European Commission

JRC SCIENCE FOR POLICY REPORT

# Mitigating Climate Change: Renewables in the EU

*Cutting greenhouse gas emission through renewables – Volume 2*

Banja M., Monforti-Ferrario F., Bódis K., Kona A., Jäger-Waldau A., Taylor N., Dallemand J.F.

2017

Joint Research Centre

EUR 28677 EN

**Contact information**
Name: Manjola Banja
Address: European Commission, Joint Research Centre, Directorate C - Energy, Transport and Climate,
Via Enrico Fermi, 2749, Ispra 21027, Italy
Email: Manjola.Banja@ec.europa.eu
Tel.: +390332783992

**JRC Science Hub**
https://ec.europa.eu/jrc

JRC106826

EUR 28677 EN

| | | | |
|---|---|---|---|
| PDF | ISBN 978-92-79-70479-6 | ISSN 1831-9424 | doi:10.2760/6520 |
| Print | ISBN 978-92-79-70478-9 | ISSN 1018-5593 | doi:10.2760/722355 |

Luxembourg: Publications Office of the European Union, 2017



How to cite this report: Banja M,, Monforti- Ferrario F., Bódis K., Kona A., Jäger-Waldau A., Taylor N., Dallemand J.F., *Mitigating Climate Change: Renewables in the EU – Cutting greenhouse gas emissions through renewables - Volume 2*, EUR 28677 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-70479-6, doi:10.2760/6520, JRC106826



**Mitigating Climate Change: Renewables in the EU – Cutting greenhouse gas emissions through renewables - Volume 2**

The energy sector accounts for the lion's share (55 %) of greenhouse gas emissions in the European Union (EU). While EU emissions had fallen by 22.1 % in 2015 compared with 1990, and continue to fall, the bloc's economy grew by 27 % over that period. Since the Renewable Energy Directive (RED) entered into force, use of renewables has continued to grow in the 3 EU sectors that consume most energy (electricity, heating/ cooling and transport). This has done much to cut emissions. While the renewable share in gross final energy consumption rose from 12.4 % in 2009 to almost 17 % in 2015, the EU GHG emissions savings through renewables rose year-on-year by an annual average of 9 %. Fossil fuels are increasingly being displaced by renewables. The displacement between 1990 and 2015 amounted to 139 Mtoe equal to 11.5 % of the gross inland consumption of fossil fuels. The electricity sector accounted for almost 40 % of this displacement, with rapidly growing new technologies such as wind and photovoltaics accounting for almost 18 % of total fossil fuel displacement. Without renewable energy sources, total emissions in the EU would have been 8.7 % higher in 2009, 13.8 % higher in 2014 and 14.4 % higher in 2015.
This report represents an integrated analysis and provides:
(i) a concise overview of carbon dioxide ($CO_2$ ) and aggregated emissions (in both the ETS and the ESD sectors), including recent trends in the EU as a whole, and in individual EU countries;
(ii) an assessment of the role played by renewables in mitigating climate change in the EU and individual countries between 2009 and 2014; and
(iii) a proxy estimate of emissions savings through the use of renewables in 2015.

# Contents

## Acknowledgements

This report is the work of the Energy Efficiency and Renewables Unit (C.2), Directorate C — Energy, Transport and Climate, Joint Research Centre (JRC), European Commission. It is part of the RE-PORT work package on 'Monitoring Actual and Foreseeable Renewable Energy Deployment'.

The report uses established database data from EU countries' reporting under the Renewable Energy Directive, complemented with Eurostat SHARES Tool data. The data are available for downloading.

Manjola Banja (C.2) and Fabio Monforti-Ferrario (Air and Climate Unit, C.5) led the work to maintain the renewable energy database used in this report and keep it updated.

Manjola Banja coordinated and co-authored this report, leading the analysis of: (i) greenhouse emissions trends; (ii) the role of renewables in emissions reduction; (iii) proxy estimates of emissions savings through use of renewable energy sources (RES).

Fabio Monforti—Ferrario reviewed and improved the report. Katalin Bódis (C.2) performed the GIS mapping of energy and climate indicators in the EU and the data extraction for the EUCO27 energy scenario, and organised them in an appropriate output form for subsequent use. Albana Kona (C.2) contributed to the section on trends in and projections of greenhouse emissions in EU cities.

The report also benefited from the contribution of the following co-authors from the Energy Efficiency and Renewables Unit, who mainly helped by improving the report: Arnulf Jäger-Waldau, Nigel Taylor and Jean-François Dallemand.

The authors would like to acknowledge the contribution of Heinz Ossenbrink, Former European Commission, JRC and Former Head of Energy Efficiency and Renewables Unit (C.2), on reviewing specific parts of this report.

The authors are thankful to Owen Stafford, Fiona Graham and Mark Prescott from DGT for final editing of this report.

# Executive Summary

## *Policy context*

The EU is consolidating its transition to a low-carbon economy through a wide range of interacting policies and instruments. In October 2014, the European Council agreed the EU's 2030 climate and energy policy framework [1], which sets these targets:

- an ambitious economy-wide domestic target: greenhouse gas emissions down by at least 40 % by 2030 (compared with 1990)
- a binding EU-level target: renewables to account for at least 27 % of gross final energy consumption by 2030
- an indicative EU-level target: energy efficiency to be improved by at least 27 % by 2030, compared with projections of future energy consumption.

On 30 November 2016, the Commission proposed a package of measures [2] to keep the EU competitive as global energy markets change in the wake of the clean energy transition.

## *Key conclusions*

In 2015, the EU accounted for about 10 % of $CO_2$ emissions worldwide. The EU has joined 153 countries in promising to curb carbon dioxide and other greenhouse gas emissions, developing other ways to mitigate impact and make communities more resilient to climate change. It has committed itself to a target of cutting domestic emissions by at least 40 % of 1990 levels by 2030. Emission reductions are now approaching the 2020 target. Renewables offer great potential as part of the portfolio of measures to mitigate climate change. Increasing their share of gross final energy consumption is one of the EU's main options for reducing greenhouse gas emissions in the energy system.

Fossil fuels in the EU are being displaced by renewable energy sources (RES). Between 1990 and 2015, RES displaced 139 Mtoe[1], equivalent to 11.5 % of the gross inland consumption of fossil fuels. The electricity sector accounted for nearly 40 % of total fossil fuel displacement, making the largest contribution to mitigating climate change in the EU; the main reason for this was the rapid penetration of new technologies, such as wind energy and photovoltaics. The contribution of these 2 technologies accounted to almost 18 % of the total fossil fuels displaced in the EU between 1990 and 2015 through the use of renewables.

Setting a target of cutting emissions by 20 % in the run-up to 2020 has driven an increase in the share of renewables in the EU, from almost 9 % in the baseline year to 12.4 % in 2009, and to 16.7 % in 2015. Greenhouse gas emission savings through renewables over this period increased each year by an average of 9 %. In 2015, the electricity and the heating/cooling sectors accounted for over 92 % of the gross final energy consumed in the EU, bringing their contribution to total EU emissions savings through the use of renewables to 96 %. Without renewables, total EU emissions would have been 8.7 % higher by 2009, 13.8 % higher by 2014 and 14.4 % higher by 2015.

## *Main findings*

***If fossil fuel prices remain low for a long time then progress with developing renewables could be weakened. The deployment of renewables by reducing the demand for fossil fuels can result in a price response of fossil fuels that in turns can affect their further penetration increasing the need for a higher financial support. Renewable energy sources will have to displace fossil fuels to a much greater extent in the upcoming years.***

Prices of all fossil fuels (most notably oil) have declined after 2008. European wholesale electricity prices peaked in the third quarter of 2008 and, apart from a slight recovery in 2011, have been falling ever since. Prices have fallen by almost 70 % since 2008 and by 55 % since 2011; in 2016 they reached levels not experienced in the last 12 years. Investment on renewables saw the largest expansion around 2010-2011, at 80% above the 2005 figure. Because of energy and environmental protection policies fossil fuels are replaced in the EU by growing consumption of energy from renewable sources. Between 1990 and 2015, renewables displaced 139 Mtoe - 11.5 % of the gross inland consumption of fossil fuels. However, renewables still account for only a small share (almost 14 %) of gross domestic energy consumption in the EU. Overall, consumption is still dominated by fossil fuels — 34.4 % for oil, 22 % for gas and 16 % for solid fuels (coal and lignite).

---

([1]) The renewables are kept at their 1990 level

***Currently hard coal and lignite jointly provide over a quarter of electricity generated in the EU. There is a disparity between EU countries in their approach towards the future role of coal.***

Some EU countries have significantly decreased their power production from coal in recent years and announced phasing out coal completely in the coming 10-15 years (e.g. the UK, Finland, France), others are building or planning to build new coal-fired power plants (e.g. Poland and Greece). In Germany and the UK, the production of hard coal fell between 1990 and 2015 by a factor larger than 10; in Poland this drop was with a factor just above 2.

***The rapid deployment of renewables in the electricity sector brought the largest displacement of fossil fuels in the EU. The gradual displacement of gas by renewables accounts for the near flat lining of greenhouse emissions in the EU over the last 2 years.***

Fossil fuels displaced in the electricity sector account for nearly 40 % of all fossil fuels displaced through the increasing use of renewables. Until 2008, solid fuels for energy generation were displaced mainly by gas. The rapid rise of the competition with renewables after 2009 and the environmental constrains shifted displacement from coal towards gas, especially after 2011 when the gas prices saw a larger fall comparing with coal prices. Due to this factors gas was displaced 3 times faster than solid fuels between 2008 and 2015. The slight increase of coal prices after 2015 has improved the price ratio between gas and coal, decreasing the competitive disadvantage of gas compared to coal.

***Although the rate of EU greenhouse emissions reduction slowed down slightly in 2015, emissions were below the 20 % reduction target anyway. Although Effort Sharing Decision (ESD) emissions in the EU rose by 1.7 % between 2005 and 2015, they remained below the 2015 ESD target. Malta was the only EU country to miss its 2015 ESD target.***

While global $CO_2$ emissions have nearly stopped rising since 2014, EU emissions rose by 1.35 % in 2015. After EU greenhouse emissions fell to the lowest level ever in 2014 (23 % below 1990 levels), they rose slightly in 2015 by 0.7 % over the previous year. The EU's Effort Sharing Decision (ESD) emissions remained below the target for 2015 (an 11.5 % reduction) and also below projections for that year. Malta's ESD emissions were 18 % above its 2015 target.

***Between 2005 and 2015, energy from renewable sources almost doubled its overall share of energy in the EU. On this basis the proposed EU 2030 binding target - that renewable energy sources should account for at least 27 % of overall energy sources in gross final energy consumption – looks achievable. A majority of EU countries are on track to meet their 2020 target for renewables as a proportion of overall energy sources.***

According to reports issued by the EU countries in March 2017, the share of renewables in gross final energy consumption in the EU reached at 16.7 % in 2015. Energy from renewable sources contributed 18.6 % to heating/cooling, 28.8 % to electricity and 6.7 % to the transport sector.

***Since the entry into force of the Renewable Energy Directive, renewables have already made a major contribution to reducing greenhouse emissions: in 2014, total EU emissions would otherwise have been 13.8 % higher. This contribution varied from country to country, depending on the technologies in use.***

By 2014, emissions with a warming potential equivalent to 709 Mt $CO_2$-eq. were saved for the EU as a whole through the use of renewables. Aggregated savings of greenhouse emissions through the use of renewables in the EU increased by over 50 % compared with 2009. Over the same period the use of renewables increased apace, but accounting for half of the increase in emissions savings. By 2015, the emissions saved through the use of renewables were estimated at 751 Mt $CO_2$-eq., accounting for 14.4 % of the overall reduction in total emissions that year.

***Decarbonising the energy sector by deploying energy from renewable sources is part of the EU's climate change mitigation strategy. Renewables are already helping to significantly cut emissions in the power and heat sectors. In 2014, these emissions would have been 38.5 % higher without use of renewables.***

Energy use (including transport) accounted for 78 % of the EU's total annual greenhouse emissions in 2015. Power and central heat production are responsible for at least a third of emissions, followed by transport. We estimate that emissions savings achieved in both the electricity and the heating/cooling sectors by using renewables cut emissions from power and heat generation by 40.2 % in 2015.

***Electricity plays a key role in EU greenhouse emissions savings. It accounted for over two thirds of total emissions saved through renewables in 2015. Savings in this sector increased much faster than in others, by an average of 8.7 % every year since 2009.***

Greenhouse emissions saved through the use of electricity generated from renewable sources in the EU came to 461 Mt $CO_2$-eq**.** in 2014 - almost twice the savings in 2009. Year-on-year fluctuation of these savings saw the largest increase over 2010-2011 and the lowest over 2012-2013. Greenhouse emissions of 215 Mt $CO_2$-eq was saved in the heating/cooling sector, representing an increase at an average yearly rate of 1.3 % from 2009. The use of biofuels in the EU transport sector enabled emissions of 32.3 Mt $CO_2$ –eq. to be saved in 2014, representing an increase at an average rate of 4.8 % since 2009.

***Germany's use of renewables contributed most to the total emissions savings made in the EU through renewables. In about 16 countries, over half of emissions savings are made thanks to electricity generated from renewable resources.***

Over 22 % of total EU greenhouse emissions were generated through the use of renewables in Germany. Germany's absolute share of savings was 154 Mt $CO_2$-eq in 2014. Relatively speaking, Italy made the second largest contribution, followed by France, Romania and the UK. Renewable electricity dominated in about 16 EU countries (Austria, Belgium, Croatia, the Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Romania, Slovakia, Spain, and the UK).

## *Related and future JRC work*

This 2017 report reflects the changes in EU countries' methods for calculating greenhouse emissions savings through the use of renewables. It updates the results set out in the previous JRC publication on this matter, [14]. The report complements the set of recent JRC reports [8], [9], [10], [11], [12], [13], [14], [15] and [16] on the deployment and impact of renewables. Future updates will be based on Member State progress reports on the development of renewable energy sources in line with the requirements of the 2009 Renewable Energy Directive [17].

## *Quick guide*

The ***first part*** of this report outlines recent trends in the EU's progress towards its '20-20-20' targets. It gives an overview of recent trends in $CO_2$, total greenhouse emissions, Effort Sharing Decision (ESD) emissions and EU Emissions Trading Scheme (ETS) emissions. This section also covers EU emissions targets and projections up to 2030, based on the latest publications from the European Environment Agency [4] and the EUCO27 scenario [5]. Recent trends in the deployment of renewables in the EU are also presented. The ***second part*** introduces EU emissions savings thanks to renewables. The analysis is based on aggregate emissions savings as reported by EU countries in their biennial progress reports [6]. This section also includes an analysis of the contribution to the EU total, over the same period, of emissions savings thanks to renewables, using data from European Environment Agency sources as a benchmark. A short description of some EU energy system indicators in provided here. The estimates of the displacement of fossil fuels in the electricity, heating/cooling and transport sectors by renewables are presented in this part of the report. The ***third part*** outlines recent developments by individual EU countries towards climate and renewables targets and the role these countries play in the overall picture of EU emissions savings achieved through the use of renewables. The ***annex*** to the report covers the methods EU countries use to calculate emissions savings due to renewables in 3 main sectors: electricity, heating/cooling and transport, as reported in the 3 sets of biennial Member State progress reports.

## *Data sources*

Since 2011, JRC has kept a database of EU Member State reporting under the Renewable Energy Directive, sourced by **national renewable energy action plans (NREAPs)** [7] and **biennial progress reports**. JRC updated this database in 2016 following the release of the 2013-2014 progress reports, due for end-2015 but actually completed in mid-2016. This database also includes the updates and the latest figures that Member States prepare in their reporting to Eurostat through the SHARES Tool[2]. As the NREAPs are now outdated for some Member States, this report makes use of renewable energy deployment projections sourced from the EU reference

---

([2]) The EU Member States reporting to Eurostat SHARES Tool includes the figures for renewable energy deployment, updated every year since 2004. This report is sourced from the updated data reported by EU Member States to the Eurostat SHARES Tool in March 2017.

scenario 2016[3] and EUCO27 scenario[4] to complement the picture for 2020. The report makes use of data on **$CO_2$ emissions** sourced by the online JRC Emission Database for Global Atmospheric Research (EDGAR)[5]. This database provides global past and present day anthropogenic emissions of greenhouse gases and air pollutants by country and on spatial grid. As a benchmark, the report included data on **GHG emissions** in the EU, taken from Eurostat[6] and European Environment Agency sources [4].

### *Data publishing and visualization*

The JRC renewable energy database is easily accessible to the public through the Data Portal[7] for NREAPs and progress reports. This data portal is an interactive tool for comparing the renewable energy data provided by each EU Member State as required under the RED. The report can be explored through the dedicated visualisation[8] visiting the EU Science Hub[9].

(3) EU Reference Scenario 2016 https://ec.europa.eu/energy/en/data-analysis/energy-modelling
(4) EUCO scenarios: https://ec.europa.eu/energy/en/data-analysis/energy-modelling
(5) JRC EDGAR https://ec.europa.eu/jrc/en/scientific-tool/emissions-database-global-atmospheric-research
(6) Eurostat, http://ec.europa.eu/eurostat/web/environment/air-emissions-inventories/database (last access July 2017)
(7) NREAPs and progress reports Data Portal - https://ec.europa.eu/jrc/en/scientific-tool/nreap-data-portal
(8) Banja M,, Monforti- Ferrario F., Bódis K., Kona A., Jäger-Waldau A., Taylor N., Dallemand J.F., Mitigating Climate Change: Renewables in the EU – Cutting greenhouse gas emissions through renewables - Volume 2, EUR 28677 EN https://visualise.jrc.ec.europa.eu/t/NREAPs/views/GHGreport2017_visualisation/Story1?:embed=y&:showShareOptions=true&:display_count=no&:showVizHome=no
(9) EU Science Hub https://ec.europa.eu/jrc/en/publications

# 1. Introduction

2015 was a milestone for climate action, with the negotiation at the 21st Conference of the Parties (COP 21) [18] in December of the **Paris Agreement on climate change**. The Paris Agreement is the first international climate agreement extending mitigation obligations to all countries, both developed and developing.

The Agreement notably includes the collective aim to hold 'the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C' [19]. To achieve this, the Parties aim to reach a global peaking of GHG emissions as soon as possible, and to undertake rapid reductions thereafter 'so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of GHGs in the second half of this century'.

With the energy sector accounting for approximately two thirds of global greenhouse gas (GHG) emissions, action in this sector can make or break efforts to achieve global climate goals. Traditionally, industrialised countries have emitted by far most anthropogenic greenhouse gases. More recently, developing country emissions have exceeded those of industrialised countries and have kept rising very rapidly. A move towards a low-carbon world will require mitigation efforts by all the world's countries: decarbonising the energy supplies of industrialised countries, and shifting developing countries onto a low-carbon development path [20].

So far, 153 countries[10], representing 67 % of global emissions [21], have ratified or otherwise joined the Paris Agreement. Several major economies, including Canada, Germany and Mexico, have also developed long-term plans to decarbonise their economies.

Accordingly, the European Union has adopted ambitious goals to move toward a low-carbon economy and fully integrated energy markets. The European Commission has already made key proposals to implement the EU's target to reduce greenhouse gas emissions by 2030. In July 2015 it presented a legislative proposal to revise the EU **Emissions Trading Scheme (ETS)** for its next phase (2021-2030), in line with the EU's 2030 climate and energy policy framework. The proposal is designed to cut emissions covered by the ETS by 43 % compared with 2005 [22]. In the summer of 2016, the Commission brought forward proposals to accelerate the low-carbon transition in the key sectors of the European economy not covered by the ETS [23].

For 2050, EU leaders have endorsed the objective of reducing Europe's emissions by 80-95 % compared with 1990 levels, as part of similar joint efforts by developed countries [24]. While we are still some way from discussing specific targets for renewable energy sources, ambitious targets for reducing greenhouse emissions must be reflected in a truly consistent role for renewables.

The main policy instruments to achieve these targets are the ETS [25] and the Effort Sharing Decision (ESD) [26]. The ETS sets a single EU-wide cap for over 11 000 power stations and industrial plants and for the aviation industry. It enables them to trade emission allowances among themselves. The cap shrinks each year, the aim being to cut emissions by 21 % between 2005 and 2020.

The **Effort Sharing Decision (ESD)** sets binding annual greenhouse emissions targets for EU countries in sectors not covered by the ETS. National targets for these sectors (transport, buildings, agriculture, waste, etc) vary from a 20 % cut to a 20 % rise in emissions by 2020, reflecting differences in starting points and wealth. Less wealthy economies are allowed to increase emissions to accommodate higher economic growth. Their targets still limit emissions compared with business-as-usual scenarios; hence all EU countries are committed to reduction efforts.

By 2020, national targets should help cut non-ETS emissions throughout the EU by 10 %, compared with 2005. Together, the ETS and the Effort Sharing Decision are designed to reduce overall emissions to about 14 % below 2005 levels by 2020. In addition to these overarching instruments, the EU has an array of policy tools to tackle emissions from specific sectors and activities.

Use of renewables EU-wide reached nearly 17 % in 2015, meaning the EU is on track for its target of 20 % by 2020. Renewables are key to meeting the commitment to decarbonise the EU

(10) On 1 June 2017 the United States announced that it would cease all participation in the 2015 Paris Agreement on climate change mitigation. Under Article 28 of the Paris Agreement, the earliest possible date on which the US can withdraw is 4 November 2020; 4 years after the Agreement came into effect. Until the withdrawal takes effect, the US may be obliged to maintain its commitments under the Agreement, including the requirement to continue reporting its emissions to the UN.

economy, provided for in the EU Climate and Energy Package [27]. This is why the Renewable Energy Directive sets a legally binding target that 20 % of gross final energy consumption (GFEC) must come from renewables by 2020. Moreover, in October 2014 the Commission proposed a climate and energy policy framework for 2030 [28] that includes a target of reducing emissions to 40 % below 1990 levels and increasing the proportion of renewables in the EU's energy consumption to at least 27 %.

The Commission closely monitors the deployment of renewable energy in the EU on the basis of the progress reports submitted every 2 years by EU countries. This report offers a combined analysis of member countries' 2011, 2013 and 2015 progress reports, thus identifying trends in emissions savings through the final consumption of energy from renewable sources in the EU in 3 main sectors: electricity; heating/cooling and transport.

**Box 1. The EU Emissions Trading System (ETS)**

The ETS is the cornerstone of the EU's drive to cut its emissions of manmade greenhouse gases, which are largely responsible for warming the planet and causing climate change. The system works by putting a limit on overall emissions from covered installations which is reduced each year. Within this limit, companies can buy and sell emission allowances as needed. This **'cap-and-trade' approach** gives companies the flexibility they need to cut their emissions in the most cost-effective way.

The ETS covers approximately 11 000 power stations and manufacturing plants in the 28 EU countries and Iceland, Liechtenstein and Norway, plus aviation activities in these countries. In total, around 45 % of total EU greenhouse emissions are regulated by the ETS. The ETS remains the world's biggest emissions trading market, accounting for over three quarters of international carbon trading. It continues to inspire the development of other national or regional systems. Europe is looking to link the ETS with compatible schemes in other countries. In July 2015, the Commission presented a legislative proposal on revising the ETS for its next phase (2021-2030), in line with the EU's 2030 climate and energy policy framework. The proposal aims to reduce ETS emissions by 43 % compared to 2005.

**ETS: Development in phases**

**2005-2007:** 1st trading period was 'learning by doing.' ETS was successfully established as the world's biggest carbon market. However, the number of allowances, based on estimated needs, turned out to be excessive; as a result, the price of first-period allowances fell to zero in 2007.

**2008-2012:** 2nd period. Iceland, Norway and Liechtenstein joined (1.1.2008). The number of allowances was reduced by 6.5 % for the period, but economic downturns depress emissions, and thus demand, even more. This led to a surplus of unused allowances and credits which continues to weigh on the carbon price. Aviation was brought into the system (1.1.2012).

**2013-2020:** 3rd period. Major reform took effect (1.1.2013). The biggest changes have been the introduction of an EU-wide cap on emissions (reduced by 1.74 % each year) and a gradual shift towards auctioning allowances, instead of allocating them at no charge. Croatia joined the ETS (1.1.2013).

**2021-2030:** 4th period. The Commission's proposal of July 2015 on revising the ETS for phase 4:

(i) is in line with the European Council conclusions of October 2014 on the 2030 climate and energy policy framework;

(ii) aims to cut ETS emissions by 43 % compared with 2005 levels.

The key aspects of the proposal:

(i) The overall number of allowances to fall annually by 2.2 % from 2021, compared with 1.74 % currently (corresponding to a substantial emissions cut)

(ii) Better targeted and more dynamic allocation of free allowances, including:

(a) update of benchmarks to reflect technological progress

(b) more targeted carbon leakage classification

(c) free allocation better aligned with production levels.

*Summarised from 'The EU Emissions Trading System' factsheet [29]*

**Box 2. Calculating the contribution of greenhouse emissions savings to final greenhouse emissions**

The contribution of greenhouse emissions savings in a year to total greenhouse emissions for that year is calculated as the ratio of net savings in the year concerned to total hypothetical greenhouse emissions for that year. The total hypothetical emissions in a year are obtained by adding the absolute values of net emissions avoided in a year through use of renewables to actual emissions in that year.

For each year, the contribution of RE-related net GHG emissions savings to energy-related GHG emissions is obtained as a ratio between RE-related net GHG emission savings and total hypothetical energy-related GHG emissions. Total hypothetical energy-related GHG emissions in a year are obtained by adding the absolute values of net RE-related avoided GHG to the actual GHG emissions in that year.

For each year, the contribution of RE-related GHG emission savings to total GHG emissions reductions are obtained as the ratio of net RE-related GHG emissions savings to the hypothetical GHG emissions reductions. Hypothetical GHG emissions reductions are obtained by adding the absolute values of net avoided GHG emissions attributable to renewable energy to the actual GHG emissions reductions, defined as the difference between actual GHG emission in the given year and GHG emissions in 1990. This methodology is also applied in calculating each sector's contribution to GHG emissions reductions in the EU.

For each year, the contribution of net renewable electricity and heat GHG emissions savings to public power and heat-related GHG emissions is obtained as the ratio of net renewable electricity and heat GHG emission savings to total hypothetical public power and heat-related GHG emissions. The total hypothetical public power and heat-related GHG emissions are obtained by adding the absolute values of net avoided GHG emissions attributable to renewable energy to the actual public power and heat GHG emissions.

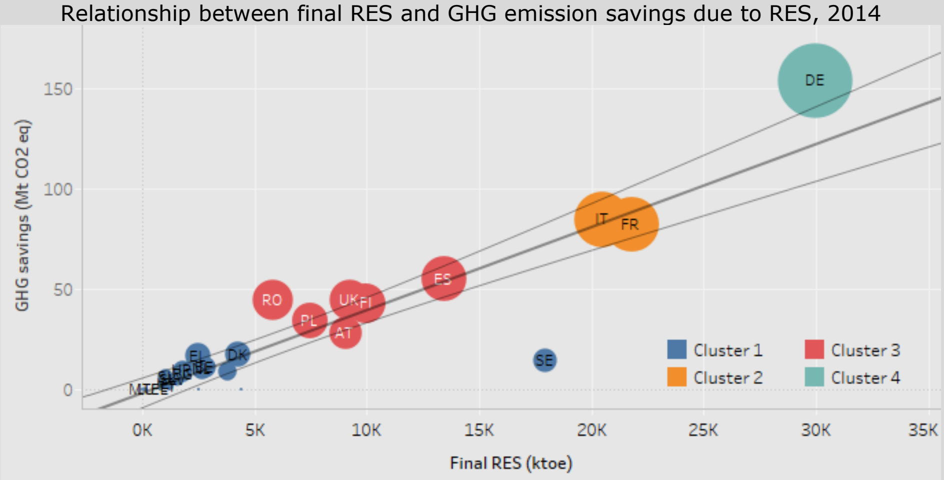
For each year, the contribution of net GHG emissions savings through the use of renewables in the transport sector to the transport sector-related GHG emissions is obtained as the ratio of net GHG emissions savings from renewable energy in transport to the total hypothetical transport-related GHG emissions. Total hypothetical transport-related GHG emissions are obtained by adding the absolute values of net avoided GHG emissions attributable to renewable energy to the actual transport-related GHG emissions.

**Box 3. Estimating greenhouse emission savings (proxy)**

Estimated emissions savings in each EU country[11] are based on the relationship between final renewable energy sources (RES) and greenhouse emissions saved by using RES, using the following formula:

$$\text{GHG emission savings}_{(2015)} = (\text{RES}_{(2015)} / \text{RES}_{(2014)}) * \text{GHG emissions savings}_{(2014)}$$

Relationship between final RES and GHG emission savings due to RES, 2014




([11]) Unless otherwise stated the calculation of proxy GHG emission savings is based in the formula above.

**Box 4. Estimation of fossil fuels displacement through the use of renewables**

The estimation of fossil fuels displacement through the use of renewables in each EU country is based on the energy data sheets as they are published by DG Energy on August 2017[12].

The estimation of fossil fuels displacement through the use of renewables over period 1990 – 2015 assumes that renewable energy has remained unchanged, at the 1990 figure.

The estimation of fossil fuels displacement through the use of renewables over period 2005 – 2015 assumes that renewable energy has remained unchanged, at the 2005 figure.

In both these estimations it is assumed the equivalent substitution of one unit of energy from fossil fuels (in this case solid fuels, oil products and gas) by one unit of renewable energy.

([12]) https://ec.europa.eu/energy/en/data-analysis/country

# 2. EU cities: CO2 emissions projections

Cities have come to play an important role in the global response to climate change as the urban energy consumption generates about three-quarters of the global carbon emissions [31], [32] and are particularly vulnerable to climate change effects [33], [34].

In 2008, acknowledging the role of the local authorities, the European Commission (EC) launched the Covenant of Mayors (CoM) initiative to endorse their efforts in the implementation of sustainable energy policies. Since its launch, the CoM has proved successful as the mainstream European movement involving those local authorities which commit voluntarily to contributing to the European Union's objective of reducing greenhouse gas emissions by both meeting and exceeding the target of a 20 % cut in $CO_2$ emissions by 2020, through better energy efficiency and the use of renewable energy sources within their territories. In 2014, in the context of the European Commission's European Strategy on adaptation to climate change [35], the European Commission launched a separate initiative called Mayors Adapt, based on the Covenant of Mayors model, with the aim of engaging cities in taking action to adapt to climate change. Building on the Covenant of Mayors and Mayors Adapt, the new **Covenant of Mayors for Climate and Energy** was announced in October 2015 by Commissioner Miguel Arias Cañete.

**Box 5. Covenant of Mayors for Climate and Energy: Three pillars**

| MITIGATION | ADAPTATION | SECURE, SUSTAINABLE AFORDABLE ENERGY |
|---|---|---|
| Low carbon cities | Resilient cities | |

- At least 40 % CO2 reduction in their respective territories by 2030
- Increased resilience to the impacts of climate change
- Increased cooperation with fellow local and regional authorities within the EU and beyond to improve access to secure, sustainable and affordable energy

Under the Covenant of Mayors for Climate and Energy initiative, over 7500 local and regional authorities inside and outside the EU are, covering 235 million inhabitants, have signed the initiative, voluntarily committing to implement climate and energy objectives in their territories (as of 30/08/2016). The municipalities that have signed are required to develop a Sustainable Energy and Climate Action Plan involving public and private participants, which is monitored and evaluated regularly by the Joint Research Centre (JRC) of the European Commission. Based on 5403 Sustainable Energy Action Plans in the JRC harmonised CoM dataset 2016, covering 183.8 million inhabitants, the Covenant signatories commit to ambitious GHG emission reduction targets by 2020 [36],[37]:

- overall commitment of 27 %, almost 7 percentage points higher than the minimum target;
- Improving energy efficiency aiming at reducing the final energy consumptions by 20 % in 2020 compared to baseline years;
- Increasing the share of renewable energy and integrating district energy systems on final energy consumptions of 9 percentage points by 2020 compared to baseline years.

The assessment of the Covenant of Mayors initiative, representing all local authorities' sizes in Europe, demonstrates that climate change has moved now to the forefront of the urban priorities. Developing a **Sustainable Energy and Climate Action Plan** that requires the establishment of a baseline emission inventory, setting ambitious targets and adopting policy measures is already a tangible achievement for cities. This is the first step towards an effective, transparent system for tracking progress and concrete results [37]. The Covenant's rapid growth (235 million inhabitants and over 7500 signatories in 9 years) and the extended coverage at EU level and beyond proves the success of the governance model developed under the Covenant of Mayors which is encouraging the local voluntary initiative on sustainable energy management and adaptation since October 2015, in the framework of a European Union's policy framework for climate and energy.

The large majority (96.5 %) of the CoM signatories (5984 signatories, covering 85 % of inhabitants) are from the EU countries. The estimation of the contribution of local actions towards achieving EU GHG emission reduction targets showed that:

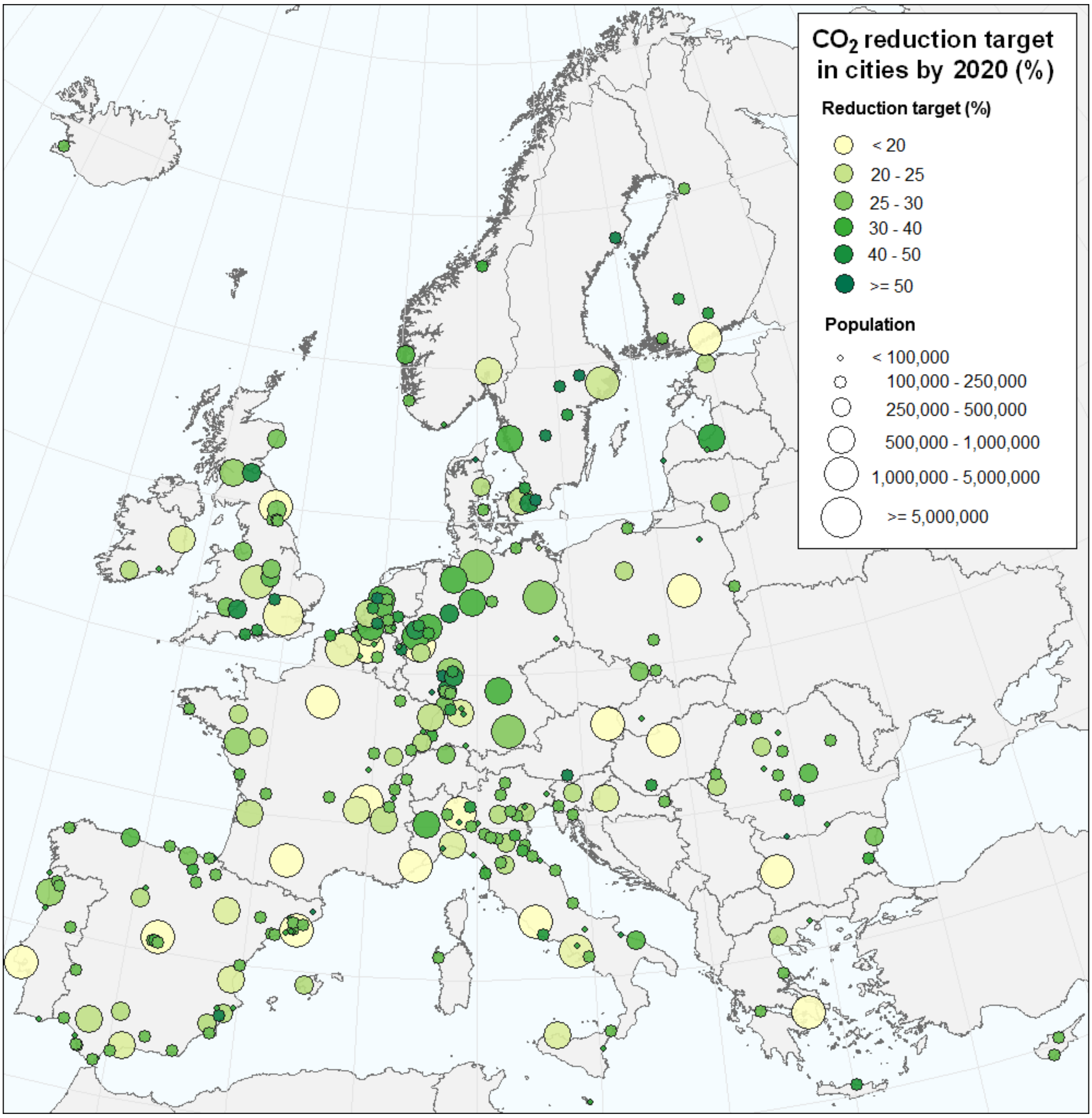
- the emission reduction committed by 2020 by the CoM signatories of the EU countries (239 MtCO2-eq) represents 98 % of the overall reduction committed by all CoM signatories;
- by achieving their commitment, the EU countries CoM signatories would achieve 31 % of the EU's overall emission reduction target by 2020, including all sectors.

**Table 1.** CoM contribution to the EU GHG emission reduction 2020 target[13]

| | | |
|---|---|---|
| EU 2005 GHG emissions | Mt $CO_2$-eq. | 5199 |
| EU 2020 GHG emissions reductions target | Mt $CO_2$-eq. | 778 |
| CoM EU 2020 estimated GHG emissions reductions | Mt $CO_2$-eq. | 239 |
| CoM potential contribution to EU GHG emissions reduction target | % | 31 |

Figure 1 shows the $CO_2$ emissions reduction targets in 294 EU cities. These reductions ranged from less than 20% up to 60%. Riga (55%), Amsterdam (40%), Berlin (40%), London (38%) and Stockholm (37%) are the leading cities in the EU in regard to $CO_2$ emissions 2020 reduction targets.

**Figure 1.** $CO_2$ reduction targets by 2020 in EU cities[14]



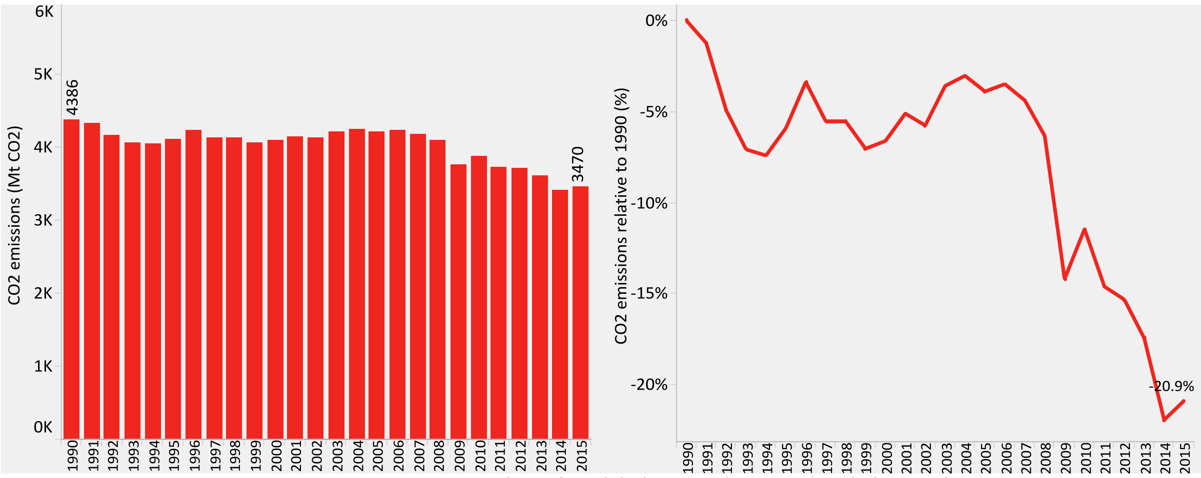

([13]) Adapted by "Covenant of Mayors in Figures – 8 year assessment" [37].
([14]) Adapted by "The State of European Cities, 2016" [32]. Reduction targets (as of 01/06/2016) refer in most cases to the absolute value of $CO_2$ emissions; in others are $CO_2$ values per capita reductions.

# 3. EU $CO_2$ emissions: recent trends

Meanwhile, global $CO_2$ emissions have risen by 60 % over the 25 years since 1990, $CO_2$ emissions in the EU, however, have fallen by almost 21 % (916 Mt $CO_2$). In 2015, the EU was one of 6 countries/regions emitting $CO_2$ that were collectively responsible for 9.6 % of global $CO_2$ emissions[15] from fossil fuels and industrial processes [3]. $CO_2$ emissions in the EU took a downward trajectory after 2011. However, they rose by 1.35 % (46.1 Mt $CO_2$) between 2014 and 2015, reaching 3470 Mt $CO_2$. Over the same period, global $CO_2$ emissions remained almost unchanged, with only a 0.1 % rise above 2014 levels.

Figure 2 shows the overall trend of EU $CO_2$ emissions from 1990 to 2015, and relative changes by comparison with 1990.

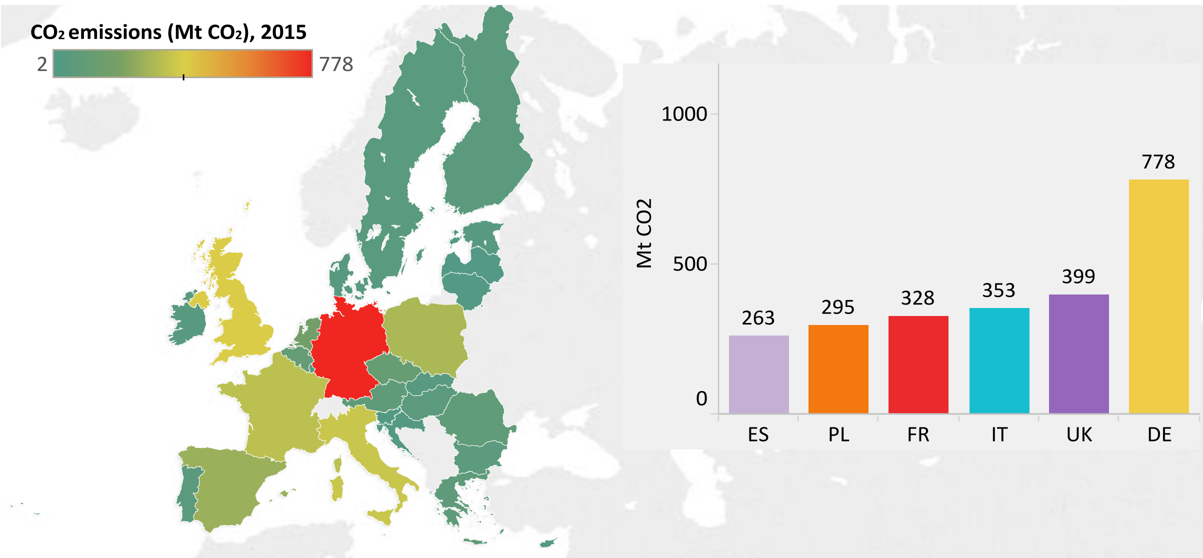
**Figure 2.** $CO_2$ emissions in the EU, 1990 – 2015 (left) [16] - Relative change vs. 1990 (right)




*Source:* JRC Emission Database for Global Atmospheric Research (EDGAR)

Six EU countries (France, Germany Italy, Poland Spain, UK) produced almost 70 % of total CO2 emissions in 2015, with Germany's share (22.4 %) far exceeding all the others. Aggregated, these 6 top emitters alone produced 2416 Mt CO2. Although Germany, Italy, Poland, Romania and the UK are all big emitters, they were the 5 countries that did most to cut CO2 emissions between 1990 and 2015.

**Figure 3.** $CO_2$ emissions in EU countries (left) - Top 6 emitters (right), 2015



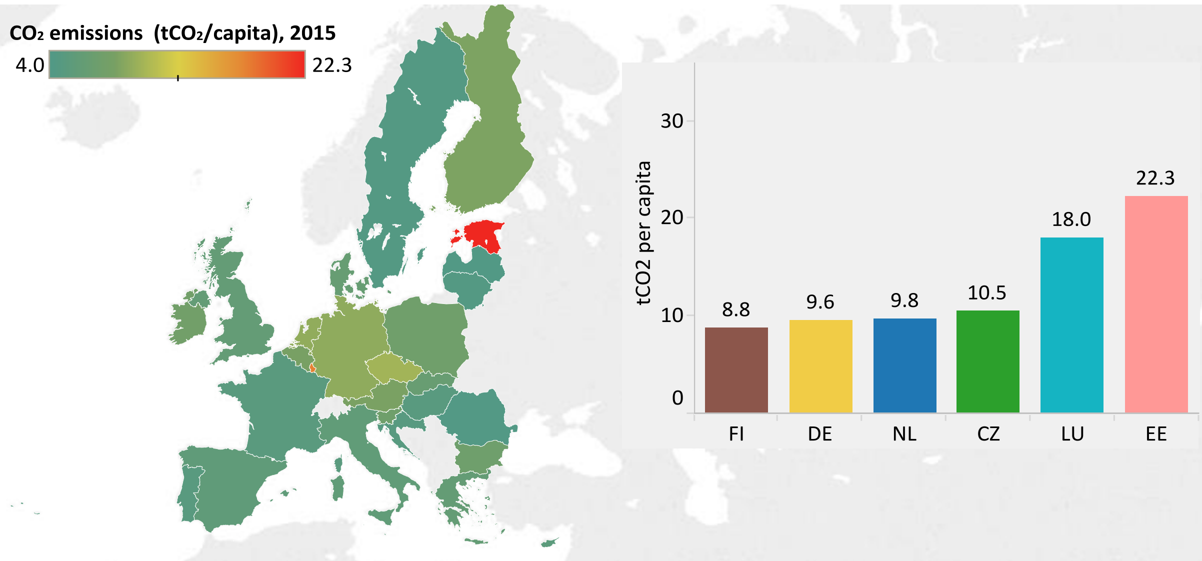

*Source:* JRC Emission Database for Global Atmospheric Research (EDGAR)

([15]) The main greenhouse gas emitted in the EU is $CO_2$. Its share in total emissions ranged from 76.5 % in 1990 to 78 % in 2015.

([16]) To facilitate the link between Figure 2 and Figure 6, the same scale for the Y axis is used for total $CO_2$ and GHG emissions

Eight MS (Austria, Cyprus, Finland, Ireland, Malta, the Netherlands, Portugal and Spain) emitted more $CO_2$ in 2015 than in 1990. In 2015, total $CO_2$ emissions in Lithuania were down by 64.3 % from 1990. Cyprus's emissions, on the other hand, were over 35 % higher in 2015 than in 1990. Austria was the second EU country to report higher $CO_2$ emissions in 2015 than in 1990. Bulgaria (+2.6 %) and Estonia (+64.6 %) were the only countries whose emissions rose between 2005 and 2015. Between 2014 and 2015, only 5 countries (Denmark, Finland, Greece, Sweden and the UK) cut their $CO_2$ emissions.

**Figure 4.** $CO_2$ emissions per capita in EU countries, 2015

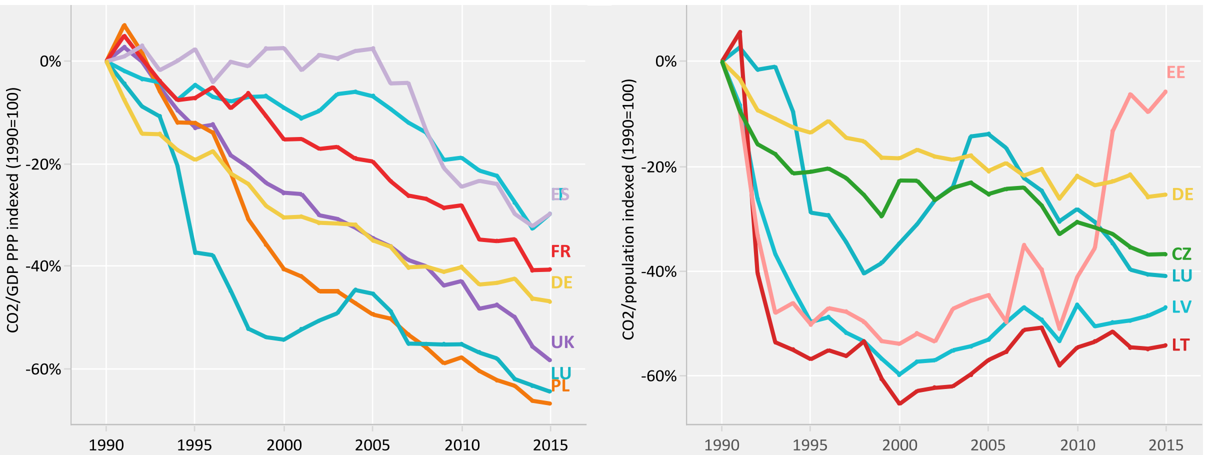



*Source:* JRC Emission Database for Global Atmospheric Research (EDGAR)

Per capita $CO_2$ emissions in the EU fell by 25.3 %, from 9.2 $tCO_2$ in 1990 to 6.87 $tCO_2$, in 2015. Per capita emissions vary significantly across the EU, highlighting how the various countries use energy. In 2015, Luxembourg almost halved its $CO_2$ emissions per capita compared with 1990. Having experienced a marked fall after 1993, Estonia's $CO_2$ emissions per capita exceeded Luxembourg's in 2012, and the country remained in first position even in 2015. Emissions fell in all 6 of the biggest emitters between 1990 and 2015. As regards $CO_2$ emissions per unit of GDP, emissions fell in all 6 top emitters between 1990 and 2015. The trend was most pronounced in Poland and Luxembourg, and less marked in Italy and Spain.

Figure 5 illustrates trends in $CO_2$ emission intensities for the Czech Republic, Estonia, France, Germany, Italy, Latvia, Lithuania, Luxembourg, Poland, Spain and the UK.

**Figure 5.** Trend in $CO_2$ emission intensities in some EU countries, 1990 - 2015



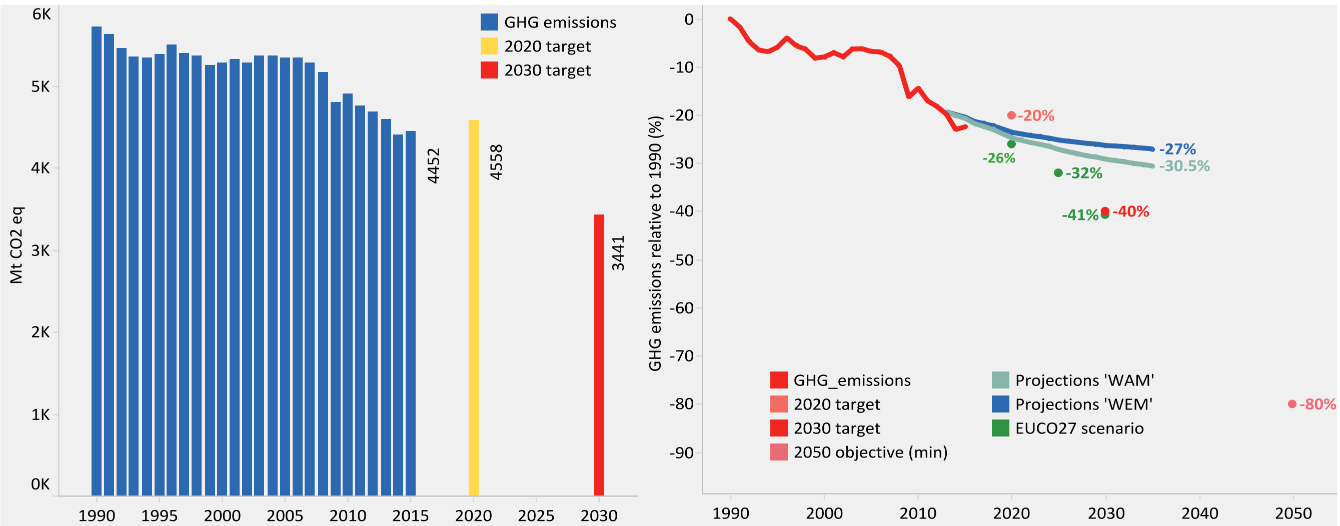

*Source:* JRC Emission Database for Global Atmospheric Research (EDGAR)

# 4. EU greenhouse gas emissions: trends & projections

EU emissions[17] fell by 22.1 % (1265 Mt $CO_2$ –eq.) between 1990 and 2015, reaching 4452 Mt $CO_2$-eq. Between 2005 and 2015, they fell by 16.7 % (893 Mt $CO_2$ –eq.). Comparing with 2014 they rose by 0.6 % (28 Mt $CO_2$-eq) in 2015. While the EU's emissions fell over the 25 years between 1990 and 2015, its economy grew steadily by a total of 27 %. The target for 2020 is projected to reach 4588 Mt $CO_2$ –eq., 20 % below 1990 emissions. By 2030, the EU is expected to cut emissions to 40 % below their 1990 level, at 3441 Mt $CO_2$-eq. In 1990, emissions in per capita terms in the EU were 11.8 Mt $CO_2$-eq./capita. In 2015, the figure was 8.8 Mt $CO_2$-eq./capita.

Figure 6 (left side) illustrates the overall trend in greenhouse emissions in the EU between 1990 and 2015 and emissions targets for 2020 and 2030. The right side of the figure shows how the emissions, the 2020 and 2030 targets, projected emissions until 2035 'with existing[18] and additional measures[19]', the EUCO27 projections and the 2050 objective change compare with 1990.

**Figure 6.** GHG emissions in EU, (1990-2015), targets and projections – Relative change vs 1990[20]



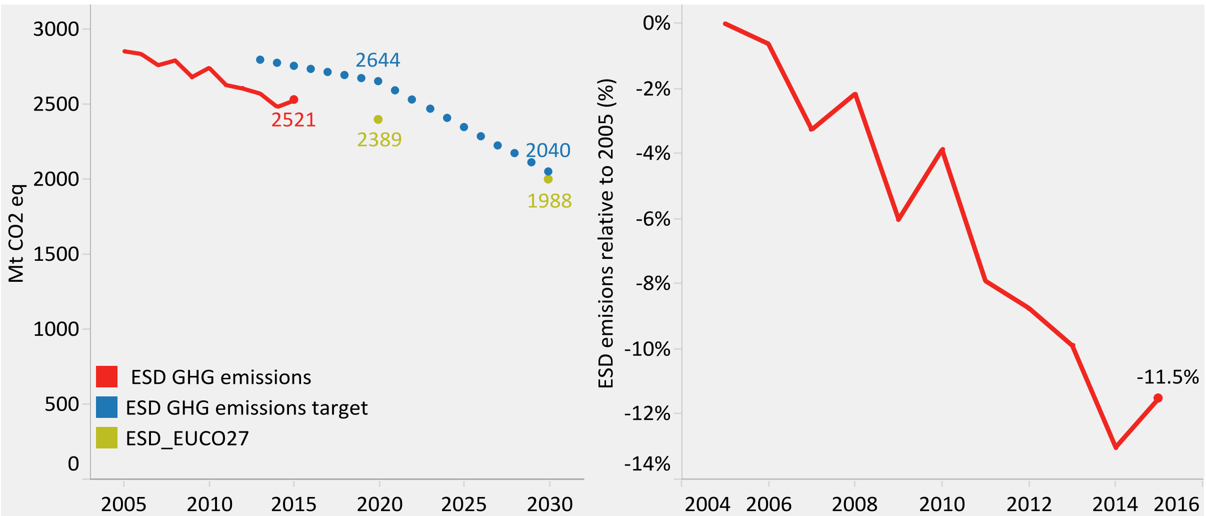

Both projections 'with existing and additional measures' show that emissions in the EU in 2020 will be reduced by more than the target for that year. The reduction in EUCO27 scenario projection for 2020 is slightly larger than the 'WAM' projection, at 26 %, compared with 24.7 %. For 2030, the 'WAM' projection shows a smaller reduction than the target, whereas the EUCO27 scenario projects a reduction in line with the target (by 40.7 %) for that year.

