this indicator has been changed to the following ‘energy affordability index’ which is a temporary solution until the above work delivers a better, commonly agreed metric for monitoring energy poverty:

- **IM8: Energy affordability** – this indicator measures energy-related expenditure as a proportion of total household expenditure for the lowest quintile (i.e. poorest 20 %) of population. It is based on Eurostat's Household Budget Survey (HBS), for which expenditure data are collected every five years. DG Energy worked with national statistical institutes and Eurostat on an *ad hoc* data collection to gather all the necessary information to complete the data series of energy affordability.

The harmonised index of consumer prices (HICP) for energy-related expenditure is presented as a supporting complementary indicator. It estimates the proportion of total household expenditure accounted for by energy products and is used by central banks to calculate inflation. This is useful additional information as regards potential vulnerabilities, e.g. to energy price shocks.

Another supporting indicator is inability to keep the home adequately warm (as measured for the SILC), expressed as the proportion of the total population at risk of poverty (i.e. below 60 % of the median national income).

Electricity and gas prices for residential consumers are also presented as additional information.

2.2.3. ENERGY EFFICIENCY AND MODERATION OF DEMAND

"Energy efficiency first" is a key principle of the Energy Union – this proposal puts it into practice. The EU as a whole has an indicative 2020 target of a 20 % reduction of primary energy consumption compared to projections and the 2030 climate and energy framework is currently negotiated by the European institutions.

In the *Clean energy for all Europeans* package, the Commission proposes a 30 % binding EU target for 2030, thereby recognising the importance of energy efficiency and aiming to provide Member States and investors with a longer-term perspective for adapting their strategies to greater energy efficiency.

The Energy Efficiency Directive[26] translates the energy efficiency targets into maximum levels of primary and final energy consumption by 2020 and 2030. Therefore, the first elements to be monitored are primary and final energy consumption.

- **EE1: Primary energy consumption** – this indicator monitors changes in primary energy consumption[27] in the EU as a whole and in the Member States.

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[26] Directive 2012/27/EU and COM(2016) 761 final.

[27] Primary energy corresponds to gross inland consumption minus final non-energy consumption.

Primary energy intensity is also assessed as a supporting indicator, providing complementary information on the (potential) decoupling of energy consumption from economic growth.

- **EE2: Final energy consumption** – this indicator monitors changes in final energy consumption in the EU as a whole and in the Member States.

However, energy consumption is influenced by several drivers other than energy efficiency improvements, such as economic growth, structural changes in the economy, fuel shifts, climate, etc. The limitations of available official statistics mean that producing a robust breakdown of the impact of sectoral and economy-wide energy efficiency is still a challenge. Current attempts to do so include EU-funded projects using decomposition analysis (e.g. the Odyssee-MURE[28] project – see assessment chapter below), but these have yet to establish a widely agreed methodology. Decomposition analysis will continue to be scrutinised for inclusion on the list of Energy Union indicators, including through ongoing work by the Commission's Joint Research Centre[29].

Monitoring sectoral energy-consumption and energy-intensity developments can provide an indication of progress in terms of energy efficiency by revealing the extent to which energy consumption is decoupled from economic growth, or the specific energy used in producing a unit of GDP or value added. Therefore, energy intensities in the industrial, residential and services sectors and final energy consumption in transport are taken into account as main indicators.

- **EE3: Final energy intensity in industry -** this indicator represents energy consumption for a unit of value added in industry and the construction sector. It is calculated by dividing the sectors' final energy consumption by their total gross value added (GVA) at constant 2010 prices. Energy intensity in industry reflects potential specialisation in energy-intensive sectors and the effort to decouple industrial growth from energy consumption: the lower the value, the more energy-efficient the use of energy for the unit of GVA.

- This indicator may be refined by also measuring final energy consumption per amount of physical output, e.g. so as to capture potential structural changes in the sector, which are not easily observable by comparing energy consumption with value added. This option is still under consideration for a future revision.

- **EE4: Final energy consumption per square metre in the residential sector, climate-corrected** – this indicator measures specific energy consumption per m^2 of floor area in residential buildings. The figures are climate-corrected in order to provide a more accurate assessment of trends over time in a sector in which heating (and cooling) still accounts for the largest part of energy consumption. The indicator can show the relative efficiency of the building stock and energy equipment: lower values indicate that the building sector has become more energy-efficient.

[28] More information on the decomposition analysis performed under the Odyssee-MURE project is available on the project website at: http://www.indicators.odyssee-mure.eu/

[29] The decomposition analysis developed by the Commission's Joint research Centre is described in the Energy Efficiency Progress report (COM(2017)56)

In addition to these indicators, it might also be relevant to monitor the uptake of energy-efficient equipment. However, indicators on the market diffusion of efficient heating or appliances, for example, remain scarce[30] and could not be compiled in the context of this SWD. The Commission's new EU Buildings Stock Observatory may in time provide more details, which will be considered for future updates.

- **EE6: Final energy consumption in transport -** this indicator represents the final energy consumption in transport sector.

  Transport related issues are covered in the energy efficiency and moderation of demand dimension of the Energy Union strategy.

Data on specific energy intensity for passenger and freight transport are needed to compile a more accurate picture of transport activities and related energy consumption, and enable in-depth analysis of energy-efficiency developments in transport. These two indicators correspond, respectively, to energy used (expressed in tonne of oil equivalent) per passenger-kilometre and tonne-kilometres travelled within a Member State: the lower the value, the more energy-efficient the transport sector. However, Member States do not provide Eurostat with a breakdown of final energy by passenger and freight transport. Therefore, currently it is not possible to have the energy intensity of passengers and freight traffic activity based on statistical data. Also, the methodology for reporting traffic activity does not always follow the territoriality principle, which renders the calculation of the intensity indicators even more difficult.

Pending the availability of more disaggregated statistical data, final energy consumption in transport is proposed as a main indicator, accompanied by information on passenger and freight activity, and on collective passengers transport as a share of total passenger transport.

Variations in final energy consumption in transport over the period are also assessed in comparison with GDP developments and changes in passenger transport (passenger-km) and freight transport (tonne-km). A reduction of energy consumption in transport compared to an increase in passengers and freight transport activity suggests a more energy-efficient use of transport means. In addition, we assess the relative importance of public transport (trains, coaches, buses and trolley buses) in passenger transport.

In addition to pure energy-efficiency considerations, information is collected on decarbonisation in the transport sector in terms of the average CO_2 emissions of new cars. This indicator is further assessed for the 'decarbonisation' dimension, supporting the main indicator (GHG intensity of the economy).

This analysis should include more indicators on e-mobility, the deployment of hybrid cars and the availability of alternative fuels and related infrastructure. Currently, however, available data are highly dispersed and some important data are missing or potentially unreliable. A first step in this direction has been the creation of the European Alternative Fuels Observatory[31] as the reference point for information about alternative fuels in Europe.

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[30] See, for instance, http://www.indicators.odyssee-mure.eu/market-diffusion.html

[31] Source: http://www.eafo.eu/

- **EE5: Final energy intensity in the services sector** – this indicator represents energy consumption for a unit of GVA in the services sector. It is calculated by dividing the sector's final energy consumption by its total GVA at constant 2010 prices: the lower the value, the more efficient the sector is in producing a unit of GVA.

The use of better energy-efficiency indicators will be facilitated by Eurostat's work to develop statistical data collections on sectorial energy consumption by type of end-use. Data are already collected on energy consumption in households by type of end-use (heating, lighting, cooking, etc.) and reports are available from twelve Member States[32].

2.2.4. DECARBONISATION

The decarbonisation dimension of the Energy Union is very much driven by efforts towards meeting the EU's and Member States greenhouse gas emissions (GHG) reduction and renewable energy targets.

The following indicator is proposed to monitor progress towards the EU's 2020 and 2030 decarbonisation targets and to provide information on changes in Member States' GHG emissions:

- **DE1: GHG emission reduction** – this indicator represents total GHG emissions as considered for the EU's 2020 climate targets. It covers total GHG emissions, excluding LULUCF but including indirect CO_2 emissions and CO_2 emissions from international aviation.

Additional information is provided by several supporting indicators showing the proportions of EU emissions trading system (ETS)/effort-sharing emissions, LULUCF emissions and a breakdown of GHG emissions by economic sectors.

The ETS is the key instrument in the EU for limiting GHG emissions in the power sector, energy-intensive industries and EU domestic aviation. While the ETS provides an EU-wide cap, the Effort-Sharing Decision (ESD) sets national binding targets to be met through mitigation action in the effort-sharing sectors (transport, buildings, small businesses and services, agriculture and waste).

In line with the EU reduction target of 30 % by 2030 (as compared with 2005) in non-ETS sectors, the Commission has recently presented a proposal for an Effort-Sharing Regulation[33] that sets binding national annual targets for 2021-2030 for those sectors. The following indicators are used to monitor progress in the sectors not covered by the EU ETS:

- **DE2: Gap between GHG emission projections and 2020 target in the Effort-Sharing sectors** – this indicator monitors each Member State's progress towards its 2020 GHG emission target. The Member States estimate projections for

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[32] Eurostat data collection on energy consumption in households by type of end-use. Reporting for reference years 2013 and 2014 and the provision of historical series up to 2010 are voluntary. Mandatory reporting starts with reference year 2015. For more information, see http://ec.europa.eu/eurostat/web/energy/data

[33] Proposal for a Regulation of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 for a resilient Energy Union and to meet commitments under the Paris Agreement (Effort-Sharing Regulation proposal) (COM(2016) 482 final).

2020 in the effort-sharing sectors on the basis of existing measures. The ESD sets the EU 2020 target and binding targets from 2013 to 2020 for each Member State. The gap is expressed as a percentage of base year (2005) emissions.

- **DE3: Gap between latest proxy inventory of effort sharing sector greenhouse gas emissions and targets.** This indicator measures the gap between the latest approximated inventory emissions available[34] and its respective effort sharing target expressed as a percentage of base year emissions (2005).

Another relevant indicator from the decarbonisation perspective is the GHG intensity of the economy, which is also used as a global sustainability indicator.

- **DE4: Greenhouse gas intensity of the economy:** this indicator represents Member States' emissions against Gross Domestic Product. Lower the value, the less carbon-intensive the economy[35].

Additional information and further analysis is provided as regards GHG emissions *per capita* and those relating to power & heat generation, and CO_2 emissions from new cars.

The increased use of renewable energy has triggered a decoupling of GHG emissions from economic growth and progress towards a low-carbon economy. The European Union has established a common target of 20 % renewable energy share in gross final energy consumption by 2020. Within the 2030 Framework for energy and climate, the European Council agreed to an EU-level binding target of at least 27 % renewable energy consumed in the EU by 2030. This target will be met through the contributions of individual Member States, guided by the need to deliver collectively for the EU.

Therefore, monitoring progress on renewable energy penetration gives an important indication of the extent of decarbonisation of the economy.

- **DE5: Share of renewable energy in percentage of gross final energy consumption:** this indicator monitors progress towards renewable energy developments as it is defined under the Renewable Energy Directive and statistically collected by Eurostat[36].

The gap to the 2020 targets is the difference between the target and the actual renewable energy share in the year. A negative gap means the overachievement of the target.

The overall renewable energy (RES) share indicator is complemented with information regarding RES share developments at sectorial level, namely in electricity, transport and heating and cooling sectors.

The deployment of renewable energy has a major contribution to the decarbonisation of the Union but also contributes to the energy security dimension of the Energy Union and more specifically to the reduction of import dependence. In order to provide a better

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[34] Based on 2015 proxies provided by Member States under article 8 of Regulation 525/2013 or estimated by the European Environmental Agency on behalf of the Commission, where necessary.

[35] This indicator reflects the overall GHG intensity of the economies and does not explain the drivers behind the Member States' performances

[36] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources. The Renewable energy shares in gross final energy consumption are available at: http://ec.europa.eu/eurostat/web/energy/data/shares

assessment of these two contributions, two supporting indicators are considered in the assessment, both elaborated by the European Environmental Agency and based on statistical data:

- fossil fuels avoided due to renewables (from 2005 onwards and as share of gross inland consumption) and
- GHG emissions avoided due to renewables (from 2005 onwards and as share of GHG emissions).

The research and innovation spending and patents on renewable energy technologies, as well as the turnover of the EU renewable energy industry and changes over time are also presented in the research, innovation and competitiveness dimension.

2.2.5. RESEARCH, INNOVATION AND COMPETITIVENESS

2.2.5.1. RESEARCH AND INNOVATION

The 2030 climate and energy framework refers to the need to monitor technological innovation (R&I expenditure, EU patents, competitive situation on technologies compared with other non-EU countries).

The transition to a low-carbon economy requires the development and implementation of new technologies, as they have been prioritised in the research, innovation and competitiveness dimension of the Energy Union. Innovation is key to the success of decarbonisation, starting with R&I investments.

The Integrated SET-Plan Communication[37] sets out an R&I Strategy for the Energy Union for the coming years, stepping up the efforts to bring new, efficient and cost-competitive low-carbon energy technologies faster to the market and deliver the energy transition in a cost-competitive way. The achievement of these goals will be also facilitated by the research public-private partnerships such as the Joint Technology Initiatives on Fuel Cells and Hydrogen, CleanSky, Shift2Rail, the BioBased Initiative, as well as contractual Public-Private Partnerships such as Green Vehicles and Sustainable Process Industry through Resource and Energy Efficiency.

In the transport sector, the Strategic Transport research and Innovation Agenda (STRIA) though its core priority areas[38] outlines the contribution of transport R&I to the political ambition identified in the Energy Union strategy.

Building on experience with the SET-Plan, the Accelerating Clean Energy Innovation Strategy[39] proposes specific measures to further address innovation challenges, in

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[37] COM(2015) 6317 final

[38] STRIA foresees an integrated approach to Energy Union research, innovation and competitiveness that would focus on the following core priority areas: 1) connectivity and automation of transport; 2) electrification in all modes (e.g. hybrid lorries, hybrid planes, electrical ferries); 3) alternative fuels; 4) vehicle design and manufacturing; 5) transport infrastructure; 6) networks and traffic management systems; 7) smart transport and mobility services.

[39] COM(2016) 763 final

particular attracting necessary private investments and proposing focus areas for future activities.

The SET-Plan, through SETIS[40], the SET-Plan Information System, monitors the level of investment in research and innovation (both in the private and public sectors) and the trends in patents in energy on an annual basis, to map the evolution of the European energy R&I landscape. SETIS has been producing indicators on R&I expenditure and patent trends related to the Energy Union R&I priorities, namely on renewables, smart system, efficient systems, sustainable transport, CCUS and nuclear safety as well as the SET-Plan actions defined in the Integrated SET-Plan Communication.

Base on SETIS indicators mentioned above, the following two indicators are proposed to monitor R&I investments and patents in the EU.

- **RIC1: Public investments on Energy Union R&I priorities as share of GDP:** this indicator divides public investments in the field of Energy Union R&I priorities by the GDP. It is accompanied by the share of public investments in the field of Energy Union R&I priorities in total public R&I investments in civil research-GBAORD[41] (i.e. excluding military public R&I spending).

While R&I investments does not always translate into development and deployment of new technologies, it can be assumed that the latter will benefit.

Corporate (or private) R&I investments is essential in the overall R&I efforts in a given country, but information from statistics is still quite scarce. Nevertheless, estimates of private R&I investments performed by JRC/SETIS are provided in the next chapter.

In addition, a comparison of R&I investment intensity in the Energy Union R&I priorities of the EU and main EU trading partners is provided.

Complementary indicators on the specialisation of R&I investments in the Energy Union R&I priorities in the EU and main EU trading partners are also presented.

Another R&I indicator included in this report is the number of patents.

- **RIC2: Low-carbon technology patents per million inhabitants -** this indicator provides information about the level of energy technology innovation, adjusting the absolute number of patents by population of the country. The indicator is based on the work within JRC/SETIS, itself based on data from PATSTAT[42] which are further processed to avoid double counting and eliminate inconsistencies and errors.[43] It is accompanied by another indicator showing the number of patents normalised by GDP.

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40 https://setis.ec.europa.eu/

41 Government budget appropriations or outlays for research and development

42 European Patent Office – PATSTAT The Worldwide Patent Statistical Database: https://www.epo.org/searching-for-patents/business/patstat.html#tab1

43 A full dataset for a given year is completed with a 3.5-year delay due to the procedural timeline in recording patents. Thus detailed data have a 4-year delay. Estimates with a 2-year lag are provided by JRC/SETIS at EU-28 level only. The trends specifically address advances in the area of low carbon energy and climate mitigation technologies (Y-code of the CPC). Patent statistics are based on the priority date, simple patent families and fractional counts of submissions made both to national and international authorities to avoid double counting of patents.

According to the data availability in the upcoming years, the R&I indicators may be further refined in order to provide a more refined monitoring framework and increased linkage with the priority areas defined in the Accelerating Clean Energy Innovation Strategy. As an example, the Commission's services and Joint Research Centre are currently setting-up a Transport Research and Innovation Monitoring and Information System (TRIMIS)[44], a new tool aiming to support monitoring the progress of transport research and innovation actions.

The above indicators on R&I are accompanied by additional analysis on renewable energy (i.e. the levelised cost of electricity, turnover of the EU renewable energy industry and worldwide investments), which puts R&I activities on renewables into the market perspective and compares them with those in other regions of the world.

2.2.5.2. COHESION POLICY INVESTMENTS SUPPORTING THE ENERGY UNION

EU cohesion policy makes a key contribution to 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 68.8 billion in 2014-2020, for investments relating to all five dimensions of the Energy Union.

The strategic policy framework, major financial allocations (to be complemented by national public and private co-financing), technical assistance and capacity-building mean that the conditions are in place to exploit the full potential of the funding to invest 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 pertinent to monitor progress in cohesion policy investments supporting the Energy Union. This can be done by dividing the amount of ERDF and CF allocations to specific projects by the end of each year (or a certain cut-off date) by the total amount of planned allocations for ERDF and CF investments supporting the Energy Union in a given country in 2014-2020, i.e. the project selection rate. This tells us about progress in cohesion policy investments supporting the Energy Union in that country, controlling for the size of the allocation. This information will be provided from end 2017 onwards and will be considered for inclusion as a scoreboard indicator.

2.2.5.3. EMPOWERING LOCAL INITIATIVES: COVENANT OF MAYORS

Urban energy consumption generates about three quarters of global carbon emissions[45]. Therefore, cities play a crucial role in terms of energy and climate policy; they can offer wide-ranging opportunities to shift energy consumption onto more sustainable pathways and create local openings for investment and growth. They are also in a privileged position when it comes to meeting the climate change challenge, as they can encourage citizens to participate and build partnerships with local stakeholders.

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[44] https://ec.europa.eu/transport/themes/research/sttp/trimis_en

[45] IPCC 2014, *Climate change 2014: mitigation of climate change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK and New York, NY, USA.

Since its launch in 2008, the Covenant of Mayors (CoM) has become a mainstream European movement involving local authorities who voluntarily commit to contributing to the EU's GHG emissions reduction objective by meeting and exceeding a 20 % CO2 emissions reduction objective by 2020, through energy efficiency improvements and the use of renewable energy sources on their territories.

The CoM's international dimension includes countries from the EU Neighbourhood to the East, South and in Sub-Saharan countries. In June 2016, the EU Covenant of Mayors and the Compact of Mayors[46] announced the formation of the Global Covenant of Mayors for Climate & Energy, an initiative of cities and local governments leading in the fight against climate change. The Global Covenant of Mayors for Climate & Energy already cumulates commitments from more than 7100 cities from 119 countries, representing 600 million inhabitants.

The methodological framework that the Commission's Joint Research Centre has produced in collaboration with city networks offers municipalities a comprehensive tool to support the development of climate and energy policies, and a coherent framework for monitoring against their objectives. Progress to date will be presented in this SWD.

2.2.5.4. 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 its major trading partners, building on the 2014 report on energy prices and costs.[47] The Commission recently released a second Energy prices and costs report[48] which provides an extensive update of the analysis based on available statistics and an *ad hoc* data collection undertaken with Member States' statistical offices. Consequently, energy prices and costs data have been further updated, giving the latest available picture of the state of energy prices in electricity, gas and in the oil products sectors. In addition, the report also provides an in-depth assessment of trends and the impacts of energy prices for (especially, low-income) households and (in particular, energy-intensive) industries.

Building on the above mentioned analysis, indicators on wholesale price differentials between EU Member States and main trading partners[49] are considered 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 users[50], combining Eurostat data for Member States and

[46] https://www.compactofmayors.org/

[47] COM(2014) 21 /2

[48] COM(2016) 769 final and SWD(2016) 420 final

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

[50] Eurostat data are reported for the median consumption bands, as well as minimum and maximum prices. However, it is difficult to interpret to which specific industrial users each price applies.

International Energy Agency (IEA) data for trading partners and Member States that are also IEA members.

When monitoring the impacts of energy prices on competitiveness, it is also important to take a holistic approach that takes account of overall energy costs. We therefore propose the following indicator:

- **RIC3: Real unit energy costs:** this indicator measures the amount of money spent on the energy needed to obtain one unit of value added in manufacturing, excluding the refinery sector. It provides a more comprehensive approach to competitiveness issues relating to energy costs, as it combines the impacts of energy prices and of energy-intensity level, when comparing with value added. The higher the value of this indicator, the higher the energy cost component in the overall cost structure of the manufacturing sector in a given Member State[51].

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

The indicators presented above are based on currently available data; they therefore show a best available picture based on today's information, while recognising that there is still room for improvement in the years to come. The major limitations are data availability, data quality (in a few cases) and the current lack of better indicators on certain topics relating to the Energy Union objectives (e.g. the internal market).

Further EU-level and national support for European statistics is key to improving the timeliness and quality of the data and extending data coverage as necessary for monitoring progress on the Union's energy and climate objectives. The availability of sufficient, more timely and more accurate statistical data could make a basic contribution to the monitoring of policy impact and will provide the public with a clearer, quantified image of energy and climate policies in the EU.

The following table summarises the coverage limitations of existing indicators and some further needs:

Table 2.2. Identified needs for new or improved indicators and data for monitoring progress towards Energy Union objectives

Dimension	Main area of relevance	Identified potential needs
Energy security, solidarity and trust	Energy imports	Increase accuracy of statistical data on energy imports-exports by country of origin.
	Security of electricity supply	Further elaboration of a risk preparedness indicator.
A fully integrated internal energy	Flexibility within the electricity market	Such an indicator should monitor the degree of market flexibility and the ability

[51] Note, that this indicator covers the manufacturing sector as a whole. To capture developments and conditions in individual sectors, e.g. in energy intensive sectors, a more disaggregated analysis would be needed.

market		of the energy system to cope with an increasing share of new and renewable energy sources (taking into account variable generation, storage capacity, demand response)
	Electricity interconnections	Improved methodology on electricity interconnection in a 2030 perspective, acknowledging Member States' particularities (ongoing Commission work). Set up a data collection on the uptake of smart grids.
	Gas interconnections	
	Energy market coupling	Additional indicators providing better monitoring of intra-EU market coupling and energy trade flows; this may include components beyond price convergence.
	Switching rates	New indicators on switching rates to green/renewable energy supply (including with the same supplier), i.e. customers asking to be supplied with 90-100 % renewable energy.
	Vulnerable consumers	Additional indicators/analysis for EU-wide assessment of energy poverty.
Energy efficiency and moderation of demand	Overarching	Widely agreed decomposition analysis to identify the impact of energy efficiency on consumption trends.
	Energy intensity/efficiency - industry	Refined indicator based on further disaggregation of energy use by end-use type (with particular emphasis on energy intensive industries).
	Energy intensity/efficiency - transport	A refined indicator for transport modes (mainly for road transport) based on further disaggregation of energy use by end-use type (i.e. passengers and freight) New indicators on e-mobility and alternative transport (also on the deployment of recharging stations) drawing on data available in the future at the European Alternative Fuels Observatory.
	Energy intensity/efficiency – residential	Refined indicator(s) for energy consumption by main end-use types (heating, appliances etc.), based on further disaggregation of energy consumption by type of end-use.

	Energy intensity/efficiency – services	Need for additional indicators allowing a better estimate of energy efficiency impact, based on further disaggregation of energy consumption by type of end-use.
Decarbonisation	Renewable energy	Indicators on the cross-border integration of renewable energy could be developed further. Indicators on the local deployment of renewables and self-consumption could be developed further.
Research, innovation and competitiveness	Public R&D	To further improve the data collection on R&D investments in Energy Union priority areas.
	Innovation deployment	Indicators, including regional or EU-wide ones, on the market uptake of innovation in the Energy Union priority areas and the competitive position of such sectors on global markets

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. It builds on the selected indicators included in the scoreboard, complemented with other relevant information when possible and necessary.[52]

The scoreboard showing the main indicators is presented in the figure 3.a-c from below. For increasing transparency, an interactive web-tool for visualisation of the Energy Union indicators will be soon available on the DG Energy website.

[52] Note that this SWD has been elaborated in 2016, based on latest data available at the time. Therefore, data from Eurostat, carbon inventories from EEA/UNFCCC as well as from other sources, was extracted in June/October 2016.

Dimension	Energy Security, solidarity and trust						Internal energy market															
Relevance	Import dependency/diversification of supply				Gas security		Interconnection & wholesale market functioning										consumers					
Indicators	SoS1: Net import dependency [%]		SoS2: Supplier concentration index - aggregate [0-100]		SoS3: N-1 rule for gas [%]*		IM1- Electricity interconnection capacity		IM2 - Market concentration index - power generation		IM3 - Market concentration index - wholesale gas supply		IM4 - Wholesale electricity prices		IM5- Wholesale gas prices		IM6 -Annual switching rates - electricity retail markets**		IM7 - Annual switching rates - gas retail markets**		IM8: Energy affordability - energy expenditure share in final consumption expenditure for the lowest quintile**	
Source	Eurostat		Commission services, based on Eurostat		IHS , Gas coordination group		ENSTO-E		Commission services based on Platts		ACER/CEER		European Commission		European Commission		ACER/CEER		ACER/CEER		Commission services, based on Eurostat	
Unit	Net imports [% of gross inland consumption+international bunkers]	absolute change 2005-2014 [pp]	0-100 (100 means maximum concentration) [-]	absolute change 2005-2014 [-]	% of total demand that can be satisfied if disruption of largest gas infrastructure [%]	absolute change 2009-2016 [pp]	% of installed capacity [%]	absolute change 2014-2016 [pp]	0-10000 (10000 means a single supplier) [-]	relative change 2005-2015 [%]	0-10000 (10000 means a single supplier) [-]	relative change 2011-2015 [%]	[EURO/MWh]	relative change 2013-2015 [%]	[EURO/MWh]	relative change 2013-2015 [%]	% of total consumers [%]	average 2009-2015 [%]	% of total consumers [%]	average 2009-2015 (available years over the period) [%]	[%]	absolute change 2005-2014 [pp]*
Year	2014	2005-2014	2014	2005-2014	2016	2009-2016	2016	2014-2016	2015	2005-2015	2015	2011-2015	2015	2013-2015	2015	2013-2015	2015	2009-2015	2015	2009-2015	2014	2005-2014
EU28	53.5%	1.3%	9.7	1.6	na	na	na	na	3726	-24.1%	4771	-1.5%	40.6	-10.8%	20.9	-24.9%	6.2%	5.3%	7.0%	5.1%	8.6%	1.5%
BE	80.1%	0.0%	14.5	-3.0	279.0%	82.0%	13%	-4.0%	3209	-51.2%	1721	0.7%	44.9	-6.1%	19.7	-27.4%	12.2%	11.1%	15.8%	12.0%	7.8%	1.3%
BG	34.5%	-12.2%	60.3	6.0	35.2%	6.2%	7%	-4.0%	3210	-38.0%	9484	25.0%	na	na	24.4	-24.0%	0.0%	0.0%	0.0%	0.0%	14.2%	2.9%
CZ	30.4%	2.4%	27.3	1.6	373.5%	226.5%	19%	2.0%	4072	-20.9%	4773	-47.3%	32.4	-11.9%	21.6	-26.6%	3.6%	4.8%	5.9%	7.3%	12.4%	0.1%
DK	12.8%	62.6%	8.1	3.8	141.0%	68.0%	47%	3.0%	933	-42.6%	2330	-9.3%	23.7	-39.7%	20.0	-28.7%	3.7%	4.0%	10.1%	5.3%	9.7%	1.2%
DE	61.6%	1.2%	15.3	3.7	197.0%	-48.0%	7%	-3.0%	378	-61.4%	3505	76.8%	31.7	-16.3%	20.0	-26.7%	8.7%	7.2%	9.2%	7.2%	8.4%	1.0%
EE	8.9%	-17.2%	76.7	3.8	104.5%	-39.5%	23%	13.0%	7134	-21.2%	4926	-50.7%	31.1	-27.9%	28.1	-16.1%	2.0%	0.4%	5.9%	5.7%	10.7%	-1.4%
IE	85.3%	-4.2%	13.9	10.0	134.0%	116.0%	6%	-3.0%	2319	-52.5%	1288	6.0%	49.7	-26.3%	20.2	-20.0%	14.0%	15.3%	15.1%	14.1%	8.1%	-0.2%
EL	66.2%	-2.4%	37.2	-2.2	108.8%	-126.2%	10%	-1.0%	3480	-56.6%	6453	24.5%	52.5	26.7%	21.7	-28.9%	0.3%	0.9%	0.0%	0.0%	7.4%	2.0%
ES	72.9%	-8.6%	25.2	11.9	112.0%	-12.0%	5%	2.0%	969	-42.2%	3295	64.8%	51.2	13.7%	21.6	-18.8%	10.7%	9.7%	11.1%	12.7%	5.5%	1.6%
FR	46.1%	-5.5%	9.0	1.8	131.0%	28.0%	8%	-2.0%	5929	-28.1%	2924	135.9%	38.6	-10.9%	20.3	-29.9%	4.3%	3.4%	9.4%	5.7%	5.7%	-0.2%
HR	43.8%	-8.7%	19.7	-15.2	101.0%	101.0%	66%	-3.0%	7305	-26.6%	5617	-6.2%	na	na	26.6	-32.9%	2.3%	3.0%	0.0%	0.0%		na
IT	75.9%	-7.5%	13.3	-2.3	105.5%	-18.5%	7%	0.0%	815	-60.5%	2924	39.7%	52.3	-16.9%	22.2	-20.9%	8.0%	6.0%	6.1%	4.8%	7.1%	na
CY	93.4%	-7.2%	0.0	-1.4	na	na	na	na	9551	-4.5%	na	na	na	na	na	na	0.0%	0.0%	na	na	4.4%	-0.2%
LV	40.6%	-23.3%	23.1	-25.8	220.7%	57.7%	23%	13.0%	9080	-5.7%	10000	0.0%	41.8	-18.7%	24.3	-23.5%	0.0%	0.0%	0.0%	0.0%	12.4%	4.4%
LT	77.9%	21.1%	87.5	-9.0	117.0%	60.0%	23%	13.0%	5055	-27.5%	6376	-36.2%	41.8	-14.7%	28.2	-24.7%	0.0%	0.0%	0.0%	0.0%	13.2%	4.4%
LU	96.6%	-0.8%	2.9	-24.7	78.1%	-28.9%	163%	-82.0%	5405	-2.6%	1989	-37.5%	na	na	na	na	0.1%	0.1%	0.0%	0.0%	5.6%	0.6%
HU	61.7%	-1.4%	75.6	30.0	129.0%	48.0%	37%	8.0%	2124	-6.2%	6446	101.5%	40.5	-4.3%	22.8	-25.9%	0.0%	na	0.0%	7.6%	16.9%	3.0%
MT	97.7%	-2.3%	na	na	na	na	35%	35.0%	9297	-7.0%	na	na	na	na	na	na	na	na	na	na	3.3%	na
NL	33.8%	-4.2%	17.0	6.0	198.0%	33.0%	18%	1.0%	950	-25.0%	3317	33.4%	40.1	-22.8%	19.8	-26.8%	15.1%	12.8%	15.1%	13.8%	6.5%	0.9%
AT	65.9%	-5.8%	36.3	13.8	232.6%	87.6%	29%	0.0%	1601	-18.0%	5797	-22.7%	31.8	-16.0%	20.6	-24.1%	2.3%	1.9%	3.4%	2.0%	7.5%	1.7%
PL	28.6%	11.4%	27.4	1.6	103.7%	-30.3%	4%	2.0%	1542	-17.3%	4508	-0.9%	37.8	2.2%	21.2	na	0.9%	0.9%	0.4%	0.1%	12.5%	1.0%
PT	71.6%	-16.9%	28.2	7.0	88.3%	-16.7%	8%	1.0%	3156	-44.0%	4681	65.9%	50.4	15.6%	23.6	-19.1%	26.6%	14.7%	23.8%	26.4%	8.2%	1.8%
RO	17.0%	-10.7%	14.1	-4.7	100.7%	5.7%	8%	1.0%	1367	-35.6%	4729	44.6%	36.4	3.1%	24.4	-14.5%	0.1%	0.0%	0.0%	na	15.0%	1.6%
SI	44.6%	-7.8%	28.3	-1.8	57.4%	-17.6%	85%	20.0%	5873	1.6%	7778	54.7%	41.4	-4.1%	22.9	-26.9%	6.7%	3.6%	6.0%	3.5%	14.9%	3.6%
SK	60.9%	-4.4%	70.4	-4.0	305.2%	187.2%	59%	-2.0%	5695	-1.4%	6115	-36.3%	33.6	-9.7%	20.3	-16.4%	2.7%	2.4%	3.2%	3.5%	21.7%	-2.5%
FI	48.8%	-5.4%	67.5	4.4	129.1%	129.1%	21%	-9.0%	1088	-18.3%	10000	0.0%	29.7	-27.9%	22.1	-26.9%	12.5%	9.8%	na	na	3.9%	0.7%
SE	32.1%	-4.7%	21.8	6.8	14.0%	4.0%	25%	-1.0%	2079	-30.6%	1987	-28.2%	22.1	-44.0%	25.7	-24.3%	10.3%	9.7%	0.2%	0.6%	3.6%	0.2%
UK	45.5%	32%	6.3	3.7	140.0%	26.0%	6%	0.0%	706	-24.4%	1073	13.1%	56.1	-6.2%	20.0	-26.8%	12.2%	14.1%	12.7%	13.2%	10.2%	3.9%
					*SE, SI, LU-exempted FI fulfill it with DSM												**available years and period of change is not the same for all MS					
legend	x>=50%	x>0	x>=50%	x>0	x<90%	x<0	x<10%		x>5000	x>0	x>5000	x>0		x>0		x>0					x>=15%	x>0%
	30=<x<50		30=<x<50		90%=<x<100%				2000<x=<5000		2000<x=<5000										9%<x<15%	
	x<30	x=<0	x<30	x=<0	x>=100%	x>0	x>10%	x>0	x=<2000	x<0	x=<2000	x<0		x<0		x<0					x=<9%	x<0%

note: all indicators and trends are assessed at the level of each MS.

Figure 3. a. Scoreboard of main Energy Union indicators (energy security and internal market dimensions)

Dimension	Energy efficiency and moderation of demand												Decarbonisation of the economy							
Relevance	primary and final energy consumption				final sectors								Greenhouse gas emissions					Renewable energy		
Indicators	EE1 - Primary energy consumption		EE2 - Final energy consumption		EE3 - Final energy intensity in industry		EE4 - Final energy consumption per m2 in residential sector		EE5 - Final energy in transport sector		EE5 - final energy intensity in services sector		DE1-GHG emissions reductions - base year=1990 (EU target)	DE2: Gap between GHG emissions projections and target in 2020 in the Effort Sharing sectors	DE3: Gap between latest (proxy) inventory of Effort Sharing emissions and interim targets	DE4 - GHG intensity of the economy		DE5 - renewable energy share		
Source	Eurostat		Eurostat		Eurostat		Odyssee/Mure		Eurostat		Eurostat		EEA, European Commission	EEA, European Commission		EC/EEA/UNFCCC		Eurostat		
Unit	[Mtoe]	average annual change 2005 - 2014 [%]	[Mtoe]	average annual change 2005 - 2014 [%]	final energy consumption (industry)/GVA (industry) [toe/ M€'10]	average annual change [%]	Final energy consumption per m2 in residential sector, climate corrected [ktoe/m2]	average annual change [%]	[Mtoe]	average annual change [%]	Final energy consumption in services / GDP2010 [Mtoe/Mn Euro 2010]	average annual change [%]	(% of 1990 base year emissions)	(% of 2005 base year emissions)	(% of 2005 base year emissions)	[tons CO2 equiv. per million euro]	relative change 1990-2015 [%]	RES share in gross final energy consumption [%]	gap to interim trajectory 2013/2014 [pp]	gap to 2020 target [pp]
Year	2014	2005 - 2014	2014	2005 - 2014	2014	2005-2014	2014	2005-2014	2014	2005-2014	2005-2014	2005-2014	1990-2015**	gap 2020	gap interim 2015**	2015**	1990-2015**	2014	2014	2014
EU28	1507.10	-1.4%	1061.24	-1.2%	96	-1.9%	15.1	-2.3%	352.50	-0.5%	16.0	-1.3%	-22.4%	-5.3%	-7.8%	332	-48.1%	16.0%	na	4.0%
BE	44.98	-1.3%	34.05	-0.6%	148	-0.9%	22.3	-2.6%	10.03	0.2%	16.6	-0.4%	-18.3%	5.0%	-2.9%	318	-46.7%	8.0%	-2.3%	5.0%
BG	17.22	-0.9%	9.01	-1.2%	272	-6.3%	10.8	-0.8%	3.11	0.9%	40.2	-1.5%	-42.6%	-25.5%	-17.3%	1478	-61.4%	18.0%	-7.1%	-2.0%
CZ	38.55	-0.9%	23.02	-1.3%	141	-5.0%	19.6	-1.0%	6.22	0.3%	30.6	-2.5%	-37.9%	-16.9%	-11.8%	743	-59.5%	13.4%	-4.7%	-0.4%
DK	16.65	-1.5%	13.52	-1.5%	42	-2.5%	14.2	-1.6%	4.92	-0.8%	11.4	-1.6%	-29.5%	0.8%	-6.9%	205	-51.1%	29.2%	-7.3%	0.8%
DE	291.81	-0.8%	208.88	-0.4%	80	-1.3%	16.3	-2.1%	63.47	0.2%	19.5	-0.9%	-25.9%	-0.8%	-2.1%	335	-48.4%	13.8%	-3.6%	4.2%
EE	6.62	2.6%	2.82	-0.1%	124	-4.5%	22.5	-1.0%	0.78	0.2%	46.2	0.9%	-55.8%	-13.0%	-11.4%	1006	-71.7%	26.5%	-5.9%	-1.5%
IE	13.35	-1.0%	10.77	-1.6%	57	-0.6%	12.4	-4.4%	4.47	-1.1%	10.3	-4.6%	10.0%	12.4%	-2.1%	321	-65.9%	8.6%	-1.2%	7.4%
EL	23.73	-2.7%	15.57	-3.1%	134	3.2%	10.7	-2.7%	6.47	-2.3%	12.6	0.4%	-8.7%	-21.6%	-23.7%	529	-26.3%	15.3%	-4.9%	2.7%
ES	112.57	-2.0%	79.23	-2.3%	91	-1.6%	9.4	-1.4%	31.98	-2.4%	12.5	-0.8%	21.3%	-2.4%	-10.2%	330	-25.4%	16.2%	-3.7%	3.8%
FR	234.49	-1.1%	141.75	-1.3%	79	-1.4%	15.6	-1.9%	49.54	-0.2%	14.1	-0.8%	-12.8%	-3.2%	-4.6%	233	-39.7%	14.3%	0.0%	8.7%
HR	7.66	-1.9%	6.24	-1.6%	119	-1.8%	20.0	-1.9%	2.02	0.6%	27.2	-0.3%	-27.8%	-19.9%	-31.2%	521	-32.3%	27.9%	-13.1%	-7.9%
IT	143.84	-2.5%	113.35	-2.1%	81	-2.7%	12.8	-0.8%	40.09	-1.2%	14.0	0.0%	-16.3%	-5.4%	-9.4%	284	-28.6%	17.1%	-8.2%	-0.1%
CY	2.20	-1.1%	1.61	-1.3%	128	3.2%	6.1	-3.5%	0.84	-1.6%	15.0	1.0%	49.1%	-37.8%	-25.3%	544	-22.7%	9.0%	-2.6%	4.0%
LV	4.36	-0.3%	3.89	-0.3%	183	2.5%	24.4	-1.9%	1.09	0.6%	46.7	-0.9%	-55.2%	-9.6%	-2.5%	558	-62.3%	38.7%	-3.0%	1.3%
LT	5.63	-3.4%	4.83	0.6%	107	-2.2%	16.7	-1.4%	1.74	2.6%	30.2	-1.8%	-59.7%	-18.4%	-11.4%	574	-69.7%	23.9%	-6.0%	-0.9%
LU	4.18	-1.4%	4.00	-1.2%	117	-1.4%	19.1	-3.7%	2.49	-1.1%	11.6	-2.6%	-11.8%	4.7%	-3.4%	256	-64.3%	4.5%	-0.1%	6.5%
HU	20.69	-2.2%	14.93	-2.1%	159	3.6%	13.2	-3.6%	3.56	-1.7%	37.5	-5.3%	-35.3%	-37.5%	-22.0%	573	-53.1%	9.5%	-2.6%	3.5%
MT	0.88	-0.6%	0.54	4.4%		na	3.5	-3.0%	0.29	5.8%	na	na	18.6%	-20.9%	19.3%	328	-50.6%	4.7%	-1.2%	5.3%
NL	62.66	-1.1%	47.28	-1.4%	116	-1.7%	11.0	-3.2%	13.92	-1.0%	14.0	-2.3%	-8.4%	-4.5%	-12.9%	319	-43.7%	5.5%	0.7%	8.5%
AT	30.65	-0.6%	26.80	-0.3%	113	-0.2%	17.7	-0.3%	8.73	-0.4%	14.8	-2.9%	1.5%	3.7%	-3.9%	261	-35.8%	33.1%	-6.2%	0.9%
PL	89.12	0.2%	61.61	0.5%	123	-5.7%	20.3	-1.0%	16.37	3.1%	34.7	-1.3%	-19.3%	-7.5%	-8.2%	914	-66.9%	11.4%	-1.9%	3.6%
PT	20.66	-2.0%	15.81	-2.0%	136	-1.0%	6.0	-4.0%	6.47	-1.1%	16.6	-1.9%	12.5%	-25.9%	-22.2%	407	-18.4%	27.0%	-2.7%	4.0%
RO	30.77	-1.8%	21.71	-1.4%	143	-6.4%	27.6	-0.6%	5.47	2.9%	25.1	-0.5%	-55.8%	-15.3%	-12.5%	793	-70.9%	24.9%	-4.7%	-0.9%
SI	6.53	-0.7%	4.61	-0.5%	128	-3.5%	18.7	-0.6%	1.82	2.7%	19.8	-1.6%	-9.8%	-12.4%	-14.4%	452	-43.5%	21.9%	-3.5%	3.1%
SK	15.25	-1.6%	10.06	-1.4%	184	-5.1%	15.1	-1.4%	2.21	-0.5%	33.2	-5.1%	-44.3%	-16.8%	-19.4%	548	-73.0%	11.6%	-2.0%	2.4%
FI	33.43	0.1%	24.42	-0.2%	241	-0.1%	21.6	-0.2%	4.76	0.3%	25.7	0.6%	-20.3%	0.0%	-2.4%	308	-46.4%	38.7%	-6.3%	-0.7%
SE	46.23	-0.5%	31.19	-0.8%	124	-1.4%	18.7	-1.1%	8.52	-0.1%	17.6	-1.6%	-23.5%	-11.4%	-14.3%	138	-54.4%	52.6%	-9.7%	-3.6%
UK	182.39	-2.1%	129.75	-1.7%	77	-2.1%	18.4	-3.3%	51.13	-0.9%	11.1	-1.7%	-33.6%	-2.9%	-5.4%	268	-59.8%	7.0%	-0.9%	8.0%
													** based on 2015 proxies							
		x>0%		x>0%									x=<-20%	x>0%	x>0%				x>0%	x>0.5%
		x<0%		x<0%									x>-20%	x<0%	x<0%				x=<0%	x<0.1%

Figure 3.b. Scoreboard of main Energy Union indicators (energy efficiency and decarbonisation dimensions)

Dimension	Research, innovation and competitiveness					
Relevance	R&D investments and patents				Competitiveness	
Indicators	RIC1-Public spending on Energy Union related R&D as share of GDP		RIC2-patents related to Energy Union topics		S23 - Real unit energy costs in manufacturing sector (excl. Refining)	
Source	JRC		JRC		Commission services	
Unit	[% of GDP]	absolute change 2010-2014 [pp]	[patents per million inhabitants]	average over the period [patents per million inhabitants]	[% of value added]	relative change [%]
Year	2014	2010-2014	2012	2005 - 2012	2014	2005-2014
EU28	0.030%	-0.006%	1.44	0.80	15.26	11.5%
BE	0.042%	0.025%	1.06	0.55	25.95	31.9%
BG	na	na	0.11	0.04	65.82	2.0%
CZ	0.023%	0.003%	0.38	0.20	17.39	-12.2%
DK	0.058%	-0.019%	3.92	2.23	6.02	1.4%
DE	0.030%	0.004%	4.43	2.51	12.23	12.9%
EE	0.012%	-0.019%	0.08	0.14	13.28	3.9%
IE	0.015%	-0.010%	0.71	0.42	8.46	-24.8%
EL	0.003%	0.000%	0.04	0.03	12.87	-8.2%
ES	0.009%	-0.004%	0.49	0.30	20.82	18.2%
FR	0.050%	-0.002%	1.64	0.85	15.95	23.9%
HR	na	na	0.02	0.02	13.31	12.6%
IT	0.022%	0.000%	0.57	0.34	18.87	5.6%
CY	na	na	0.41	0.41	26.36	21.0%
LV	na	na	0.27	0.25	19.29	19.7%
LT	0.006%	-0.003%	0.07	0.04	13.26	13.1%
LU	0.105%	-0.020%	5.06	2.96	19.39	-55.3%
HU	0.044%	-0.047%	0.09	0.06	21.19	2.4%
MT	na	na	0.14	0.31	8.00	-22.5%
NL	0.020%	-0.038%	1.68	1.07	17.21	-0.1%
AT	0.044%	-0.001%	2.40	1.22	12.70	15.4%
PL	0.020%	-0.016%	0.44	0.19	20.33	-7.9%
PT	0.005%	0.004%	0.13	0.10	15.52	14.1%
RO	0.012%	0.011%	0.15	0.11	21.42	-12.5%
SI	na	na	0.30	0.19	14.06	-5.6%
SK	0.027%	-0.003%	0.09	0.06	22.83	-9.3%
FI	0.106%	-0.052%	2.83	1.34	21.76	46.7%
SE	0.039%	-0.007%	1.98	0.92	12.27	-1.5%
UK	0.021%	-0.021%	0.74	0.43	10.94	33.6%

Figure 3.c. Scoreboard of main Energy Union indicators (research, innovation and competitiveness dimension)

3.1. ENERGY SECURITY, SOLIDARITY AND TRUST

Key points

- The EU imports more than half of the energy it consumes. **Import dependency** seems to have stabilised in recent years: since 2005, it has fluctuated between 52 % and 55 %; it was 53.5 % in 2014.
- In 22 Member States, **net import dependency** actually decreased between 2005 and 2014, indicating an improvement in energy security. This was due to an increase in indigenous renewable energy production (Austria, Estonia, IE, Italy, Latvia, Portugal, Spain) and a general decrease in energy consumption. However, this positive trend was offset by a significant increase in net import dependency in a few countries due to the decline of indigenous fossil fuel production (Denmark, Poland, UK) or the closure of nuclear plants (Lithuania).
- There are only two net **gas** exporters in the EU: Denmark and the Netherlands. Net import dependency for gas exceeds 90 % in 16 Member States, about half of which are fully reliant on imports (100 % net import dependency). Two producing countries, the Netherlands and Romania, recorded significant improvement: although their gas output decreased, this was offset by a bigger decrease in consumption.
- Among all fuels, the EU's import dependency is the greatest for **crude oil**[53]; this increased from 81.3 % in 2005 to 87.9 % in 2014. In this period, indigenous oil production fell by almost a half. As a result of falling consumption, net oil imports also decreased (by 12 %), but imports cover a growing proportion of demand.
- The EU’s net import dependency for **hard coal** was 55.7 % in 2005 and rose to 67.9 % by 2014. In this period, indigenous production of hard coal fell by nearly 40 %. Net imports remained stable but accounted for a growing proportion of consumption. The Czech Republic is the only net exporter of hard coal in the EU. In 2014, even Poland, the EU's largest coal producer, became a marginal net importer and net import dependency exceeded 90 % in 19 Member States.
- In 2015, 90 % of the natural **uranium** included in fuel loaded in EU reactors came from outside the EU. The proportion originating in the EU has increased significantly since 2005, but from a very low base.
- The EU has a wide range of **import sources** for all fuels. However, the supplier concentration index rose from 8.1 in 2005 to 9.7 in 2014, indicating a slight deterioration in energy security. Some central and eastern Member States (Bulgaria, Estonia, Finland, Hungary, Lithuania and Slovak Republic) rely to a large extent on Russia as the main source of imports, in particular for gas but often also for oil and/or coal.
- New interconnections and LNG terminals led to greater **security of gas supply** in the last couple of years, as reflected in the increase in the N-1 indicator in the

[53] Including NGL.

majority of Member States. Only two Member States remain below the 100 % threshold (not counting countries with a derogation).