**ESD[21] emissions** in the EU totalled 2521 Mt $CO_2$ –eq. in 2015. The smallest decrease since 2005 was in 2014 (13 %), while the reduction was smaller in 2015, at 11.5 %. This reduction is larger than that actually expected for 2020 (a 10 % fall). The projection of the EUCO27 scenario for 2020 shows that the EU's ESD emissions will be 16 % below the 2005 level. Under this scenario, this reduction is projected to reach -30 % in 2030.

Transport is the main source, contributing over a third (889.7 Mt $CO_2$-eq.) of ESD emissions. Buildings follow, sharing a fifth of emissions in 2015 (630 Mt $CO_2$-eq). Between 2005 and 2015, emissions from agriculture grew at a rate of 17.3 %, their relative share in total ESD emissions shifting industry emissions – which fell at the same time - to third place at 16.8 %. Emissions from waste fell further between 2005 and 2015, to 5.6 %.

(17) Unless otherwise stated, all figures for the EU as a whole and individual EU countries provide greenhouse emissions without LULUCFC, with indirect $CO_2$ and international aviation.
(18) Projections 'with existing measures' (WEM) reflect the effects of all adopted and implemented measures at the time the projections were prepared. Source [4].
(19) Projections 'with additional measures' (WAM) take into account the measures that were at planning stage at the time the projections were prepared. Source [4].
(20) Adopted from "Trends and projections in Europe 2016 - Tracking progress towards Europe's climate and energy targets" [4] and EUCO27 scenario [5].
(21) Effort Sharing Decision emissions include emissions from: transport (excluding aviation and shipping), buildings, agriculture, industry and waste. For each EU country, the relative change in ESD emissions since 2005 is calculated taking 2005 as the base year, as defined in [4].

**Figure 7.** EU ESD greenhouse emissions, 2020 & 2030 targets and projections — change relative to 2005

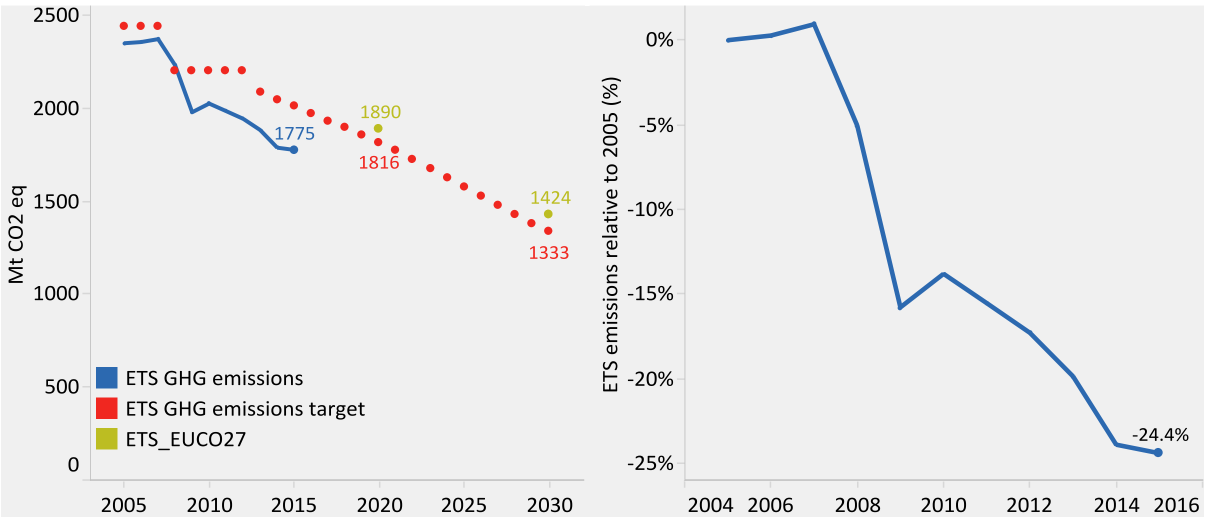



*Source:* EEA [4], EUCO27 scenario [5]

The trend in greenhouse **emissions covered by the ETS** was slightly different from that of ESD emissions. After the marginal increase between 2005 and 2007 and the drop in 2009, greenhouse emissions covered by the ETS scheme remained below that level until 2015. In this year these emissions were 24.4 % below 2005 levels, reaching 1775 Mt $CO_2$-eq.

These emissions represent about 40-45 % of EU greenhouse emissions, and a large proportion of them fall within the power generation sector. The ETS target was defined to cut emissions by 21 % between 2005 and 2020. The ETS targets for 2020 and 2030 project a 22.6% reduction in emissions in 2020 and 43.2% in 2030. The EUCO27 scenario has projected lower emissions cuts in 2020, by 19.5 % and in 2030, by 39.4 %.

**Figure 8.** EU ETS greenhouse emissions, 2020 & 2030 targets and projections — change relative to 2005




*Source:* EEA [4], EUCO27 scenario [5]

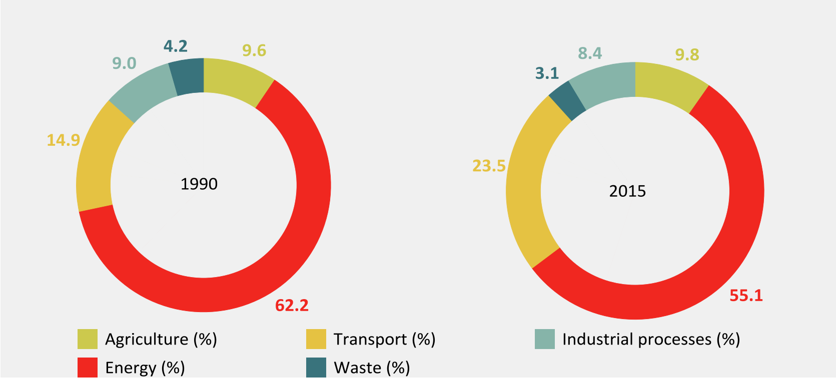
Year-on-year fluctuations in EU greenhouse emissions were mainly due to the improved energy intensity of the EU economy, the development of renewable energy sources and the economic slowdown [EEA, 2011]. Period 2008-2009 saw the sharpest emissions drop in both absolute and relative terms. During this period, the economic slowdown accounted for less than half of the total reduction achieved.

Since 1990, emissions in the EU have fallen in most sectors except transport. 2007 saw the biggest rise in emissions in this sector between 1990 and 2015, - 32.2 %. Since 1999, emissions from waste management have fallen, with the biggest drop since 1990 (by 42.2 %) occurring in 2015. Energy-related emissions[22] totalled 2452 Mt $CO_2$-eq. in 2015, which is 31 % (1103 Mt $CO_2$-eq.) below 1990 levels. Although this sector remained the main source of emissions, its share fell

([22]) Energy-related greenhouse emissions include emissions from fuel combustion and fugitive emissions from fuels without emissions from the transport sector.

from 62.2 % in 1990 to 55.1 % in 2015. The transport sector[23] remained the second largest source of emissions in the EU, accounting for 1048 Mt $CO_2$-eq. in 2015 (23.2 % of total emissions in that year). In 2015, emissions from transport came to 23 % (197 Mt $CO_2$-eq.) higher than in 1990.

**Figure 9.** Greenhouse emissions in the EU, broken down by source, 1990 (left) — 2015 (right)[24]




**Agriculture** remained the third largest source of greenhouse emissions, its share of total emissions reached 9.8 % in 2015, slightly higher than in 1990. The steepest drop from 1990 levels occurred in 2012 (22.7 %), while there was a fall of 20.3 % in 2015 (112 Mt $CO_2$-eq.).

The contribution of emissions from **waste management** remained marginal, having fallen from 4.2 % in 1990 to 3.3 % in 2015. Waste management emissions rose until 1998. They then fell continuously, reaching 139.3 Mt $CO_2$-eq. in 2015, which is 42.2 % below 1990 levels. The share of emissions from **industrial processing** fell slightly to 8.5 % in 2015, reaching 374 Mt $CO_2$ –eq., which is 27.7 % below 1990 levels. Emissions from **public power and heat production**[25] amounted to 1 440 Mt $CO_2$-eq. in 1990. This represented 25.2 % of total greenhouse emissions in that year and 33 % of energy-related emissions. In 2015, emissions from public power and heat reached 1 070 Mt $CO_2$-eq. (24 %), accounting for 32 % of energy-related emissions.

Germany, the UK, Romania, Italy and France were the 5 countries that cut emissions by the largest amount between 1990 and 2015. One third of overall emissions were dominated by the 2 largest emitters: Germany (20.8 %) and the UK (12 %). Germany cut its emissions by the largest amount (336.5 Mt $CO_2$ -eq.) over this period, followed by the UK, which achieved cuts of 272.2 Mt $CO_2$-eq.

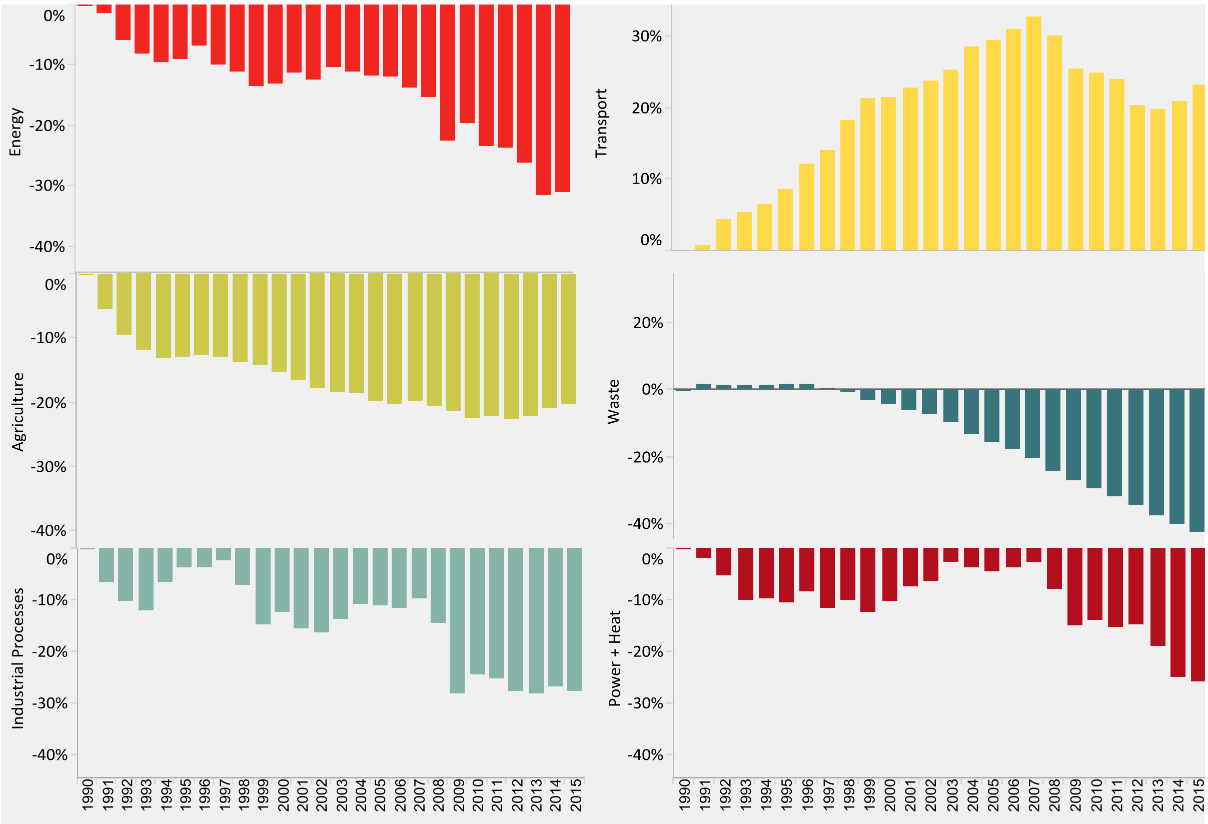
Between 2009 and 2015, the countries that reduced their emissions most were the UK (92 Mt $CO_2$-eq.), Italy (62 Mt $CO_2$ -eq.), France (45 Mt $CO_2$ -eq.), Spain (32.3 Mt $CO_2$-eq.) and Greece (28.5 Mt $CO_2$-eq.). These 5 countries together accounted for 74 % of the reduction.

Only 4 countries - Spain, Cyprus, the Netherlands and Portugal - increased energy-related greenhouse emissions between 1990 and 2015. Almost two thirds of energy-related emissions came from 5 countries: Germany, the UK Italy, France and Poland). These countries retained their positions in absolute terms in the ranking between 1990 and 2015.

In 2015, Germany had the highest greenhouse emissions from energy, 601.4 Mt $CO_2$-eq. The country also achieved the largest absolute reduction from 1990 levels (271 Mt $CO_2$-eq. or 31 %). Malta's energy-related emissions were the EU's lowest in both 1990 and 2015 (1.1 Mt CO2–eq.). In 2015, the 5 countries with the highest level of energy-related emissions per capita were Estonia (10.3 t $CO_2$-eq./capita), the Netherlands (7.7 t $CO_2$-eq./capita), the Czech Republic (7.6 t $CO_2$-eq./capita) and Germany (7.4 t $CO_2$-eq./capita).

([23]) Greenhouse emissions from the transport sector (excluding international aviation) were 906 Mt $CO_2$ -eq. in 2015.
([24]) In this figure for EU and each country: (i) Energy emissions include fuel combustion and fugitive emissions from fuels excluding transport; (ii) Greenhouse emissions from transport include emissions from international aviation.
([25]) Output from public thermal power stations covers gross electricity generation and any heat also produced by public thermal power stations. Public thermal power stations generate electricity and/or heat for sale to third parties, as their primary activity. They may be privately or publicly owned. The gross electricity generation is measured at the outlet of the main transformers, i.e. the consumption of electricity in the plant auxiliaries and in transformers is included.

**Figure 10.** Changes in the EU greenhouse emissions relative to 1990, by sector[26]




Five EU countries (Cyprus, Finland, Luxembourg, the Netherlands, Portugal and Spain) increased emissions from **public power and heat production** between 1990 and 2015. In 1990, almost two thirds of emissions came from just 5 countries: Germany, Italy, Poland, Romania and the UK, In 2015, the picture was almost the same; the only change was that Spain was now in 5$^{th}$ place. Germany had the highest absolute level of emissions from public power and heat in both 1990 and 2015: 341 Mt $CO_2$-eq. in 1990 and 306 Mt $CO_2$-eq. in 2015. The UK was third, but also achieved the largest reduction in this type of emission between 1990 and 2015, having reduced emissions to 104 Mt $CO_2$ –eq., a fall of 100 Mt $CO_2$-eq. compared with the 1990 level. **Per capita**, Estonia had the highest emissions from public power and heat production, at 9.6 t $CO_2$-eq./capita. The Czech Republic came second with 5.0 t $CO_2$-eq./capita, followed by Malta (4.9 t $CO_2$-eq./capita), Greece (4.6 t $CO_2$-eq./capita) and Poland (4.2 t $CO_2$-eq./capita).

Only 6 countries (Estonia, Finland, Germany, Lithuania, Slovakia and Sweden) had lower **transport-related emissions** in 2015 than in 1990. In 1990, over 70 % of transport emissions came from 5 countries: France, Germany, Italy, Spain and the UK. The ranking was the same in 2015, but the 5 countries' contribution to the overall figure had fallen to 66 %. In 2015, Luxembourg had the highest **per capita** value (12.4 t $CO_2$-eq./capita), followed by Slovenia (2.8 t $CO_2$-eq./capita), Austria (2.6 t $CO_2$-eq./capita), Cyprus (2.4 t $CO_2$-eq./capita) and Ireland (2.4 t $CO_2$-eq./capita).

([26]) To make it easier to compare how different sectors perform in terms of changes in greenhouse emissions since 1990, the same scale is used for the Y axis (positive or negative) in all graphs used in this report related to the changes by sector in the EU and EU countries greenhouse emissions relative to 1990.

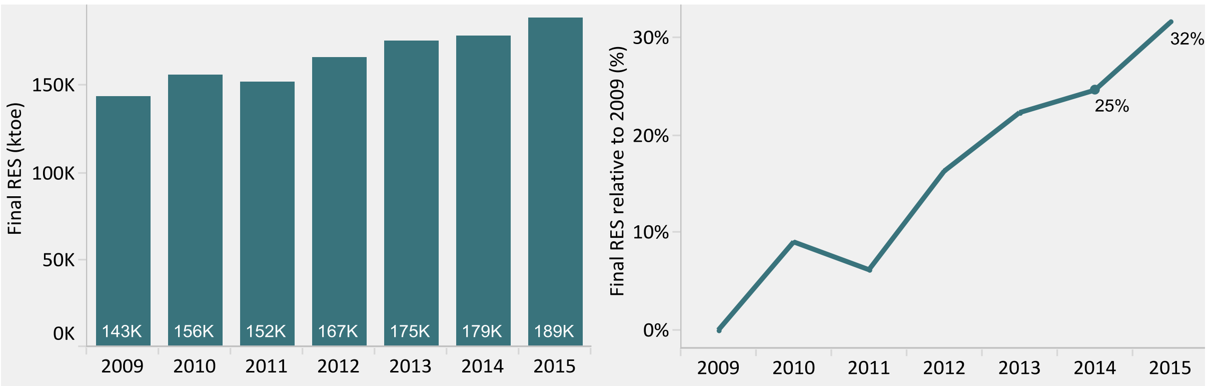
# 5. EU renewables: trends & projections

In 2015, renewables accounted for 16.7 % of gross final energy consumption in the EU, with the heating/cooling sector accounting for 8.4 %, electricity for 7 % and transport for 1.3 %. On the basis of the aggregated **national renewable energy action plans (NREAPs)**, renewables are expected to represent 20.6 of energy in the EU by 2020, slightly above the 20 % target. Their share is expected to reach at least 27 % by 2030.

During 2009-2015, final consumption of renewables in the EU rose by 32 %[27] to 189 Mtoe. Renewables grew faster than predicted in the aggregated NREAPs, which predicted 248.2 Mtoe by 2020. The EUCO27 scenario for 2020 is consistent with these plans, projecting final renewable energy consumption at 249 Mtoe. According to this scenario, final consumption of renewables in the EU will reach 291 Mtoe by 2030.

Figure 11 illustrates the trend in final renewable energy deployment in the EU between 2009 and 2015 and relative changes by comparison with 2009.

**Figure 11.** Deployment of renewables in the EU (left) – Change relative to 2009 (right)




*Source:* JRC renewable energy database, 2017

Energy from renewable sources has become one of the mainstays of the **electricity sector**. In 2005, the share of renewables in total EU electricity consumption was just above 14 %, so over 85 % of electricity consumed came from fossil fuels and nuclear energy. The share of the EU's gross electricity consumption derived from renewables doubled to almost 29 % within a decade. Between 2009 and 2015, the final consumption of renewable electricity in the EU rose by 52 % or 317 TWh (Figure 12).

**Wind and solar power** have become central to the transformation of the EU's power system. At just over 39 %, hydropower still accounted for the largest share of renewable electricity in 2015. However, its share has been falling steadily in recent years, as the amount of electricity generated from wind and solar energy in particular, but also from biomass, has been growing much faster. By 2015, wind energy already accounted for 29.5 % of final renewable electricity, biomass for 18.7 % and solar technology for 11.5 %. Photovoltaics generated over 100 TWh of electricity, accounting for slightly more than 3 % of gross final electricity consumption in the EU in 2015. According to the EUCO27 scenario for 2020, final renewable electricity consumption in the EU is projected at 1217 TWh. Wind power is forecast to be the largest contributor at 38.1 %, followed by hydropower at 30.9 %, biomass at 17.6 %, solar photovoltaic at 12.7 % and other renewables at 0.7 %.

In the course of 2015, a total of 23.4 GW of renewable electricity was installed in the EU. By the end of 2015, the EU had installed 374 GW of renewables-based electricity generation, or almost 38 % of total electricity capacity. By 2015, wind power accounted for the largest share of total electricity capacity in the EU, at 37.8 %, covering almost 33 % of global wind installed capacity in that year. Solar photovoltaic has now exceeded 100 GW, almost 22 % above the level planned for 2020. In 2015 this technology presented 42.8 % of global solar photovoltaic installed capacity. Over the decade since 2005, Germany remained the largest mature European market in both solar photovoltaic and wind power, whereas Italy experienced the fastest deployment of solar photovoltaic. By 2015, the UK was home to half of new photovoltaic capacity in the EU. The EUCO27 scenario for 2020 forecasts a net generation capacity of 475 GW, with wind power accounting for 43.6 %, solar electricity for 28.6 %, hydropower for 27.7 % and other renewables for just 0.1 %.

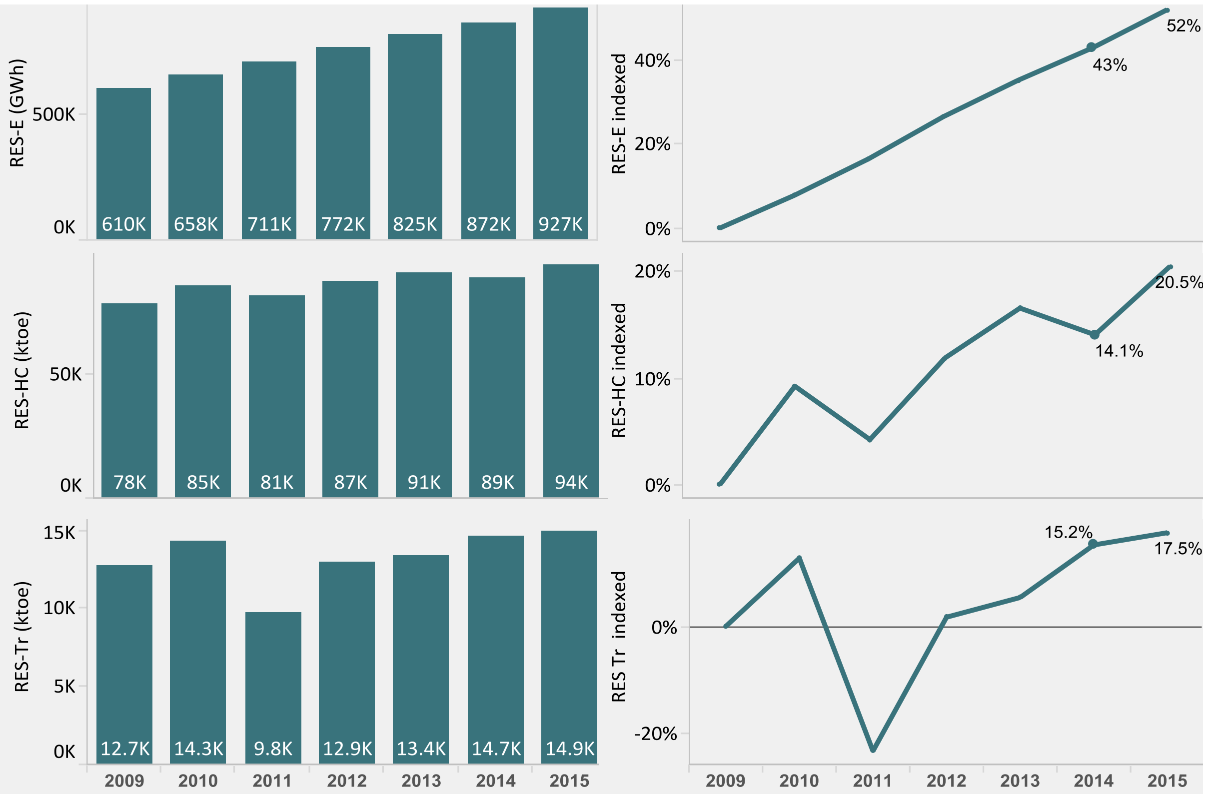
(27) Reaching 179 Mtoe, the final renewable energy consumed in the EU in 2014 was 25 % higher than in 2009.

By 2015, almost half of the EU's energy from renewable sources was consumed in the **heating/cooling sector**. This contribution is expected to reach just over 45 % by 2020. Over 2009- 2015, renewable energy deployment in this sector reached over 20 % (+16 Mtoe). Almost 19 % of gross final energy consumption for heating/cooling was covered by energy from renewable sources in 2015. Almost 90 % of this energy came from biomass, 9.1 % from heat pumps, 2.2 % from solar thermal and just 0.7 % from geothermal. The heating/cooling consumption originated from renewable energy sources is expected to reach 111.8 Mtoe in 2020 in which the relative contribution of biomass will fall to 81 % while solar thermal is expected to double its share to 5.8 %. The contribution of heat pumps is expected to rise to 11 % and geothermal will reach 2.4 %.

The use of final renewable energy in the **transport sector** has risen by almost 18 % since 2009 and now accounts for 6.7 % of gross final energy consumption in this sector. Transport is dominated by the use of biodiesel, whose share had risen to just over 70 % by 2015. Electricity from renewable sources accounted for a tenth of final use of energy from renewables in this sector.

Figure 12 illustrates the trend in final renewable energy deployment over 2009-2015 in three sectors in the EU: electricity, heating/cooling and transport.

**Figure 12.** Renewables in electricity, heating/cooling and transport (right) – Change relative to 2009 (right)



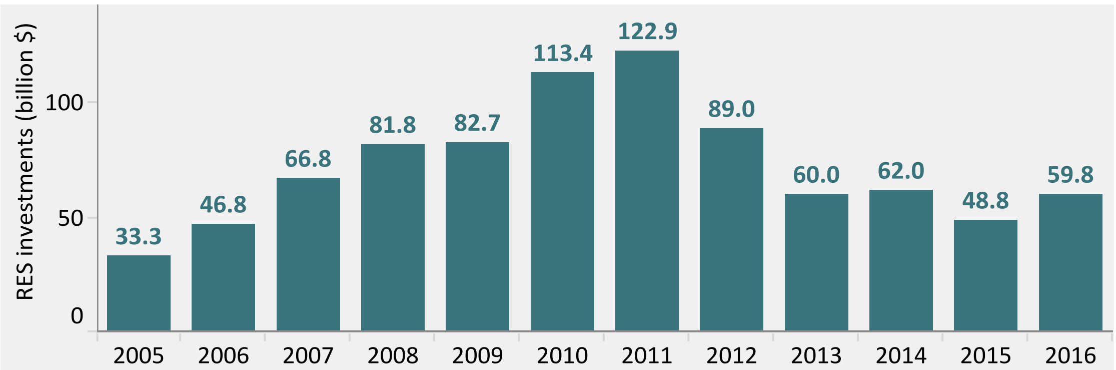

*Source:* JRC renewable energy database, 2017

# 6. EU energy system: some indicators

At the present time **investments in renewables** are mainly driven by the enabling legal and regulatory framework and the presence of specific support schemes. Support schemes represent currently the major driver for investments in electricity sector, while investments in grid assets are mainly driven by regulation that guarantees investors a reasonable return on equity.

Figure 13 shows how the EU investments for renewables saw the largest expansion around 2010-2011, almost four times the 2005 figure. These investments enjoyed a 2.2% increase in 2016 comparing with previous year. The amount came to $59.8 billion, led by the UK on $24 billion and Germany on $13.2 billion [41].

**Figure 13.** Investments in renewables in the EU, 2005-2016




Source: Global Trends in Renewable Energy Investment 2017 (Frankfurt School-UNEP Centre/BNEF) [41][28]

Europe's investment owed its resilience to wind, totalling $43.8 billion in 2016, up 14 % from 2015 (Table 2). Record investments were reached for offshore wind, totalling $25.9 billion. Among individual European countries, the UK ($24 billion) was the biggest investor in renewables for the second successive year. Germany was the second-largest of the European markets, with investment of $13.2 billion.

**Table 2.** RES investments in the EU broken down by technology ($ billion), 2015-2016

| | Unit | Wind | Solar | Small hydro | Marine | Geothermal | Biomass & waste | Biofuels | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| 2015 | $billion | 28.4 | 15.8 | 0.1 | 0.1 | 1.2 | 2.5 | 0.7 | 48.8 |
| 2016 | $billion | 43.8 | 10.2 | 0.1 | 0.1 | 0.8 | 4.2 | 0.6 | 59.8 |

Source: Global Trends in Renewable Energy Investment (Frankfurt School-UNEP Centre/BNEF) [40], [41]

The EU **energy import bill** rose from €238 billion in 2005 to €403 billion in 2013. Falls in the prices of energy commodities and in consumption brought it down to €261 billion in 2015, some 35 % below the 2013 level. Some 68% of this 2015 import bill went for the imports of oil products and the rest for gas (27.6%) and coal (3.8%) [39].

**Table 3.** Estimated EU fossil fuels import bill

| | Unit | Oil | Gas | Coal | Total |
|---|---|---|---|---|---|
| | | | | | |
| 2013 | €billion | 294 | 95 | 14 | 408 |
| 2014 | €billion | 271 | 74 | 13 | 358 |
| 2015 | €billion | 178 | 72 | 10 | 261 |

Source: COM (2016) 769 final [39]

**Prices of all fossil fuels** (most notably oil) have declined after 2008. This has been driven by increases in supply (US shale oil and gas, Canadian oil sands, robust OPEC production, increased global gas (including LNG) and coal production) and weaker demand (slower global growth, notably in China, but also structural changes on the demand side, such as growing energy efficiency and alternative fuels in the housing and transport sectors, driven by efficiency policies for buildings and cars) [39]. Since January 2016, oil prices started to recover which means that oil-indexed prices are set to start increasing from about mid-2016 [42].

The EU **wholesale electricity prices** peaked in the third quarter of 2008 and, apart from a slight recovery in 2011, have been falling ever since. Prices have fallen by almost 70 % since 2008 and by 55 % since 2011 and in 2016 reached levels not experienced for last 12 years. In the first quarter of 2008 the price difference between the most expensive and the cheapest European

([28]) Investment volume is not adjusted for the re-invested equity. Total values do not include estimates for undisclosed deals.

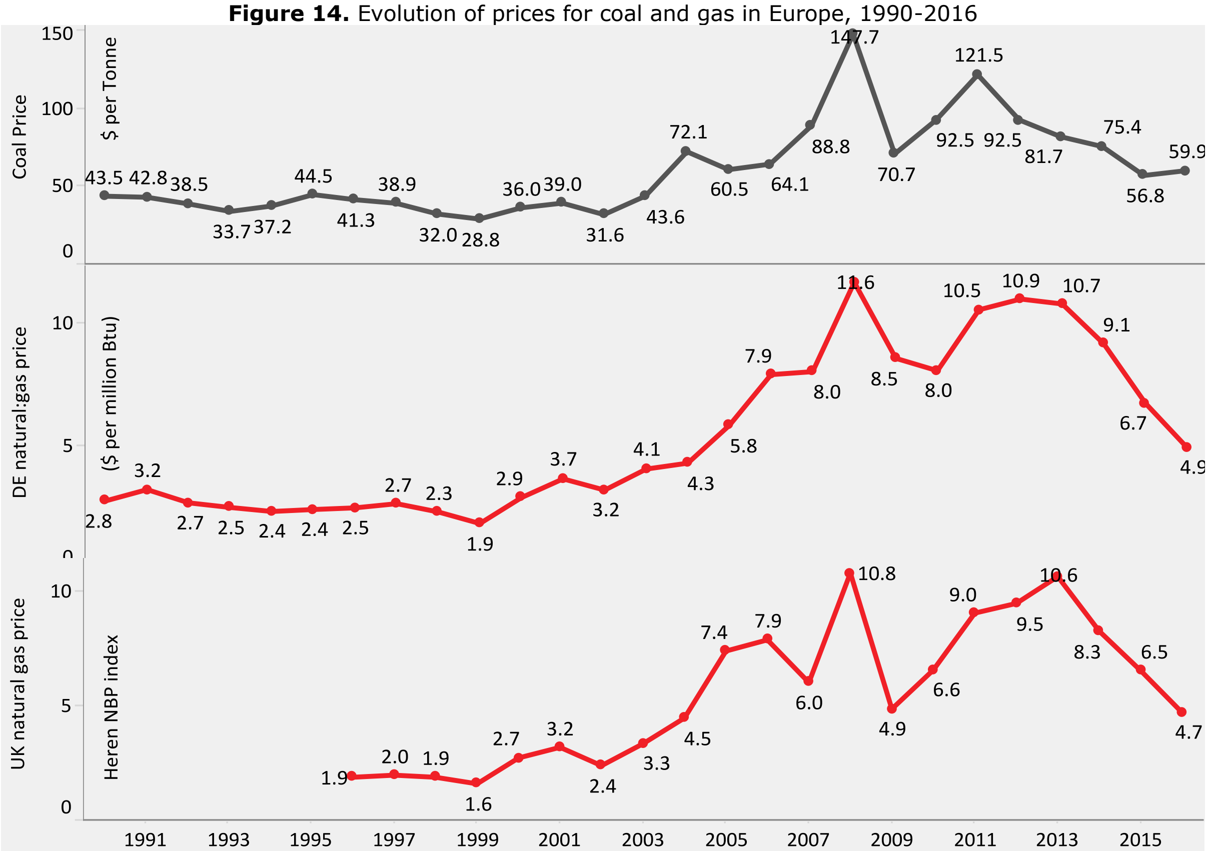
wholesale electricity market was 44 €/MWh, eight years later this difference has shrunk to 24 €/MWh [39]. Wholesale electricity prices in the EU, represented by the Platts' European Power Index (PEP), fell to 30 €/MWh in February 2016, which was the lowest since March 2007. Decreasing fossil fuel prices impacted marginal electricity generation costs; also adding to the downward pressure on wholesale electricity prices [43].

Along with decreasing average wholesale electricity prices the decreasing **price volatility** can be observed in most European wholesale markets. Several factors, including market coupling, demand response, improved methods to forecast the output of renewables installations, and overcapacity in most markets, have contributed to declining prices and reduced volatility [44].

Natural gas prices were relatively high compared to import **coal prices** in the EU over the last few years. While in 2008-2009 the estimated value of gas-coal price ratio was 1.7 on average, in 2014-2015 it amounted to 2.7, implying that gas-fired generation became costlier and the competitive disadvantage of gas increased compared to coal. In parallel with the recent fall in gas prices, the gas-coal price ratio has slightly improved, though in the first quarter of 2016 it was still above 2 [39].

Figure 14 shows how the coal[29] and gas prices[30] developed in Europe over period 1990-2016. These prices saw the largest increase around 2008. Coal prices have been pushed down again year on year over 2011-2015 increasing slightly (by 5.5 %) in 2016. **Gas prices** start falling again only after 2013 experiencing in 2016 a drop by more than 55 % of the 2013 figure. During the same period renewable energy costs decreased but to a much lesser extent than competing gas energy costs [45].

**Figure 14.** Evolution of prices for coal and gas in Europe, 1990-2016




Source: BP Statistical Review of World Energy June 2017 [45]

The penetration of renewable energy into the power market can directly result in a **price response of fossil fuels** which in turn affects the relative competitiveness of renewable power generation, thereby reducing the rate of the renewable energy transition or increasing the cost of the policy support measures required to achieve it. Renewables such as solar are displacing fossil fuels at daily peak times when wholesale electricity prices are higher. Due to this fossil fuels do not benefit from the same level of public support for renewables [46] depending on energy market prices to recover their costs.

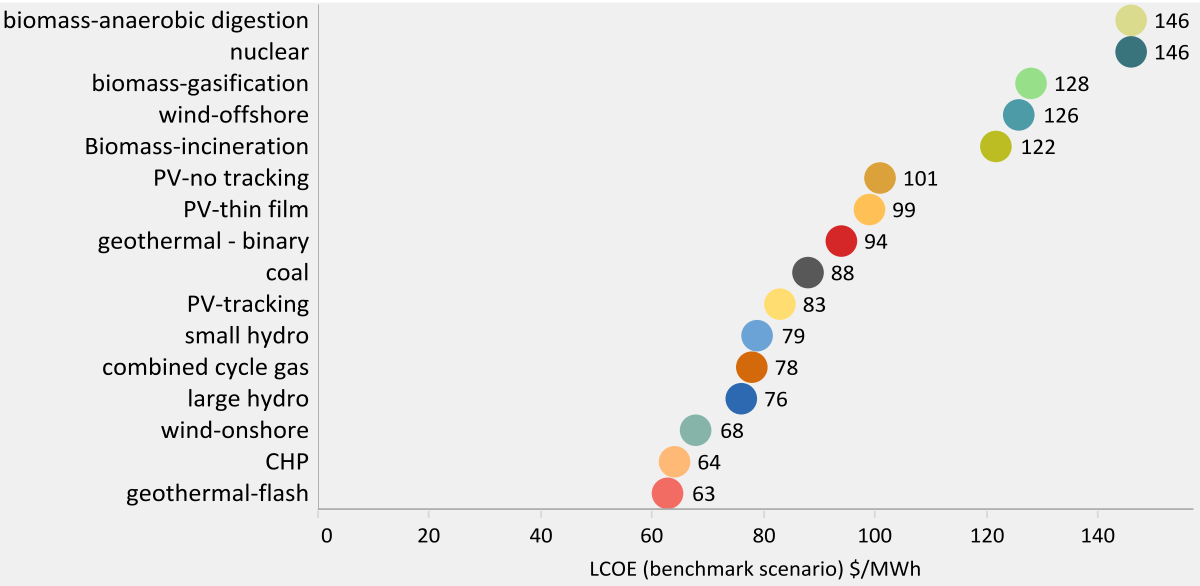
([29]) Data based on Northwest Europe marker price [45].
([30]) Data based on average German import price and Heren NBP Index [45].

The **Levelised Cost of Electricity** (LCOE) metric is valuable to policy makers for its relative simplicity and the ease with which it allows for comparability [47].

Figure 15[31] shows the 2016 LCOE global benchmark figures for fossil fuels, nuclear[32] and some renewable energy technologies. Over 2015-2016 the LCOE benchmark for PV has remained stable at 100 $/MWh whereas the LCOE benchmark for onshore wind has fallen 16 % to 68 $/MWh due to the improved capacity factors. The estimated on offshore wind have seen a step change in costs, falling 22 % to 126 $/MWh over this period due to the introduction of competitive bidding procedure for offshore wind subsidies in Denmark and the Netherlands [48].

Biomass for power, hydropower, geothermal and onshore wind can all now provide electricity competitively, compared to fossil fuel-fired power generation. The LCOE of solar PV fell 58% between 2010 and 2015, making it increasingly competitive at utility scale. Despite the fact that offshore wind is in its deployment infancy, this technology is already attractive in some markets, with costs continuing to fall [49].

**Figure 15.** Levelised Costs of Electricity – Global benchmark and regional scenarios, 2016 ($/MWh, nominal)




Source: H2 2016 Global LCOE Outlook [48]

**Box 6. Falls in offshore wind and solar prices**

**Offshore wind:** Many observers were stunned at the huge declines in prices for offshore wind, which more than halved in price in 2016. In 2015, the best price signed for offshore wind was 103 €/MWh (Vattenfall's Horns Rev 3). In 2016, new records were constantly beaten, until November when Vattenfall signed for Denmark's Kriegers Flak at an incredible 49.9 €/MWh (before grid connection of around 5 €/MWh).

**Solar:** German solar auctions prices fell by 14 % in 2016. They fell from 80 €/MWh in the December 2015 auction to 69 €/MWh in the December 2016 auction. Most stunningly, the cross-border German-Danish auction in December 2016 cleared at only 54 €/MWh.6 Solar Power Europe calculated that when you adjust the German prices for increased sunshine, the price would fall to 45 €/MWh in Madrid and Athens.

Solar panel prices fell aggressively by 30 % across 2016, mostly at the end of the year, signalling even more power price declines are yet to come.

*Summarised from " Energy Transition in the Power Sector in Europe: State of Affairs in 2016" [50]*

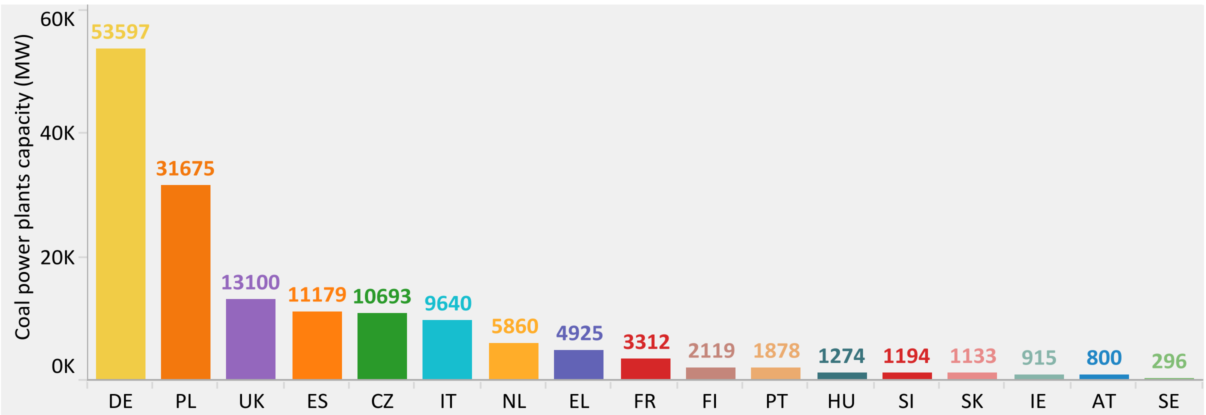
([31]) Adapted from "H2 2016 Global LCOE outlook" [45].
([32]) The LCOE benchmarks for fossil fuels and nuclear are estimated by region. In this figure data refers to EMEA region

# 7. EU fossil fuels displacement: role of renewables

The EU **dependency on imported fossils fuels**[33] has increased, with 73 % of the total imported in 2015, compared with 53 % in 1990. While the ratio of net imports of fossil fuels to EU-produced fossil fuels was just over 1 in 1990, by 2015 over 2 Mtoe of fossil fuels were imported for each Mtoe of fossil fuels produced in the EU.

The EU **energy system** is still a relatively high-emission, fossil-fuel-heavy portfolio. There are wide disparities in countries' energy use, largely owing to the geographic distribution of energy sources. Northern Europe (Belgium, the Czech Republic, Germany, the Netherlands, Poland and the UK) is home to heavy concentrations of coal-fired generation plants for electricity generation. Similarly, gas-fired generation is concentrated in the major production region around the North Sea (Belgium, the Netherlands and the UK), and around the Mediterranean (Italy, Spain).

**Figure 16.** Current coal power plants capacity (operating & under construction) in the EU countries

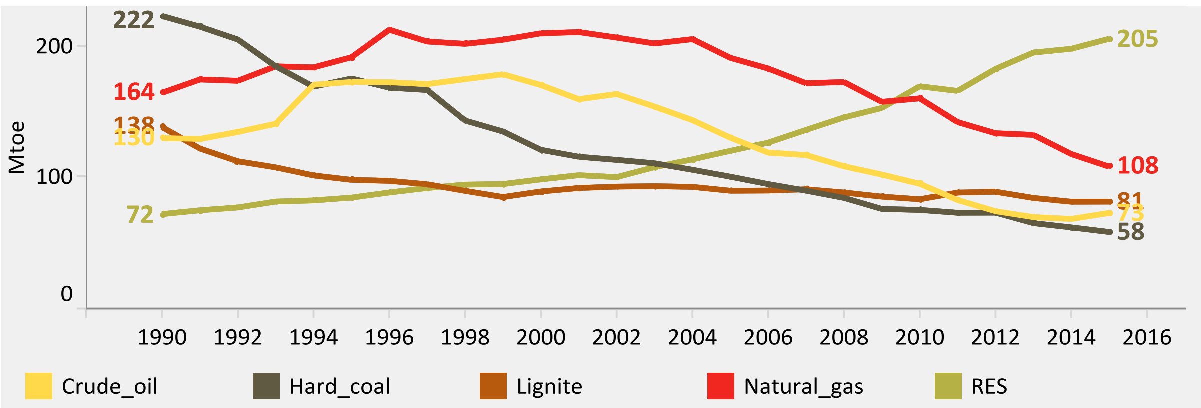



Source: A stress test for coal in Europe under the Paris Agreement [38]

Just two countries – Germany and Poland – are jointly responsible for 51% of the EU's installed capacity (9 GW) and 54% of the emissions from the **coal-fired power plants**. Other big coal users in terms of capacity (emissions) are Czech Republic, Spain, Italy and the UK, with a share of 6.4% (6.2%), 6.7% (4.9%), 5.7% (5.1%) and 7.8% (7.5%) respectively. Smaller coal using countries have hardly built any new power plants in the last decade. As a result, a large part of their current capacity is already more than 30 years old [38].

Figure 17 shows primary production trends in the main fossil fuels (hard coal, lignite, crude oil, natural gas) and renewables from 1990 to 2015. As shown in this figure at EU aggregate level, the primary production of fossil fuels nearly halved between 1990 and 2015. The biggest fall was in hard coal primary production. After 2009, primary production of renewables overtook that of each fossil fuel. Primary production of hard coal fell to a quarter of 1990 levels.

**Figure 17.** Fossil fuels and RES primary production progress in the EU (1990-2015)




Some EU countries have significantly decreased their power production from coal in recent years and announced phasing out coal completely in the coming 10-15 years (e.g. the UK, Finland,

([33]) The dependency rate of fossil fuels is calculated as net imports of fossil fuels (solid fuels, gas and petroleum products) divided by the sum of their gross inland consumption plus bunkers. In 2015 the net import of fossil fuels reached 894.6 Mtoe from 751.4 Mtoe in 1990. Gross inland consumption of fossil fuels (including bunkers) was 1420 Mtoe in 1990 and 1223 Mtoe in 2015.

France), others are building or planning to build new coal-fired power plants (e.g. Poland and Greece) [38]. In Germany and the UK, the production of hard coal fell between 1990 and 2015 by a factor larger than 10; in Poland this drop was with a factor just above 2.

The EU's gross domestic energy consumption - the amount of energy needed to meet all domestic consumption needs - amounted 1628 Mtoe in 2015. This was 2.5 % below 1990 levels and down by 11.6 % compared with its peak of almost 1840 Mtoe in 2006. Fossil fuels continued to represent the lion's share of energy sources, accounting for over 72 % of the EU's domestic energy consumption in 2015, though this was lower than its share in 1990 (83 %). About 16 % of consumption was met by solid fuels, 22 % by gas and 34 % by petroleum products. Hard coal accounts for over two thirds of domestic consumption of solid fuel, while lignite accounts for up to 30.8 %.

Figure 18 shows gross inland consumption trends in the main fossil fuels (hard coal, crude oil, natural gas) and renewables from 1990 to 2015.

Between 1990 and 2015 gross inland consumption of hard coal and lignite fell by 43 %, while the gross inland consumption of gas for energy purposes increased by 20 %. Between 1990 and 2005, the gross inland consumption of gas in the EU rose by 50%; after 2005, it started to fall. The consumption of renewables grew by 193 % between 1990 and 2015; it started to rise faster after 2002 and grew faster than that of other energy sources between 1990 and 2015; nonetheless, it is comparable with the increase of gas.

**Figure 18.** Fossil fuels and RES gross inland consumption progress in the EU (1990-2015)

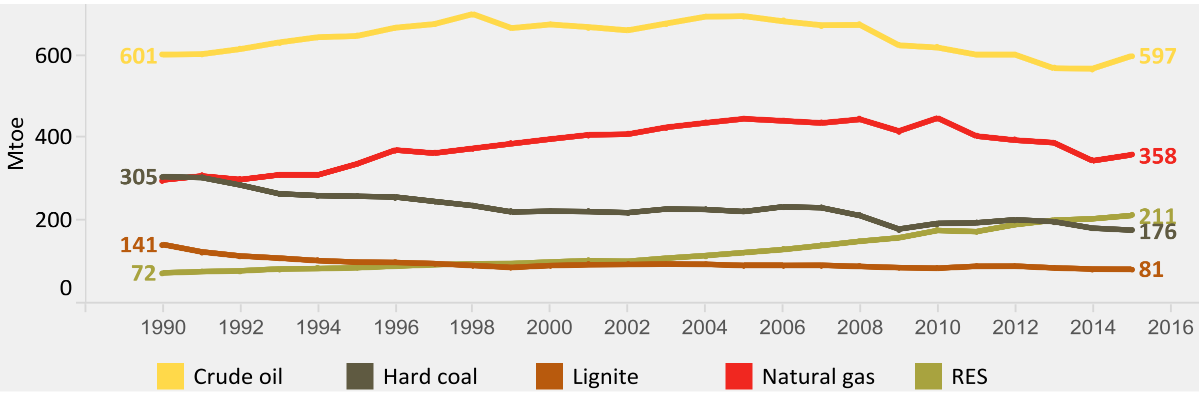



Table 4 shows how the gross inland consumption of solid fuels, petroleum products, gas and renewables changed year-on-year over period 2005-2015. Gross inland consumption of gas has seen the largest year-on-year drop around 2014. This year-on-year decrease overcomes that of solid fuels after 2010.

**Table 4.** Year-on-year change of fossil fuels gross inland consumption, 2005-2015

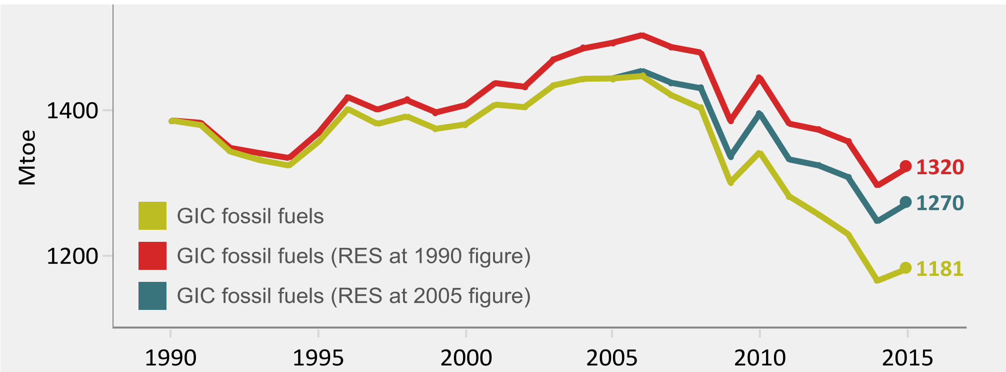
| | Unit | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RES | Mtoe | 7.3 | 17.0 | 27.5 | 35.8 | 53.5 | 50.7 | 67.5 | 78.4 | 81.8 | 90 |
| Solid fuels | Mtoe | 11.6 | 10.3 | -12.8 | -49.2 | -34.9 | -30.3 | -23.7 | -31.1 | -49.2 | -56 |
| Petroleum products | Mtoe | -3.4 | -23.2 | -26.8 | -64.1 | -68.5 | -90.0 | -111.7 | -125.3 | -127.6 | -119 |
| Gas | Mtoe | -4.9 | -10.1 | -1.3 | -29.7 | 1.8 | -41.9 | -51.8 | -57.9 | -101.7 | -87 |
| Total fossil fuels | Mtoe | 3.2 | -23.0 | -41.0 | -143.0 | -101.6 | -162.2 | -187.2 | -214.2 | -278.5 | -262 |

After 2013 the gross inland consumption of renewables overtook that of hard coal. The increasing consumption of renewables after 1990 had **displaced 139 Mtoe[34] of fossil fuels in the EU by 2015** (Figure 19). This displacement equals to 11.5% of gross inland consumption of fossil fuels in 2015. In each Mtoe of fossil fuels decrease since 1990 the contribution of renewables by 2015 was with 0.68 Mtoe.

Keeping the renewables at 2005 level resulted to **a drop of 90 Mtoe** in gross inland consumption of fossil fuels in 2015 equal to 7.6% of gross inland consumption of fossil fuels in 2015 (Figure 20). For each Mtoe of fossil fuels displaced after year 2005 the contribution of renewables by 2015 was with 0.34 Mtoe.

([34]) The calculation keeps the contribution of renewables over period 1990-2015 equal to the 1990 figure. Unless otherwise mentioned the calculation for the displacement of fossil fuels through the use of renewables is done for solid fossil fuels, gas and total oil products. This calculation refers to the gross inland consumption of fossil fuels displaced by renewables.

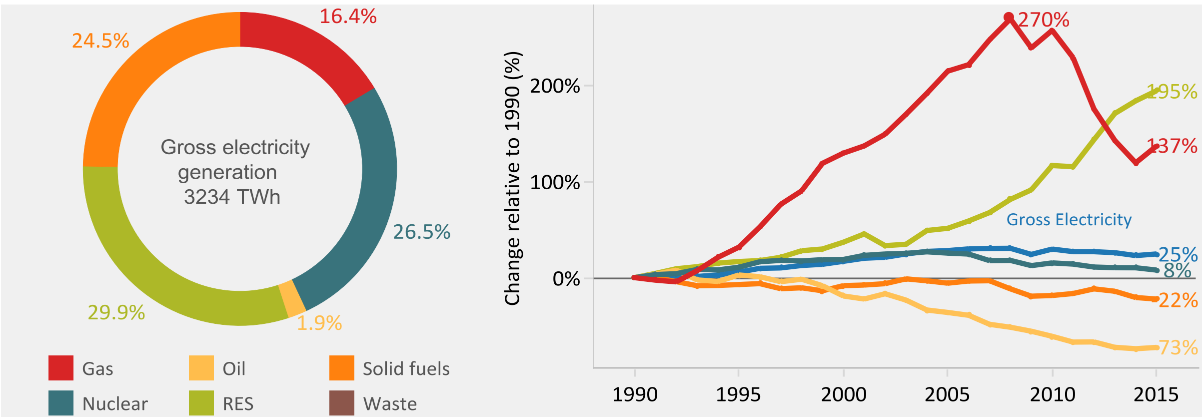
**Figure 19.** Fossil fuels displacement in the EU from the increase of renewable energy consumption since 1990




In 2015, over 42 % of **gross electricity generation** in the EU came from fossil fuels. The share of gas doubled in 2015, compared with 1990. Over the same period, the relative share of oil fell more than 4 times, while the relative contribution of renewables increased two-fold. Currently hard coal and lignite jointly provide over a quarter of electricity generated in the EU.