The EU imports more than half of the energy it consumes and several Member States are heavily reliant on a single supplier for key energy sources. This is mainly true for gas but to a lesser extent also for oil and coal. As a result, the EU remains vulnerable to supply disruptions, whether caused by geopolitical conflicts, political or commercial disputes, infrastructure failure or other reasons. This was recognized by the 2014 Energy Security Strategy[54] and the stress tests[55] carried out in the same year. The strategy proposed action in a number of areas to strengthen security of energy supply.

Building on the Energy Security Strategy, the Energy Union strategy puts a significant emphasis on this aspect of energy policy: its first dimension is designed to enhance energy security, solidarity and trust, with the aim of ensuring uninterrupted supply of energy for European citizens and businesses. To address the security of supply challenges, the Energy Union strategy called for the diversification of energy sources, suppliers and routes, the improvement of emergency preparedness, engagement with external energy partners and more transparency on energy supplies.

3.1.1. IMPORT DEPENDENCY

SoS1: Net import dependency – net energy imports (imports minus exports) divided by gross inland consumption of energy and marine bunkers, based on tonnes of oil equivalent.[56]

The most common indicator of energy security is import dependency, showing the role of imported energy sources in a country's energy consumption.

The EU is a net importer of energy: in 2014, the import dependency stood at 53.5 %, i.e. the EU needed to import just over half of the energy it consumed. Import dependency is particularly high in the case of fossil fuels: in 2014, it was 87.9 % for crude oil, 67.4 % for natural gas and 67.9 % for hard coal.

Overall, EU energy import dependency seems to have stabilised in recent years: since 2005, it has fluctuated between 52 % and 55 %. While the import dependency of fossil fuels continues on an increasing trend (driven by the depletion of EU fossil fuel reserves), their share within the energy mix is gradually decreasing. The share of renewables, on the other hand, is steadily growing and contributes to the decrease of

[54] COM (2014)330
[55] https://ec.europa.eu/energy/en/news/stress-tests-cooperation-key-coping-potential-gas-disruption
[56] Net import dependency as it is defined above may reach values above 100 % in case of increasing stock levels. A negative value indicates that the country is a net exporter.

import dependency since these are generally produced within the EU.[57] A high share of nuclear in the energy mix also helps to limit import dependency.[58]

Although all Member States were net importers of energy in 2014 (Denmark was the last one to become a net importer, in 2013), the level of import dependency, as well as the change seen in the last decade, greatly varies across Member States.

Looking at individual countries reveals that in 22 Member States net import dependency actually decreased between 2005 and 2014, indicating an improvement in energy security. In some countries this improvement was helped by an increase in indigenous energy production (e.g. Austria, Estonia, Ireland, Italy, Latvia, Portugal and Spain) but in most cases it was facilitated by a decrease in energy consumption.[59] Measured in percentage points, Estonia, Latvia and Portugal had the most significant fall in net import dependency. All three countries experienced an increase in renewables production in this period; in Estonia this was complemented by rising oil shale[60] output.

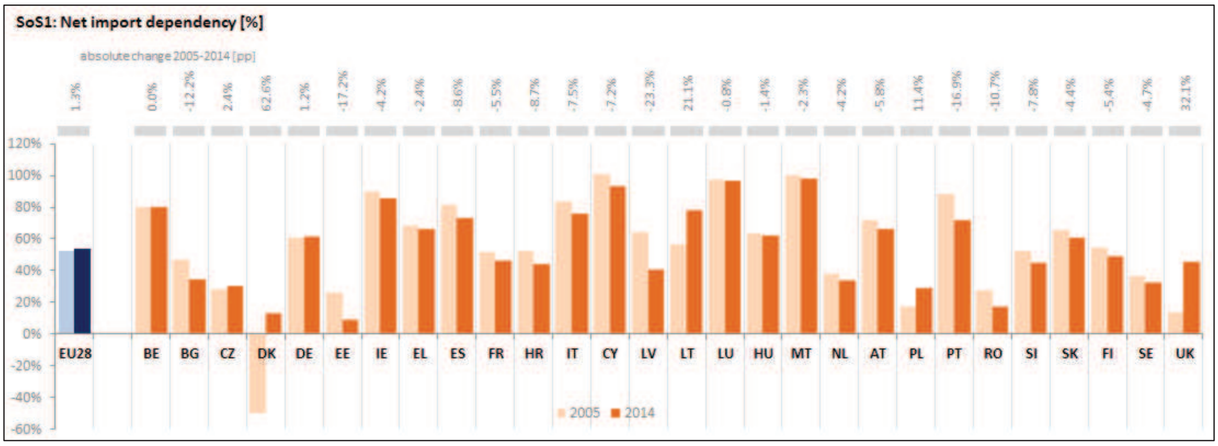


Figure 3.1.1: Net import dependency (Source: Eurostat)

However, this general positive trend was offset by a significant increase of net import dependency in a few countries. In the case of Denmark and the UK, this was clearly related to the decline of oil and gas production in the North Sea while Poland experienced a significant fall in its coal output. For Lithuania, the closure of the Ignalina nuclear plant at the end of 2009 was the main driver of increasing import dependency.

In addition to looking at the overall import dependency, the indicator was also calculated for the main fossil fuels: natural gas, crude oil and hard coal. These fuels cover nearly 70 % of the EU's gross inland energy consumption and the overwhelming majority (96 % in 2014) of net energy imports. Crude oil alone makes up more than half of the EU's net energy imports.

In case of natural gas, the EU's net import dependency increased from 57.1 % in 2005 to 67.4 % in 2014. In this period, indigenous gas production fell by nearly 40 %. While net

[57] This is the case for hydro, wind and solar, but not necessarily for biomass.
[58] When calculating overall (not fuel-specific) net import dependency, nuclear is included in the gross inland consumption but net imports of uranium and nuclear fuel are disregarded.
[59] Between 2005 and 2014, the EU's gross inland consumption of energy decreased by 12 %.
[60] Oil shale is a solid fuel which can be burned to generate electricity or one can extract oil from it.

gas imports in absolute terms also decreased (by 9 %), these make up a growing share of consumption.

Figure 3.1.2: Net import dependency of natural gas (Source: Eurostat)

With the exception of Cyprus and Malta, all Member States use natural gas. There are only two net gas exporters in the EU: Denmark and the Netherlands. In 16 Member States, net import dependency exceeds 90 %, with about a half of them fully reliant on gas imports (100 % net import dependency).

In eight Member States, net import dependency decreased between 2005 and 2014 but in most cases only marginally. Two producing countries, the Netherlands and Romania, recorded a significant improvement: although their gas output decreased in this period, this was offset by a bigger decrease in consumption.

In 17 Member States, net import dependency increased in this period. This group includes the other two major gas producers: Denmark and the UK. Both countries experienced a nearly 60 % decline of gas output, leading to a significant deterioration of import dependency.

Among all fuels, the EU's import dependency is the greatest for crude oil and NGL; this increased from 81.3 % in 2005 to 87.9 % in 2014. In this period, indigenous oil production fell by almost a half. As a result of falling consumption, net oil imports also decreased (by 12 %) but imports cover a growing proportion of demand.

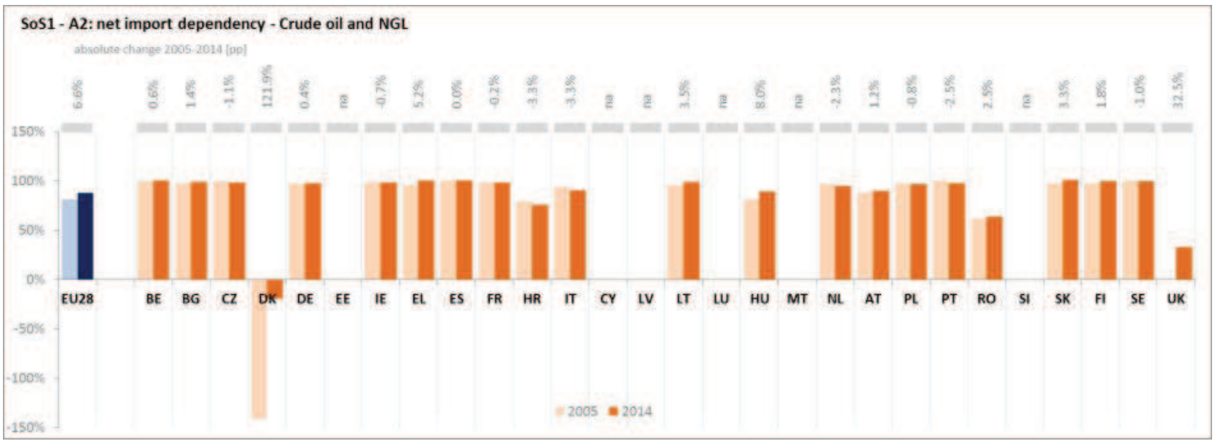


Figure 3.1.3: Net import dependency of crude oil and NGL (Source: Eurostat)

22 of the 28 Member States use and import crude oil; the remaining six have no operating refineries. Denmark is the only net exporter of oil in the EU but its net exports have significantly decreased over the last decade. In sixteen Member States, net import dependency exceeds 90 %.

In ten Member States, net import dependency slightly decreased between 2005 and 2014 which was typically caused by falling consumption rather than a rise in oil production.

Net import dependency increased in twelve Member States, with the biggest increases observed in Denmark and the UK which together covered 72 % of EU oil production in 2014. Both countries experienced a decline of more than 50 % in oil output, leading to a significant increase of import dependency.

As far as petroleum products are concerned, exports and imports are of a similar magnitude but this hides the fact that the EU typically exports motor gasoline and imports middle distillates. Eurostat statistics show that, in 2014, net exports of gasoline amounted to 46.1 million tons which was offset by net imports of gas/diesel oil (22.6 million tons) and jet fuel (15.3 million tons).

Lignite/brown coal is typically not traded internationally and the imports arriving to the EU are negligible. Therefore, the analysis of solid fuels was restricted to hard coal. The EU's net import dependency for hard coal was 55.7 % in 2005 and had risen to 67.9 % by 2014. In this period, indigenous production of hard coal fell by nearly 40 %. Net imports remained stable but accounted for a growing proportion of consumption.

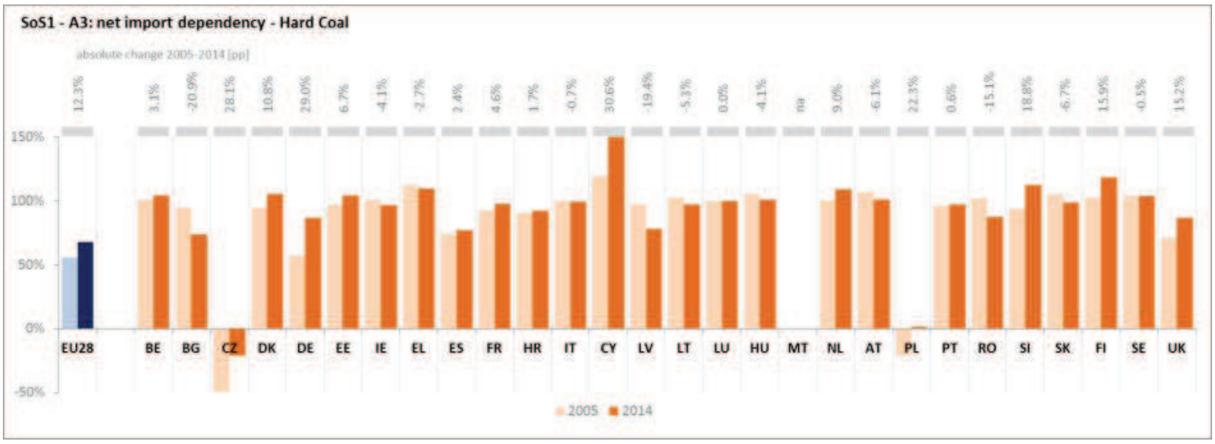


Figure 3.1.4: Net import dependency of hard coal (Source: Eurostat)

Hard coal is used in all Member States except Malta. The Czech Republic is the only net exporter of hard coal in the EU. In 2014, even Poland, the EU's largest coal producer, became a marginal net importer and net import dependency exceeded 90 % in 19 Member States.

In 11 Member States, net import dependency decreased between 2005 and 2014. The sizable improvements in case of Bulgaria, Latvia and Romania seem to be related to stock changes (all three countries consume a relatively low amount of hard coal and none of them produced hard coal in this period).

Net import dependency rose in 15 Member States, with the biggest coal producers (Czech Republic, Germany and Poland) showcasing considerable increases. All three countries experienced a decline of indigenous production in the last decade.

Imports of uranium and nuclear fuels are not included in Eurostat's energy balances and therefore import dependency cannot be calculated in the same way as for the main fossil fuels. Hence, complementary information is provided on imports of uranium and nuclear fuels.

In 2015, 90 % of the natural uranium included in fuel loaded in EU reactors came from outside the EU. According to 2014 figures, Russia and other CIS countries were the most important suppliers; their market share has considerably grown compared to 2005 when Canada was the main import source. The proportion of uranium originating in the EU has increased significantly since 2005, but from a very low base.

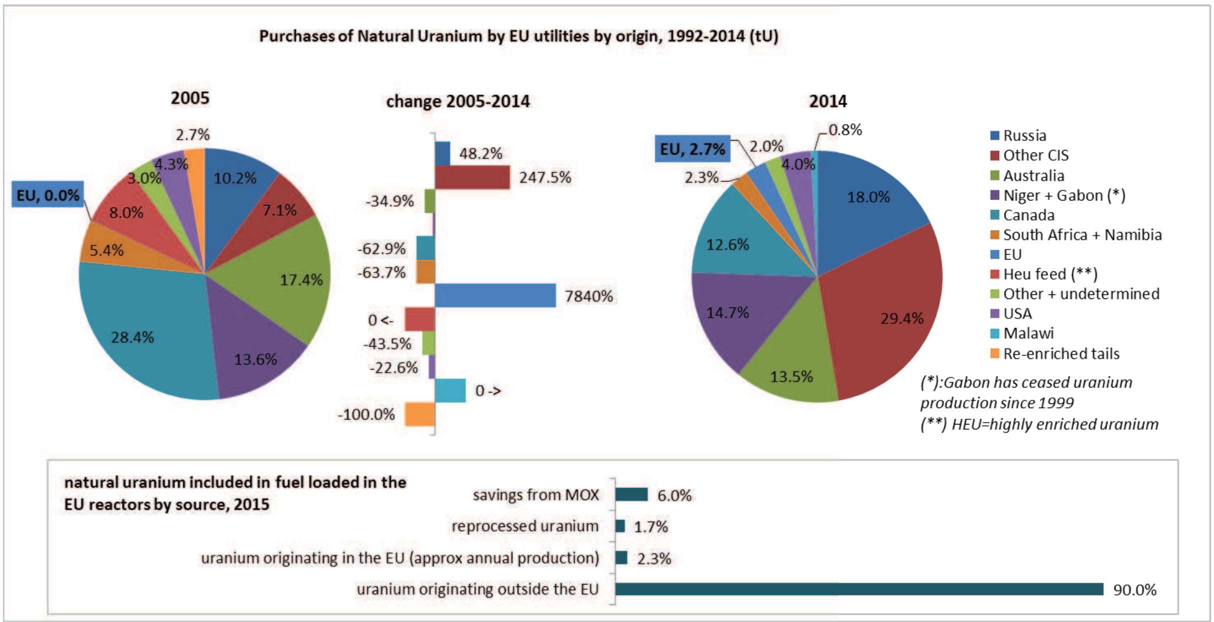


Figure 3.1.5: Purchases of natural uranium by EU utilities by origin (Source: Euratom Supply Agency)

In 2015, 128 nuclear reactors were operating in 14 Member States, with an additional four reactors under construction. In France, Hungary and Slovakia, the share of nuclear power exceeded 50 % of total electricity production. As far as nuclear fuels are concerned, the nuclear power plants of four Member States were fully reliant on Russian fuels. The share of Russian nuclear fuels in the EU as a whole was about 39 % in 2015.

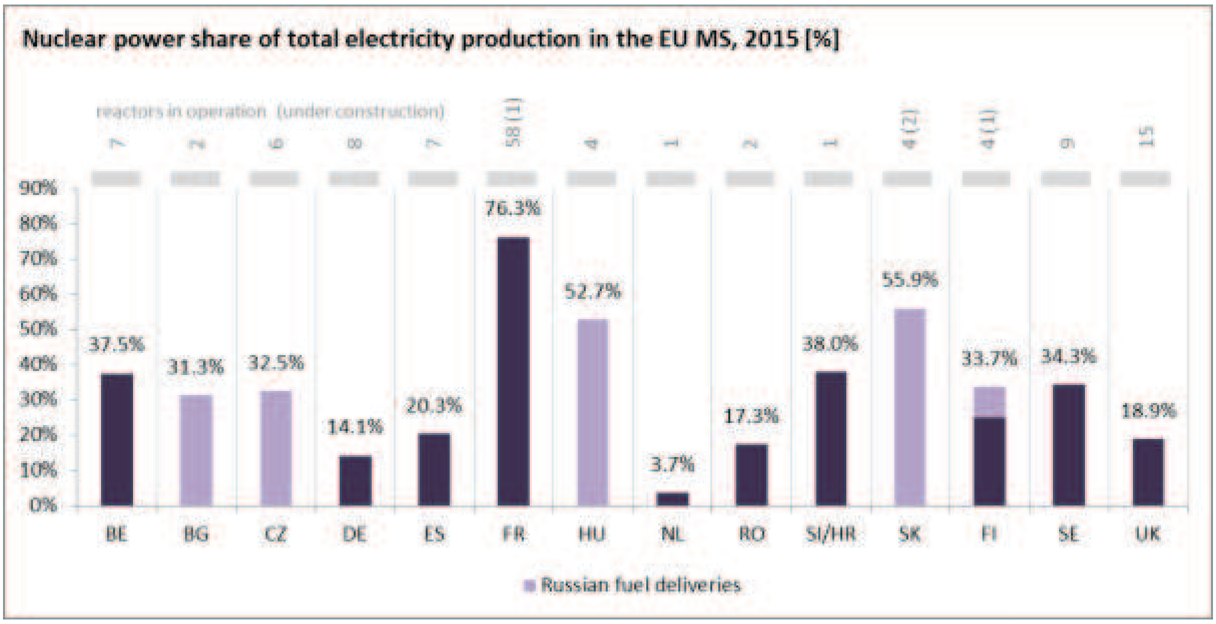


Figure 3.1.6: The share of nuclear power from total electricity production in 2015 (Source: Euratom Supply Agency)

3.1.2. SUPPLIER CONCENTRATION

SoS2: Aggregate Supplier Concentration Index (SCI) – this indicator is calculated as the weighted average of the three fuel specific SCIs[61], weighted by the share of the respective fuels in the country's gross inland consumption.

Net import dependency on its own does not reflect the vulnerability of Member States and the EU to energy supply disruptions. In particular, it provides no information on the number of various sources of imports and their relative significance. Member States with no or limited fossil fuel reserves can hardly improve their import dependence but they can certainly make efforts to achieve a better diversification of energy sources, suppliers and routes, the importance of which was highlighted in the Energy Union strategy. Therefore, a supplier concentration index (SCI) is used to complement the analysis on energy security.

When calculating the SCIs, only the fossil fuel imports coming from outside of the European Economic Area (EEA) were considered, i.e. imports from other EU Member States and EEA members were disregarded.[62]

[61] A 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/or a smaller share of net imports from consumption. Hence, the SCI can be seen as a proxy for lower risk to energy supply shocks. Although SCIs are often correlated with net import dependency, they provide additional insight on the level of diversification in import sources. The SCI can have a value between 0 and 100. 0 indicates that the country is fully relying on indigenous production while 100 indicate that the country has a single supplier and no indigenous production. In some cases, the calculated SCI is higher than 100 (this can occur if imports are higher than consumption); in such cases, the value was reduced to 100.

[62] Norway is the only EEA country exporting significant volumes of fossil fuels to the EU.

In addition to calculating the SCI for each of the main fossil fuels (crude oil, natural gas and hard coal), an aggregate SCI was calculated for each country and the EU as a whole.

A Member State importing most of its fossil fuel sources, but from a wide range of countries, such as Spain, shows a relatively low SCI. 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 mostly relying on fossil fuels.

Figure 3.1.7 shows the aggregate supplier concentration index for each Member State and the EU in 2005 and 2014. For the EU as a whole, the level of the indicator is rather low, indicating a relatively high degree of diversification of import sources. However, the level of the indicator has increased in the last decade, from 8.1 in 2005 to 9.7 in 2014, indicating a slight deterioration in energy security.

Looking at individual Member States, the level of the aggregate SCI varies from less than 10 in countries with significant indigenous production (Denmark, UK), in countries mostly relying on imports from EEA countries (Luxembourg) and in countries with a relatively low share of fossil fuels in the energy mix and diverse supply sources (France) to more than 60 in a few Member States mostly in the eastern part of the EU which rely on Russia as the main source of imports (Bulgaria, Estonia, Finland, Hungary, Lithuania and Slovakia). In Cyprus and Malta, the level of the aggregate SCI was 0 in 2014; Malta imported no crude oil, natural gas or hard coal while Cyprus imported some hard coal but it was coming from the EU. For Estonia, the SCI is rather high although domestically produced oil shale has a dominant role in the country's energy mix; however, this solid fuel is not taken into account by the formula calculating the SCI.

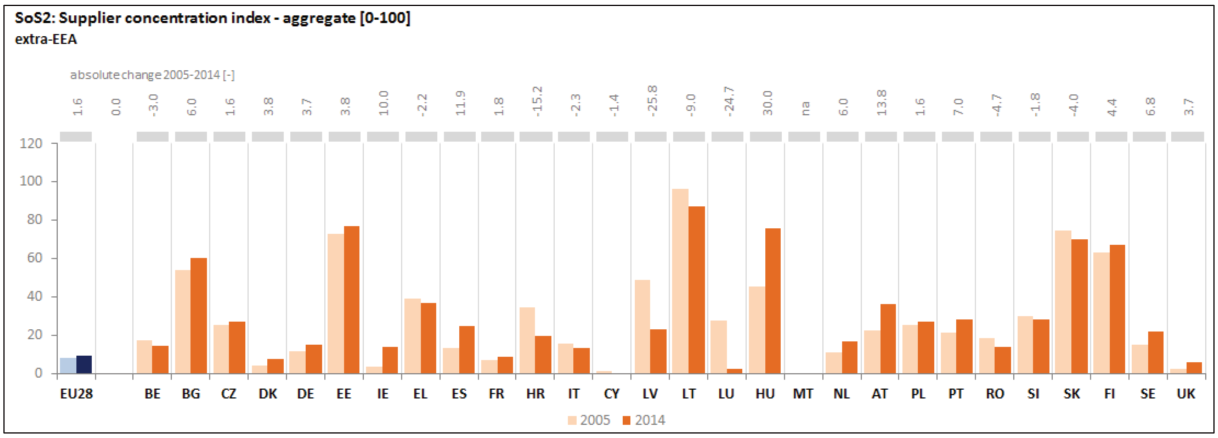


Figure 3.1.7: Aggregate supplier concentration index (Source: European Commission services calculations, based on Eurostat)

In 11 Member States, the level of the aggregate SCI decreased between 2005 and 2014, suggesting an improvement in energy security. Croatia, Latvia and Luxemburg showed the biggest decreases. In case of Croatia, this was helped by lower crude oil imports and more diversified gas imports (in 2014, all gas imports were reported to come from other Member States). For Latvia, Russia remained the dominant supplier of gas and hard coal (the country imports no crude oil) but the share of these fuels has fallen in the energy mix and, furthermore, gas imports were well below consumption in 2014.[63] Luxembourg

[63] Presumably because of decreasing stocks.

improved the diversification of both gas[64] and hard coal imports (the country imports no crude oil).

In 16 Member States, the level of the aggregate SCI grew between 2005 and 2014, a potential sign of increased vulnerability. Hungary saw the biggest increase, driven by a worsening diversification of gas supplies: in 2014, practically all gas imports arrived from Russia while in 2005 gas imports were also reported from western European and central Asian countries. The aggregate SCI also increased to a relatively great extent in the case of Austria, Ireland and Spain.

Figure 3.1.8 depicts the aggregate supplier concentration index in 2014 with three different methodologies: considering both intra- and extra-EU trade, considering only extra-EU trade and considering only extra-EEA trade. As can be seen, for most Member States the results are very similar but for those countries which rely on intra-EU and/or Norwegian supplies to a considerable extent, especially in Northwest Europe, there can be significant differences.

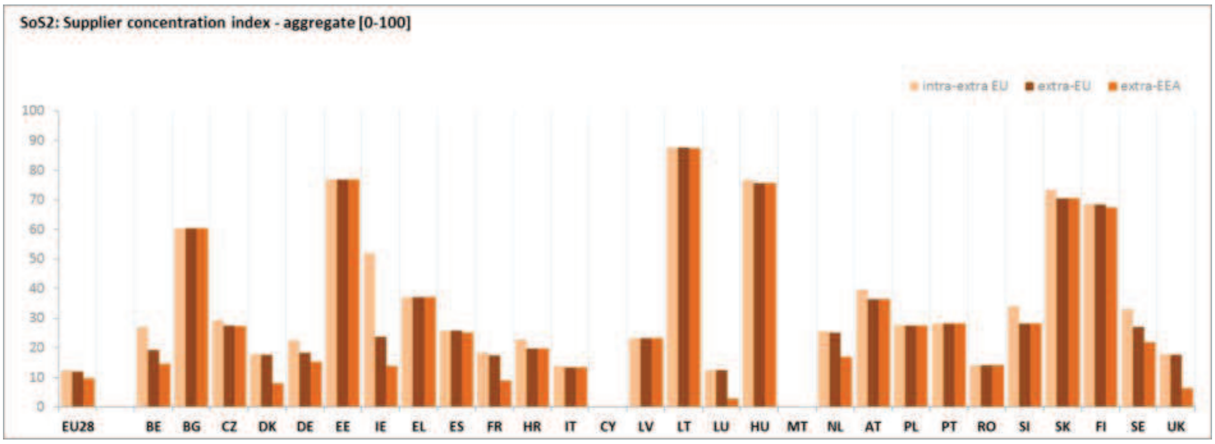
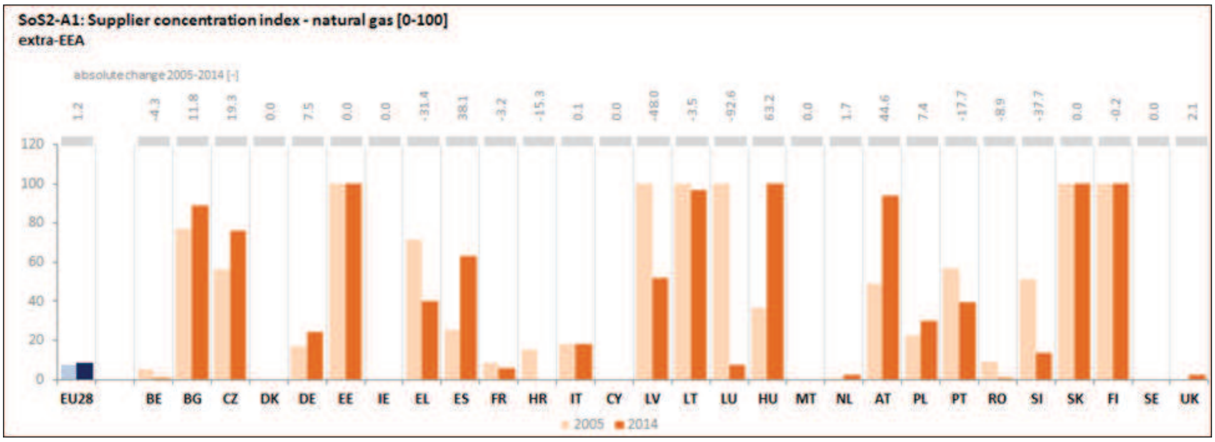


Figure 3.1.8: Aggregate supplier concentration index in 2014: a comparative view of SCI calculations considering the intra & extra-EU trade, extra-EU only and extra-EEA only (Source: European Commission services calculations, based on Eurostat)

In case of natural gas, gas, the supplier concentration index for the EU increased from 7.6 in 2005 to 8.8 in 2014.



[64] In 2005, the source of all gas import of Luxembourg was "not specified"; in 2014, the biggest part was reported to come from Norway.

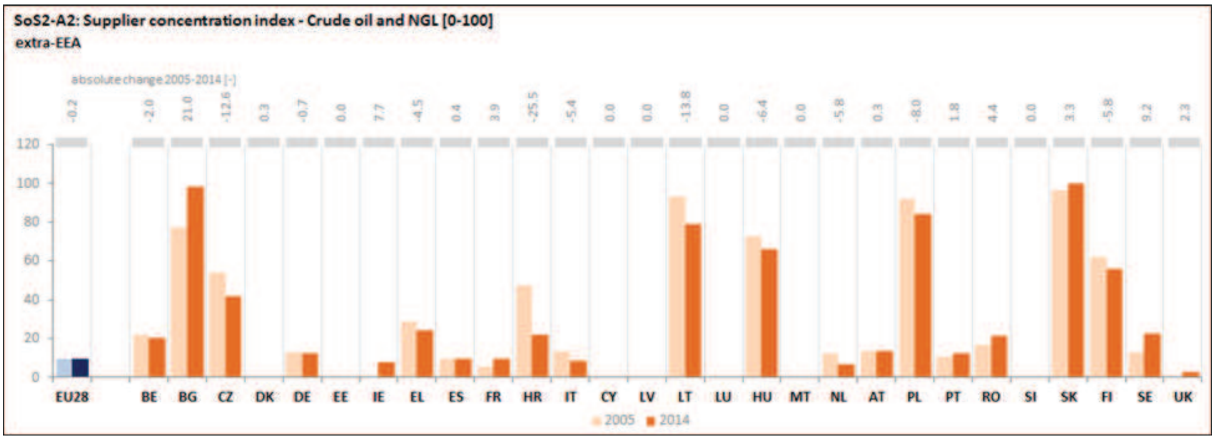
Figure 3.1.9: Supplier concentration index for natural gas (Source: European Commission services calculations, based on Eurostat)

In 11 Member States, the gas SCI has decreased, with the biggest improvements observed in Luxembourg, Latvia, Slovenia and Greece. As mentioned above, in 2005 all of Luxembourg's gas imports were reported as "not specified" so it is difficult to verify whether supply diversification has really improved. For Latvia, Russia remained the only supplier but imports were well below consumption in 2014. The share of Russia in Slovenia's imports has significantly decreased in the period, with the majority of 2014 imports arriving from other Member States. In case of Greece, pipeline imports from Turkey[65] and higher LNG imports allowed the country to reach a lower SCI. Lithuania's LNG terminal was brought online at the end of 2014 so LNG imports from Norway had a small impact on the 2014 SCI figure.

The gas SCI increased in ten Member States, with particularly big increases observed in Austria, Hungary and Spain. In the case of Austria, this might be an issue related to statistical declaration: in 2014, all gas imports were reported as "not specified". In 2014, Hungary reported practically all gas imports coming from Russia while in 2005 gas imports were also reported from western European and central Asian countries. Spain continued to import gas from numerous sources but the share of the largest supplier, Algeria, has significantly increased, reaching nearly 60 % in 2014. [66]

Sources of gas imports by pipeline are rather limited but LNG provides a real opportunity for import diversification, as it was highlighted in the Commission's LNG and storage strategy adopted in February 2016.[67] Cargoes of LNG are available from a wide variety of different supplier countries worldwide; therefore, LNG can give a real boost to the EU's diversity of gas supply and hence greatly improve energy security. In 2015, LNG was arriving from 7 supplying countries to 20 terminals in 10 Member States.[68]

The SCI for crude oil and NGL has been rather stable in the last decade: it was 9.8 in 2005 and 9.6 in 2014.



[65] Presumably this is mostly gas of Russian origin.
[66] Furthermore, in 2014 net imports of Spain well exceeded consumption (presumably related to increasing stock levels).
[67] COM(2016) 49 final
[68] Including Poland (the Świnoujście terminal received its first cargo in December) but without small-scale, off-grid terminals

Figure 3.1.10: Supplier concentration index for crude oil and NGL (Source: European Commission services calculations, based on Eurostat)

In 11 Member States, the oil SCI has decreased. Croatia recorded the biggest decrease which was facilitated by a better diversification of imports: the share of Russia from total imports decreased from 86 % in 2005 to 56 % in 2014 and several new suppliers appeared.

In the other 11 crude oil-importing Member States the oil SCI increased. The biggest increase was observed in Bulgaria: in 2014, all crude oil imports to the country arrived from Russia while in 2005 Kazakhstan was also a crude oil supplier.

The EU's SCI for hard coal has more than doubled from 5.3 in 2005 to 11.1 in 2014.

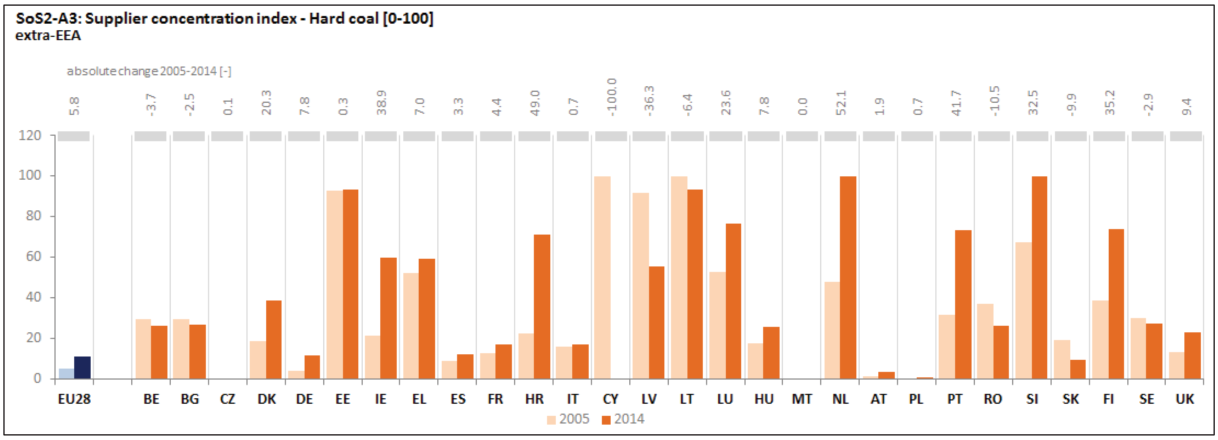


Figure 3.1.11: Supplier concentration index for hard coal (Source: European Commission services calculations, based on Eurostat)

In eight Member States, the hard coal SCI has decreased. In Cyprus, the value of the indicator decreased from 100 to 0 as imports from Ukraine were replaced by imports from Greece. Latvia also showed a sizable improvement, helped by a decreasing share of Russia in total imports.

In most Member States (19), the value of the hard coal SCI increased, with the biggest increases in Croatia, Ireland, the Netherlands and Portugal. Croatia had a well-diversified hard coal import portfolio in 2005 but in 2014 Russia was the dominant supplier, with a 90 % share. For Ireland and Portugal, Columbia became a dominant supplier in 2014 with a market share of 79 % and 88 %, respectively. In case of the Netherlands, reporting issues seem to distort the SCI.[69]

[69] Significant volumes of hard coal are transited through the Netherlands to Germany which appear in Dutch imports in 2014.

3.1.3. SECURITY OF GAS SUPPLY

S3: N-1 formula for gas infrastructure – it measures the ability of the gas infrastructure of a country to satisfy, in the event of a disruption of the single largest gas infrastructure, total gas demand during a day of exceptionally high gas demand occurring with a statistical probability of once in 20 years, expressed as a percentage of that demand. Annex I of the security of gas supply regulation[70] specifies the calculation of the formula.

From all energy sources, natural gas is the one which generates most concern about security of supply, not least because its important role in the heating of homes and the disruptions experienced in recent years. In particular, the disruption resulting from the gas dispute between Russia and Ukraine in early 2009 left several consumers, mainly in south-east Europe, without gas at the peak of the heating season.[71] An established indicator for measuring the adequacy of the infrastructure of a Member State to face a gas supply disruption is the so-called N-1 formula.

Article 6 of the security of gas supply regulation requires Member States to meet the "N-1 rule" from 3 December 2014. In other words, they have to ensure that, if the single largest gas infrastructure fails, the capacity of the remaining infrastructure is able to satisfy total gas demand during a day of exceptionally high gas demand occurring with a statistical probability of once in 20 years. This condition is met if the value of the N-1 indicator is equal to or above 100 %.

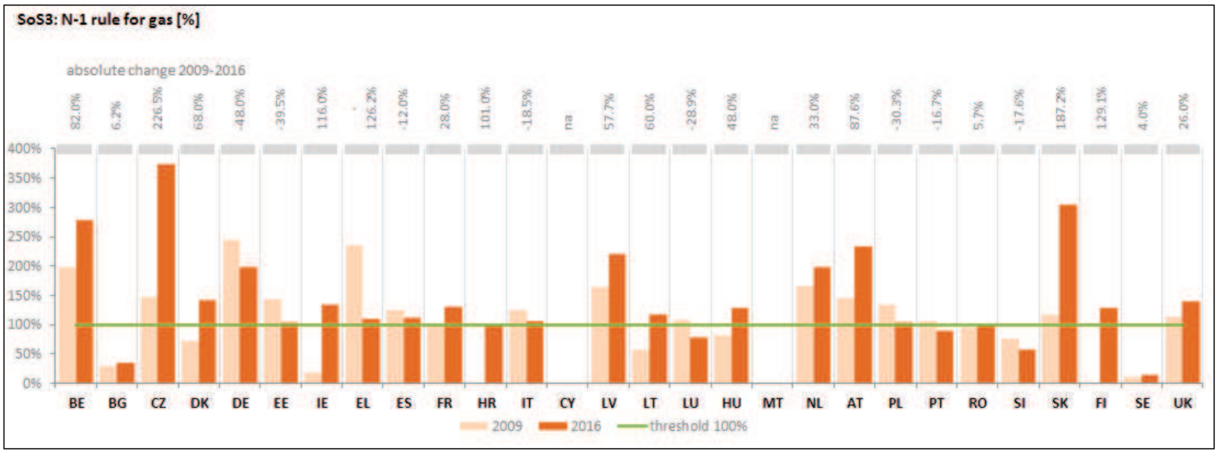
It is also possible to fulfil the N-1 rule on a regional level if relevant Member States establish a joint preventive action plan. Alternatively, the Member State can demonstrate that a supply disruption may be sufficiently compensated for, in a timely manner, by appropriate market-based demand-side measures.

Figure 3.12 shows the latest available data regarding Member States' compliance with the N-1 rule. According to this, five Member States had an N-1 value of less than 100 %: Bulgaria, Luxembourg, Portugal, Slovenia and Sweden. However, Luxembourg, Slovenia and Sweden have a derogation from complying with the N-1 rule.

In more than half of the Member States the value of the indicator increased since 2009. There have been notable improvements in some countries helped by specific infrastructure projects. Lithuania had been non-compliant with the N-1 rule until 2014 but the inauguration of the Klaipeda LNG terminal increased the value of the indicator to 117 %. New pipeline interconnections helped countries in central eastern Europe (Austria, the Czech Republic, Hungary and Slovakia) to reach a significant improvement in the N-1 value.

[70] Regulation (EU) No 994/2010 of the European Parliament and of the Council of 20 October 2010 concerning measures to safeguard security of gas supply and repealing Council Directive 2004/67/EC

[71] http://europa.eu/rapid/press-release_IP-09-30_en.htm



Notes: Finland complies with the N-1 rule using demand-side measures; Ireland complies with the N-1 rule at regional level (UK-IE); Luxembourg, Slovenia and Sweden have a derogation from the N-1 rule; the 2016 figure for the UK corresponds to the Gone Green Scenario; figures for BG, DK, EE, EL, ES, FR, HR, LV, LU, NL, PL, PT, RO, SK, SE are from 2014-2015, while for the other Member States the data is from the risk assessments submitted in September/October 2016

Figure 3.1.12: Member States' position as regards the N-1 criteria (Source: Member States' risk assessments and preventive action plans)

The second list of projects of common interest (PCIs) includes 77 gas projects, the realisation of which will help several Member States to further improve compliance with the N-1 rule. In fact, compliance with the N-1 rule is one of the benchmarks in the attribution of PCI status under the energy infrastructure regulation[72].

During 2016, significant funds were allocated from the Connecting Europe Facility (CEF) to the interconnector linking gas networks in Romania, Bulgaria, Austria and Hungary and to the Balticconnector project, the first gas pipeline to link Estonia and Finland.

The N-1 infrastructure standard is a crucial indicator to test whether the entry capacities into a country's gas transmission system are sufficiently balanced and are not overly-concentrated on a single pipeline or a single underground gas storage facility. On the other hand, it has some limitations: it does not take possible bottlenecks in a country's internal gas network into account and it is solely based on capacities (the existence of such capacities does not guarantee the availability of gas in a crisis). Regarding the latter, the N-1 rule is complemented by another standard (the so-called supply standard) that focuses on ensuring the availability of the commodity even under very extreme conditions such as exceptionally high gas demand situations or, also, the disruption of the single largest infrastructure.

In the context of the recent review of the security of gas supply regulation, the Commission examined the validity of the N-1 standard. Some of the limitations are addressed by the Commission's proposal to revise the regulation[73]: according to this, Member States would have to submit a simulation of the N-1 scenario with a hydraulic

[72] Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009

[73] COM(2016) 52 final

model (this should reveal if, for example, there is a bottleneck within the country) and calculate the N-1 formula with both 30 % and 100 % storage levels (lower storage levels usually entail lower storage withdrawal rates).

3.2. A FULLY INTEGRATED INTERNAL ENERGY MARKET

Key points

- Important new **electricity interconnections** were put into operation in 2015. In the case of Malta, the interconnection level jumped from 0 % to 35 %, while for the three Baltic states it grew from 10 % to 23 %. Poland also increased its interconnection level (to 4 %), thanks to the LitPol Link. The indicator remains below the 10 % target in 11 Member States.
- Based on ownership of generation capacity, **concentration in the electricity generation market** decreased over the last 10 years in practically all Member States, indicating an increase in the level of competition. In many countries, increasing wind and photovoltaic capacity facilitated the entry of new market players and less market concentration. Nevertheless, electricity generation remained highly concentrated in several countries, mainly those with relatively small markets.
- In the case of **gas**, market concentration measured at the level of upstream sourcing companies increased in the last few years in about half of the Member States. On the other hand, some Baltic and central European countries showed a marked improvement, helped by better import diversification. In 2015, only five Member States had a concentration index under the threshold set in the ACER target model[74] for a well-functioning gas market. In general, Member States with well-functioning hubs and/or those that benefit from varied supply sources exhibit low market concentration.
- **Wholesale electricity prices** fell in most Member States between 2013 and 2015, largely because of falling coal and gas prices, the gradual penetration of renewables in the power sector and subdued demand. Regional differences remained significant, with prices highest in the UK and southern Europe and lowest in the Scandinavian countries. Varying electricity mixes and national regulations, the availability of interconnections and bottlenecks in trading explain most of the differences.
- **Wholesale gas prices** fell in all Member States between 2013 and 2015 on the back of relatively weak demand, oversupply in the main regional markets, low oil prices and steady LNG imports. In contrast to electricity, there was a clear convergence of national prices, facilitated by lower oil prices, which allowed oil-indexed prices to approximate north-west European hub prices. In the case of Lithuania, the LNG terminal helped to reduce import prices.
- Unlike wholesale prices, **retail prices** of gas and electricity generally rose in the last five years. In the case of electricity, this was partly due to the increasing tax component. The tax component in the retail price of the main oil products also grew.

[74] European gas target model review and update, January 2015; http://www.acer.europa.eu/events/presentation-of-acer-gas-target-model-/documents/european%20gas%20target%20model%20review%20and%20update.pdf

- A market performance indicator measuring **consumers' perceptions** of the functioning of retail markets shows average results for gas and below-average results for electricity markets. In most Member States, the indicator improved for both electricity and gas from 2010.
- Italy, Finland and Sweden achieved a full roll-out of electricity **smart meters** and about half of households in Estonia, Spain, Denmark and Malta are equipped with such meters. As regards penetration rates for gas smart meters, only the Netherlands has made significant progress (almost 30 % of households).
- Energy expenditure as a proportion of total consumption expenditure increased for the poorest households in the majority of Member States over the last decade, indicating that energy affordability has become a more significant issue. At EU level, the indicator rose from 7.1 % in 2005 to 8.6 % in 2014. A growing proportion of low-income households (23 % in 2015) do not have sufficient financial means to heat their homes adequately.

The Energy Union strategy envisages a fully integrated continent-wide energy system where energy flows freely across borders, based on competition and the best possible use of resources, and with effective regulation of energy markets at EU level where necessary. Furthermore, the vision is of an Energy Union with citizens at its core, where citizens take ownership of the energy transition, benefit from new technologies to reduce their bills, participate actively in the market, and where vulnerable consumers are protected.

In order for the internal energy market to work properly, cross-border connections have to be enhanced, and the remaining energy islands have to be eliminated. In addition, a well-functioning internal energy market needs an effective regulatory framework. Existing energy and related legislation, in particular the 3rd internal energy market package, have to be fully implemented and strictly enforced. The proposal on the new electricity market design adopted on 30 November 2016 aims to improve the functioning of the internal electricity market in order to allow electricity to move freely to where and when it is most needed, reap maximum benefits for society from cross-border competition and provide the right signals and incentives to drive the right investments, while fully integrating increasing shares of renewable energies.[75]

In addition to leading to more competition, increased choice and affordable prices for consumers, the completion of the internal energy market is a key driver of energy security.

3.2.1. ELECTRICITY INTERCONNECTION

Well interconnected infrastructure is a key condition for a fully integrated and competitive internal market. Insufficient interconnections impede competition, add to the costs faced by consumers and create vulnerability in terms of energy security. Connecting Europe's electricity systems would also allow the integration of more

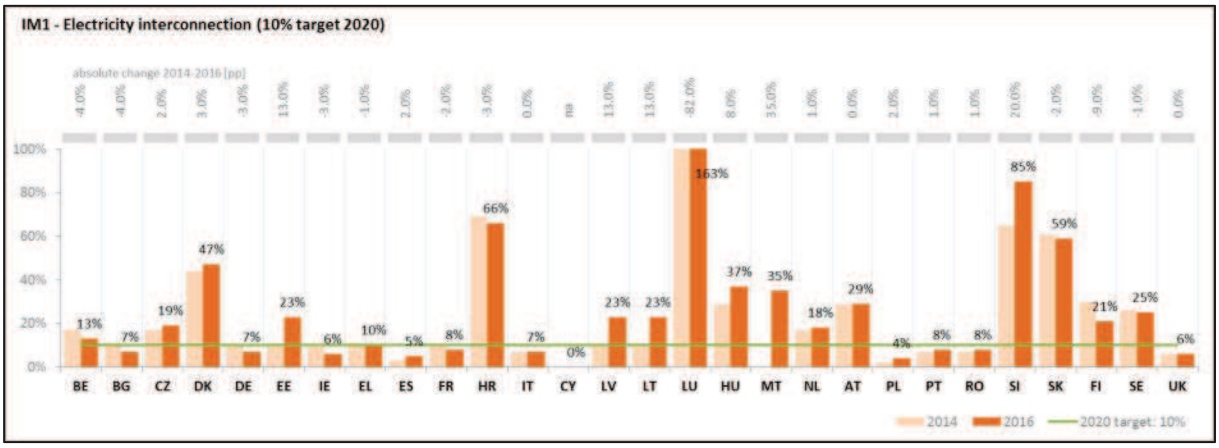
[75] COM(2016) 861 final, COM(2016) 862 final, COM(2016) 863 final, COM(2016) 864 final

renewable energy as surplus electricity produced in one country could be used in another country with a high demand.

IM1: Electricity interconnection – the electricity interconnection capacity of a given Member State, divided by its total generation capacity.

For electricity, the European Council of March 2002 called for all Member States to achieve interconnection levels of at least 10 % of their installed generation capacity[76]; this objective was reinforced in October 2014 with a deadline of 2020.[77] This means that each Member State should have in place electricity cables that allow at least 10 % of the electricity that can be produced by their power plants to be transported across its borders to neighbouring countries. The necessary measures to achieve this 10 % target by 2020 were set out in a communication[78] presented with the Energy Union strategy. The conclusions of the European Council of October 2014 made also reference to an objective of arriving at a 15 % target by 2030. The projects of common interest are the key European tool to achieve the target.

Compared to 2014, 12 Member States recorded an improvement in terms of electricity interconnection. For Malta, the value of the indicator increased from 0 % to 35 % after the inauguration of the Malta-Italy Interconnector in April 2015, thereby putting an end to the isolation of the Maltese electricity grid from the rest of Europe. In case of the three Baltic states, the interconnection level grew from 10 % to 23 %, helped by the commissioning of new interconnections linking Lithuania with Poland (LitPol) and Sweden (Nordbalt) in December 2015. Improvements were also seen in Poland and Spain but both countries remained below the 10 % target. Poland doubled its interconnection capacity to 4 % thanks to the LitPol Link. Similarly, Spain almost doubled its interconnection capacity with France as a result of the INELFE interconnector.



Note: The three Baltic states (Estonia, Latvia and Lithuania) are not yet synchronised with the European grid and are therefore treated as one entity. The value of 23 % for the three Baltic States refers to the interconnectivity of the entire Baltic zone with the European electricity market; the interconnectivity between the individual countries is higher.

[76] SN 100/1/02 REV 1
[77] EUCO 169/14
[78] COM(2015) 82 final

Figure 3.2.1: Electricity interconnection (Source: ENTSO-E)

According to the latest data, 11 Member States are insufficiently connected with the EU electricity market. These are: Bulgaria, Cyprus, France, Germany, Ireland, Italy, Poland, Portugal, Romania, Spain and the UK. In the case of Cyprus, the country's geographical position clearly makes reaching the 10 % target difficult. The implementation of further electricity-related projects of common interest in the coming years – including those between Belgium and the UK (already under construction), France and Spain, Cyprus and Greece – will help most of these countries to reach the 10 % target.

Depending on the geographical position of a country and its energy mix, for example the weight of renewables in it, achieving the required 10 % minimum may not be enough. Therefore, in 2016 the Commission has set up an expert group to provide technical advice on how to break down the 15 % electricity interconnection target by 2030 into regional, country and/or border interconnection targets, while taking costs into account.[79] The group had its first meeting in October 2016.

3.2.2. MARKET CONCENTRATION

Market concentration indices provide information about the relative share of market players in a given market and hence they are indicative of the degree of competition. The lower the value of a market concentration index, the higher the degree of potential competition is. In general, markets with higher levels of competition (i.e. lower concentration indices) show a lower price level than markets dominated by one or few players.

There are various indicators measuring market concentration, with different advantages and drawbacks. In order to give a balanced picture, we present the development of several different indices, both for electricity and gas markets. We monitor market concentration at Member State level but obviously the size of a country will strongly influence the level of market concentration: small, unconnected markets are not likely to support a large number of suppliers.

IM2: 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.

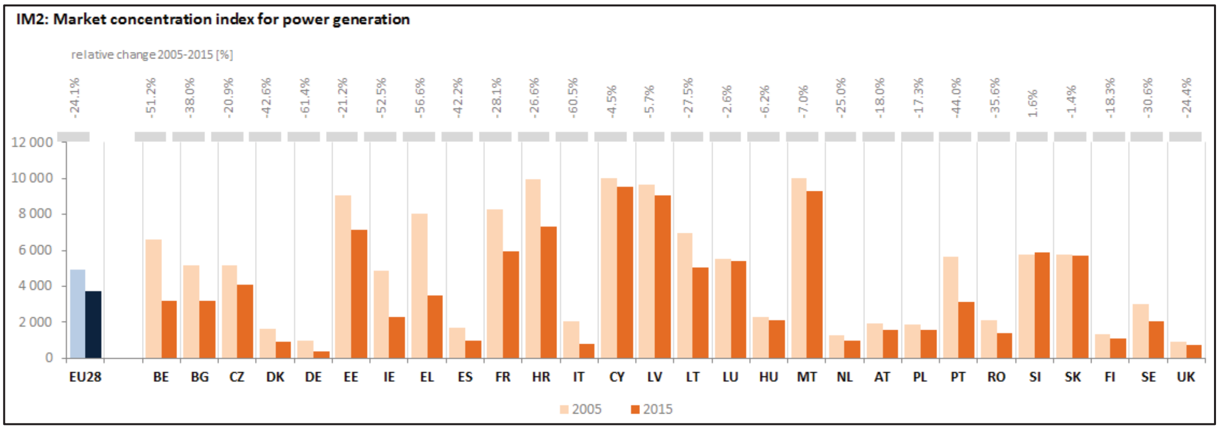
In practically all Member States (the only exception is Slovenia[80]), the market concentration index for power generation has decreased between 2005 and 2015, indicating an increase in the level of competition. The most significant decreases in concentration levels were observed in Greece, Belgium, and Croatia. In Greece, the share of the main generator from total installed capacity has fallen from 89 % in 2005 to 58 % in 2015. In Belgium, the share of the main generator decreased from 80 % to 56 % while in Croatia, the share of the main generator decreased from 100 % to 85 % in the same

[79] Commission Decision of 9 March 2016 setting-up a Commission expert group on electricity interconnection targets (2016/C 94/02)

[80] In Slovenia, the largest generator slightly increased its market share between 2005 and 2015

period. In many countries, increasing wind and photovoltaic capacity facilitated the entry of new market players and the decrease in market concentration.

In spite of the decreasing trend, in ten Member States the index remains above 5000. These are typically small countries (with the highest levels of concentration in Cyprus, Estonia, Croatia, Latvia and Malta) but they also include France where one company controlled 77 % of the installed generation capacity in 2015.



Note: the index for the EU is the average of the Member State indices

Figure 3.2.2: Market concentration index for power generation (Source: EC services based on Platts PowerVision)

IM2-A1: Cumulative Market Share Power Capacities, Main Entities – the combined share from total generation capacity of the electricity generating companies having a share of more than 5 % of national electricity generation.

In the majority of Member States (19), the value of the indicator decreased between 2006 and 2014, suggesting that smaller companies (those with less than 5 % market share) represent an increasing share of generation capacity. Italy, Latvia and Greece showed the biggest decreases in this period. Again, the penetration of wind and photovoltaic generation facilitated the entry of new market players and the decrease in market concentration in many Member States.

On the other hand, the UK, Austria and Germany saw sizable increases of this indicator.

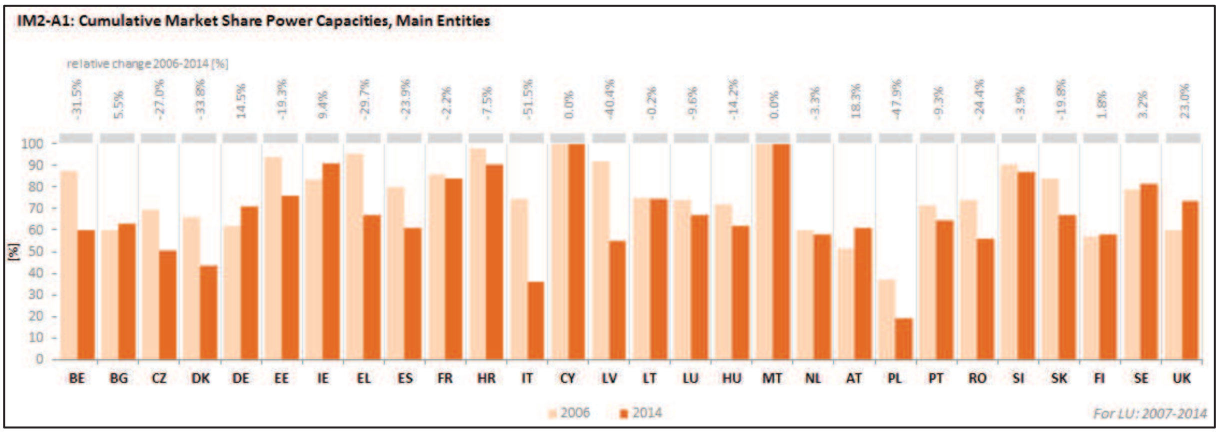


Figure 3.2.3: Cumulative Market Share Power Capacities, Main Entities (Source: Eurostat - Electricity market indicators)

IM2-A2: Cumulative Market Share Power Generation, Main Entities – the combined market share of the electricity generating companies having a share of more than 5 % of national electricity generation.

Unlike IM2 and IM2-A1, this indicator is not based on capacity but on actual electricity generation. As many generators do not operate at their full capacity all the time, the difference between electricity generation capacity and electricity generation can be significant. Nuclear and coal-fired plants typically run at full capacity, producing baseload electricity; for variable renewables (wind and solar), on the other hand, the utilisation of generation capacity may be rather volatile.

In 20 Member States, the value of this indicator decreased between 2006 and 2014, showing that smaller companies (those with less than 5 % market share) have an increasing role in power generation. Italy, Greece and Lithuania showed the biggest decreases in absolute value. In many Member States, the penetration of wind and photovoltaic generation facilitated the entry of new, relatively small market players.

At the other end of the spectrum, the value of the index increased perceivably in the UK and Ireland.

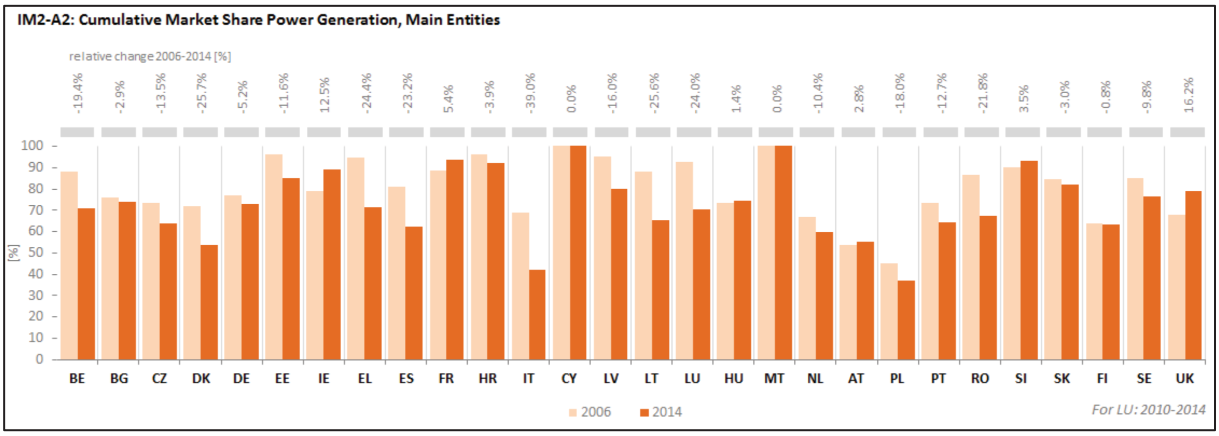


Figure 3.2.4: Cumulative Market Share Power Generation, Main Entities (Source: Eurostat - Electricity market indicators)

IM3: 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 each wholesale gas supply company measured in percentages of total wholesale gas supply, with 10,000 corresponding to a monopoly.[81]

This index published by ACER measures market concentration at the level of upstream sourcing companies supplying gas to a given Member State. Thus, in addition to

[81] See the detailed calculation methodology in Annex 1 of the gas wholesale market volume of ACER's 2015 Market Monitoring Report; http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Market%20Monitoring%20Report%202015%20-%20GAS.pdf

considering geographical diversification, this indicator also takes into account diversification at supplier company level. In general, Member States with well-functioning hubs and/or those that benefit from varied supply sources exhibit low HHI values.

According to ACER, the threshold for a well-functioning market is 2000. In 2015, only five Member States (Belgium, Ireland, Luxembourg, Sweden and the UK) had a concentration index under this threshold. These are countries largely relying on gas from the North Sea, a region characterised by a high number of gas producers and some of them can also source LNG. In turn, countries relying on Europe's largest gas supplier, Russia, will inevitably have a higher concentration index as this practically means dependence on a single company.

Between 2011 and 2015, ten Member States experienced a decrease in the concentration index, with the biggest improvements in Estonia, the Czech Republic and Lithuania. The Czech Republic gradually reduced its dependence on Russia and increased imports from other sources, in particular Norway. In case of the two Baltic States, the decrease was clearly facilitated by the inauguration of the LNG importing facility in Klaipeda (Lithuania). Latvia has apparently not taken advantage of this diversification option and remained fully dependent on Gazprom.

In 14 Member States, the concentration index increased between 2011 and 2015. Hungary, Slovenia and Bulgaria saw the biggest increases, presumably driven by a growing reliance on Russian gas and/or dwindling domestic gas production.[82] ACER argues that in Hungary the impact of the nationalisation policy also contributed to a higher HHI index.

The index also increased for Mediterranean countries; according to ACER, this is explained by a comparative decline in LNG import volumes and the result of demand decline in recent years, combined with the obligation to honour legacy long-term gas supply contracts.

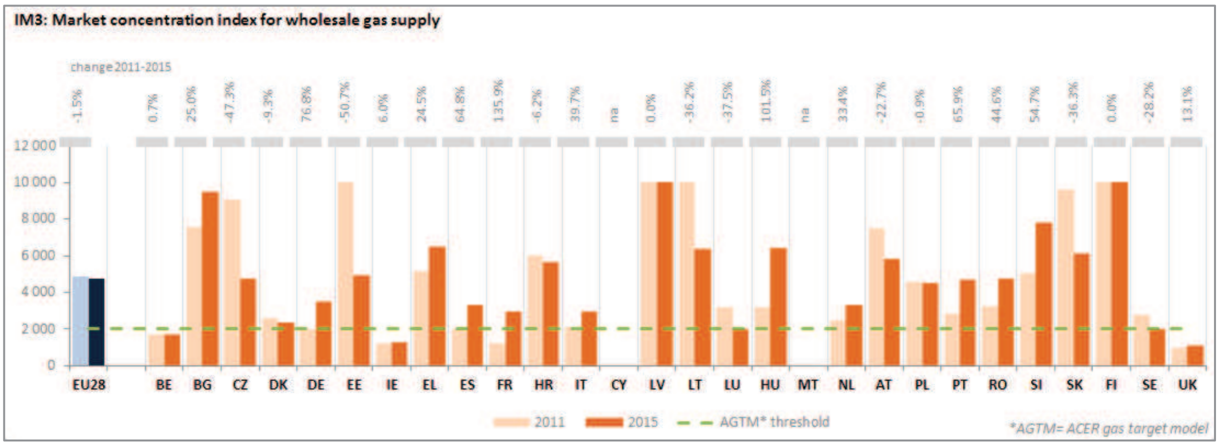


Figure 3.2.5: Market concentration index for wholesale gas supply (Source: ACER)

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[82] As explained in footnote 152 of the gas wholesale market volume of ACER's 2015 Market Monitoring Report, in the case of Hungary and Slovenia the increase may be caused by methodological reasons; http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Market%20Monitoring%20Report%202015%20-%20GAS.pdf

IM3-A1: Cumulative market share of main entities bringing gas in the country – the combined market share of the gas importers with a market share of 5 % or more

This indicator shows that smaller companies (those with less than 5 % market share) play a relatively small role in the wholesale gas markets of most Member States. In 15 of the 23 Member States for which data is available, "main entities" covered more than 90 % of the market in 2014.

In nine Member States, the value of this indicator decreased between 2010 and 2014, suggesting that smaller companies gained ground. This trend is most visible in Spain and Belgium.

In eight Member States, the cumulative market share of main entities increased, with the biggest increase observed in Italy.

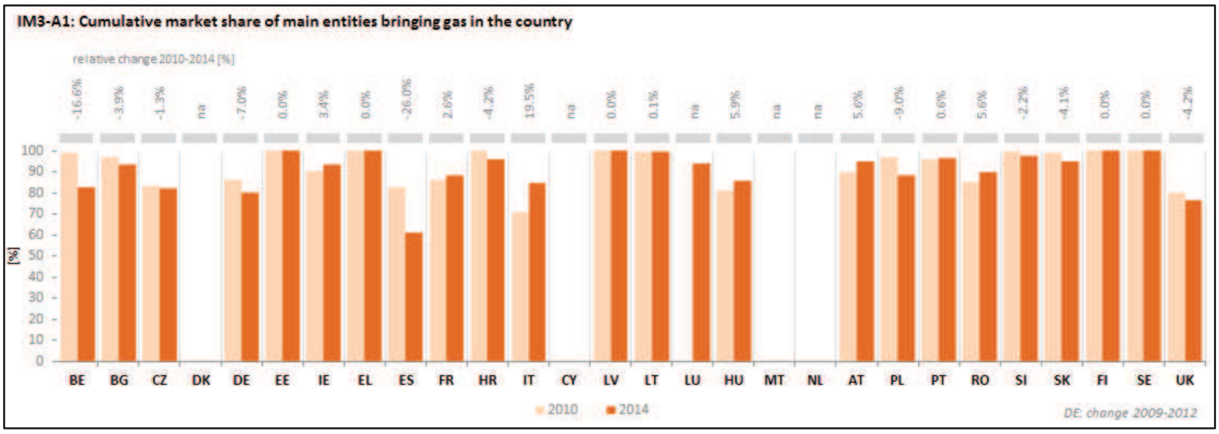


Figure 3.2.6: Cumulative market share of main entities bringing gas in the country (Source: Eurostat - Natural gas market indicators)

3.2.3. WHOLESALE PRICES

The development of wholesale energy prices in Europe is largely dependent on global price trends. This is particularly the case for gas, most of which is imported from third countries. In case of electricity, extra-EU imports are rather small but power generation is often based on imported fossil fuels so global prices will obviously have an impact.

In addition, the level of competition also influences wholesale prices: markets with stronger competition generally show a lower price level than markets characterised by a dominant player. The availability of interconnection capacities can also have an impact on the wholesale prices in individual Member States: in the absence of sufficient cross-border interconnector capacities, regional prices can vary significantly.

With the completion of the internal market, as physical, legal and other obstacles to cross-border energy flows are eliminated, one can also expect a convergence of wholesale prices across Europe.

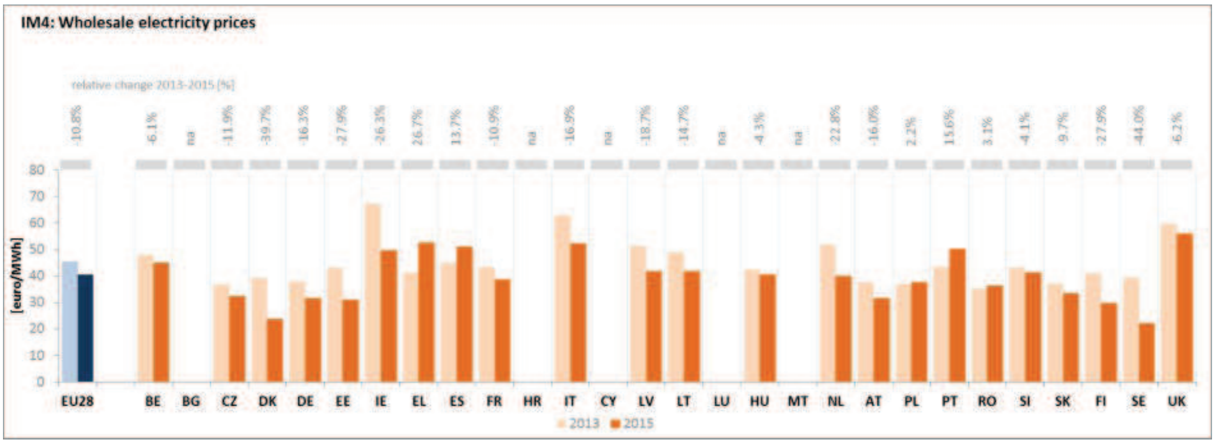
In case of electricity, prices are also impacted by the national electricity mix (the fuels used as an input). In particular, the share of renewable electricity, notably wind and PV, has a strong influence on the wholesale price development. National regulation, for example renewable support schemes or carbon taxes can also have a noticeable impact.

IM4: Wholesale electricity prices – annual average electricity price at the national power exchanges or the annual average of prices in bidding zones.

Largely driven by falling coal and gas prices, the gradual penetration of low marginal cost renewables into the power sector and subdued demand due to energy efficiency measures, wholesale electricity prices decreased in most Member States (in 18 out of the 23 countries for which prices are available) between 2013 and 2015.

In 2015, the three Nordic countries had the lowest prices, facilitated by a high share of renewables (hydro in Finland and Sweden, biomass in Finland and wind in Denmark) and nuclear (in Finland and Sweden) in the electricity mix. The UK had the highest price, followed by four Mediterranean countries (Greece, Italy, Spain and Portugal). Wholesale electricity prices in the UK are largely impacted by the carbon price floor imposed on fossil fuels used for generating electricity, the closure of several coal-fired plants in recent years and the limited level of electricity interconnections with continental Europe.

Ireland, Sweden and Denmark experienced the most significant decreases in the wholesale electricity price between 2013 and 2015 while in Greece, Portugal and Spain prices showed a noticeable increase in the same period. As a result, we have seen a diverging trend: the difference between the highest and the lowest price increased from 32 €/MWh in 2013 to 34 €/MWh in 2015.[83] (In 2016, however, wholesale electricity prices continued their long-term convergence.)



Note: EU28 is the weighted average of Member States' prices

Figure 3.2.7: Wholesale electricity prices (Source: Platts, European power exchanges)

IM5: Wholesale gas prices – average annual price at national gas hubs, or – in the absence of such data – estimated average border price of imported gas, based on customs data.

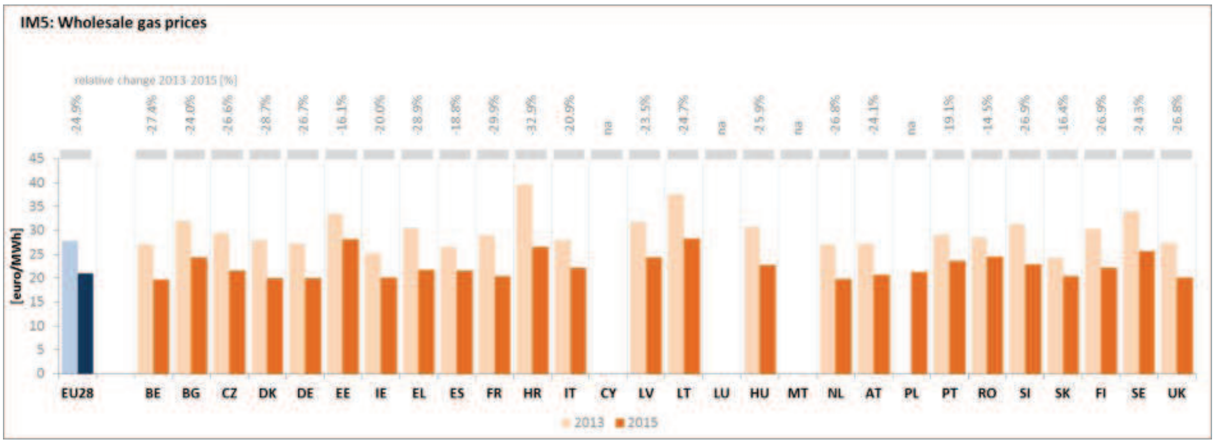
[83] The diverging trend is also confirmed by the standard deviation of wholesale gas prices which increased from 8.65 €/MWh in 2013 to 9.35 €/MWh in 2015.

Between 2013 and 2015, gas wholesale prices decreased in all Member States as relatively weak demand, oversupply in the main regional markets, low oil prices and steady LNG imports put pressure on European gas prices. The extent of the price decrease varied between 14 % and 33 %.

In absolute value, prices decreased the most in Croatia, Lithuania and Greece. Croatia had the highest estimated border price in 2013 and, in spite of the significant decrease, the wholesale price remained one of the highest in Europe, on par with the Baltic states. In Lithuania, the new LNG terminal facilitated the diversification of import sources and the reduction of prices.[84] In the case of Greece, the development of estimated border prices suggests that during 2015 the pricing of Russian gas shifted from oil-indexation towards hub-based pricing.

While Slovakia experienced the smallest decrease (in absolute value), the Slovakian price remained under the EU average and was the lowest in Central Eastern Europe in 2015.

Wholesale gas prices show a clear converging trend: the difference between the highest and the lowest price decreased from 15 €/MWh in 2013 to 9 €/MWh in 2015. The convergence was mainly driven by the lowering of the oil prices which allowed oil-indexed prices to approximate north-west European hub prices. Oil-indexed gas prices have a diminishing role in the European market: between 2005 and 2015, the share of gas priced under such a mechanism decreased from 78 % to 30 %.[85] However, oil-indexation continues to be the main pricing mechanism in certain regions, in particular the Mediterranean, south-east Europe and the Baltics.



Note: hub prices for BE, DK, DE, FR, IT, NL, AT, PL, FI and UK; estimated border prices based on customs data for the other countries. EU28 is the weighted average of Member States' prices

Figure 3.2.8: Wholesale gas prices (Source: Platts, gas hubs, Eurostat)

[84] The inauguration of the LNG terminal allowed Lithuania to renegotiate the contract with Gazprom and further discounts were granted. Apparently these discounts are not fully reflected in the estimated border prices.

[85] International Gas Union Wholesale Gas Price Survey 2016 Edition

3.2.4. RETAIL MARKETS

Effective competition in retail energy markets requires the participation of a sufficient number of suppliers, rewards for active consumer participation in the market in the form of monetary gains or better services, the awareness of consumers about their right to choose the supplier and simple, low-cost and fast switching processes.

Switching rates are one element that can inform about the degree of competition and the empowerment of consumers on retail energy markets. In a well-functioning retail market, consumers can and do exercise the option of switching suppliers in order to benefit from better conditions (lower price and/or better services). In reality, the lack of trust in new suppliers and the perceived complexity of switching processes often discourage consumers from switching supplier, even if there are potential savings.

IM6: Annual switching rates - electricity - household customers – the percentage of household electricity consumers changing suppliers in a given year.

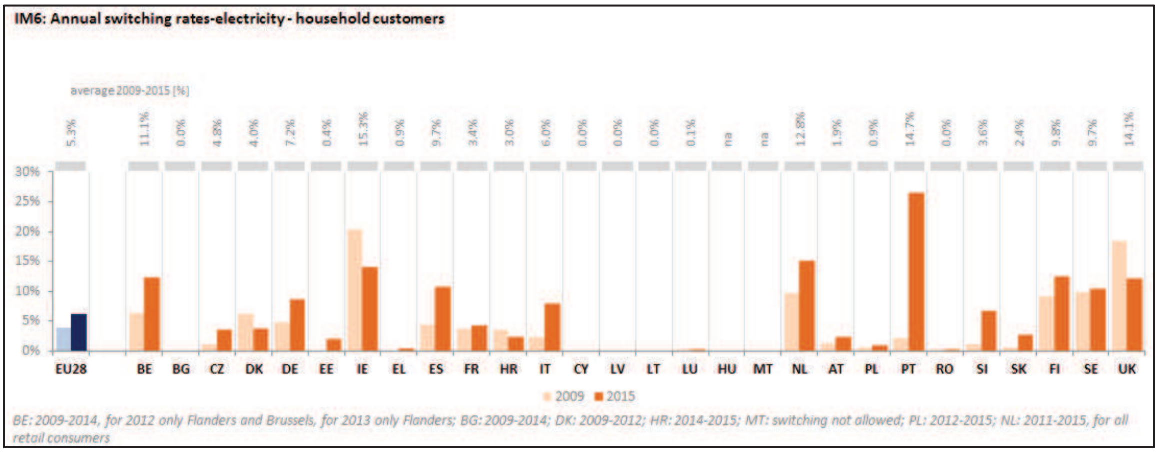
In 2015, on average 6.2 % of household consumers in the EU changed their electricity suppliers. This represents an increase compared to 20109 when this rate was 4.0 %. The rate increased in the majority of the Member States for which data are available. As there can be significant changes in the switching rate from one year to another, Figure 3.2.9 also depicts the average switching rates observed in the 2009-2015 period. In general, consumers in countries with a longer liberalisation history are able to choose from a considerably larger number of offers and switching rates in such markets are higher than in markets which liberalised more recently.

Portugal had the highest switching rate in 2015, with about a quarter of household consumers changing supplier in that year. Portugal is also the country with the biggest growth in this indicator: the switching rate increased from 2.1 % in 2009 to 26.6 % in 2015. As ACER's market monitoring report explains, the high switching rates (for both electricity and gas) in Portugal "might be explained by the ongoing liberalisation process of retail energy markets in which, during the defined transition period, the NRA regulates a so-called 'transitory tariff', which may include an optional surcharge, with the objective of promoting switching to a non-regulated tariff".[86] Spain, Belgium, Italy, Slovenia and the Netherlands also experienced a noticeable increase of the switching rate between 2011 and 2015.

At the same time, the switching rate decreased in a few countries; the biggest decreases were observed in Ireland and the UK.

A handful of Member States continue to have a 0 % switching rate. In these countries, household consumers are not able to benefit from lower prices by switching to another electricity supplier. In certain cases consumers are allowed to switch but regulated prices provide no incentive to do so.

[86] http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Market%20Monitoring%20Report%202015%20-%20ELECTRICITY%20AND%20GAS%20RETAIL%20MARKETS.pdf



Note: The switching rate for the EU is an arithmetic average of Member State's switching rates.

Figure 3.2.9: Annual switching rates - electricity - household customers (Source: ACER/CEER)

IM6-A1-Market performance indicator (MPI), retail electricity services – a composite index which indicates how well the retail electricity market performs, according to consumers. It takes into account five key aspects of consumer experience: comparability, trust, problems & detriment, expectations and choice. The five components of the index are weighted on the basis of their relative importance as stated by consumers. The maximum total score is 100; a high MPI score indicates good market performance.[87]

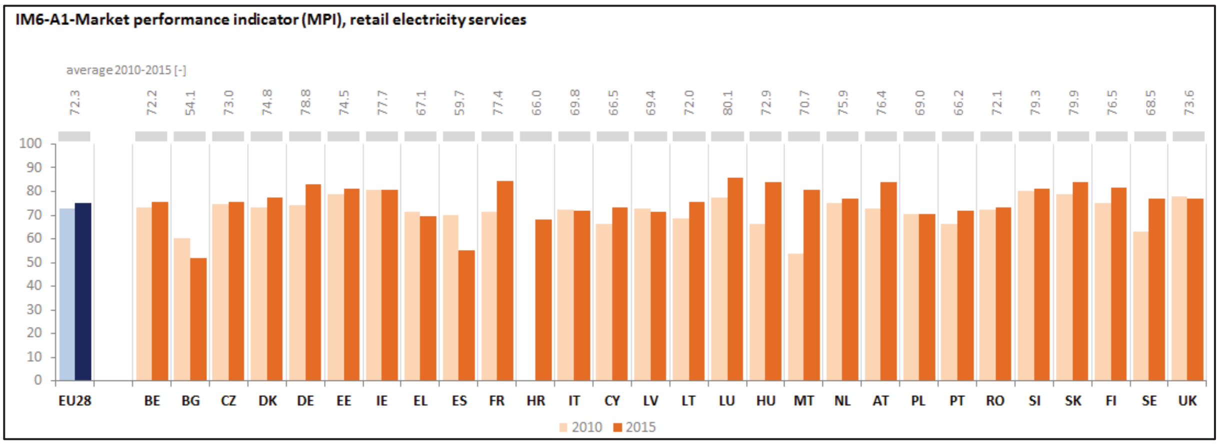
The 2015 survey covered 29 different service markets and the retail electricity market was ranked well below average, on the 26th place with an MPI score of 75.3 (the average of all service sectors was 78.6). On a scale of 1 to 10, choice (consumers' satisfaction with the number of suppliers) had a score of 6.9.

There are considerable differences among Member States: in 2015, the MPI values for the retail electricity market ranged from 51.8 to 85.9. For 24 Member States, the MPI exceeded 70 and for 11 of them it was above 80. The results show that this market performs relatively well in western and northern Europe while scores are below average in southern and eastern Europe.

Between 2010 and 2015, the MPI for the retail electricity market increased from 72.6 to 75.3, indicating a slight improvement in the perception of consumers.[88] The countries with the biggest improvement were Malta, Hungary, Sweden and France. On the other hand, the MPI value decreased for seven Member States, with the biggest decreases in Spain and Bulgaria.

[87] See the detailed methodology and the detailed results of the survey at http://ec.europa.eu/consumers/consumer_evidence/consumer_scoreboards/market_monitoring/index_en.htm

[88] It should be noted that, over the years, there have been some changes in the methodology of the surveys which may distort the chronological comparison of the MPIs.



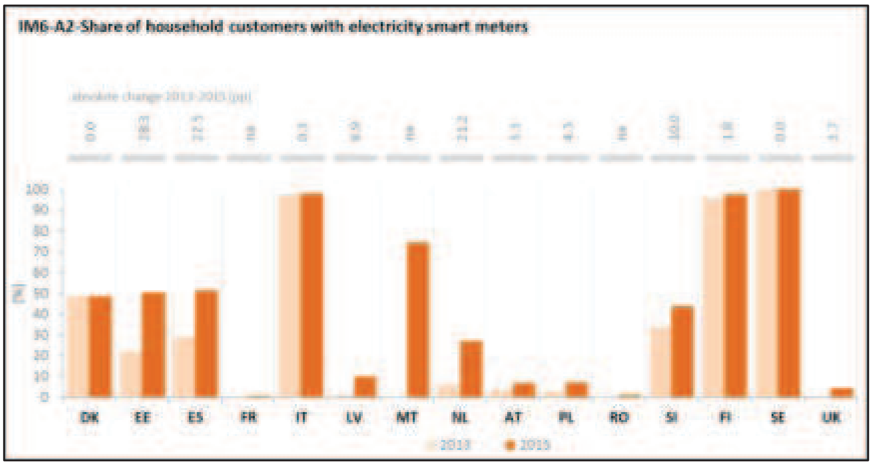
Note: the 2010 MPI for the EU refers to EU-27 (without Croatia)

Figure 3.2.10: Market performance indicator (MPI), retail electricity services (Source: Consumer Market Monitoring Surveys carried out by the Directorate-General for Justice and Consumers (DG JUST), European Commission)

IM6-A2 Share of household customers with electricity smart meters – the indicator is the ratio between the number of customers having electricity smart meters and the total number of customers.

The third energy package requires Member States to ensure the implementation of intelligent metering systems for the long-term benefit of consumers. Currently, 17 Member States have set minimal technical requirements for electricity smart meters. However, the smart meters' functionalities vary largely, mainly including the provision of information on household's consumption patterns and billing based on actual consumption (e.g. billing based on the actual consumption in the previous month rather than the average consumption in the previous year).

Italy, Finland and Sweden already achieved a full roll-out and in Estonia, Spain, Denmark and Malta about half of household customers are already equipped with electricity smart meters. Lower penetration levels of smart meters are also reported in the Netherlands, Austria, Latvia, Poland, the UK, France and Romania[89].



[89] Based on the last ACER market monitoring report; http://www.acer.europa.eu/en/electricity/market%20monitoring/pages/default.aspx

Figure 3.2.11: Share of household consumers with electricity smart meters (Source: ACER/CEER)

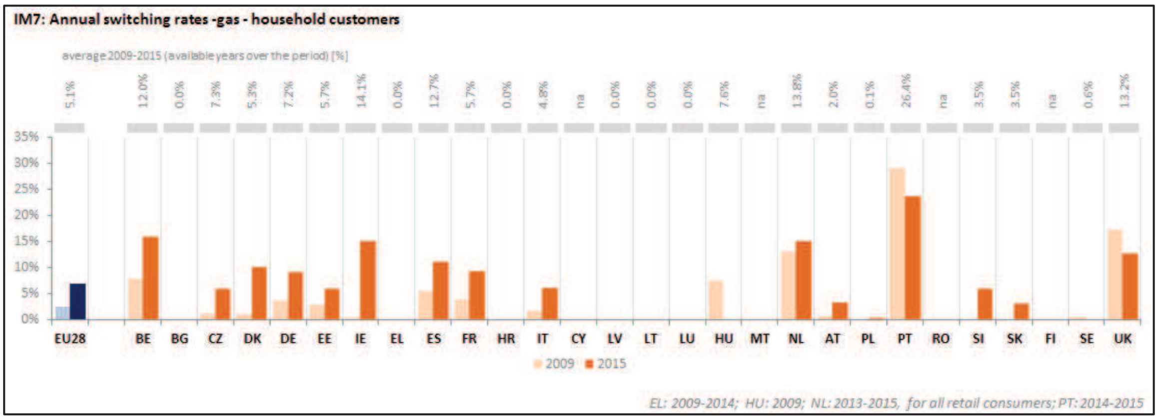
IM7: Annual switching rates - gas - household customers – the percentage of household gas consumers changing suppliers in a given year.

In 2015, on average 7.0 % of household consumers in the EU changed their gas suppliers. This represents a significant increase compared to 2009 when this rate was 2.5 %. The rate increased in about half of the Member States for which data is available. As there can be significant changes in the switching rate from one year to another, Figure 3.2.12 also depicts the average switching rates observed in the 2009-2015 period. Similarly to electricity, consumers in countries with a longer liberalisation history can typically choose from a larger number of gas offers and switching rates in such markets are higher than in markets which liberalised more recently.

Similarly to the electricity market, Portugal had the highest switching rate in 2015, with almost a quarter of household consumers changing supplier in that year, although this represents a decrease compared to the previous year.[90] In the 2009-2015 period, Ireland, Denmark and Belgium were the countries with the biggest growth in this indicator.

At the same time, the switching rate decreased between 2009 and 2015 in a few countries including the UK.

Six Member States (Bulgaria, Greece[91], Croatia, Latvia, Lithuania and Luxembourg) continue to have a 0 % switching rate. In these countries, household consumers are not able or not interested to switch to another gas supplier.



Notes: switching rate for the EU is an arithmetic average of Member State's switching rates

Figure 3.2.12: Annual switching rates - gas - household customers (Source: ACER/CEER)

IM7-A1-Market performance indicator (MPI), retail gas services – a composite index which indicates how well the retail gas market performs, according to consumers. It takes into account five key aspects of consumer experience: comparability, trust, problems & detriment, expectations and choice. The five components of the index are

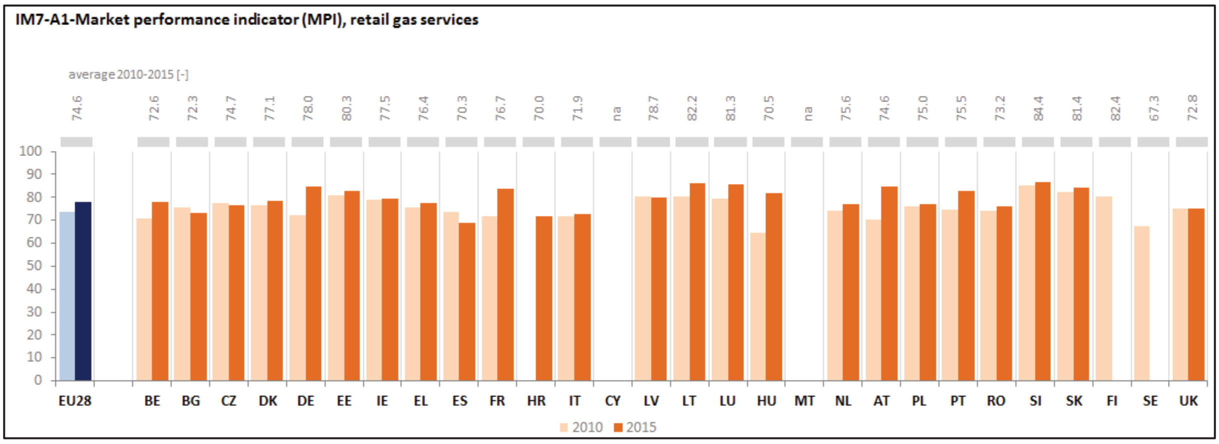
[90] In case of Portugal, data is not available for 2009-2013.
[91] In case of Greece, 2015 data is not yet available.

weighted on the basis of their relative importance as stated by consumers. The maximum total score is 100; a high MPI score indicates good market performance.[92]

From the 29 different service markets covered by the 2015 survey, the retail gas market was ranked on the 14th place with an MPI score of 78.1. This more or less corresponds to the average of all service sectors (78.6). On a scale of 1 to 10, choice (consumers' satisfaction with the number of suppliers) had a score of 7.1.

In 2015, the MPI values for the retail gas market ranged from 68.7 to 86.6, a significantly narrower range than in the case of electricity. For all except one Member State, the MPI exceeded 70 and for 10 of them it was above 80. At regional level, the retail gas market scores higher than the EU average in the western region and lower than average in the southern region.

Between 2010 and 2015, the MPI for the retail gas market increased from 73.6 to 78.1, indicating an improvement in the perception of consumers. The countries with the biggest improvement were Hungary, Austria, Germany and France. On the other hand, the MPI value decreased for five Member States, with the biggest decrease in Spain.



Note: gas is not used in Cyprus and Malta; the 2010 MPI for the EU refers to EU-27 (without Croatia); the 2015 survey did not cover Finland and Sweden

Figure 3.2.13: Market performance indicator (MPI), retail gas services (Source: Consumer Market Monitoring Surveys carried out by the Directorate-General for Justice and Consumers (DG JUST), European Commission)

IM7-A2 Share of households' customers with gas smart meters – the indicator is the ratio between the number of customers having gas smart meters and the total number of customers.

The market uptake of gas smart meters is limited to only a few Member States. Currently, only the Netherlands seem to have made significant progress in the deployment of gas smart meters (29.8 % penetration rate in households in 2015); this is also the case, but to a lesser extent in the United Kingdom (3.6 % penetration rate in 2015).

[92] See the detailed methodology and the detailed results of the survey at http://ec.europa.eu/consumers/consumer_evidence/consumer_scoreboards/market_monitoring/index_en.htm

3.2.5. Energy Affordability

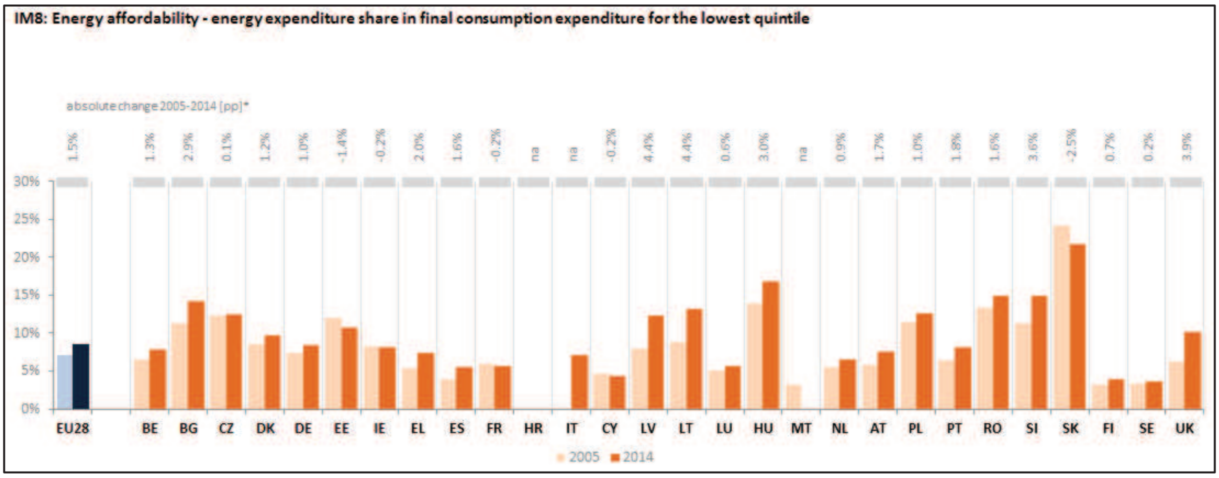
Energy is an important part of household expenditure: in 2014, EU households spent on average 1300 euros on domestic energy products, equivalent to almost 6 % of their total expenditure. This share was higher for low-income households: they spend proportionally more on energy products than the average. This provides a good reason to focus on low income households when analysing expenditures on energy from an affordability perspective.

IM8: Energy affordability – the share of domestic energy expenditure[93] in final consumption expenditure for the lowest quintile – the share of energy related expenditure in total household expenditure for the poorest 20 % of the population. The indicator is based on the Household Budget Survey (HBS) undertaken by Eurostat, for which expenditure data are collected every 5 years. DG Energy jointly worked with national statistical institutes and Eurostat on an ad-hoc data collection to gather all the necessary information to complete the series of energy affordability.

It should be pointed out that this indicator is likely to under-estimate energy poverty as, due to financial constraints, many low-income households cannot afford to consume the necessary amount of energy to heat (or cool) their homes to an adequate temperature.

The available data indicates an increase in the share of energy expenditure in total consumption expenditure for the poorest households over the last decade: the value of the indicator increased at the EU28 level from 7.1 % in 2005 to 8.6 % in 2014. There has been an increase in 19 Member States, with the biggest increases observed in Lithuania, the UK and Latvia. The share of energy expenditure decreased in six Member States; Slovakia showed the biggest improvement but it still had the highest share in the EU in 2014.

The share of energy in total household expenditure was significantly higher for the lowest income quintile (8.6 %) than for the entirety of households (5.8 %) in 2014.