Figure 20 shows that gross electricity generated from gas peaked around 2008 compared with 1990 (by 270 %), after which it fell by 137 % in 2015. Renewables increased in 2015 by 195 %, compared with 1990 levels. In the meanwhile, oil products fell by 73 % and solid fuels by 22 %. Over 1990-2008, renewables increased by 81 %, while solid fuels fell by 12 %. After 2008, consumption of renewables for electricity generation rose by 62 % while gas consumption fell by 36 %. Consumption of solid fuels was moderate, only 12 % below 2008 levels. Oil consumption fell by 44 % compared with 2008 levels. After 2012 the consumption of renewables for electricity generation overtook that of each fossil fuel.

**Figure 20.** Breakdown of the EU 2015 gross electricity generation and the relative change vs. 1990




Until 2008, the use of solid fuels in electricity generation was displaced mainly by gas. The rapid increase in renewables after 2009 shifted the displacement of solid fuels towards gas, especially after 2011. Between 2008 and 2015, gas was displaced 3 times faster than solid fuels (in relative terms). In absolute terms, the use of solid fuels in the electricity sector fell by 9.3 Mtoe between 2008 and 2015, while the use of gas fell by 25.4 Mtoe and that of nuclear power by 7 Mtoe. From the data one could conclude that renewables actually displaced gas more than other sources.

The use of renewables in gross electricity generation rose by 32 Mtoe over the same period. In 2015, the total amount of fossil fuel used in generating electricity that was displaced by the increase in electricity from renewable sources was **estimated at 56.3 Mtoe**, assuming that renewables were kept at 1990 levels. The quantity of fossil fuels avoided amount to just over 40 % of all fossil fuels displaced in the EU by renewables. Rapid deployment of wind and solar electricity contributed almost 45 % to the overall amount of fossil fuels displaced by renewables.

Due to the low price of carbon allowances in the EU ETS, rather than replacing coal, a big share of the new renewable energy capacity has replaced more expensive energy sources like gas, leading to a slower than required decrease in the power sector's carbon intensity [38].

Half of the coal-gas switch happened in the UK, which was due to coal plant closures and the increase in carbon price floor support. Spanish coal fell early in 2016 as hydro levels returned to normal; French gas generation increased aggressively in late 2016 because of widespread nuclear outages. Germany and Netherlands had a temporary coal-gas switch because gas became cheaper than coal in August, September and October 2016. Greek gas generation took market share from lignite because of a lower gas price and the removal of a tax on gas in June 2016. Italy saw a big change too [50].

Fossil fuels contributed over 75 % of heat production in 2015. Over 1990-2015, the share of solid fuels in **heat production** fell by more than half. Gas used for heating purposes increased by almost 60 % and its share rose to 41.8 %, from 22.7 % in 1990. Meanwhile, the use of oil for heat fell by a factor greater than 4, while the contribution of renewables increased almost 8-fold from its 1990 level.

**Figure 21.** Breakdown of the EU 2015 heat production and the relative change vs. 1990

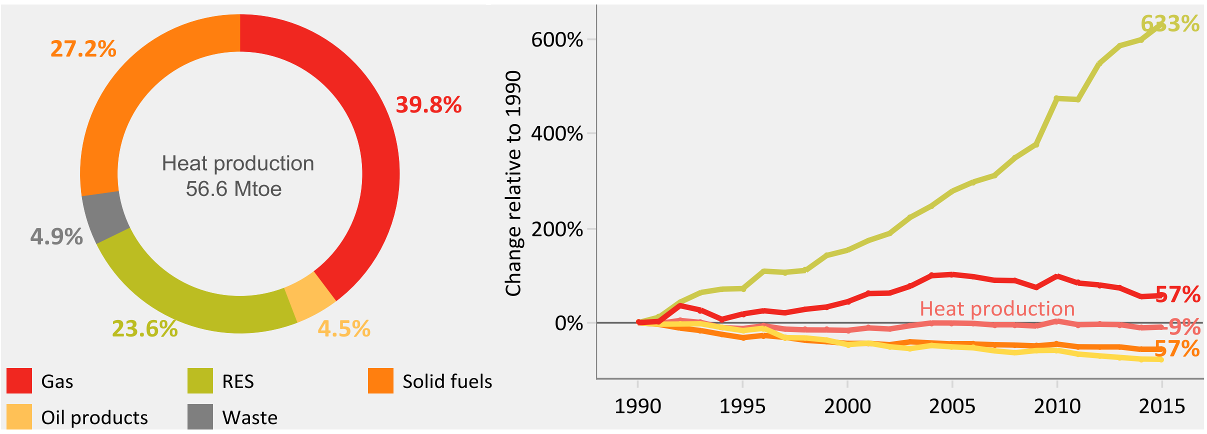
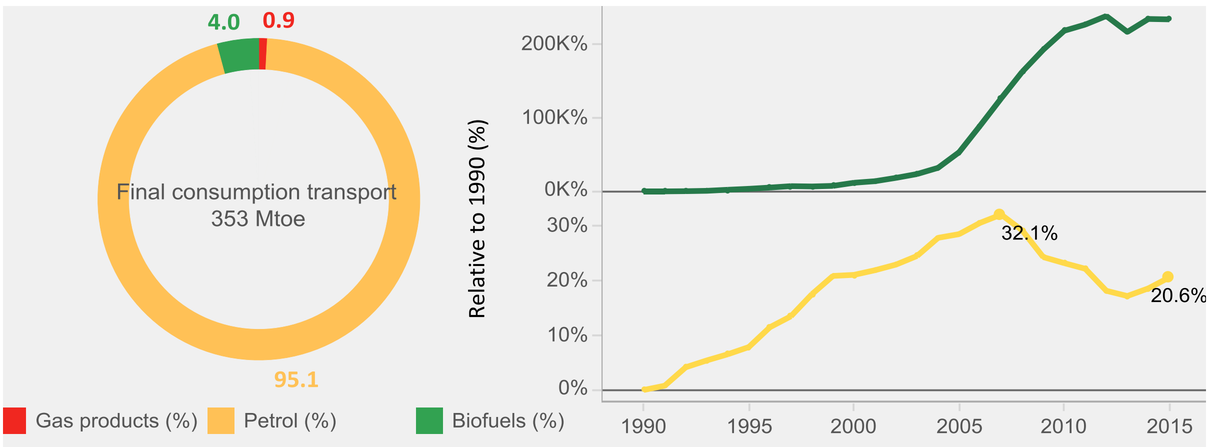



Figure 21 shows that after 1999 gas became the main source of energy for heating/cooling in the EU, exceeding the contribution of solid fuels. In 2003 renewables overtook oil products in this sector. The use of renewables continued to grow; by 2015 their contribution was 5 times that of oil products. The overall amount of fossil fuels used for heat production displaced from renewables in 2015 (keeping renewables at their 1990 level) was **estimated at 11.2 Mtoe** comparable to 8% of overall fossil fuels displacement in the EU from renewables in terms of gross inland consumption.

Final consumption of petroleum products, biofuels and gas products in **transport sector** rose by 27 % (74.3 Mtoe) over the period 1990-2015. It reached 353 Mtoe in 2015. Petroleum products contributed with 95 % at final consumption of fuels in transport sector in 2015. Over period 1990-2015 their contribution rose by 20.6 % (57.3 Mtoe).

**Figure 22.** Breakdown of the EU 2015 final fuels consumption in transport and the relative change vs. 1990




Petroleum products saw the fastest expansion around 2007, at 33 %. Biofuels used in transport sector reached a very fast expansion over the period 1990-2015. Their use reached an increase by 53200 % (3.2 Mtoe) around 2005. After this year the use of biofuels expanded by 338 % (10.8 Mtoe) reaching 14 Mtoe in 2015.

The overall amount of petroleum products used in transport sector displaced from biofuels in 2015 (keeping biofuels at their 1990 level) was **estimated at 11 Mtoe** comparable to almost 8 % of overall fossil fuels displacement in the EU from renewables in terms of gross inland consumption.

By 2015, Germany, the EU's biggest user of coal, was consuming 28 % less of that fuel than in 1990, while UK demand fell by 63 % between 1990 and 2015.

Table 5 shows how much the deployment of renewables has displaced fossil fuels (keeping renewables at their 1990 level) in the EU countries over 1990-2015. Germany was the country where the largest proportion of fossil fuels was displaced during this period. Together with Italy, the UK, Spain and Poland, Germany accounted for almost two-thirds of total displacement of fossil fuels in the EU in 2015. Germany had also the largest fossil fuels displacement in electricity sector. Sweden was the EU country that displaced more fossil fuels in the heating production process.

**Table 5.** Fossil fuels displacement from renewables in the EU countries, 1990-2015[35]

| | Unit | Gross inland consumption | Gross electricity generation | Heat production |
|---|---|---|---|---|
| BE | Mtoe | 3 | 1.3 | 0.04 |
| BG | Mtoe | 2 | 0.6 | 0.01 |
| CZ | Mtoe | 2 | 0.6 | 0.20 |
| DK | Mtoe | 4 | 1.5 | 1.12 |
| DE | Mtoe | 33.6 | 15.4 | 1.29 |
| EE | Mtoe | 0.7 | 0.1 | 0.22 |
| IE | Mtoe | 1 | 0.6 | 0.00 |
| EL | Mtoe | 1.1 | 1.1 | 0.00 |
| ES | Mtoe | 10 | 6.4 | 0.00 |
| FR | Mtoe | 7 | 3.1 | 0.9 |
| IT | Mtoe | 20 | 6.2 | 0.91 |
| CY | Mtoe | 0.2 | 0.1 | 0.001 |
| LV | Mtoe | 0.5 | 0.2 | 0.20 |
| LT | Mtoe | 1.1 | 0.2 | 0.45 |
| LU | Mtoe | 0.1 | 0.1 | 0.01 |
| HR | Mtoe | 0.7 | 0.3 | 0.02 |
| HU | Mtoe | 2.2 | 0.1 | 0.15 |
| MT | Mtoe | 0.1 | 0.1 | 0.00 |
| NL | Mtoe | 2.9 | 1.1 | 0.26 |
| AT | Mtoe | 4.6 | 1.5 | 0.85 |
| PL | Mtoe | 7.4 | 1.7 | 0.04 |
| PT | Mtoe | 1.7 | 1.3 | 0.00 |
| RO | Mtoe | 5 | 1.9 | 0.08 |
| SI | Mtoe | 0.6 | 0.1 | 0.03 |
| SK | Mtoe | 1.2 | 0.3 | 0.13 |
| FI | Mtoe | 5 | 1.3 | 1.66 |
| SE | Mtoe | 7.6 | 2.4 | 2.59 |
| UK | Mtoe | 13.7 | 6.7 | 0.02 |
| EU | Mtoe | 139 | 56.3 | 11.2 |

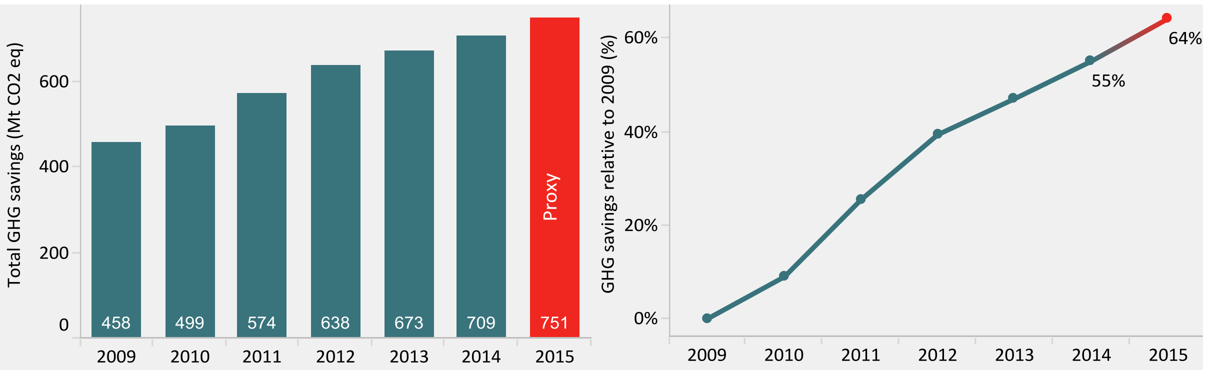
([35]) The calculation kept the contribution of renewables at its 1990 level.

# 8. EU greenhouse emissions savings: role of renewables

In 2014, aggregated greenhouse emissions savings through the use of renewables in the EU[36] were estimated at 709 Mt $CO_2$-eq[37]. Since 2009 the figure rose by 55 % (243.5 Mt $CO_2$-eq.). Per capita emissions savings in the EU rose from 0.9 Mt $CO_2$-eq./capita in 2009 to 1.4 Mt $CO_2$-eq./capita in 2014.

Figure 23 illustrates the trend in emissions savings thanks to the use of renewables in the EU between 2009 and 2014, and the estimated emissions savings in this sector for 2015. As Figure 23 shows, the trend of total greenhouse savings broadly follows the trend of final renewable energy consumption, but the increase was much faster, with a margin of 2 (see Figure 10). The estimated greenhouse emissions savings for 2015 are 751 Mt $CO_2$-eq., 64 % higher than savings in 2009.

**Figure 23.** Trend in greenhouse emissions savings due to RES in EU (left) — Change relative to 2009 (right)

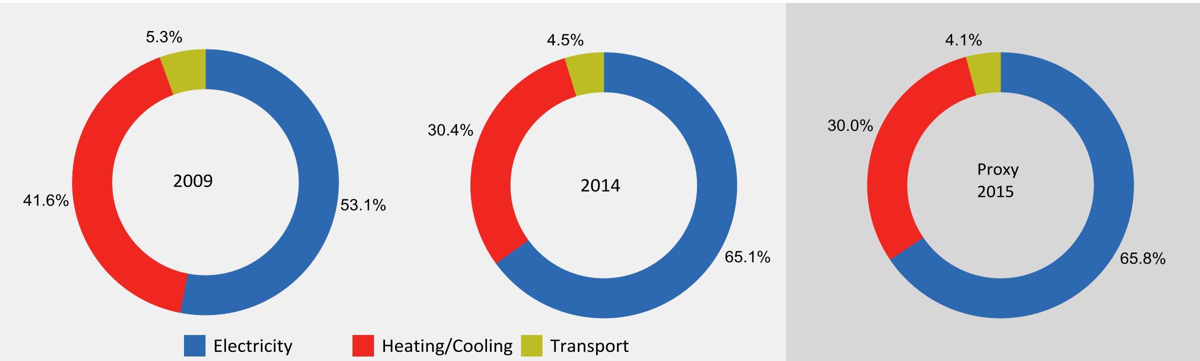



*Source:* JRC renewable energy database, 2017

Electricity from renewable sources was the main contributor to final greenhouse emissions savings in the EU, with a 65.1 % share in 2014, higher than 53 % in 2009. In 2015, the contribution of the electricity sector is estimated to have reached 65.8 %. The role of both heating/cooling and of the transport sector in final greenhouse emissions savings in the EU declined between 2009 and 2014. The decline continued even in 2015. This decline is partly the result of the slower progress of renewable energy in the heating/cooling sector compared with the electricity sector. At the same time, the transport sector is lagging behind expectations. This is because some EU countries refrained from reporting on the use of biofuels in transport because such fuels fall short of the sustainability criteria set out in Article 17 of the RED.

Over 2009-2014, total greenhouse emission savings followed the same trend as the final renewable energy consumption in electricity and heating/cooling sectors. For transport, however, the trends were different.

**Figure 24.** Breakdown of GHG savings from renewables in EU, 2009-2014 and 2015 (proxy)




*Source:* JRC renewable energy database, 2017

Table 6 shows how EU greenhouse emission savings developed from year to year in three sectors: electricity, heating/cooling and transport. The table shows that the absolute year-on-year change

(36) The analysis of the role of renewables in greenhouse emission savings focuses exclusively on 2009-2014. However, an estimate of emissions savings in 2015 is also presented. The figure for the EU as a whole was calculated by adding the proxies of the individual EU countries.

(37) Total greenhouse emissions avoided through the use of renewables in 2014 do not include the contributions of Estonia, Luxembourg or Hungary. Estonia provided no data for 2011-2014, Hungary for 2013-2014 and Luxembourg for 2014.

in EU emissions savings thanks to renewables was more significant around 2011 and in the electricity sector.

**Table 6.** YtY change in EU emissions savings thanks to renewable RES-E, RES-HC and RES-T (Mt $CO_2$-eq.)

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| Electricity | 17.2 | 88.4 | 49.2 | 26.6 | 37.1 | 33.0 |
| Heating/Cooling | 19.8 | -11.9 | 12.0 | 9.3 | -4.0 | 10.2 |
| Transport | 4.0 | 3.1 | 1.8 | -3.8 | 2.8 | -1.2 |

*Source:* JRC renewable energy database, 2017

Table 7 shows how deploying renewables has helped: (i) reduce total emissions; (ii) reduce energy and transport emissions; (iii) reduce emissions from power and heat; (iv) reduce transport emissions.

**Table 7.** Emissions reduction in the EU through the use of renewables, 2009-2015

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 8.7 | 9.2 | 10.8 | 12.0 | 12.8 | 13.8 | 14.4 |
| GHG (E+Tr) emissions reduction (%) | 11.0 | 11.6 | 13.6 | 15.0 | 16.1 | 17.6 | 18.3 |
| GHG (P+H) emissions reduction (%) | 26.5 | 27.9 | 31.1 | 33.2 | 35.5 | 38.5 | 40.2 |
| GHG (Tr) emissions reduction (%) | 2.6 | 3.0 | 3.3 | 3.6 | 3.2 | 3.5 | 3.3 |

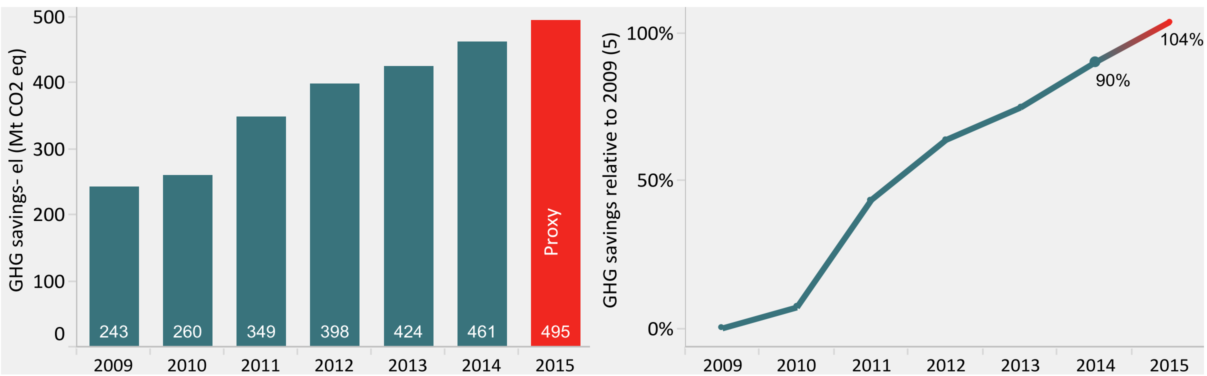
*Source:* EEA [4] and JRC renewable energy database, 2017

Without the current deployment of renewables, EU emissions would have been 8.7 % higher in 2009, 13.8 % higher in 2014 and 14.4 % higher in 2015. Emissions reductions in the energy sector (including transport) through the use of renewables ranged from 11 % in 2009 to 17.6 % in 2014 and 18.3 % in 2015. Over the same period, the largest reduction through the use of renewables in electricity and heating/cooling was experienced in emissions from power and heat, from 26.5 % in 2009 to 38.5 % in 2014 and 40.2 % in 2015. Transport emissions saw the lowest contribution of renewables in this sector during the period under consideration: 2.6 % in 2009, 3.5 % in 2014 and 3.3 % in 2015.

## 8.1 Saving greenhouse emissions in the electricity sector

The electricity sector was the main contributor to overall emissions savings through the use of renewables in the EU. In 2009, these savings accounted for 53 % (243 Mt $CO_2$-eq.) of total emissions savings attributable to the use of renewables in the EU. By 2014, the figure had risen to 65.1 % (451 Mt $CO_2$-eq.). Emissions savings thanks to electricity generated from renewable sources rose from 0.5 t $CO_2$-eq./capita in 2009 to 0.9 t $CO_2$-eq./capita in 2014. Figure 25 illustrates the trend in emissions savings in the EU through the use of renewables in the electricity sector between 2009 and 2014 and estimated emissions savings in this sector in 2015.

**Figure 25.** Trends in emissions savings in the EU thanks to RES-E in EU (left)–Change relative to 2009 (right)



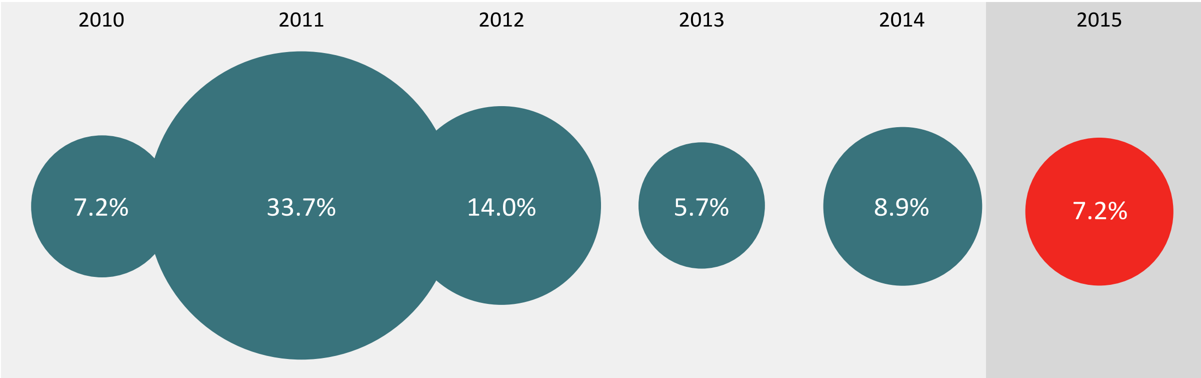

*Source:* JRC renewable energy database, 2017

As Figure 25 shows, emissions savings in the EU attributable to the use of renewable electricity rose by 90 % (216 Mt $CO_2$-eq.) over 2009-2014. This trend replicated the upward trend in the deployment of renewable electricity sources in the EU, but the increase was much faster.

Estimated emissions savings in this sector through the use of electricity from renewables were 495 Mt $CO_2$-eq. – twice the savings achieved by 2009.

Figure 26 shows how emissions savings have changed from year to year owing to the use of renewables to generate electricity. The biggest change (2010-2011) came about because a variety of RES technologies (wind, photovoltaic, etc) were deployed faster at that time.

**Figure 26.** Year-to-year change in EU emissions savings through RES use in electricity generation, 2009-2015

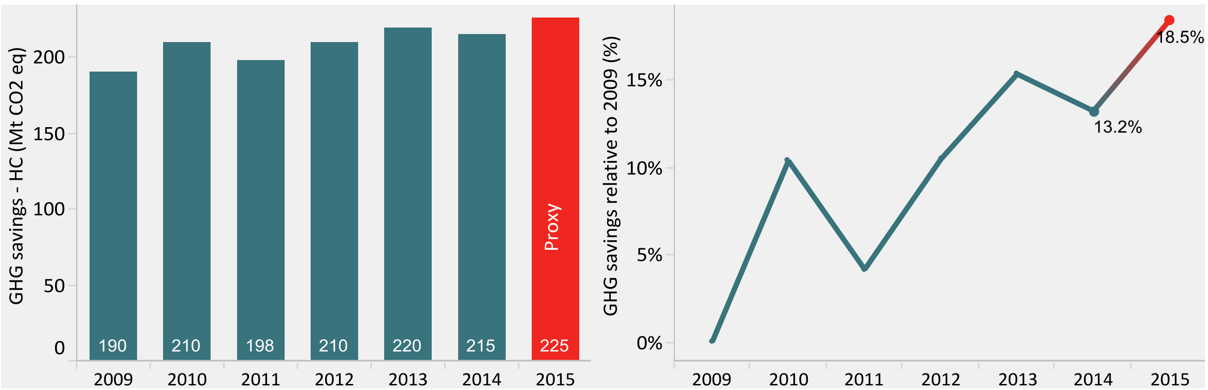



## 8.2 Saving greenhouse emissions in the heating/cooling sector

In 2009, the heating/cooling sector accounted for 41.6 % of total emissions savings (190 Mt $CO_2$-eq.). By 2014 the absolute figure had risen to 215 Mt $CO_2$-eq., even though the sector's share of the total had fallen to 30.4 %. Emissions savings per capita remained almost unchanged at 0.4 t $CO_2$-eq./capita throughout this period.

Figure 27 shows how emissions savings from the use of renewable energy sources in the EU heating/cooling sector changed between 2009 and 2014 and estimated savings for 2015.

**Figure 27.**Trend of GHG emission savings due to RES-HC (left)–Change relative to 2009 (right)

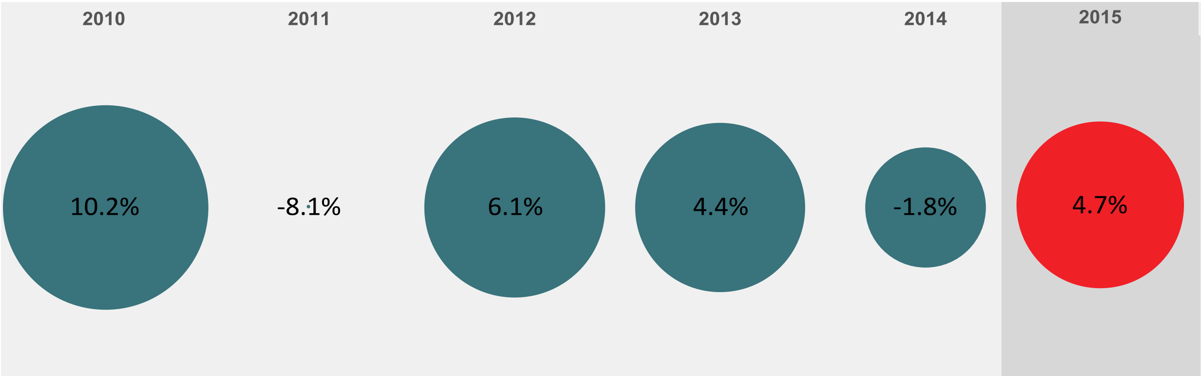



*Source:* JRC renewable energy database, 2017

As shown above, savings thanks to RES deployment in the EU heating/cooling sector over 2009-2014 rose by 13.2 % (19.9 Mt $CO_2$-eq.). This trend replicated the trend in deploying renewable energy sources in the EU heating/cooling sector, but the increase was slower by a margin of almost 2. Estimated emissions savings in this sector through the use of renewables were 225 Mt $CO_2$-eq., or 18.6 % higher than savings in 2009.

Figure 28 shows how emissions savings have changed from year to year owing to the use of renewables to heat production. These savings have seen the largest increase around 2010.

**Figure 28.** Year-to-year change in EU emissions savings through RES use in heat production, 2009-2015

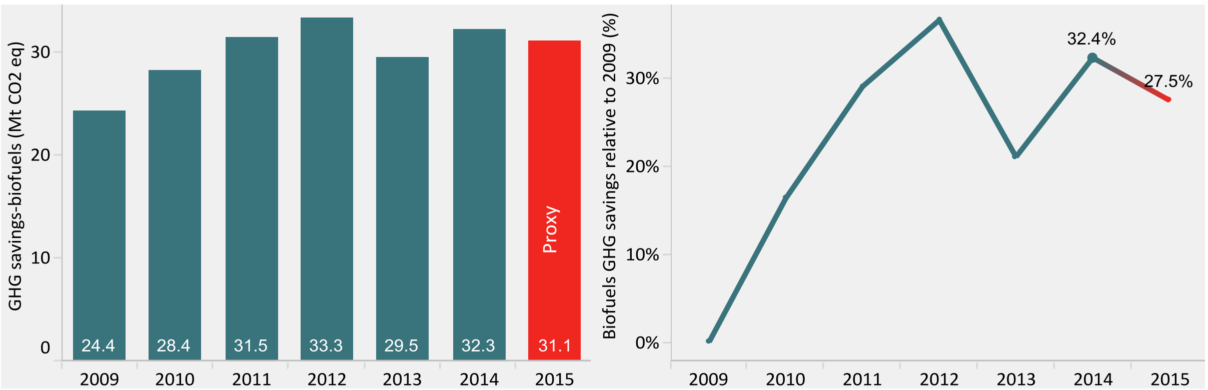



## 8.3 Saving greenhouse emissions in the transport sector [38]

The absolute level of GHG emission savings due to the biofuels use in transport sector increased from 24.4 Mt $CO_2$-eq. in 2009 to 32.3 Mt $CO_2$-eq. in 2014. The proportion of GHG emission savings in this sector rose from 5.3 % in 2009 to 5.7 % in 2010 and then fell back to 4.5% in 2014. The GHG emission savings due to the biofuels used in this sector increased from 50 kg $CO_2$-eq./capita in 2009 to 60 kg $CO_2$-eq./capita in 2014.

Figure 29 illustrates the trend of development of GHG emissions savings from the use of biofuels sector in the EU during period 2009-2014 and the estimated GHG emission savings in this sector for year 2015.

**Figure 29.** Trend of GHG emission savings due to Biofuels (left)–Change relative to 2009 (right)




*Source:* JRC renewable energy database, 2017

As shown in this figure GHG emission savings due to biofuels use in transport sector resulted 32.4% (+7.5 Mt $CO_2$-eq.) higher in 2014 compared with 2009. This trend developed differently from the trend of biofuels in transport sector. It saws the fastest deployment around 2010. The proxy for 2015 is estimated at 31.1 Mt $CO_2$-eq., or 27.6% over the level in 2009.

([38]) Due to the requirements of Article 17 of the RED relating to sustainability criteria for biofuels and bioliquids, some Member States did not report on the use in transport of biofuels that did not fulfil the criteria. It is not clear from the three sets of progress reports whether all biofuels were taken into account when calculating the GHG emission savings from this sector.

# 9. Role of EU countries in EU greenhouse emissions savings through the use of renewables

We set out below a summary of the Member States' contribution to the total GHG emission saving for 2009-2015 due to renewable energy use in three sectors: electricity, heating/cooling and transport.

Germany reported the largest GHG emission savings due to the use of renewable energy, at 154 Mt $CO_2$-eq. in 2014 estimated at 156 Mt $CO_2$-eq. in 2015. Italy was the second Member State to have saved more GHG emissions through the role of renewable energy, at 85 Mt $CO_2$-eq. in 2014 estimated at 89 Mt $CO_2$-eq. in 2015.

The five best performing Member States with the highest additional GHG emission savings due to renewable energy use between 2009 and 2014 were Germany (+47 Mt $CO_2$-eq.), France (+40.6 Mt $CO_2$-eq.), the United Kingdom (+33.3 Mt $CO_2$-eq.), Italy (+30 Mt $CO_2$-eq.) and Romania (+18.5 Mt $CO_2$-eq.). These five accounted for more than 72 % of the additional GHG emission savings in the EU in 2009-2014.

The fastest growth in GHG emission savings between 2009 and 2014 took place in Malta, which recorded a compound annual growth rate (CAGR) of 50.8 %. However, the absolute value of Malta's savings was very marginal. Slovenia recorded the second highest CAGR of 29.6 %, followed by the United Kingdom with 26 %, France with 12 % and Belgium with 11.2%.

In 2014, Finland had the highest GHG emission savings per capita with 7.9 Mt $CO_2$-eq./capita, followed by Austria with 3.3 Mt $CO_2$-eq./capita, Denmark with 3.1 Mt $CO_2$-eq./capita, Slovenia with 3 Mt $CO_2$-eq./capita and Latvia with 2.7 Mt $CO_2$-eq./capita.

During period 2009-2014 the use of renewable energy_resulted in lower additional savings of GHG emissions in three Member States: Hungary, Lithuania, Austria and Slovakia. The picture for the change in renewable energy consumption from 2009 to 2014 was slightly different. This is because almost all Member States increased their consumption of renewable energy during this period, except Portugal.

More than two thirds of total GHG emission savings in the EU in 2014 came from renewable energy growth in six Member States: Germany (22.3%), Italy (12.3%), France (11.9%), Spain (8%), Romania (6.5%) and United Kingdom (6.4%).

GHG emission savings from the use of **renewable electricity** was led by Germany with 111 Mt $CO_2$-eq. in 2014, estimated at 118 Mt $CO_2$-eq. in 2015. Italy followed with 63.8 Mt $CO_2$-eq. in 2014 together with France (56.4 Mt $CO_2$-eq.), UK (41.5 Mt $CO_2$-eq.) and Spain (40.8 Mt $CO_2$-eq.). Together they accounted for almost 69 % of the total GHG emission savings from the consumption of renewable electricity.

Slovenia had the fastest increase in GHG emission saved in electricity sector during period 2009-2014, with a CAGR of 280 %, but its contribution in absolute values remained very marginal. Malta, Cyprus and France experienced the other four fastest increases during this period respectively with a CAGR of 121%, 48% and 45.7%. In per capita terms, Finland had in 2014 the highest savings of GHG emissions in electricity sector, recording a figure of 3.1 Mt $CO_2$-eq.. It was followed by Slovenia with 2.3 t $CO_2$-eq./capita, Austria with 1.96 t $CO_2$-eq./capita and Denmark with 1.8 t $CO_2$-eq./capita.

The largest GHG emissions savers due to the use of renewable energy in **heating/cooling** sector in 2014 were Germany with 38 Mt $CO_2$-eq., estimated at 34 Mt $CO_2$-eq. in 2015. Finland followed with 25 Mt $CO_2$-eq. together with France (19.9 Mt $CO_2$-eq.), Italy (19.1 Mt $CO_2$-eq.), and Poland (18 Mt $CO_2$-eq.). Their contribution accounted for 58.4 % of the total GHG emission saving from the use of renewable energy in heating/cooling. In this sector, six Member States reported lower GHG emission savings between 2009 and 2014: Ireland, Spain, France, Lithuania, Austria and Slovakia.

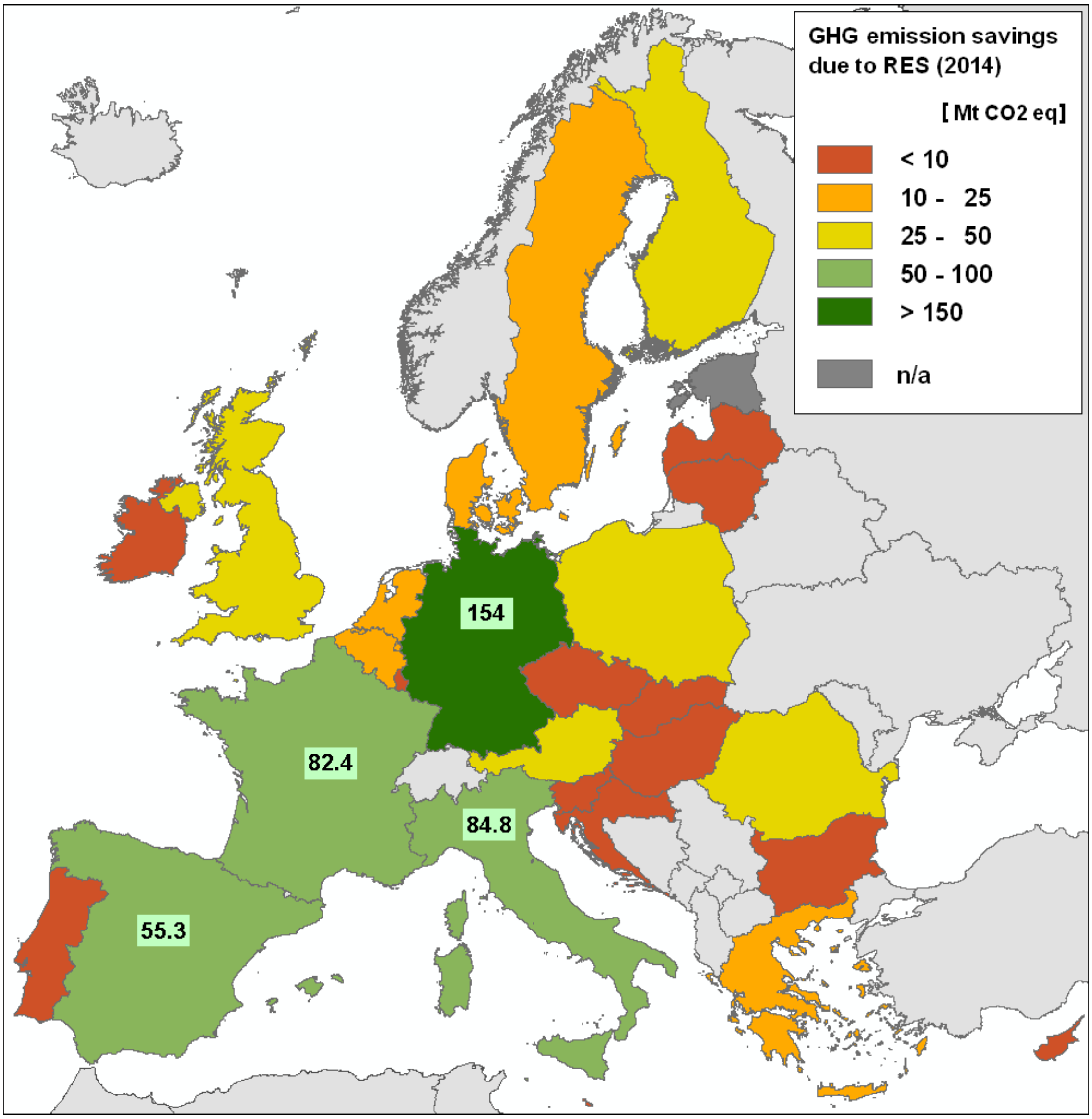
Due to France's use of two different methodologies in its two progress reports, its GHG emission savings due to renewable energy use on heating/cooling in 2009-2010 were almost double its GHG emission savings for 2011-2012. France actually recorded a slight slowdown in renewable energy consumption on heating/cooling in 2011 compared with 2010, as the figure almost returned to its 2009 level. In 2014, the use of renewable energy in heating/cooling sector in France increased and the GHG emission savings followed the same trend.

Germany had the highest additional GHG emission savings in heating/cooling between 2009 and 2014, with 5.0 Mt $CO_2$-eq., followed by Finland with 4.6 Mt $CO_2$-eq.. Malta had the fastest increase between 2009 and 2014, recording a CAGR of 38.2 %. Belgium reported the second fastest increase in savings of GHG in heating/cooling sector, with a CAGR of 11.5 %. In per capita terms, Finland recorded the highest GHG emission savings due to renewable heat with 4.6 t $CO_2$-eq./capita followed by Latvia with 2.25 t $CO_2$-eq./capita.

France had the highest GHG emission savings (6.16 Mt $CO_2$-eq.) due to renewable energy use in **transport sector**, followed by Germany with 5 Mt $CO_2$-eq., United Kingdom with 2.9 Mt $CO_2$-eq., Poland with 2.7 Mt $CO_2$-eq. and Sweden with 2.3 Mt $CO_2$-eq..

Five Member States (Belgium, Spain, France, Hungary and Slovenia) produced lower savings of GHG emissions from renewable energy use in transport between 2009 and 2014. Austria had the highest additional savings of GHG emissions due to the use of biofuels between 2009 and 2014 with +1.9 Mt $CO_2$-eq., followed by Sweden with +1.5 Mt $CO_2$-eq., United Kingdom with +1.1 Mt $CO_2$-eq., Romania with +1.0 Mt $CO_2$-eq. and Denmark with +0.7 Mt $CO_2$-eq.. Bulgaria and Malta had the highest positive CAGRs between 2009 and 2014, recording figures of 54.6 % and 39.3 % respectively. Luxembourg had the highest savings in per capita terms, with 0.3 t $CO_2$-eq./capita, followed by Sweden (0.24 t $CO_2$-eq./capita), Austria (0.23 t $CO_2$-eq./capita) and Denmark (0.12 t $CO_2$-eq./capita).

**Figure 30.** Estimated GHG emission savings in the EU Member States, 2015



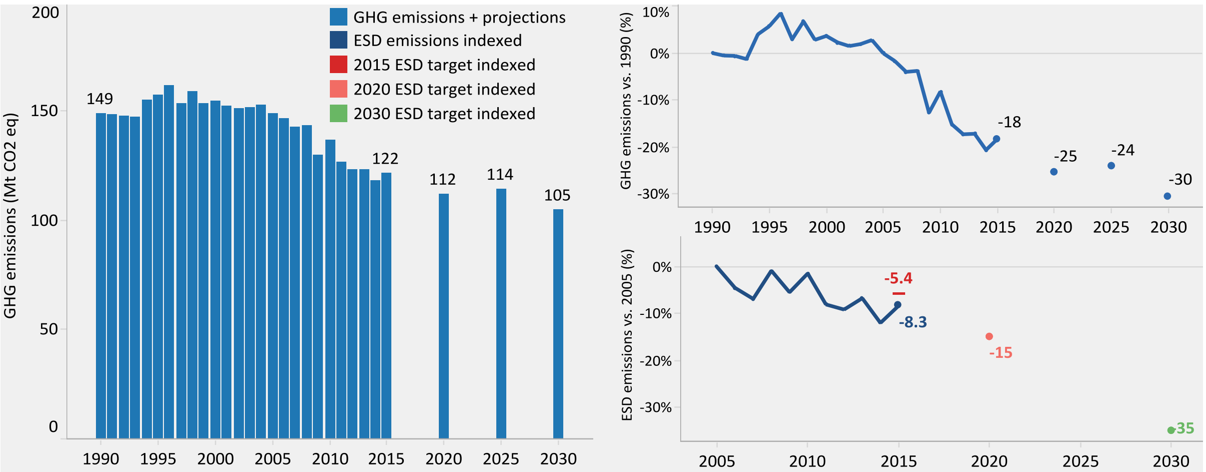
## 9.1 Belgium

### 9.1.1 GHG emissions: trends & projections

In 2015, Belgium emitted 97 Mt $CO_2$, a fall of 16.4 % (or 19 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by ESD reached 73 Mt $CO_2$-eq., 3.1 % (2.3 Mt $CO_2$-eq.) **below the ESD target**[39]. Total GHG emissions in Belgium were almost 122 Mt $CO_2$-eq. in 2015, or 18 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Belgium are projected to fall below the 1990 level by 25 % and 30 % respectively.

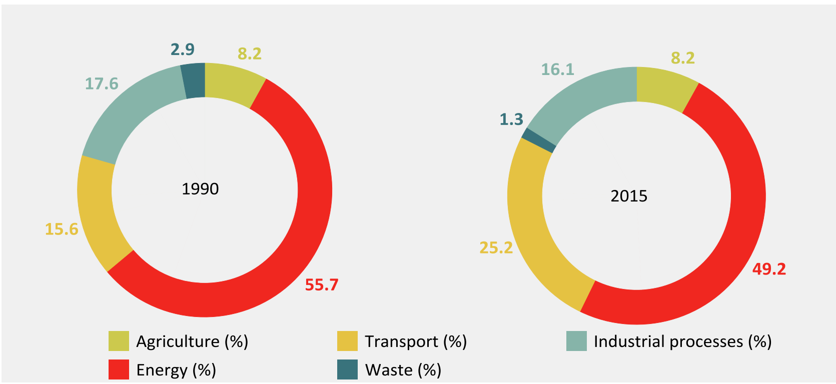
Figure 31 illustrates (i) the overall trend in GHG emissions in Belgium over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year[40]; and (v) the 2020 and 2030 ESD targets.

**Figure 31.** GHG emissions in BE, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Belgium since 1990. They totalled 59.8 Mt $CO_2$-eq. in 2015, having decreased by almost 28 % since 1990. GHG emissions from the transport sector reached 30.7 Mt $CO_2$-eq. in 2015, 32.5 % higher than the 1990 figure, making it the second largest source of GHG emissions.

**Figure 32.** GHG emissions in BE broken down by source, 1990 (left) — 2015 (right)

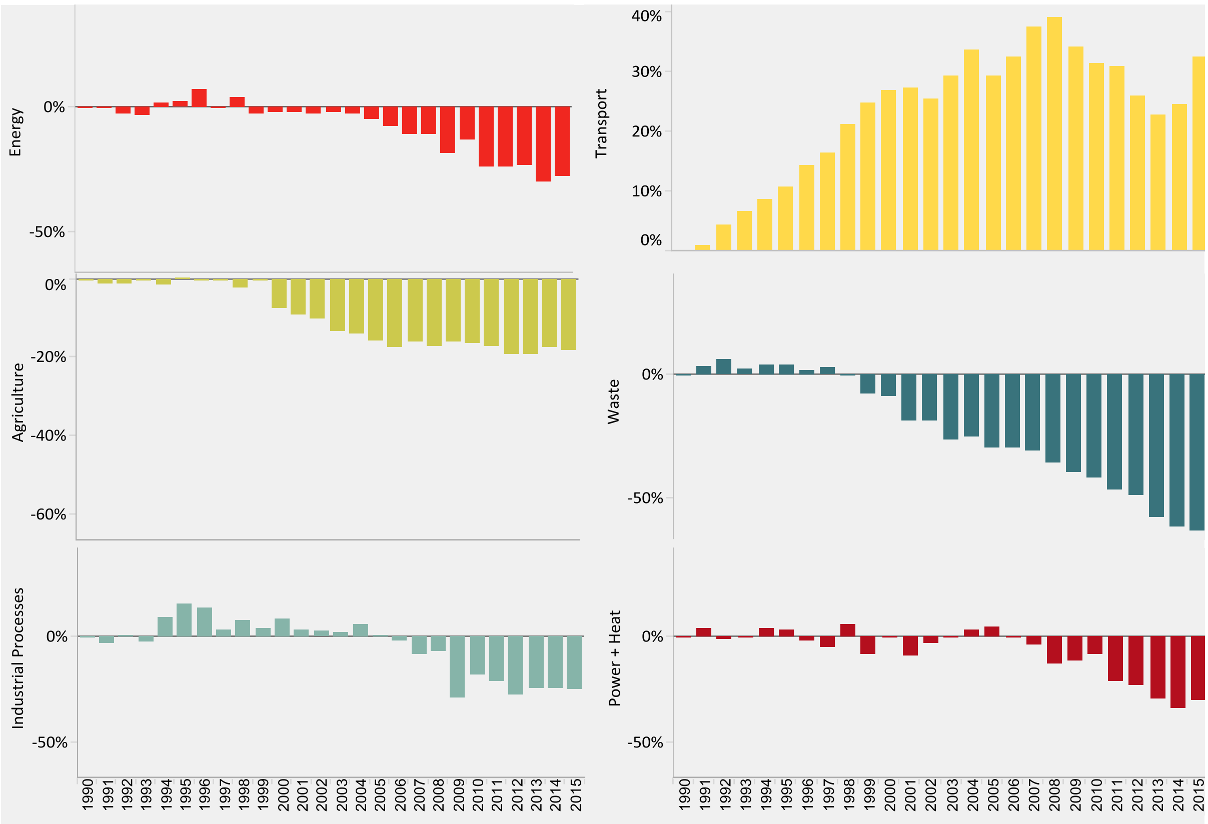



Some sectors in Belgium, such as energy and waste management, did not see a fall in their GHG emissions until after 1998. Only GHG emissions from agriculture decreased immediately after 1990. Even then, the 18.3 % decline in emissions from that sector between 1990 and 2015 kept its relative share unchanged. The decrease in emissions from industrial processes and product use only began after 2005. In 2015 their absolute contribution amounted to 19.5 Mt $CO_2$-eq., a lower share than in 1990. GHG emissions from public power and heat production also began to fall after 2005. In 2015, they came to 16.4 Mt $CO_2$-eq., or 27.4 % of energy-related GHG emissions in that

([39]) Belgium's ESD GHG emissions target for 2015 was 75.32 Mt $CO_2$-eq. The target for 2020 is set to 67.68 Mt $CO_2$-eq.
([40]) For all EU countries ESD GHG emissions are indexed against the 2005 base year as sourced by [4].

year. The fall in emissions from waste management began after 1998. These emissions decreased by more than 63 % (or 2.7 Mt $CO_2$-eq.) compared with 1990, to stand at 1.6 Mt $CO_2$-eq.

**Figure 33.** Changes of GHG emissions from sectors relative to 1990 — BE

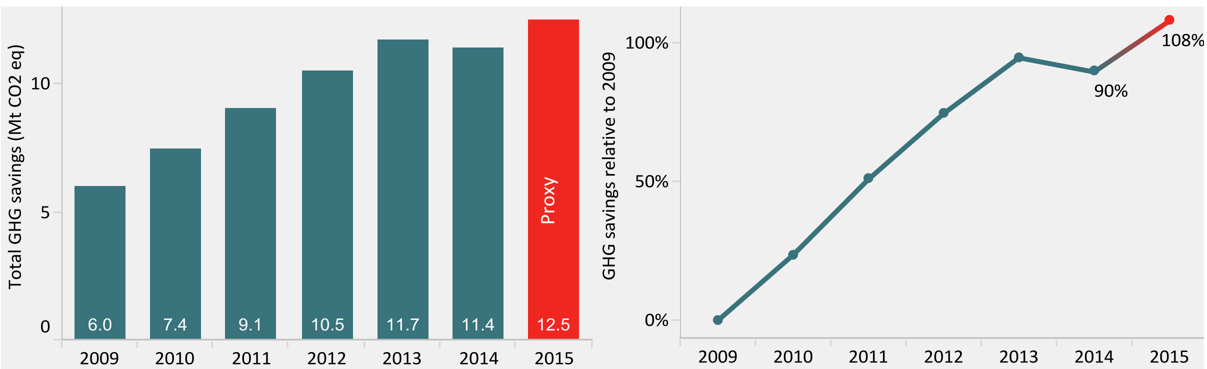



## 9.1.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Belgium from the use of renewable energy in three sectors — electricity, heating/cooling, and transport — rose sharply, by 90 % (or 5.4 Mt $CO_2$-eq.) over 2009-2014, reaching 11.4 Mt $CO_2$-eq. In per capita terms GHG emissions almost doubled, from 0.56 to 1 t $CO_2$-eq.

Figure 34 illustrates the trend in GHG emissions savings from renewable energy use in Belgium over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 34.** Trend in GHG emissions savings from RES in BE (left) — Change relative to 2009 (right)




Renewable electricity was the main contributor to overall GHG emissions savings in Belgium between 2009 and 2014, increasing from 53.7 % to 58.6 %. This contribution increased further to 62.5 % in 2015. The contribution of renewable energy in the heating/cooling sector remained almost unchanged, at just over 35 %. The contribution from savings from biofuels in the transport sector almost halved in 2014 compared with 2009, from 10.9 % to 5.7 %. It fell by two thirds in 2015, to 3.2 %.

**Figure 35.** Breakdown of GHG savings from renewables in BE, 2009-2014 and 2015 (proxy)

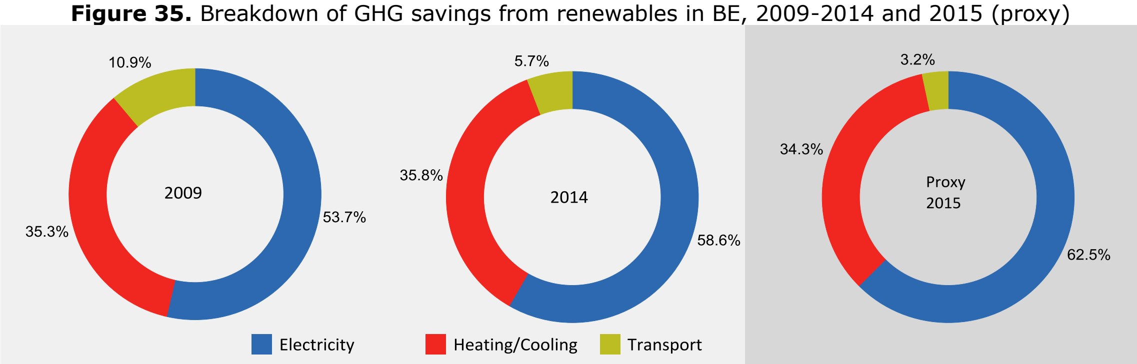



Table 8 shows how the deployment of renewable energy in Belgium during the period 2009-2015 has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 8.** Emissions reduction in BE through the use of renewables, 2009-2014 and 2015 (proxy)

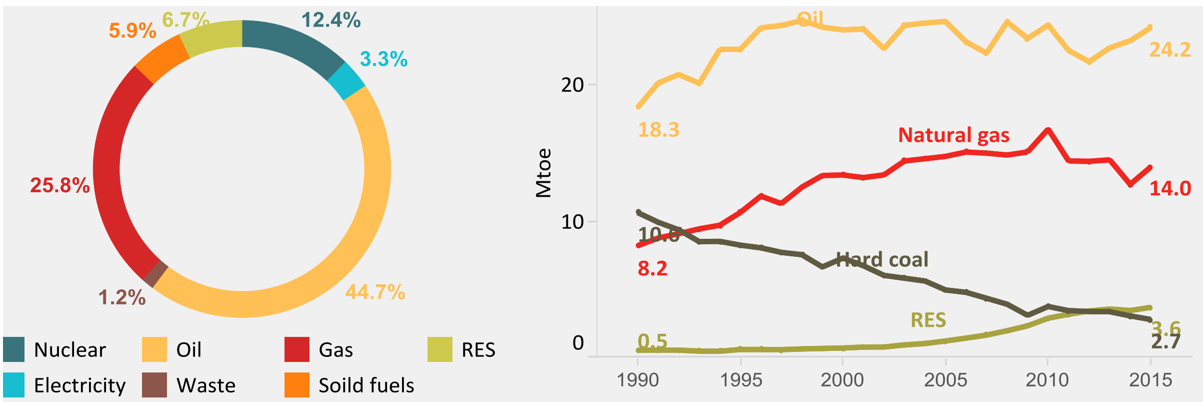
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 4.4 | 5.2 | 6.7 | 7.9 | 8.7 | 8.8 | 9.3 |
| GHG (E+Tr) emissions reduction (%) | 6.0 | 7.0 | 9.3 | 10.7 | 11.8 | 12.1 | 12.7 |
| GHG (P+H) emissions reduction (%) | 20.4 | 23.0 | 31.7 | 35.6 | 40.1 | 40.9 | 42.5 |
| GHG (Tr) emissions reduction (%) | 2.4 | 3.7 | 1.8 | 1.9 | 2.2 | 2.5 | 1.5 |

Without the current deployment of renewable energy, GHG emissions in Belgium would have been 4.4 % higher in 2009 and 8.8 % higher in 2014. The reduction in GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 6 % in 2009 to 12.2 % in 2014. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewables in the electricity and heating/cooling sectors, from 20.4 % in 2009 to 40.9 % in 2014. The contribution of biofuels to the reduction of GHG emissions from transport remained marginal, at almost 2.5 % in 2009 and 2014 alike.