Note: because of data availability, the observed periods are different: BE 2005-2014, BG 2005-2014, CZ 2005-2014, DK 2005-2014, DE 2003-2013, EE 2010-2012, IE 2005-

[93] The following energy products were taken into account for analysing the energy related expenditure of households: electricity, gas, liquid fuels (mainly heating oil), solid fuels and heat energy (primarily meaning district heating). Transport fuels were not included.

2010, EL 2008-2014, ES 2006-2014, FR 2006-2011, HR -, IT only 2014, CY 2003-2009, LV 2005-2014, LT 2005-2012, LU 2005-2013, HU 2005-2014, MT only 2008, NL 2004-2013, AT 2005-2010, PL 2005-2014, PT 2005-2010, RO 2005-2014, SI 2005-2012, SK 2005-2014, FI 2006-2012, SE 2005-2012, UK 2005-2014

Figure 3.2.14: Energy affordability - energy expenditure share in final consumption expenditure for the lowest quintile (Source: DG ENER ad-hoc data collection across national statistics institutes – with Eurostat support – on household budget survey)

IM8-A1: Harmonised index of consumer prices (HICP) - electricity, gas and other fuels' weight into total household expenditure[94] – HICP measures the change over time of the prices of consumer goods and services acquired by households. Weighted HICP for electricity, gas and other fuels indicate the relative importance of the energy expenditure in total household expenditure.

Unlike IM8, this indicator is based on the consumption of the whole population, not just the poorest households.

There is a significant variation across the EU in the value of this indicator, driven by income (higher income typically mean a lower share of energy expenditure) and climate (warmer climate also induces a lower share of energy expenditure).

Between 2005 and 2015, the weight of energy products increased from 5.0 % to 6.3 % in the harmonised index of consumer prices, indicating an increasing share of energy in households' expenditure. In the last few years (since 2012) the weight shows a decreasing trend, helped by falling energy prices. In fact, the fall in energy prices create downward pressure on the overall price level, adding to deflationary risk.

21 Member States showcased an increase between 2005 and 2015; the biggest increases were seen in Croatia and Estonia. On the other hand, in seven Member States the weight of energy products decreased, with a prominent decline in Romania.

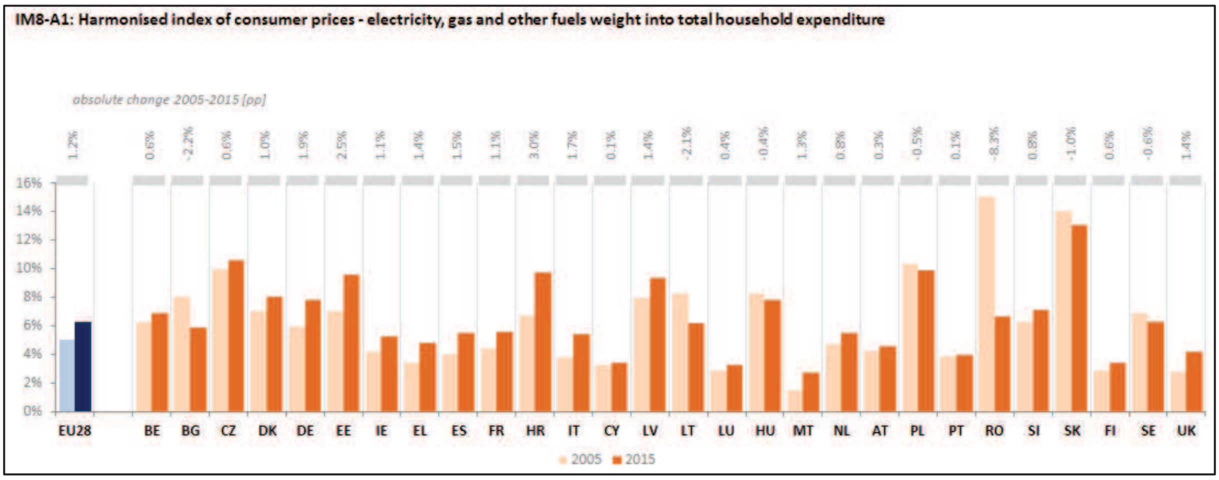


Figure 3.2.15: Harmonised index of consumer prices - electricity, gas and other fuels weight into total household expenditure (Source: Eurostat HCIP item weights)

[94] Transport fuels are excluded.

IM8-A2 Inability to keep home adequately warm (share in total population at risk of poverty) – the share of low income households (those being below 60 % of the median national income) that cannot afford to keep their homes adequately warm.

Keeping homes adequately warm is essential for the quality of living; hence space heating is of particular importance from an affordability perspective.[95] As Figure 3.2.15 shows, Member States show a large diversity regarding the share of those low income households that cannot afford to keep their homes adequately warm. In 2015, the share of such households in the EU was 23 % on average, ranging from 2 % in Sweden to 67 % in Bulgaria. Inability to keep homes adequately warm is not necessarily a question of financial means but also of the housing stock: homes may be cold because of poor energy performance (i.e. poor thermal insulation).

Over the last decade, there have been significant changes in many Member States in the share of such households. In Belgium, Bulgaria, Latvia, Poland and Portugal[96] the value of the indicator fell by more than 10 percentage points between 2005 and 2015, with the biggest improvement seen in Poland. On the other hand, in Greece[97] and Malta the ratio increased by more than 10 percentage points.

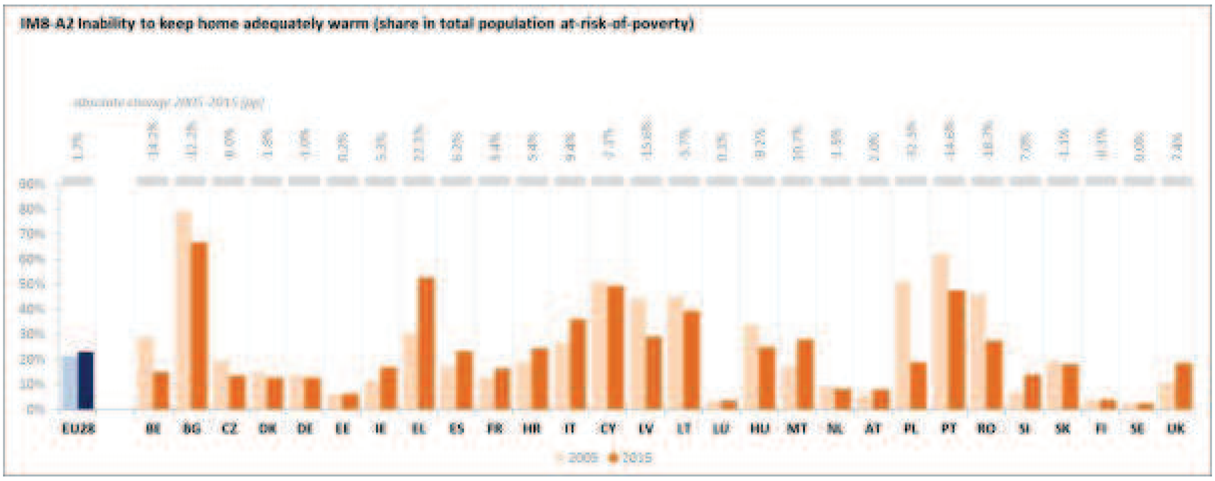


Figure 3.2.16: Inability to keep home adequately warm (share in total population at risk of poverty) (Source: Eurostat SILC)

3.2.6. RETAIL PRICES AND TAXATION

IM8-A3 Households electricity prices – electricity price paid by household consumers in consumption band DC (2 500 kWh < Consumption < 5 000 kWh) in the second half of the year, all taxes and levies included.

Looking at the EU average, nominal electricity prices paid by household consumers increased by more than 20 % between 2010 and 2015. In this period, the price increased in the majority of Member States. Consumers in the UK, Portugal, Latvia, Ireland and Greece faced the biggest price increase in absolute value in this period. Six Member States bucked this trend, with a sizeable reduction of prices in Hungary and Malta. In

[95] The same applies to cooling in southern Member States.
[96] In case of Portugal between 2005 and 2014 (2015 figure is not yet available).
[97] In case of Greece, between 2005 and 2014 (2015 figure is not yet available).

Hungary, significant retail electricity (and gas) price cuts have been implemented by the government in 2013 and 2014 while in Malta the regulated electricity tariff was lowered in 2014.

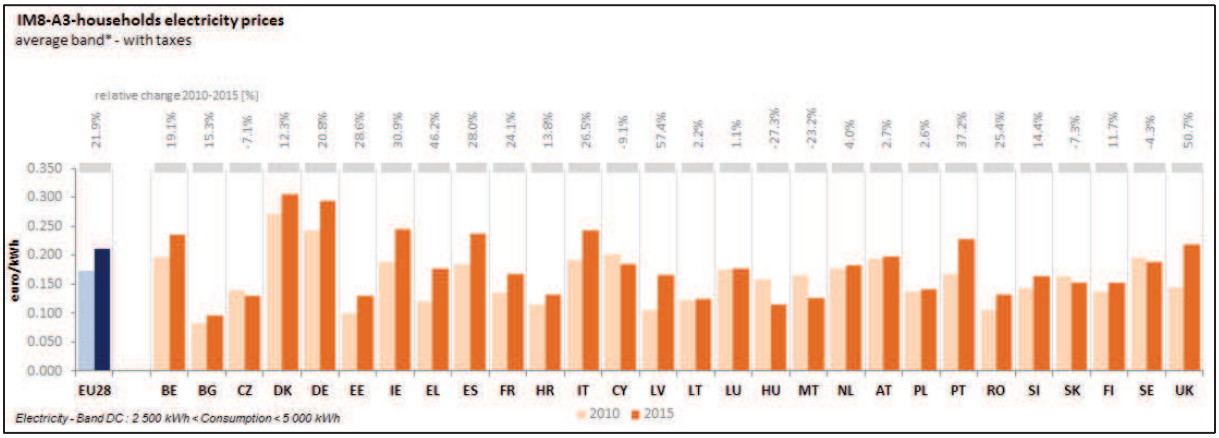


Figure 3.2.17: Households electricity prices (Source: Eurostat)

IM8-A4 Households gas prices – gas price paid by household consumers in consumption band D2 (20GJ < Consumption < 200GJ) in the second half of the year, all taxes and levies included.

Similarly to electricity, retail gas prices also increased between 2010 and 2015. On average, the increase was 25 %. In 17 out of 25 Member States, the gas price paid by household consumers increased in this period, with the biggest increases observed in Spain, Portugal and the UK. On the other hand, the price fell in eight Member States, with the biggest decreases enjoyed by consumers in Greece[98], Hungary and Denmark. The Greek gas price was the second highest in the EU in 2012 but, since then, was gradually lowered. In Hungary, retail energy prices were significantly cut by the government in 2013 and 2014.

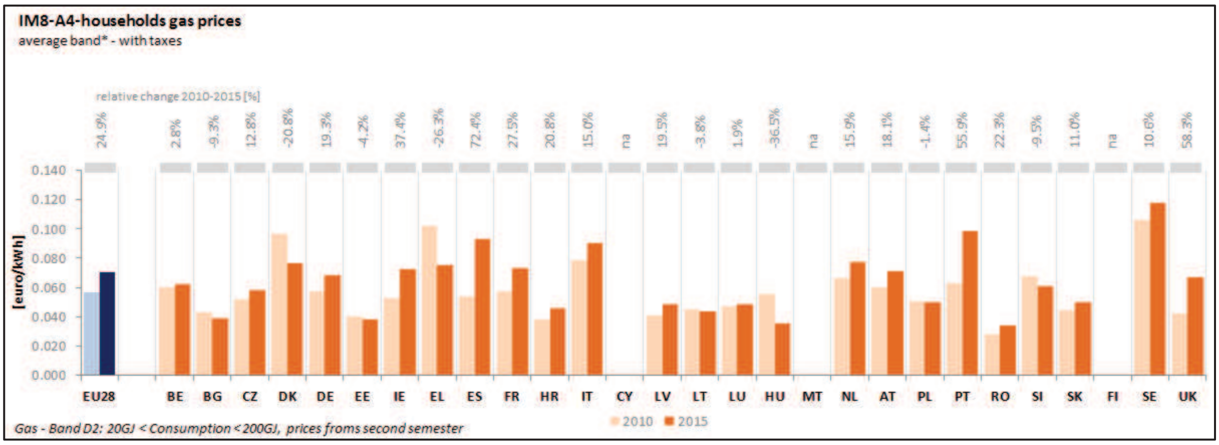


Figure 3.2.18: Households gas prices (Source: Eurostat)

The development of retail prices is very much dependent on wholesale prices but other factors, in particular network costs, taxes and levies, also influence the price paid by the final consumer. Below we present the share of taxes and levies in the retail price of the

[98] Decrease observed between 2012 and 2015 (prices for 2010 and 2011 are not available).

main energy products. Based on an ad hoc data collection, the recently published report on energy prices and costs in Europe[99] provides detailed analysis on the evolution of the different price components between 2008 and 2015, explaining how various taxes and levies (including fiscal taxes that contribute to the financing of overall public expenditures and levies or earmarked taxes that cover various energy system and policy costs) contributed to retail price increases. The report also presents the development of the "network" component (transmission and distribution tariffs); these have also increased since 2008 (although to a lesser extent than taxes and levies) and, considering that significant investments in distribution networks and smart grid deployment need to be made in the next 10 years, this price component is likely to increase further.

The above report found that levies imposed on gas and electricity follow an increasing trend, reflecting the national policies pursued to comply with the EU policy for renewable energy and energy efficiency. It is important that the levies ensure cost recovery of the support cost in order to avoid the creation of tariff deficits that are built up in the energy system, either in various state-owned or private companies or in the transmission and distribution system operators. Such a deficit will impede the future potential to undertake investments by these actors and will eventually have to be paid by consumers or tax payers.

IM-A1: Share of taxes in retail electricity prices for households – the share of taxes and levies in the electricity price paid by household consumers in consumption band DC (2 500 kWh < Consumption < 5 000 kWh) in the second half of the year.

On average, nearly one third of the electricity price paid by household consumers could be attributed to taxes and levies in 2015. This represents an increase from 2010 when this share was 28 %. In 2015, the share of taxes exceeded 50 % of the total consumer price in two Member States.

While VAT remained the main tax component in retail electricity prices, its share from total taxes and levies decreased from 45 % in 2010 to 37 % in 2015. In the same period, the share of levies imposed to support renewable energy sources and combined heat and power increased from 16 % to 33 %.[100]

The share of taxes and levies increased in 23 Member States since 2010, with the biggest increases observed in Latvia, Lithuania and Portugal. Three Member States experienced a modest decrease while in two countries the share remained unchanged.

[99] COM(2016) 769 final and SWD(2016) 420 final
[100] See detailed analysis of the composition of taxes and levies in SWD(2016) 420 final

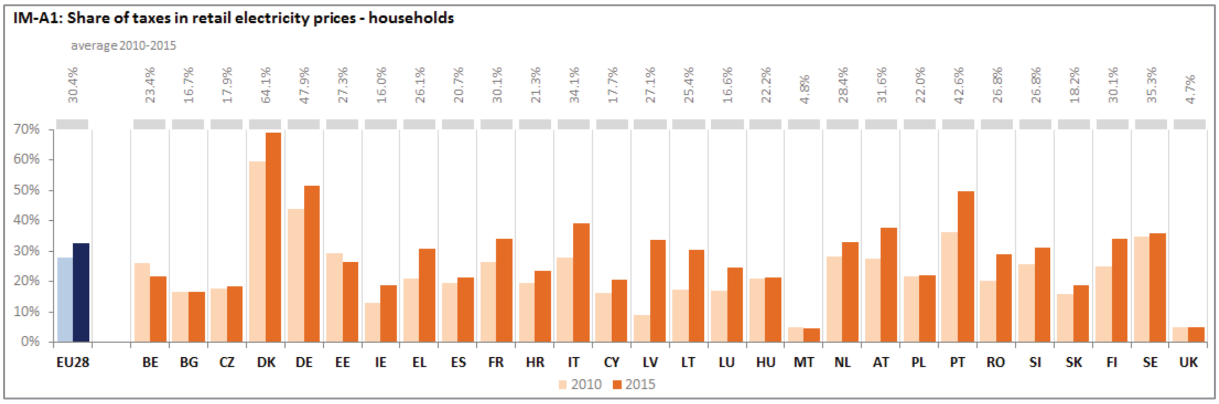


Figure 3.2.19: Share of taxes in retail electricity prices - households (Source: Eurostat)

IM-A2: Share of taxes in retail gas prices for households – the share of taxes and levies in the gas price paid by household consumers in consumption band D2 (20GJ < Consumption < 200GJ) in the second half of the year.

In 17 Member States, the share of taxes and levies in the retail gas prices increased between 2010 and 2015. The increase was more than 10 percentage points in the case of Portugal and Latvia. In eight Member States, the share of taxes and levies showed a modest decrease or remained unchanged. On the EU28 average, the share remained practically unchanged: it was 23 % in both 2010 and 2015.

The share of taxes and levies in the retail gas prices paid by household customers is lower than for electricity. Denmark is the only Member State where the share of taxes and levies exceeded 50 %.

In 2015, non-earmarked taxes (VAT, excise duty and other taxes) accounted for 93 % of the total taxes and levies component; energy policy relevant levies accounted for only 7 % of the total taxes and levies component.[101]

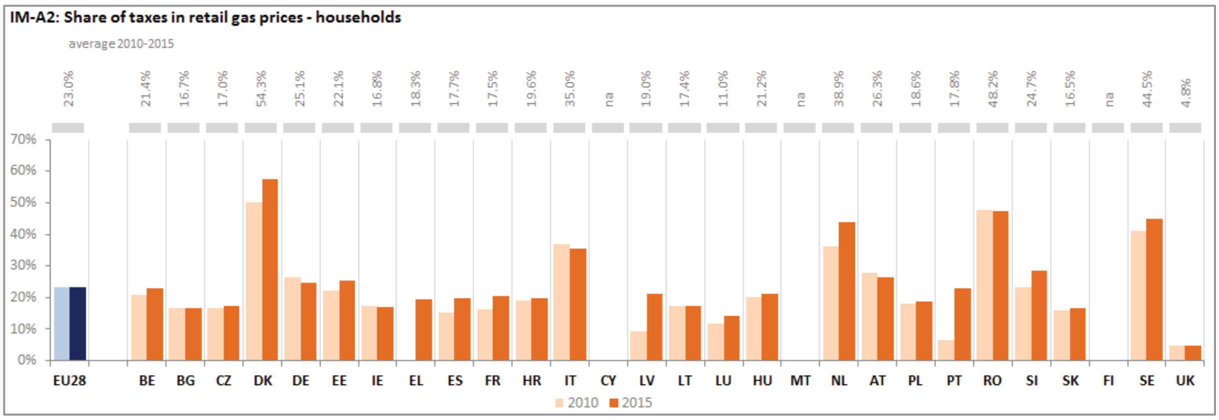


Figure 3.2.20: Share of taxes in retail gas prices - households (Source: Eurostat)

IM-A3: Share of taxes in retail gasoline prices – the share of taxes (VAT, excise duty and other indirect taxes) from the consumer price of motor gasoline (Euro-super 95).

[101] SWD(2016) 420 final

In the case of motor gasoline, the energy tax directive[102] sets a relatively high minimum excise duty rate: 0.359 €/litre. As a result, the tax component of the gasoline price is rather high: in 2015, on average 63 % of the final consumer price was made up by taxes. Excise duties (including other indirect taxes) and VAT covered 46 % and 17 % of the consumer price, respectively. With the exception of Bulgaria, the share of taxes exceeded 50 % in all Member States.

In most Member States, the share of taxes increased between 2010 and 2015. Cyprus, Italy and Romania experienced the biggest growth, driven by the increase in the excise duty rate. In the case of Bulgaria, Hungary and Sweden there was a minimal decrease in the share of taxes.

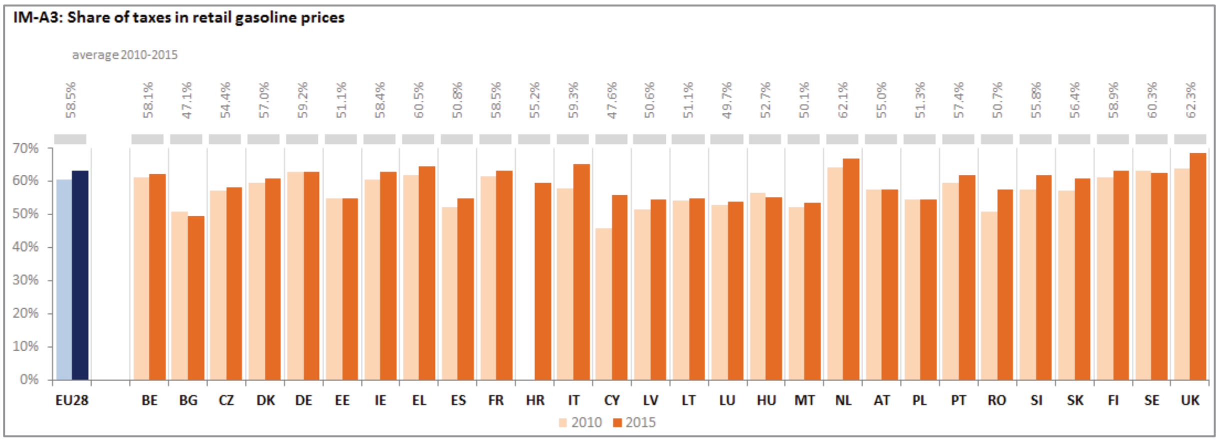


Figure 3.2.21: Share of taxes in retail gasoline prices (Source: Oil Bulletin, European Commission)

IM-A4: Share of taxes in retail diesel prices – the share of taxes (VAT, excise duty and other indirect taxes) in the consumer price of diesel (automotive gas oil).

For diesel, almost all Member States set a lower excise duty rate than for gasoline. The minimum excise duty rate set by the energy tax directive is also lower, 0.33 €/litre. The UK is the only Member State which imposes the same excise duty rate for the two main motor fuels. In 2015, taxes made up on average 57 % of the retail diesel price in the EU. Excise duties (including other indirect taxes) and VAT covered 40 % and 17 % of the consumer price, respectively.

In all but three Member States, the share of taxes increased between 2010 and 2015. Cyprus, Italy and Finland experienced the biggest increases; in these three countries the excise duty rate increased by about 50 % in this period.

[102] Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity

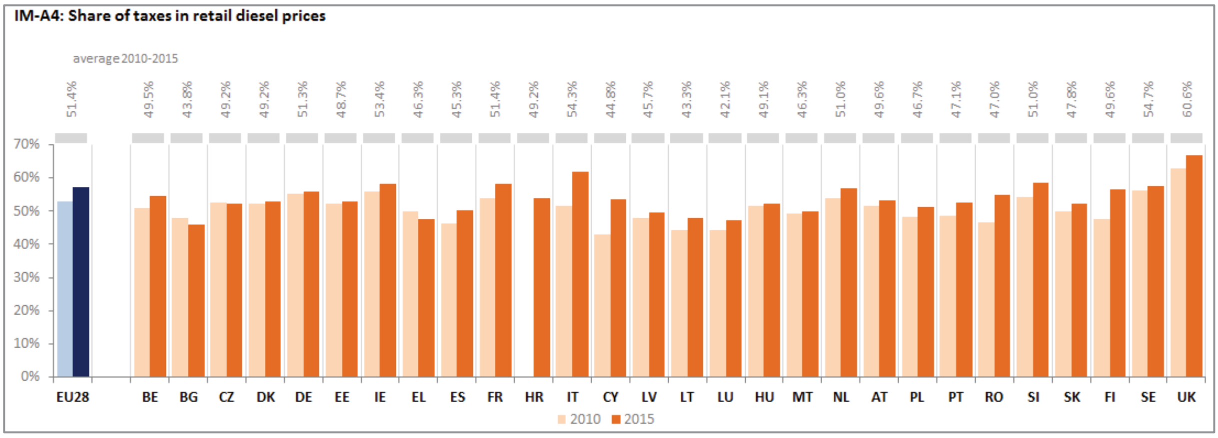
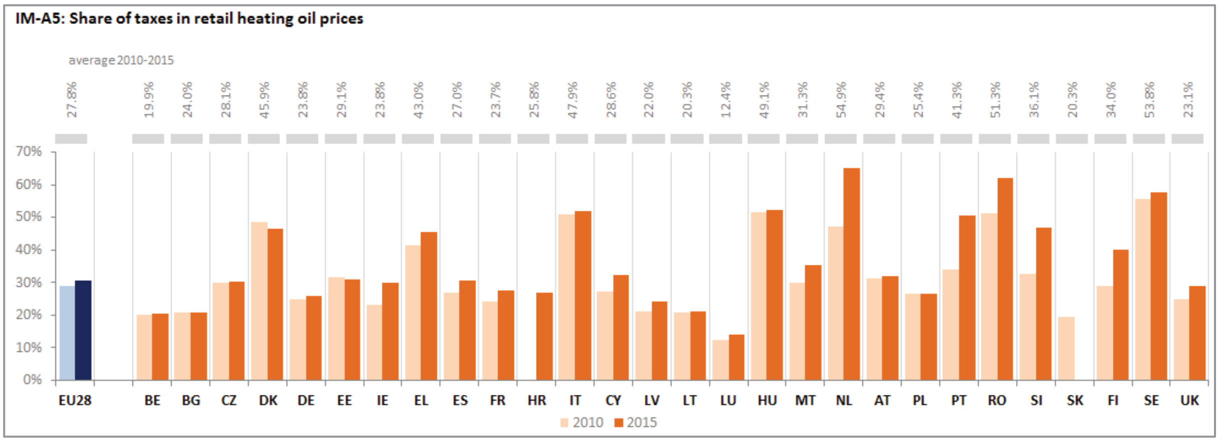


Figure 3.2.22: Share of taxes in retail diesel prices (Source: Oil Bulletin, European Commission)

IM-A5: Share of taxes in retail heating oil prices – the share of taxes (VAT, excise duty and other indirect taxes) from the consumer price of heating oil (heating gas oil).

For heating oil, the minimum excise duty rate set by the energy tax directive is only 0.021 €/litre and most Member States impose a significantly lower rate than for gasoline and diesel. As a result, the share of taxes and levies in the final consumer price was just above 30 % in 2015. Excise duties (including other indirect taxes) and VAT covered 14 % and 17 % of the consumer price, respectively. The big differences in the excise duty rates for heating oil result in a wide dispersion of the share of the tax component across the EU (from 14 % to 65 %).

In 24 Member States, the share of taxes increased between 2010 and 2015. The increase was most significant in the Netherlands, Portugal and Slovenia.



Note: Slovakia does not report heating oil price since October 2011.

Figure 3.2.23: Share of taxes in retail heating oil prices (Source: Oil Bulletin, European Commission)

3.3. ENERGY EFFICIENCY AND MODERATION OF DEMAND

Key points

- Primary energy consumption reached 1507 Mtoe in 2014. This means that the Union's primary energy consumption was only 1.6 % above its absolute primary energy consumption target for 2020. Nevertheless, additional efforts are needed if the 20 % target is to be reached by 2020.
- Final energy consumption declined to 1061.2 Mtoe in 2014. This means that the Union's final energy consumption was already 2.2 % below its absolute final energy consumption target for 2020. Nevertheless, the Union has to continue the efforts on keeping the final energy consumption at this level.
- Energy intensity in industry decreased in most Member States in 2014 compared with 2005, the exceptions being Cyprus, Greece, Hungary and Latvia. Notable decreases were registered in most central and eastern Member States (e.g. Romania, Bulgaria, the Czech Republic, Poland, Slovakia and Estonia).
- In the residential sector, energy consumption per inhabitant and climate corrected per square meter decreased between 2005 and 2014.
- The biggest reductions in final energy consumption in transport between 2005 and 2014 were registered in Greece and Spain. Increases (mainly from road transport) were recorded in Lithuania, Malta, Poland, Romania and Slovenia.
- The modal split of passenger transport (almost unchanged between 2005 and 2014 at EU level) remains largely in favour of private cars. Increases in the share of collective passenger transport in Belgium, the Czech Republic, Ireland, the UK, Luxembourg, Austria and Lithuania were counterbalanced by decreases in other Member States such as Poland, Bulgaria, Slovakia, Romania, Latvia and Estonia.
- The energy intensity of the EU services sector decreased between 2005 and 2014 by an annual average of 1.3 %. It improved in 16 Member States (notably Austria, Hungary, Ireland and Portugal), but increased in Bulgaria, Croatia, Finland, Greece, Italy, Luxembourg and Spain.

3.3.1. PRIMARY ENERGY CONSUMPTION

EE1: Primary energy consumption: this indicator monitors the evolution of primary energy consumption[103] of the EU as a whole and in EU Member States.

Looking at the time-horizon 2005-2014, primary energy consumption peaked in 2006 before declining constantly in the past few years due to the economic crisis, which decreased economic growth and therefore the need for energy, and to more ambitious energy efficiency policies and other related climate policies[104].

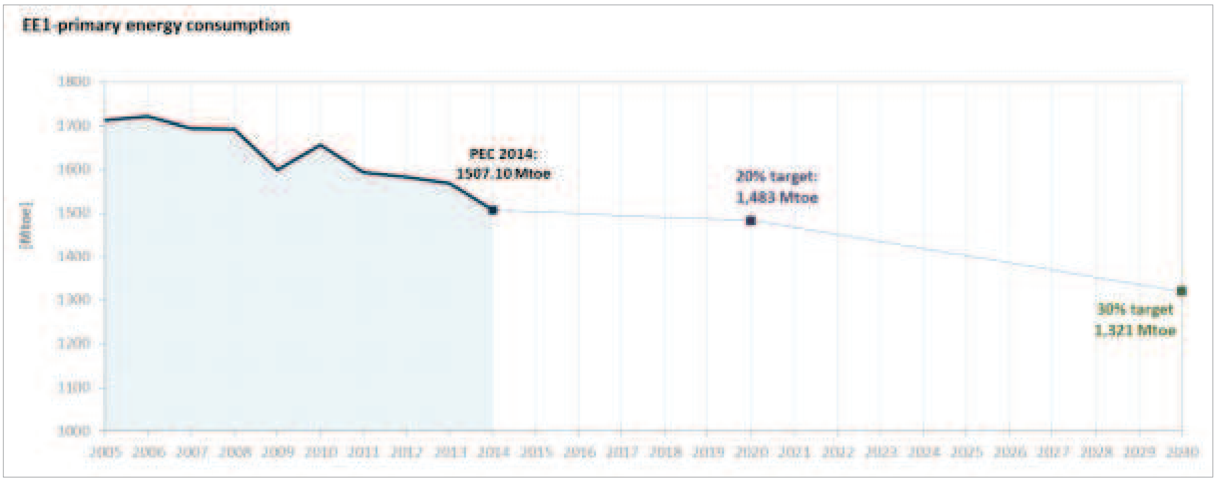


Figure 3.3.1: Evolution of EU28 Primary energy consumption towards 2020/2030 targets. (Source of data: Eurostat)

The primary energy consumption of the EU28 dropped from 1713 Mtoe in 2005 to 1507 Mtoe in 2014. This means that the Union's primary energy consumption was only 1.6 % above its absolute primary energy consumption target for 2020[105].

A decomposition analysis performed by the JRC examines the impact of different drivers in historical trends in primary energy consumption at the EU level over the last decade (2005-2014) based on EUROSTAT data[106]. According to this analysis, although the activity effect led to an increase in energy consumption by 123 Mtoe this was offset by an almost three times higher reduction (-353 Mtoe) led by significant improvements in energy intensity. This provides a sound indication that also energy efficiency improvements have been realised in the past decade. The finding that public policy has

[103] Primary energy corresponds to the Gross Inland consumption minus final non-energy consumption

[104] More details on energy efficiency developments can be found in the Energy Efficiency Progress Report (COM(2017)56).

[105] However, primary energy consumption is expected to have increased by around 1.5 % in 2015 compared to 2014 levels A detailed analysis of 2015 data will be undertaken in the next update of this SWD.

[106] Idem 104

been the key driver of efficiency improvements has been also confirmed by the IEA recently[107].

Since 2005, the primary energy consumption declined in almost all Member States except Estonia, Finland and Poland. The average annual reduction 2005-2014 was most pronounced in Lithuania, Greece, Italy, Hungary, Spain, the United Kingdom, and Romania.

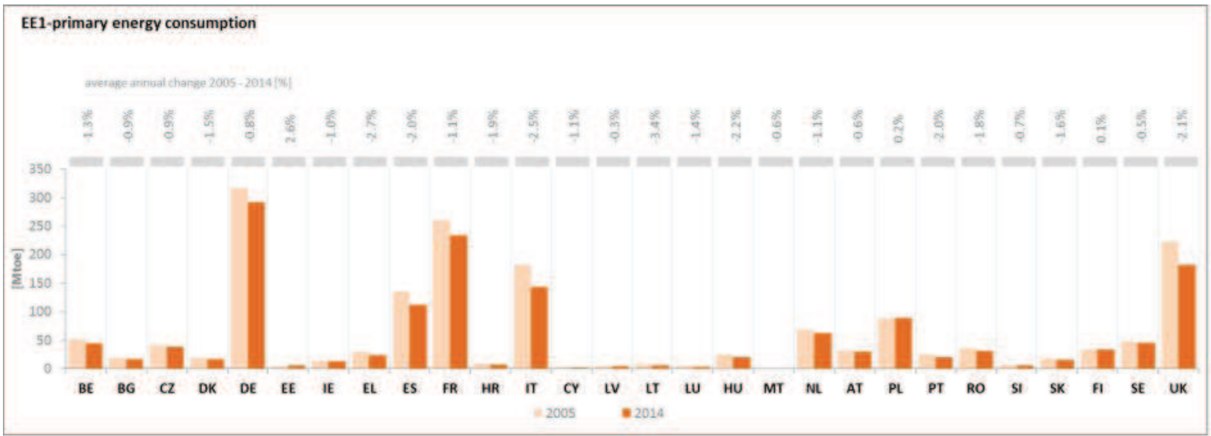


Figure 3.3.2: Primary energy consumption per Member State in 2014 (Source of data: Eurostat)

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 3.3.3, many Member States significantly reduced their primary energy intensity from 2005 to 2014, with an average reduction of 2.2 %/year at the EU level.

EE1-A1: Primary energy intensity is the primary energy consumption per unit of GDP.

Estonia is the only Member State where average primary energy intensity increased from 2005 to 2014, whereas it decreased in all other Member States. Belgium, Bulgaria, Czech Republic, Germany, 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. Highest annual average decrease of primary energy intensity over this period has been recorded in Lithuania (-5.7 %/year), Slovak Republic (-4.9 %/year), Romania (-4.3 %/year), Luxembourg (-3.9 %/year) and Poland (-3.5 %/year).

[107] IEA(2016). Energy Efficiency market report 2016; https://www.iea.org/eemr16/files/medium-term-energy-efficiency-2016_WEB.PDF

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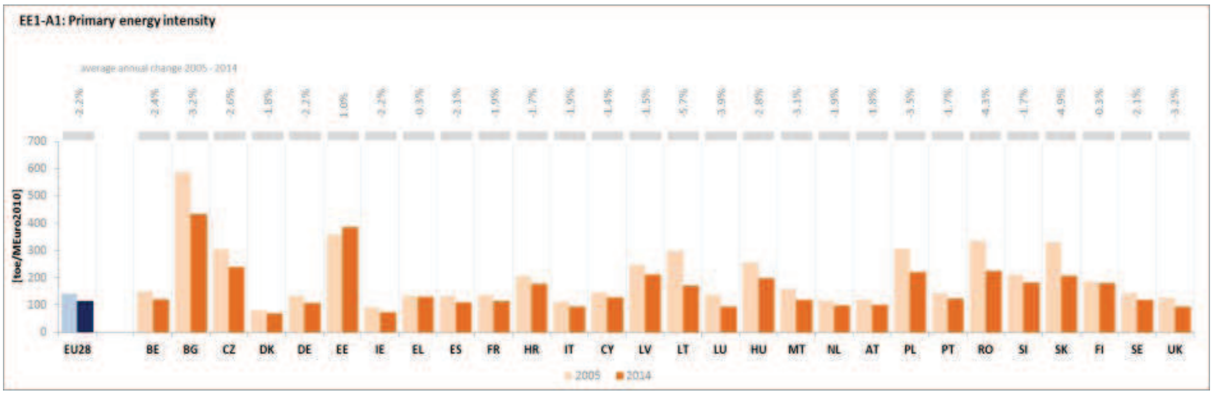


Figure 3.3.3: Primary energy intensity and annual average change 2005-2014. (Source of data: Eurostat)

3.3.2. FINAL ENERGY CONSUMPTION

EE2: Final energy consumption (indexed by 2020 targets): this indicator monitors the evolution of final energy consumption of the EU as a whole and in EU Member States.

Final energy consumption declined from 1191 Mtoe in 2005 to 1061.2 Mtoe in 2014. This means that the Union's final energy consumption was already 2.2 % below its absolute final energy consumption target for 2020. The EU28 has already achieved its final energy consumption target 2020. However, final energy consumption is expected to have increased by 2.1 % in 2015 compared to 2014 levels[108], and the Union has to continue the efforts for keeping the final energy consumption at this level.

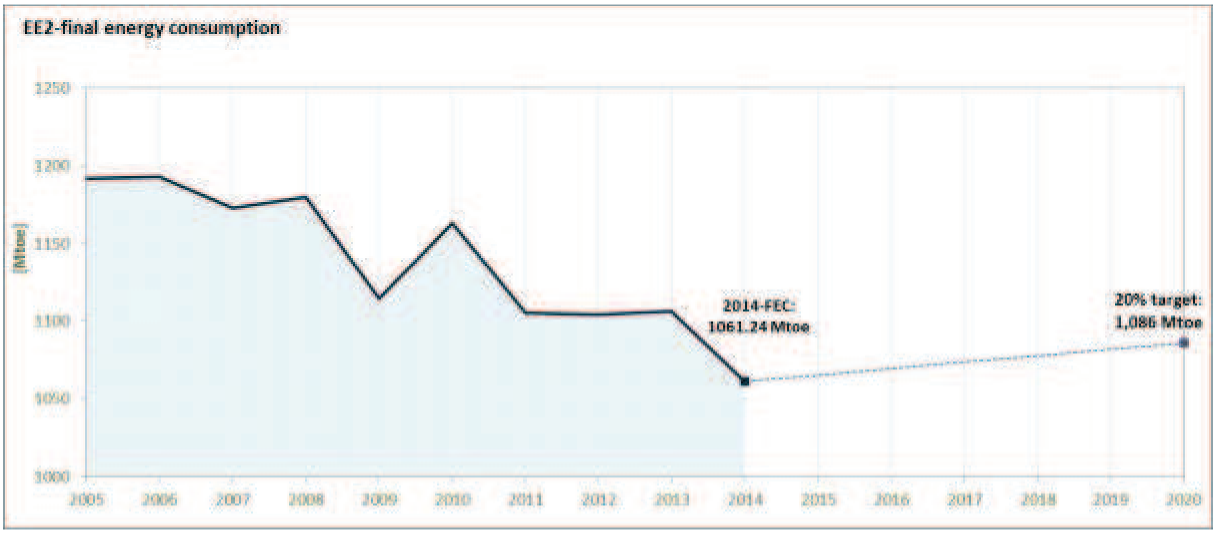


Figure 3.3.4: Evolution of EU28 final energy consumption towards 2020 target. (Source of data: Eurostat)

The absolute final energy consumption of all Member States has declined since 2005 except in Lithuania, Malta and Poland. The average annual reduction 2005-2014 was more pronounced in Greece, Spain, Italy, Hungary and Portugal.

[108] A detailed analysis of 2015 data will be undertaken in the next update of this SWD.

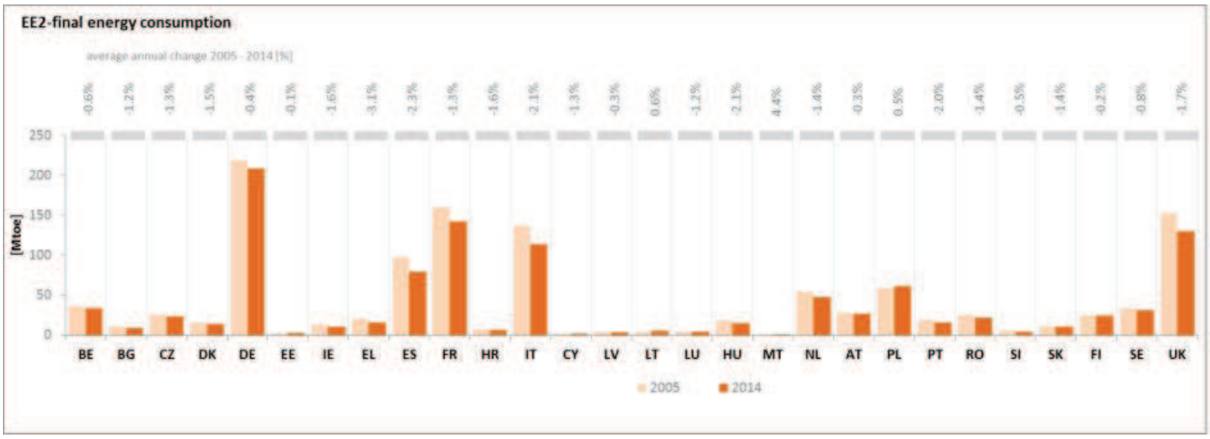


Figure 3.3.5: Final energy consumption per Member State in 2014 (Source of data: Eurostat)

In 2014, the final energy consumption of the EU28 was below the 2005 levels, having over this period an annual average decrease of -1.2 %/year. Over the same period of time, the GDP increased by an annual average of 0.8 %/year. These divergent trends indicate a decoupling of energy consumption from economic activities which provides indirect evidence that energy efficiency measures are effective. From 2010 onwards, the final energy consumption of all main economic sectors remained constantly below 2005 level except the services sector. The climate conditions (i.e. HDD) are mainly influential on the evolution of the final energy consumption in the residential and services sectors where heating needs are more important than for other sectors. This is reflected by similar patterns of the HDD and FEC in residential and services sectors from the below figure.

According to the decomposition analysis performed within the Odyssee-MURE project, the energy savings achieved in the EU28 final energy consumption over the period 2005-2014 were at about 167 Mtoe[109].

[109] Decomposition facility of Odyssee-MURE, available at: http://www.indicators.odyssee-mure.eu/

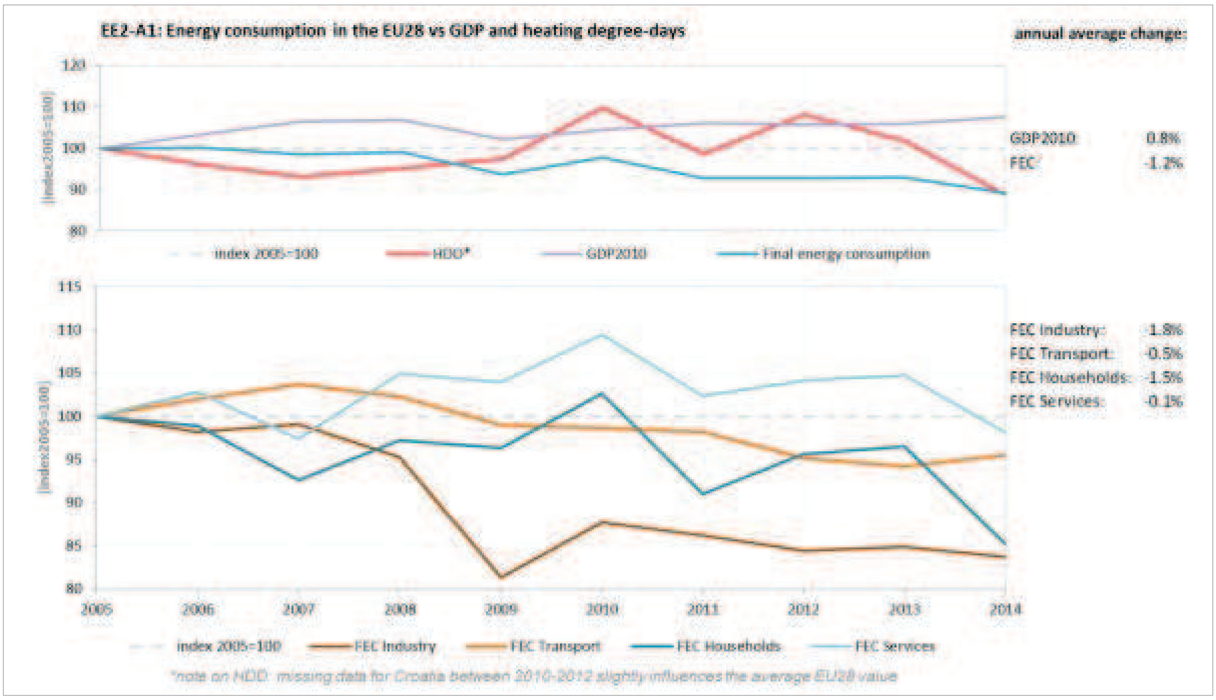


Figure 3.3.6: Final energy consumption of main sectors vs. GDP and heating degree days (index 2005=100) (Source of data: Eurostat)

3.3.3. Energy intensity of industry

EE3: Final energy intensity in industry: this indicator represents the energy consumption for a unit of value added in the industry and construction sector. The indicator is calculated by dividing final energy consumption in industry (including construction) sector by total gross value added (GVA) for industry and construction sectors (at constant 2010 prices). Energy intensity in industry reflects both potential specialisation in energy intensity sectors and the effort in decoupling industrial growth from energy consumption. The lower the value the most energy efficient the use of energy for the unit of GVA in industry is.

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 2014.

Figure 3.3.7 shows 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 in 2014 compared to 2005, the exceptions being Cyprus, Greece, Hungary, and Latvia. Notable decreases of the energy intensity in industry have been registered in most of Central and Eastern EU countries such as Romania, Bulgaria, Czech Republic, Poland, Slovak Republic and Estonia.

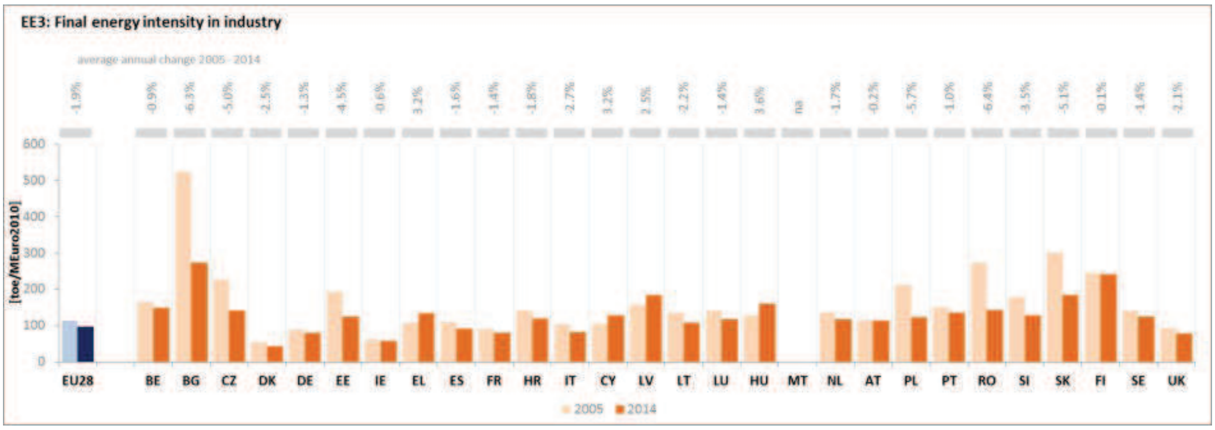


Figure 3.3.7: Energy intensity in industry. Source of data: Eurostat

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 within the EU project Odyssee-MURE shows that, in absolute terms, about 34 Mtoe were saved in the industry sector across the EU28 in the period 2005-2014. According to this decomposition analysis, the main reason for the variation of energy consumption in industry was a decrease of industry activity, followed by the impact of energy efficiency improvements, which was almost three times bigger than the impact of changes in the structure of the industry[110].