### 9.1.3 Fossil fuel displacement: role of renewables

The features of the energy mix in Belgium include a higher share of petroleum products and gas and a lower share of solid fuels and renewables. In 2015 more than 76 % of Belgium's gross inland consumption of energy was met by fossil fuels. Belgium is an import-dependent country; in 2015 it recorded its highest dependency rate since 1990, at 84.3 %. The role of renewables became more prevalent around 2005 and by 2015 it had achieved the fastest expansion, at 214 %. This served to displace fossil fuels — by as much as 3 Mtoe in 2015[41]. Forty-three per cent (1.3 Mtoe) of this displacement took place in the electricity sector; the main fossil fuel displaced was hard coal.

**Figure 36.** Breakdown of gross inland consumption in Belgium, 2015 (left) — trend over 1990-2015 (right)




([41]) The calculation freezes the contribution of renewables at its 1990 level.

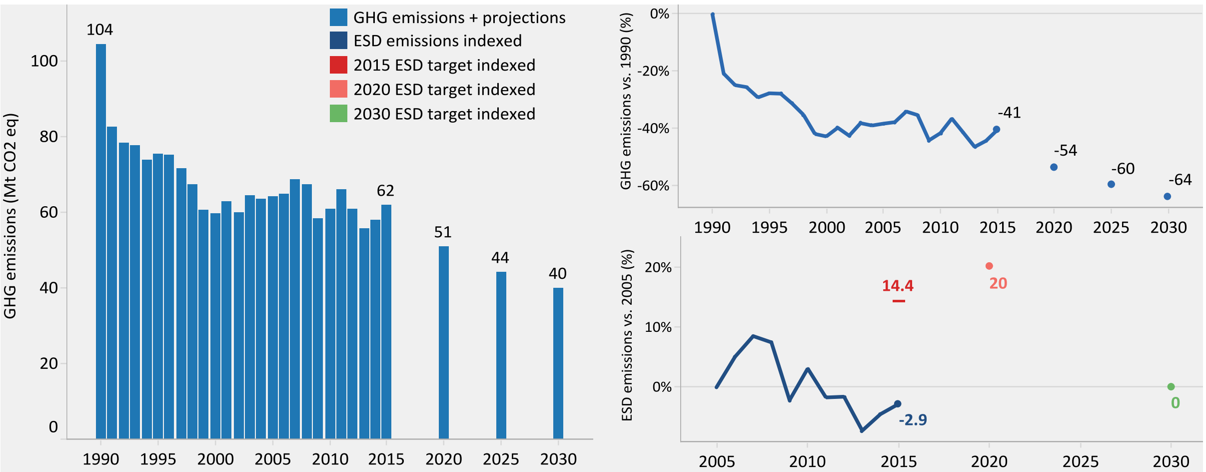
## 9.2 Bulgaria

### 9.2.1 GHG emissions: trends & projections

In 2015, Bulgaria emitted 53.4 Mt $CO_2$, a fall of 34.4 % (or 28 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by the ESD scheme reached 23.3 Mt $CO_2$-eq., 15 % (4.2 Mt $CO_2$-eq.) **below the ESD target**[42]. Total GHG emissions in Bulgaria reached 62 Mt $CO_2$-eq. in 2015, or 40.6 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Bulgaria are projected to fall below the 1990 level by 54 % and 64 % respectively.

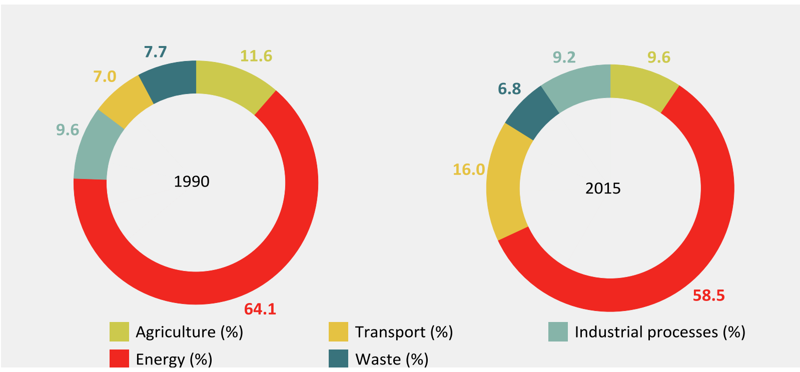
Figure 37 illustrates (i) the overall trend in GHG emissions in Bulgaria over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 37.** GHG emissions in BG, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Bulgaria since 1990. They totalled 36.3 Mt $CO_2$-eq. in 2015, having decreased by 45.8 % since 1990. GHG emissions from the transport sector reached 9.4 Mt $CO_2$-eq. in 2015, 42.2 % higher than the 1990 figure, making it the second largest source of GHG emissions.

**Figure 38.** GHG emissions in BG broken down by source, 1990 (left) — 2015 (right)

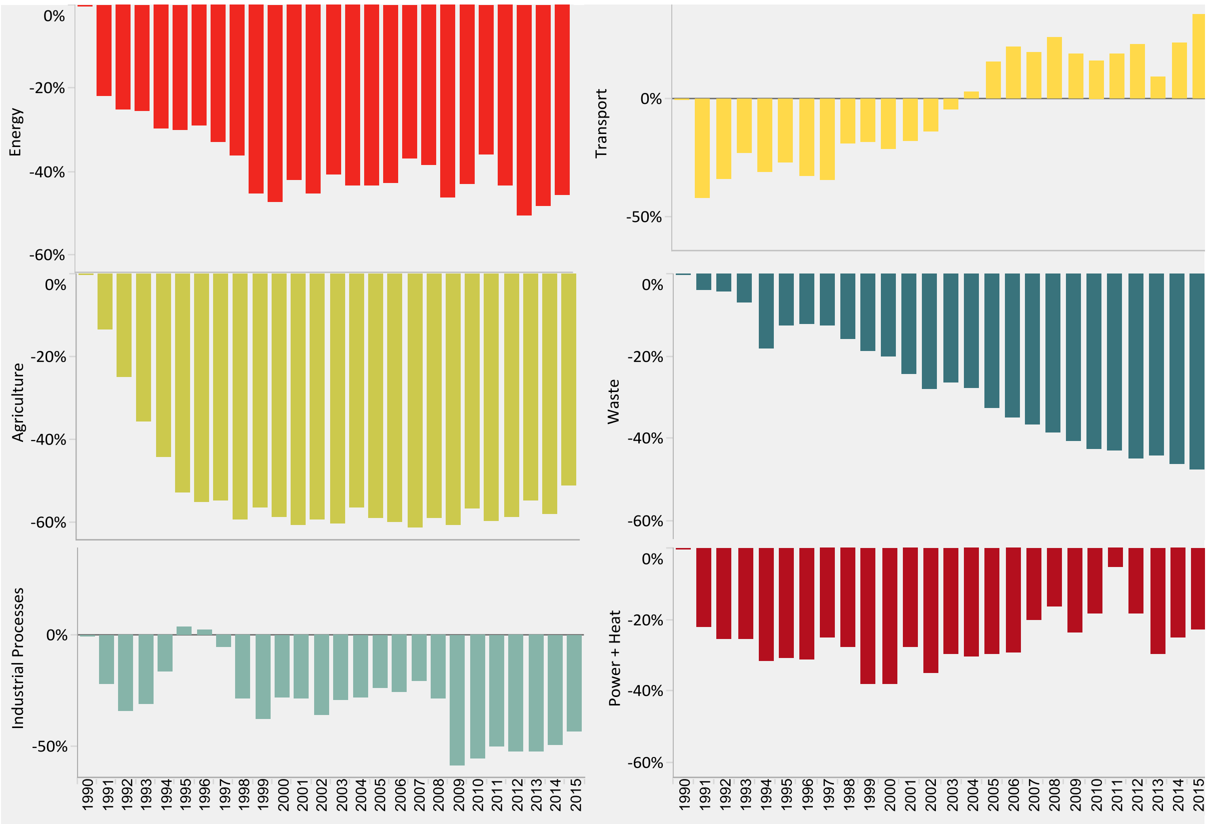



All sectors in Bulgaria saw their GHG emissions fall immediately after 1990. The increase in GHG emissions from transport only began after 2004. The largest fall of GHG emissions since 1990 was experienced in the agriculture sector. In 2015 their absolute contribution came to 5.9 Mt $CO_2$-eq., a fall of 51 % compared with the 1990 figure. GHG emissions from industrial processes and product use came to 5.7 Mt $CO_2$-eq. in 2015, from 10 Mt $CO_2$-eq. in 1990. GHG emissions from public power and heat production came to 29 Mt $CO_2$-eq. in 2015, 23 % below their 1990 level. In the same year these emissions covered more than 80 % of Bulgarian energy-related GHG

([42]) Bulgaria ESD GHG emissions target for 2015 was 27.47 Mt $CO_2$ eq. The target for 2020 is set to 28.8 Mt $CO_2$-eq.

emissions. GHG emissions from waste management were 4.2 Mt $CO_2$-eq. in 2015, or 47.6 % below their 1990 figure.

**Figure 39.** Changes of GHG emissions from sectors relative to 1990 — BG

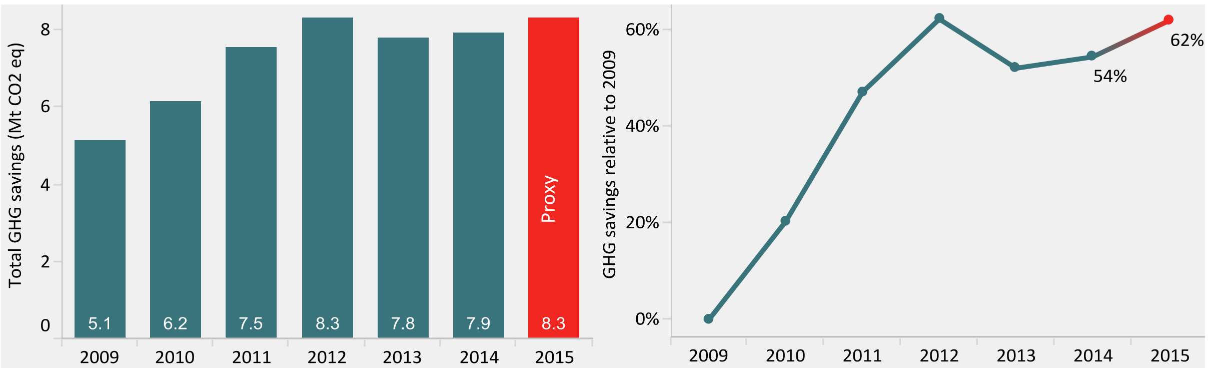



## 9.2.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Bulgaria through the use of renewable energy in three sectors— electricity, heating/cooling and transport – rose by 54 % (or 2.8 Mt $CO_2$-eq.) over 2009-2014, reaching 7.9 Mt $CO_2$-eq. In per capita terms GHG emissions in Bulgaria rose from 0.7 to 1.1 t $CO_2$-eq. in 2014.

Figure 40 illustrates the trend in GHG emissions savings from renewable energy use in Bulgaria over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 40.** Trend in GHG emissions savings from RES in BG (left) — Change relative to 2009 (right)




Renewable energy in heating/cooling was the main contributor to overall GHG emissions savings in Bulgaria between 2009 and 2014. These savings reached 3.9 Mt $CO_2$-eq. in 2014, or 40.8 % above the 2009 level. The contribution of renewable electricity reached 3.8 Mt $CO_2$-eq. in 2014, 64.5 % more than in 2009. The impact of biofuels on overall GHG emissions savings has been marginal even though their relative share increased tenfold between 2009 and 2014.

**Figure 41.** Breakdown of GHG savings from renewables in BG, 2009-2014 and 2015 (proxy)

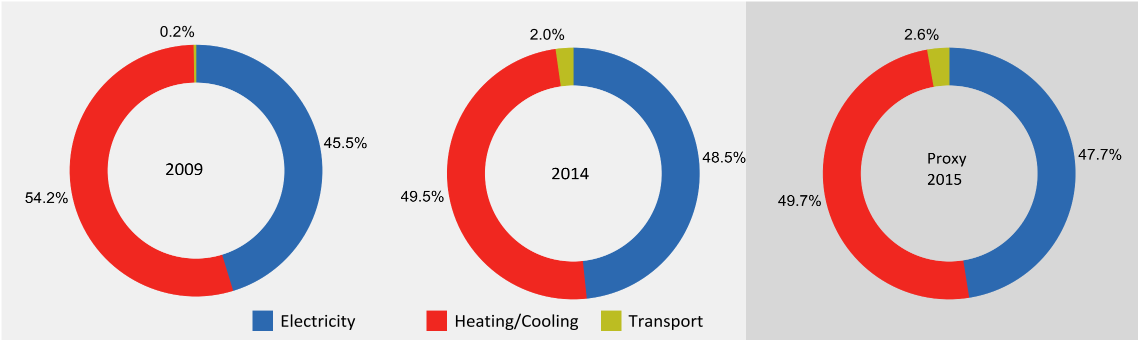



Table 9 shows how the deployment of renewable energy in Bulgaria during period 2009-2015 has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 9.** Emissions reduction in BG through the use of renewables, 2009-2014 and 2015 (proxy)

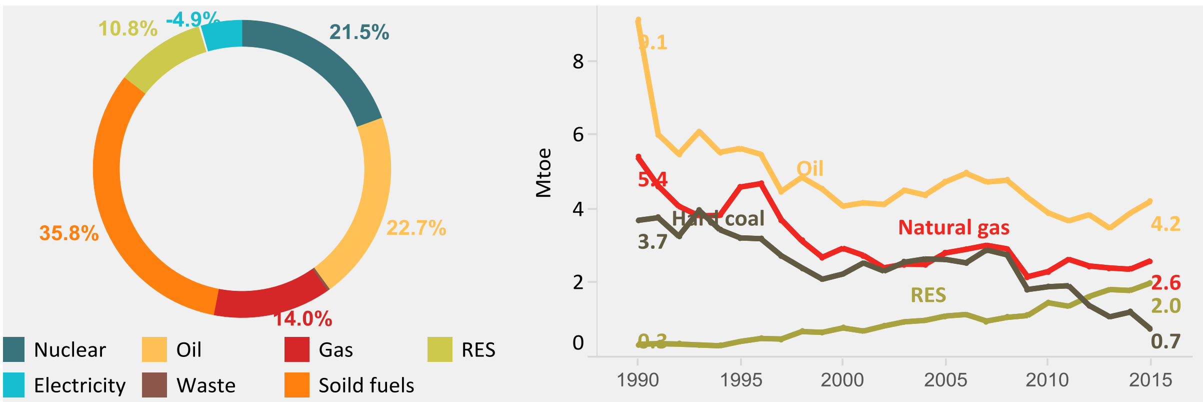
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 8.1 | 9.2 | 10.2 | 12.0 | 12.3 | 12.0 | 11.8 |
| GHG (E+Tr) emissions reduction (%) | 10.4 | 11.8 | 12.9 | 15.2 | 16.1 | 15.5 | 15.4 |
| GHG (P+H) emissions reduction (%) | 15.2 | 16.7 | 17.5 | 21.3 | 22.5 | 21.6 | 21.8 |
| GHG (Tr) emissions reduction (%) | 0.1 | 0.3 | 0.2 | 0.1 | 2.0 | 1.9 | 2.2 |

Without the current deployment of renewable energy, GHG emissions in Bulgaria would have been 8.1 % higher in 2009 and 12 % higher in 2014. The reduction in GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 10.4 % in 2009 to 15.5 % in 2014. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 15.2 % in 2009 to 21.6 % in 2014. The contribution of biofuels to the reduction of GHG emissions from transport remains marginal: 0.1 % in 2009 and 1.9 % in 2014.

## 9.2.3 Fossil fuel displacement: role of renewables

The energy mix in Bulgaria includes a higher share of solid fuels, petroleum products and nuclear and a lower share of gas and renewables. In 2015 more than 72 % of Bulgaria's gross inland consumption of energy was met by fossil fuels. Bulgaria's domestic solid fuels and nuclear production influences the relatively low-import dependency that reached 35.4 % in 2015. The role of renewables became more prevalent after 2010 surpassing the gross inland consumption of hard coal. This deployment served to displace fossil fuels — by as much as 2 Mtoe in 2015. One-third (0.6 Mtoe) of this displacement took place in the electricity sector; the main fossil fuel displaced was hard coal.

**Figure 42.** Breakdown of gross inland consumption in Bulgaria, 2015 (left) — trend over 1990-2015 (right)



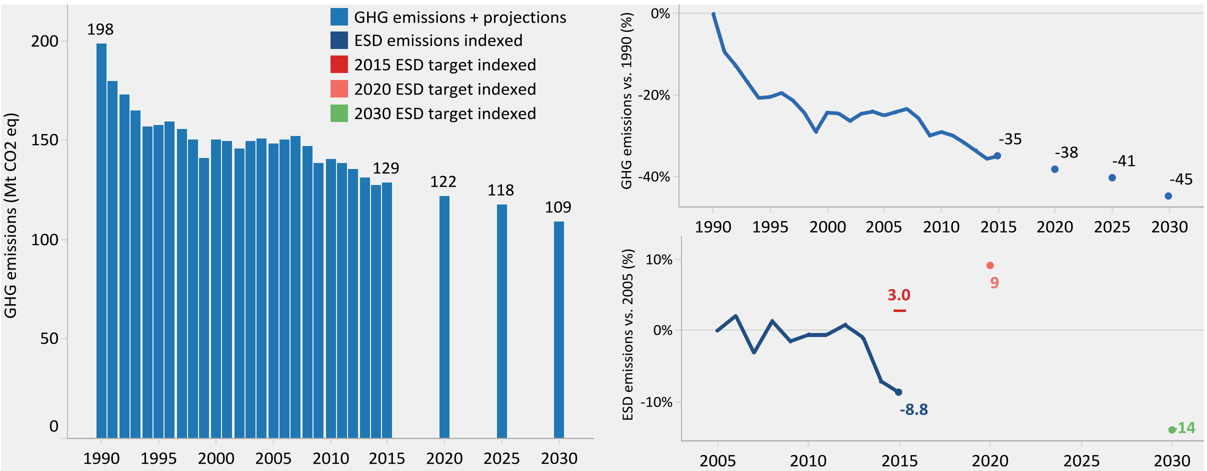
## 9.3 Czech Republic

### 9.3.1 GHG emissions: trends & projections

In 2015, the Czech Republic emitted 111 Mt $CO_2$, a fall of 35.4 % (or 60.8 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by ESD sectors reached 56.6 Mt $CO_2$-eq., 11.5 % (7.3 Mt $CO_2$-eq.) **below the ESD target**[43]. Total GHG emissions in the Czech Republic were almost 129 Mt $CO_2$-eq., or 35 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in the Czech Republic are projected to fall below the 1990 level by 38 % and 45 % respectively.

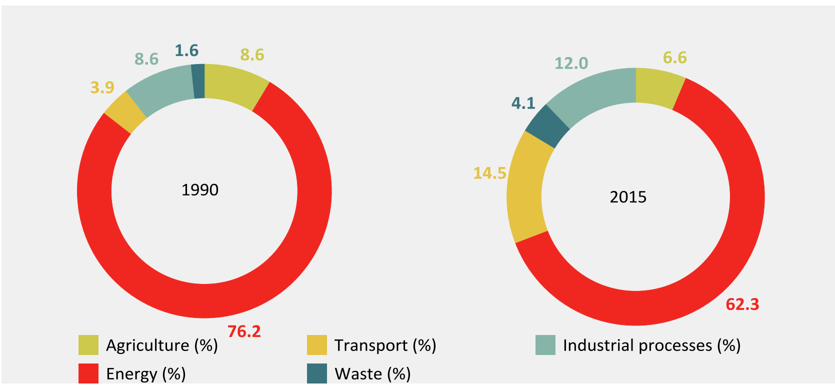
Figure 43 illustrates (i) the overall trend in GHG emissions in the Czech Republic over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 43.** GHG emissions in CZ, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions remained the main source of total GHG emissions in the Czech Republic since 1990. They totalled 80.2 Mt $CO_2$-eq. in 2015, a fall of 47 % in comparison with the 1990 figure. GHG emissions from the transport sector totalled 17.7 Mt $CO_2$-eq. in 2015, or 144 % higher than the 1990 figure. Their share in overall GHG emissions more than tripled over the period 1990-2015, making it the second largest source of GHG emissions in the Czech Republic.

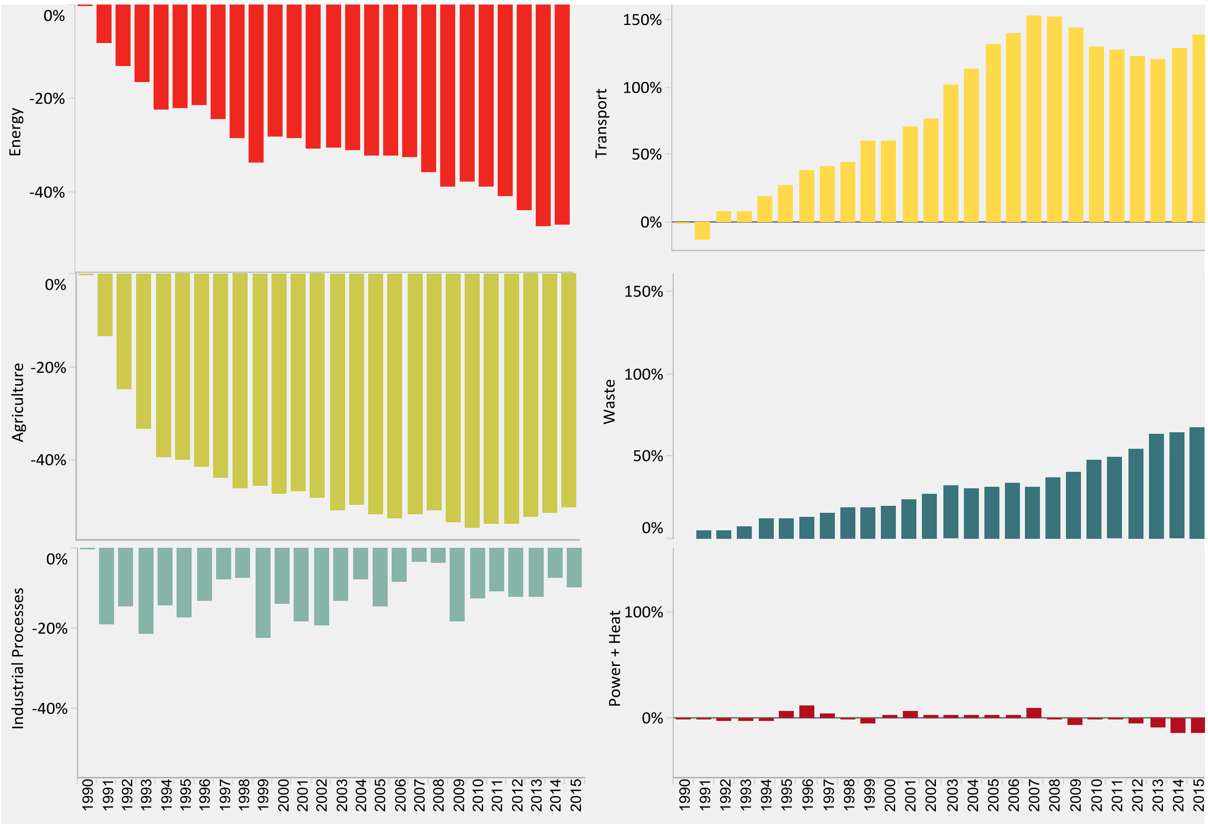
**Figure 44.** GHG emissions in CZ broken down by source, 1990 (left) — 2015 (right)




Some sectors in the Czech Republic such as energy, agriculture and industrial processes saw a fall in their GHG emissions immediately after 1990. Agriculture experienced the largest drop reaching 8.5 Mt $CO_2$-eq. in 2015, 50 % below the 1990 figure. Emissions from industrial processes and product use came to 15.4 Mt $CO_2$-eq. in 2015, a fall of 9.8 % since 1990. GHG emissions from public power and heat production came to 47 Mt $CO_2$-eq. in 2015, 15 % below the level in 1990. In that year, these emissions covered more than 58 % of energy-related GHG emissions. GHG emissions from transport had the highest relative change.

([43]) Czech Republic ESD GHG emissions target for 2015 was 63.95 Mt $CO_2$-eq. The target for 2020 is set to 67.65 Mt $CO_2$-eq.

**Figure 45.** Changes of GHG emissions from sectors relative to 1990 — CZ

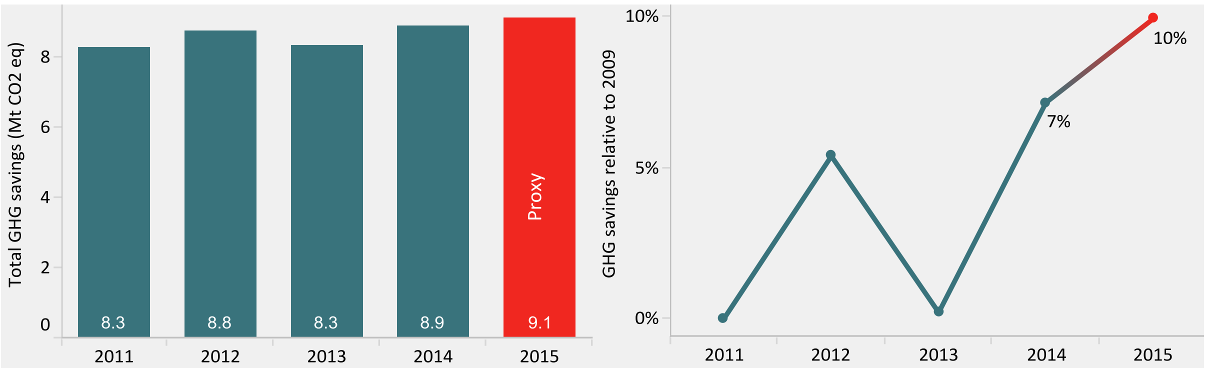



## 9.3.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in the Czech Republic from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by 7 % (+0.6 Mt $CO_2$-eq.) over 2011-2014 reaching 8.9 Mt $CO_2$-eq. In per capita terms GHG emissions rose slightly from 0.8 t $CO_2$-eq. in 2011 to 0.9 t $CO_2$-eq. in 2014.

Figure 46 illustrates the trend in GHG emissions savings from renewable energy use in the Czech Republic over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 46.** Trend of GHG emissions savings from RES in CZ (left) — Change relative to 2009 (right)




Renewable energy in electricity sector was the main contributor to overall GHG emission savings in the Czech Republic throughout period 2011-2014[44]. Even though their absolute contribution rose to 4.6 Mt $CO_2$-eq. in 2014, 4.9 % above the 2011 figure, its relative share decreased to 52.3 %. The contribution of biofuels increased rapidly, 33 % over 2011-2014. Its relative share reached 7 % in 2014. Even though the contribution of the heating/cooling sector rose by 5.5 % over 2011-2014 its relative share remained almost unchanged.

([44]) No data on GHG emissions savings through renewables were reported in the first CZ's progress report for period 2009-2010.

**Figure 47.** Breakdown of GHG savings from renewables in CZ, 2009-2014 and 2015 (proxy)

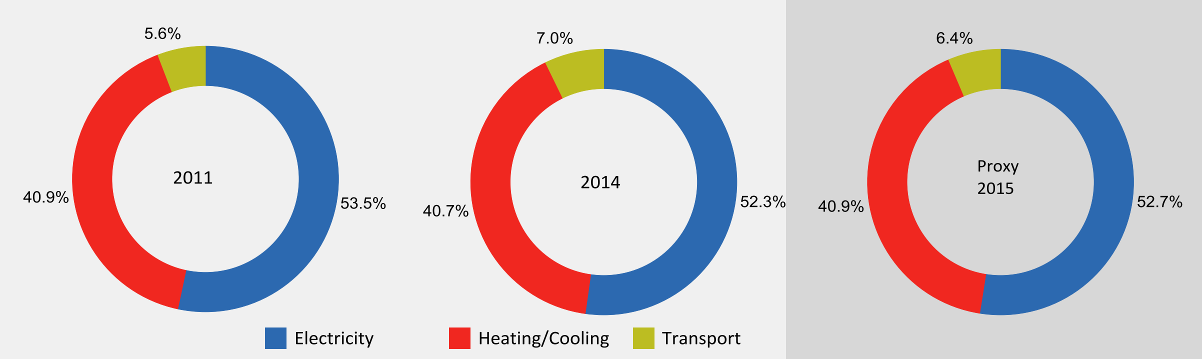



Table 10 shows how the deployment of renewables in the Czech Republic over the period 2009-2015 has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 10.** Emissions reduction in CZ through the use of renewables, 2009-2014 and 2015 (proxy)

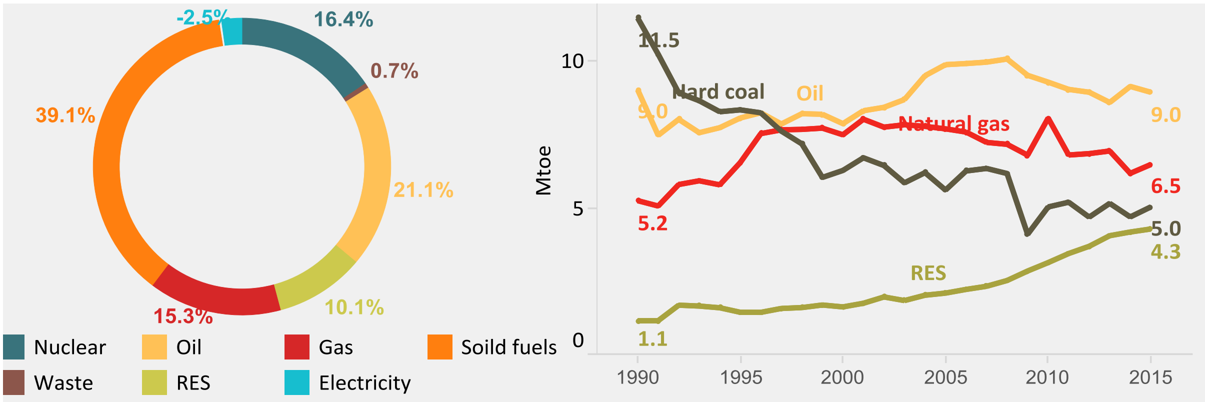
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | . | . | 5.7 | 6.1 | 6.0 | 6.5 | 6.6 |
| GHG (E+Tr) emissions reduction (%) | . | . | 7.1 | 7.7 | 7.6 | 8.4 | 8.5 |
| GHG (P+H) emissions reduction (%) | . | . | 12.6 | 13.7 | 13.6 | 15.0 | 15.4 |
| GHG (Tr) emissions reduction (%) | . | . | 2.7 | 2.8 | 2.9 | 3.5 | 3.2 |

Without the current deployment of renewable energy, GHG emissions in the Czech Republic would have been 5.7 % higher in 2011, 6.5 % higher in 2014 and 6.6 % higher in 2015. The reduction in GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 7.1 % in 2011 to 8.4 % in 2014 and 8.5 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors: from 12.6 % in 2011 to 15 % in 2014 and 15.4 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport remains marginal: 2.7 % in 2011, 3.5 % in 2014 and 3.2 % in 2015.

### 9.3.3 Fossil fuels displacement: role of renewables

In 2015 more than 75 % of the Czech Republic gross inland consumption of energy was met by fossil fuels. The Czech Republic has a relatively low-import dependency which increased nevertheless in 2015 to 31.9 %. Gross inland consumption of hard coal and lignite almost halved in comparison with their 1990 levels. The effect of this increase resulted in a displacement of fossil fuels at the level of 2 Mtoe in year 2015. 0.6 Mtoe of fossil fuels was displaced in electricity sector. The main fossil fuels displaced from renewables were solid fuels.

**Figure 48.** Breakdown of gross inland consumption in Czech Republic, 2015 (left)-trend over 1990-2015 (right)



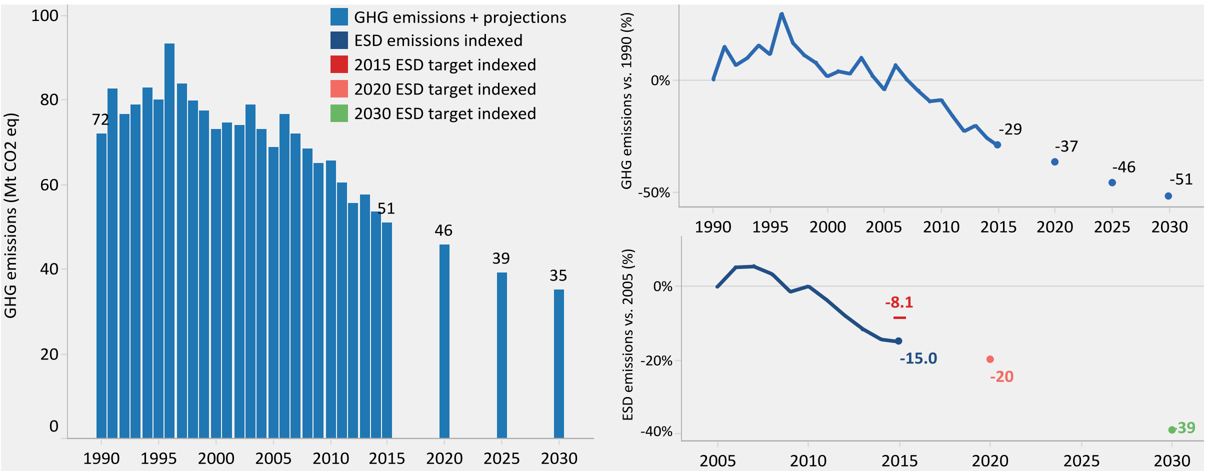
## 9.4 Denmark

### 9.4.1 GHG emissions: trends & projections

In 2015, Denmark emitted 37 Mt $CO_2$, a drop of 30.4 % (16 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by ESD reached 32.4 Mt $CO_2$-eq., 7.5 % (2.6 Mt $CO_2$-eq.) **below the ESD target**[45]. Total GHG emissions in Denmark were 51 Mt $CO_2$-eq. in 2015, or 29 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Denmark are projected to fall below the 1990 level by 37 % and 51 % respectively.

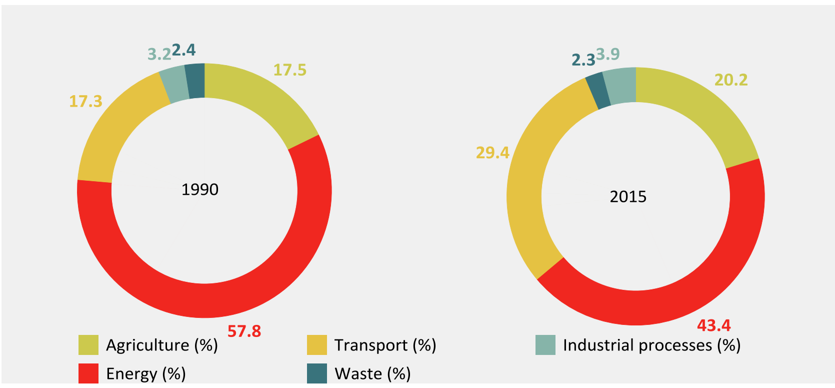
Figure 49 illustrates (i) the overall trend in GHG emissions in Denmark over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 49.** GHG emissions in DK, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions remained the main source of total GHG emissions in Denmark since 1990. They totalled 22 Mt $CO_2$-eq. in 2015, a fall of 47 % in comparison with the 1990 figure. GHG emissions from transport came to 12.3 Mt $CO_2$-eq. in 2015, 15 % higher than the 1990 figure, making it the second largest source of GHG emissions.

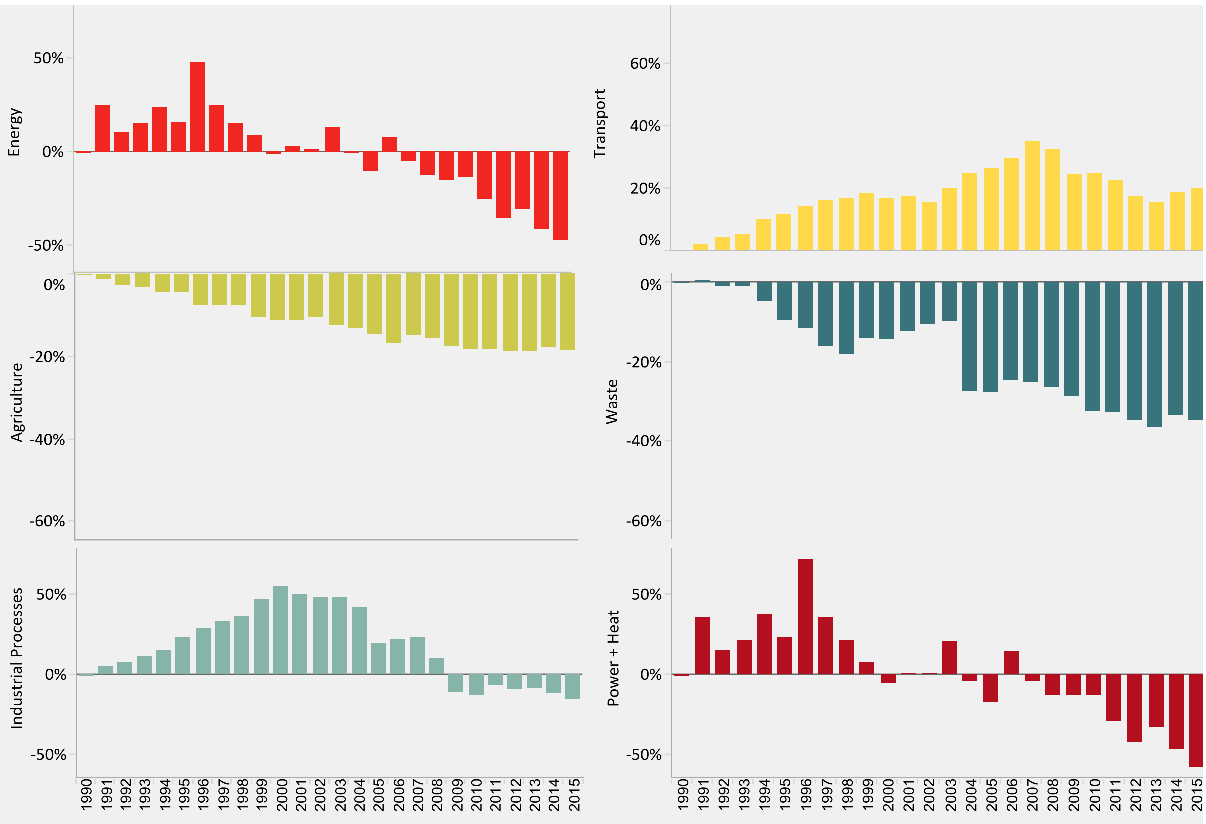
**Figure 50.** GHG emissions in DK broken down by source, 1990 (left) — 2015 (right)




Some sectors in Denmark such as energy and industrial processes did not see a fall in their emissions until after 2007. Only GHG emissions from agriculture and waste management fell immediately after 1990. Despite a fall of 18.5 % in agricultural emissions between 1990 and 2015, this sector's relative share increased up to 20.2 %. The 34.6 % drop of emissions from waste management over 1990-2015 kept their relative share almost unchanged. The power and heat sectors saw a significant fall in their emissions which came to 10.4 Mt $CO_2$-eq., in 2015, or 58 % below the 1990 level. In the same year these emissions covered 47 % of energy-related GHG emissions in Denmark.

([45]) Denmark's ESD target for 2015 was 35 Mt CO2-eq. The target for 2020 is set to 30.5 Mt $CO_2$-eq.

**Figure 51.** Changes of GHG emissions from sectors relative to 1990 — DK

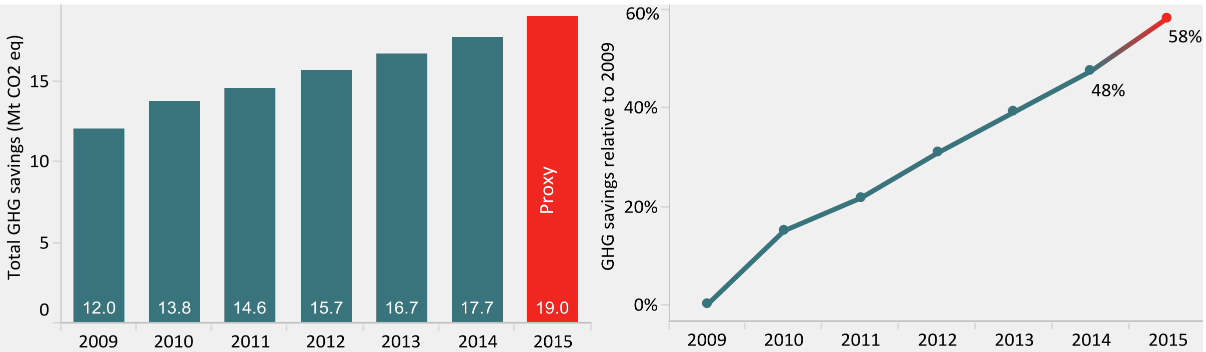



## 9.4.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Denmark from the use of renewable energy in three sectors – electricity, heating/cooling and transport – rose by 48 % over the period 2009-2014 reaching 17.7 Mt $CO_2$-eq. In per capita terms GHG emissions in Denmark rose from 2.2 t $CO_2$-eq. to 3.1 t $CO_2$-eq.

Figure 52 illustrates the trend in GHG emissions savings from renewable energy use in Denmark over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 52.** Trend of GHG emission savings from RES in DK (left) — Change relative to 2009 (right)




Renewable energy in heating/cooling was the main contributor to overall GHG emissions savings in Denmark throughout the period 2009-2014. Although these savings reached 3.9 Mt $CO_2$-eq. in 2014, an increase of 40.8 % since 2009, this sector's relative contribution decreased to 39.5 % in 2014. The upward trend between 2009 and 2014 of renewable electricity rose by 64.5 % (+1.5 Mt $CO_2$-eq.) increasing the relative share of savings from this sector. The role of biofuels in GHG emission savings remained marginal despite increasing from almost 0 % to 4 % between 2009 and 2014.

**Figure 53.** Breakdown of GHG savings from renewables in DK, 2009-2014 and 2015 (proxy)

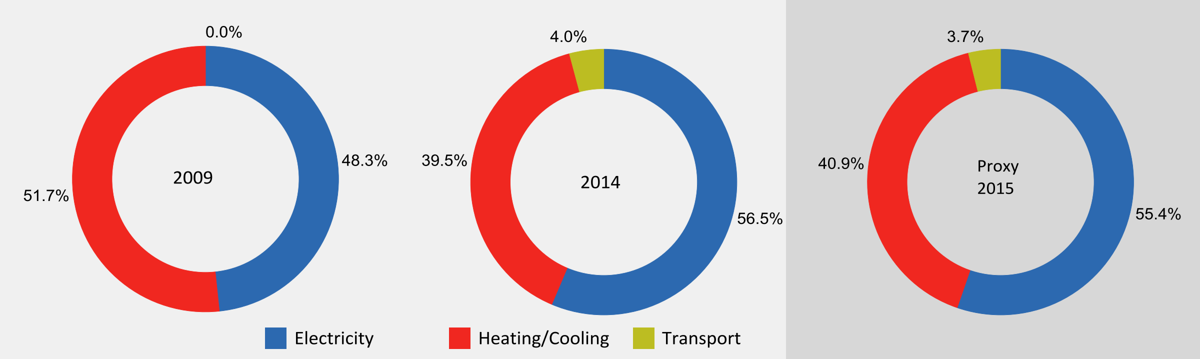



Table 11 shows how the deployment of renewable energy in Denmark during the period 2009-2015 has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 11.** Emissions reduction in DK through the use of renewables, 2009-2014 and 2015 (proxy)

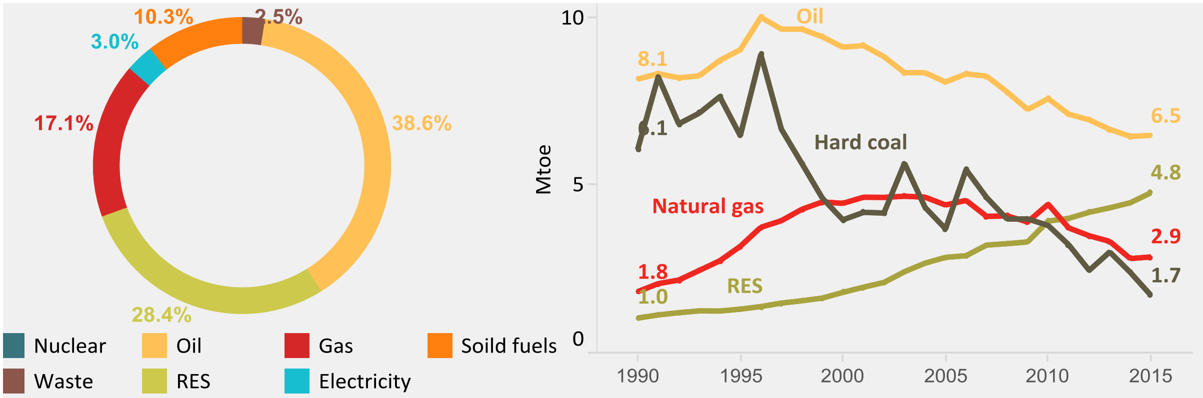
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 15.5 | 17.4 | 19.4 | 22.0 | 22.5 | 24.9 | 27.1 |
| GHG (E+Tr) emissions reduction (%) | 19.8 | 21.9 | 25.0 | 28.6 | 28.9 | 32.5 | 35.5 |
| GHG (P+H) emissions reduction (%) | 35.6 | 38.9 | 44.5 | 51.3 | 49.0 | 56.3 | 63.7 |
| GHG (Tr) emissions reduction (%) | 0.0 | 0.0 | 3.0 | 4.7 | 5.5 | 5.5 | 5.4 |

Without the current deployment of renewable energy, GHG emissions in Denmark would have been 15.5 % higher in 2009, 24.9 % higher in 2014 and 27.1 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) due to the deployment of renewable energy rose from 19.8 % in 2009 to 32.5 % in 2014, reaching 35.5 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in electricity and heating/cooling sectors, from 35.6 % in 2009 to 56.3 % in 2014 and 63.7 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport ranged from 3 % in 2011 to 5.5 % in 2014 and 5.4 % in 2015.

### 9.4.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Denmark include a high share of renewables that in 2011 became the second largest energy source after petroleum products. But fossil fuels still covered two-thirds of gross domestic energy consumption in Denmark. Even though Denmark has a very low-import dependency for all products, at 13 % in 2015; the import dependence for solid fuels is high, at 85 %. The role of renewables became more evident after 2000 and by 2015 it expanded by 175 %. This served to displace fossil fuels — by as much as 4 Mtoe in 2015. Almost 40 % (1.54 Mtoe) of this displacement took place in the electricity sector.

**Figure 54.** Breakdown of gross inland consumption in Denmark, 2015 (left) — trend over 1990-2015 (right)



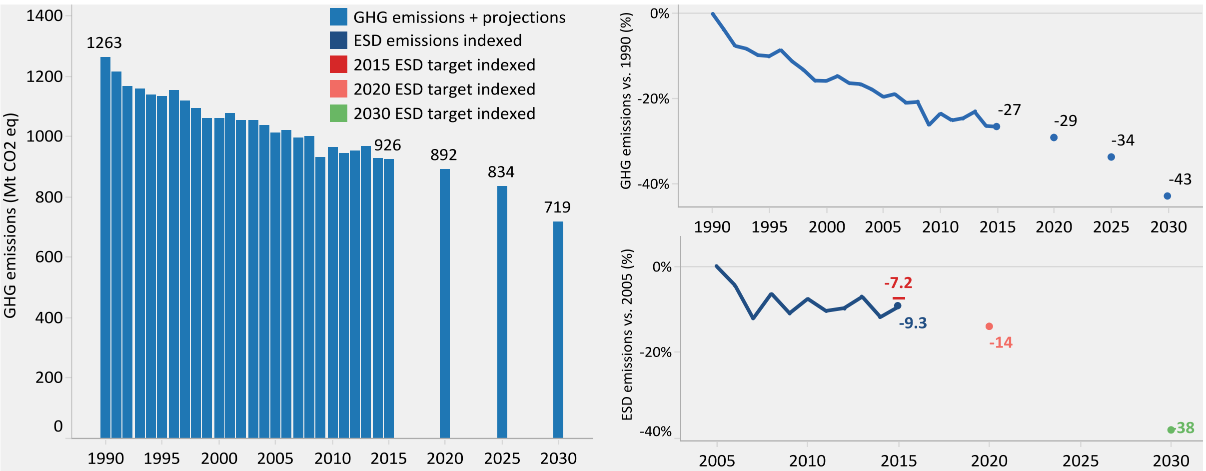
## 9.5 Germany

### 9.5.1 GHG emissions: trends & projections

In 2015, Germany emitted 778 Mt $CO_2$, a drop of 23.7 % (or 242 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions in ESD sectors reached 448.7 Mt $CO_2$-eq., 2.3 % (10.4 Mt $CO_2$-eq.) **below the ESD target**[46]. Total GHG emissions in Germany were 926 Mt $CO_2$-eq., or 27 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Germany are projected to fall below the 1990 level by 29 % and 43 % respectively.

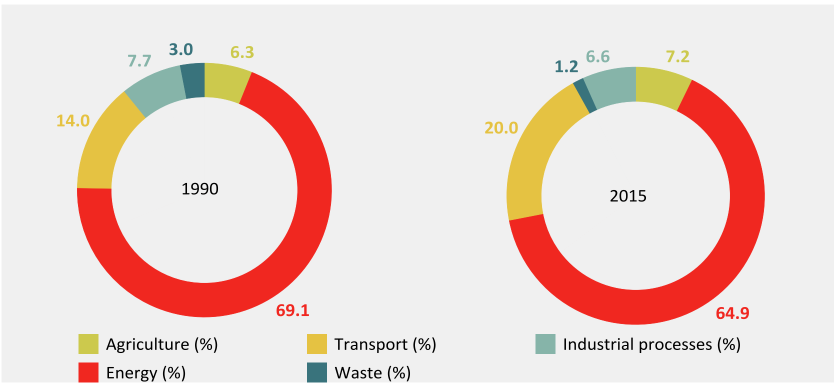
Figure 55 illustrates (i) the overall trend in GHG emissions in Germany over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 55.** GHG emissions in DE, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Germany since 1990. They totalled 601.4 Mt $CO_2$-eq. in 2015, a fall of 31 % in comparison with the 1990 figure. Transport sector emissions saw their largest increase around 1999, a rise of 16 % compared to 1990. Even though, emissions from that sector declined by 10 % between 1999 and 2015, it is still the second largest source of GHG emissions, reaching 185.4 Mt $CO_2$-eq.

**Figure 56.** GHG emissions in DE broken down by source, 1990 (left) — 2015 (right)

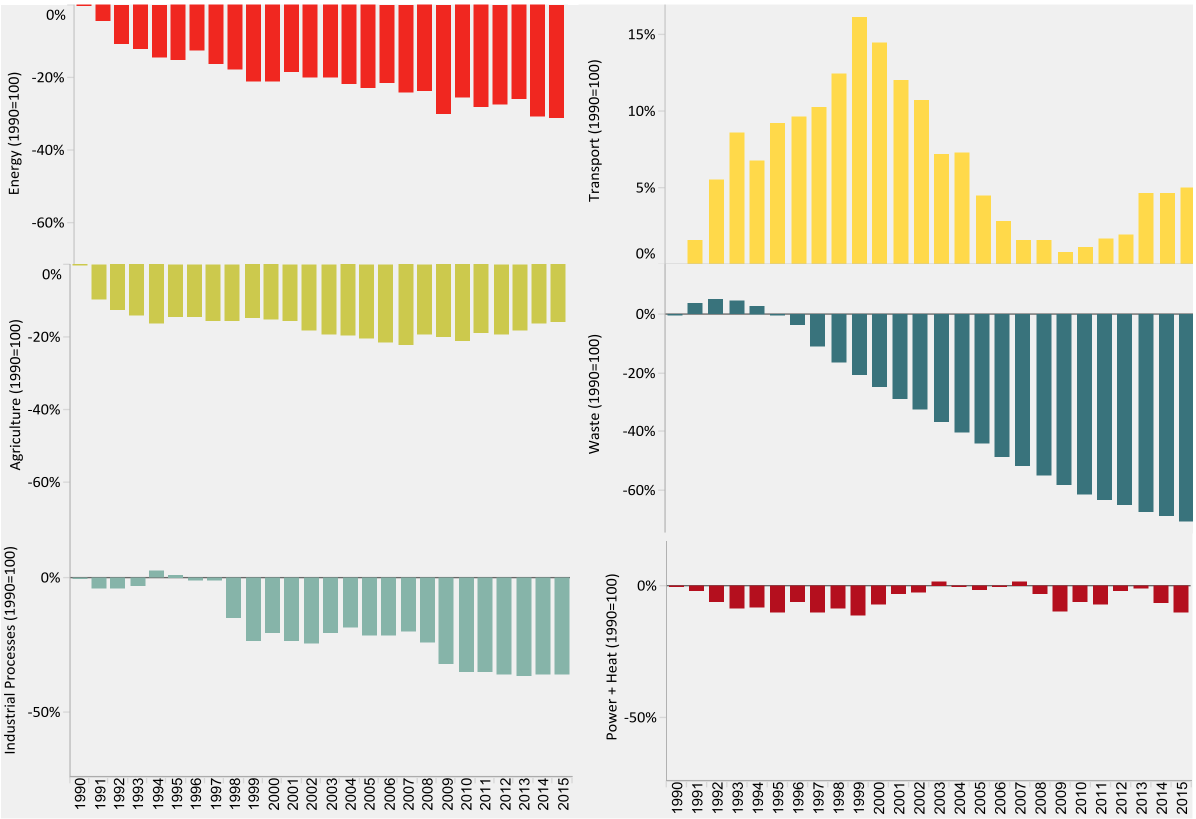



Some sectors in Germany, except the transport sector, saw a fall in their GHG emissions throughout the period 1990-2015. GHG emissions from transport dropped below the 1990 level around 2009 after recording the largest increase in 1999. A significant decrease in emissions over 1990-2015 took place in waste management, 70.5 % below the 1990 figure. GHG emissions from industrial processes and product use dropped mainly after 1995. They came to 61.5 Mt $CO_2$-eq. in 2015, 36.3 % below the 1990 figure. By 2015 emissions from the public power and heat sectors

([46]) Germany's ESD target for 2015 was 459 Mt CO2 eq. The target for 2020 is set to 425.65 Mt $CO_2$-eq.

had dropped by 10 % compared to the 1990 figure. In 2015, they came to 306.7 Mt $CO_2$-eq., or 51 % of energy-related GHG emissions in that year.