3.3.4. Energy intensity in the residential sector

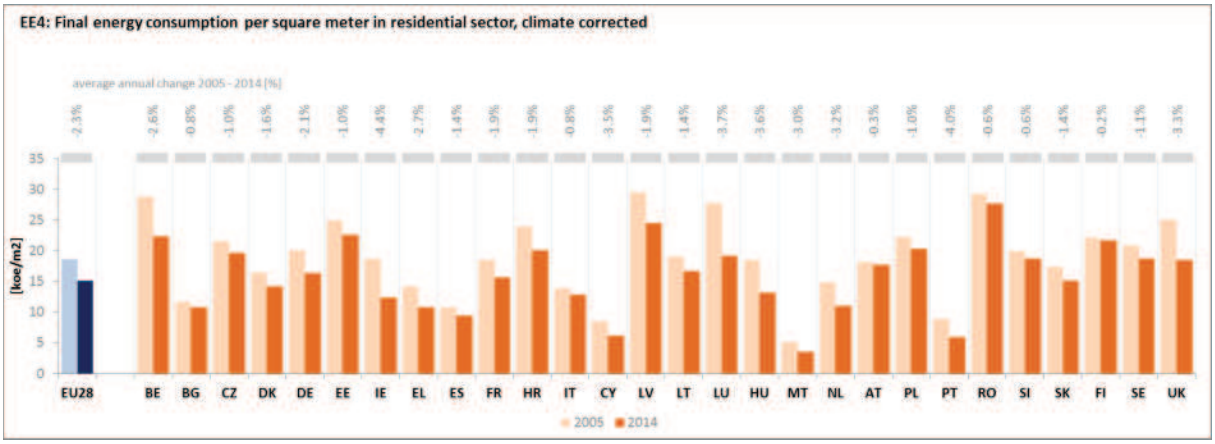
When looking at the residential sector, different factors influencing energy consumption must be taken into account such as climate variations over the years, changes in consumption in terms of comfort and a change in the size of dwellings. In addition, consumption might be driven by the economy, by demographics and by concrete efficiency measures, such as building renovation or the installation of efficient equipment or equipment assisting consumers in optimising their energy use.

EE4: Final energy consumption per square meter in residential sector climate corrected: this indicator measures the specific energy consumption per m2 of floor area of residential buildings. The figures are climate corrected in order to have a more accurate assessment of trends over time in a sector where heating (and cooling) still represent the largest part of energy consumption. This indicator and can inform on the relative efficiency of the buildings stock and of energy equipment. The decrease of this indicator's value means that the buildings sector becomes more energy efficient.

As data on floor area in residential and services buildings are not yet collected periodically by Eurostat, findings from the Odyssee-Mure project are taken into account. Data from Odyssee-Mure show that between 2005 and 2014 energy consumption per

[110] Decomposition facility of Odyssee-MURE, available at: http://www.indicators.odyssee-mure.eu/

square meter decreased in all Member States, with an average annual change of 2.3 %/year for the EU28 as a whole[111].



Note: Odyssee estimations for the complete data series of Belgium, Luxembourg and Malta, for Portugal (2014) and Romania (2014)

Figure 3.3.8: Final energy consumption per m2 in residential sector, climate corrected (Source: Odyssee-Mure database & direct communication with project coordinators)

EE4-A1: Final energy consumption per inhabitant in the residential sector. It represents the ratio between final energy consumption in the residential sector and the number of inhabitants in the country. The decrease of the value of this indicator will reflect the lowering of the energy consumption per capita in the residential sector.

Between 2005 and 2014, the final energy consumption in the residential sector as per number of inhabitants decreased in almost all Member States. The average annual change at the EU28 level between 2005 and 2014 has been at around -1.8 %/year. The highest average annual changes have been recorded in Hungary, Belgium, Greece, Luxembourg, Slovak Republic, the UK, and Cyprus and Portugal. A slight increase had been recorded only in Bulgaria, Estonia and Lithuania.

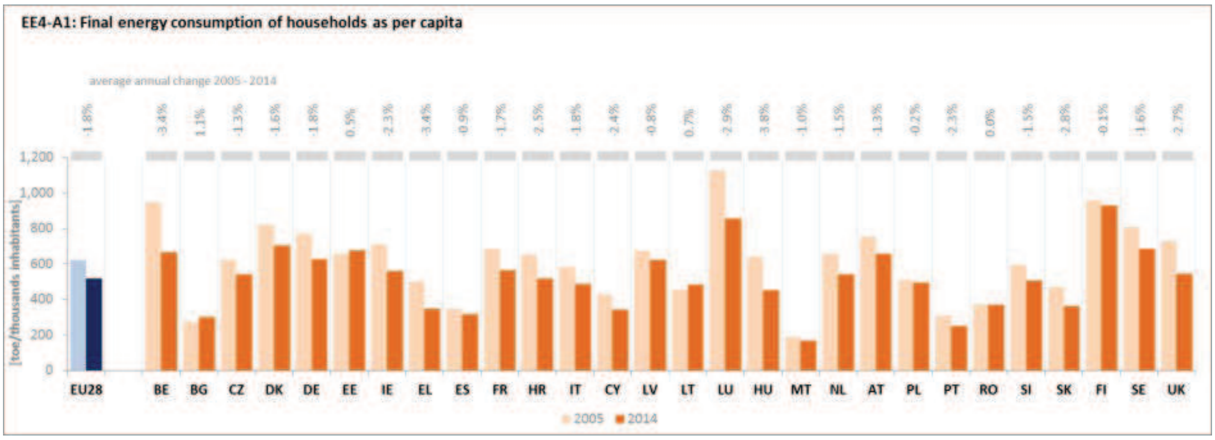


Figure 3.3.9: Final energy consumption per capita (toe/thou. inhabitants) (Source of data: Eurostat)

[111] See Odyssee-Mure database: http://www.indicators.odyssee-mure.eu/online-indicators.html

However, the above recorded decreases of energy consumption in residential, both per floor area and inhabitants, have been influenced by several drivers on top of energy efficiency improvements, e.g. climate (i.e. lower heating degree-days-HDD in a year) and economic evolution among the most important ones.

According to the decomposition analysis performed within the Odyssee-Mure project, the energy consumption reduction between 2005 and 2014 at the EU28 level decreased mainly due to energy savings of about 63Mtoe. Nevertheless, these energy savings were partially offset by the increase of number of dwellings (23.6Mtoe), larger new homes (15Mtoe) and higher penetration of and bigger appliances (7.3Mtoe)[112].

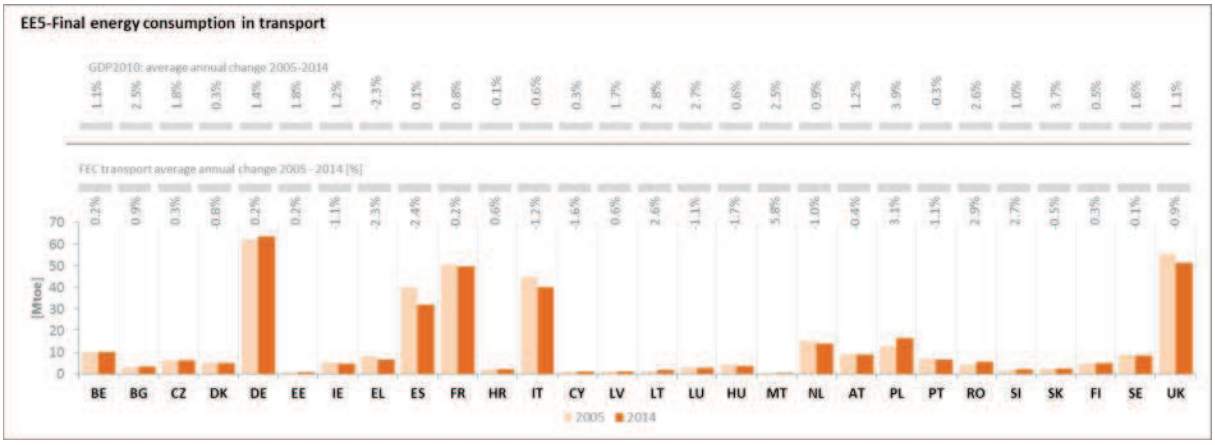
Additional indicators or analysis can also be considered to assess energy consumption improvements in the residential sector, for instance to better capture changes in the fuels used for heating purposes. Additional information on fuel use for heating and cooling is presented below when describing developments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

3.3.5. ENERGY CONSUMPTION IN TRANSPORT SECTOR

EE6: Final energy consumption in transport: this indicator represents the final energy consumption in the transport sector.

It is challenging to identify energy efficiency in the transport sector at the level of each Member States since final energy consumption in transport 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.

However, a comparison between final energy consumption and GDP changes provides a relatively fair picture of the evolution over time since transport is ubiquitous in all final sectors of an economy. Nevertheless, this indication is very generic and has to be accompanied by detailed indicators able to provide a more accurate image of a specific transport mean, fuel consumption, GHG emissions etc.



[112] Decomposition facility of Odyssee-Mure, available at: http://www.indicators.odyssee-mure.eu/

Figure 3.3.10: Average annual change 2005-2014 of final energy consumption and final energy intensity in transport vs GDP (Source: Eurostat)

Between 2005 and 2014, the final energy consumption in transport[113] in the EU28 decreased by about 4.5 % from 369.4 Mtoe to 352.5 Mtoe respectively. Over the period, the highest annual average reductions in final energy consumption in the transport sector were registered in Spain and Greece. A more considerable increase in relative terms was recorded in Lithuania, Malta, Poland, Romania and Slovenia. Generally, the increase of final energy consumption in transport originated from road transport.

According to the decomposition analysis of the Odyssee-Mure project, at the EU28 level the energy savings delivered in transport sector between 2005 and 2014 were at about 47.6Mtoe[114].

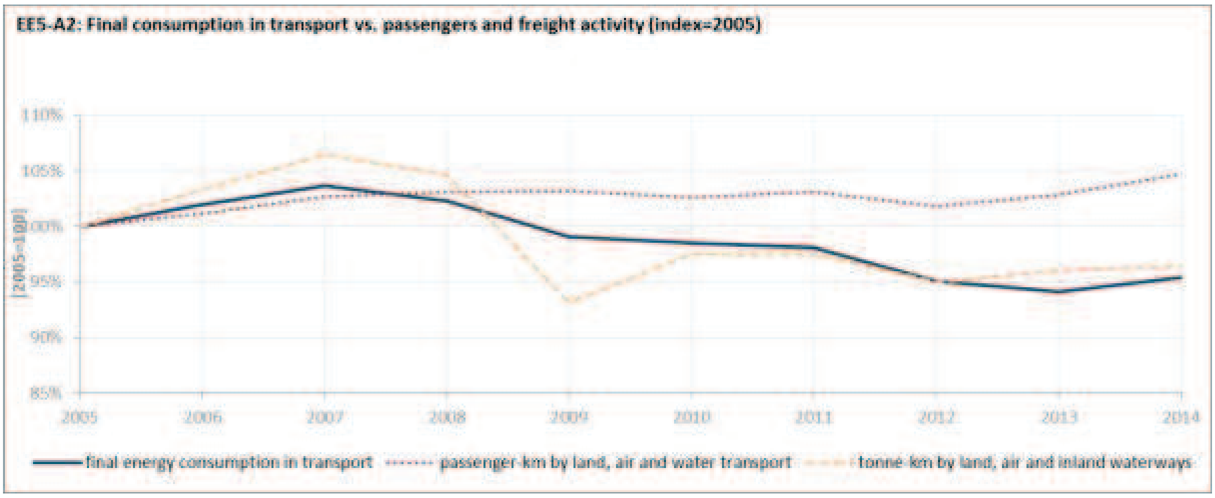


Figure 3.3.11: Evolution of final energy consumption in transport vs. passenger-km and tonnes-km in the transport sector of EU28 (Source of data: Eurostat, DG MOVE Transport in Figures[115])

Findings from the Odyssee-Mure project show that the majority of transport measures undertaken at Member State level concern the passenger modes. It is estimated that about 60 % of the decrease of energy consumption from 2007 onwards can be attributed to energy efficiency mostly originating from improvements in energy efficiency of new passenger cars. Energy efficiency improvements for road freight apparently 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 factors[116].The energy efficiency improvements are mainly related to three sets of measures, *i.e.* measures concerning the energy and CO_2 standards for new cars[117], measures addressed to the renewal of the car fleet, and measures addressed to traffic management[118].

113 Eurostat data used with the code: tsdpc320.

114 Decomposition facility of Odyssee-MURE, available at: http://www.indicators.odyssee-mure.eu/

115 http://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2016_en.htm

116 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)

117 The evolution of CO2 emissions for new cars is presented in the next section, under the decarbonisation dimension

118 Idem 116

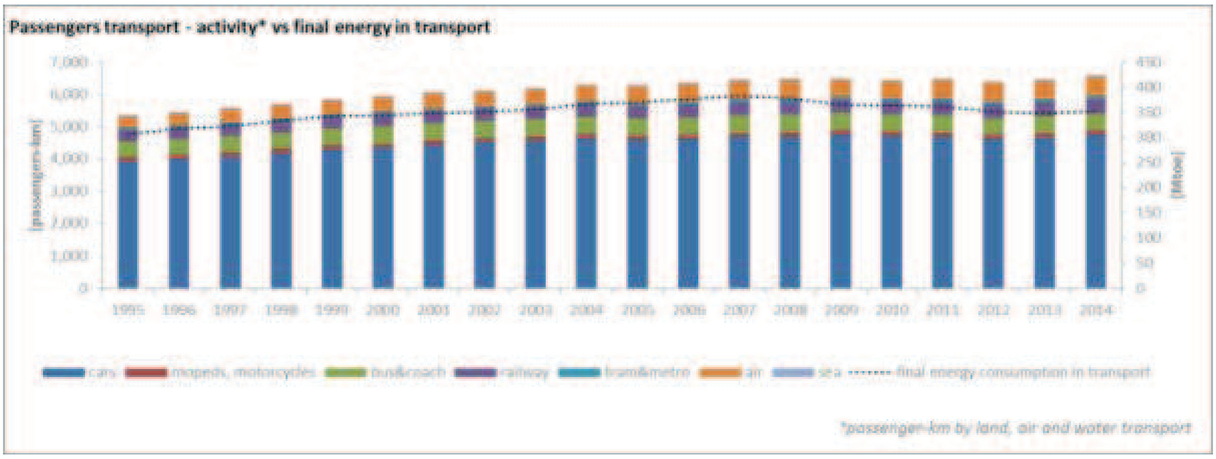


Figure 3.3.12: Evolution of final energy consumption in transport vs. passenger-km per type of transport in the EU28 (Source of data: Eurostat, DG MOVE Transport in Figures)

The modal split of passenger transport remains largely in favour of private cars. Therefore, between 2005 and 2014, the relative share of collective transport in total passenger transport remained stable at the EU28 level (recording a variation of -0.1 % points only). The share of collective transport increased most in Belgium and Czech Republic but also significantly increased in Ireland, the UK, France, Luxembourg, Austria and Lithuania. This means that in the above Member States more people are using collective transport in 2014 as compared to 2005. However, these improvements have been counterbalanced by decreases of collective transport use relative to private cars recorded in Poland, Bulgaria, Slovak Republic, Romania, Latvia and Estonia.

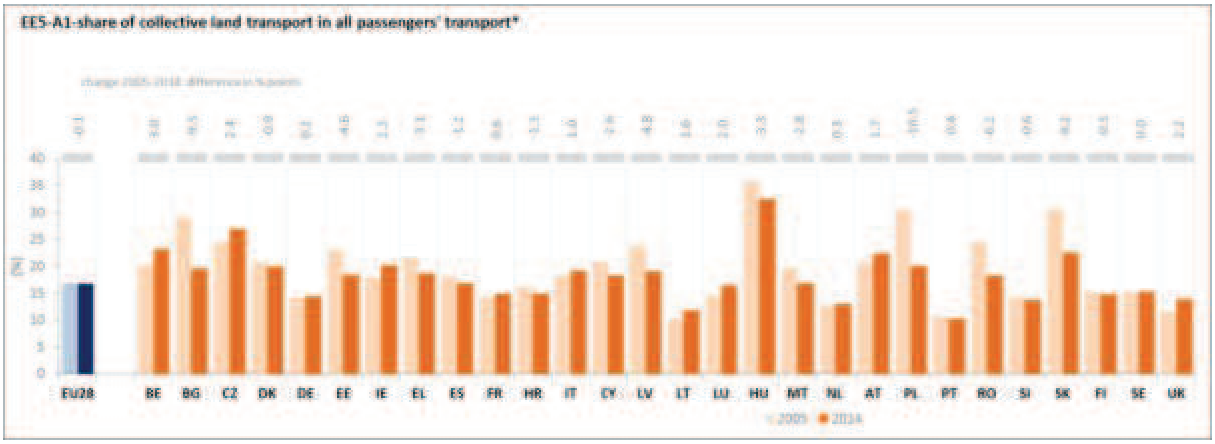


Figure 3.3.13: Evolution of collective transport share in all passengers transport (Source: Eurostat)

According to the findings of the Odyssee-Mure project, significant energy efficiency improvements took place between 2000 and 2007 in freight transport, 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). Such evolution however did not continue to the same extent post 2007, which seems to be mainly driven by the economic downturn.

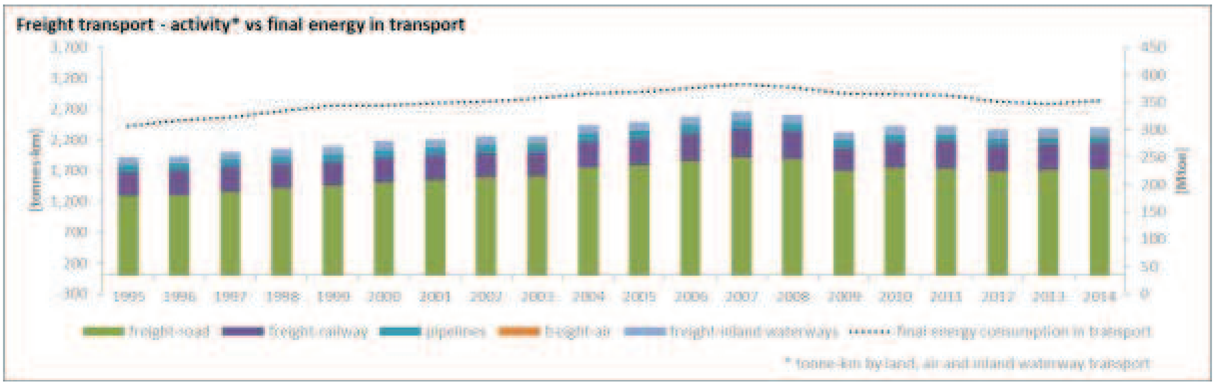


Figure 3.3.14: Evolution of final energy consumption in transport vs. tonnes-km per type of transport in the EU28 (Source of data: Eurostat, DG MOVE Transport in Figures)

3.3.6. ENERGY INTENSITY IN SERVICES SECTOR

EE5: Final energy intensity in services sector: this indicator represents the energy consumption for a unit of value added by the services sector. The indicator is calculated by dividing final energy consumption in the services sector by total gross value added for services sector (at constant 2010 prices). The lower the value the more efficient the sector is in producing a unit of GVA.

The energy intensity of the services sector of EU-28 decreased between 2005 and 2014 annually on average by 1.3 %. 16 Member States that improved their energy intensity in the services sector most between 2005 and 2014 were Hungary, Slovak Republic, Ireland, Austria, and Luxembourg. Cyprus, Estonia, Finland and Greece increased their energy intensity over this period.

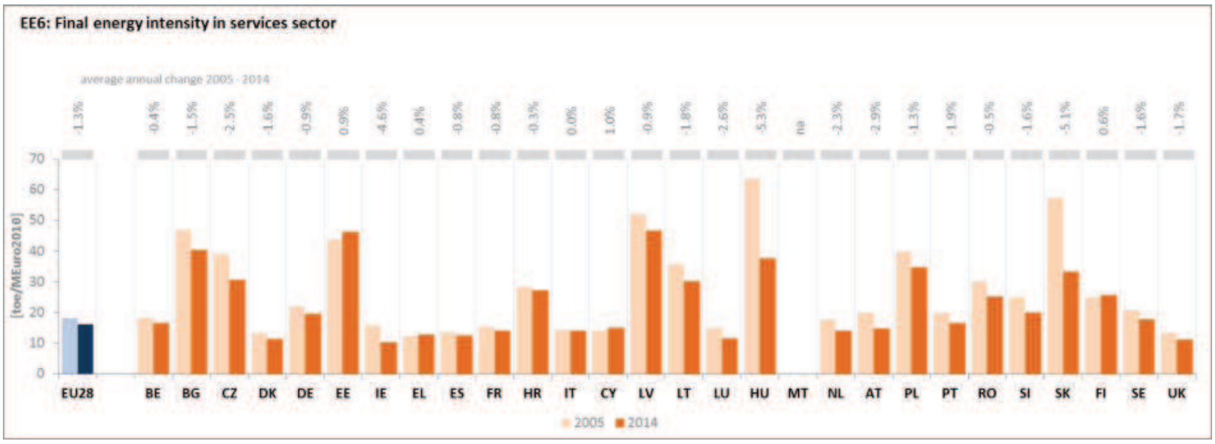


Figure 3.3.15: Energy intensity in services sector. Source of data: Eurostat

According to the Odyssee-MURE decomposition analysis, 16.5Mtoe of energy savings were achieved in the EU28 services sector between 2005 and 2014. However, these savings had been fully offset by the increase of economic activity within the sector (16.4Mtoe)[119].

[119] Decomposition facility of Odyssee-MURE, available at: http://www.indicators.odyssee-mure.eu/

3.4. DECARBONISATION

Key points

- According to the 2015 approximated inventory, the EU greenhouse gas emissions were 22 % below the 1990 level. Despite a temporary increase in 2015 (mainly due to cold weather), emissions remain on a decreasing trend.
- Member States' latest projections based on existing measures indicate that emissions will be 24 % lower in 2020 than in 1990. This means that the 2020 20 % reduction target will be overachieved. According to Member States' projections with existing measures, total EU emissions in 2030 are expected to be 26 % below 1990 levels.
- A decreasing trend in GHG emissions was recorded in most Member States in 1990-2015, the exceptions being Cyprus, Spain, Malta, Portugal, Ireland and Austria, where emissions rose.
- The EU saw a net loss of carbon sinks in 2005-2014, due mainly to harvested wood products that offset forest-land sinks, but also to increased settlements.
- At EU level, the sector responsible for the highest proportion of GHG emissions (around 30 %) is the energy industry (notably power production, district heating and refineries), followed by the transport sector and manufacturing industry (around 20 % each).
- 23 Member States are expected to meet their 2020 targets in the effort-sharing sectors with existing policies and measures. However, five (Ireland, Luxembourg, Belgium, Austria and Denmark) will need to make additional efforts to meet the targets.
- In the EU, real GDP increased by nearly 50 % between 1990 and 2015 while emissions decreased by 22 %. The GHG intensity of the EU economy decreased by nearly 48 % over the same period. GHG intensity fell from 1990 in all Member States except Portugal, Spain and Cyprus, which stayed closer to initial levels.
- GHG intensity in the EU power and heat sector decreased by a third compared with 1990 levels. The introduction of renewable energies and the use of less carbon-intensive fuels led to a significant (35 %) decrease in GHG emissions per unit of energy produced (gross electricity and derived heat).
- In 2014 the share of renewable energy sources reached 16 % of the gross final energy consumption of the EU, one percentage point closer than in 2013 to the 20 % target by 2020 and 11 percentage points short of the to the 2030 target of at least 27 %.
- Croatia, Bulgaria, the Czech Republic, Estonia, Lithuania, Romania, Finland and Sweden already overachieved their national 2020 renewable energy targets in 2014. Also in 2014, all but one Member State (the Netherlands) exhibited average 2013/2014 RES shares which were equal or higher than their corresponding indicative trajectory as set in the Renewable Energy Directive (RED)[120]. 25 Member States already exceeded their 2015/2016 indicative RED trajectories in 2015. Three Member States (France, the Netherlands and Luxembourg) showed 2015 estimated RES shares below their 2015/2016 indicative RED trajectory[121].

[120] Directive 2009/28/EC – Annex 1(B). 2013/2014 average share.
[121] Renewable Energy Progress Report (COM(2017)57)

- In 2014, the renewable energy share in transport has generally increased in most EU countries, but the current progress rate would not be sufficient to reach the binding 10 % target for 2020. In particular Finland and Sweden are the only Member States that have already reached their renewable energy target for transport, being in 2014 well above 10 %.
- In 2014, 27.5 % of electricity in the EU was generated from renewable energy sources, a 12.6 percentage point increase since 2005. In Austria, Sweden, Portugal and Latvia, the renewable electricity share exceeded 50 % in 2014.
- The renewable energy share in the heating and cooling sector was estimated at 17.7 % in 2014 at EU level, as compared with 10.8 % in 2005. In Sweden, Latvia and Finland , the renewable heating and cooling share exceeded 50 % in 2014.
- At EU level, GHG emissions avoided due to renewables deployment since 2005 amount to almost 8.8 % of the total (389 Mt CO_2 equivalent), the equivalent of Poland's annual emissions.
- The increased consumption of renewable energy as compared with the 2005 level enabled the EU to cut its demand for fossil fuels by 115.4 Mtoe in 2014, the equivalent of Spain's gross inland energy consumption.
- Deployment of RES contributes to energy security by reducing the reliance on imported fossil fuels. It is estimated that the renewable energy consumption growth after 2005 has roughly avoided import of energy carriers worth €18bn at 2014 prices. The fossil fuel imports displaced by the projected RES consumption in 2020 are estimated at 10 % of the EU28's current fossil fuel imports, leading to a reduction of the energy import bill of up to EUR 42 billion (at projected, higher, energy prices). Taking a bit further, in 2030 a projected EUR 59 billion could be avoided compared to 2005.

3.4.1. GREENHOUSE GAS (GHG) EMISSIONS REDUCTION

DE1: GHG emission reduction (base year 1990). The indicator represents the total GHG emissions as considered for the EU's 2020 climate target. It comprises the total GHG emissions without LULUCF and with indirect CO_2 emissions plus the CO_2 emissions from the international aviation.

According to the 2015 approximated inventory[122], the EU greenhouse gas emissions were 22 % below the 1990 level. The EU's share of global emissions has also been declining over this time and stood at 8.8 % in 2012.

Emissions seem to have increased slightly by 0.7 % in 2015 after a significant drop of 4 % in 2014. This is due to cyclical factors. Although it is widely acknowledged that the year 2015 was the warmest ever globally, the weather in Europe was colder in 2015 than in 2014 with an increase of "heating degree days" of 4 %. Furthermore, the price of fossil fuels, notably propellant, also decreased in 2015 contributing to increasing the purchases compared to 2014.

In the long run, however, emissions remain on a decreasing trend. According to the projections based on existing measures provided by Member States in 2015, emissions are expected to be 24 % lower in 2020 than in 1990 (26 % lower according to the EU Reference Scenario 2016). As part of its 2020 Strategy, the EU committed to cut greenhouse gas emissions in 2020 by 20 % from 1990 levels. The EU is consequently on track to meet this target domestically.

According to Member States' projections with existing measures, the total EU emissions in 2030 are estimated to be 26 % below 1990 levels. The EU Reference Scenario 2016 projects GHG emission reductions of 34 % by 2030. Hence, without new mitigation policies, the EU target agreed in Paris of at least 40 % domestic reduction in greenhouse gas emissions by 2030 compared to 1990 is expected to be missed. Consequently, the EU is putting in place new legislative instruments to meet this target[123].

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122 Based on 2015 proxies provided by Member States under Article 8 of Regulation 525/2013 or estimated by European Environmental Agency on behalf of the Commission, where needed.

123 Effort Sharing Regulation Proposal 20 July 2016; COM(2016) 482 final. Agricultural land use and forestry – LULUCF – Proposal 20 July 2016; COM(2016) 479 final. Revision of the EU ETS – phase 4 (2021-2030), 15 July 2015; COM(2015) 337 final.

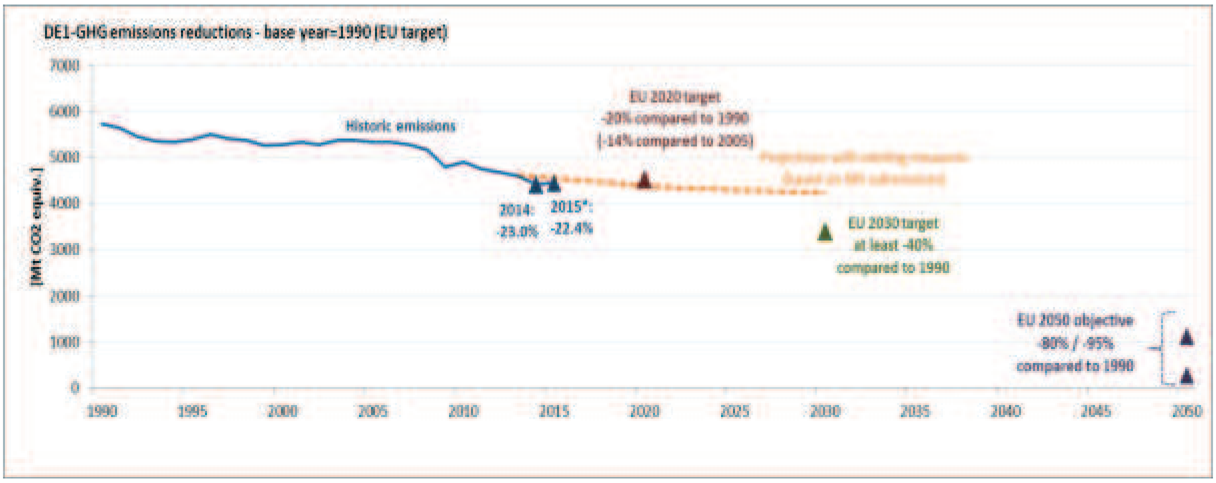


Figure 3.4.1: GHG emissions reductions and progress towards targets–base year 1990- (Source of data: EEA/UNFCCC GHG inventories)

In most Member States a decreasing trend of GHG emissions has been recorded in the period 1990-2015, with exceptions in Cyprus, Spain, Malta, Portugal, Ireland and Austria where emissions were higher in 2015 compared to 1990 levels.

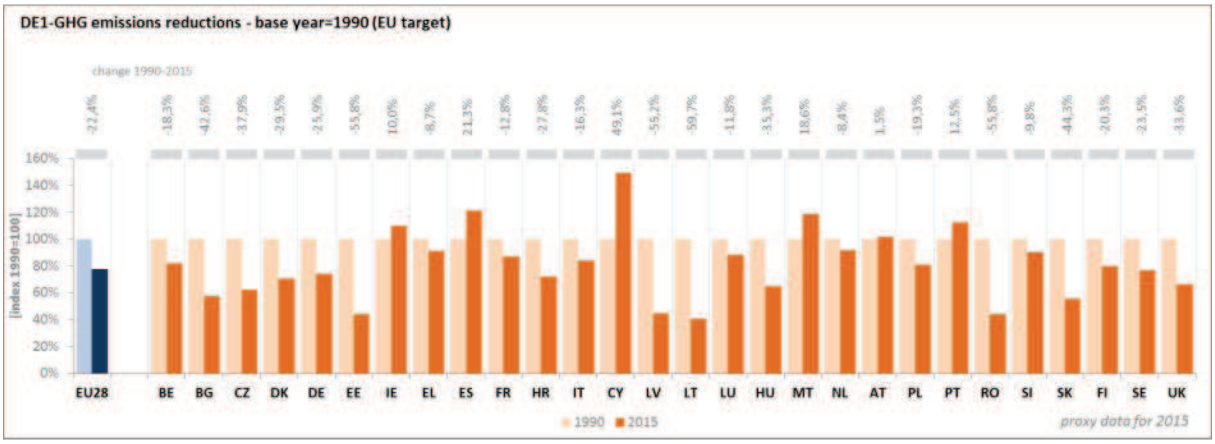


Figure 3.4.2: GHG emissions change 1990-2005 in Member States (% 1990=100) (Source of data: EEA/UNFCCC GHG inventories)

The GHG emissions are covered under the EU emissions trading system (ETS)[124] and the sectors covered under the Effort Sharing Decision[125] respectively. The ETS category includes emissions stemming from industry and power sector mainly, and the effort sharing covers all sectors where emissions are produced in a diffuse manner, i.e. buildings, transport (except aviation), waste and agriculture. At EU level, diffuse effort sharing emissions represent more than half (currently 58.1 %) of the emissions (under ETS (41.9 %)). Nevertheless, at Member State level the picture differs widely. The share of ETS emissions is the highest in Estonia, Bulgaria, Malta and Greece, where the industrial and power sectors remain having higher importance in terms of emissions and

[124] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC.

[125] Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020.

solid fuel (or oil) are used predominantly in the electricity mix. On the opposite side, Luxembourg, Latvia, France and Ireland show a strong dominance of effort sharing emissions reflecting their economic specialisation due to the importance of their transport and/or agriculture sectors and/or a relatively limited size of energy intensive industrial sectors. For Latvia and France, a strongly decarbonised power sector contributes to this.

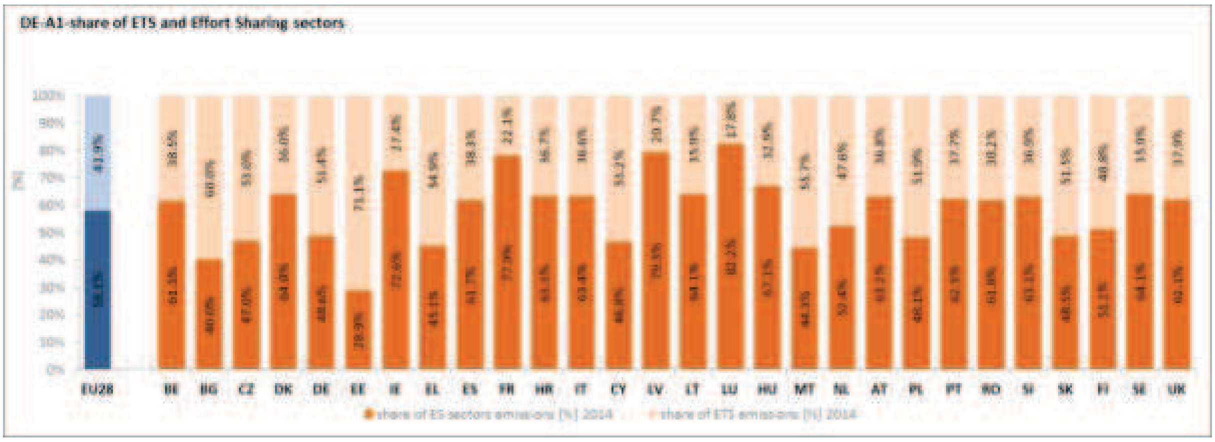


Figure 3.4.3: Share of ETS and ES emissions (Source: EEA)

The EU has recently launched a proposal on emissions and removals (mainly CO_2) from agricultural land use and forestry (LULUCF)[126] which sets out a binding commitment for each Member State and the accounting rules to determine compliance. The Commission proposal requires each Member State to ensure that accounted greenhouse gas emissions from land use are entirely compensated by an equivalent removal of CO_2 from the atmosphere through action in the sector. Land use, land use change and forestry are in a unique position to contribute to a robust climate policy, because the sector not only emits greenhouse gas but can also remove CO_2 from the atmosphere. Therefore, it becomes fundamental to monitor the absolute change of net increases or net loss of sinks over the period in the Member States.

At EU level there has been a net loss of carbon sinks for the period 2005-2014, mainly due to the harvested wood products category that offset the forest land sinks, and secondarily due to the increase of settlements. At Member State level the situation varies widely. On the one hand countries like Sweden, Portugal and Lithuania present a net increase of this category for the analysis period. On the other hand countries like Poland, Finland and Latvia present during the same period a clear loss of forest land with almost no increase of sinks in any category. Looking at particular cases, half of the loss of carbon sinks in Italy during the last decade is due to the increase of settlements and cropland, which cannot be completely compensated with grasslands removals.

[126] Agricultural land use and forestry – LULUCF – Proposal, 20 July 2016; COM(2016) 479 final.

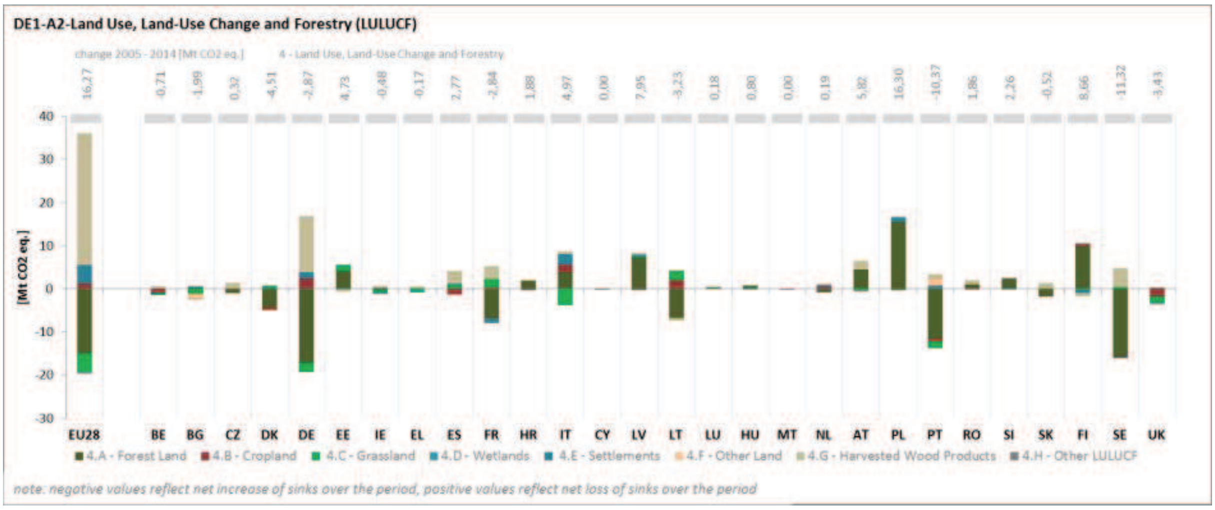


Figure 3.4.5: Net change of emissions from LULUCF 2005-2014 in MS: total and per category (Source of data: EEA/UNFCCC GHG inventories)

The share of GHG emissions per sector at EU level (without international aviation) shows that the energy industry is the sector with the highest share of around 30 % (covering notably power production, district heating and refineries), followed by the transport and manufacturing industry with around 20 % each (23 % in the case of transport if international aviation is included). In a different order of magnitude residential and commercial buildings and agriculture have comparable shares of around 10 % at EU average level.

The share of emissions per sector is specific to the particular situation of Member States in the field of energy mix, climate and economic structure. For the energy industry sector, Estonia has the highest share of emissions (71 %), having increased since 2005 by 20 % and being more than double the EU average (31 %). As regards manufacturing industry, Estonia presents the lowest share (7 %) compared to Slovakia which outstands with 40 % of the emissions (double the EU average). In the transport sector, Luxembourg (57 %)[127] and Sweden (33 %) show the highest share of emissions in this sector. Ireland presents the highest share of GHG emissions in agriculture (33 %) which reflects the relevance of this sector in its economic activity. For the residential and commercial sectors, Belgium shows the highest share (18 %) and Portugal outstands for its share of emissions in the waste sector (11 %).

[127] in the case of Luxembourg, relatively low excise duties on fuels attract demand from neighbouring countries

Table 3.4.1: Share of greenhouse gas emissions by economic sector (excluding LULUCF, international aviation[128] and international shipping), 2014 (Source of data: EEA/UNFCCC GHG inventories)

Note: sector allocation to IPCC CRF codes: Energy industries: 1.A.1 + 1.B; Transport: 1.A.3; Industry: 1.A.2 + 2; Residential and commercial: 1.A.4.a + 1.A.4.b; Agriculture: 3+1.A.4.c; Waste: 5; Other: 1A5+6+ Indirect CO2.

[%]	Energy industries		Industry		Transport		Agriculture		Residential and commercial		Waste		Other	
	Share in 2014	Change 2005-2014	Share in 2014	Change 2005-2014	Share in 2014	Change 2005-2014	Share in 2014	Change 2005-2014	Share in 2014	Change 2005-2014	Share in 2014	Change 2005-2014	Share in 2014	Change 2005-2014
EU28	31,1%	-22,1%	20,2%	-21,0%	20,8%	-8,5%	12,0%	-2,5%	12,2%	-24,0%	3,4%	-29,5%	0,2%	-30,6%
BE	18,6%	-29,5%	29,1%	-26,5%	22,2%	-3,7%	10,4%	-7,2%	18,2%	-24,8%	1,6%	-42,8%	0,0%	-64,8%
BG	52,6%	6,8%	13,1%	-47,5%	14,9%	8,7%	9,8%	-5,8%	2,2%	-20,6%	7,4%	-12,8%	0,0%	0,0%
CZ	45,4%	-17,2%	20,1%	-23,8%	13,6%	-1,7%	7,6%	-1,4%	7,2%	-25,9%	4,0%	24,9%	2,0%	-13,8%
DK	31,2%	-33,6%	12,3%	-25,0%	23,7%	-8,4%	24,3%	-7,3%	4,6%	-52,9%	2,6%	-9,8%	1,3%	-41,3%
DE	39,6%	-9,7%	20,1%	-5,2%	17,9%	-0,2%	8,0%	4,4%	13,1%	-22,5%	1,2%	-46,0%	0,1%	-41,1%
EE	71,0%	20,4%	6,7%	-2,6%	10,8%	5,3%	7,9%	27,4%	1,9%	-5,4%	1,6%	-34,8%	0,2%	-6,1%
IE	19,2%	-29,4%	12,5%	-24,0%	19,5%	-13,5%	33,2%	-4,6%	12,9%	-22,5%	2,6%	-16,4%	0,1%	-14,1%
EL	46,5%	-21,2%	17,6%	-30,5%	17,4%	-18,9%	9,1%	-21,3%	4,4%	-61,5%	5,0%	-5,8%	0,0%	0,0%
ES	24,5%	-37,4%	23,8%	-30,6%	24,3%	-22,8%	15,0%	1,2%	7,7%	-18,8%	4,8%	14,6%	0,0%	0,0%
FR	9,4%	-40,3%	21,8%	-20,5%	28,5%	-7,1%	20,0%	0,1%	15,8%	-27,4%	4,2%	-13,6%	0,2%	-32,4%
HR	23,4%	-33,2%	22,7%	-29,3%	24,6%	1,5%	12,8%	-19,5%	9,9%	-37,8%	6,5%	42,2%	0,0%	0,0%
IT	25,8%	-36,4%	19,7%	-34,3%	25,0%	-18,5%	9,0%	-10,7%	15,9%	-23,3%	4,3%	-24,9%	0,1%	-54,7%
CY	35,1%	-15,3%	24,7%	5,6%	21,7%	-13,5%	7,5%	-12,8%	4,6%	-26,1%	6,0%	9,2%	0,4%	83,0%
LV	16,0%	-16,9%	13,7%	3,9%	26,0%	-4,8%	27,6%	17,2%	9,1%	-9,5%	7,4%	10,4%	0,3%	1,4%
LT	18,0%	-41,9%	22,5%	-19,6%	26,5%	14,2%	20,8%	3,7%	6,0%	-0,9%	5,9%	-26,5%	0,2%	180,8%
LU	7,1%	-41,4%	16,1%	-25,1%	56,6%	-12,6%	6,8%	5,2%	13,0%	-17,1%	0,5%	-31,8%	0,0%	0,0%
HU	24,6%	-33,8%	18,1%	-26,2%	19,5%	-5,7%	14,0%	7,7%	16,3%	-43,9%	7,5%	-9,6%	0,0%	0,0%
MT	53,9%	-18,8%	9,1%	224,9%	21,8%	16,4%	3,5%	-8,2%	6,5%	16,0%	5,2%	60,5%	0,0%	0,0%
NL	35,5%	-5,9%	18,9%	-20,4%	16,3%	-13,2%	14,9%	-1,4%	12,2%	-21,6%	1,9%	-43,0%	0,2%	-22,1%
AT	13,3%	-39,8%	34,9%	-3,1%	29,1%	-11,1%	10,4%	-1,8%	10,0%	-39,4%	2,3%	-38,0%	0,1%	11,1%
PL	47,0%	-10,3%	15,8%	-2,4%	11,7%	26,1%	10,9%	-5,3%	11,9%	-0,7%	2,8%	-15,1%	0,0%	0,0%
PT	24,9%	-40,3%	21,4%	-25,9%	24,4%	-19,0%	12,9%	-4,8%	5,1%	-43,3%	11,0%	-16,8%	0,3%	-7,1%
RO	33,0%	-38,5%	22,7%	-35,5%	14,0%	24,2%	16,6%	-8,6%	8,2%	-15,5%	5,2%	1,1%	0,4%	-53,4%
SI	29,0%	-31,1%	16,8%	-28,8%	32,5%	21,6%	11,7%	-4,7%	7,0%	-50,7%	3,0%	-38,1%	0,0%	12,8%
SK	21,2%	-38,1%	39,9%	-13,5%	16,1%	-14,0%	7,9%	-0,7%	10,9%	-29,6%	3,9%	8,7%	0,1%	-32,9%
FI	33,0%	-11,8%	24,5%	-20,2%	18,7%	-14,6%	13,3%	-2,2%	4,7%	-28,7%	3,7%	-22,2%	2,1%	-23,0%
SE	18,5%	-11,8%	26,2%	-23,5%	33,0%	-15,0%	16,0%	-4,2%	3,2%	-54,4%	2,8%	-43,2%	0,3%	-26,6%
UK	31,2%	-29,1%	17,7%	-23,8%	22,1%	-9,3%	9,4%	-3,5%	15,7%	-23,0%	3,6%	-63,8%	0,4%	-28,9%

[128] The sectorial disaggregation is based on the IPCC sectors from the CRF GHG inventory tables, and where international aviation is an international bunker category.

3.4.2. GHG EMISSIONS IN THE EFFORT SHARING SECTORS

DE2: Gap between greenhouse gas emissions projections and target in 2020 in the effort sharing 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).

DE3: Gap between latest proxy inventory of greenhouse gas emissions and interim targets in the Effort sharing sectors. This indicator measures the gap between the latest approximated inventory emissions available[129] and its respective non ETS target expressed as a percentage of base year emissions (2005).

According to the projections submitted by Member States, 23 Members States are projected to meet their 2020 targets in the effort sharing sectors domestically with existing policies and measures. However, five Member States - Ireland, Luxembourg, Belgium, Austria and Denmark - 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.

Regarding the 2015 estimates, all Member States present emissions below their annual limit except Malta. Furthermore, the comprehensive ESD review concluded recently that in previous years 2013 and 2014 all Member States are expected to be below their respective 2013 and 2014 targets under the ESD, with the exception of Malta, who will have to make use of the flexibilities foreseen in the effort sharing decision to ensure compliance.

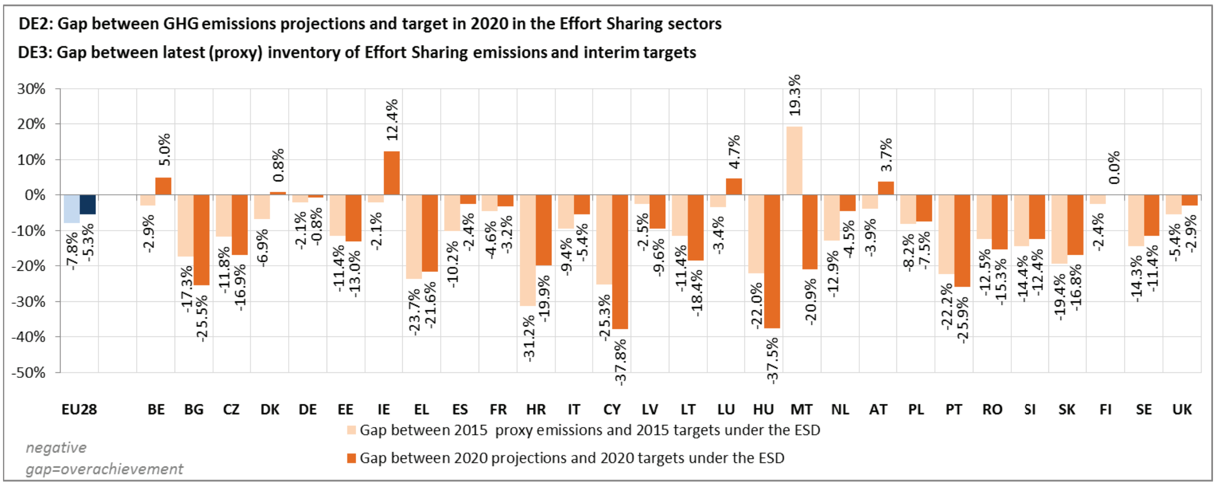


Figure 3.4.6: Gap between greenhouse gas emissions in the non-ETS sector and targets (as % of 2005 base year) (Source: Climate Action Progress Report, EEA)

[129] The proxy for effort sharing GHG emissions sectors is provided by Member States under Article 8 of Regulation 525/2013 or estimated by European Environmental Agency on behalf of the Commission, where needed.

The current Effort Sharing Decision, which obliges Member States to meet binding annual greenhouse emission targets in sectors outside the ETS except for land use, is applicable for the 2013-2020 period. For the 2021-2030 period, the Commission presented a legislative proposal[130] which sets Member States binding annual greenhouse gas emission targets for sectors not regulated under the EU ETS.

3.4.3. GREENHOUSE GAS INTENSITY OF THE ECONOMY

DE4: 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 nearly 50 % between 1990 and 2015 while emissions decreased by 22 %. At the same time, the GHG intensity of the EU economy decreased by nearly 50 % over this period of time.

The GHG intensity of all the Member States has also been decreasing since 1990. On one hand countries like Portugal, Cyprus, and Spain reduced their intensities at a slower pace, and on the contrary, Slovakia, Estonia, and Romania experienced the biggest reductions in their intensities. As a result, the figure below shows a tendency of the GHG intensity convergence for all MS.

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 their lower energy efficiency, but also for some of the Member States the importance of solid fuels 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 a high share of low-carbon technologies (renewable and nuclear) in their electricity mix.

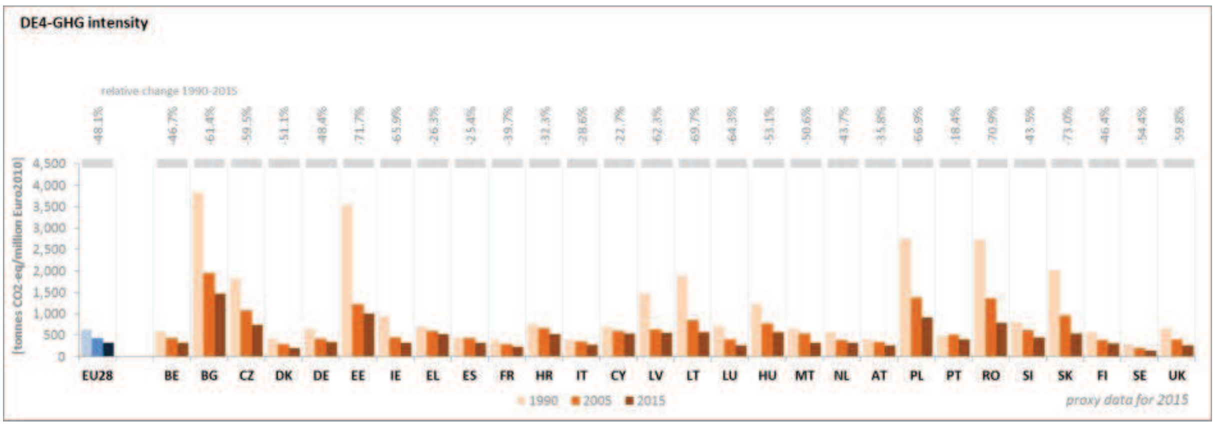


Figure 3.4.7: Greenhouse gas intensity in MS between 1990-2015 proxy data (Source: EEA, UNFCCC, AMECO database)

[130] Effort Sharing Regulation Proposal 20 July 2016; COM(2016) 482 final.

DE4- A1: GHG per capita. The GHG emissions per capita indicator is the ratio between emissions and population.

Croatia, Romania, Sweden, Latvia, Malta and Hungary have the lowest emissions per capita in the EU while Luxembourg, Ireland, Estonia, the Netherlands, Czech Republic, Germany and Cyprus 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 effort sharing emissions) due to low excise duties on motor fuel as well as to a large number of commuters and transit traffic (which imply that a substantial amount of transport emissions are produced by non-residents in the country). High per capita emissions in Estonia, Czech Republic 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.

The evolution of the trends shows that Lithuania, Romania and Estonia have reduced by almost 50 % their GHG emissions per capita compared to 1990 levels; however emissions per habitant in Lithuania and Estonia have not substantially changed in the last decade. Portugal, Spain and Cyprus present nowadays slightly higher intensities than in 1990, though with a decreasing trend since 2005.

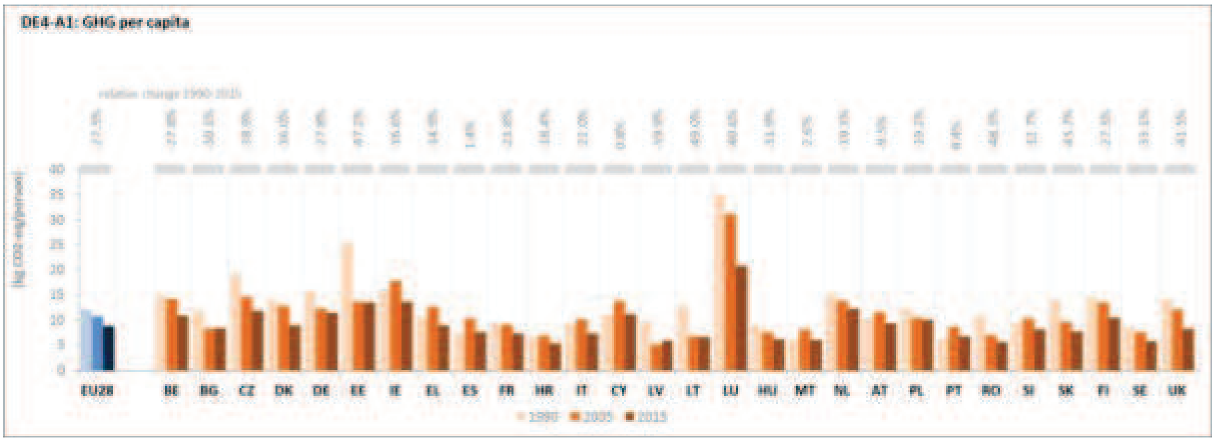


Figure 3.4.8: Greenhouse gas per capita in MS between 1990-2015 proxy data (Source: EEA, UNFCCC, Eurostat)

DE4-A2: GHG Power & Heat. This indicator is the ratio between total gross electricity and heat production and GHG emissions of public electricity and heat production.

The GHG intensity in the power and heat sector in the EU has decreased one third compared to 1990 levels. The introduction of renewable energies and the use of less carbon intensive fuels have led to a significant decrease (35 %) of GHG emissions per unit of energy produced (gross electricity and derived heat). Even if the biggest reductions at EU level occurred from 1990 until 2005, the GHG decrease happened at a higher rate in the last decade. At Member State level the picture varies widely depending on the tradition of use of fossil fuels and whether the introduction of renewables happened at early stages. Currently Sweden, France and Austria present the lowest carbon intensities in their power and heat sector given its large tradition deploying renewable energies (together with nuclear energy in the case of France). Greece, Estonia, Malta, Cyprus and Poland have the highest carbon intensive energy sectors (large tradition of fossil fuels in the eastern countries, and in the case of Malta and Cyprus with domination of fossil-fuelled energy generation and lower interconnection).

If the analysis is focused on the period 1990-2014, the country that decarbonized most its power and heat production is Slovakia (-70 %), followed by France (-59.5 %), Austria and Denmark (-59.3 % and -58.2 % respectively).

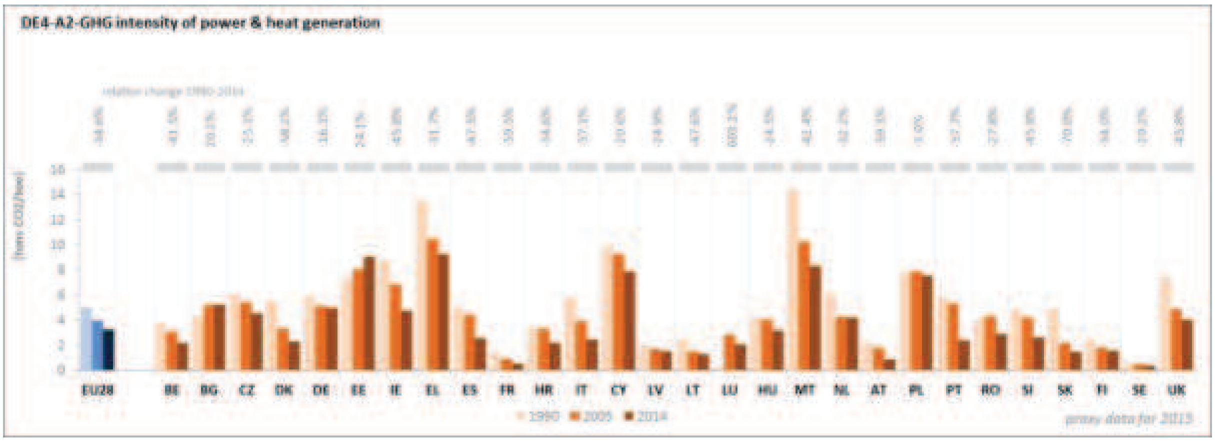


Figure 3.4.9: Greenhouse gas intensity of power and heat generation (IPCC sector 1.A.1.a) between 1990 and 2014 (Source of data: EEA/UNFCCC inventories, Eurostat)

DE4-A3: Average CO_2 emissions from new passenger cars. This indicator measures the average CO_2 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.

The graph below displays per Member State the change between the average emissions of new cars according to the test cycle in two points in time: 2005 and 2015. The data shows that in all Member states, the average new car emits significantly less than ten years ago, mainly thanks to the sectorial regulation that limited CO_2 emissions of new cars. The CO_2 and Cars Regulation (EC) No 443/2009 limits CO_2 emissions from new cars to a fleet average of 130 grams of CO_2 per kilometre (g/km) by 2015 and 95 g/km by 2021. The 2015 and 2021 targets represent reductions of 18 % and 40 % respectively, compared with the 2007 fleet average.

According to the results shown in the graph, the Netherlands, Portugal and Denmark present the least emitting new car fleet, compared to countries like Estonia, Latvia and Bulgaria, which have on average the most emitting new cars. The biggest reductions in the last ten years occurred in the Netherlands, Greece and Sweden.

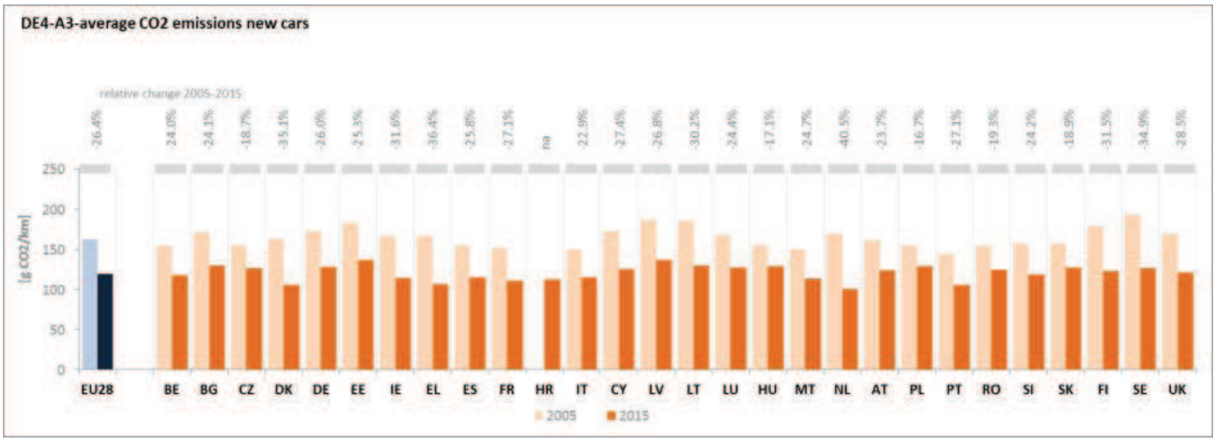


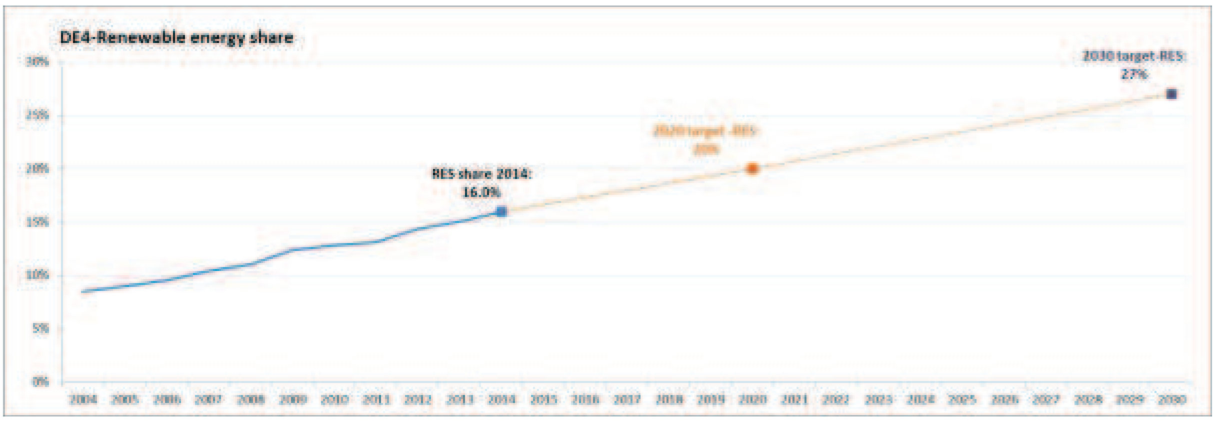
Figure 3.4.10: CO_2 from new cars: 2005-2015 (Source: EEA)

3.4.4. Renewable Energy

Renewable energy indicators set out in this report are based, unless otherwise specified, on latest official data available at the time of publication, i.e. Eurostat Shares 2014[131]. Additional information on renewable energy progress, based on 2015 proxies, including detailed information on technology deployment, are available on the 2017 Renewable Energy Progress Report[132].

DE5: Share of renewable energy in gross final energy consumption: this indicator monitors progress towards renewable energy developments as it is defined and statistically collected by Eurostat under the Renewable Energy Directive[133].

In 2014 the share[134] of renewable energy sources in gross final energy consumption represented 16 % of the (gross) final energy consumption of the EU, 1 percentage point closer than in 2013 to the 20 % target by 2020 and 11 percentage points to 2030 target.



[131] The Renewable energy shares in gross final energy consumption is available at: http://ec.europa.eu/eurostat/web/energy/data/shares

[132] Renewable Energy Progress Report (COM(2017)57)

[133] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources.

[134] Idem 131

Figure 3.4.7: EU progress towards Renewable energy targets (Source: Eurostat-SHARES[135])

Between 2005 and 2014, the renewable energy share in gross final energy consumption increased in all Member States.

In its Annex 1, the Renewable Energy Directive set interim trajectories towards the national binding 2020 renewables targets. In all Member States but the Netherlands the average of the renewable energy share in 2013/2014 was higher than their interim trajectories set for 2013/2014, notably in Sweden, Denmark, Finland, Italy, Romania and Czech Republic.

Regarding the 2020 renewable energy targets, Croatia, Bulgaria, Czech Republic, Estonia, Lithuania, Romania, Finland and Sweden reached in 2014 an already higher renewable energy share than their respective 2020 targets. In terms of RES shares, France, the Netherlands, the UK and Luxembourg have to make the biggest efforts to fill their gap to 2020 targets.

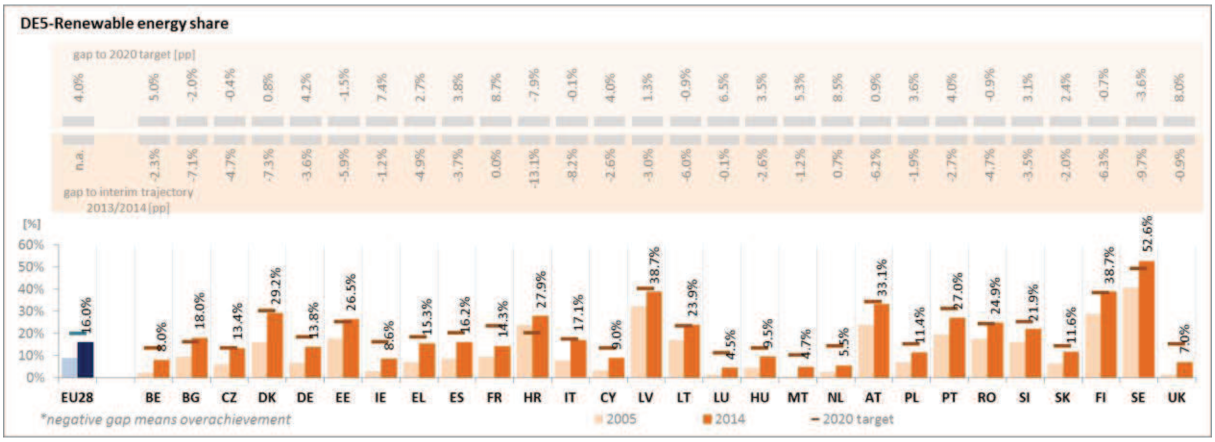


Figure 3.4.8: Share of energy from Renewable energy sources in gross final energy consumption: 2005-2014 (Source: Eurostat-SHARES)

DE5-A1: Renewable energy share in transport (RES-T). This indicator monitors the progress of final consumption of energy from renewable sources in transport.

Transport is the only renewable sector where Member States have national binding targets, with a 10 % RES-shares by 2020 on the top of their overall RES-target.

At EU level, the share of renewable energy in the transport sector in 2014 was 5.9 %. Despite the increases compared to 2005, the renewable energy share in transport in 2014 has generally been lagging behind the binding 10 % target for 2020[136] in the EU as whole and in most Member States, except Finland (21.6 % share) and Sweden (19.2 %) that are already well above the 2020 target. In 2014, notable renewable energy use in transport had been reported also for Austria, France, Slovak Republic, Hungary, Germany and Czech Republic.

[135] Idem 131

[136] Idem 133

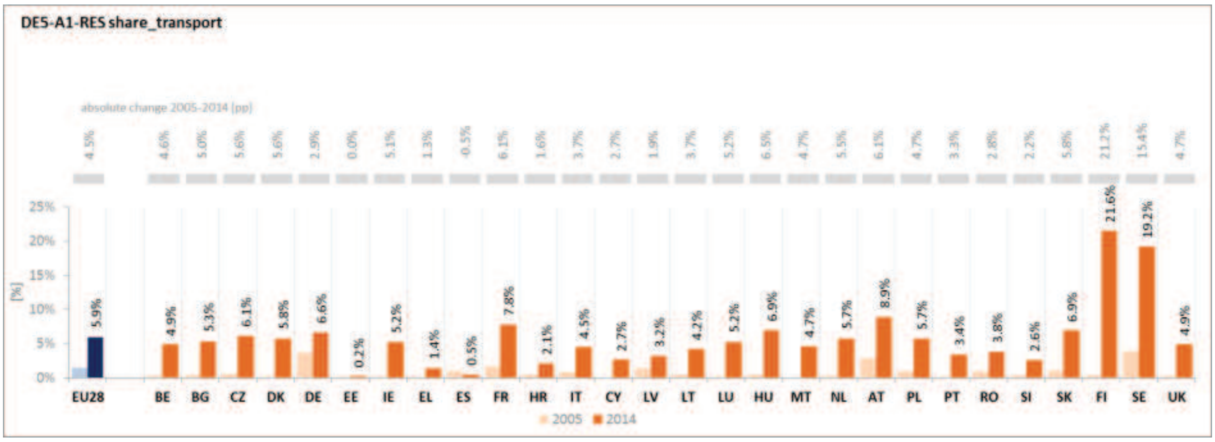


Figure 3.4.9: Share of Renewable energy sources in transport sector: 2005-2014. (Source: Eurostat-SHARES)

DE5-A2: Renewable electricity share (RES-E). This indicator monitors the progress of gross final consumption of electricity from renewable energy sources.

In 2014, 27.5 % of electricity in the EU28 was generated from renewable energy sources, a 12.6 percentage point increase since 2005. All Member States have seen the share of renewables in electricity increase since 2005. Notably, in 2014, Austria (70.0 %), Sweden (63.3 %), Portugal (52.1 %) and Latvia (51.1 %) had more than half of the electricity generated from renewable sources.

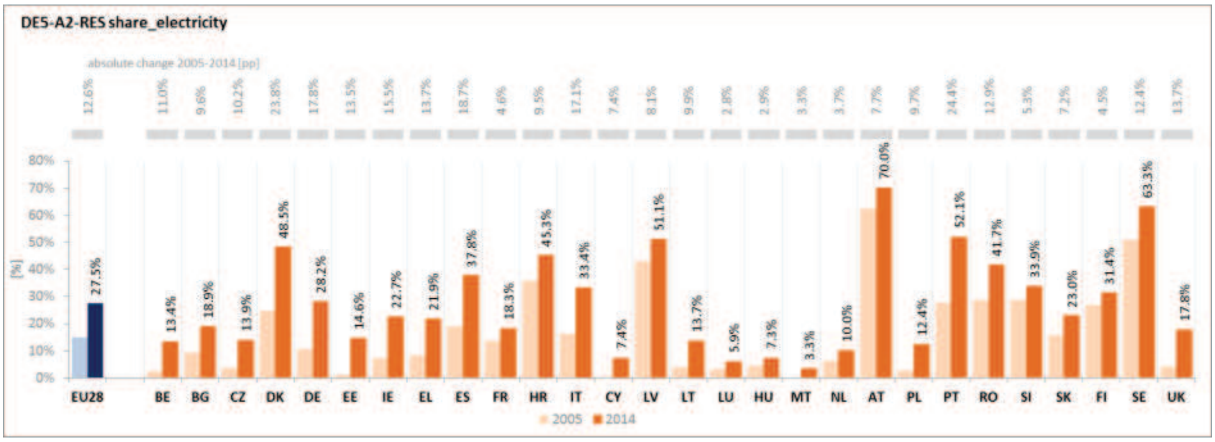


Figure 3.4.10: Share of Renewable energy sources in electricity: 2005-2014 (Source: Eurostat-SHARES)

DE5-A3: Renewable energy for heating & cooling (RES-H&C). This indicator monitors the progress of gross final consumption of energy from renewable sources for heating and cooling.

About half of final energy consumption in the EU28 is used for heating and cooling, predominantly in residential and services buildings. Renewable heating is increasingly being used as a cost-efficient and secure alternative to fossil fuels in Member States in district heating and at descentralised level. At EU level, the renewable energy share in the heating and cooling sector was estimated to be 17.7 % in 2014[137], while it was 10.8 % in 2005. The share increased in all Member States, notably in Sweden, Denmark, Slovenia, Bulgaria and Greece. In Sweeden, Latvia and Finland , the renewable heating and cooling share exceeded 50 % in 2014.

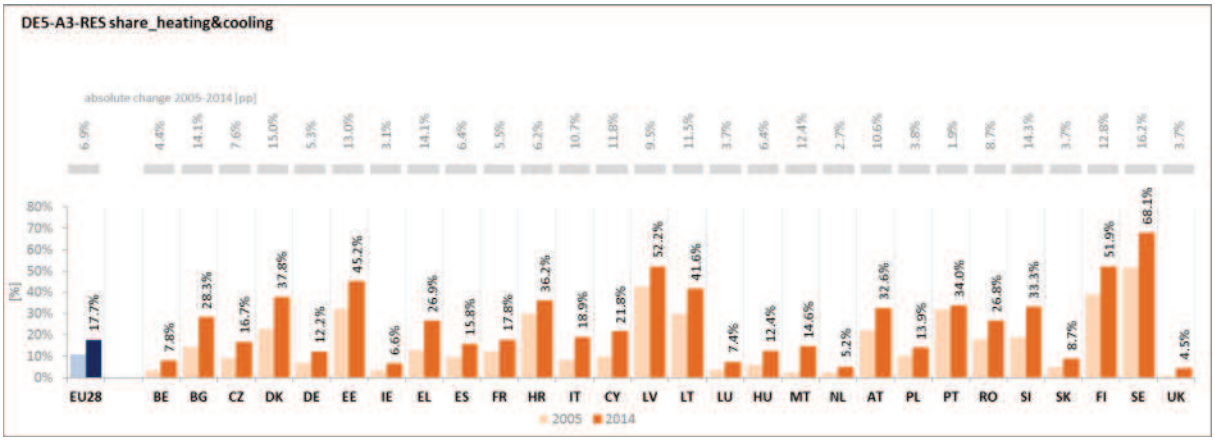


Figure 3.4.11: Share of renewable energy sources in gross final consumption for heating and cooling: 2005-2014 (Source: Eurostat-SHARES)

DE5-A4: Fossil fuel avoidance by renewable energy. This indicator is based on the EEA estimates assuming that the growth in renewable energy since 2005 has substituted for an equivalent amount of energy that would have been supplied by other sources[138]. The estimated amount of avoided fossil fuels is represented as share of gross inland consumption of fossil fuels.

The European Energy Security Strategy (EESS) has 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.

The increased consumption of renewable energy compared to the 2005-level has enabled the EU to cut its demand for fossil fuels by 115.4 Mtoe in 2014, the equivalent of the gross inland energy consumption of Spain. In 2014, the EU's gross inland consumption of fossil fuels would have been almost 9 % higher without the deployment of a significant amount of renewable energy. Coal was the fuel most substituted by renewables across Europe, followed by gas[139].

Between 2005 and 2014, reduction of fossil fuel use due to renewable energy penetration had been observed in all Member States, notably in Denmark (-21.3 %point), Sweden (-20.9 %point), Finland (14.3 %point), and Austria (-13.5 %point). Portugal, Spain and Italy also replaced their fossil fuel use in a significant range between 11-12 %point.

Deployment of RES contributes to energy security by reducing the reliance on imported fossil fuels. It is estimated that the renewable energy consumption growth after 2005 has roughly avoided import of energy carriers worth €18bn at 2014 prices. The fossil fuel

[137] Idem 131

[138] The method is described in detail in the 2015 EEA report *Renewable energy in Europe — approximated recent growth and knock-on effects*

[139] Renewable energy in Europe - recent growth and knock-on effects. European Environment Agency technical report No4/2016

imports displaced by the projected RES consumption in 2020 are estimated at 10 % of the EU28's current fossil fuel imports, leading to a reduction of the energy import bill of up to EUR 42 billion (at projected, higher, energy prices). Taking a bit further, in 2030 a projected EUR 59 billion could be avoided compared to 2005[140].

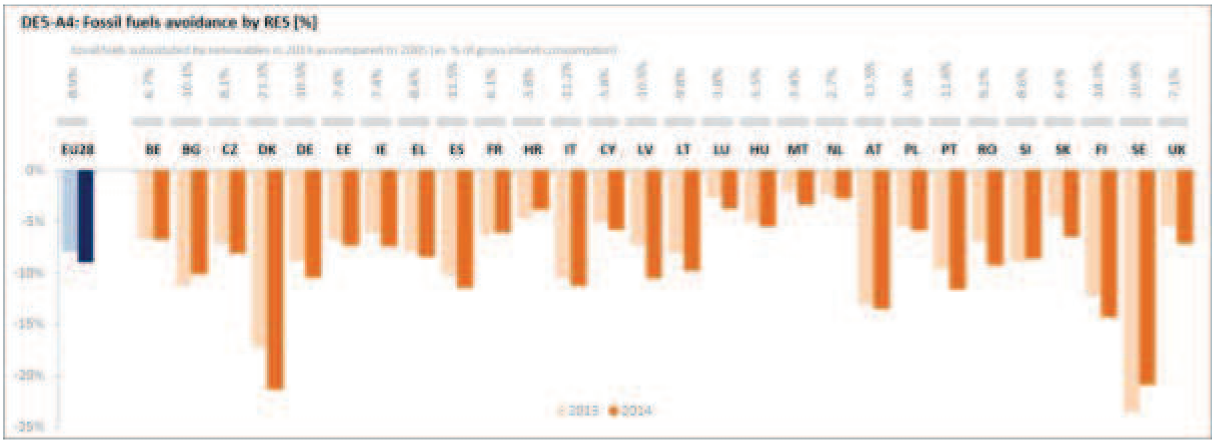


Figure 3.4.12: Fossil fuel avoidance by renewable energy sources (as % of gross inland consumption): 2013- 2014 (Source: EEA, Eurostat)

DE5-A5: GHG avoided emissions due to RES. This indicator estimates the avoided GHG emissions due to the fossil fuel substitution by renewable energy[141]. The estimated GHG emissions avoidance is represented as share of total GHG emissions.

At EU28 level, the GHG avoided due to renewables since 2005 amounts to 8.1 % of total GHG emissions (i.e. 389 Mton CO_2 equivalent), the equivalent to the annual emissions of Poland. The most significant GHG emissions avoided since 2005 due to renewable energy have been recorded for Sweden, Denmark, Finland and Austria. In a more detailed analysis, in the case of Sweden, Denmark and Finland, there has been a strong substitution of petroleum products consumption (oil represents more than half of all fossil fuels substituted in Sweden and Finland, and around 85 % in Denmark). In the case of Austria, coal and gas where principally the two fossil fuels that were most replaced (approximately one third of fossil fuel substituted was coal, and one third gas).

Portugal, Germany, Italy and Spain have also substantial GHG avoided emissions since 2005 due to renewable energy, in the range of 11.5 % and 9.8 %. In these cases, coal was the main fossil fuel replaced by renewable energies, except in Italy where natural gas was the most substituted fuel, followed by coal.

[140] More details can be found in the Renewable Energy Progress Report (COM(2017)57)

[141] The method is described in detail in the 2015 EEA report *Renewable energy in Europe — approximated recent growth and knock-on effects*

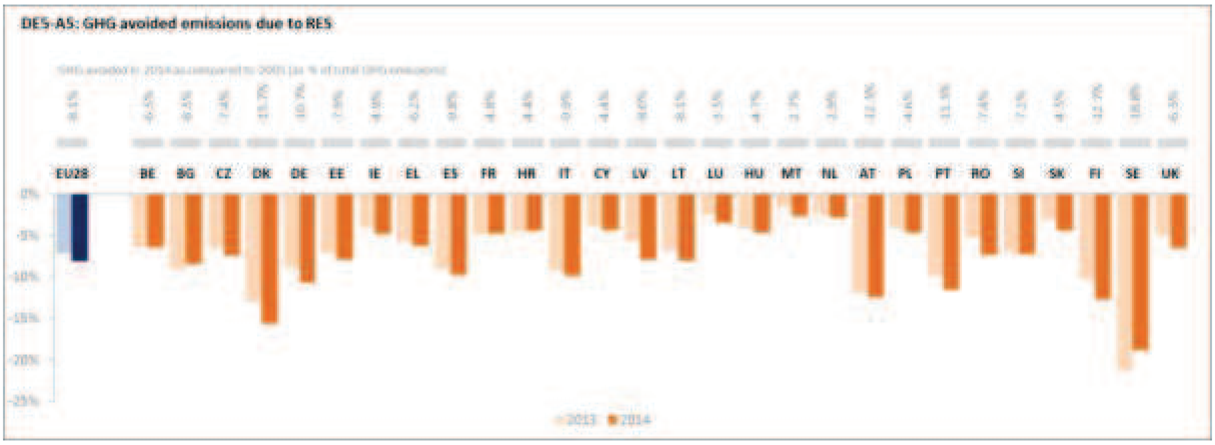


Figure 3.4.13: Greenhouse gas avoided emissions (% of total emissions) due to renewable energy sources: 2005- 2014 (Source: EEA, Eurostat)

3.5. Research, innovation and competitiveness

Key points

- National public investment in R&I in Energy Union areas decreased slightly between 2010 and 2014, both in absolute terms and as a proportion of GDP. The focus of national public programmes shifted towards topics relating to smart energy, the only Energy Union R&I priority area in which investment increased.
- Nevertheless, total R&I investment is increasing due to the contribution of the private sector. Private-sector investments increased from 2010, both in absolute terms and as a proportion of total investment (estimated to account for 85 % in 2014). The sustainable transport sector attracted 43 % of private investment.
- The share of national R&I investments (excluding EU funding) on Energy Union priorities in total public R&I spending is in the EU about half of that in the USA and Japan.
- The EU was the world leader in terms of the number of patents in certain areas of renewable energy, but trends showed that it is about to lose that status to China. Sustainable transport was the R&I priority with the highest number of patents since 2009 in the EU.
- EUR 29.1 billion and EUR 39.7 billion have been allocated to low-carbon energy and transport respectively under EU cohesion policy for 2014-2020. The biggest amounts are for energy efficiency in public and residential buildings, and sustainable urban mobility and rail.
- Between 2010 and 2014, global levelised costs of electricity generation (LCOE) decreased significantly for both solar photovoltaic (PV) and concentrated solar power (CSP) technologies.
- Despite the growth in global investments, investment in renewable energy in Europe fell by a 21 % in 2015 as compared with 2014, to EUR 48.8 billion. An opposite trend was recorded in China and the US where investments in renewable energy continued to grow in 2015.
- The EU's renewable energy industry recorded increased turnover for the second year in a row in 2014 (EUR 14.36 billion), after decreases between 2010 and 2012.
- As compared with its main economic partners, the EU's manufacturing industry had the second lowest real unit energy costs (RUEC) as a percentage of value added in 2014, just above those in the USA. RUECs in China, Russia, Japan and Australia were substantially higher. RUECs in some Member States were significantly lower than the EU average, while Bulgaria, Cyprus and Belgium were the Member States with the highest RUECs.

3.5.1. Research and Innovation

As mentioned in chapter 2, the monitoring of research and innovation (R&I) efforts in the field of energy in general and specifically for low-carbon technologies is made difficult by a certain lack of data, in particular when trying to identify most recent trends[142] and by the need to interpret with caution the situation across countries, given differences in size, population, economic development and national Smart Specialisation Strategies[143].

The analysis in this section addresses investments and patent trends in the four core and the two additional research priorities of the Energy Union, called Energy Union R&I priorities hereafter, namely:

- Four core priorities:
  - Renewable energy,
  - Smart EU energy system with consumers at the centre,
  - Efficient energy systems, and
  - Sustainable transport.
- Two additional priorities:
  - Carbon capture utilisation and storage (CCUS), and
  - Nuclear safety.

All figures in this section should be considered in this context. Since the Energy Union R&I priorities do not encompass all aspects of the energy and transport sectors, the figures may not be directly comparable with other public data associated with different definitions of these sectors.[144]

Taking account of these methodological points and limitations in the above, this section highlights:

- the public R&I intensity in the energy sector, that is, public R&I investments in the energy sector compared to GDP and to public civil R&I spending.
- the degree of specialisation of public R&I investments across the Energy Union R&I priorities, for the EU and major trading partners.
- estimates of private R&I investments in the energy field across the Energy Union R&I priorities.
- patenting trends in the Energy Union R&I priorities in absolute terms and normalised by population and GDP.

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[142] R&I investment and patent data usually becomes available quite late, as compared to other energy statistics. The present analysis is based on data at the disposal of the JRC in September 2016.

[143] 'Smart specialisation strategy' means the national or regional innovation strategies which set priorities in order to build competitive advantage by developing and matching research and innovation own strengths to business needs in order to address emerging opportunities and market developments in a coherent manner, while avoiding duplication and fragmentation of efforts. (Regulation (EU) 1301/2013)

[144] A brief definition of each of the Energy Union R&I priorities is provided in the methodological note in Annex 2. More details can be found in the JRC Science for Policy Report "Monitoring R&I in Low Carbon Energy Technologies: Methodology for the R&I indicators in the State of the Energy Union Report - 2016 Edition".

3.5.1.1. INVESTMENTS IN THE ENERGY UNION R&I PRIORITIES

Public (national) R&I investments

RIC1: Public investments on Energy Union R&I priorities as share of GDP: this indicator divides public R&I spending in the field of Energy Union priorities by the GDP. It is accompanied by the share of public R&I spending in the field of Energy Union priorities in total public R&I spending in civil research (i.e. GBAORD[145] and therefore excluding military public R&I spending).

In 2014, the EU28 invested EUR 4.2 billion from national budgets[146] on Energy Union R&I priorities, the equivalent of 0.03 % of the EU GDP. National investment in the EU28 has decreased slightly both in absolute terms and in relation to GDP compared to 2010. This is also the case for a large number of Member States and in particular those investing high shares of their GDP, such as Finland and Denmark[147]. Internationally, both the USA and Japan have increased the proportion of GDP invested in these topics, although investment in absolute terms remained stable in Japan.

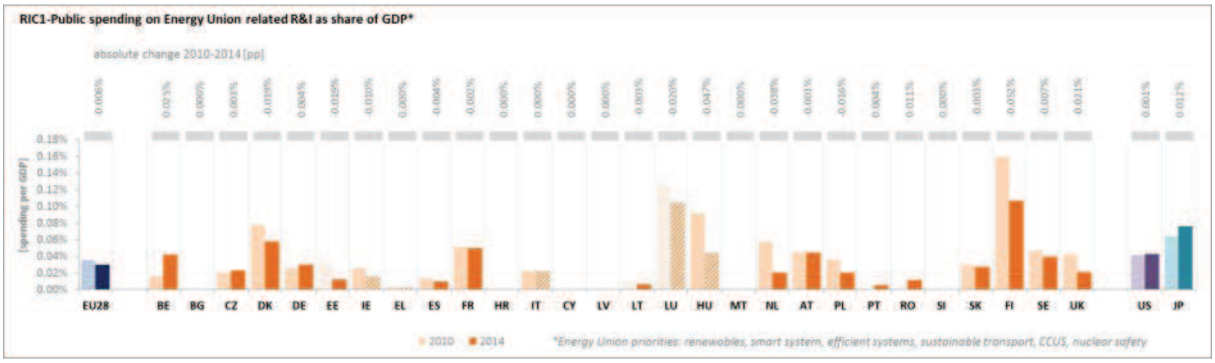

Figure 3.5.1: Investment from national R&I programmes in Energy Union priorities as a share of GDP (2010-2014) (Data sources: IEA[148], European Commission[149,150], Eurostat[151]). Note: the bars in texture are estimates.

The share of national funding directed to the Energy Union R&I priorities in total civil R&I spending in the Member States for the years 2010-2014 is shown in Figure 3.5.2. The EU28 average in 2014 was 4.7 % having steadily dropped from 5.3 % in 2010. For the majority of the Member States, spending was below 5 % of the total civil R&I budget. Notable exceptions, maintaining a higher share, are Finland, France, Slovakia

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145 GBAORD = government budget appropriations or outlays for research and development

146 This figure does not include the funding from the European Union framework programme for research and innovation (Horizon 2020), which reached EUR 1.1 billion in 2014.

147 Luxembourg and Hungary also invest a large share of their GDP and are notably well above the 5 % share of total civil R&I spending. However, data reporting for these Member States is not regular and as such the data provided here are European Commission estimates based on GBAORD (denoted by hatching in the graphs).

148 International Energy Agency. Statistics, RD&D Online Data Service. Available from: http://www.iea.org/statistics/RDDonlinedataservice/.

149 JRC Science for Policy Report " Energy R&I financing and patenting trends in the EU – 2016 edition"

150 Data gaps are supplemented with information provided by the Member States through the SET-Plan Steering Group and JRC data mining. Alternatively, where possible, estimates are provided based on the correlation of macroeconomic indicators such as R&I budgets (GBAORD) or GDP.

151 GDP and main components (output, expenditure and income) [nama_10_gdp]. Available from: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_gdp&lang=en

and Denmark[152]. Internationally, both Japan and the USA have increased their share of civil R&I spending on these topics in the same period to 10.6 % and 11.1 % respectively in 2014.

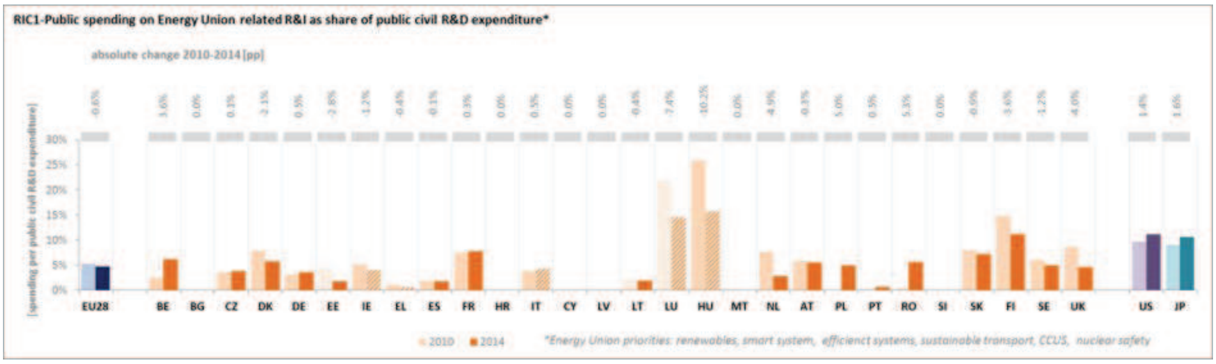

Figure 3.5.2: Investment from national R&I programmes in Energy Union priorities as a share of total public civil R&D spending (2010-2014) (Data sources: IEA[153], European Commission[154,155], Eurostat[156]). Note: the bars in texture are estimates.

In absolute terms, between 2010 and 2014, the EU28 has consistently invested in R&I on Energy Union priorities through national funds, more than Japan but less than the USA (Figure 3.5.3). National funding in 2014 reached EUR 4.2 billion in the EU28, EUR 2.6 billion in Japan and EUR 5.6 billion in the USA.

Compared to the USA and Japan, where there are pronounced shifts in focus, the allocation of public support over the Energy Union R&I priorities has remained relatively stable in the EU28. Nonetheless, emphasis on smart energy system R&I has steadily increased in the EU28 where investments grew from under a fifth in 2010 to just over a quarter of the total in 2014. The share of sustainable R&I transport has remained relatively stable at a fifth of total national investments, while that of R&I on renewables and efficient systems has decreased slightly. Nuclear energy continues to receive high levels of national support for R&I, which accounts for around a quarter of the EU28 national funds, notably in France, Germany, Belgium, Czech Republic and Finland. In absolute terms, public funding has decreased slightly across the R&I priorities, with the exception of smart systems, which saw an increase in financial support.

The distribution of national funds to R&I priorities in the USA differs substantially to that in the EU28, mainly due to an apparent shift of national investment in the USA from sustainable transport to smart system. From 14 % in 2010 the share of public R&I funding for the smart system has increased to 45 % of the total in 2014. The trade-off has been a decrease in the share of funds allocated to sustainable transport, efficient systems and renewables. Public funding for nuclear has remained constant, albeit at a decreasing share of the total.

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152 Idem 147

153 Idem 148

154 Idem 149

155 Idem 150

156 Total government budget appropriations or outlays on R&I (GBAORD) by socio-economic objectives of the nomenclature for the analysis and comparison of scientific programmes and budgets (NABS 2007) [gba_nabsfin07]. Available from: http://ec.europa.eu/eurostat/web/products-datasets/-/gba_nabsfin07

In Japan, while the share of nuclear R&I has steadily been decreasing over the period 2010-2014, it still draws almost half of the national investments. Nonetheless, an increasing share of national R&I investment in Japan is directed to renewables and efficient systems.

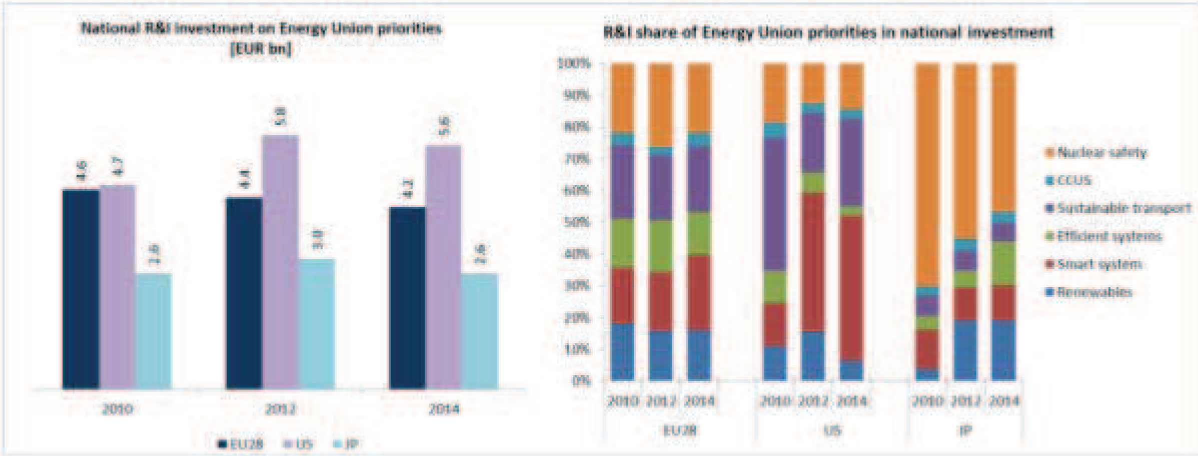
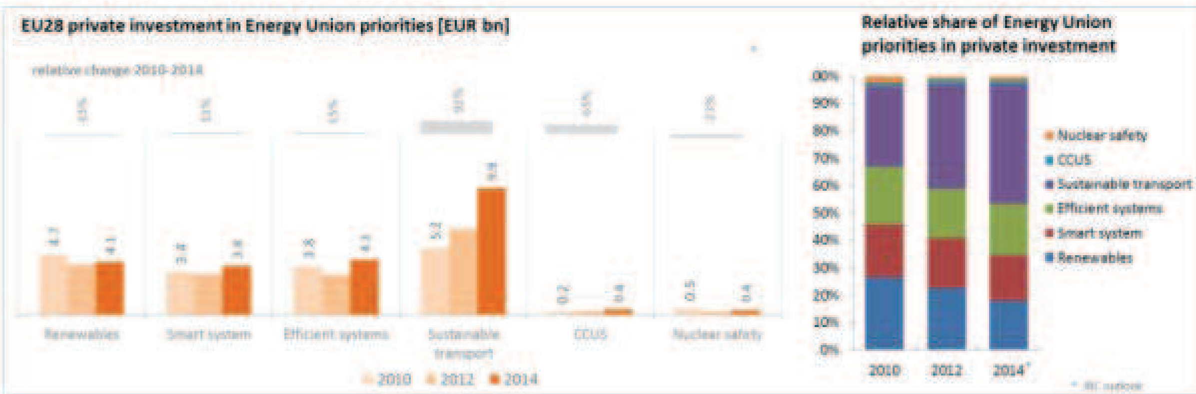


Figure 3.5.3: EU28 national R&I investments in Energy Union R&I priorities compared with other major economies (2010-2014). (Data sources: IEA[157], European Commission[158,159])

Private R&I investments

It is estimated that in 2012, the private sector invested about EUR 17.4 billion on topics related to the Energy Union R&I priorities. It is further estimated that private R&I investments in the EU28 have increased to EUR 22.9 billion in 2014.