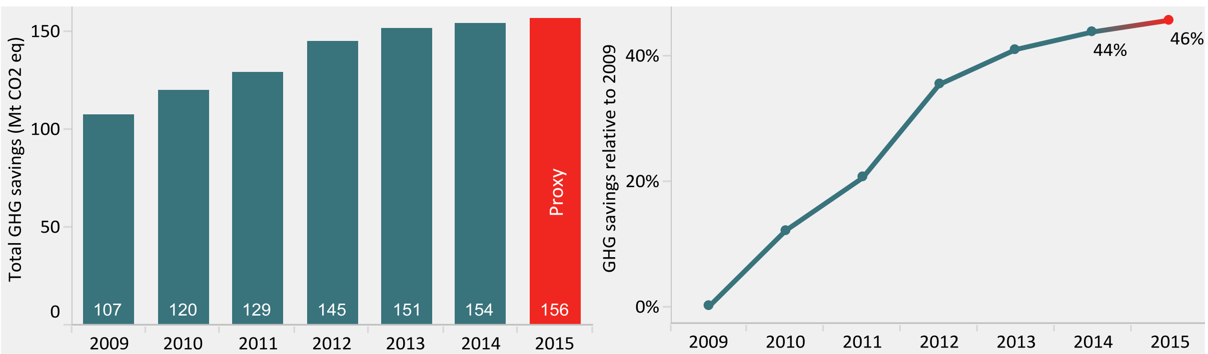
**Figure 57.** Changes of GHG emissions from sectors relative to 1990 — DE




## 9.5.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Germany due to the use of renewable energy in three sectors – electricity, heating/cooling and transport –rose by 44 % (+47 Mt $CO_2$-eq.) during the period 2009-2014 reaching 154 Mt $CO_2$-eq. In 2015[47] the GHG emissions savings were estimated to have reached 156 Mt $CO_2$-eq. In per capita terms GHG emissions savings increased from 1.3 t $CO_2$-eq. to 1.9 t $CO_2$-eq. Figure 58 illustrates the trend in GHG emissions savings from renewable energy use in Germany over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 58.** Trend in GHG emissions savings from RES in DE (left) — Change relative to 2009 (right)




Renewable electricity was the main contributor to overall GHG emissions savings in Germany between 2009 and 2014, increasing from 64.5 % to 72.1 %. This contribution increased further to 75.3 % in 2015. These savings reached 111 Mt $CO_2$-eq. in 2014, rising to an estimated 117.6 Mt $CO_2$-eq. in 2015. The contribution of renewable energy in the heating/cooling sector fell from 30.8 % in 2009 to just under 22 % in 2015. The contribution from savings from biofuels in the transport sector almost halved in 2015 compared with 2009, from 4.7 % to 2.8 %.

([47]) The estimation of GHG emissions savings from renewable energy in Germany are based on the method and coefficients described in 'Emissionsbilanz erneuerbarer Energieträger 2013' .

**Figure 59.** Breakdown of GHG savings from renewables in DE, 2009-2014 and 2015 (proxy)

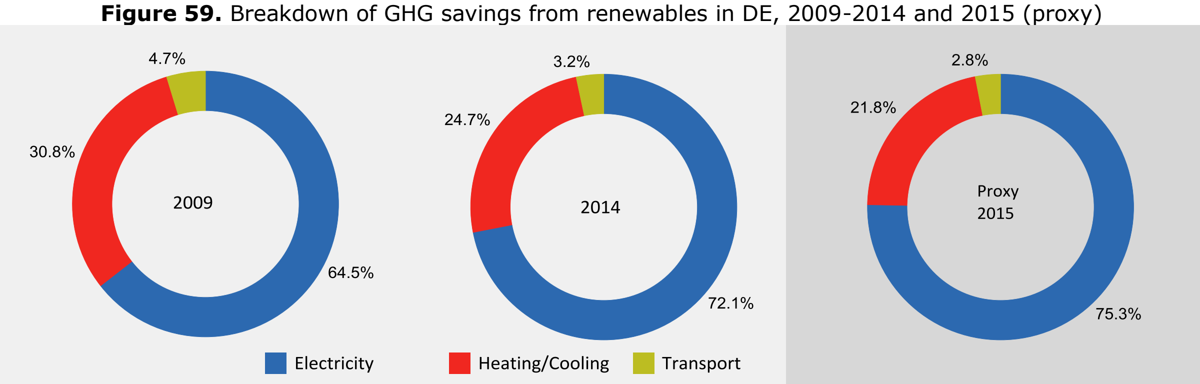



Table 12 shows how the deployment of renewable energy in Germany over 2009-2015 has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 12.** Emissions reduction in DE through the use of renewables, 2009-2014 and 2015 (proxy)

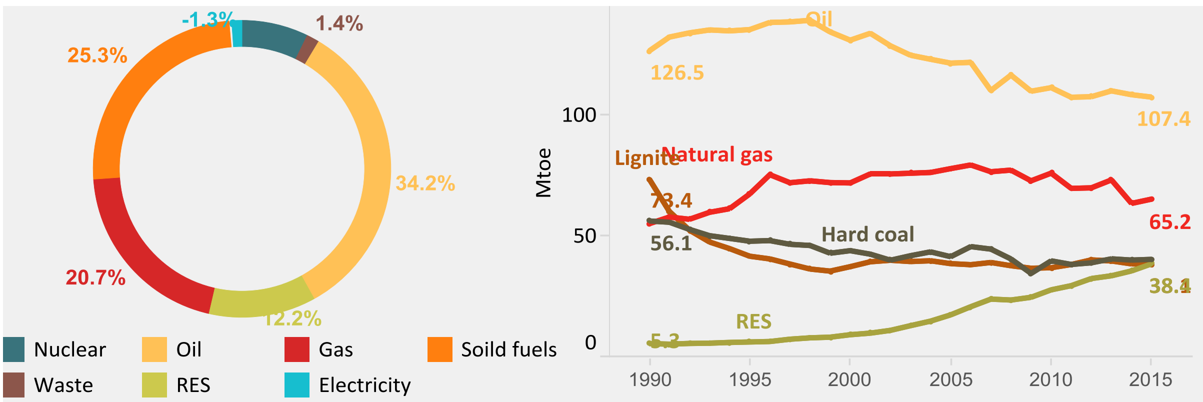
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 10.3 | 11.1 | 12.0 | 13.2 | 13.5 | 14.2 | 14.4 |
| GHG (E+Tr) emissions reduction (%) | 12.3 | 13.0 | 14.2 | 15.5 | 15.8 | 16.8 | 17.0 |
| GHG (P+H) emissions reduction (%) | 24.8 | 26.5 | 28.1 | 29.4 | 30.2 | 31.8 | 33.1 |
| GHG (Tr) emissions reduction (%) | 3.2 | 3.1 | 3.1 | 3.7 | 3.0 | 3.0 | 2.7 |

Without the current deployment of renewable energy, GHG emissions in Germany would have been 10.3 % higher in 2009, 14.2 % higher in 2014 and 14.4 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 12.3 % in 2009, 16.8 % in 2014 and 17 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 24.8 % in 2009 to 31.8 % in 2014 and 33.1 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport ranged from 3.2 % in 2009 to 3 % in 2014, and further down to 2.7 % in 2015.

## 9.5.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Germany include a higher share of petroleum products and solid fuels and a lower share of nuclear and renewables. In 2015 more than 80 % of Germany's gross inland consumption of energy was met by fossil fuels. Germany is an import-dependent country; in 2015 its dependency rates for gas and oil remained above 90 % whereas the dependency for solid fuels came to 45.5 %. The role of renewables became more prevalent around 2005 and by 2015 it had expanded by 123 %. This served to displace fossil fuels — by as much as 34 Mtoe by 2015. Forty-five per cent (15.4 Mtoe) of this displacement took place in the electricity sector; the main fossil fuels displaced were solid fuels.

**Figure 60.** Breakdown of gross inland consumption in Germany, 2015 (left) — trend over 1990-2015 (right)



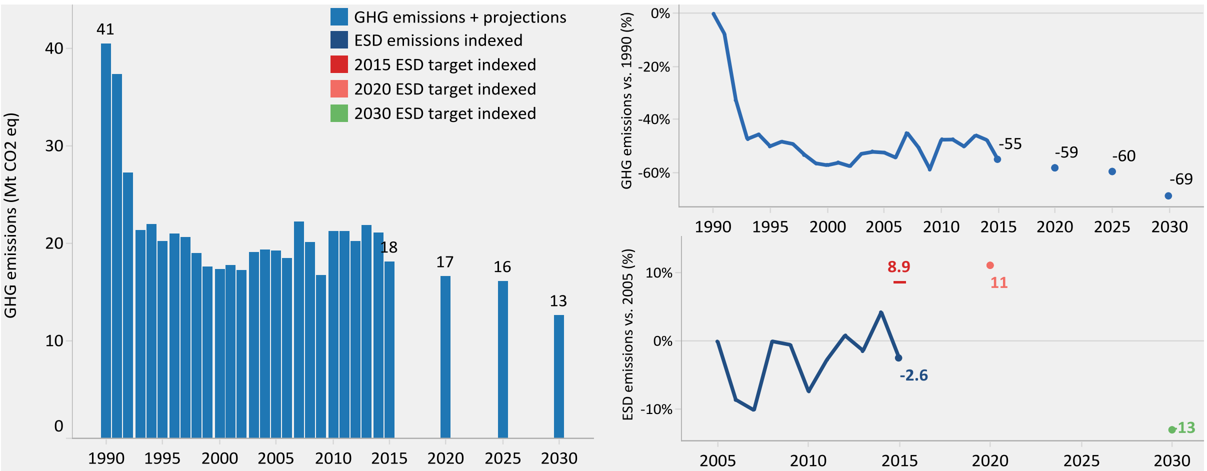
## 9.6 Estonia

### 9.6.1 GHG emissions: trends & projections

In 2015, Estonia emitted 29.3 Mt $CO_2$, a drop of 21 % (or 7.7 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by ESD sectors reached 5.7 Mt $CO_2$-eq., 10.6 % (0.7 Mt $CO_2$-eq.) **below the ESD target**[48]. Total GHG emissions in Estonia were 18 Mt $CO_2$-eq. in 2015, or 55 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Estonia are projected to fall by 59 % and 69 % respectively.

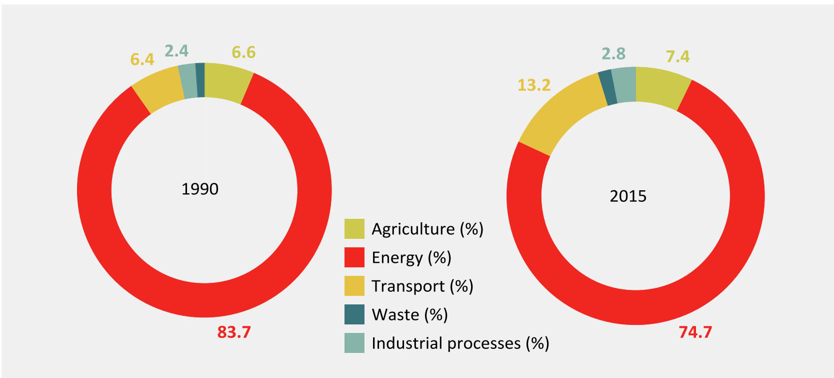
Figure 61 illustrates (i) the overall trend in GHG emissions in Estonia over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 61.** GHG emissions in EE, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Estonia since 1990. They totalled 13.5 Mt $CO_2$-eq. in 2015, a fall of 60 % in comparison with the 1990 figure. GHG emissions from the transport sector dropped by 7.2 % between 1990 and 2015 reaching 2.4 Mt $CO_2$-eq. Over this period the GHG emissions from this sector almost doubled their relative share, making it the second largest source of GHG emissions.

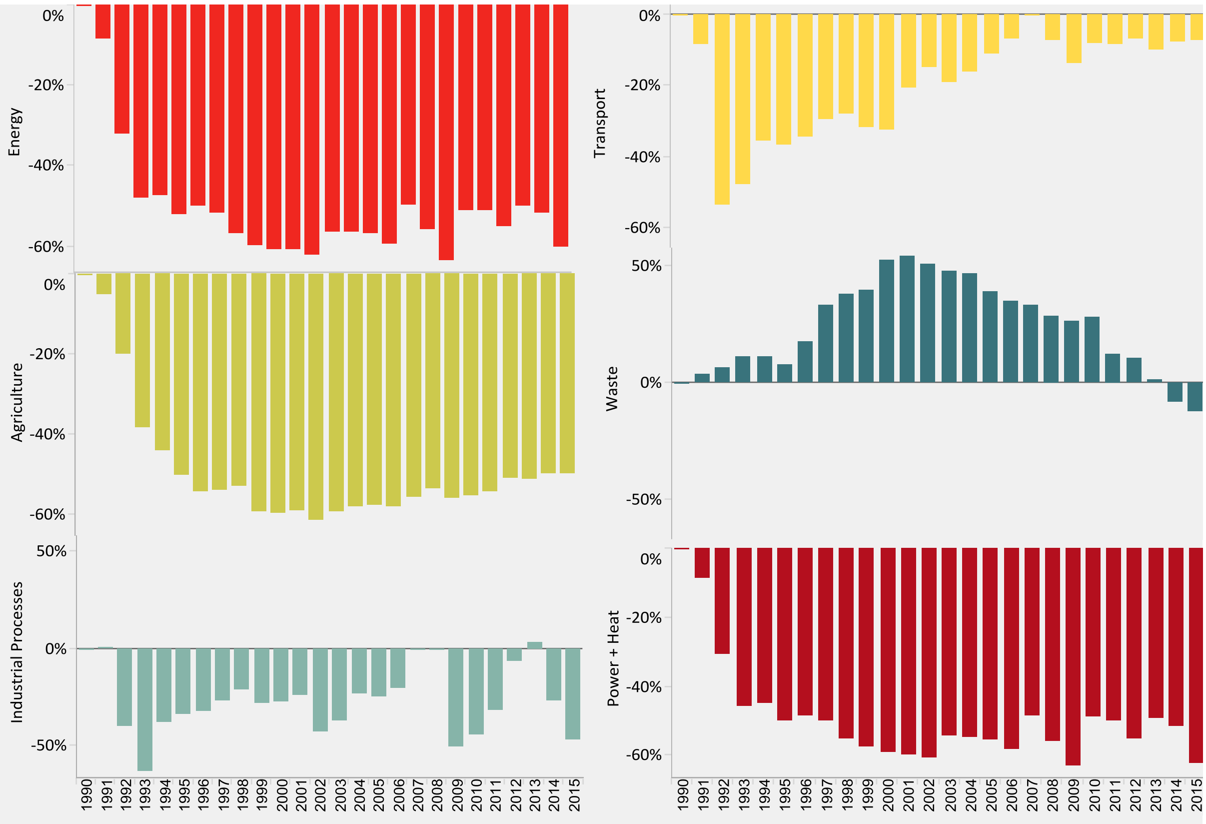
**Figure 62.** GHG emissions in EE broken down by source, 1990 (left) — 2015 (right)




Almost all sectors in Estonia saw a fall in their GHG emissions immediately after 1990, with only those emissions from waste management not decreasing immediately. The emissions from agriculture almost halved over 1990-2015 reaching only 1.3 Mt $CO_2$-eq**.** GHG emissions from public power and heat production also began to fall immediately after 1990. In 2015, they came to 11 Mt $CO_2$-eq., or 81.4 % of energy-related GHG emissions in that year. In 2015 the absolute contribution of emissions from industrial processes and product use amounted to only 0.5 Mt $CO_2$-eq., a lower share than in 1990.

([48]) Estonia's ESD target for 2015 was 6.35 Mt $CO_2$-eq. The target for 2020 is set to 6.47 Mt $CO_2$-eq.

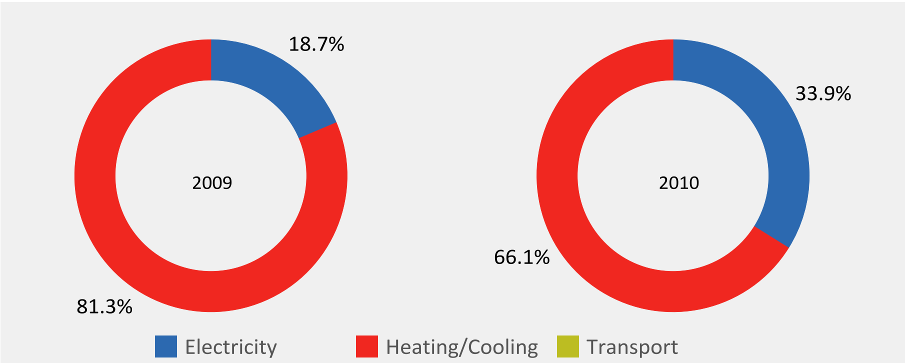
**Figure 63.** Changes of GHG emissions from sectors relative to 1990 — EE




## 9.6.2 GHG emissions savings: role of renewables

No data are available for GHG emissions saving in Estonia covering the period 2011-2014[49]. In 2009 the overall GHG emissions savings from the use of renewable energy in three sectors — electricity, heating/cooling and transport — were 2812 t $CO_2$-eq. These savings reached 3281 Mt $CO_2$-eq. in 2010, a rise of 16.7 %.

**Figure 64.** Breakdown of GHG savings from renewables in EE, 2009-2010




Renewable energy in heating/cooling was the main contributor to overall GHG emissions savings in Estonia in 2009 reaching 2287 t $CO_2$-eq. This contribution decreased in 2010 by 5.2 % (119 t $CO_2$-eq.). In relative terms this contribution decreased from 81.3 % in 2009 to 66.1 % in 2010. The contribution from renewable electricity reached 1113 t $CO_2$-eq. in 2010, a rise of 112 % from 2009. In relative terms this contribution increased from 18.7 % in 2009 to 33.9 % in 2010.

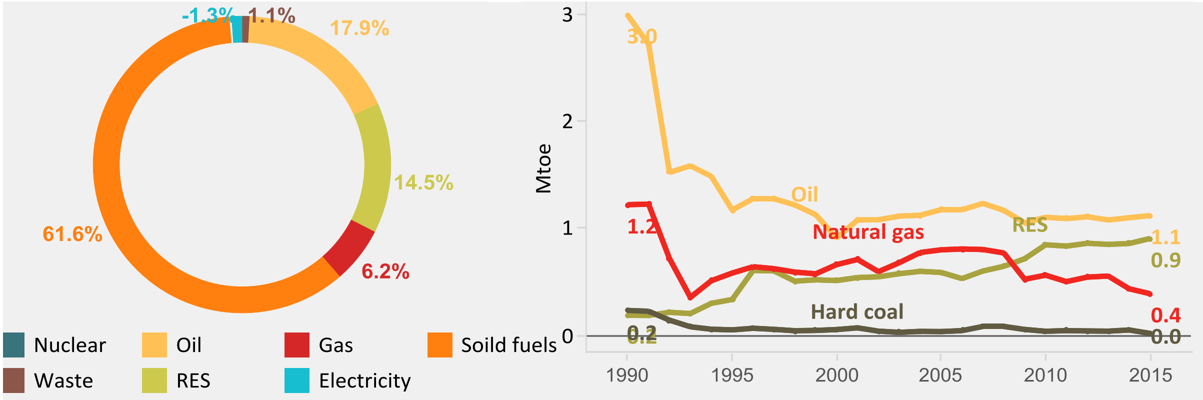
## 9.6.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Estonia include a higher share of solid fuels and petroleum products and a lower share of renewables and gas. In 2015 almost 8 % of Estonia's gross inland

([49]) See more information in the Annex of this report.

consumption of energy was met by fossil fuels. Estonia's import dependency rate was 7.4 % in 2015 remaining very high for gas (100 %). Renewables in Estonia expanded by 382 % over the period 1990-2015. This deployment served to displace fossil fuels — by only 0.7 Mtoe by 2015. Only 12 % of this displacement took place in the electricity sector (0.09 Mtoe); the main fossil fuel displaced was hard coal.

**Figure 65.** Breakdown of gross inland consumption in Estonia, 2015 (left) — trend over 1990-2015 (right)



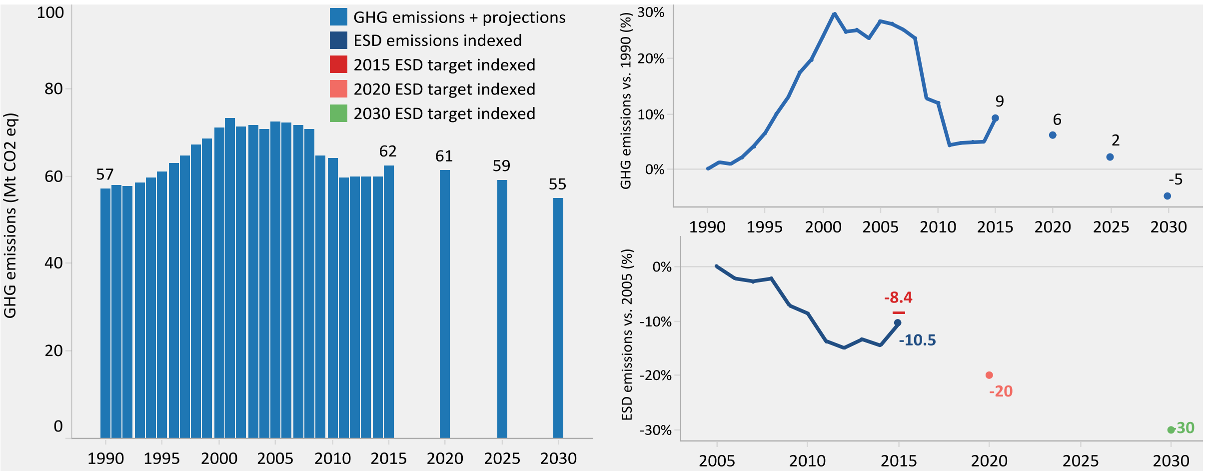
## 9.7 Ireland

### 9.7.1 GHG emissions: trends & projections

In 2015, Ireland emitted 36.6 Mt $CO_2$, a rise of 13 % (or 4.3 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by the ESD scheme reached 43.6 Mt $CO_2$-eq., 2.3 % (1 Mt $CO_2$-eq.) **below the ESD target**[50]. Total GHG emissions in Ireland were 62 Mt $CO_2$-eq. in 2015, or 9 % (5.2 Mt $CO_2$-eq.) above the 1990 figure. Under the EUCO27 scenario, by 2020 GHG emissions in Ireland are projected to be 6 % above the 1990 figure. Under the same scenario GHG emissions in 2030 are projected to fall below the 1990 level by 5 %.

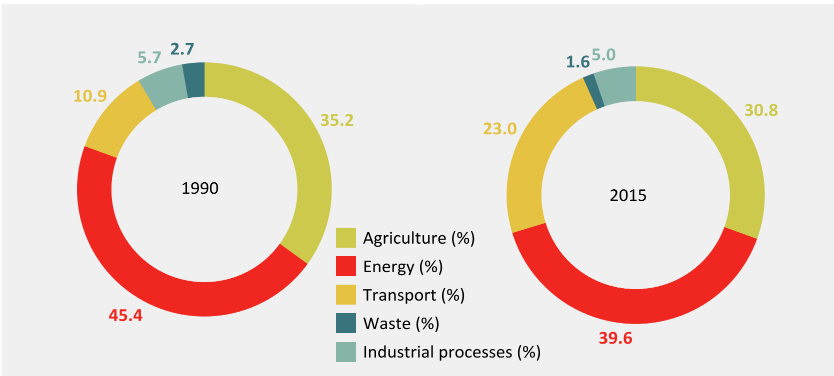
Figure 66 illustrates (i) the overall trend in GHG emissions in Ireland over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 66.** GHG emissions in IE, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Ireland since 1990. They totalled 24.7 Mt $CO_2$-eq. in 2015, a fall of 4.9 % in comparison with the 1990 figure. In the same period transport sector emissions saw the largest increase, at 131 %, more than doubling their relative share. Nevertheless the transport sector remained the third largest source of emissions with agriculture being the second. Emissions from agriculture dropped by 4.6 % over 1990-2015 reaching 19.2 Mt $CO_2$-eq.

**Figure 67.** GHG emissions in IE broken down by source, 1990 (left) — 2015 (right)

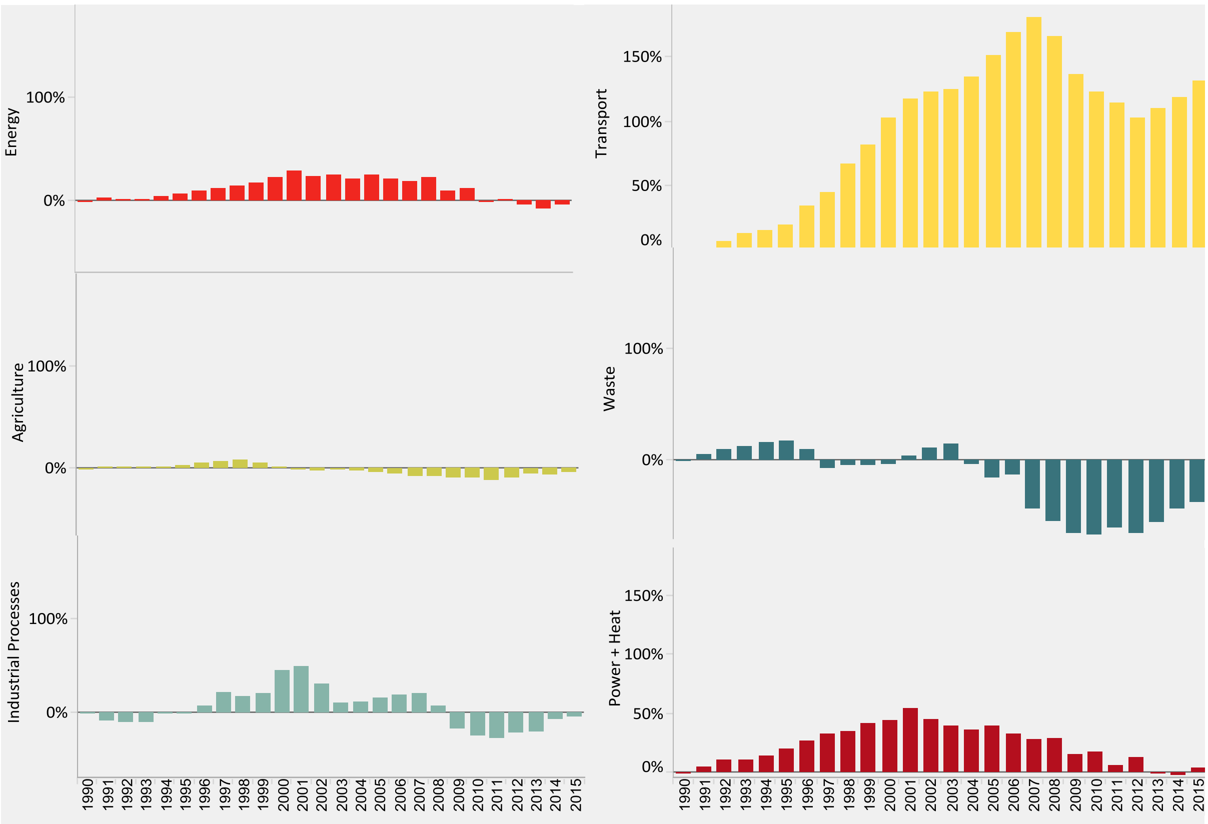



Some sectors in Ireland, such as energy, agriculture and waste management did not see an immediate fall in their emissions after 1990. GHG emissions from transport saw the largest increase around 2007, at 181 % in comparison with the 1990 level. They came to 14.4 Mt $CO_2$-eq. in 2015. The decrease in emissions from waste management only began after 2003. In 2015 the total amount in emissions from waste management amounted to only 1.0 Mt $CO_2$-eq., a lower share than in 1990. GHG emissions from public power and heat production did not fall over 1990-

([50]) Ireland's ESD target for 2015 was 44.63 Mt $CO_2$-eq. The target for 2020 is set to 38.97 Mt $CO_2$-eq.

2015. In 2015, they came to 11.3 Mt $CO_2$-eq., or 45.8 % of energy-related GHG emissions in that year.

**Figure 68.** Changes of GHG emissions from sectors relative to 1990 — IE

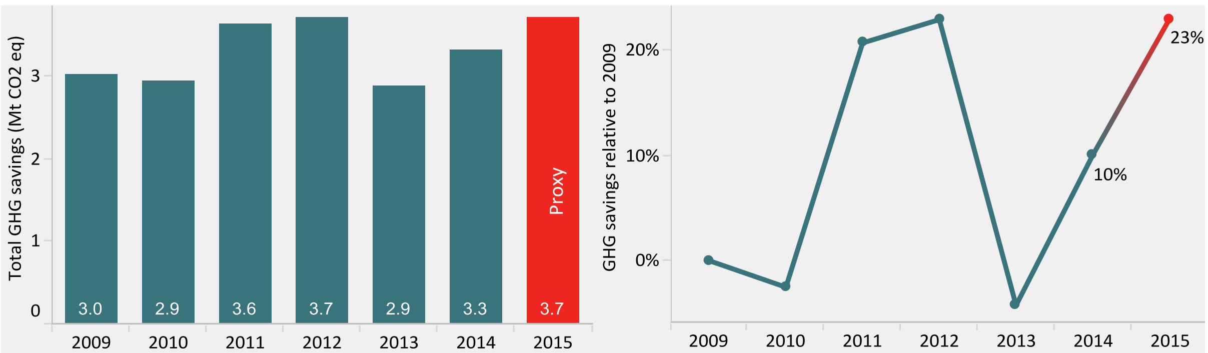



## 9.7.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Ireland from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by 10 % (0.3 Mt $CO_2$-eq.) during the period 2009-2014 reaching 3.3 Mt $CO_2$-eq. In per capita terms GHG emissions remained almost unchanged from 0.67 t $CO_2$-eq. to 0.72 t $CO_2$-eq.

Figure 69 illustrates the trend in GHG emissions savings from renewable energy use in Ireland over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 69.** Trend in GHG emissions savings from RES in IE (left) — Change relative to 2009 (right)




Renewable electricity was the main contributor to overall GHG emissions savings in Ireland between 2009 and 2014, increasing from 67.4 % to 79.2 %. This contribution increased further to 80.4 % in 2015. The contribution of renewable energy in the heating/cooling sector almost halved, at just over 13 %. The contribution from savings from biofuels in the transport sector remained at the same percentages, at 7.2 % in 2009 and 2015.

**Figure 70.** Breakdown of GHG savings from renewables in IE, 2009-2014 and 2015 (proxy)

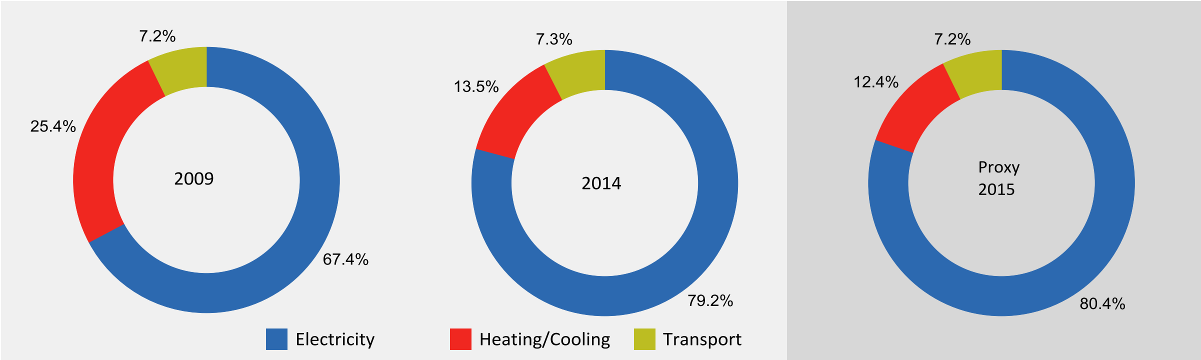



Table 13 shows how the deployment of renewable energy in Ireland during the period 2009-2015 has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 13.** Emissions reduction in IE through the use of renewables, 2009-2014 and 2015 (proxy)

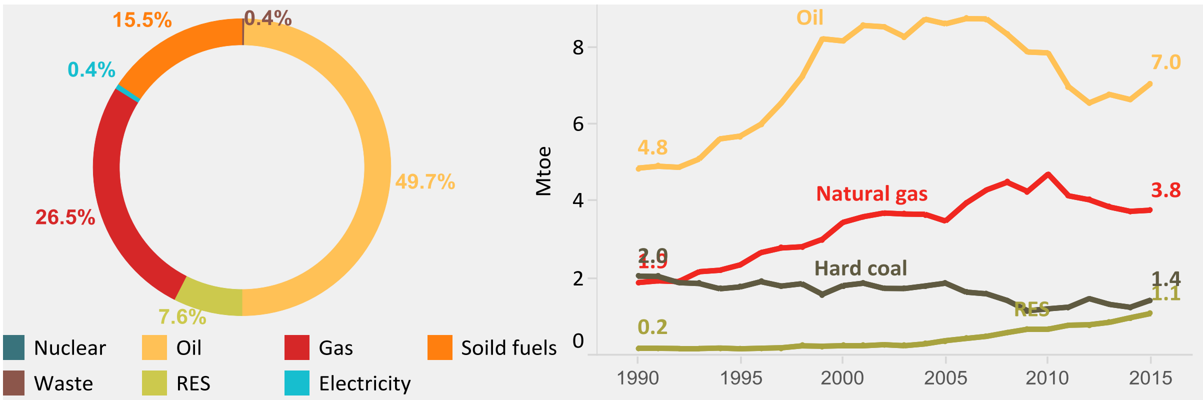
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 4.5 | 4.4 | 5.8 | 5.8 | 4.6 | 5.2 | 5.6 |
| GHG (E+Tr) emissions reduction (%) | 6.9 | 6.8 | 9.0 | 9.1 | 7.5 | 8.7 | 9.2 |
| GHG (P+H) emissions reduction (%) | 18.2 | 17.2 | 23.2 | 22.4 | 19.6 | 22.2 | 23.3 |
| GHG (Tr) emissions reduction (%) | 1.7 | 2.2 | 1.3 | 1.3 | 1.9 | 2.1 | 2.2 |

Without the current deployment of renewable energy, GHG emissions in Ireland would have been 4.5 % higher in 2009, 5.2 % higher in 2014 and 5.6 % higher in 2015. The reduction in GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 6 .9 % in 2009 to 8.7 % in 2014, increasing to 9.2 % in 2015. Over the same period emissions from power and heat recorded the largest reductions that resulted from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 18.2 % in 2009 to 22.2 % in 2014 and 23.3 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport remained marginal, at almost 2.2 % in 2010 and 2015 alike.

### 9.7.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Ireland include a higher share of petroleum products and solid fuels. In 2015 only 7.6 % of Ireland's gross inland consumption of energy was met by renewables. Ireland is an import-dependent country; in 2015 its dependency rates for gas remained above 95 % while the dependency for petroleum products came to 104 %. The role of renewables became more prevalent around 2005 and by 2015 it had had expanded by 193 %. This served to displace fossil fuels — by as much as 1 Mtoe by 2015. Sixty per cent (0.6 Mtoe) of this displacement took place in the electricity sector; the main fossil fuel group displaced were solid fuels.

**Figure 71.** Breakdown of gross inland consumption in Ireland, 2015 (left) — trend over 1990-2015 (right)



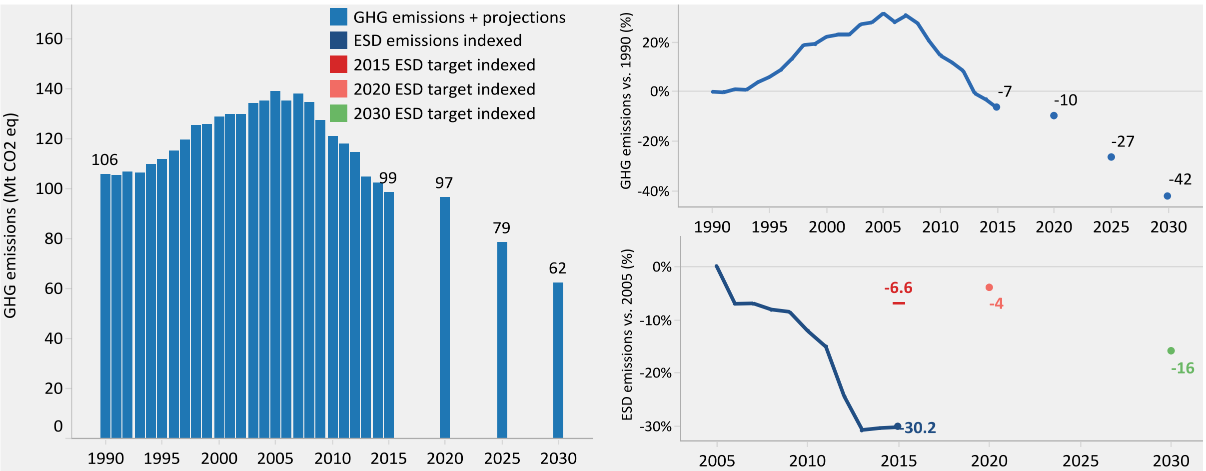
## 9.8 Greece

### 9.8.1 GHG emissions: trends & projections

In 2015, Greece emitted 68.3 Mt $CO_2$, a fall of 12.6 % (or 9.8 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by ESD sectors reached 44.5 Mt $CO_2$-eq., 25.3 % (15.1 Mt $CO_2$-eq.) **below the ESD target**[51]. Total GHG emissions in Greece were 99 Mt $CO_2$-eq. in 2015, or 7 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Greece are projected to fall below the 1990 level by 10 % and 42 % respectively.

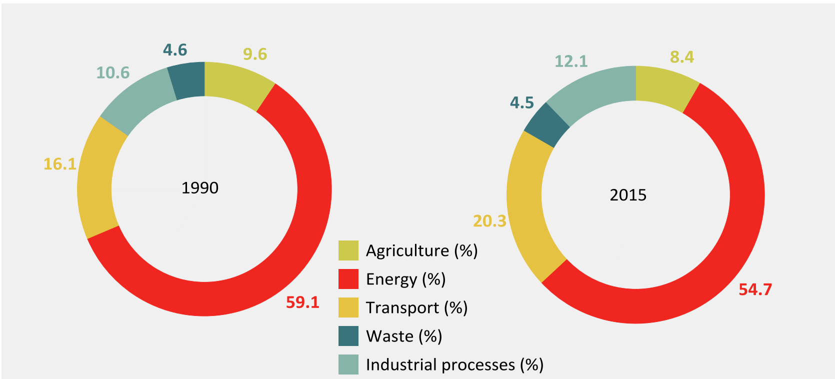
Figure 72 illustrates (i) the overall trend in GHG emissions in Greece over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 72.** GHG emissions in EL, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Greece since 1990. They totalled almost 54 Mt $CO_2$-eq. in 2015, a fall of 13.5 % in comparison with the 1990 figure. GHG emissions from the transport sector reached 20 Mt $CO_2$-eq. in 2015, 17.6 % higher than the 1990 figure, making it the second largest source of GHG emissions. These emissions had the largest expansion around 2009, 65 % above the 1990 level.

**Figure 73.** GHG emissions in EL broken down by source, 1990 (left) — 2015 (right)

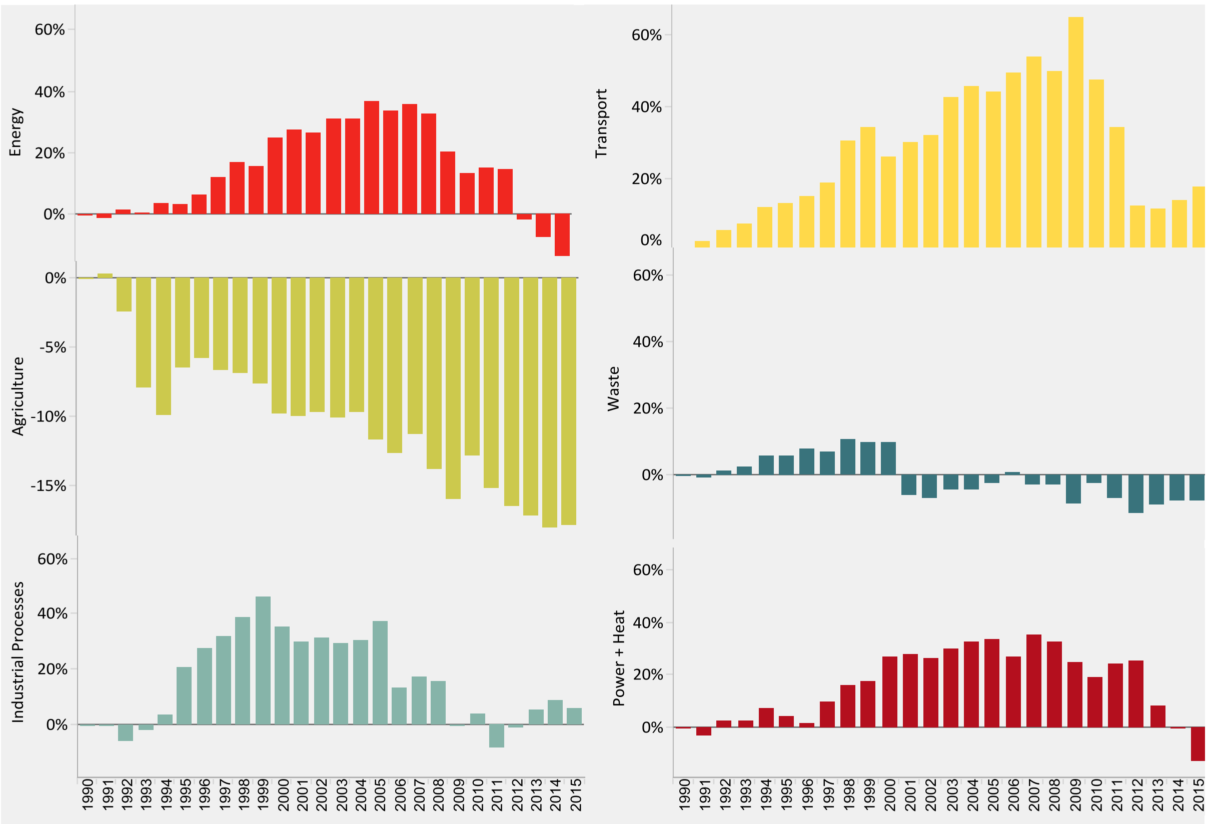



The sectors related to energy in Greece did not see a fall in their GHG emissions until after 2013. Only GHG emissions from agriculture decreased immediately after 1990. They came to 8.3 Mt $CO_2$-eq. in 2015, a fall of 18 % in comparison with the 1990 figure. The decrease in emissions from industrial processes and product use took place only in 2011. In 2015 their absolute contribution amounted to 11.9 Mt $CO_2$-eq., a higher share than in 1990. GHG emissions from public power and heat production fell only after 2014. In 2015, they came to 35.6 Mt $CO_2$-eq., or 66 % of energy-related GHG emissions in that year. The fall in GHG emissions from waste management began

([51]) Greece's ESD target for 2015 was 59.6 Mt $CO_2$-eq. The target for 2020 is set to 61.24 Mt $CO_2$-eq.

after 2001. These emissions decreased by 7.8 % (or 0.4 Mt $CO_2$-eq.) compared with 1990, to stand at 4.5 Mt $CO_2$-eq.

**Figure 74.** Changes of GHG emissions from sectors relative to 1990 — EL

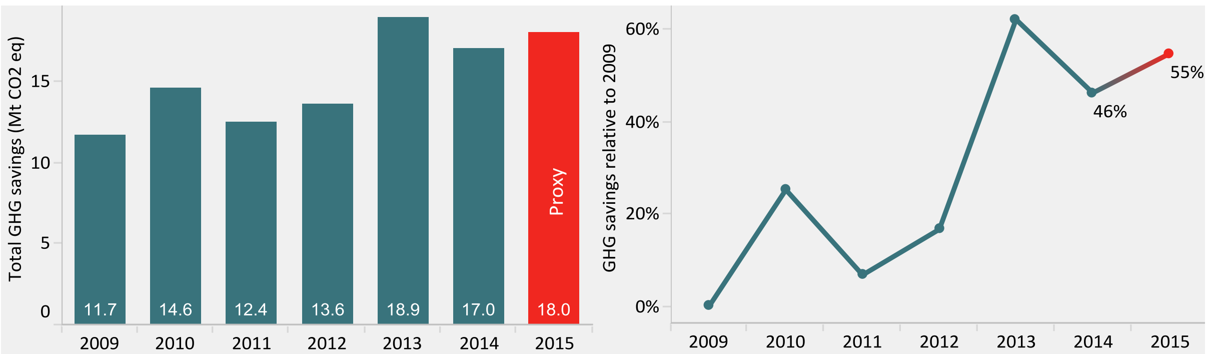



## 9.8.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Greece from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by 46 % (or 5.4 Mt $CO_2$-eq.) over 2009-2014, reaching 17 Mt $CO_2$-eq. In per capita terms GHG emissions ranged from 1.1 to 1.6 t $CO_2$-eq.

Figure 75 illustrates the trend in GHG emissions savings from renewable energy use in Greece over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 75.** Trend in GHG emission savings from RES in EL (left) — Change relative to 2009 (right)




Renewable electricity was the main contributor to overall GHG emissions savings in Greece between 2009 and 2014, increasing its contribution from 70.6 % to 73.9 %. This contribution was estimated to have reached 73 % in 2015. The contribution of renewable energy in the heating/cooling sector declined, from 28 % to 24 %. A slight increase to 24.7 % was estimated for 2015. The contribution from savings from biofuels in the transport sector increased from 1.5 % in 2009 to 2.3 % in 2014 and was estimated to remain at this level even in 2015.

**Figure 76.** Breakdown of GHG savings from renewables in EL, 2009-2014 and 2015 (proxy)

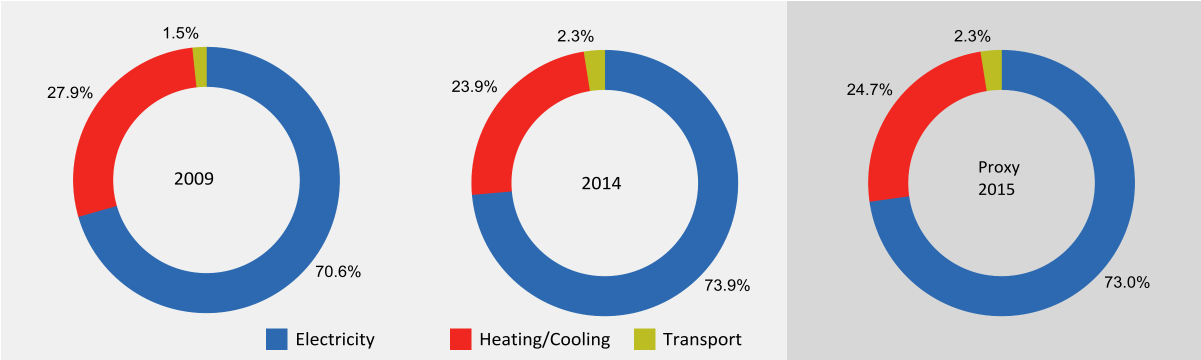



Table 14 shows how the deployment of renewable energy in Greece during the period 2009-2015 has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 14.** Emissions reduction in EL through the use of renewables, 2009-2014 and 2015 (proxy)

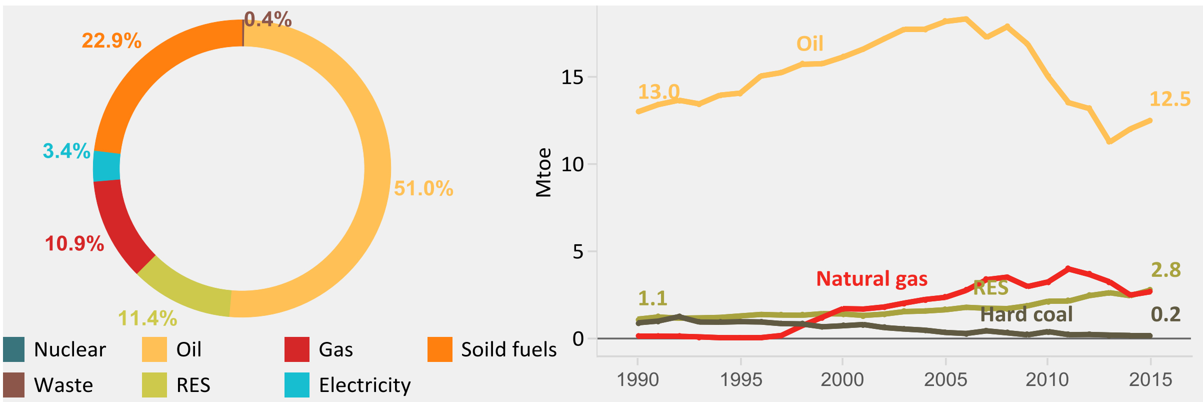
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 8.4 | 10.8 | 9.5 | 10.6 | 15.3 | 14.3 | 15.5 |
| GHG (E+Tr) emissions reduction (%) | 10.4 | 13.6 | 11.9 | 13.4 | 19.5 | 18.7 | 20.2 |
| GHG (P+H) emissions reduction (%) | 18.4 | 22.8 | 19.4 | 20.6 | 29.6 | 29.1 | 33.1 |
| GHG (Tr) emissions reduction (%) | 0.7 | 1.2 | 1.4 | 2.2 | 2.0 | 2.3 | 2.4 |

Without the current deployment of renewable energy, GHG emissions in Greece would have been 8.4 % higher in 2009, 15 % higher in 2014 and 14 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 10.3 % in 2009 to 19.3 % in 2014, coming to 18.5 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 18.4 % in 2009 to 29.6 % in 2014, coming to 29.1 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport remains marginal increasing its contribution from 0.7 % in 2009 to 1.8 % in 2014, coming to 2.2 % in 2015.

## 9.8.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Greece include a higher share of petroleum products and solid fuels and a lower share of gas and renewables. In 2015 almost 85 % of Greece's gross inland consumption of energy was met by fossil fuels. Greece has a considerable import dependence rate, reaching 77.1 % in 2015, influenced by the high dependence rate for petroleum products (105.4 %) and gas (99.9 %). The role of renewables became more prevalent around 2005 and by 2015 it had expanded by 69 %. This served to displace fossil fuels — by as much as 1.1 Mtoe by 2015. All this displacement took place in the electricity sector; the main fossil fuel displaced was hard coal.

**Figure 77.** Breakdown of gross inland consumption in Greece, 2015 (left) — trend over 1990-2015 (right)



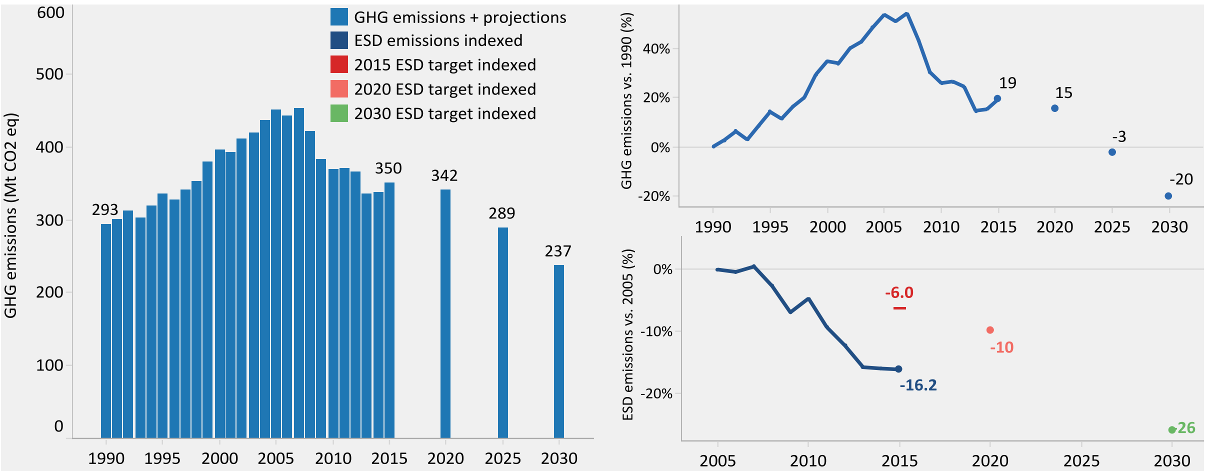
## 9.9 Spain

### 9.9.1 GHG emissions: trends & projections

In 2015, Spain emitted 262.7 Mt $CO_2$, a rise of 14.3 % (or 32.8 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by the ESD scheme reached 199.4 Mt $CO_2$-eq., 10.9 % (24.3 Mt $CO_2$-eq.) **below the ESD target**[52]. Total GHG emissions in Spain were 350 Mt $CO_2$-eq. in 2015, or 19 % above the 1990 figure. Under the EUCO27 scenario, by 2020 GHG emissions in Spain are projected to be 18 % above the 1990 figure. Under the same scenario the GHG emissions by 2030 are projected to fall 20 % below the 1990 level.

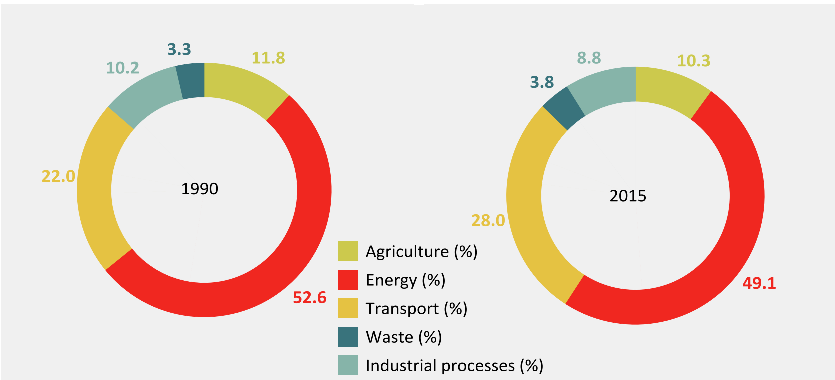
Figure 78 illustrates (i) the overall trend in GHG emissions in Spain over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 78.** GHG emissions in ES, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Spain since 1990. They totalled 172 Mt $CO_2$-eq. in 2015, a rise of 11.5 % in comparison with the 1990 figure but with a decreased share overall at 49 %. GHG emissions from the transport sector reached 98 Mt $CO_2$-eq. in 2015, 52 % higher than the 1990 figure, making it the second largest source of GHG emissions. The largest expansion of emissions occurred around 2007, when they came to 88 % above the 1990 level.

**Figure 79.** GHG emissions in ES broken down by source, 1990 (left) — 2015 (right)




Some sectors in Spain, such as energy, transport, waste management, did not see a fall in their GHG emissions over 1990-2015. Only GHG emissions from industrial processes and use decreased immediately after 1990, but increased again after 1993. They reached 30.8 Mt $CO_2$-eq. in 2015, a rise of 2.6 % in comparison with the 1990 level. GHG emissions from public power and heat production had seen only some falls over this period. In 2015, they came to 73.8 Mt $CO_2$-eq., or 43 % of energy-related GHG emissions in that year. The GHG emissions from waste management reached 13.5 Mt $CO_2$-eq. in 2015, a rise of 37 % compared to the 1990 figure.