The private sector is the main investor in all Energy Union R&I priorities except for nuclear safety, which is primarily funded through public (national) investments. Between 2010 and 2014, the EU industry focused R&I investments on sustainable transport, the share of which increased from 29 % to 43 % of the private investment (Figure 3.5.4). Renewables were the second highest priority in 2010. However, due to a decrease in R&I investments, by 2014 it was on par with the smart system and efficient systems. Nuclear safety and CCUS attracted only a small share of the private R&I funds.



[157] Idem 148
[158] Idem 149
[159] Idem 150

Figure 3.5.4: EU28 private investment in Energy Union priorities in absolute terms and relative share (2010-2014). (Data sources: European Commission[160])

Total R&I investments

Overall, it is estimated that EUR 27 billion were invested in the Energy Union R&I priorities in 2014 by the public and private sectors across the EU28[161]. This signifies a 22 % increase from the 2010 R&I investment levels. Investment intensity, defined as investment as a share of the GDP, has also increased during the same period, from 0.17 % in 2010 to 0.19 % in 2014. This increase is due to the private sector, which contributed 85 % of the total R&I investment in 2014, compared to 80 % in 2010.

The distribution of investments has not been consistent across the R&I priorities (Figure 3.5.5). The largest share of funding, almost 40 % of the total in 2014, was dedicated to sustainable transport, which has seen a near doubling of R&I investment in the period 2010-2014 mainly due to the increasing investment from the private sector. Renewables, efficient systems and the smart system received comparable amounts of funding over the last five years. While R&I funding related to the latter two R&I priorities has increased with time, funding for renewable energy has decreased (total R&I investments for renewables dropped from EUR 5.5 billion in 2010 to EUR 4.7 billion in 2014). CCUS and nuclear safety have a very low share in the overall R&I investments in comparison to other priorities, reaching 2 % and 4 % of the total in 2014 respectively. R&I funds for CCUS have been steadily increasing over the last 5 years, while research funding for nuclear safety experiences a continuous decline both from public and private sources.

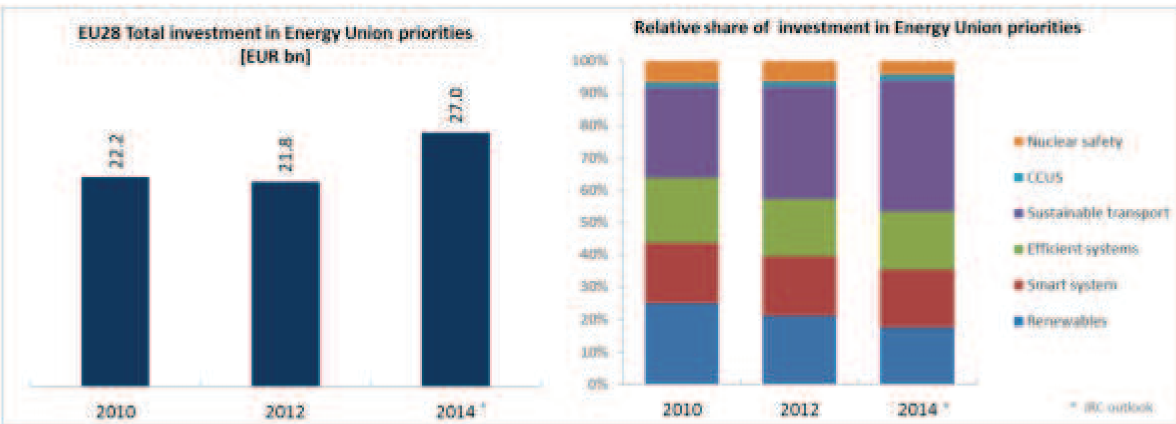


Figure 3.5.5: EU28 total investments in Energy Union R&I and the relative share per Energy Union R&I priority (2010-2014). (Data sources: IEA[162], European Commission[163])

The intensity of investment varies significantly across Member States (Figure 3.5.6). In 2012[164], Finland had the highest intensity, as investments in Energy Union R&I priorities

[160] Idem 149
[161] Idem 149
[162] Idem 148
[163] Idem 149
[164] While an outlook of private investments for 2013-2014 is available at EU level, the completeness and quality of the data for 2013 (and more so for 2014) does not allow for similar estimates at Member

represented 0.38 % of GDP, with Germany and Denmark following closely with intensities around 0.30 %[165]. The R&I intensity in these three countries has however decreased compared to 2010, as was the case for a further 13 Member States. The trend was similar for the EU28 average for this period. Nonetheless, estimations indicate that the EU28 average R&I intensity in 2014 has recovered and increased compared to 2010. Six other Member States had intensities between 0.1 % and 0.2 % (Belgium, France, Hungary, Netherlands, Austria, and Sweden).

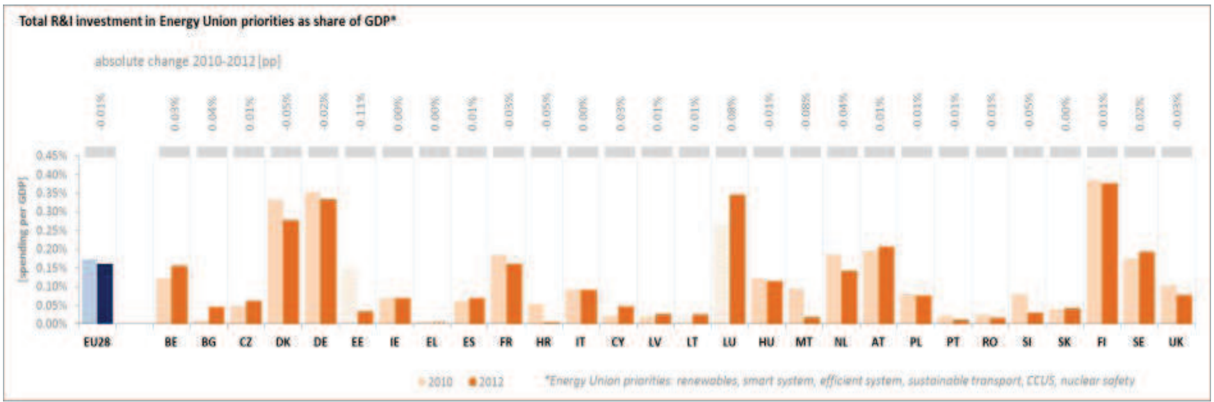


Figure 3.5.6: Intensity of Energy Union R&I investment, defined as a share of GDP per Member State (2010-2012). (Data sources: IEA[166], European Commission[167], Eurostat[168])

3.5.1.2. TRENDS IN PATENTS ON ENERGY UNION R&I PRIORITIES

In 2012, in the EU, more than 7200 patents[169] related to the Energy Union R&I priorities were filed. The number of patents in the EU28 was similar to that of South Korea and higher than that of the USA (around 4500 patents). The EU has been lagging behind China and Japan, which produced 18000 and 16000 patents that year respectively (Figure 3.5.7). Patent generation in China has increased significantly since 2007 and intensified after 2010, to the point of overtaking the world-leader Japan in 2012. However, when normalised by population, South Korea and Japan are still clear leaders in patenting activity, with the rest following at a similar level (Figure 3.5.8).

State level. Thus the presentation of the total investments at Member State level is limited to the period 2010-2012.

165 Luxembourg is also among the Member States with the highest R&I intensity; however, as it is the place of registration of a large number of corporate headquarters, relative to the size of the economy, calculations of private investment (and in turn of the total) are skewed. Hence, this does not allow for direct comparisons.

166 Idem 148

167 Idem 149

168 Idem 151

169 In the context of this document, the term 'patent' refers to patent families, which include all documents (supplementary applications, or applications to different authorities) relevant to a single invention, to avoid multiple counting.

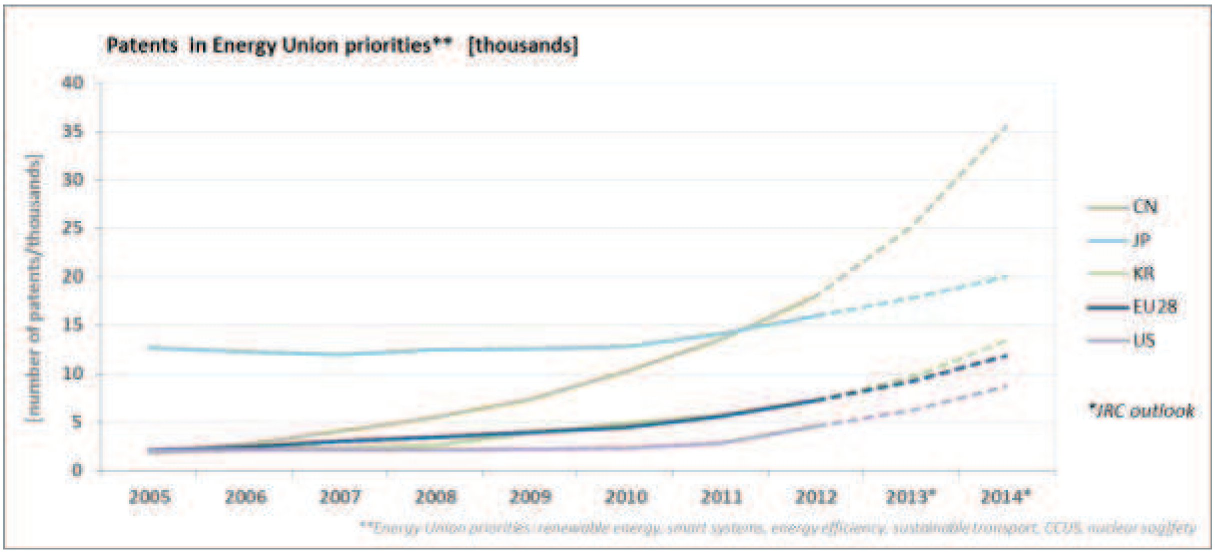


Figure 3.5.7: *Trend of patents filed per year in the Energy Union R&I priorities for the EU28 and major international partners (Data source: European Commission[170] based on EPO data[171])*

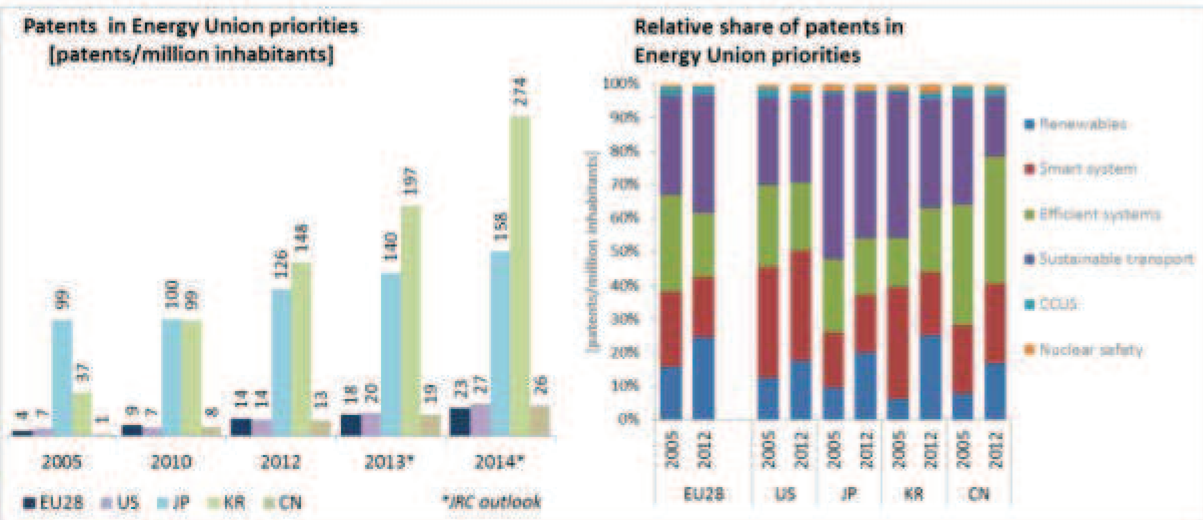


Figure 3.5.8: Patents in topics related to the Energy Union R&I priorities in the EU and major international investors; and relative share per Energy Union priority (2005-2014). (Data source: European Commission[172] based on EPO data[173])

In all major economies the share of patents in renewables has increased relative to the other priorities. Patenting activity in sustainable transport has been increasing in relative share in the EU28 while remaining stable or decreasing elsewhere. The increasing trend is more prominent after 2006 for renewables and 2009 for sustainable transport. Patenting activity on CCUS and nuclear remains very low (Figure 3.5.9).

[170] Idem 149
[171] European Patent Office – PATSTAT: The Worldwide Patent Statistical Database. https://www.epo.org/searching-for-patents/business/patstat.html#tab1
[172] Idem 149
[173] Idem 171

The EU had been a global leader in wind energy patents until 2011, when it was overtaken by China. The picture is similar for ocean energy technologies. In the solar PV sector, although the EU28 has increased patenting activity after 2006, it is still lagging behind Japan, China and South Korea by a large margin. Overall, the EU28 produced the same amount of patents in renewables as South Korea in 2012, more than twice as many as the USA, but half as many as those produced in China or Japan.

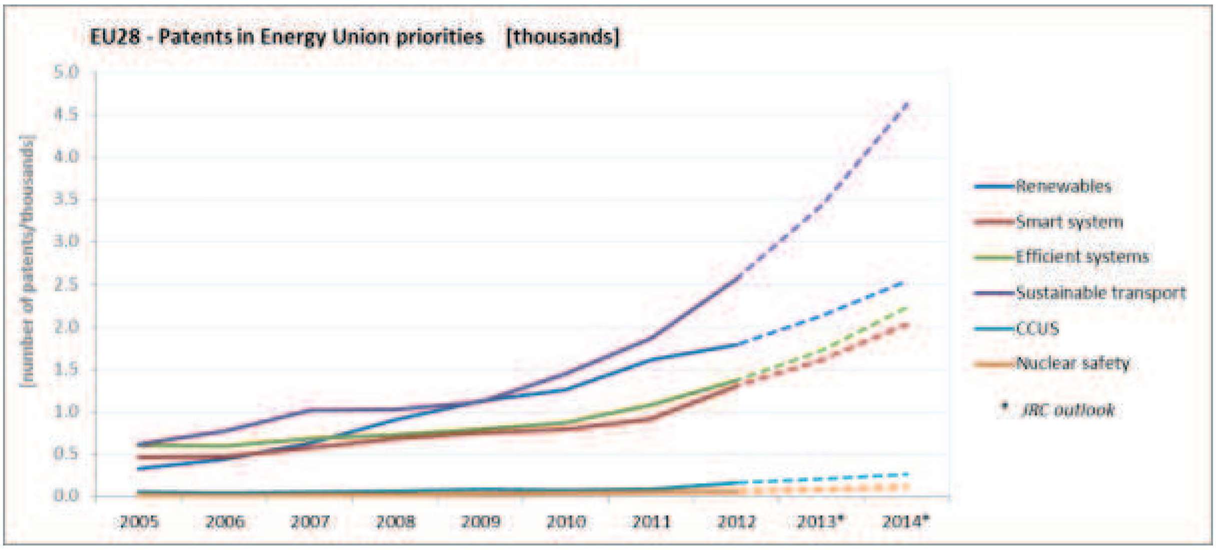


Figure 3.5.9: Trend of patents filed per year in the Energy Union R&I priorities for the EU28 (2005-2014). (Data source: European Commission[174] based on EPO data[175])

RIC2: Low-carbon technology patents per million inhabitants: this indicator shows the number of patents[176] in the field of low carbon technologies as per number of inhabitants in a given country.

Figure 3.5.10 shows the number of patents in Energy Union R&I priorities by Member State, normalised by population, for the period 2005-2012. There has been a significant growth in patenting activity in Energy Union R&I priorities in recent years, with the EU28 average climbing from 4 patents per million inhabitants in 2005 to 14 in 2012.

Figure 3.5.11 shows the number of patents in Energy Union R&I priorities normalised by GDP. Taking into account economic activity rather than population reduces the difference between the relative performance of Member States in certain cases, but does not significantly affect the general trend and ranking within the EU28[177]. Internationally however, this indicator would bring China (2.7 patents per billion EUR GDP in 2012), which is comparable to the EU28 and the USA in patents per inhabitants (Figure 3.5.8), much closer to the performance of South Korea (3.7 patents per billion Euro GDP in 2012). The patenting intensity of Japan per GDP is twice that of South Korea, while USA patents per GDP are just below the level of the EU28.

[174] Idem 149
[175] Idem 171
[176] Idem 169
[177] Luxembourg is the place of registration of a large number of corporate headquarters, relative to the size of the country and the economy; as a result indicators are skewed and do not allow direct comparison with other Member States.

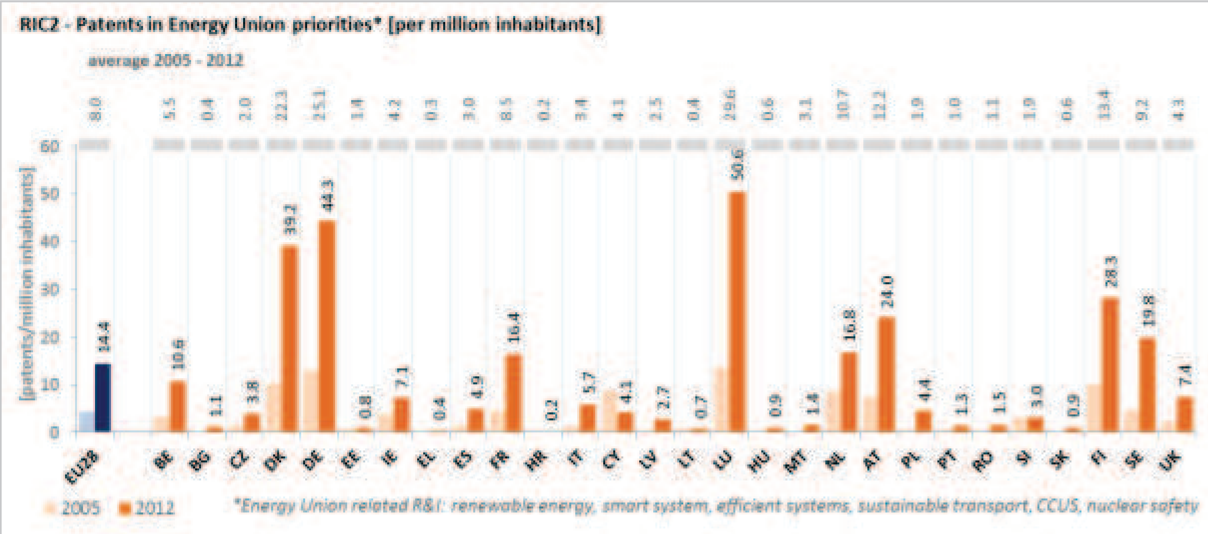


Figure 3.5.10: Patents in Energy Union priorities normalised by population per Member State (2005-2012)[178] (Source: European Commission[179] based on EPO data[180], Eurostat[181])

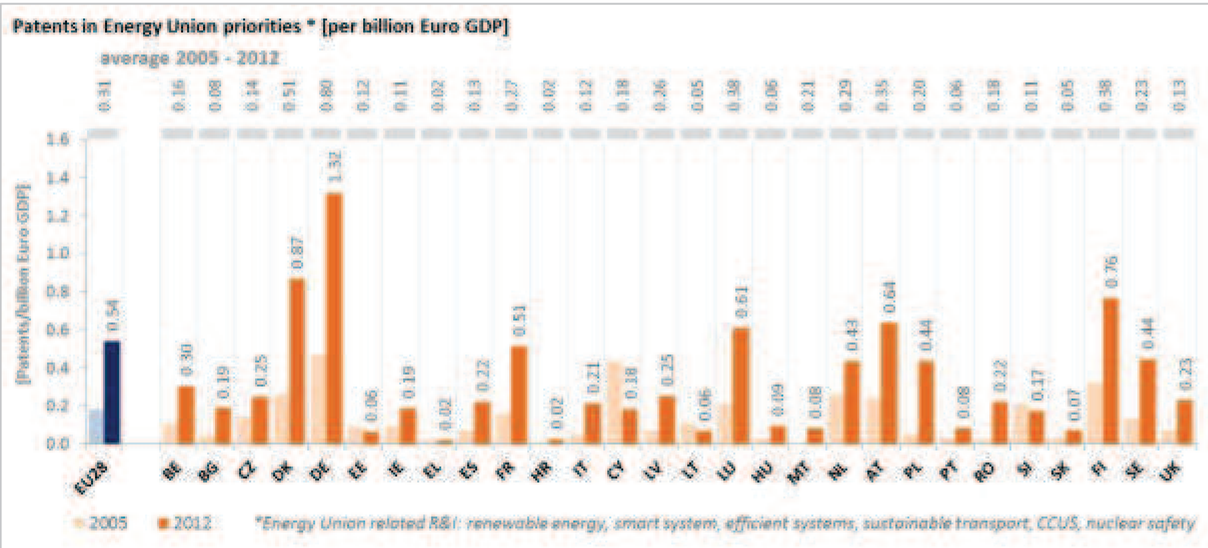


Figure 3.5.11: Patents in Energy Union priorities normalised by GDP per Member State (2005-2012)[182] (Source: European Commission[183] based on EPO data[184], Eurostat[185])

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178 While an outlook of patent trends for 2013-2014 is available at EU28 level, the completeness and quality of the data for 2013 (and more so for 2014) does not allow for similar estimates at Member State level. Thus patent trends at Member State level are limited to the period 2005-2012.

179 Idem 149

180 Idem 171

181 Population change - Demographic balance and crude rates at national level, [demo_gind] INDIC_DE: Population on 1 January – total. Available from: http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tps00001&plugin=1

182 Idem 178

183 Idem 149

184 Idem 171

185 Idem 151

3.5.2. COMPETITIVENESS OF RENEWABLE ENERGY

The levelised costs of electricity generation (LCOE)[186] are a good indication of the competitiveness of a technology across different regions and in comparison with other power generation technologies.

The LCOE is based on economic conditions at the time of the investments and 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. Therefore, the LCOEs may improve fast as cost estimates are rather on the conservative side and markets for new technologies develop fast.

According to the International Renewable Energy Agency (IRENA), between 2010 and 2014 the LCOE at global level decreased significantly especially for both solar photovoltaic (solar-PV) and concentrated solar power (CSP) technologies and to a lesser extent for on-shore wind (Figure 3.5.11).

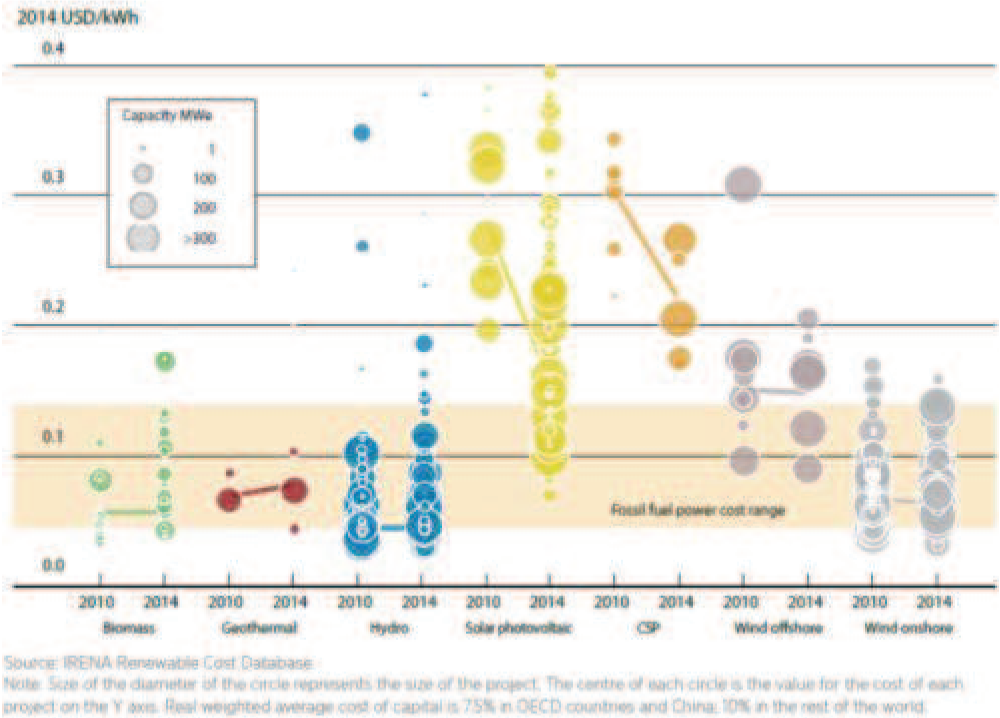


Figure 3.5.11: Trends in global renewable energy LCOE 2010-2014 (Source: IRENA[187])

The LCOE for hydropower, geothermal, onshore wind and biomass are already comparable to the cost range of fossil fuels. LCOE for offshore wind, solar-PV and CSP are still above the fossil fuels cost range but started to be competitive in certain contexts and also according to the installed capacity. Cost disparities have decreased considerably

[186] The LCOE of a given technology is the ratio of lifetime costs (including e.g. construction, fuel, maintenance) to lifetime electricity generation, both of which are discounted back to a common year using a discount rate that reflects the average cost of capital. The considered WACC (weighted average capital cost) is 8.5 % for OECD countries and China and 10 % for the rest of the world. More information on the methodology for the LCOE figures presented in this SWD is available at: http://dashboard.irena.org/download/Methodology.pdf

[187] IRENA renewable power generation costs in 2014; https://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Power_Costs_2014_report.pdf

in favour of new low-carbon technologies also due to policy-induced technological progress which foster the decrease in investment costs for solar and wind technologies.

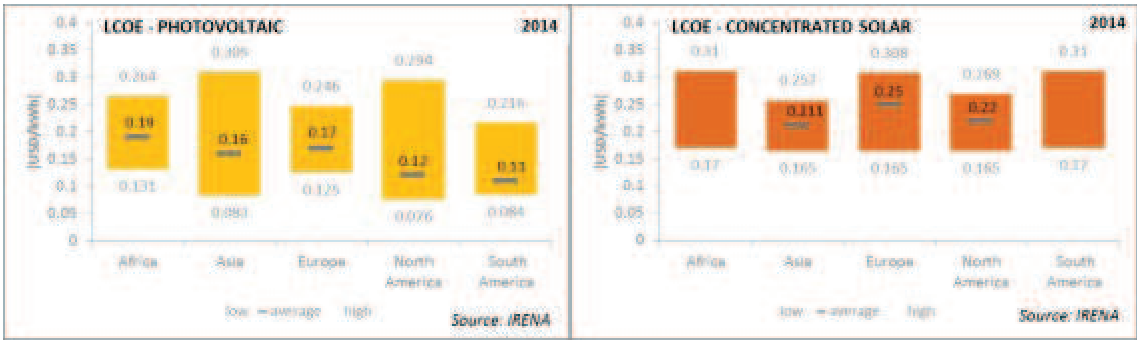
In 2014, the LCOE ranges for main renewable energy technologies in Europe are comparable with the worldwide level, but the average values are still slightly above the average in other regions and countries such as US and China. There are several reasons for the differences between LCOE estimates across world regions. First, the LCOE is calculated based on a portfolio of identified projects, of different sizes and sub-technologies and type of applications. Second, the LCOE is influenced by the availability of infrastructure and relief, maturity of the local market on a specific renewable technology, local prices, permitting and regulatory procedures and costs. Third, the differences are related to other factors such as local expertise and workers skills, labour rates etc. Therefore, it is very challenging to draw a conclusion based on LCOE only.

However, it is important to aknowledge that the costs of renewable power technologies are falling faster than for conventional power generation technologies and they become increasingly competitive or are already an attractive option on the markets.

Between 2010 and 2015, the LCOE for utility-scale PV fell by 58 % globally[188] and could fall by 57 % more between 2015 and 2025 in case of accelerated deployment and faster adoption of best available technology nowadays.

By 2015, the installation costs of onshore wind decreased by 7 % every time the capacity has doubled and there is still potential for a LCOE reduction of 26 % by 2025[189].

For offshore wind, the global LCOE may fall by 35 % by 2025[190]. In 2016 in the EU there are already signs[191] of an accelerated cost reduction for off-shore wind to below 80 €/MWh as indicated by a recent report of the European wind industry[192].



188 IRENA. The power to change: solar and wind cost reduction potential to 2025. June 2016. http://www.irena.org/DocumentDownloads/Publications/IRENA_Power_to_Change_2016.pdf

189 Idem 188

190 Idem 188

191 Bloomberg New Energy Finance H2 2016 Offshore Wind Market Outlook reported that in 2016 several auctions for off-shore wind closed at bid-equivalent LCOEs well below USD 80 /MWh. Few examples: Vattenfall with a bid-equivalent LCOE of $81/MWh for the 404MW Horns Rev III auction and with a winning bid-equivalent LCOE of $55/MWh for the 350MW Danish ‘near-shore’ tender, Dong with a winning bid-equivalent LCOE of $61/MWh for the 700MW Borssele I & II.

192 Wind Europe. Offshore wind can reduce costs to below €80/MWh by 2025. June 2016. https://windeurope.org/wp-content/uploads/files/policy/topics/offshore/Offshore-wind-cost-reduction-statement.pdf

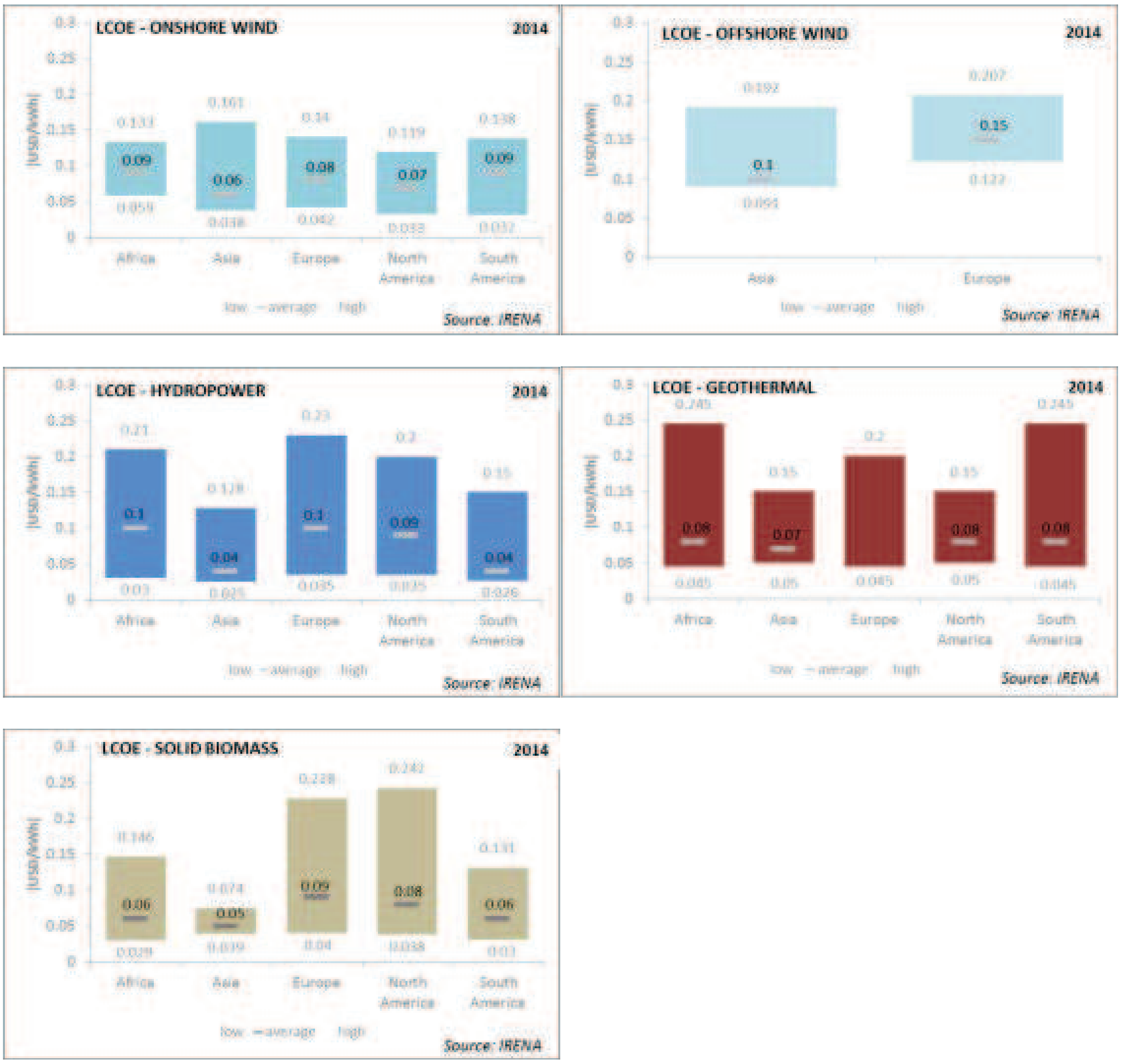


Figure 3.5.12: LCOE for main renewables per technologies and regions in 2014. Source: IRENA[193]

Global investments in renewable energy continued to recover in 2015 after the consistent drop in 2012 and 2013 induced by the economic downturn. The recovery has been facilitated by the continuous increase of investment in China and, to a lesser extent, in the US. After a boost in 2014, investments in Europe fell again in 2015 by 21 % to USD 48.8 bn.

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[193] IRENA dashboard available at: http://resourceirena.irena.org/gateway/dashboard/

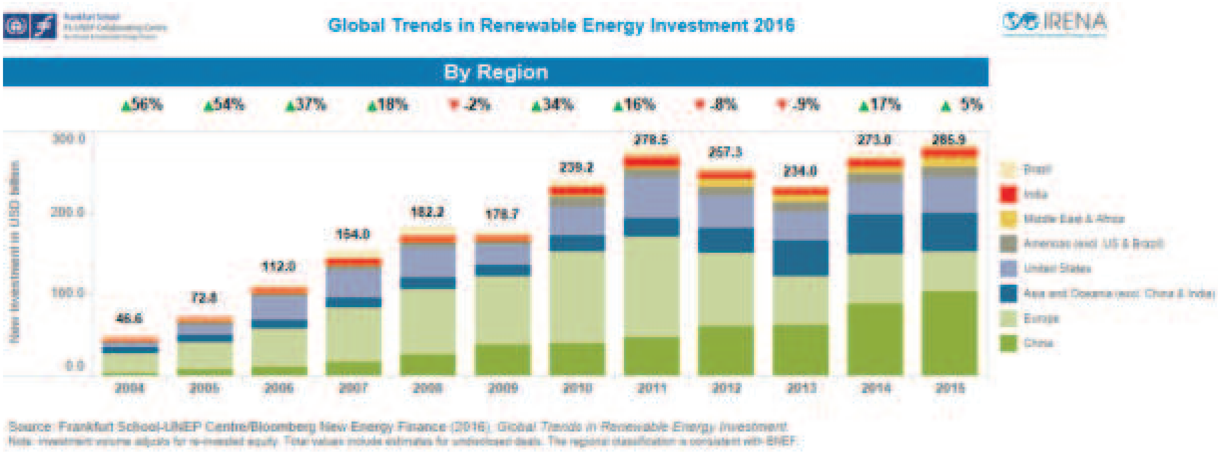

Figure 3.5.13: Global trends in renewable energy investments, by region. Source: IRENA

Solar (56 %) and wind (38 %) energy investments have been the highest in 2015, with new records for both in terms of absolute values.

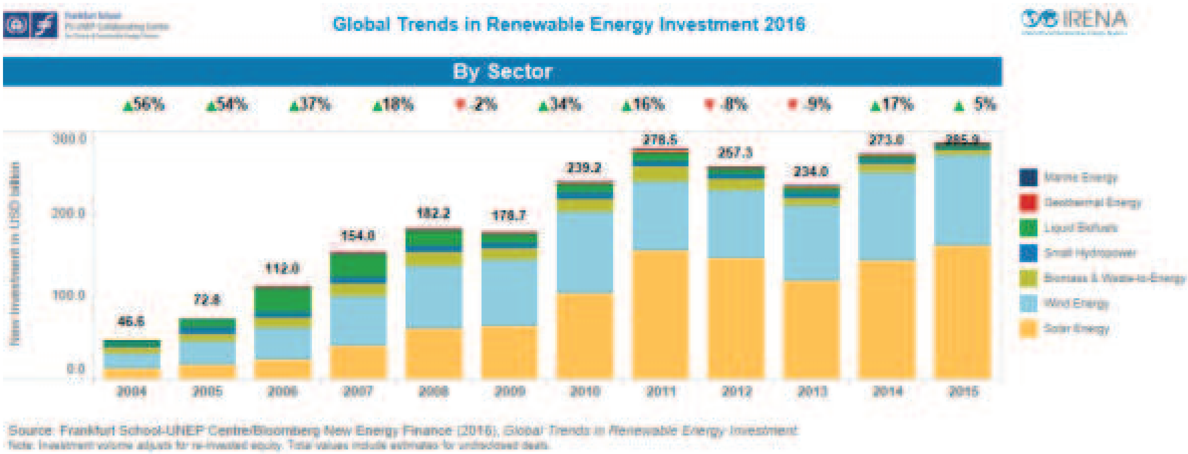

Figure 3.5.14: Global trends in renewable energy investments, by sector. Source: IRENA

The turnover of the renewable energy industry in the European Union reached EUR 143.6 billion in 2014, recording an increase for the second year in a row after the turnover reduction between 2010 and 2012.[194] In most of the Member States, the turnover of the renewable industry increased in 2014 as compared to 2010, while most notable decreases were reported in Cyprus, Czech Republic, Belgium and Sweden.

[194] According to Eurobserv'Er barometers on renewable energy, available at: http://www.eurobserv-er.org/

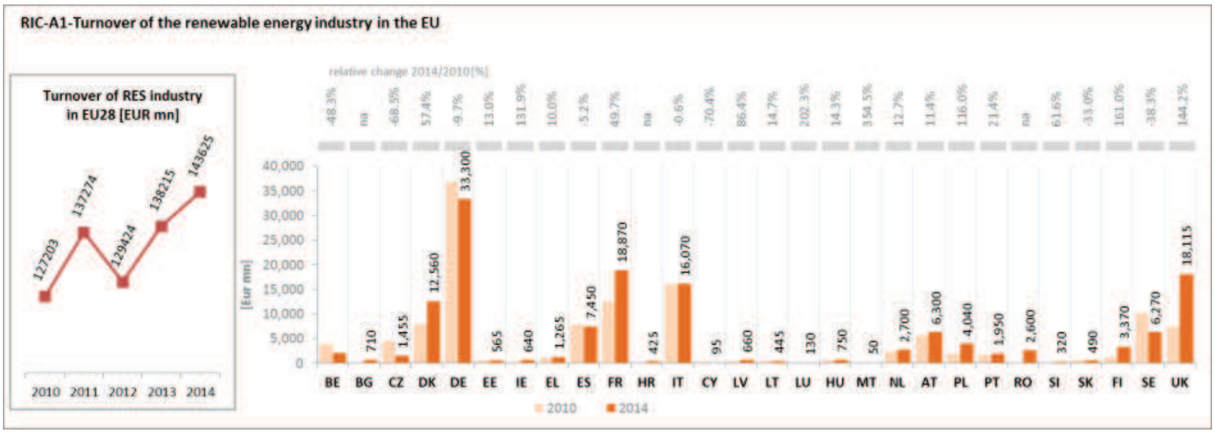

Figure 3.5.15: Turnover of renewable energy in the EU. Source: Eurobserv'Er

3.5.3. Cohesion Policy investments supporting the Energy Union

EU Cohesion Policy makes a key contribution to 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 68.8 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 29.1 billion of those allocations are foreseen for energy and low-carbon research and innovation:

- EUR 13.4 billion for energy efficiency in public and residential buildings;
- EUR 3.3 billion for energy efficiency in enterprises, with a focus on SMEs;
- EUR 1.7 billion for high-efficiency cogeneration and district heating;
- EUR 4.8 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).

The use of financial instruments is strongly encouraged for these allocations. Financial instruments can recycle contributions from the ERDF and the CF over the long term and mobilise private co-investments, ensuring greater impact on the objectives of the Energy Union. Currently, 21 Member States plan to invest an estimated EUR 4 billion via financial instruments dedicated to supporting the shift towards a low-carbon economy.[195] This represents an eight-fold increase as compared to the 2007-2013 programmes. The investments will focus on energy efficiency.

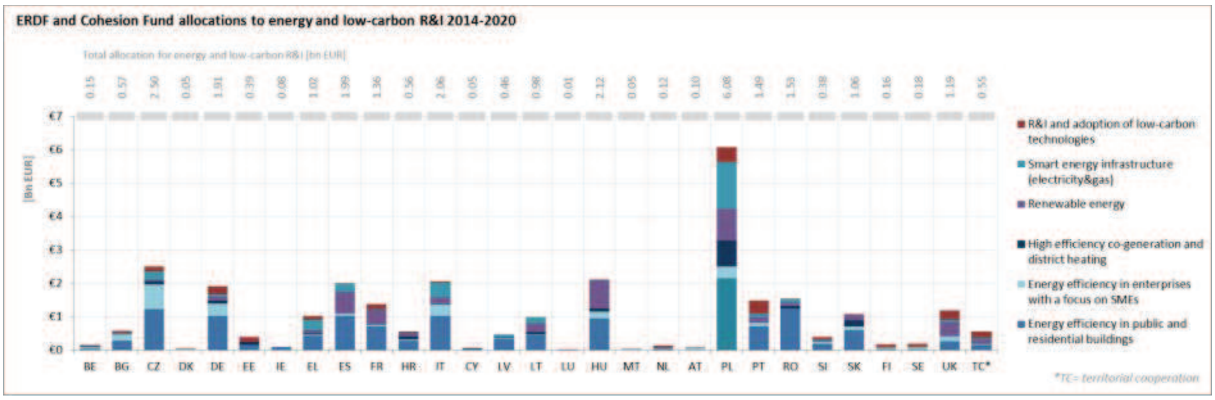

Figure 3.5.16: ERDF and Cohesion Fund allocations to energy and low-carbon R&I, 2014-2020. Source: European Commission calculations, based on operational programmes (data as of January 2017)

[195] As per estimates provided by Member States in the follow-up to the conclusions of the General Affairs Council of 23 June 2015.

The remaining EUR 39.7 billion are allocated for directly supporting the move towards an energy-efficient, decarbonised transport sector:

- EUR 16.0 billion for sustainable urban mobility, including clean urban transport infrastructure, intelligent transport systems, cycle tracks and footpaths;
- EUR 23.7 billion for other low-carbon transport, including rail, seaports and inland waterways.

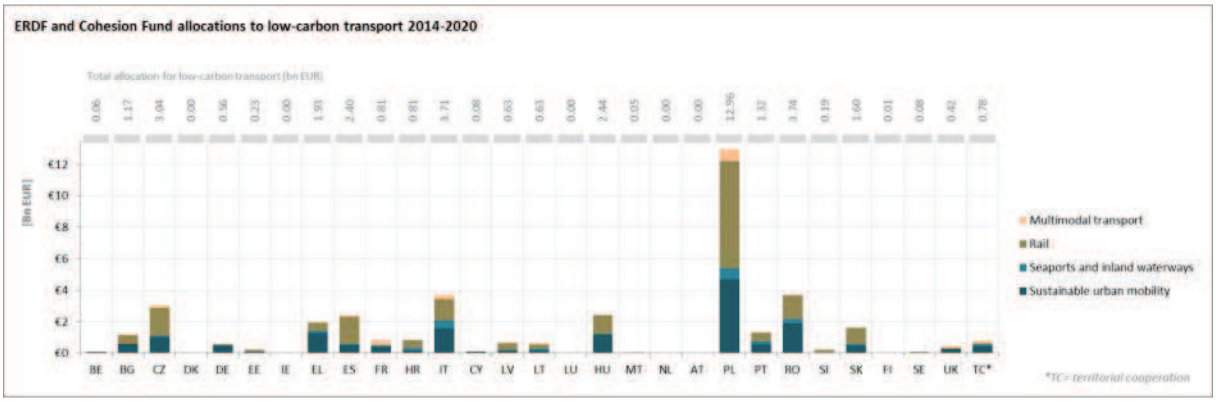

Figure 3.5.17: ERDF and Cohesion Fund allocations to low-carbon transport, 2014-2020. Source: European Commission calculations, based on operational programmes (data as of January 2017)

The expected results of the ERDF and CF investments include:

- 875 000 families living in homes renovated to reduce energy use;
- Public buildings using 5.2 TWh/year less energy than they do now;
- 7 670 MW of additional capacity of renewable energy production;
- 3.3 million additional energy users connected to smart grids;
- 748 km of new or improved tram and metro lines;
- 7 515 km of new or upgraded railway lines;
- 977 km of new or improved inland waterways.

2014 and 2015 was a time of transition between programme periods.

On the one hand, very significant investment activities were still ongoing under the 2007-2013 programmes, including important investments supporting the Energy Union, with ERDF and CF allocations of around EUR 11.9 billion for energy and EUR 38.3 billion for low-carbon transport invested in total under these programmes. It is estimated that almost half of these allocations –or some EUR 24 billion - was still being spent on the ground during 2014-2015, thus making a significant contribution to the Energy Union objectives as well as to overall investment levels, growth and jobs.[196]

On the other hand, activities related to the 2014-2020 programme period focussed mainly on preparation and adoption of the new programmes. The new legislative framework for implementing the European Structural and Investment Funds (ESI Funds)[197] over the 2014-2020 period has introduced a number of provisions aimed at improving the effectiveness and European added value of the funds.

[196] The last reports on the period 2007-2013, due by end March 2017 for ERDF and CF, will provide the final picture on financial completion and physical achievements.
[197] ERDF and CF are part of the ESI Funds.

Nevertheless, many of the new programmes already made progress with the first rounds of project selection. The majority of Member States got started already in 2014 and 2015 with selecting concrete projects in the Energy Union areas under the 2014-2020 programmes. Across the EU as a whole, over 1 200 projects had already been selected by end 2015[198], corresponding to almost EUR 1.7 billion of ERDF or CF funding contribution including EUR 580 million for energy efficiency projects, EUR 145 million for renewable energy projects, EUR 686 million for rail projects, EUR 60 million for urban mobility projects and EUR 98 million for low-carbon R&I projects. In particular Ireland, Finland, Lithuania, Sweden and Estonia have kick-started the implementation of their Energy Union measures under the new programmes, with project selection rates in this area between 14 and 41 % already at the end of 2015. Member States reporting also shows that EUR 894 million had already been committed to financial instruments supporting low carbon economy, which is another sign of implementation progress underway[199].

198 Project selection data by end 2016 will be available in the first quarter of 2017.

199 Based on Annual Implementation Reports from Member States. Source: Financial instruments under the European Structural and Investment Funds. Summaries of data on the progress made in financing and implementing the financial instruments for the programming period 2014-2020 in accordance with Article 46 of Regulation (EU) No 1303/2013 of the European Parliament and of the Council. Situation as at 31 December 2015, Brussels: European Commission, 2016.

3.5.4. EMPOWERING LOCAL INITIATIVES: COVENANT OF MAYORS COMMITMENTS AND ACHIEVED GHG EMISSION REDUCTION

The GHG mitigation commitment of the Covenant of Mayors for Climate and Energy signatories is related mainly to the emissions associated with energy consumption in sectors which can be influenced by the local authority (housing, services and urban transport) leaving out other emitters such as ETS industry and transport outside the mandate of the local authority (e.g. highways).

All together, the Covenant's signatories committed to an ambitious 27 % GHG emission reduction target by 2020, i.e. 7 percentage points higher than the EU28 GHG target by 2020. The cumulative emission reduction of the Covenant signatories from EU28 is estimated to deliver about 31 % of the requested reduction from 2005 levels to 2020 target.

Results from 315 submitted monitoring inventories (covering 25.5 million inhabitants and mainly the period 2012-2014) reveal an already achieved 23 % overall GHG emissions reduction. This decrease was driven by:

- GHG emissions due to electricity consumption decreased by 17 % as compared to the baseline due to a less carbon intensive fuel mix and more efficient electricity generation power plants;
- GHG emission in buildings for heating and cooling decreased by 36 % as compared to the baseline, driven by improved energy efficiency in buildings and consequent lower energy consumption levels, more efficient local heat production from district heating networks, and by increasing shares of renewable sources in decentralised local heating production;
- GHG emissions in the transport sector decreased by 7 % as compared to the baseline driven by more efficient vehicles, increase of shares of biofuels, shift towards public transportation and electric mobility.

These results underline the interconnected nature of climate mitigation and energy efficiency actions adopted at local level. The Covenant signatories adopted a range of policies and measures for improving energy efficiency though building regulations, increasing of renewable energy share, integrating district energy systems and a gradual transformation to more efficient and sustainable transportation.

At the cut-off date of the analysis[200], there were a total of 6,201[201] Covenant signatories covering 213 million inhabitants out of which 85 % from EU28 representing 36 % of the total EU28 population[202]. The peculiarity of the Covenant movement is the participation of the small and medium towns (with less than 50 000 inhabitants) in the effort to reduce the GHG emissions (89 % from total signatories).

[200] A. Kona, G. Melica, A. Iancu, B. Koffi, P. Zancanella, S. R. Calvete, P. Bertoldi, G. Janssens-maenhout, and F. Monforti-Ferrario, Covenant of Mayors : Greenhouse Gas Emissions Achievements and Projections, EUR 28155. Luxembourg: Publications Office of the European Union, 2016

[201] 6,201 signatories cover 6,926 local authorities, of which 725 have adopted joint action plans, thus resulting in a lower number of signatory profiles.

[202] UNDESA 2011: average from 2008-2011

Table 3.5.1: Average GHG emission per capita in Covenant Baseline Emission Inventories and corresponding estimates by 2020.

Country	Number of Sustainable Energy Action Plans assessed	Population covered by the assessed Sustainable Energy Action Plans	Average GHG emission per capita in Baseline Emission Inventories	Estimated Average GHG emission per capita by 2020	Relative change by 2020
			[t CO_2-eq/capita*year]	[t CO_2-eq/capita*year]	[%]
EU28	5,332	157,659,365	5.22	3.76	-28.0 %
BE	176	5,633,762	5.4	4.3	-20.4 %
BG	23	2,442,526	3.51	2.68	-23.6 %
CZ	5	344,041	4.86	3.66	-24.7 %
DK	36	2,943,800	7.31	5.39	-26.3 %
DE	57	15,068,945	9.03	5.48	-39.3 %
EE	3	422,608	9.42	7.53	-20.1 %
IE	5	1,357,065	10.79	8.59	-20.4 %
EL	96	4,364,270	5.26	4.04	-23.2 %
ES	1376	25,453,645	4.72	3.65	-22.7 %
FR	78	13,724,978	4.87	3.72	-23.6 %
HR	61	1,848,654	3.45	2.68	-22.3 %
IT	2953	37,175,572	4.61	3.42	-25.8 %
CY	24	474,252	7.55	5.44	-27.9 %
LV	19	1,359,685	3.62	1.82	-49.7 %
LT	14	1,441,101	4	2.1	-47.5 %
LU	1	2,200	10.59	7.41	-30.0 %
HU	27	2,443,324	5.33	4.13	-22.5 %
MT	24	104,909	5.01	3.78	-24.6 %
NL	17	3,512,259	7.26	4.81	-33.7 %
AT	12	1,713,236	4.74	3.59	-24.3 %
PL	34	3,629,693	6.41	5.08	-20.7 %
PT	111	5,763,853	4.86	3.67	-24.5 %
RO	52	3,209,632	3.18	2.44	-23.3 %
SI	29	719,466	7.57	5.98	-21.0 %
SK	4	526,932	5.11	4.08	-20.2 %
FI	10	1,594,207	6.93	5.24	-24.4 %
SE	52	3,712,333	6.15	3.45	-43.9 %
UK	33	16,672,417	6.63	4.34	-34.5 %

3.5.5. ENERGY PRICE AND COST DEVELOPMENTS IN A GLOBAL PERSPECTIVE

The Energy Union strategy underlined that energy price differences compared with other economies has an impact on the competitiveness of the EU industry. In fact, compared with other factors of production, energy plays a relatively modest role in the formation of the gross value added in most sectors of the EU economy. In 2014, the share of purchased energy was only 2.1 % of the total production value in the manufacturing sector.[203] However, several important manufacturing sectors rely on energy as a critical factor of production. For such energy intensive industries, energy prices and costs can indeed have a significant impact on their international competitiveness compared to our trading partners.

In this section, we provide an international comparison of wholesale energy prices (these are generally deemed representative for the largest energy consumers) and retail energy prices for industrial consumers. It should be borne in mind that, when comparing international prices, the evolution of the exchange rates can play a very significant role, potentially masking or accentuating the price trends in national currencies.

The section also provides comparative information on real unit energy costs in the EU and in major trading partners. In addition to energy prices, energy costs are also influenced by energy intensity. Accordingly, the rise of energy prices can be offset by improvements in terms of energy intensity, for example by the increasing specialisation on less energy intensive industries or improvements of energy efficiency.

The report on energy prices and costs in Europe[204] provides further details on the effects of energy prices and costs on the structure and the competitive position of the European economy, both at a broad macro-economic level and in sectors of selected energy intensive industries. The report also provides an analysis of the various components of energy prices, including network costs, taxes and levies.

[203] Eurostat Structural Business Statistics, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E); the average does not include Ireland, Malta and Poland for which no data is available.
[204] SWD(2016) 420 final

3.5.5.1. WHOLESALE ELECTRICITY PRICES

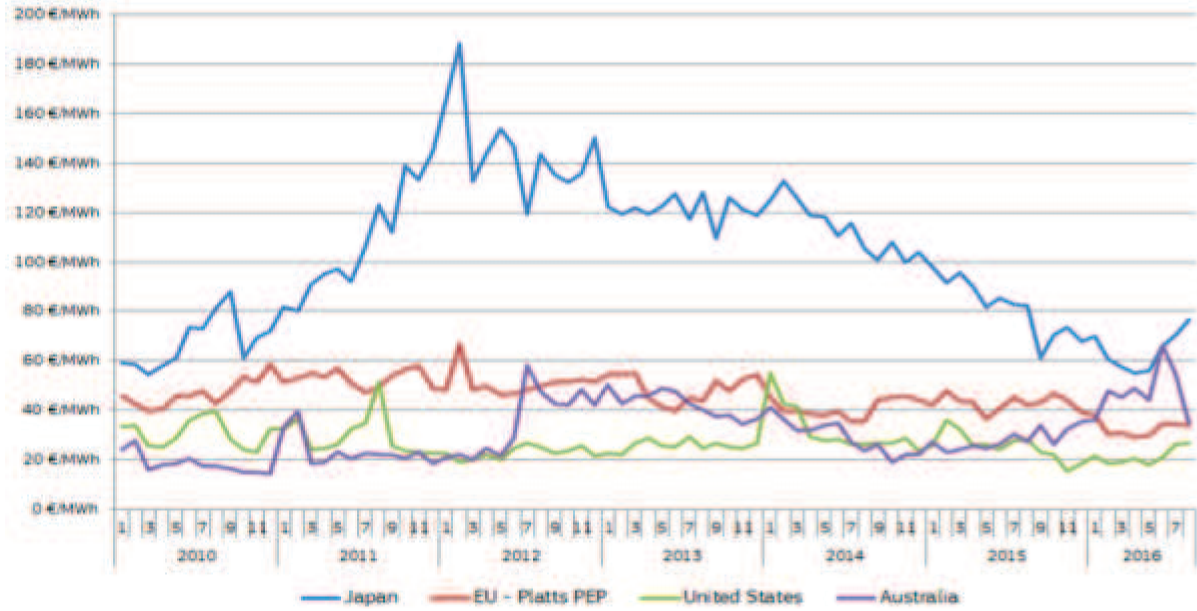

Figure 3.5.18: Wholesale electricity prices in Europe, the US, Japan and Australia
Source: Platts (EU), PJM and ERCOT (US), JPEX (Japan), AEMO (Australia)

Since 2010, with the exception of some short periods, wholesale electricity prices in the US were below the European power benchmark, Platts' Pan-European Power (PEP) index. In the first half of 2016, US prices were 35 % lower than the EU average. The difference is driven by low generation costs in the US, predominantly based on cheap domestic natural gas production. During the last few years, low gas prices triggered an increase of gas-fired generation, partly squeezing out coal from the power generation mix. Due to the increasing dependence on gas-fired generation, US power prices are more volatile than their peers in Europe, since gas prices are sensitive to changes in weather conditions. During the last few years, electricity generation costs also decreased in the EU, helped by subdued demand, falling fossil fuel prices and the gradual penetration of renewables into the power mix. As a result, the EU-US price gap shrunk.

Over the last few years, Japanese wholesale electricity prices have been consistently higher than in the EU. The price differential has peaked in the wake of the Fukushima nuclear power plant accident, as cheap nuclear generation has been replaced by gas-fired plants. However, since 2014, as LNG import prices became lower and some nuclear reactors have been restarted, power generation costs decreased, putting pressure on wholesale electricity prices. By 2016, the Japanese wholesale electricity prices returned to the pre-Fukushima levels but remained well above European prices. In the first half of 2016, Japanese prices were still almost twice as high as in the EU.

In 2010-2015, wholesale electricity prices in Australia were typically below the EU average and comparable to US prices, facilitated by abundant domestic coal resources. Since the end of 2015, however, Australian prices grew as a result of temporary reasons and exceeded the European PEP index.

It is important to recall that there is a significant variation of wholesale electricity prices in different EU Member States, and the actual price can be well above or well below the PEP index (see section 3.2.3.).

3.5.5.2. WHOLESALE GAS PRICES

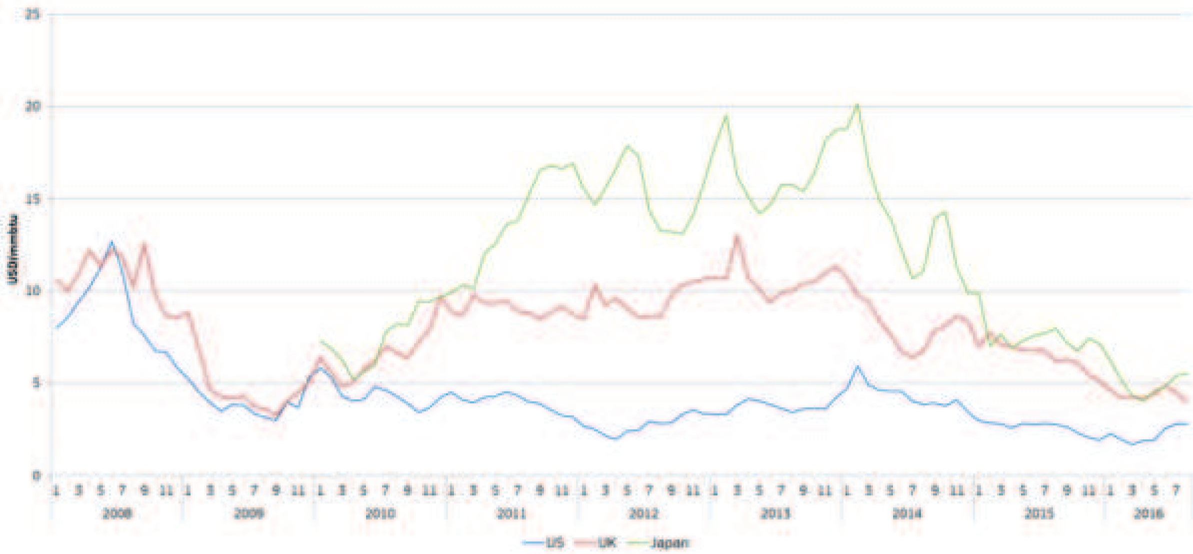

Figure 3.5.19: International comparison of wholesale gas prices. Sources: Platts

The above figure shows an international comparison of wholesale gas prices, covering the US (Henry Hub), the UK (NBP hub) and Japan (JKM spot price). In 2010-2013, there has been a marked diverging trend, with huge differences emerging between the regional benchmarks. Since 2014, however, wholesale prices decreased significantly in all regions, leading to a convergence of regional prices.

As already mentioned in the previous section, Japanese gas demand increased after the Fukushima accident, putting LNG prices on an upward trajectory. From 2014, however, LNG prices showcased a big decrease, with Japanese landed prices decreasing by nearly 80 % between February 2014 and April 2016. 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 increasing global supply. Unlike in previous years, the 2014/2015 and 2015/2016 winters failed to reverse the downward trend and Japanese prices continued to fall. By the second quarter of 2016, Japanese spot LNG prices were on a par with the price at NBP, the UK gas hub. This was a major change compared to previous years when the Japanese LNG price had a premium of 3-10 USD/mmbtu over the NBP price.

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 since January 2015, and temporarily dropped below 2 USD/mmbtu in late 2015 and in the first half of 2016. While the fall of the oil price cut the production of associated gas from oil shale plays, the resulting cost deflation helped the gas producers as they focus on gas-rich fields.

European prices have also decreased significantly since 2014, as a result of a combination of factors: weak demand, steady LNG imports and falling oil-indexed prices put pressure on hub prices. The depreciation of the euro also contributed to this trend by lowering European prices expressed in US dollars. As a result, the difference between the NBP and the Henry Hub price decreased to an average 2 USD/mmbtu in the first nine months of 2016 while in 2011-2013 this gap was 4-9 USD/mmbtu.

Again, it is important to recall that wholesale gas prices vary across EU Member States, with most countries having a higher price than NBP, the UK hub price (see section 3.2.3.).

3.5.5.3. RETAIL PRICES PAID BY INDUSTRIAL USERS

While wholesale prices serve as a proxy for the energy prices paid by the largest industrial users, it is also essential – when studying economic and industrial competitiveness – to consider the final price paid by end consumers. Therefore, Figure 3.5.20 and Figure 3.5.21 compare final electricity and gas prices paid by industrial users in EU Member States and some trading partners.

Even within a single country, there can be large discrepancies in the prices paid by industrial users, depending on the consumption band considered. At the same time, averages for the whole industrial sector can hide a huge variation of situations across the wide spectrum of industrial sectors and sub-sectors. At the level of individual companies, energy prices can also vary depending on their energy supply strategies, consumption level and patterns, connection type to grids as well as price and tax exemptions and reductions. Besides this complexity of energy prices, data availability issues and methodological limitations make international comparisons difficult. Some general observations can nevertheless be provided but the information presented below is only indicative.

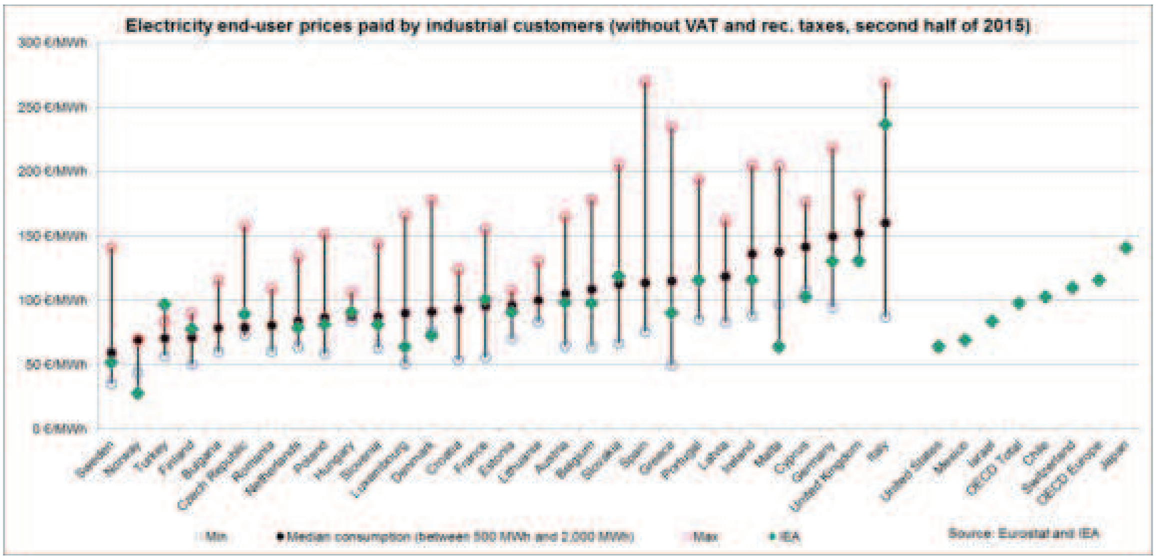

Figure 3.5.20: Electricity end-user prices paid by industrial customers (without VAT and rec. taxes, second half of 2015). Source: European Commission services calculations, based on Eurostat and IEA

End user prices for electricity show 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 while Japanese prices typically exceed European prices.

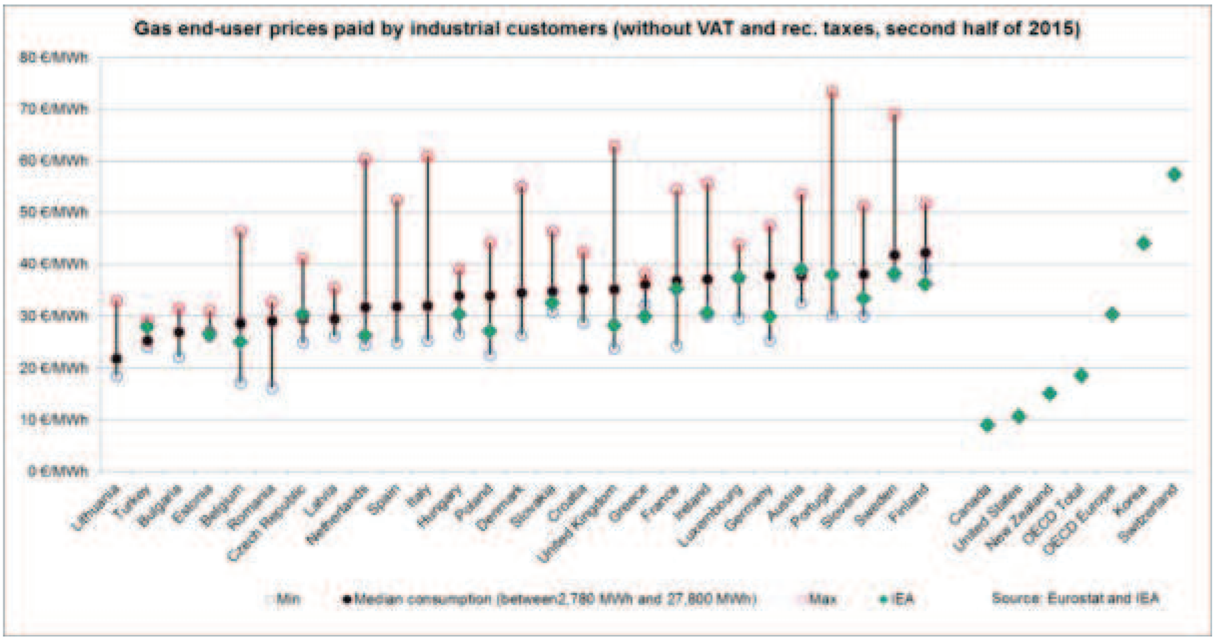

Figure 3.5.21: Gas end-user prices paid by industrial customers (without VAT and rec. taxes, second half of 2015). Source: European Commission services calculations, based on Eurostat and IEA

For gas, there is a much wider range of variation across international competitors, with a six-fold difference between Canadian and Swiss prices. End user gas prices for industrial users in the US and Canada are clearly below the prices paid in any EU Member State. On the other hand, industrial users in Korea and Switzerland typically pay more than their EU counterparts (data for Japan is not available).

3.5.5.4. ENERGY COSTS

RIC3-Real unit energy costs: This indicator measures the amount of money spent on energy needed to obtain one unit of value added in the manufacturing sector (excluding refineries[205]). 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.

Looking at energy prices only is not sufficient to assess its impact, as energy efficiency plays an important role with respect to 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 sector.[206] Results are presented as percentage of value added for the manufacturing sector (excl. refineries).

[205] The refineries are excluded from the real unit energy costs in the manufacturing sector because there is not available a further disaggregation of the costs related to purchased energy into cost for energy carriers as input material to be processed and costs of energy consumed for supporting the manufacturing process. Therefore a potential introduction of refineries in the calculation of the real unit energy costs of manufacturing sector will provide an exaggerated and not realistic cost of energy.

[206] See http://ec.europa.eu/economy_finance/publications/european_economy/2014/pdf/ee1_en.pdf for introduction to the concept of RUEC.

Compared to its main economic partners, the EU manufacturing industry had in 2014 the second lowest RUEC as a percentage of value added (just after the USA). China, Russia and Japan show substantially higher values than the EU. The good performance of the EU is mostly explained by the low levels of energy intensity of the manufacturing sector which has helped to compensate higher real energy prices.[207]

In the EU, the evolution of RUEC for Member States between 2005 and 2014 is in general characterised by an upward trend, especially up to 2011. Afterwards, a slow decline of RUEC can be observed in most of the EU Member States.

Across the EU Member States, the heterogeneity of RUEC 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 2014, the Member States for which the RUEC were the highest were Bulgaria, Cyprus and Belgium. This can be explained by a certain concentration of the industrial sector in energy intensive industries for some of these countries, but also by low performance in terms of energy intensity for the manufacturing sector in general.

At the EU level, RUEC increased by 11.5 % between 2005 and 2014. The increase over the period 2005-2011 was 19.3 % while the decline over 2011-2014 was -6.6 %. The decrease over the latter period was also supported by improved energy efficiency (indicated by lower energy intensity and by the decomposition analysis presented at chapter 3.3).

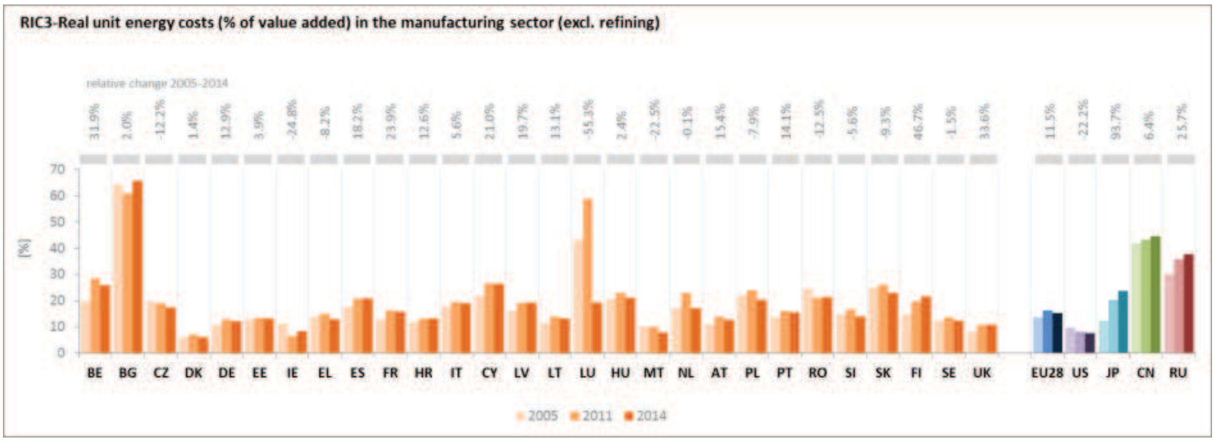

Figure 3.5.22: Real unit energy costs (% of value added) in the manufacturing sector (excl. refining). Source: European Commission DG ECFIN calculations, based on the World Input-Output Database (WIOD)

[207] The RUEC indicator enables to compare the relative importance of energy input over time also by bringing together the value of energy inputs (i.e. unit energy price) and energy intensity (the reciprocal of energy productivity).

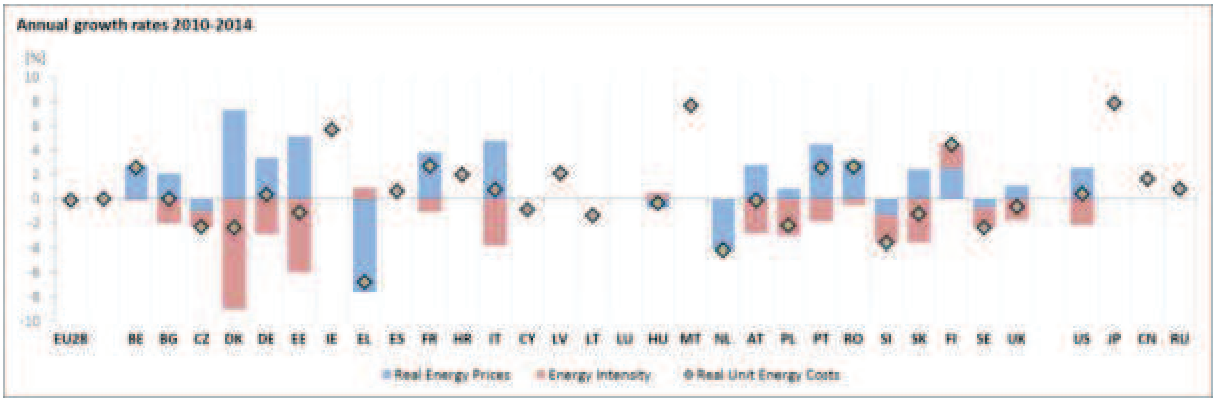

Figure 3.5.23: Contribution to annual growth rate of real unit energy costs 2010-2014 – Manufacturing excl. refining). Source: European Commission DG ECFIN calculations, based on WIOD and JRC

ANNEX 1: DEFINITION AND SOURCES FOR SELECTED INDICATORS

Energy Security, solidarity and trust

- *Net Import dependency (total and by energy carriers):*
  - Definition: Net 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: (imports-exports) / (gross inland consumption +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 to Eurostat database: http://ec.europa.eu/eurostat/data/database
- *Supplier concentration index*
  - Definition: this indicator measures the importance of total imports of main energy carriers to an EU MS from suppliers outside of the European Economic Area (EEA), thus disregarding flows within the EEA area in the volume of imports of a Member State[208]. 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. SCIs will also be lower in a country using a well-balanced source of imports.
  - Source: EC services based on Eurostat data
  - 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
- *Member States' position as regards the N-1 criteria (2015)*
  - Definition: It 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 fails[209]. The indicator is calculated by the Member States. It is the % of total demand that can be

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

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

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.

A fully-integrated internal energy market

- *Interconnection capacity for electricity in 2014*
    - Definition: it is the ratio of electricity interconnection capacity of a given Member State by its total generation capacity.
    - 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: 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.
    - Source: European Commission calculations, based on Platts data
- *Cumulative Market Share Power Capacities, Main Entities*
    - Definition: the combined share from total generation capacity of the electricity generating companies having a share of more than 5 % of national electricity generation.
    - Source: Eurostat
    - Link: http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_market_indicators
- *Cumulative Market Share Power Generation, Main Entities*
    - Definition: the combined market share of the electricity generating companies having a share of more than 5 % of national electricity generation.
    - Source: Eurostat

    Link: http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_market_indicators

- *Market concentration index for wholesale gas supply:*
    - Definition: 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.
    - Source: ACER
    - Used in ACER/CEER monitoring on the internal electricity and gas markets

    - Link: http://www.acer.europa.eu/Media/News/Pages/MMR-Presentation-2015.aspx
- *Cumulative market share of main gas retailers*
    - *Definition:* the combined market share of the gas importers with a market share of 5 % or more.
    - Source: Eurostat
    - Link: http://ec.europa.eu/eurostat/statistics-explained/index.php/Natural_gas_market_indicators
- *Wholesale gas prices*
    - Definition: this indicator presents gas prices as available on wholesale markets. It is the simple average of annual gas prices for a country, based on data and methodology developed in Quarterly report on European gas markets[210].
    - Source: European Commission
    - Used in Quaterly gas markets report
    - Link to quarterly reports: https://ec.europa.eu/energy/en/statistics/market-analysis
- *Wholesale electricity prices:*
    - *Definition:* this indicator presents electricity prices as available on wholesale markets. It is the simple average of annual electricty prices for a country, based on data and methodology developed in Quarterly report on European electricity markets[211].
    - Source: European Commission
    - Used in Quaterly electricity markets report
    - Link to quarterly reports: https://ec.europa.eu/energy/en/statistics/market-analysis
- *Annual switching rates-electricity - household customers:*
    - Definition: this indicator measures the percentage of final electricity consumers changing suppliers in a given year.
    - Source: ACER (from the source at the link below and bilateral communication)
    - Used in *ACER/CEER monitoring on the internal electricity and gas markets*
    - Link: http://www.acer.europa.eu/Media/News/Pages/MMR-Presentation-2015.aspx
- *Annual switching rates - gas - household customers:*
    - Definition: this indicator measures the percentage of final gas consumers changing suppliers in a given year.

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

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

- Source: ACER (from the source at the link below and bilateral communication)
- Used in *ACER/CEER monitoring on the internal electricity and gas markets*
- Link: http://www.acer.europa.eu/Media/News/Pages/MMR-Presentation-2015.aspx

- *Market Performance Indicator of retail gas and electricity services*
  - Definition: Market Performance Indicator' (MPI) is a composite index taking into account four key aspects of consumer experience: the ease of comparing goods or services on offer, consumers' trust in retailers/suppliers to comply with consumer protection rules, problems experienced and the degree to which they have led to complaints and consumer satisfaction (i.e. the extent to which the market lives up to what consumers expect). The four components of the index are weighted equally and the maximum total score is 100.
  - Source: Consumer Market Monitoring Surveys carried out by Directorate-General for Justice and Consumers (DG JUST), European Commission. Available at: http://ec.europa.eu/consumers/consumer_evidence/consumer_scoreboards/market_monitoring/index_en.htm
- *Share of household customers with electricity and gas smart meters*
  - Definition: it is the share of households customers with smart meters in total households supplied by electricity/gas in the country
  - Source: ACER/CEER data, also presented in the ACER Market Monitoring Report 2015. Available at: http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER_Market_Monitoring_Report_2015.pdf
- *Energy affordability*
  - Definition: this indicator is defined as the share of energy related expenditure in total household expenditure for the lowest quintile (i.e. poorest 20 % of population). The indicator is based on the Household Budget Survey (HBS) undertaken by EUROSTAT, for which expenditure data are collected every 5 years.
  - Source: it is based on the ad-hoc data collection exercise undertaken by the Commission with support of Eurostat and Member States' statistical offices. It is an update of the Household Budget Survey organised by Eurostat every 5 years and available in Eurostat database [hbs_str_t223]
- *Harmonised index of consumer prices - electricity, gas and other fuels weight into total household expenditure*
  - Definition: Share of energy products in households' expenditure (transport fuels excluded), as used for the calculation of HICP. HICP are economic indicators that measure the change over time of the prices of consumer goods and services acquired by households. In other words, they are a set

    of consumer price indices (CPI) calculated according to a harmonised approach and a single set of definitions. Undertaken by EUROSTAT.
  - Source: Eurostat [prc_hicp_inw]
- *Inability to keep home adequately warm.*
  - Definition: The share of low income households (those being below 60 % of the median national income) that cannot afford to keep their homes adequately warm.
  - Source: SILC [ilc_mdes01]
  - Link: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_mdes01&lang=en
- *Households electricity prices*
  - Definition: electricity price paid by household consumers in consumption band DC (2 500 kWh < Consumption < 5 000 kWh) in the second half of the year, all taxes and levies included.
  - Source: Eurostat database at [nrg_pc_204]
- *Households gas prices*
  - Definition: gas price paid by household consumers in consumption band D2 (20GJ < Consumption < 200GJ) in the second half of the year, all taxes and levies included.
  - Source: Eurostat database at [nrg_pc_202]
- *Share of taxes in retail electricity prices - households*
  - Definition: the share of taxes and levies from the electricity price paid by household consumers in consumption band DC (2 500 kWh < Consumption < 5 000 kWh) in the second half of the year.
  - Source: Eurostat database at [nrg_pc_204]
- *Share of taxes in retail gas prices - households*
  - Definition: the share of taxes and levies from the gas price paid by household consumers in consumption band D2 (20GJ < Consumption < 200GJ) in the second half of the year.
  - Source: Eurostat database at [nrg_pc_202]
- *Share of fuel related taxes, i.e. for gasoline, diesel and heating oil*
  - It measures the amount of taxes (VAT, excise duty and other indirect taxes), from the consumer price of motor gasoline (Euro-super 95), diesel (automotive gas oil) and heating oil (heating gas oil) respectively
  - Source: Weekly Oil Bulletin, DG Energy, available at: https://ec.europa.eu/energy/en/data-analysis/weekly-oil-bulletin

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 table [nrg_110a], also presented in DG ENER country datasheets released annually at: https://ec.europa.eu/energy/en/statistics/country

- *Final energy consumption:*
  - Definition: total energy consumed by end users, such as households, industry, transport and services. It is the energy which reaches the final consumer's door and excludes that which is used by the energy sector itself.
  - Source: Eurostat database, complete energy balances, annual data [nrg_110a]
- *Primary energy intensity:*
  - Definition: Primary energy intensity is the primary energy consumption per unit of GDP. 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 (as from above). GDP data in euro, chain linked volumes 2010 from Eurostat database [nama_10_gdp]
- *Final energy intensity in industry:*
  - Definition: final energy consumption of industry divided by gross value added for industry and construction sectors.
  - Sources: final energy consumption of industry (Eurostat database [nrg_110a]), gross value added for industry and construction sectors (chain linked volumes 2010): Eurostat database [nama_10_a10].
- *Final energy consumption in industry sector*
  - Definition: The final energy consumed in the industry sector
  - Source: final energy consumption in transport sector from Eurostat database [nrg_110a]
- *Final energy consumption per m2 in residential sector, at normal climate*
  - Definition (as in Odyssee): It is obtained by dividing the energy consumption per dwelling at normal climate, by the average size of dwellings (floor area). Climate normalisation is performed for the energy consumption used for heating only and by the use of heating degree-days (i.e. ratio of actual heating degree days in a year and the mean heating degree-days over a 25 years period).
  - Source: Odyssee project, from the online database at below link and early updates through direct communication between Commission and ENERDATA, technical coordinator of the project. http://www.indicators.odyssee-mure.eu/energy-efficiency-database.html
- *Final energy consumption of households as per capita.*
  - Definition: it is the final energy consumption of the residential sector divided to the population of the country
  - Source: Eurostat database, final energy consumption of households from [nrg_110a] and total population in the country at 1st January from [demo_pjan]
- *Final energy consumption in household sector*
  - Definition: The final energy consumed in the household sector
  - Source: final energy consumption in transport sector from Eurostat database [nrg_110a]
- *Final energy consumption in transport sector*

- Definition: The final energy consumed in the transport sector
- Source: final energy consumption in transport sector from Eurostat database [nrg_110a]

- *Share of collective land transport in all passengers' transport means*
  - Definition: it is the share of trains, motor coaches, buses and trolley buses in total passenger transport
  - Source: Eurostat database, modal split of passenger transport [tran_hv_psmod]
- *Final energy intensity in services sector*
  - Definition: final energy consumption in services sector divided by gross value added for services related sectors
  - Sources: final energy consumption of services (Eurostat database [nrg_110a]), gross value added for services sectors (chain linked volumes 2010), as the sum of the NACE codes G to U: Eurostat database [nama_10_a10].
- *Final energy consumption in services sector*
  - Definition: The final energy consumed in the services sector
  - Source: final energy consumption in transport sector from Eurostat database [nrg_110a]

Decarbonisation

- *Greenhouse gas emissions reductions (base year 1990)*
  - Definition: The Greenhouse gas emissions are calculates as the sum of the total GHG emissions (without LULUCF and with indirect CO2 emissions) and the CO2 emissions of international aviation. The GHG emission reduction is calculated as the difference between GHG emissions in the given year and in the base year 1990 , divided to GHG emissions in the base year 1990
  - Source: EEA/UNFCCC carbon inventories, i.e. Total (without LULUCF, with indirect CO2) and 1.D.1.a - International Aviation. It is also available at the EEA data viewer from: http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer
- *Gap between greenhouse gas emissions projections and target in 2020 in the effort sharing sectors*
  - Definition: This indicator monitors progress of each Member State towards its EU 2020 GHG emission target in the Effort sharing sectors. The projections for the year 2020 in the effort sharing 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).
  - Source: EEA, European Commission
  - Used in Climate Action Progress Report
  - Link:http://ec.europa.eu/clima/policies/strategies/progress/documentation_en.htm

- *Gap between latest (proxy) inventory of Effort Sharing emissions and interim targets*
  - Definition: This indicator measures the gap between the latest approximated inventory emissions available[212] and its respective effort sharing target expressed as a percentage of base year emissions (2005).
  - Source: EEA, European Commission
  - Used in Climate Action Progress Report
  - Link:http://ec.europa.eu/clima/policies/strategies/progress/documentation_en.htm
- *Greenhouse gas intensity of the economy*
  - Definition: this indicator represents Member States' emissions relative to Gross Domestic Product. A lower value indicates that a particular economy is less carbon intensive.
  - 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*
  - Definition: The greenhouse gas emission level per capita is the ratio of the greenhouse gas emissions to population.
  - 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
- *Land Use, Land-Use Change and Forestry (LULUCF) emissions*
  - Definition: it represents the emissions and removals (mainly CO_2) from agricultural land use and forestry (LULUCF)
  - Source: EEA/UNFCCC carbon inventories, i.e. code 4 - Land Use, Land-Use Change and Forestry (and sub-divisions). It is also available at the EEA data viewer from: http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer
- *Average CO_2 emissions of new passenger cars*
  - Definition: This indicator measures the average CO2 emissions from new passengers cars sold in a country in a given year, in order to observe progress towards 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.
  - Source: European Environment Agency

[212] Based on 2015 proxies provided by Member States under article 8 of Regulation 525/2013 or estimated by European Environmental Agency on behalf of the Commission, where needed.

- Used in: EEA publications: Monitoring CO_2 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
- *Share of ETS in total GHG emissions*
  - Definition: Is the share of an "artificial total" GHG emissions (without LULUCF, with indirect CO2) - NF3 - CO2 emissions from domestic aviation (MS inventories extracted by EEA)
  - 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
- *GHG intensity of power & heat generation*
  - Definition: it is the ratio between GHG emissions related to public electricity and heat production and the gross electricity and heat generation.
  - Sources: EEA/UNFCCC carbon inventories, i.e. code 1.A.1.a - Public Electricity and Heat Production and Eurostat database tables [nrg_105a] and [nrg_106a]
- *Share of renewable energy in gross final energy consumption*
  - Definition: this indicator monitors progress towards renewable energy developments as it is defined and statistically collected by Eurostat under the Renewable Energy Directive[213].
  - Source: Eurostat
  - Used in SHARES tool
  - Link: http://ec.europa.eu/eurostat/web/energy/data/shares
- *Renewable energy share in transport (RES-T).*
  - Definition: This indicator monitors the progress of final consumption of energy from renewable sources in transport as it is defined and statistically collected by Eurostat under the Renewable Energy Directive[214].
  - Source: Eurostat
  - Used in SHARES tool
  - Link: http://ec.europa.eu/eurostat/web/energy/data/shares
- *Renewable electricity share (RES-E).*
  - Definition: This indicator monitors the progress of gross final consumption of electricity from renewable energy sources as it is defined

[213] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources. The Renewable energy shares in gross final energy consumption is available at: http://ec.europa.eu/eurostat/web/energy/data/shares

[214] Idem 213

and statistically collected by Eurostat under the Renewable Energy Directive[215].
    - Source: Eurostat
    - Used in SHARES tool
    - Link: http://ec.europa.eu/eurostat/web/energy/data/shares
- *Renewable energy for heating & cooling (RES-H&C).*
    - Definition: This indicator monitors the progress of gross final consumption of energy from renewable sources for heating and cooling as it is defined and statistically collected by Eurostat under the Renewable Energy Directive[216].
    - Source: Eurostat
    - Used in SHARES tool
    - Link: http://ec.europa.eu/eurostat/web/energy/data/shares
- *Fossil fuel avoidance by renewable energy*
    - Definition: This indicator is based on the EEA estimates assuming that the growth in renewable energy since 2005 has substituted for an equivalent amount of energy that would have been supplied by other sources. The estimated amount of avoided fossil fuels is represented as share of gross inland consumption.
    - Source: EEA (for the estimate of fossil fuels avoided), EUROSTAT (for gross inland consumption)
    - The method is described in detail in the 2015 EEA report Renewable energy in Europe — approximated recent growth and knock-on effects
    - Link: http://ec.europa.eu/eurostat/web/energy/data/shares
- *GHG avoided emissions due to renewable energy*
    - Definition: This indicator estimates the avoided GHG emissions due to the fossil fuel substitution by renewable energy[217]. The estimated GHG emissions avoided due to renewables are represented as share of total GHG emissions (with indirect CO2, without LULUCF).
    - Source: EEA
    - The method is described in detail in the 2015 EEA report Renewable energy in Europe — approximated recent growth and knock-on effects
    - Link: http://ec.europa.eu/eurostat/web/energy/data/shares

Research, innovation and competitiveness

- *Public spending on Energy Union R&I priorities as share of GDP:*
    - Definition: it is the share in the GDP of public spending on the Energy Union R&I priorities.

[215] Idem 213
[216] Idem 213
[217] The method is described in detail in the 2015 EEA report *Renewable energy in Europe — approximated recent growth and knock-on effects*

- Source: JRC/SETIS, based on IEA for national R&I expenditure data provided by the SET-Plan Steering Group; and Eurostat for the GDP [nama_10_gdp]

- *Public investments on Energy Union R&I priorities in total public civil R&I spending:*
  - Definition: The share of public spending on the Energy Union R&I priorities in total public R&I spending in civil research-GBAORD (therefore excluding military public R&D spending).
- Source: JRC/SETIS, based on IEA for national R&I expenditure and data provided by the SET-Plan Steering Group; and Eurostat database for the total GBAORD by NABS 2007 socio-economic objectives [gba_nabsfin07]
- *Total (public and private) investments in Energy Union R&I priorities as a share of GDP.*
  - Definition: it is the share in the GDP of the sum of the public and private R&D investments in Energy Union R&I priorities
  - *Source:* JRC/SETIS based on IEA for national R&I expenditure and data provided by the SET-Plan Steering Group; Eurostat for the GDP [nama_10_gdp] and JRC/SETIS calculations for private investment estimates, see Annex 2.
- *Patents on Energy Union priorities (patents per million habitants):*
  - Definition: it represents the number of patents on Energy Union R&I priorities divided by total population.
  - Source: JRC/SETIS based on EPO/PATSTAT for patent data and Eurostat for total population [demo_pjan]
- *Levelised costs of electricity*
  - Definition: The LCOE of a given technology is the ratio of lifetime costs to lifetime electricity generation, both of which are discounted back to a common year using a discount rate that reflects the average cost of capital. The considered WACC (weighted average capital cost) for OECD countries and China is 8.5 % and 10 % for the rest of the world. More information on the methodology for the LCOE figures presented in this SWD is available at: http://dashboard.irena.org/download/Methodology.pdf
  - Source: International Renewable Energy Association – IRENA, available at http://resourceirena.org/gateway/dashboard/
- *Turnover in the renewables energy sector*
  - Definition: it measures the turnover in the renewable energy sector.
  - Source: Eurobserv'er barometers available at: http://www.eurobserv-er.org/
- *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 in the manufacturing sector (excluding refineries) as % of value added:*
  - 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 – DG ECFIN
  - 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
- *Progress in Cohesion Policy investments supporting the Energy Union:*
  - Definition: This indicator, to be provided from end 2017 onwards, divides the amount of ERDF and CF allocations allocated to specific projects by the end of each year 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/

ANNEX 2: NOTE ON METHODOLOGY USED FOR THE R&I INVESTMENTS AND PATENTS

Overview of topics under each of the Energy Union R&I Priorities

No1 in Renewables	Solar energy (photovoltaics, solar heating and cooling, concentrated solar power); wind energy, ocean energy (tidal, wave, salinity gradient power); geothermal energy; hydroelectricity
Smart system (Smart EU energy system with consumers at the centre)	Residential and commercial building appliances and equipment; energy management systems (incl. smart meters) and ICT; lighting technologies and control systems; heating, cooling and ventilation technologies; electric power generation; combustion technologies, coal, oil and gas; electricity transmission and distribution; grid communication, control systems and integration; energy storage (non-transport applications); batteries and other electrochemical storage (excl. vehicles); thermal, electromagnetic and mechanical storage; energy system analysis.
Efficient energy systems	Residential and commercial building design and envelope; building integration of renewables; waste heat recovery and utilisation; heat pumps and chillers; industrial techniques and processes, equipment and systems for energy efficiency.
Sustainable transport	Biofuel production and use; hydrogen technology and fuel cell technology; vehicle batteries/storage technologies; advanced power electronics; motors and EV/HEV/FCV systems and combustion engines; electric vehicle infrastructure.
CCUS	CO2 capture, transport, utilisation and storage
Nuclear safety	Nuclear fission reactors, fuel cycle, waste management, plant safety and integrity, environmental protection, decommissioning. Nuclear fusion.

Public (national) R&I investments

The IEA statistics[218] are the main source of data for national R&I investments. They address 20 of the EU Member States with varying regularity and granularity of technology detail. There is a 2-year time delay in reporting for most Member States. Data gaps are supplemented by the Member States through the SET-Plan Steering Group and

[218] The methodology in described in detail in the JRC Science for Policy Report "Monitoring R&I in Low Carbon Energy Technologies: Methodology for the R&I indicators in the State of the Energy Union Report, - 2016 Edition".

through targeted data mining. Where data are not available, estimates are provided by JRC/SETIS based on the correlation of macroeconomic indicators such as GBAORD and/or GDP.

Private R&I investments[219]

Calculated by JRC/SETIS, based on financial data from public company statements and patent data from PATSTAT[220]. A complete PATSTAT dataset is only available with a 3.5-year delay. Thus complete data series for the assessment of indicators have a 4-year delay. Estimates with a 2-year lag can be made at EU28 level only.

Trends in patents

Data originate from PATSTAT[221]. A full dataset for a given year is completed with a 3.5-year delay. Thus, detailed data used for the assessment of indicators have a 4-year delay. Estimates with a 2-year lag are provided at EU28 level only. The data specifically address advances in the area of low carbon energy and climate mitigation technologies (Y-code of the Cooperative Patent Classification[222]). Datasets are processed by JRC/SETIS to eliminate errors and inconsistencies. Patent statistics are based on the priority date, simple patent families and fractional counts of submissions made both to national and international authorities to avoid multiple counting of patents.

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[219] Fiorini et al., Estimation of corporate R&D investment in Low-Carbon Energy Technologies: a methodological approach. R&D Management Conference 2016 "From Science to Society: Innovation and Value Creation" 3-6 July 2016, Cambridge, UK

[220] Idem 171

[221] Idem 171

[222] EPO and USPTO, *Cooperative Patent Classification (CPC).* Available from: http://www.cooperativepatentclassification.org/index.html