([52]) Spain's ESD target for 2015 was 223.73 Mt $CO_2$-eq. The target for 2020 is set to 214.16 Mt $CO_2$-eq.

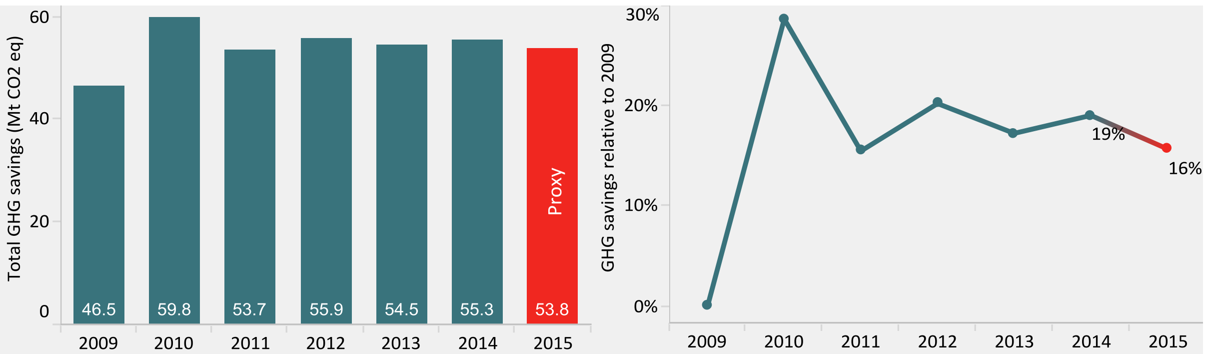
**Figure 80.** Changes of GHG emissions from sectors relative to 1990 — ES


## 9.9.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Spain from the use of renewable energy in three sectors — electricity, heating/cooling and transport — only rose by 19 % (or 8.8 Mt $CO_2$-eq.) over 2009-2014, reaching 55.3 Mt $CO_2$-eq. In per capita terms GHG emissions ranged from 1.0 to 1.2 t $CO_2$-eq.

Figure 81 illustrates the trend in GHG emissions savings from renewable energy use in Spain over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 81.** Trend in GHG emissions savings from RES in ES (left) — Change relative to 2009 (right)




Renewable electricity was the main contributor to overall GHG emissions savings in Spain between 2009 and 2014, increasing from 63.6 % to 73.8 %. This contribution increased further to 75.9 % in 2015. The contribution of renewable energy in the heating/cooling sector decreased from 28.7 % in 2009 to 22.4 % in 2014. This contribution was estimated at 24.1 % in 2015. The contribution from savings from biofuels in the transport sector halved in 2014 compared with 2009, from 7.7 % to 3.8 %. It fell to nearly zero in 2015.

**Figure 82.** Breakdown of GHG savings from renewables in ES, 2009-2014 and 2015 (proxy)

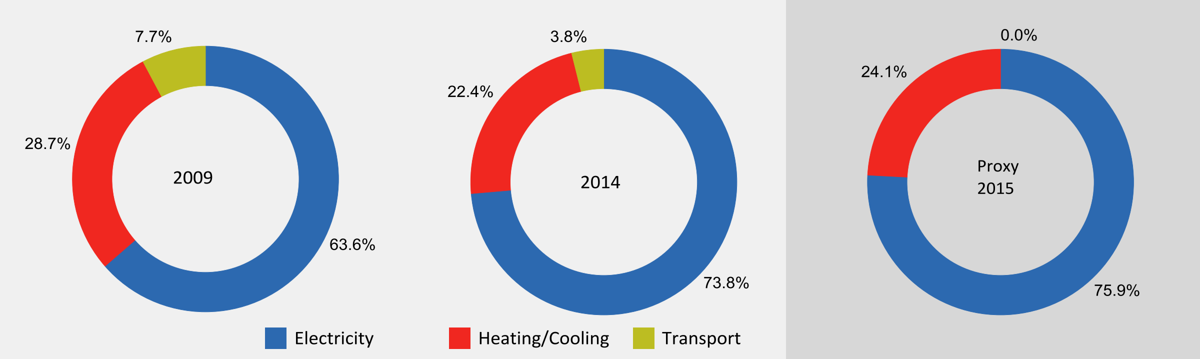



Table 15 shows how the deployment of renewable energy in Spain during the period 2009-2015 has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 15.** Emissions reduction in ES through the use of renewables, 2009-2014 and 2015 (proxy)

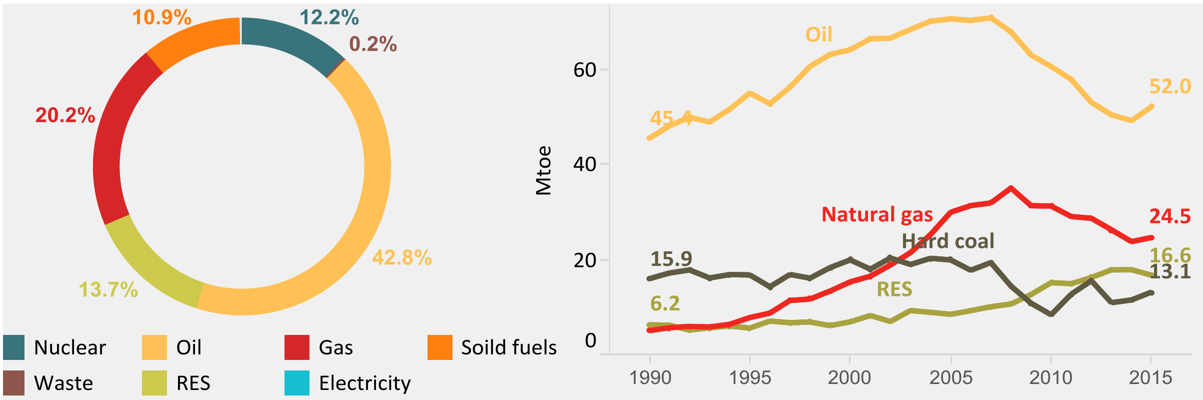
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 10.8 | 13.9 | 12.6 | 13.3 | 13.9 | 14.1 | 13.3 |
| GHG (E+Tr) emissions reduction (%) | 14.2 | 18.3 | 16.6 | 17.3 | 18.5 | 18.8 | 17.4 |
| GHG (P+H) emissions reduction (%) | 35.8 | 47.9 | 39.4 | 38.9 | 47.1 | 45.8 | 42.1 |
| GHG (Tr) emissions reduction (%) | 3.6 | 5.0 | 6.2 | 6.8 | 2.4 | 2.5 | 0.0 |

Without the current deployment of renewable energy, GHG emissions in Spain would have been 10.8 % higher in 2009, 14 % higher in 2014 and 13.3 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 14.2 % in 2009 to 18.8 % in 2014, coming down slightly to 17.4 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in electricity and the heating/cooling sectors, from 35.8 % in 2009 to 45.8 % in 2014 42.1 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport increased only around the period 2010-2012. Their contribution was 3.6 % in 2009 and 2.5 % in 2014.

### 9.9.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Spain include a higher share of petroleum products and gas and a lower share of nuclear and renewables. In 2015 almost 74 % of Spain's gross inland consumption of energy was met by fossil fuels. Spain has a considerable import dependence rate, at 73.3 % in 2015, influenced by the high dependence rate for both petroleum products (102.1 %) and gas (96.9 %). The role of renewables became more prevalent around 2005 and by 2015 it had achieved an expansion, at 98 %. This served to displace fossil fuels — but as much as 10 Mtoe by 2015. Sixty-four per cent of this displacement took place in the electricity sector (6.4 Mtoe); the main fossil fuel displaced was hard coal.

**Figure 83.** Breakdown of gross inland consumption in Spain, 2015 (left) — trend over 1990-2015 (right)



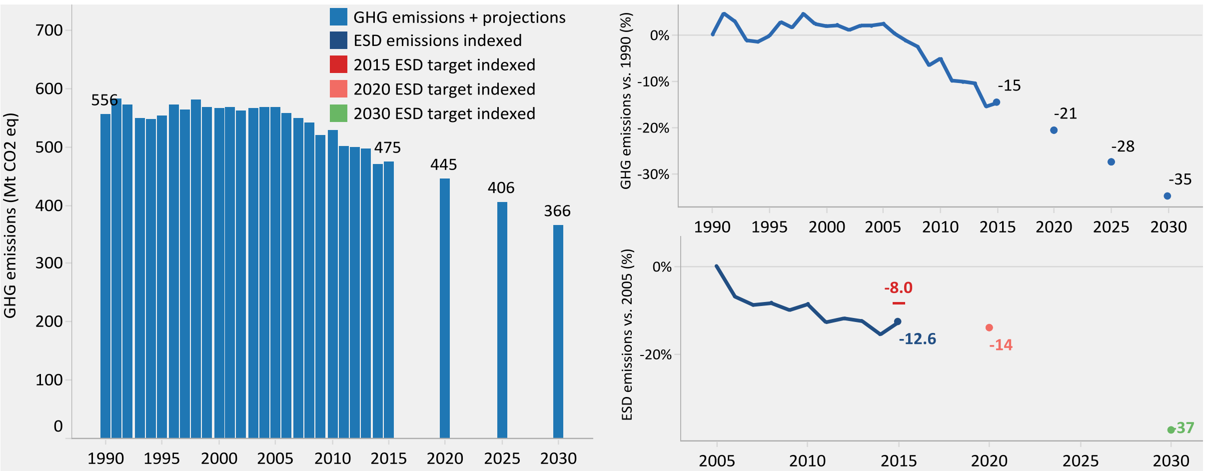
## 9.10 France

### 9.10.1 GHG emissions: trends & projections

In 2015, France emitted almost 328 Mt $CO_2$, a fall of 14 % (or 53.8 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by ESD reached 365 Mt $CO_2$-eq., 5 % (19.3 Mt $CO_2$-eq.) **below the ESD target**[53]. Total GHG emissions in France were 475 Mt $CO_2$-eq. in 2015, or 14.6 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in France are projected to fall below the 1990 level by 21 % and 35 % respectively.

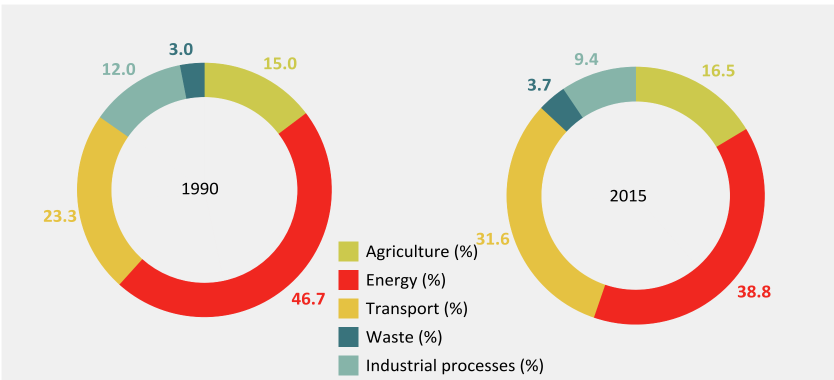
Figure 84 illustrates (i) the overall trend in GHG emissions in France over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 84.** GHG emissions in FR, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in France since 1990. They totalled 184.4 Mt $CO_2$-eq. in 2015, a fall of 29 % in comparison with the 1990 figure. GHG emissions from the transport sector reached 150 Mt $CO_2$-eq. in 2015, 16 % higher than the 1990 figure, making it the second largest source of GHG emissions.

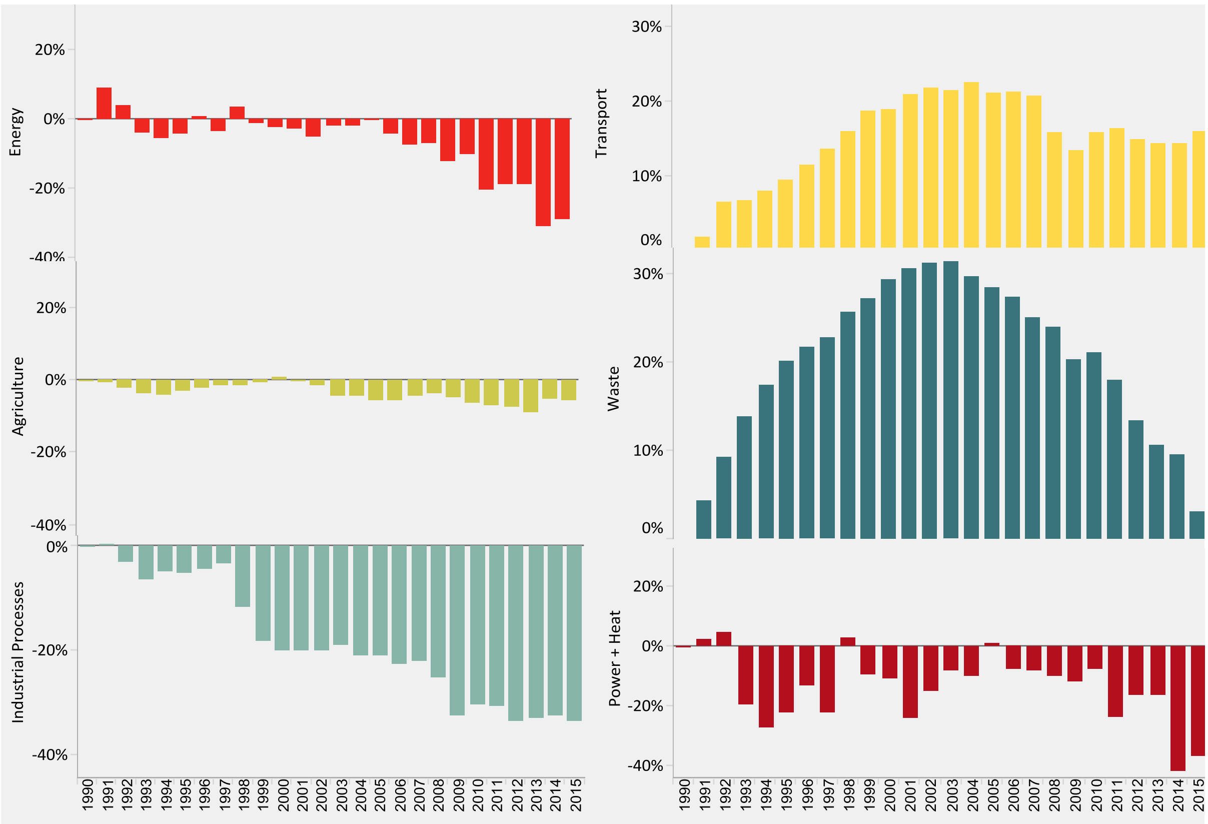
**Figure 85.** GHG emissions in FR broken down by source, 1990 (left) — 2015 (right)




Some sectors in France, such as agriculture and industrial processes and product use, saw a fall in their GHG emissions immediately after 1990. Emissions from transport and waste management only increased after 1990. In 2015 the absolute contribution of emissions from industrial processes and product use amounted to 44.5 Mt $CO_2$-eq., a fall of 33.4 % in comparison with 1990 level. Emissions from agriculture came to 78.4 Mt $CO_2$-eq. in 2015, 5.7 % below the 1990 figure. GHG emissions from public power and heat production began to fall after 1993. In 2015, they came to 31.4 Mt $CO_2$-eq., or 17 % of energy-related GHG emissions in that year. GHG emissions from waste management had their largest expansion around 2003, 31 % above the 1990 level. They stood at 17.4 Mt $CO_2$-eq. in 2015, 3.1 % above the 1990 figure.

([53]) France's ESD target for 2015 was 384.43 Mt $CO_2$-eq. The target for 2020 is set to 359.29 Mt $CO_2$-eq.

**Figure 86.** Changes of GHG emissions from sectors relative to 1990 — FR

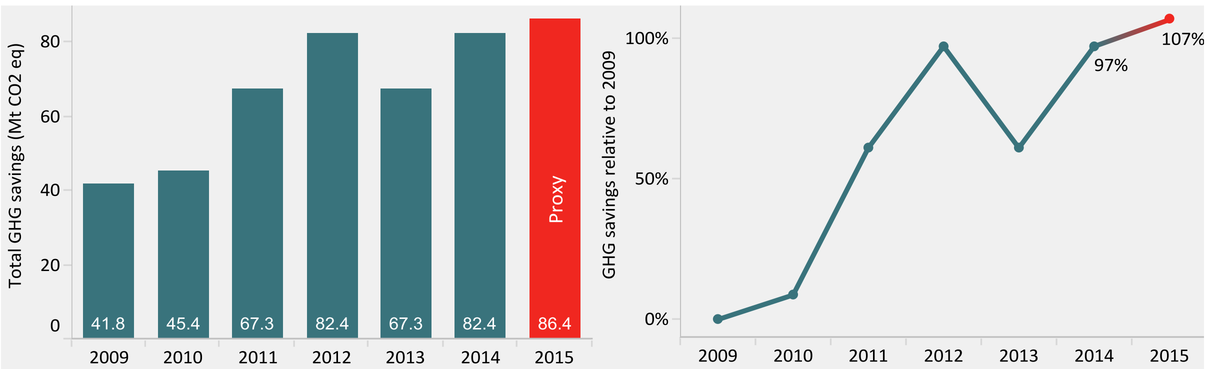



## 9.10.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in France from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose sharply by 97 % (or 40.6 Mt $CO_2$-eq.) over 2009-2014, reaching 82.4 Mt $CO_2$-eq. In per capita terms GHG emissions almost doubled, from 0.65 to 1.24 t $CO_2$-eq.

Figure 87 illustrates the trend in GHG emissions savings from renewable energy use in France over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 87.** Trend in GHG emission savings from RES in FR (left) — Change relative to 2009 (right)




Renewable heating/cooling was the main contributor to overall GHG emissions savings in France in 2009. In 2014 renewable electricity contribution[54] reached 68.4 % and was estimated to have remained at this level in 2015. The contribution of renewable energy in the heating/cooling sector reached 24.1 % in 2014 and was estimated at 24.8 % in 2015. The contribution from savings from biofuels in the transport sector almost was 7.5 % in 2014 and was estimated at 7.2 % in 2015.

**Figure 88.** Breakdown of GHG savings from renewables in FR, 2009-2014 and 2015 (proxy)

([54]) The methodology used for France for the 2009-10 calculations differs slightly from that used for 2011-2014, and this influenced the results obtained for these periods. See Annex for more information.

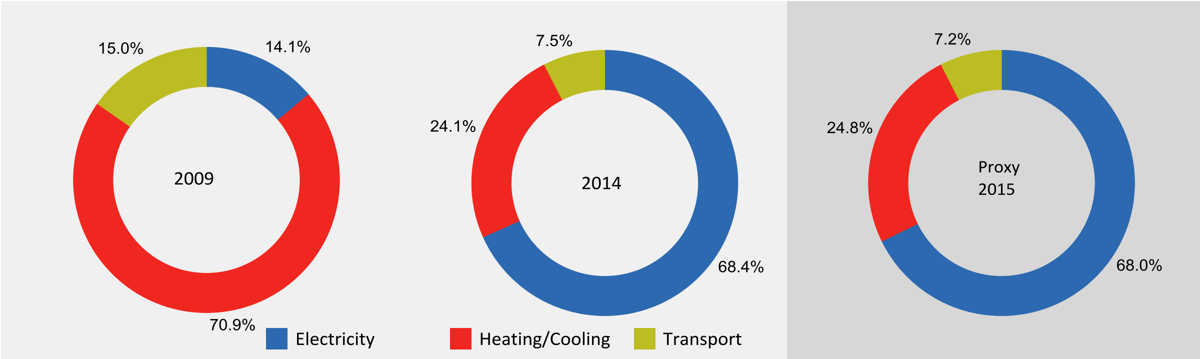



Table 16 shows how the deployment of renewable energy in France during the period 2009-2015 has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 16.** Emissions reduction in FR through the use of renewables, 2009-2014 and 2015 (proxy)

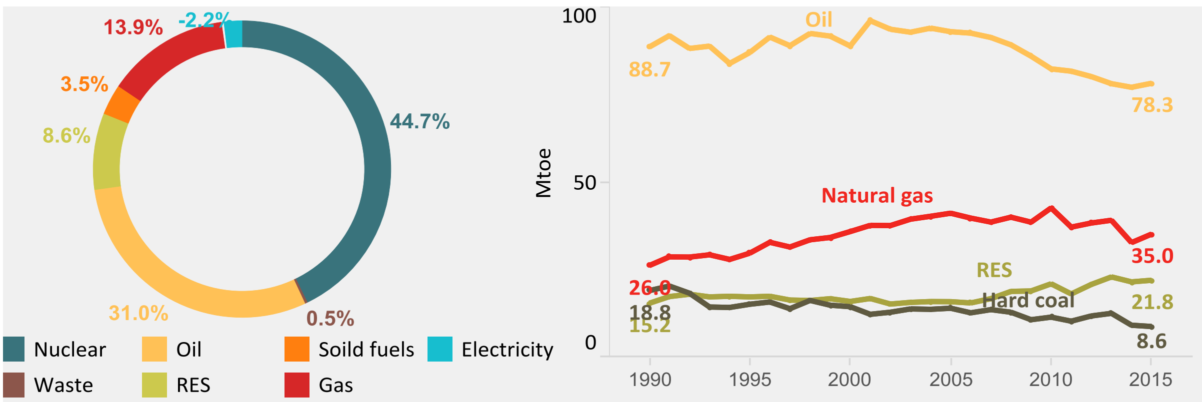
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 7.4 | 7.9 | 11.8 | 14.2 | 11.9 | 14.9 | 15.4 |
| GHG (E+Tr) emissions reduction (%) | 10.4 | 11.0 | 16.5 | 19.4 | 16.4 | 20.9 | 21.4 |
| GHG (P+H) emissions reduction (%) | 44.7 | 46.2 | 61.8 | 64.8 | 59.7 | 72.6 | 71.8 |
| GHG (Tr) emissions reduction (%) | 4.6 | 4.2 | 4.2 | 4.5 | 4.2 | 4.5 | 4.5 |

Without the current deployment of renewable energy, GHG emissions in France would have been 7.4 % higher in 2009, 14.9 % higher in 2014 and 15.4 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 10.4 % in 2009 to 20.9 % in 2014 and 21.4 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 44.7 % in 2009 to 72.6 % in 2014, coming in at 71.8 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport remained marginal over this period, at around 4.5 %.

## 9.10.3 Fossil fuels displacement: role of renewables

The features of the energy mix in France include a higher share of nuclear and petroleum products. In 2015 only 48.4 % of France's gross inland consumption of energy was met by fossil fuels. France had an import dependence rate at 46 % in 2015, influenced by the high dependence rate for petroleum products (98.5 %), gas (98.7 %) and solid fuels (98.4 %). The role of renewables became more prevalent around 2005 and by 2015 it had expanded by 40 %. This served to displace fossil fuels — by as much as 7 Mtoe by 2015. Forty-three per cent of this displacement took place in the electricity sector (3.1 Mtoe); the main fossil fuel displaced was hard coal.

**Figure 89.** Breakdown of gross inland consumption in France, 2015 (left) — trend over 1990-2015 (right)



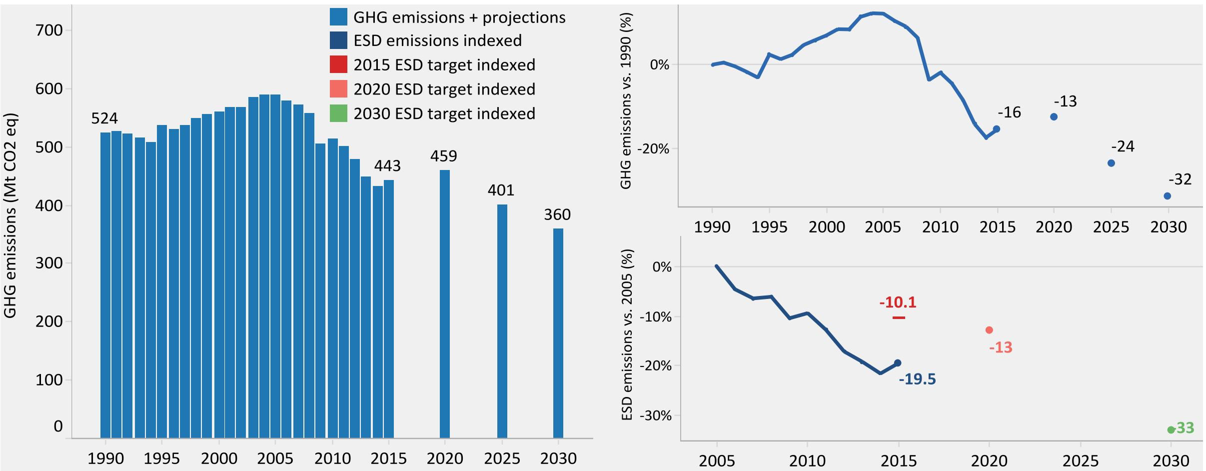
## 9.11 Italy

### 9.11.1 GHG emissions: trends & projections

In 2015, Italy emitted almost 353 Mt $CO_2$, a fall of 17.7 % (or 75.7 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions under the ESD scheme reached 272.4 Mt $CO_2$-eq., 10.5 % (31.8 Mt $CO_2$-eq.) **below the ESD target**[55]. Total GHG emissions in Italy were 443 Mt $CO_2$-eq., or 16 % below the emissions in 1990. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Italy are projected to fall below the 1990 figure by 13 % and 32 % respectively.

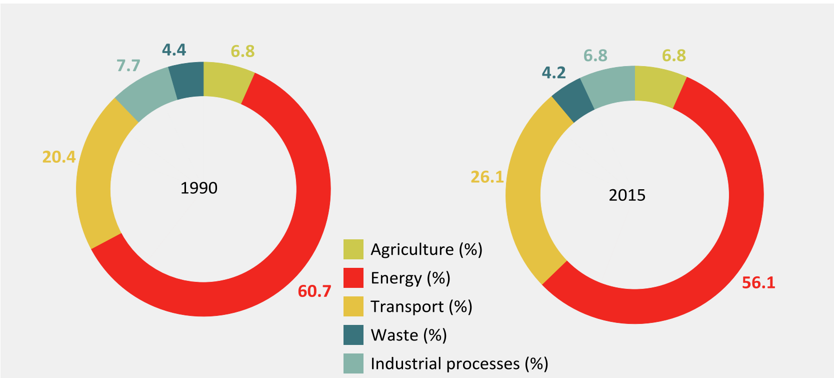
Figure 90 illustrates (i) the overall trend in GHG emissions in Italy over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 90.** GHG emissions in IT, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions remained the main source of total GHG emissions in Italy since 1990. They totalled 248.2 Mt $CO_2$-eq. in 2015, a fall of 22 % in comparison with the 1990 figure. Transport sector emissions reached 115.7 Mt $CO_2$-eq. in 2015, 8.3 % higher than the 1990 figure, making it the second largest source of GHG emissions.

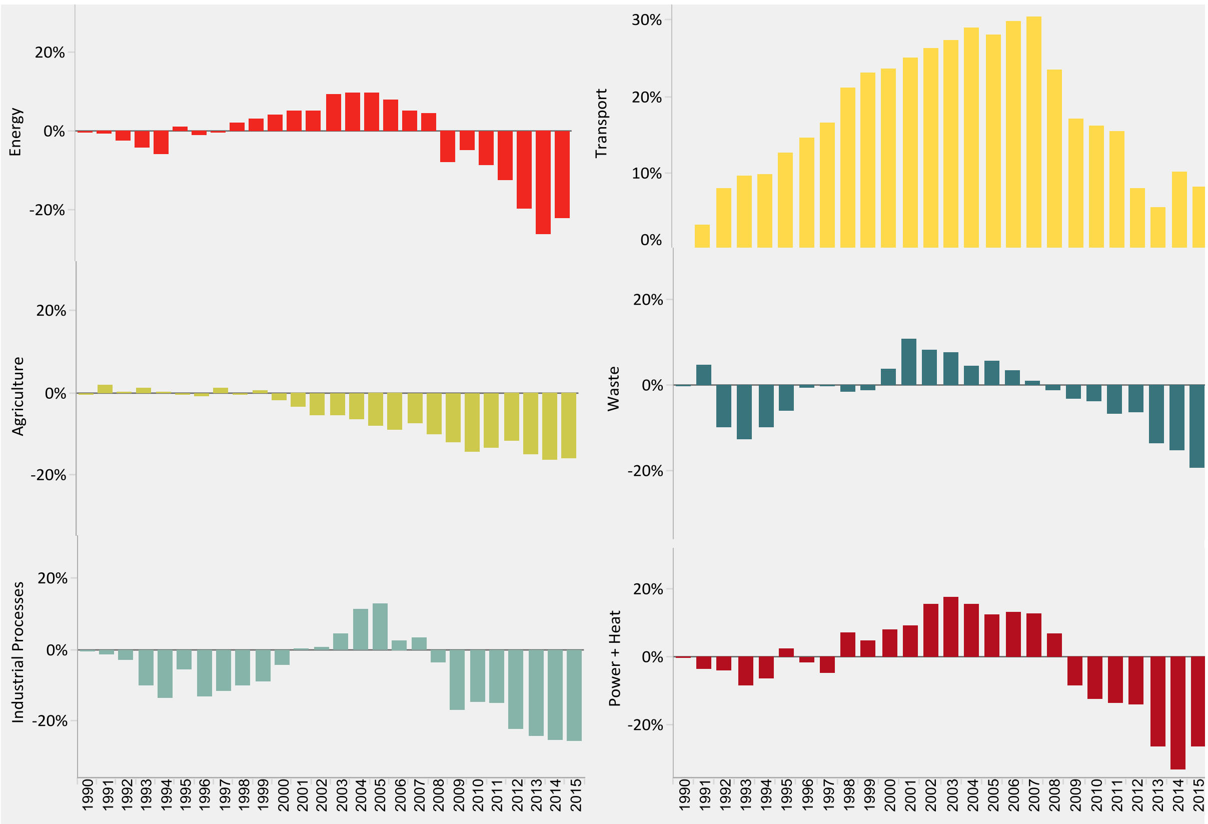
**Figure 91.** GHG emissions in IT broken down by source, 1990 (left) — 2015 (right)




Some sectors in Italy, such as energy, waste management and industrial processes and product use, saw a fall in their GHG emissions immediately after 1990. Nevertheless these emissions increased around the period 1999-2008, decreasing again afterwards. In 2015 the absolute contribution of emissions from industrial processes and product use amounted to 30 Mt $CO_2$-eq., a fall of 25.7 % in comparison with the 1990 level. GHG emissions from agriculture also came to 30 Mt $CO_2$-eq. in 2015, 16 % below the 1990 figure. GHG emissions from public power and heat production came to 79 Mt $CO_2$-eq., or 32 % of energy-related GHG emissions in that year. GHG emissions from waste management stood at 18.8 Mt $CO_2$-eq. in 2015, 19.3 % below the 1990 level.

([55]) Italy's ESD target for 2015 was 304.23 Mt $CO_2$-eq. The target for 2020 is set to 294.41 Mt $CO_2$-eq.

**Figure 92.** Changes of GHG emissions from sectors relative to 1990 — IT

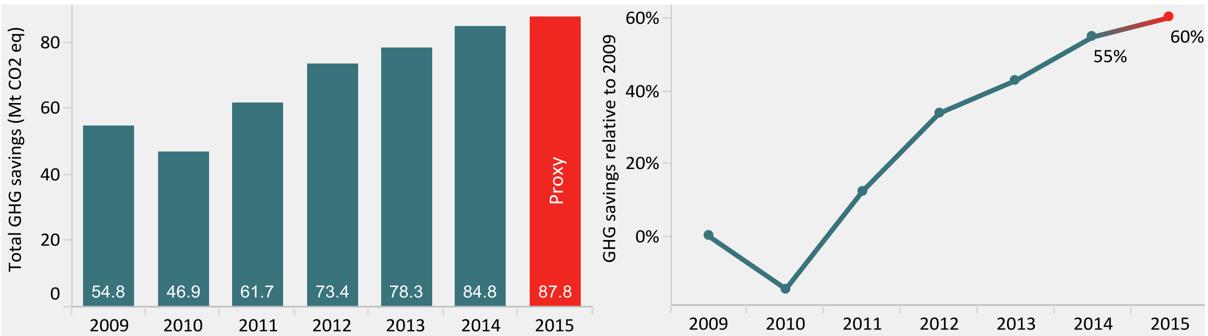



## 9.11.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Italy from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by 55 % (or 30 Mt $CO_2$-eq.) over 2009-2014, reaching 84.8 Mt $CO_2$-eq. In per capita terms GHG emissions ranged from 0.93 to 1.40 t $CO_2$-eq.

Figure 93 illustrates the trend in GHG emissions savings from renewable energy use in Italy over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 93.** Trend in GHG emissions savings from RES in IT (left) — Change relative to 2009 (right)




Renewable electricity was the main contributor to overall GHG emissions savings in Italy between 2009 and 2014, increasing from 67.2 % to 75.2 %. This contribution was estimated at 74.1 % in 2015. The contribution from renewable energy in the heating/cooling sector decreased somewhat over the years, from 29.4 % in 2009 to 22.5 % in 2014, and was estimated to have reached 23.4 % in 2015. The contribution from savings from biofuels in the transport sector remained marginal at 3.3 % in 2009 and 2.3 % in 2014. A contribution of 2.5 % was estimated for 2015.

**Figure 94.** Breakdown of GHG savings from renewables in IT, 2009-2014 and 2015 (proxy)

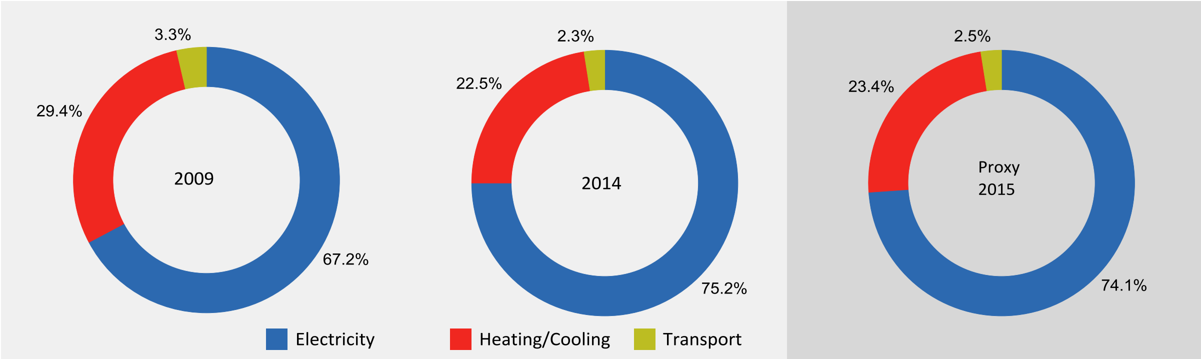



Table 17 shows how the deployment of renewable energy in Italy during the period 2009-2015 has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 17.** Emissions reduction in IT through the use of renewables, 2009-2014 and 2015 (proxy)

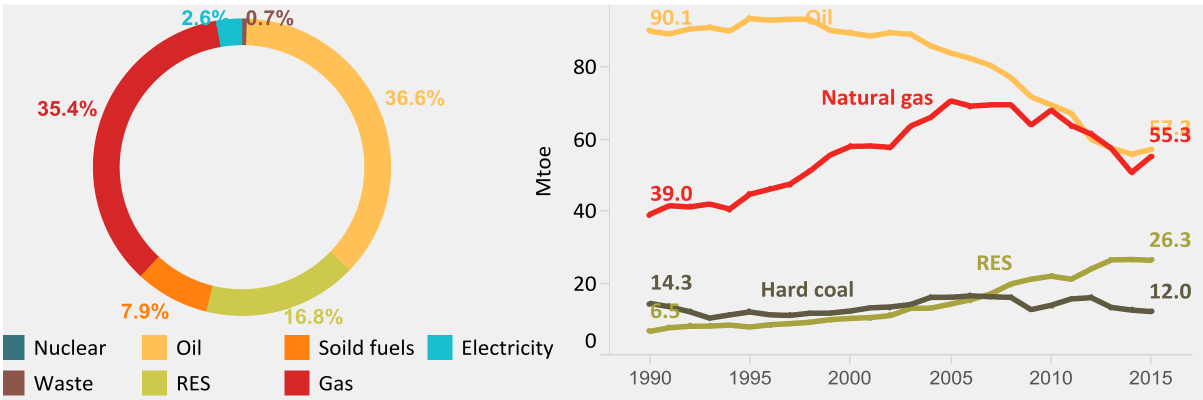
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 9.8 | 8.4 | 11.0 | 13.3 | 14.8 | 16.4 | 16.5 |
| GHG (E+Tr) emissions reduction (%) | 11.8 | 10.1 | 13.2 | 16.0 | 17.9 | 19.8 | 19.9 |
| GHG (P+H) emissions reduction (%) | 35.0 | 31.6 | 39.0 | 43.5 | 49.1 | 53.6 | 52.0 |
| GHG (Tr) emissions reduction (%) | 1.5 | 2.9 | 2.0 | 2.3 | 2.0 | 1.8 | 2.0 |

Without the current deployment of renewable energy, GHG emissions in Italy would have been 9.8 % higher in 2009, 16.4 % higher in 2014 and 16.5 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 11.8 % in 2009 to 19.8 % in 2014 and 19.9 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 35 % in 2009 to 53.6 % in 2014, coming in at 52 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport remained marginal over this period, at around 2 %.

## 9.11.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Italy include a higher share of petroleum products and gas. In 2015 almost 78 % of Italy's gross inland consumption of energy was met by fossil fuels. Italy's import dependency rate was 77 % in 2015 remaining relatively high for solid fuels (100.2 %), gas (90.4 %) and petroleum products (89.5 %). The role of renewables became more prevalent around 2005 and by 2015 it had expanded by 86 %. After 2007 the consumption of renewables had overtaken the gross inland consumption of hard coal. This served to displace fossil fuels — by as much as 20 Mtoe by 2015. Thirty per cent of this displacement took place in the electricity sector (6.2 Mtoe); the main fossil fuel displaced was hard coal.

**Figure 95.** Breakdown of gross inland consumption in Italy, 2015 (left) — trend over 1990-2015 (right)



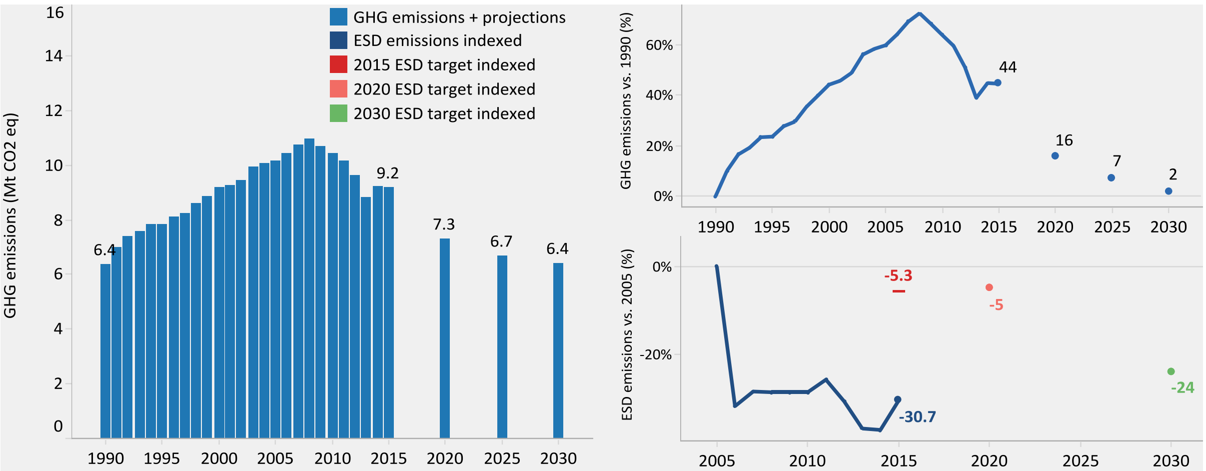
## 9.12 Cyprus

### 9.12.1 GHG emissions: trends & projections

In 2015, Cyprus emitted 6.2 Mt $CO_2$, a rise of 36.3 % (or 1.6 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by ESD reached 4.3 Mt $CO_2$-eq., 26.8 % (1.6 Mt $CO_2$-eq.) **below the ESD target**[56]. Total GHG emissions in Cyprus were 9.2 Mt $CO_2$-eq. in 2015, or 44 % above the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Cyprus are projected to rise above the 1990 level by 16 % and 2 % respectively.

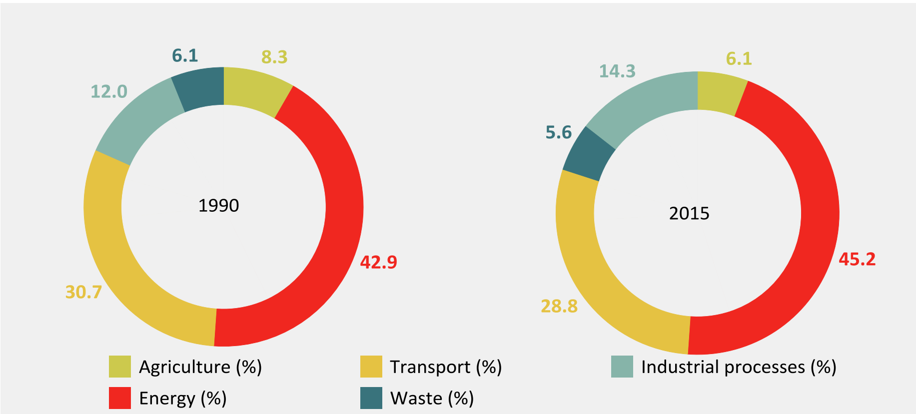
Figure 96 illustrates (i) the overall trend in GHG emissions in Cyprus over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 96.** GHG emissions in CY, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions remained the main source of total GHG emissions in Cyprus since 1990. They totalled 4.2 Mt $CO_2$-eq. in 2015, a rise of 52 % in comparison with the 1990 figure. These emissions had the largest expansion around 2008, 103 % above the 1990 level. GHG emissions from the transport sector reached 2.6 Mt $CO_2$-eq. in 2015, 35.6 % higher than the 1990 figure, making it the second largest source of GHG emissions.

**Figure 97.** GHG emissions in CY broken down by source, 1990 (left) — 2015 (right)

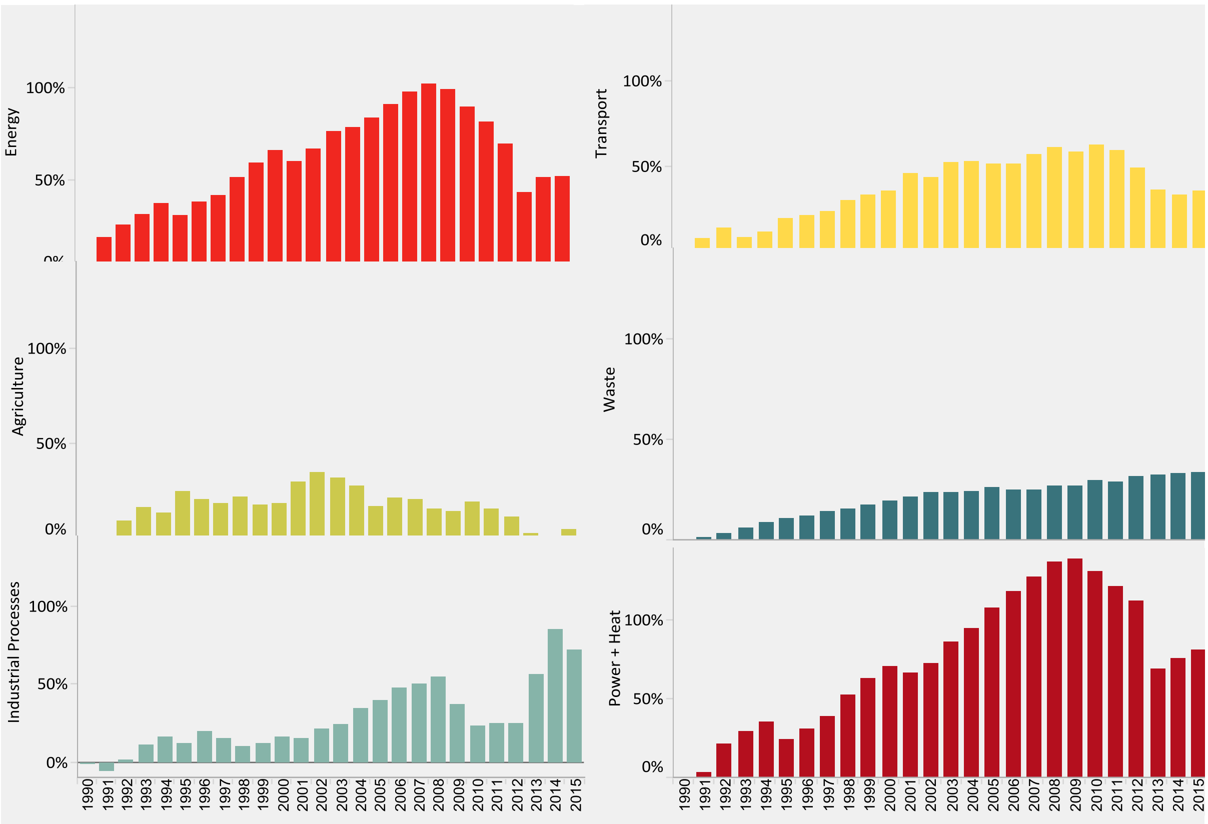



All sectors in Cyprus did not see a fall in their GHG emissions over the period 1990-2015. GHG emissions from public power and production had the fastest increase around 2009, 138 % above the 1990 figure. In 2015 their absolute contribution amounted to 3.0 Mt $CO_2$-eq., or 73 % of energy-related GHG emissions in that year. The GHG emissions from industrial processes and product use increased by 73 % (or 0.6 Mt $CO_2$-eq.) compared with 1990, to stand at 1.3 Mt $CO_2$-eq. The GHG emissions from waste management increased by 0.5 Mt $CO_2$-eq. in 2015, or 33.7 %

([56]) Cyprus's ESD target for 2015 was 5.93 Mt $CO_2$-eq. The target for 2020 is set to 5.94 Mt $CO_2$-eq.

above the 1990 figure. The agriculture sector saw an increase of only 5.3 % over the period 1990-2015 standing at 0.6 Mt $CO_2$-eq.

**Figure 98.** Changes of GHG emissions from sectors relative to 1990 — CY

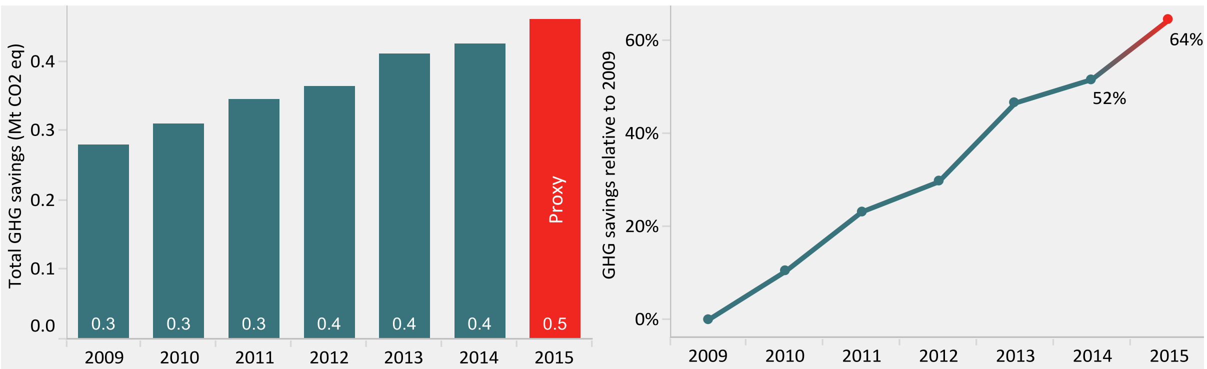



## 9.12.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Cyprus from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by 52 % (or 0.1 Mt $CO_2$-eq.) over 2009-2014, reaching 0.4 Mt $CO_2$-eq. In per capita terms GHG emissions ranged from 0.35 to 0.5 t $CO_2$-eq.

Figure 99 illustrates the trend in GHG emissions savings from renewable energy use in Cyprus over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 99.** Trend in GHG emissions savings from RES in CY (left) — Change relative to 2009 (right)




Renewable energy in the heating/cooling sector was the main contributor to overall GHG emissions savings in Cyprus between 2009 and 2014. This contribution decreased from 90.4 % in 2009 to 71.6 % in 2014. This contribution was estimated at 70.2 % in 2015. The contribution of renewable electricity expanded rapidly over the years, from only 3 % in 2009 to 21.1 % in 2014. This contribution was estimated to have reached 23.2 % in 2015. The contribution from savings from biofuels in the transport sector was 6.6 % in 2009 and rose to 7.4 % in 2014. A contribution of 6.6 % was estimated for 2015.

**Figure 100.** Breakdown of GHG savings from renewables in CY, 2009-2014 and 2015 (proxy)

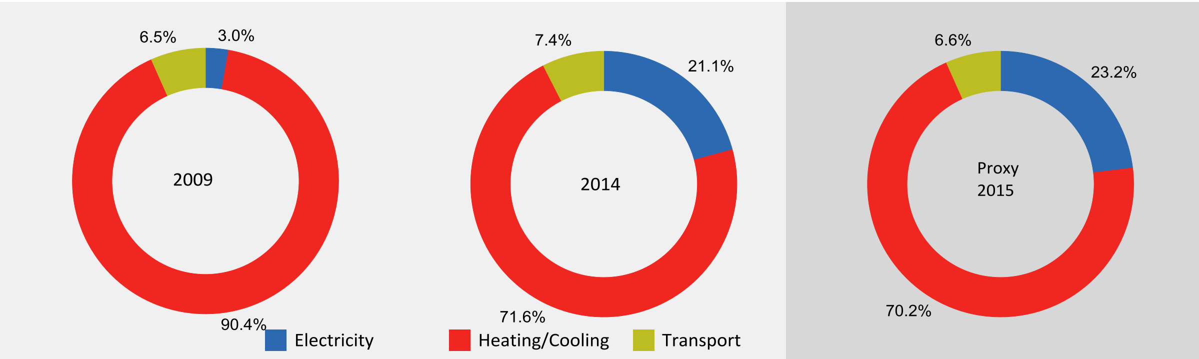



Table 18 shows how the deployment of renewable energy in Cyprus has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 18.** Emissions reduction in CY through the use of renewables, 2009-2014 and 2015 (proxy)

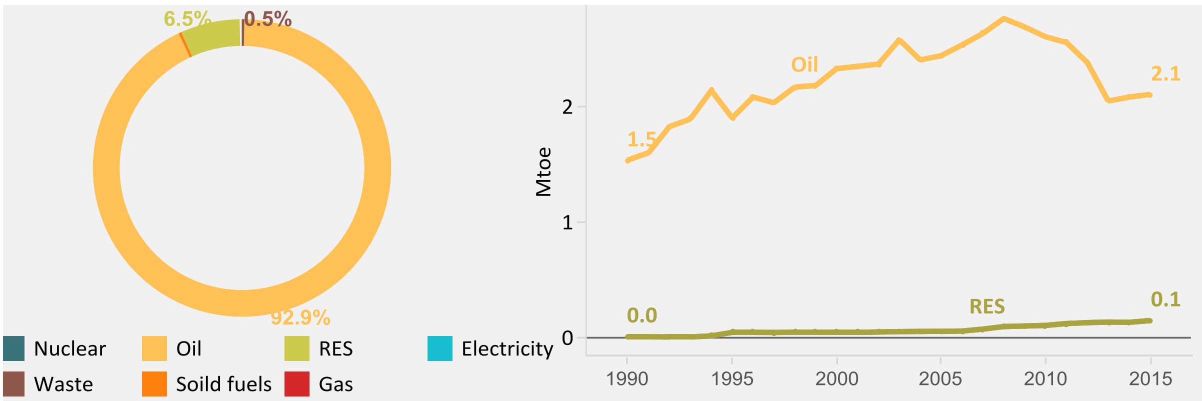
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 2.6 | 2.9 | 3.3 | 3.7 | 4.5 | 4.4 | 4.8 |
| GHG (E+Tr) emissions reduction (%) | 3.5 | 4.0 | 4.6 | 5.1 | 6.6 | 6.7 | 7.1 |
| GHG (P+H) emissions reduction (%) | 6.1 | 6.9 | 8.0 | 8.7 | 11.8 | 11.8 | 12.4 |
| GHG (Tr) emissions reduction (%) | 0.8 | 0.9 | 1.0 | 1.2 | 1.7 | 1.7 | 1.6 |

Without the current deployment of renewable energy, GHG emissions in Cyprus would have been 2.6 % higher in 2009, 4.5 % higher in 2014 and 4.4 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 3.5 % in 2009 to 6.7 % in 2014 and 7.1 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 6.1 % in 2009 to 11.8 % in 2014 and 12.4 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport remained marginal over this period, at 0.8 % in 2009 and around 1.7 % in 2014 and 2015 alike.

## 9.12.3 Fossil fuels displacement: role of renewables

In Cyprus petroleum products hold the dominant share in the energy mix. In 2015 more than 93 % of Cyprus's gross inland consumption of energy was met by fossil fuels. Cyprus's import dependency rate was 97.7 % in 2015 remaining very high for solid fuels (100 %) and petroleum products (102.8 %). The role of renewables became more prevalent around 2010 and by 2015 it had expanded by 172 %. This served to displace fossil fuels — but only by 0.2 Mtoe by 2015. Forty-three per cent of this displacement took place in the electricity sector (0.09 Mtoe).

**Figure 101**. Breakdown of gross inland consumption in Cyprus, 2015 (left) — trend over 1990-2015 (right)



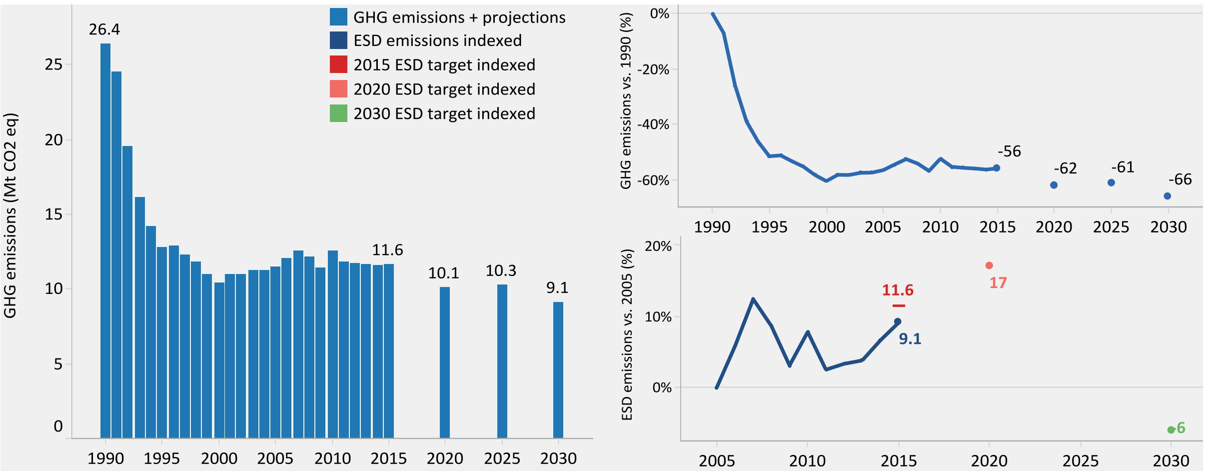
## 9.13 Latvia

### 9.13.1 GHG emissions: trends & projections

In 2015, Latvia emitted almost 8 Mt $CO_2$, a fall of 60.8 % (or 12.3 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by the ESD scheme reached 9.2 Mt $CO_2$-eq., 2.2 % (0.2 Mt $CO_2$-eq.) **below the ESD target**[57]. Total GHG emissions in Latvia were 11.6 Mt $CO_2$-eq. in 2015, or 56 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Latvia are projected to fall below the 1990 figure by 62 % and 66 % respectively.

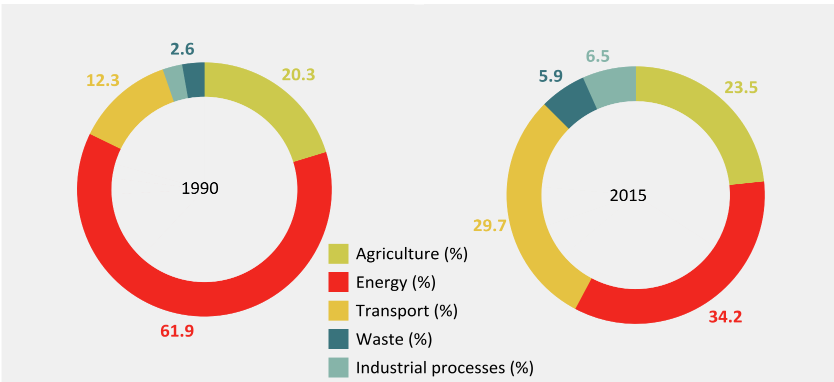
Figure 102 illustrates (i) the overall trend in GHG emissions in Latvia over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 102.** GHG emissions in LV, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Latvia since 1990 even though their share almost halved in 2015. They totalled 4.0 Mt $CO_2$-eq. in 2015, a sharp fall of 75.6 % in comparison with the 1990 figure. GHG emissions from the transport sector reached 3.5 Mt $CO_2$-eq. in 2015, 6.4 % higher than the 1990 figure, making it the second largest source of GHG emissions. These emissions saw the largest drop around 1999, 36 % below the 1990 level.

**Figure 103.** GHG emissions in LV broken down by source, 1990 (left) — 2015 (right)

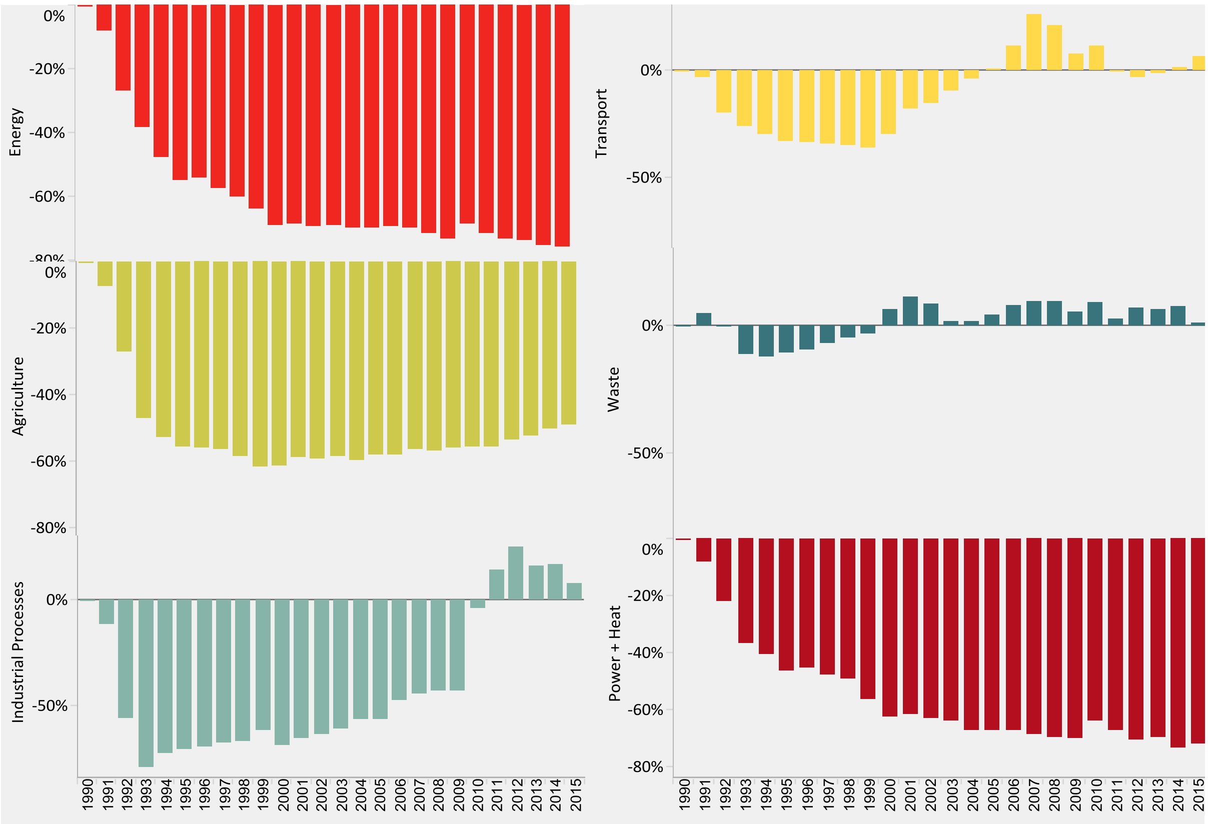



Some sectors in Latvia, such as waste management, did not see a fall in their GHG emissions immediately after 1990. The GHG emissions from agriculture almost halved over the period 1990-2015. They totalled 2.7 Mt $CO_2$-eq. in 2015. The GHG emissions from industrial processes and product use had their largest fall around 1993, of 78.6 %. These emissions started increasing after 2010 reaching 1.3 Mt $CO_2$-eq. in 2015, 72 % above the 1990 figure. The public power and production sector experienced its largest fall in GHG emissions in 2014, which came in at 73.4 %

([57]) Latvia's ESD target for 2015 was 9.44 Mt $CO_2$-eq. The target for 2020 is set to 9.9 Mt $CO_2$-eq.

below the 1990 figure. In 2015 their absolute contribution amounted to 1.7 Mt $CO_2$-eq., or 43 % of energy-related GHG emissions in that year.

**Figure 104.** Changes of GHG emissions from sectors relative to 1990 — LV

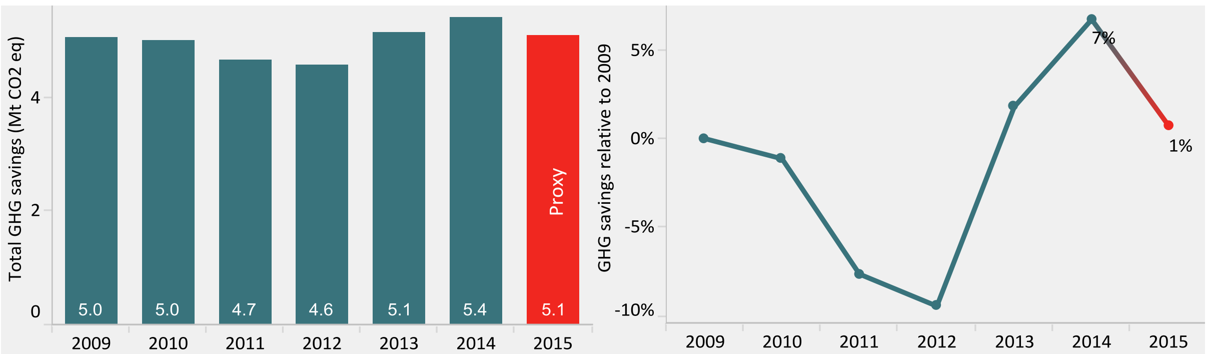



## 9.13.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Latvia from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by only 7 % (or 0.3 Mt $CO_2$-eq.) over 2009-2014, reaching 5.4 Mt $CO_2$-eq. In per capita terms GHG emissions ranged from 2.3 to 2.7 t $CO_2$-eq.

Figure 105 illustrates the trend in GHG emissions savings from renewable energy use in Latvia over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 105.** Trend in GHG emissions savings from RES in LV (left) — Change relative to 2009 (right)




Renewable energy in the heating/cooling sector was the main contributor to overall GHG emissions savings in Latvia between 2009 and 2014. This contribution decreased from 85.8 % in 2009 to 82.8 % in 2014, and was estimated at 81.6 % in 2015. The contribution of renewable electricity expanded over the years from 13.7 % in 2009 to 16.4 % in 2014. This contribution was estimated to have reached 17.5 % in 2015. The contribution from savings from biofuels in the transport sector remained very marginal at around 1 % for the years 2009, 2014 and 2015.

**Figure 106.** Breakdown of GHG savings from renewables in LV, 2009-2014 and 2015 (proxy)

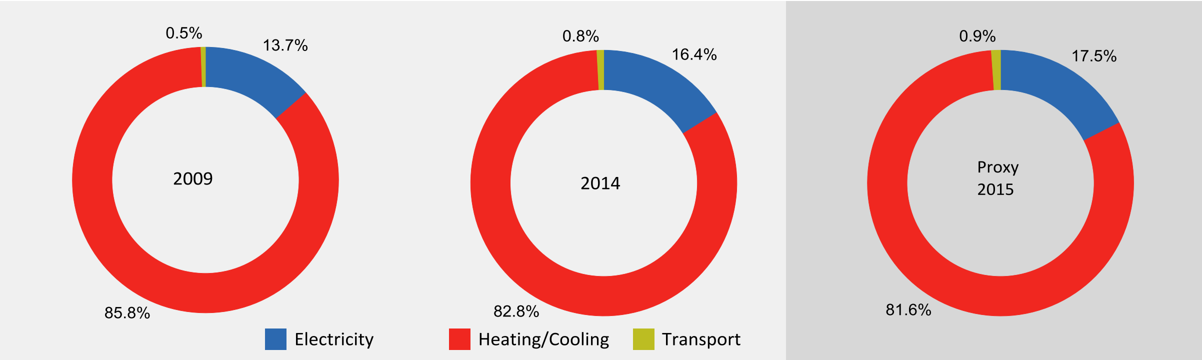



Table 19 shows how the deployment of renewable energy in Latvia has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 19.** Emissions reduction in LV through the use of renewables, 2009-2014 and 2015 (proxy)

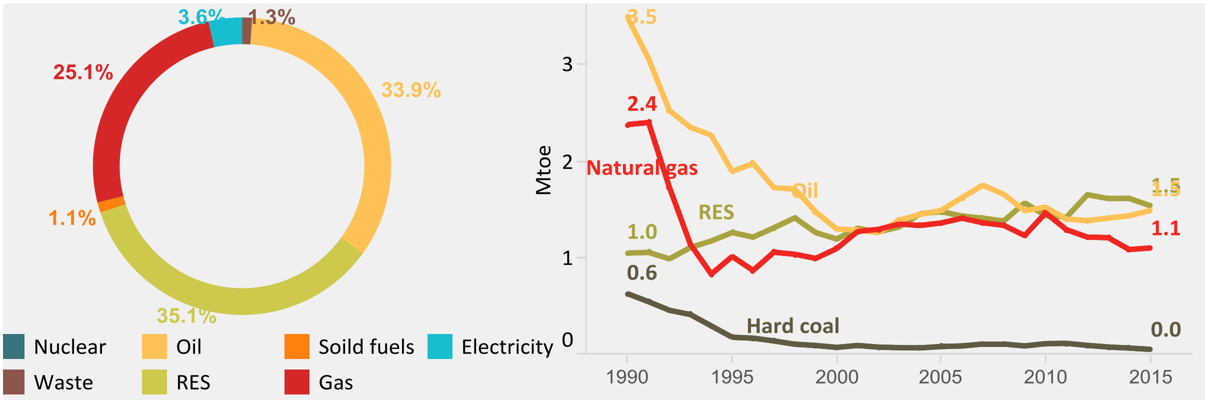
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 30.7 | 28.4 | 28.3 | 28.1 | 30.6 | 31.8 | 30.4 |
| GHG (E+Tr) emissions reduction (%) | 39.9 | 37.3 | 38.2 | 38.8 | 41.8 | 43.6 | 41.7 |
| GHG (P+H) emissions reduction (%) | 73.1 | 69.1 | 69.5 | 71.4 | 73.1 | 76.7 | 74.6 |
| GHG (Tr) emissions reduction (%) | 0.8 | 1.7 | 1.5 | 1.4 | 1.4 | 1.5 | 1.4 |

Without the current deployment of renewable energy, GHG emissions in Latvia would have been 30.7 % higher in 2009, 31.8 % higher in 2014 and 30.4 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 39.9 % in 2009 to 43.6 % in 2014, coming in at 41.7 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 73.1 % in 2009 to 76.7 % in 2014, coming in at 74.6 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport remained marginal over this period, coming in at 0.8 % in 2009 and around 1.5 % in 2014 and 2015 alike.

## 8.13.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Latvia include a higher share of renewables and petroleum products. In 2015 almost 60 % of Latvia's gross inland consumption of energy was met by fossil fuels. Latvia's import dependency rate was 51 % in 2015 remained high for gas (98.6 %) and petroleum products (103 %). Over the period 1990-2015 renewables had expanded by 47 %. This served to displace fossil fuels — but only by 0.5 Mtoe by 2015. Thirty-four per cent of this displacement took place in the electricity sector (0.18 Mtoe); the main fossil fuel displaced was hard coal.

**Figure 107.** Breakdown of gross inland consumption in Latvia, 2015 (left) — trend over 1990-2015 (right)



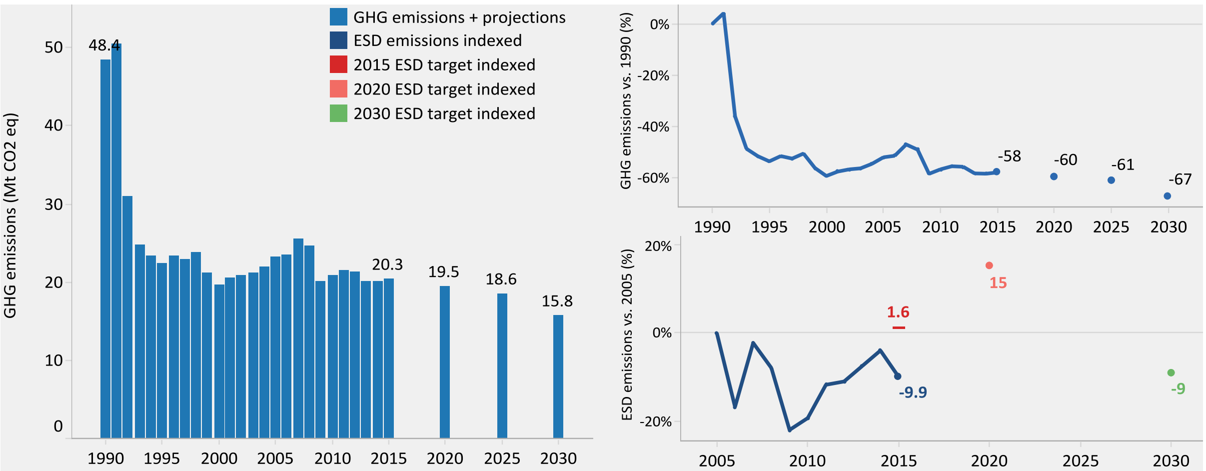
## 9.14 Lithuania

### 9.14.1 GHG emissions: trends & projections

In 2015, Lithuania emitted 12.5 Mt $CO_2$, a fall of 64.3 % (or 22.5 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by the ESD scheme reached 12 Mt $CO_2$-eq., 11.3 % (1.5 Mt $CO_2$-eq.) **below the ESD target**[58]. Total GHG emissions in Lithuania were 20.3 Mt $CO_2$-eq. in 2015, or 58 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Lithuania are projected to fall below the 1990 level by 60 % and 67 % respectively.

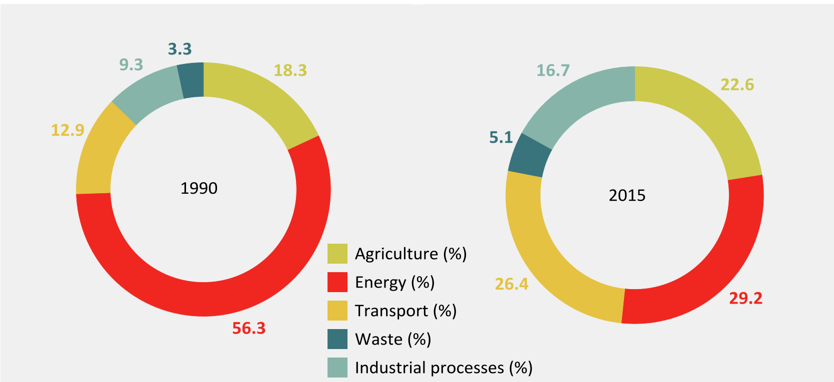
Figure 108 illustrates (i) the overall trend in GHG emissions in Lithuania over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 108.** GHG emissions in LT, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Lithuania since 1990. They totalled 5.9 Mt $CO_2$-eq. in 2015, a sharp fall of 78.2 % in comparison with the 1990 figure. Their relative share more than halved, from 56.3 % to 29.2 %. GHG emissions from the transport sector totalled 5.4 Mt $CO_2$-eq. in 2015, 14 % below the 1990 figure, making it the second largest source of GHG emissions. These emissions saw their largest fall around 1994, coming in at 57 % below the 1990 level.

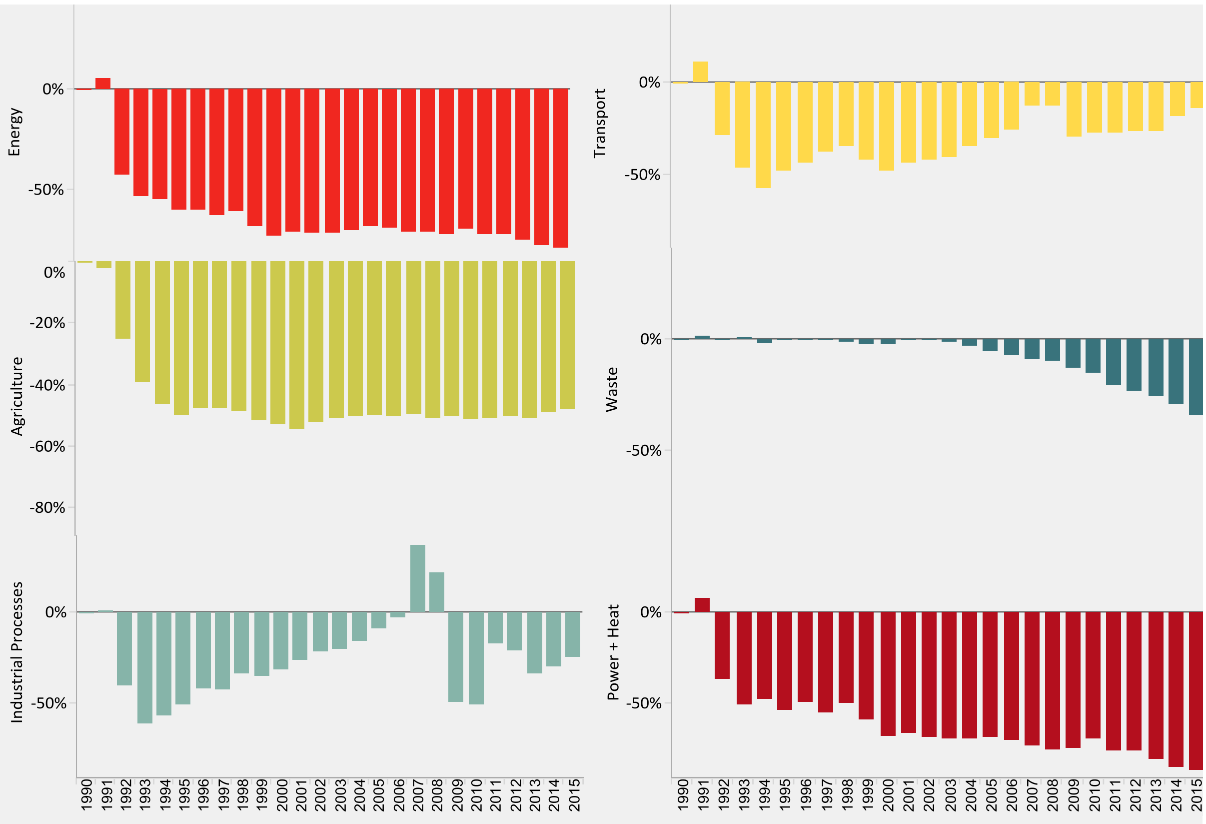
**Figure 109.** GHG emissions in LT broken down by source, 1990 (left) — 2015 (right)




Almost all sectors in Lithuania saw a fall in their GHG emissions over period 1990-2015. The GHG emissions from agriculture almost halved over the period 1990-2015. They totalled 4.6 Mt $CO_2$-eq. in 2015. The GHG emissions from industrial processes and product use saw an increase around 2007, of 36.5 % above the 1990 figure. In 2015 they totalled 3.4 Mt $CO_2$-eq. in 2015, 24.6 % below the 1990 figure. GHG emissions from public power and production saw their largest fall in 2015, 86 % below the 1990 figure. In 2015 their absolute contribution amounted to 1.7 Mt $CO_2$-eq., or 28.7 % of energy-related GHG emissions in that year.

([58]) Lithuania's ESD target for 2015 was 13.66 Mt $CO_2$-eq. The target for 2020 is set to 15.46 Mt $CO_2$-eq.

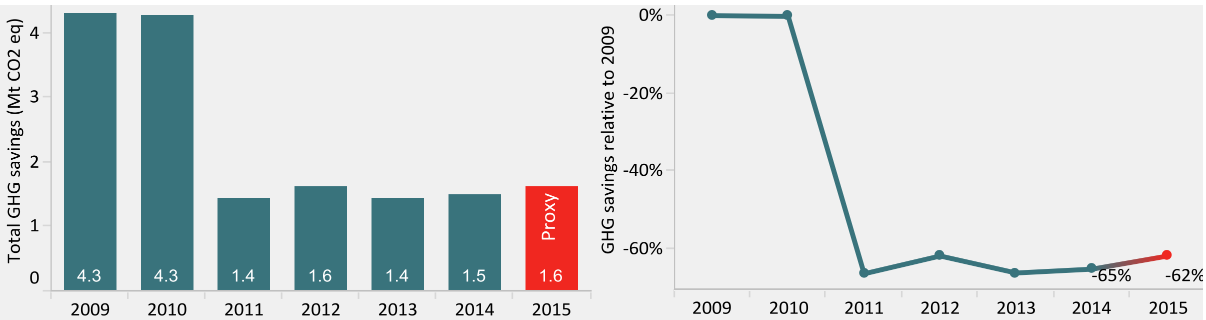
**Figure 110.** Changes of GHG emissions from sectors relative to 1990 — LT




## 9.14.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Lithuania[59] from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by only 4 % (or 0.05 Mt $CO_2$-eq.) over 2011-2014, reaching 1.5 Mt $CO_2$-eq. In per capita terms GHG emissions ranged from 0.47 to 0.51 t $CO_2$-eq. Figure 111 illustrates the trend in GHG emissions savings from renewable energy use in Lithuania over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 111.** Trend in GHG emission savings from RES in LT (left) — Change relative to 2009 (right)




Renewable energy in the heating/cooling sector was the main contributor to overall GHG emissions savings in Lithuania between 2009 and 2014. This contribution decreased from 73.6 % in 2009 to 67.7 % in 2014 and was estimated at 66.4 % in 2015. The contribution of renewable electricity decreased over the years from 25.5 % in 2009 to 22.3 % in 2014 and was estimated at 23.3 % in 2015. The contribution from savings from biofuels in the transport sector increased rapidly from only 0.9 % in 2009 to around 10 % in 2014. It remained around 10% in 2015.

([59]) Lithuania did not provide a description of the methodology used to calculate the GHG emissions savings from renewables in its three sets of progress reports. The difference between GHG emissions savings reporting for period 2009-2010 and 2011-2014 is assumed to have come from the change of methodology used for the calculations.

**Figure 112.** Breakdown of GHG savings from renewables in LT, 2009-2014 and 2015 (proxy)

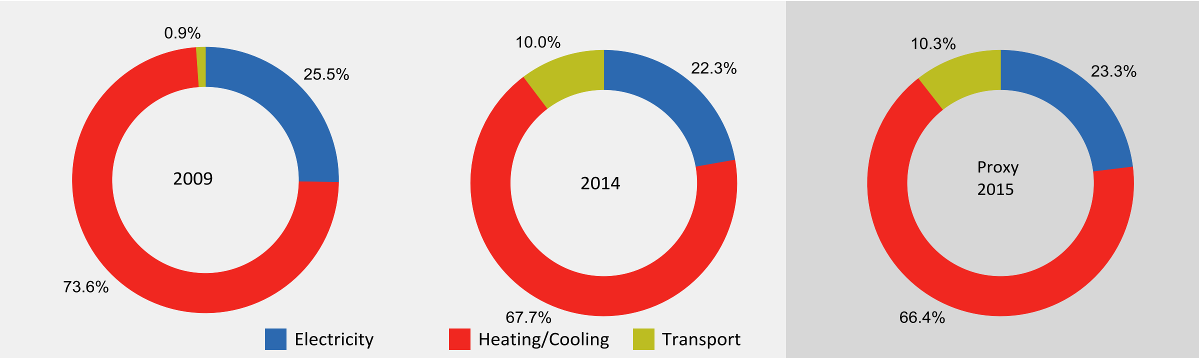



Table 20 shows how the deployment of renewable energy in Lithuania has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 20.** Emissions reduction in LT through the use of renewables, 2009-2014 and 2015 (proxy)

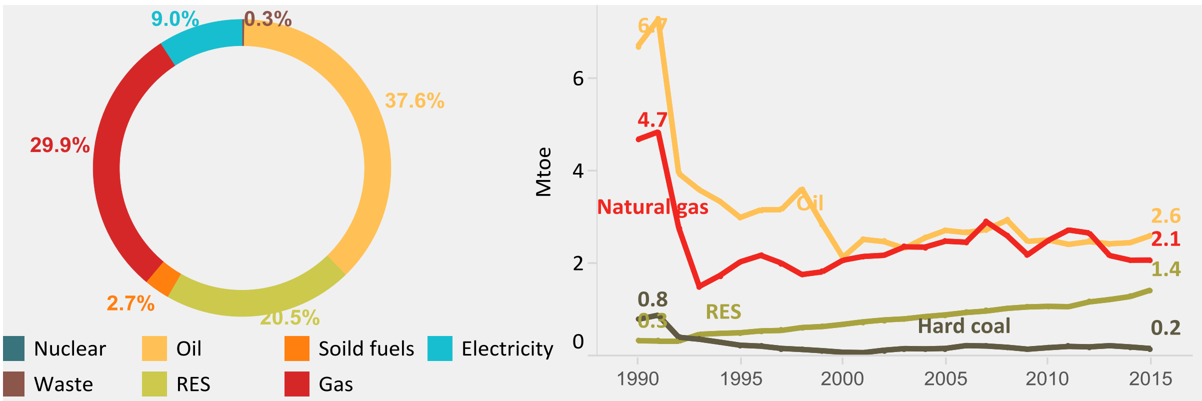
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 17.6 | 17.0 | 6.2 | 7.0 | 6.6 | 6.9 | 7.4 |
| GHG (E+Tr) emissions reduction (%) | 26.4 | 24.9 | 10.6 | 11.9 | 11.2 | 11.8 | 12.8 |
| GHG (P+H) emissions reduction (%) | 57.9 | 53.2 | 30.4 | 32.2 | 34.0 | 41.9 | 46.1 |
| GHG (Tr) emissions reduction (%) | 0.9 | 0.8 | 0.0 | 4.7 | 4.6 | 3.0 | 3.2 |

Without the current deployment of renewable energy, GHG emissions in Lithuania would have been 6.2 % higher in 2011, 6.4 % higher in 2014 and 7.4 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 10.6 % in 2011 to 11.8 % in 2014 and 12.8 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 30.4 % in 2011 to 41.9 % in 2014 and 46.1 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport remained marginal over this period, coming in at 4.6 % in 2010 and around 3 % in 2014 and 2015 alike.

### 9.14.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Lithuania include a higher share of petroleum products and gas. In 2015 almost 70 % of Lithuania's gross inland consumption of energy was met by fossil fuels. Lithuania's import dependency rate was 78.4 % in 2015 remaining relatively high for gas (99.7 %) and petroleum products (100.7 %). Over the period 1990-2015 renewables had expanded by 343 %. This served to displace fossil fuels — but only by 1.1 Mtoe by 2015. Only 15.6 % of this displacement took place in the electricity sector (0.17 Mtoe).

**Figure 113.** Breakdown of gross inland consumption in Lithuania, 2015 (left) — trend over 1990-2015 (right)



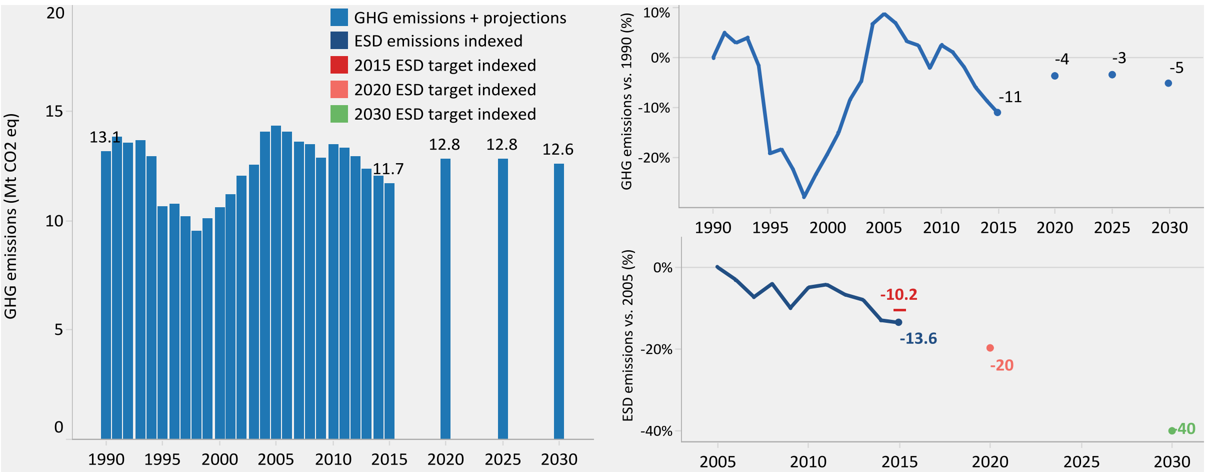
## 9.15 Luxembourg

### 9.15.1 GHG emissions: trends & projections

In 2015, Luxembourg emitted 10.2 Mt $CO_2$, a fall 12.2 % (or 1.4 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by the ESD scheme reached 8.8 Mt $CO_2$-eq., 3.7 % (0.3 Mt $CO_2$-eq.) **below the ESD target**[60]. Total GHG emissions in Luxembourg were 11.7 Mt $CO_2$-eq. in 2015, or 11 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Luxembourg are projected to fall below the 1990 level by 4 % and 5 % respectively.

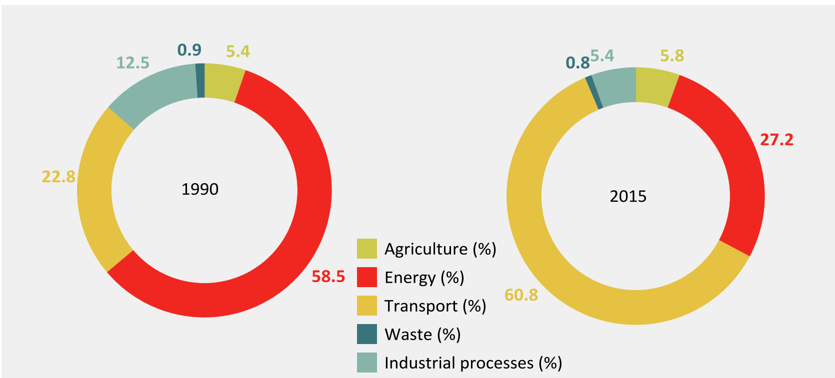
Figure 114 illustrates (i) the overall trend in GHG emissions in Luxembourg over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 114.** GHG emissions in LU, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions were the main source of total GHG emissions in Luxembourg in 1990. They totalled 3.2 Mt $CO_2$-eq. in 2015, a fall of 58.6 % in comparison with the 1990 figure. Their relative share halved from 58.5 % in 1990 to 27.2 % in 2015. GHG emissions from the transport sector reached 7.1 Mt $CO_2$-eq. in 2015, 137.6 % higher than the 1990 figure, making it the main source of GHG emissions. These emissions had their largest expansion around 2008, 183 % above the 1990 level.

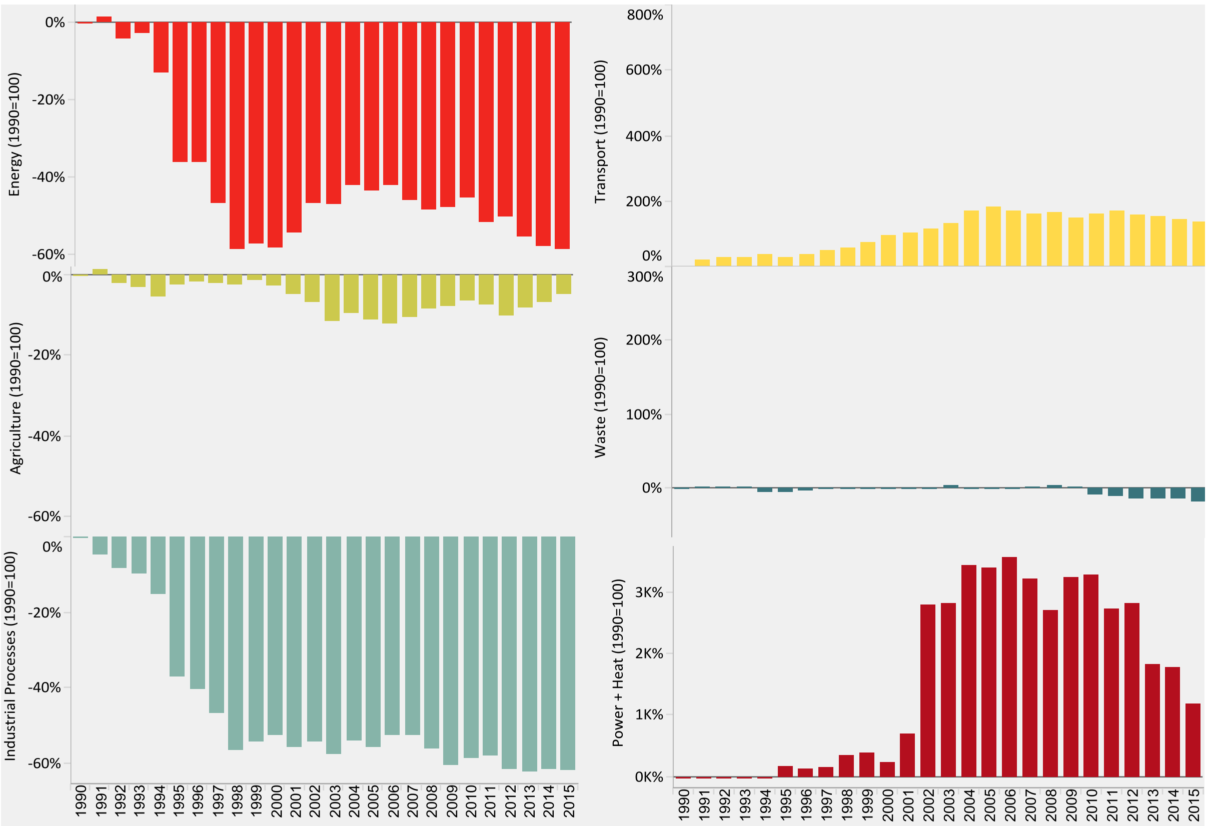
**Figure 115.** GHG emissions in LU broken down by source, 1990 (left) — 2015 (right)




Some sectors in Luxembourg, such as waste management, did not see a fall in their GHG emissions until 2010. The relative contribution of emissions from industrial processes and product use more than halved over the period 1990-2015. They totalled 0.6 Mt $CO_2$-eq. in 2015, a fall of 61.8 % in comparison with the 1990 figure. GHG emissions from agriculture came to 0.7 Mt $CO_2$-eq. in 2015, 4.7 % below the 1990 figure. GHG emissions from public power and heat production increased from 1995. They came to 0.5 Mt $CO_2$-eq. in 2015, or 14 % of energy-related GHG emissions in that year.

([60]) Luxembourg's ESD target for 2015 was 9.14 Mt $CO_2$-eq. The target for 2020 is set to 8.14 Mt $CO_2$-eq.

**Figure 116.** Changes of GHG emissions from sectors relative to 1990 — LU

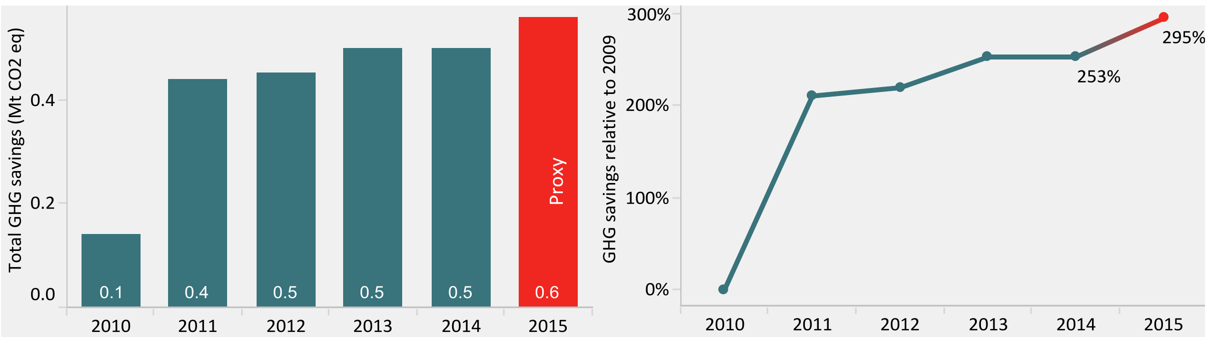



## 9.15.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Luxembourg from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose sharply by 253 % (or 4 Mt $CO_2$-eq) over 2010-2014, reaching 0.5 Mt $CO_2$-eq. In per capita terms GHG emissions tripled, from 0.27 to 0.9 t $CO_2$-eq.

Figure 117 illustrates the trend in GHG emissions savings from renewable energy use in Luxembourg over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 117.** Trend in GHG emission savings from RES in LU (left) — Change relative to 2009 (right)




The role of biofuels in GHG emissions savings in Luxembourg remained substantial over the period 2010-2014. Even though their absolute contribution increased by 21 % over this period, their relative share fell by a factor of 3. Renewable energy sources in the electricity and heating/cooling sectors split equally their contributions to overall GHG emission savings[61].

([61]) Luxembourg reported the total of GHG emission savings in both the electricity and heating/cooling sectors from the use of renewables.

**Figure 118.** Breakdown of GHG savings from renewables in LU, 2010-2014 and 2015 (proxy)

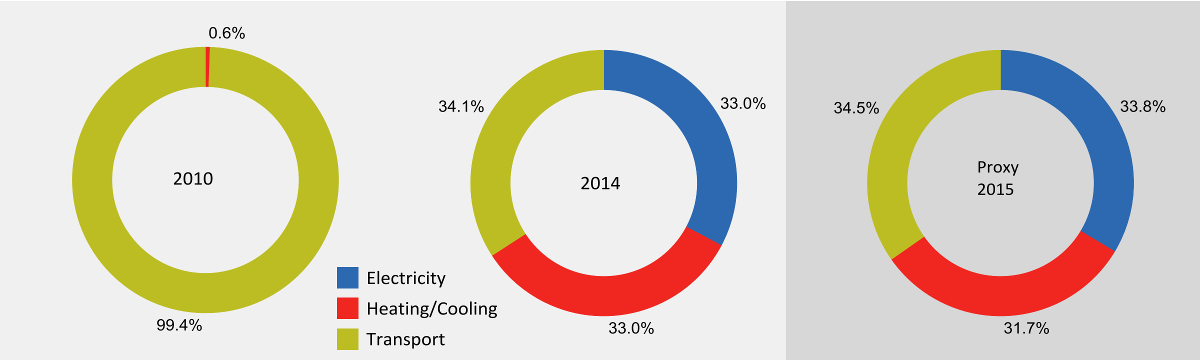



Table 21 shows how the deployment of renewable energy in Luxembourg has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 21.** Emissions reduction in LU through the use of renewables, 2009-2014 and 2015 (proxy)

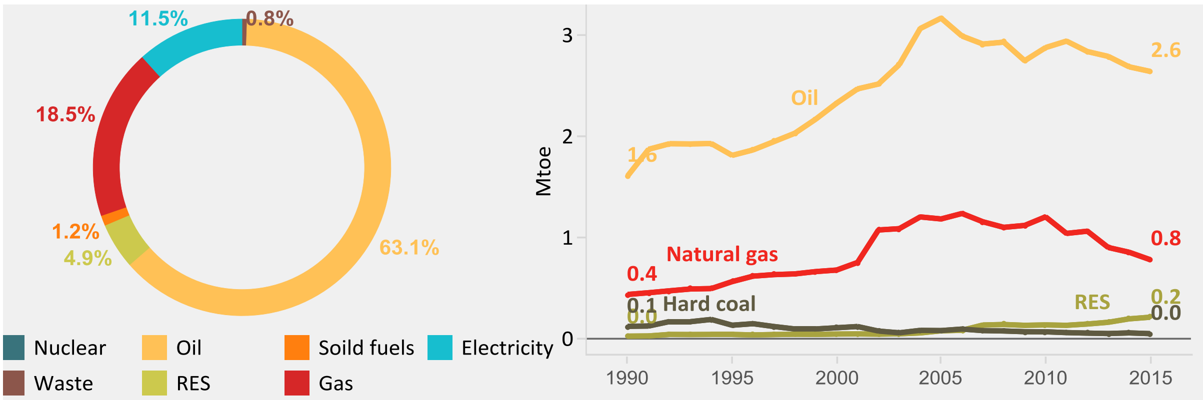
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 0.0 | 1.0 | 3.2 | 3.4 | 3.9 | 4.0 | 4.6 |
| GHG (E+Tr) emissions reduction (%) | 0.0 | 1.3 | 4.0 | 4.2 | 4.8 | 5.1 | 5.9 |
| GHG (P+H) emissions reduction (%) | 0.0 | 0.1 | 22.9 | 22.7 | 32.5 | 33.0 | 44.5 |
| GHG (Tr) emissions reduction (%) | 0.0 | 2.1 | 2.0 | 2.2 | 2.6 | 2.7 | 3.3 |

Without the current deployment of renewable energy, GHG emissions in Luxembourg would have been 1.0 % higher in 2010, 4.0 % higher in 2014 and 4.6 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 1.3 % in 2010 to 5.1 % in 2014 and 5.9 % in 2015. The emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors from 22.9 % in 2011 to 33 % in 2014 and 44.5 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport remained marginal over this period, coming in at 2.1 % in 2010, 2.7 % in 2014 and 3.3 % in 2015.

## 9.15.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Luxembourg include a higher share of petroleum products and gas and a lower share of renewables. In 2015 more than 80 % of Luxembourg's gross inland consumption of energy was met by fossil fuels. Luxembourg has a very high import dependency, at 95.7 % in 2015, particularly on gas (99.4 %) and petroleum products (100 %). The role of renewables became more prevalent around 2003 and by 2015 it had expanded by 400 %. This served to displace fossil fuels — but only by 0.1 Mtoe by 2015. Eighty-one per cent of this displacement took place in the electricity sector (0.09 Mtoe).

**Figure 119.** Breakdown of gross inland consumption in Luxembourg, 2015 (left)-trend over 1990-2015 (right)



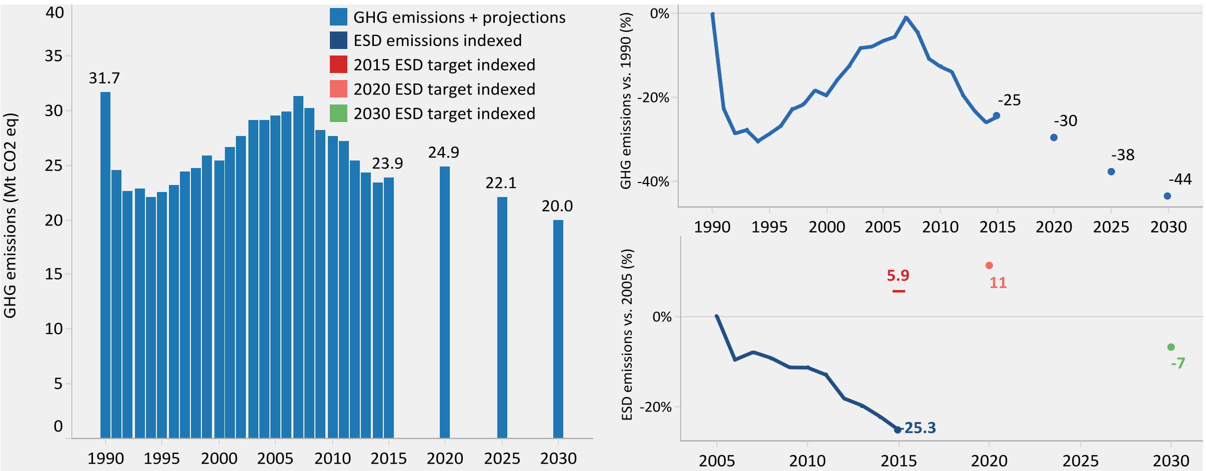
## 9.16 Croatia

### 9.16.1 GHG emissions: trends & projections

In 2015, Croatia emitted 20.5 Mt $CO_2$, a fall of 18 % (4.5 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by ESD reached 14 Mt $CO_2$-eq., 29.5 % (5.9 Mt $CO_2$-eq.) **below the ESD target**[62]. Total GHG emissions in Croatia were almost 24 Mt $CO_2$-eq. in 2015, or 25 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Croatia are projected to fall below the 1990 level by 30 % and 44 % respectively.

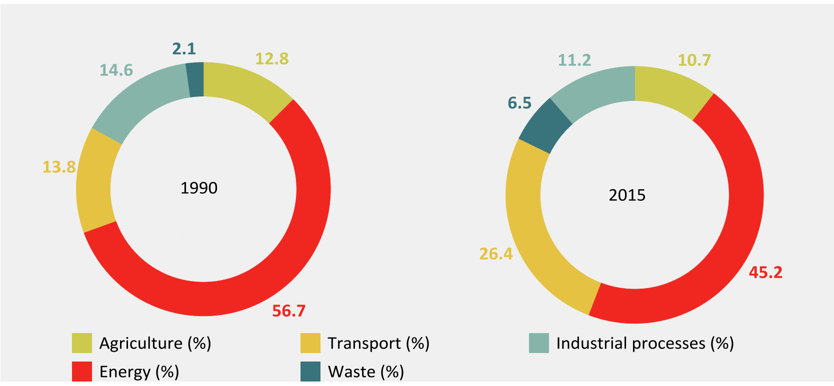
Figure 120 illustrates (i) the overall trend in GHG emissions in Croatia over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 120.** GHG emissions in HR, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Croatia since 1990. They totalled 10.8 Mt $CO_2$-eq. in 2015, a fall of 40 % in comparison with the 1990 figure. GHG emissions from the transport sector reached 6.3 Mt $CO_2$-eq. in 2015, 44 % higher than the 1990 figure, making it the second largest source of GHG emissions.

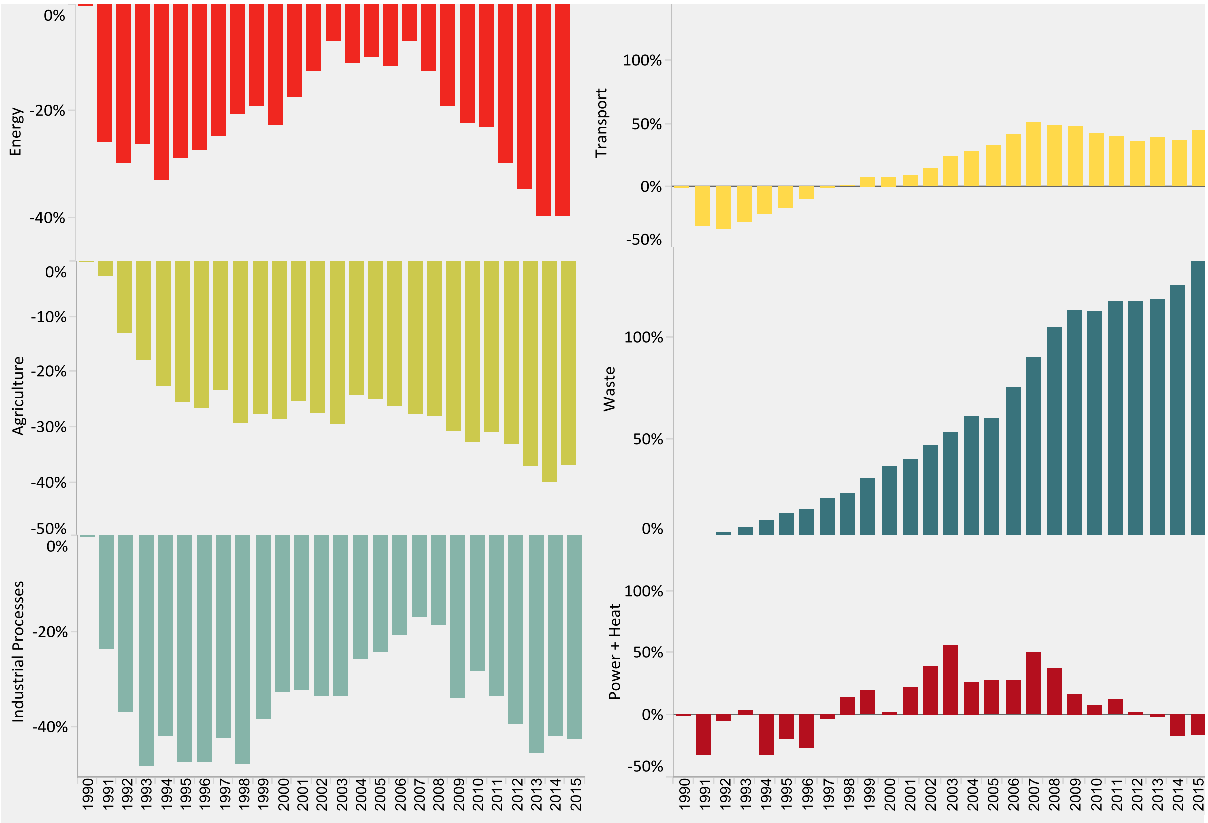
**Figure 121.** GHG emissions in HR broken down by source, 1990 (left) — 2015 (right)




Some sectors in Croatia, such as waste management, did not see a fall in their GHG emissions over the period 1990-2015. In 2015 their absolute contribution reached 1.6 Mt $CO_2$-eq., a rise of 137.5 % in comparison with the 1990 figure. Their relative share more than tripled over this period. The GHG emissions from industrial processes and product use amounted to 2.7 Mt $CO_2$-eq., a fall of 42.4 % in comparison with the 1990 level. The GHG emissions from agriculture came to 2.6 Mt $CO_2$-eq. in 2015, 36.7 % below the 1990 figure. The GHG emissions from public power and heat production did not follow the trend of energy-related emissions over 1990-2015. They came to 3.2 Mt $CO_2$-eq. in 2015, or 29.4 % of energy-related GHG emissions in that year.

([62]) Croatia's ESD target for 2015 was 20 Mt $CO_2$-eq. The target for 2020 is set to 20.95 Mt $CO_2$-eq.

**Figure 122.** Changes of GHG emissions from sectors relative to 1990 — HR

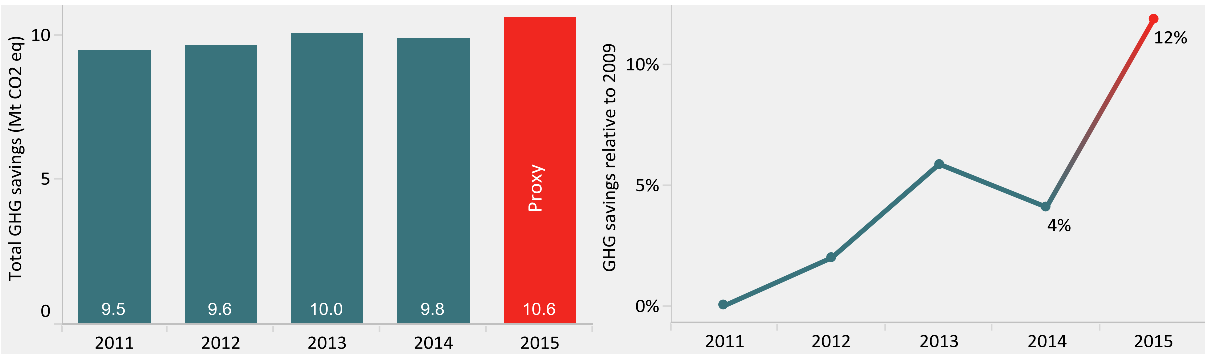



## 9.16.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Croatia from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by only 4% (0.4 Mt $CO_2$-eq.) over 2011-2014, reaching 9.8 Mt $CO_2$-eq. In per capita terms GHG emissions ranged from 2.2 to 2.3 t $CO_2$-eq.

Figure 123 illustrates the trend in GHG emissions savings from renewable energy use in Croatia over 2011-2014 and the estimated GHG emissions savings for 2015.

**Figure 123.** Trend in GHG emission savings from RES in HR (left) — Change relative to 2009 (right)




Renewable electricity was the main contributor to overall GHG emissions savings in Croatia between 2011 and 2014, increasing from 57.5 % to 62.9 %. This contribution was estimated to have reached 60.9 % in 2015. The contribution of renewable energy in the heating/cooling sector decreased slightly over the years, from 42.4 % in 2011 to 36.1 % in 2014. This contribution was estimated to have reached 38.4 % in 2015. The contribution from savings from biofuels in the transport sector remained very marginal at 0.1 % in 2011, rising to 0.9 % in 2014. A contribution of 0.7 % was estimated for 2015.

**Figure 124.** Breakdown of GHG savings from renewables in HR, 2011-2014 and 2015 (proxy)

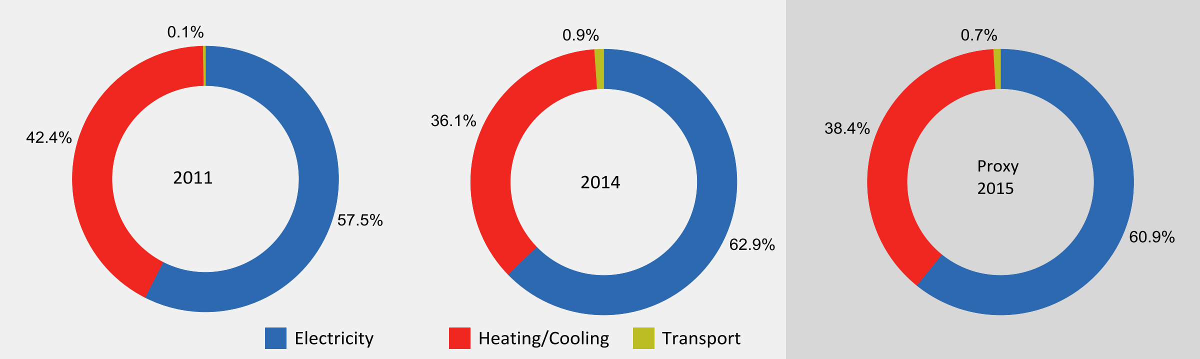



Table 22 shows how the deployment of renewable energy in Croatia has helped the country curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; (iv) its GHG emissions from transport.

**Table 22.** Emissions reduction in HR through the use of renewables, 2009-2014 and 2015 (proxy)

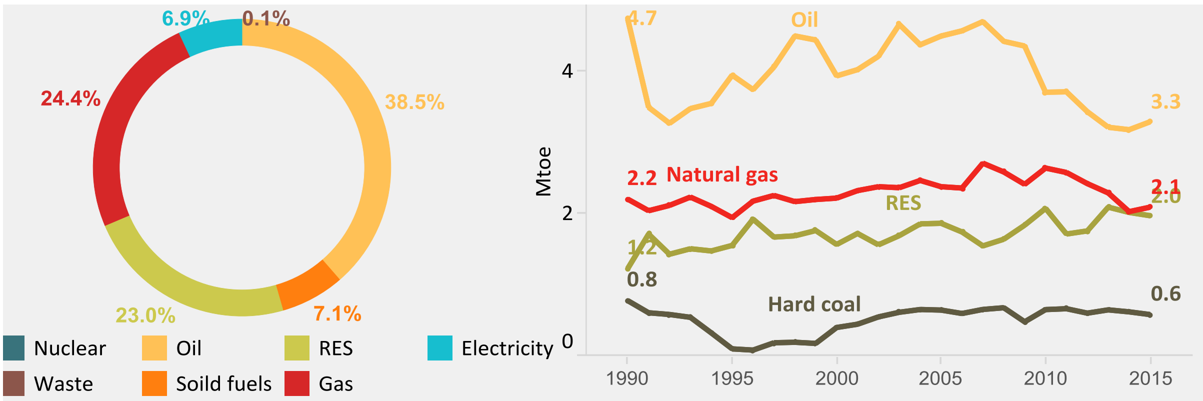
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | | | 25.8 | 27.5 | 29.2 | 29.6 | 30.7 |
| GHG (E+Tr) emissions reduction (%) | | | 32.5 | 34.6 | 36.5 | 37.4 | 38.7 |
| GHG (P+H) emissions reduction (%) | | | 69.1 | 71.2 | 72.9 | 75.9 | 76.8 |
| GHG (Tr) emissions reduction (%) | | | 0.2 | 2.0 | 1.7 | 1.6 | 1.3 |

Without the current deployment of renewable energy, GHG emissions in Croatia would have been 25.8 % higher in 2011, 29.6 % higher in 2014 and 30.7 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 32.5 % in 2011, to 37.4 % in 2014 and 38.7 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 69 % in 2011, to 75.9 % in 2014 and 76.8 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport remained marginal over this period, at around 2 % in 2011, 1.6 % in 2014 and 1.3 % in 2015.

### 9.16.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Croatia include a higher share of petroleum products, gas and renewables. In 2015 almost 70 % of Croatia's gross inland consumption of energy was met by fossil fuels. Croatia's import dependency rate was 48.3 % in 2015 remaining high for solid fuels (103 %) and petroleum products (79.6 %). Renewables expanded by 62 % over the period 1990-2015. This served to displace fossil fuels — but only by 0.7 Mtoe by 2015. Thirty-nine per cent of this displacement took place in the electricity sector (0.26 Mtoe).

**Figure 125.** Breakdown of gross inland consumption in Croatia, 2015 (left) — trend over 1990-2015 (right)



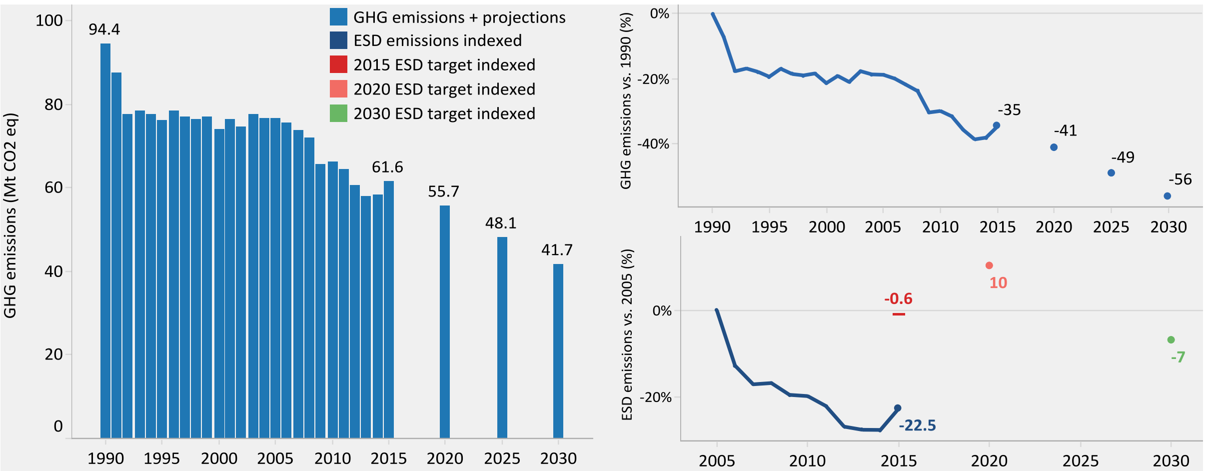
## 9.17 Hungary

### 9.17.1 GHG emissions: trends & projections

In 2015, Hungary emitted 48.2 Mt $CO_2$, a fall of 32.6 % (or 23.3 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by the ESD scheme reached 41 Mt $CO_2$-eq., 22.1 % (11.6 Mt $CO_2$-eq.) **below the ESD target**[63]. Total GHG emissions in Hungary were 61.6 Mt $CO_2$-eq. in 2015, or 35 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Hungary are projected to fall below the 1990 level by 41 % and 56 % respectively.

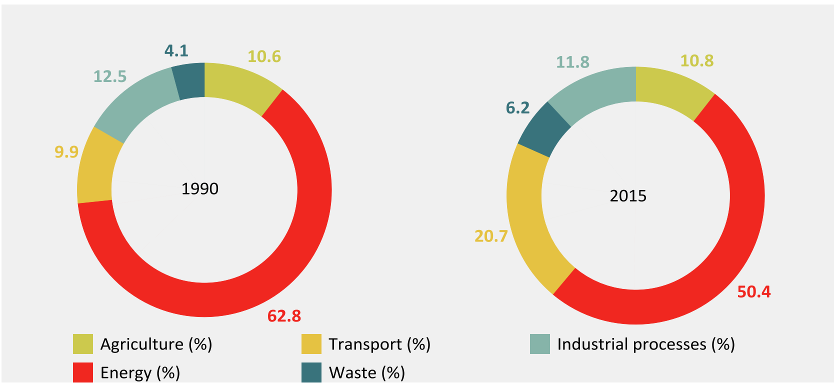
Figure 126 illustrates (i) the overall trend in GHG emissions in Hungary over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 126**. GHG emissions in HU, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Hungary since 1990. They totalled 31 Mt $CO_2$-eq. in 2015, a fall of 47.6 % in comparison with the 1990 figure. GHG emissions from the transport sector reached 12.8 Mt $CO_2$-eq. in 2015, 36 % higher than the 1990 figure, making it the second largest source of GHG emissions.

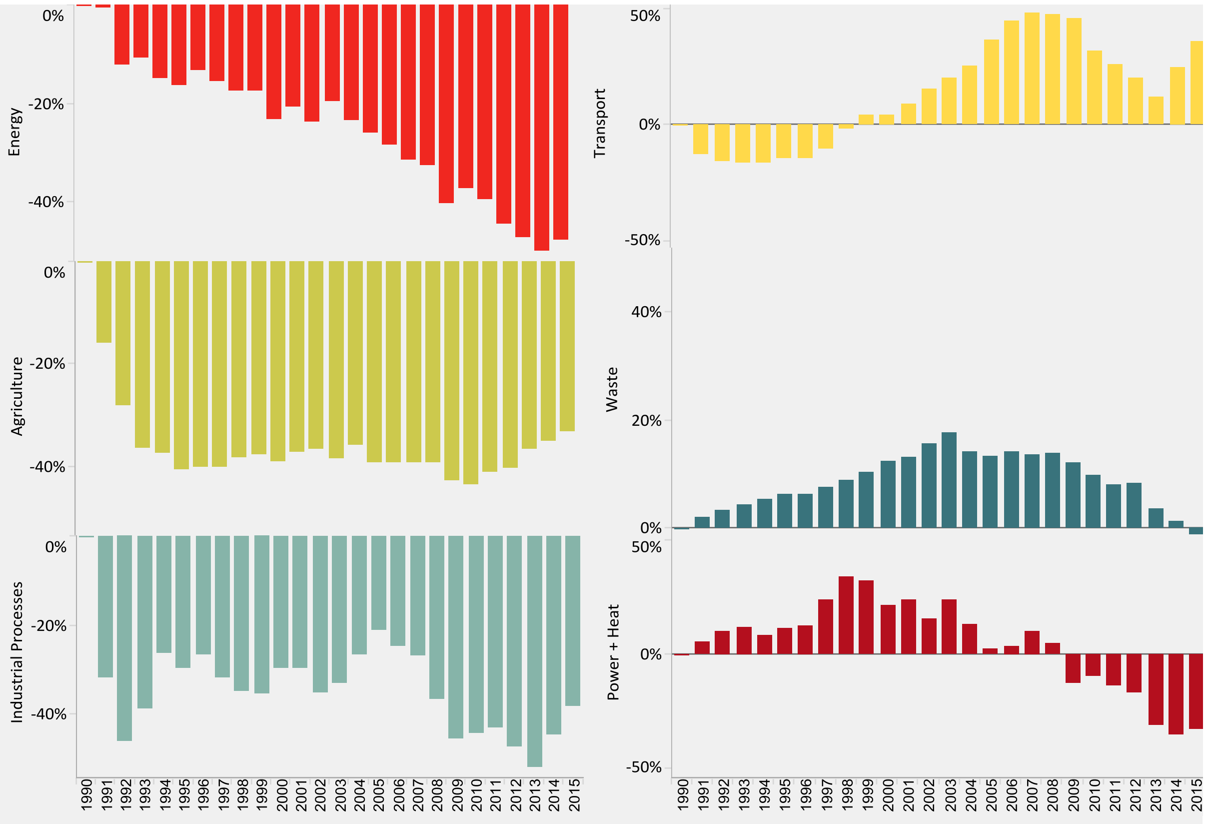
**Figure 127.** GHG emissions in HU broken down by source, 1990 (left) — 2015 (right)




Some sectors in Hungary, such as waste management and public power and heat, did not see a fall in their GHG emissions immediately after 1990. In 2015 the absolute contribution of emissions from waste management totalled 1.3 Mt $CO_2$-eq., a fall of only 1.3 % in comparison with the 1990 figure. Their relative share increased to 6.2 %. The GHG emissions from public power and heat came to 12.1 Mt $CO_2$-eq. in 2015, or 39 % of energy-related emissions. The GHG emissions from agriculture totalled 6.7 Mt $CO_2$-eq. in 2015. Even though these emissions fell by 33 % over 1990-2015, their relative share remained almost unchanged, at around 10.8 %. Industrial processes and product use released 7.3 Mt $CO_2$-eq. of emissions in 2015, a fall of 38.3 % in comparison with the 1990 figure.

([63]) Hungary's ESD target for 2015 was 52.63 Mt $CO_2$-eq. The target for 2020 is set to 58.22 Mt $CO_2$-eq.

**Figure 128.** Changes of GHG emissions from sectors relative to 1990 — HU

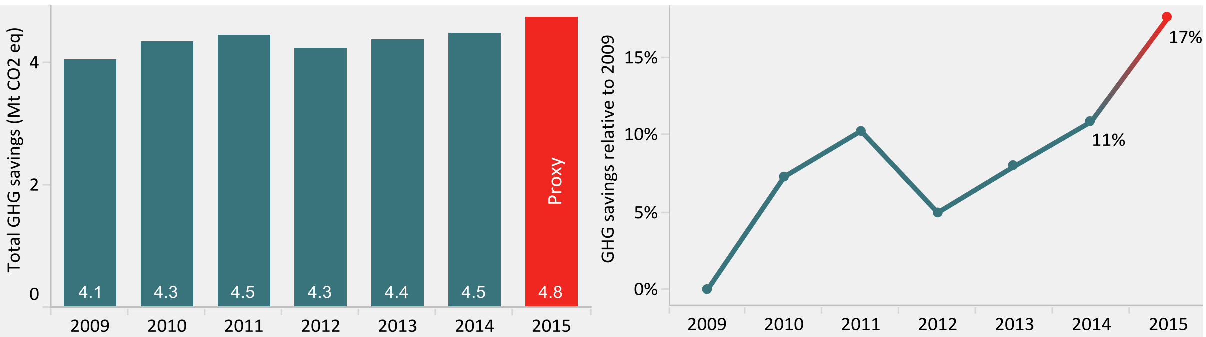



## 9.17.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Hungary from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by 11 % (or 0.4 Mt $CO_2$-eq.) over 2009-2014, reaching 4.5 Mt $CO_2$-eq. In per capita terms GHG emissions remained almost unchanged at around 0.4 t $CO_2$-eq.

Figure 129 illustrates the trend in GHG emissions savings from renewable energy use in Hungary over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 129.** Trend in GHG emission savings from RES in HU (left) — Change relative to 2009 (right)




Renewable energy in the heating/cooling sector was the main contributor to overall GHG emissions savings in Hungary between 2009 and 2014, increasing from 60.6 % to 78 %. This contribution was estimated to have reached 79.2 % in 2015. The contribution of renewable electricity decreased considerably over the years, from 32.7 % in 2009 to 17.1 % in 2014. This contribution was estimated at 16.7 % in 2015. The contribution from savings from biofuels in the transport sector remained marginal at 6.7 % in 2009, decreasing to 4.9 % in 2014. A contribution of 4.1 % was estimated for 2015.

**Figure 130.** Breakdown of GHG savings from renewables in HU, 2009-2014 and 2015 (proxy)

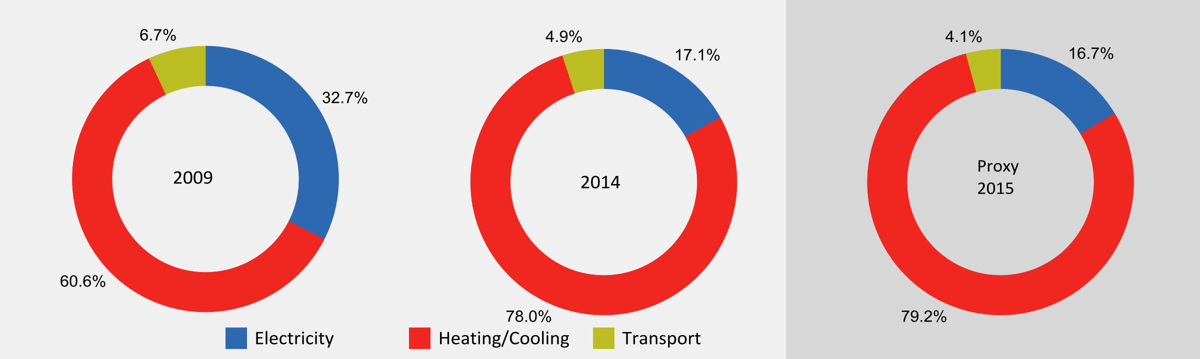



Table 23 shows how the deployment of renewable energy in Hungary has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; (iv) its GHG emissions from transport.

**Table 23.** Emissions reduction in HU through the use of renewables, 2009-2014 and 2015 (proxy)

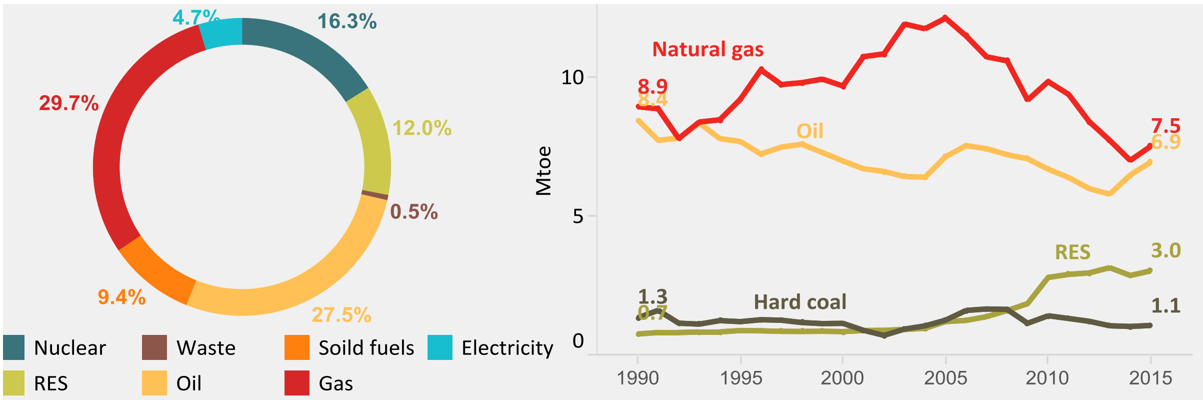
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 5.8 | 6.2 | 6.5 | 6.6 | 7.0 | 7.1 | 7.2 |
| GHG (E+Tr) emissions reduction (%) | 7.7 | 8.2 | 8.7 | 8.9 | 9.6 | 9.9 | 9.9 |
| GHG (P+H) emissions reduction (%) | 19.4 | 20.1 | 21.3 | 21.3 | 25.1 | 26.9 | 27.4 |
| GHG (Tr) emissions reduction (%) | 2.1 | 2.4 | 2.3 | 2.0 | 2.3 | 1.9 | 1.6 |

Without the current deployment of renewable energy, GHG emissions in Hungary would have been 5.8 % higher in 2009, 7.1 % higher in 2014 and 7.2 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy increased from 7.7 % in 2009 to reach 9.9 % in 2014. It remained at 9.9% in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 19.4 % in 2009 to 26.9 % in 2014 and 27.4 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport remained marginal over this period, at around 2 % in 2009, 1.9 % in 2014 and 1.6 % in 2015.

### 9.17.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Hungary include a higher share of gas and petroleum products and a lower share of renewables. In 2015 almost 67 % of Hungary's gross inland consumption of energy was met by fossil fuels. Hungary's import dependency rate was 55.6 % in 2015 remaining relatively high for petroleum products (93.2 %). The role of renewables became more prevalent around 2005 and by 2015 it had achieved the fastest expansion, at 153 %. This served to displace fossil fuels — by as much as 2.2 Mtoe by 2015. Twelve per cent of this displacement took place in the electricity sector (0.26 Mtoe).

**Figure 131.** Breakdown of gross inland consumption in Hungary, 2015 (left) — trend over 1990-2015 (right)



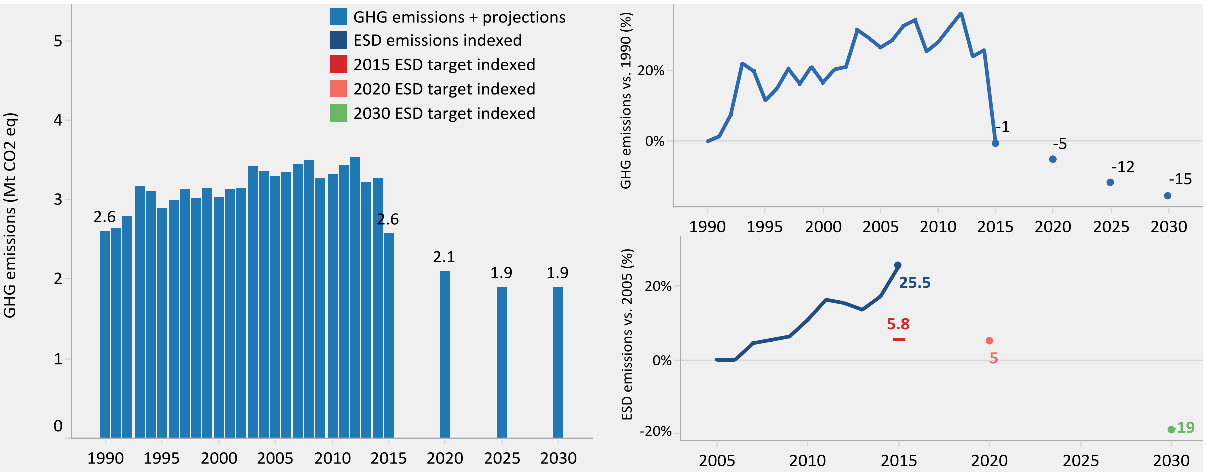
## 9.18 Malta

### 9.18.1 GHG emissions: trends & projections

In 2015, Malta emitted 2.35 Mt $CO_2$, a rise of 1.4 % (0.32 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, the GHG emissions covered by the ESD scheme reached 1.38 Mt $CO_2$-eq., 17.9 % (0.21 Mt $CO_2$-eq.) **above the ESD target**[64]. Total GHG emissions in Malta were 2.6 Mt $CO_2$-eq. in 2015, almost equal with the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Malta are projected to fall below the 1990 level by 5 % and 15 % respectively.

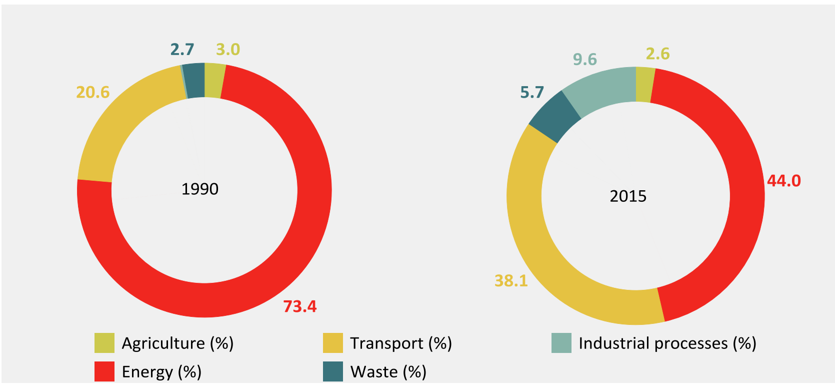
Figure 132 illustrates (i) the overall trend in GHG emissions in Malta over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 132.** GHG emissions in MT, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Malta since 1990. They totalled 1.1 Mt $CO_2$-eq. in 2015, a fall of 40.5 % in comparison with 1990 figure. The GHG emissions from the transport sector reached 1.0 Mt $CO_2$-eq. in 2015, 83 % higher than the 1990 figure, making it the second largest source of GHG emissions.

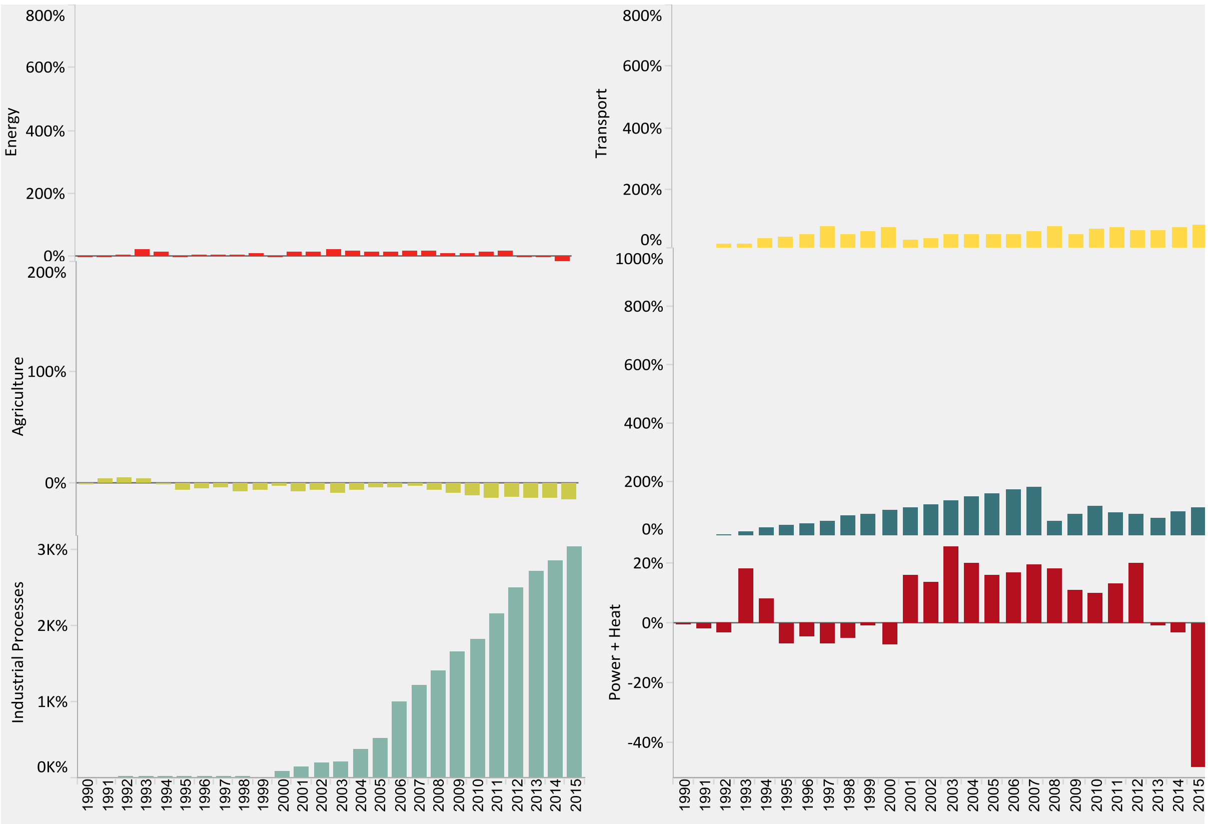
**Figure 133.** GHG emissions in MT broken down by source, 1990 (left) — 2015 (right)




Some sectors in Malta, such as waste management and industrial processes and product use, did not see a fall in their GHG emissions over 1990-2015. In 2015 the absolute contribution of emissions from industrial processes and product use amounted to 0.2 Mt $CO_2$-eq., an increase of 3028 % in comparison with the 1990 level. The GHG emissions from waste management stood at 0.1 Mt $CO_2$-eq. in 2015, 112 % above the 1990 level. The GHG emissions from agriculture came to 0.1 Mt $CO_2$-eq. in 2015, 14.6 % below the 1990 figure. GHG emissions from public power and heat production came to 0.9 Mt $CO_2$-eq. in 2015, or 78.5 % of energy-related GHG emissions in that year.

([64]) Malta's ESD target for 2015 was 1.17 Mt $CO_2$-eq. The target for 2020 is set to 1.16 Mt $CO_2$-eq.

**Figure 134.** Changes of GHG emissions from sectors relative to 1990 — MT

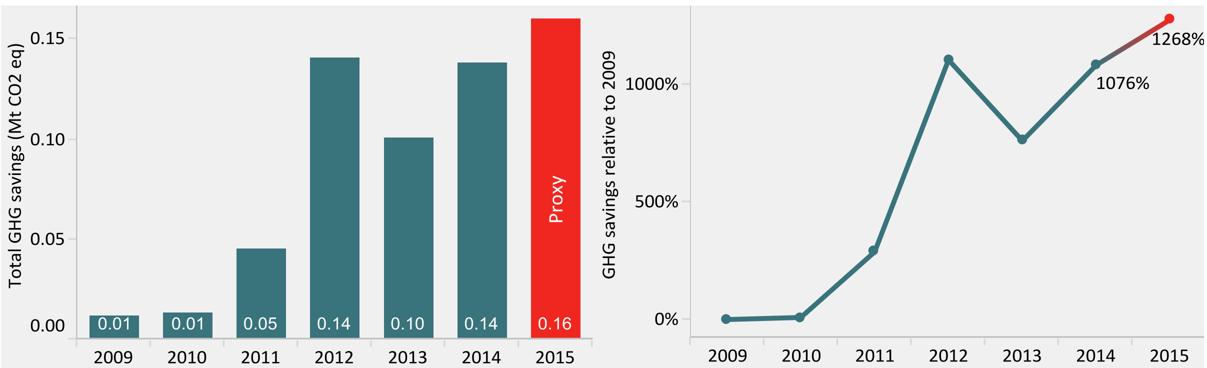



## 9.18.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Malta from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by 1076 % (or 0.126 Mt $CO_2$-eq.) over 2009-2014, reaching 0.138 Mt $CO_2$-eq. In per capita terms GHG emissions in Malta increased tenfold from 0.03 to 0.3 t $CO_2$-eq.

Figure 135 illustrates the trend in GHG emissions savings from renewable energy use in Malta over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 135.** Trend in GHG emissions savings from RES in MT (left) — Change relative to 2009 (right)




Renewable energy in the heating/cooling sector was the main contributor to overall GHG emissions savings in Malta between 2009 and 2014. Even though its absolute contribution increased by a factor of 7 over this period, its relative share decreased from 81.4 % to 48.2 %. This contribution was estimated at 42.3 % in 2015. The contribution of renewable electricity increased very rapidly over the years, from a marginal 4.2 % in 2009 to 42.9 % in 2014. This contribution was estimated to have reached 49.4 % in 2015. The contribution from savings from biofuels in the transport sector decreased from 14.3 % in 2009 to 8.9 % in 2014. A contribution of 8.4 % was estimated for 2015.

**Figure 136.** Breakdown of GHG savings from renewables in MT, 2009-2014 and 2015 (proxy)

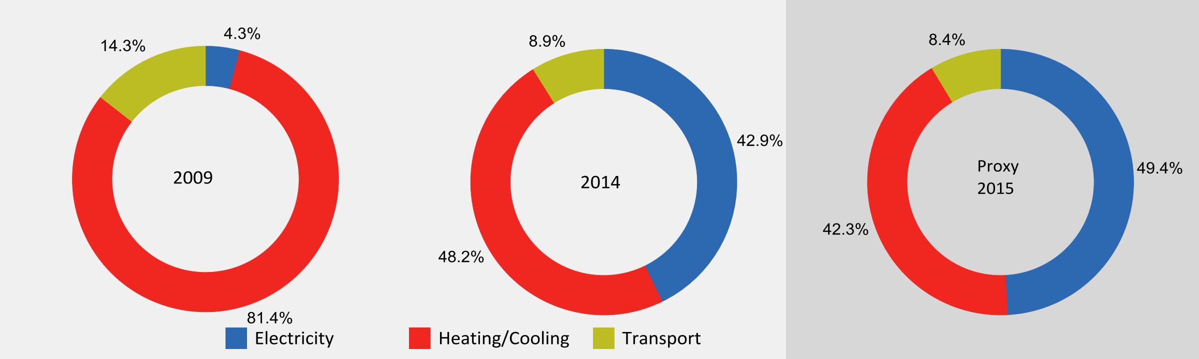



Table 24 shows how the deployment of renewable energy in Malta has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 24.** Emissions reduction in MT through the use of renewables, 2009-2014 and 2015 (proxy)

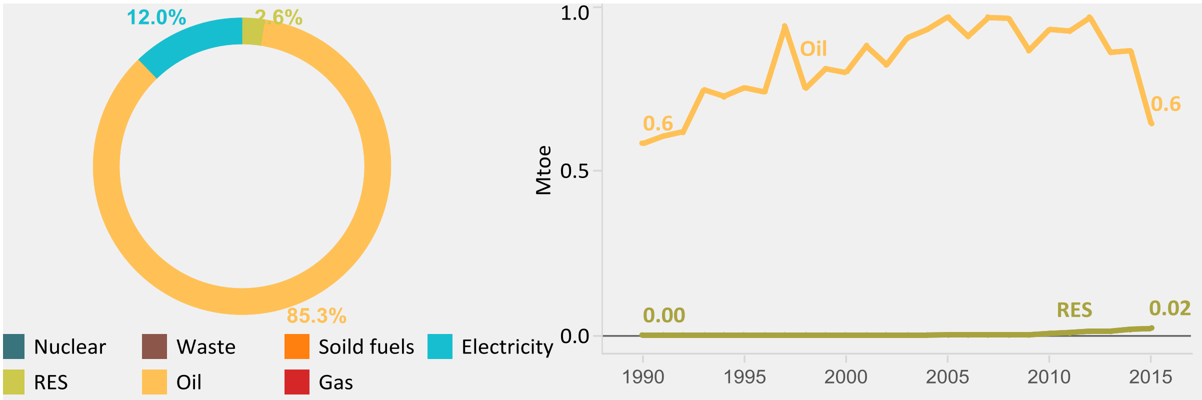
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 0.4 | 0.4 | 1.3 | 3.8 | 3.0 | 4.0 | 5.9 |
| GHG (E+Tr) emissions reduction (%) | 0.4 | 0.5 | 1.6 | 4.7 | 3.9 | 5.2 | 8.3 |
| GHG (P+H) emissions reduction (%) | 0.5 | 0.6 | 2.1 | 6.0 | 5.1 | 7.0 | 14.2 |
| GHG (Tr) emissions reduction (%) | 0.3 | 0.2 | 0.7 | 1.6 | 1.4 | 2.0 | 2.1 |

Without the current deployment of renewable energy, GHG emissions in Malta would have been 0.4 % higher in 2009, 4.0 % higher in 2014 and 5.9 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 0.4 % in 2009 to 5.2 % in 2014 and 8.3 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 0.5 % in 2009 to 7.0 % in 2014 and 14.2 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport remained marginal over this period, at around 0.3 % in 2009 and around 2.0 % in 2014 and 2015 alike.

### 9.18.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Malta see petroleum products holding a dominant share. In 2015 more than 85 % of Malta's gross inland consumption of energy was met by petroleum products. Malta's import dependency rate was 97.3 % in 2015 remaining high for petroleum products (97.8 %). The role of renewables became more prevalent around 2009 and by 2015 it had achieved the fastest expansion, at 1900 %. This served to displace fossil fuels — only by 0.1 Mtoe by 2015. Almost 9 % of this displacement took place in the electricity sector (8.6 ktoe).

**Figure 137.** Breakdown of gross inland consumption in Malta, 2015 (left) — trend over 1990-2015 (right)



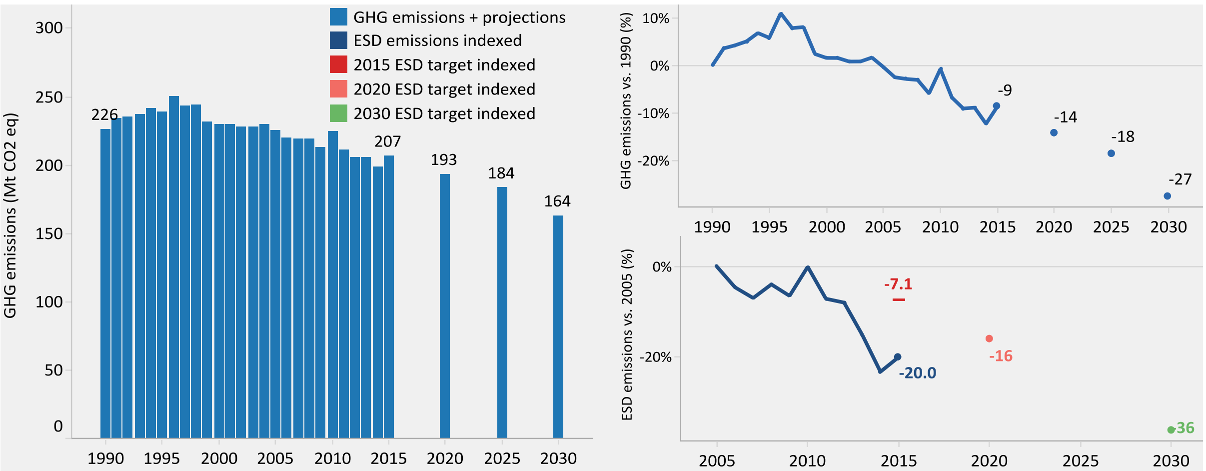
## 9.19 Netherlands

### 9.19.1 GHG emissions: trends & projections

In 2015, the Netherlands emitted 165.3 Mt $CO_2$, a rise of 3.5 % (5.6 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions in ESD sectors reached 102 Mt $CO_2$-eq., 14 % (16.4 Mt $CO_2$-eq.) **below the ESD target**[65]. Total GHG emissions in the Netherlands were almost 207 Mt $CO_2$-eq. in 2015, or 9 % below the level in 1990. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Netherlands are projected to fall below the 1990 level by 14 % and 27 % respectively.

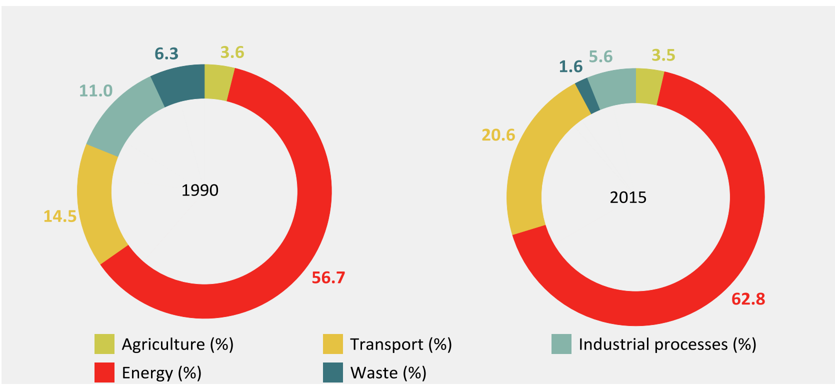
Figure 138 illustrates (i) the overall trend in GHG emissions in Netherlands over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 138.** GHG emissions in NL, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in the Netherlands since 1990. They totalled 130 Mt $CO_2$-eq. in 2015, a rise of 1.2 % in comparison with the 1990 figure. GHG emissions from the transport sector reached 42.6 Mt $CO_2$-eq. in 2015, 30 % higher than the 1990 figure, making it the second largest source of GHG emissions.

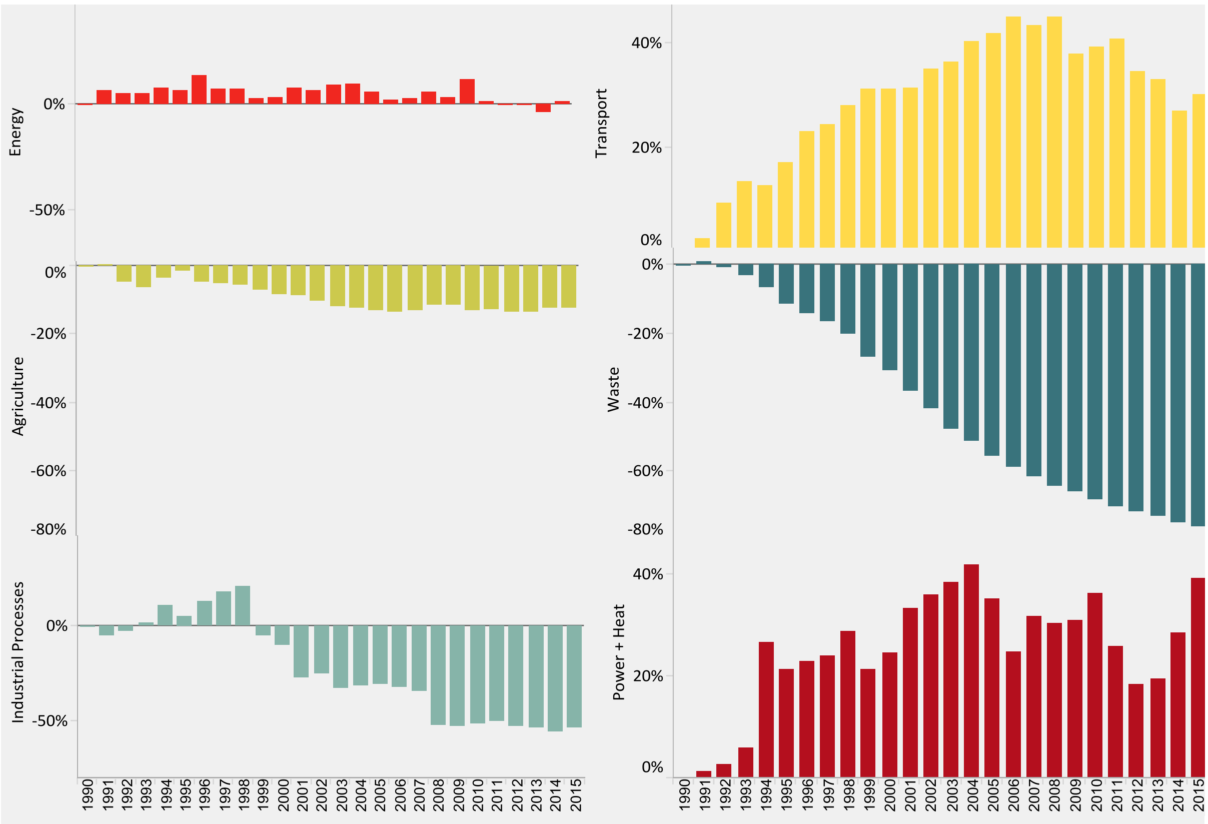
**Figure 139.** GHG emissions in NL broken down by source, 1990 (left) — 2015 (right)




Some sectors in the Netherlands, such as agriculture and waste management, saw a fall in their GHG emissions immediately after 1991. In 2015 the absolute contribution of emissions from agriculture totalled 7.2 Mt $CO_2$-eq. Even though there was a 12.5 % decrease in emissions from that sector between 1990 and 2015, its relative share remained almost unchanged. The GHG emissions from waste management amounted to 3.4 Mt $CO_2$-eq. in 2015, 76.2 % below the 1990 level. The GHG emissions from industrial processes and product use amounted to 11.5 Mt $CO_2$-eq., a fall of 53.8 % in comparison with the 1990 level. GHG emissions from public power and heat production came to 56 Mt $CO_2$-eq. in 2015, or 43 % of energy-related GHG emissions in that year.

([65]) Netherlands' ESD target for 2015 was 118.4 Mt $CO_2$-eq. The target for 2020 is set to 107.04 Mt $CO_2$-eq.

**Figure 140.** Changes of GHG emissions from sectors relative to 1990 — NL

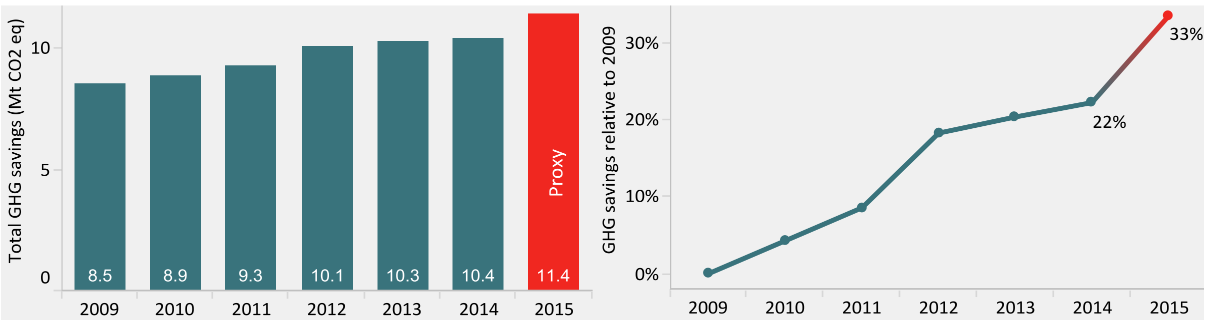



## 9.19.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in the Netherlands from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by 22 % (or 1.9 Mt $CO_2$-eq.) over 2009-2014, reaching 10.4 Mt $CO_2$-eq. In per capita terms GHG emissions ranged from 0.5 to 0.6 t $CO_2$-eq.

Figure 141 illustrates the trend in GHG emissions savings from renewable energy use in the Netherlands over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 141.** Trend in GHG emissions savings from RES in NL (left) — Change relative to 2009 (right)




Renewable electricity was the main contributor to overall GHG emissions savings in the Netherlands between 2009 and 2014. Its absolute contribution increased by 13.2 % (0.8 Mt $CO_2$-eq.) over this period, but its relative share fell from 74.4 % to 69 %. Its contribution was estimated to have reached 70.5 % in 2015. The contribution of renewable energy in the heating/cooling sector increased over the years, from 17 % in 2009 to 22 % in 2014. This contribution was estimated to have reached 22.3 % in 2015. The contribution from savings from biofuels in the transport sector rose slightly from 8.5% in 2009 to nearly 9% in 2014. A contribution of 7 % was estimated for 2015.

**Figure 142.** Breakdown of GHG savings from renewables in NL, 2009-2014 and 2015 (proxy)

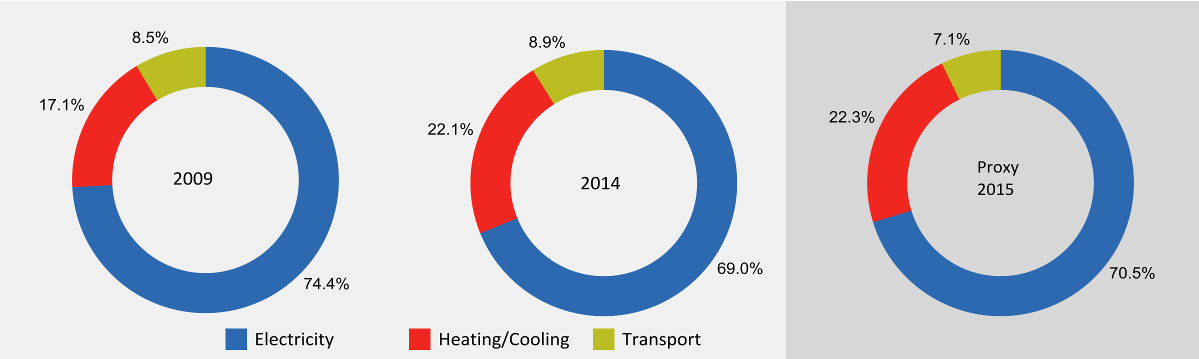



Table 25 shows how the deployment of renewable energy in the Netherlands has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 25.** Emissions reduction in NL through the use of renewables, 2009-2014 and 2015 (proxy)

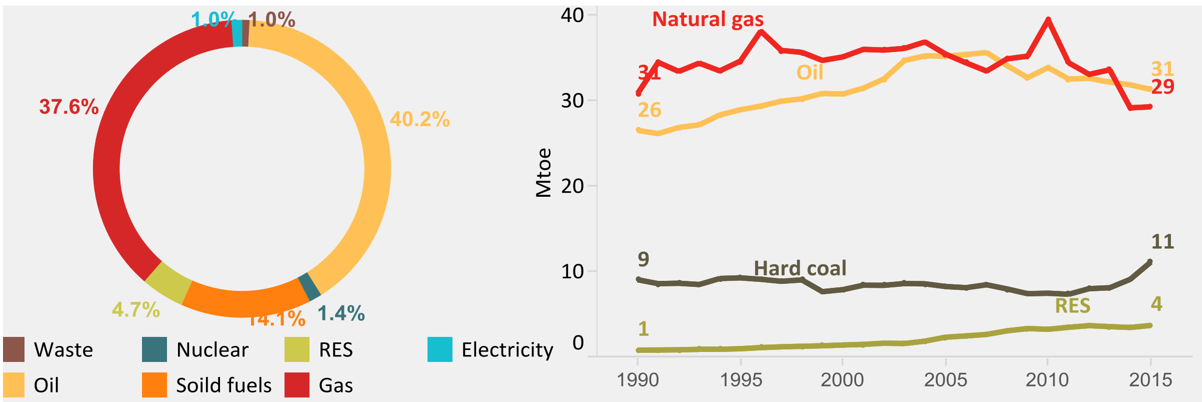
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 3.9 | 3.8 | 4.2 | 4.7 | 4.8 | 5.0 | 5.2 |
| GHG (E+Tr) emissions reduction (%) | 4.9 | 4.7 | 5.3 | 5.9 | 6.0 | 6.3 | 6.6 |
| GHG (P+H) emissions reduction (%) | 12.9 | 13.3 | 14.4 | 16.3 | 16.5 | 15.6 | 15.9 |
| GHG (Tr) emissions reduction (%) | 2.1 | 1.4 | 2.2 | 2.4 | 2.3 | 2.9 | 2.5 |

Without the current deployment of renewable energy, GHG emissions in the Netherlands would have been 3.9 % higher in 2009, 5.0 % higher in 2014 and 5.2% higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 4.9 % in 2009 to 6.3 % in 2014 and 6.6 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 12.9 % in 2009 to 15.6 % in 2014 and 15.9 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport remained marginal at around over 2 % in 2009, 2.9 % in 2014 and 2.5 % in 2015.

### 9.19.3 Fossil fuels displacement: role of renewables

The features of the energy mix in the Netherlands include a higher share of petroleum products and gas and a lower share of renewables. In 2015 more than 90 % of the Netherlands's gross inland consumption of energy was met by fossil fuels. The import dependency rate was 52 % in 2015 remaining very high for solid fuels (112.4 %) and petroleum products (101.4 %). The role of renewables became more prevalent around 2003 and by 2015 it had expanded by 138 %. This served to displace fossil fuels — by as much as 2.9 Mtoe by 2015. Thirty-nine per cent of this displacement took place in the electricity sector (1.1 Mtoe).

**Figure 143.** Breakdown of gross inland consumption in Netherlands, 2015 (left)-trend over 1990-2015 (right)



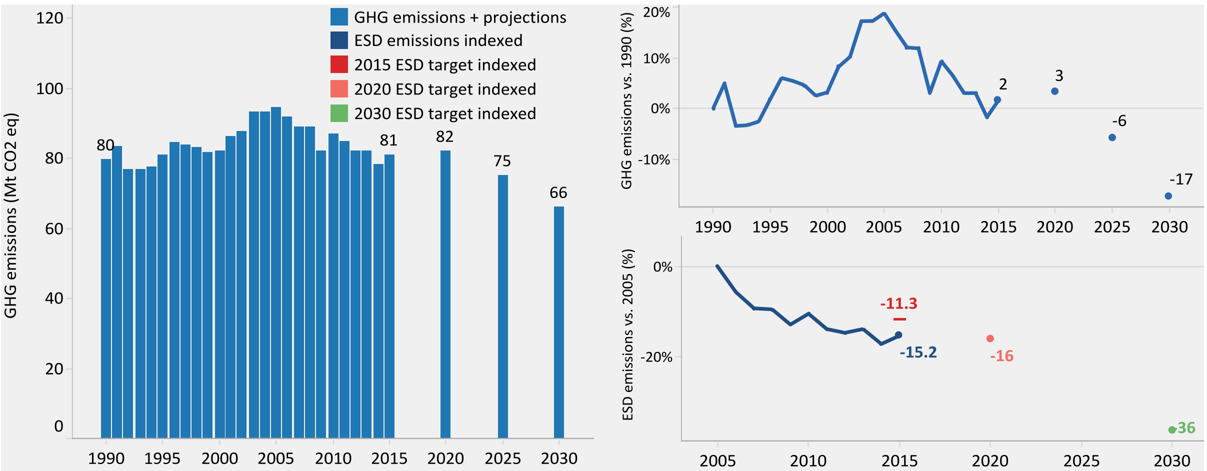
## 9.20 Austria

### 9.20.1 GHG emissions: trends & projections

In 2015, Austria emitted 74.2 Mt $CO_2$, a rise of 19.6 % (12.2 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by the ESD scheme reached 49.3 Mt $CO_2$-eq., 4.4 % (2.8 Mt $CO_2$-eq.) **below the ESD target**[66]. Total GHG emissions in Austria were 81 Mt $CO_2$-eq. in 2015, or 2 % above the 1990 figure. Under the EUCO27 scenario, by 2020 the GHG emissions in Austria are projected to rise up to 3 % above the 1990 level. Under the same scenario by 2030 the GHG emissions are projected to fall below the 1990 figure by 17 %.

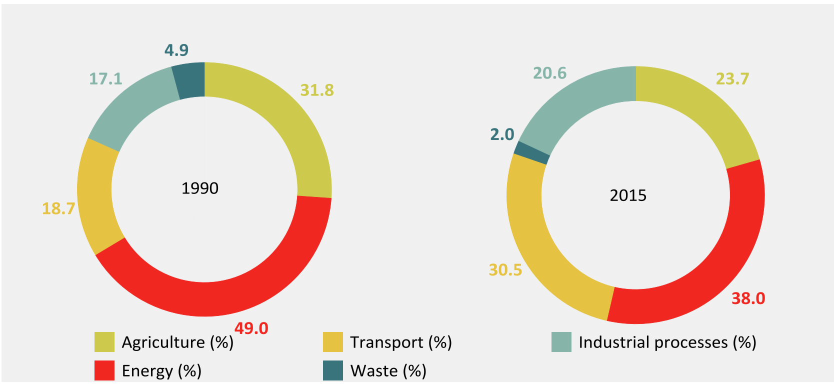
Figure 144 illustrates (i) the overall trend in GHG emissions in Austria over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 144.** GHG emissions in AT, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Austria since 1990. They totalled 30.8 Mt $CO_2$-eq. in 2015, a fall of 21.2 % in comparison with the 1990 figure. GHG emissions from the transport sector reached 24.6 Mt $CO_2$-eq. in 2015, 66.3 % higher than the 1990 figure, making it the second largest source of GHG emissions.

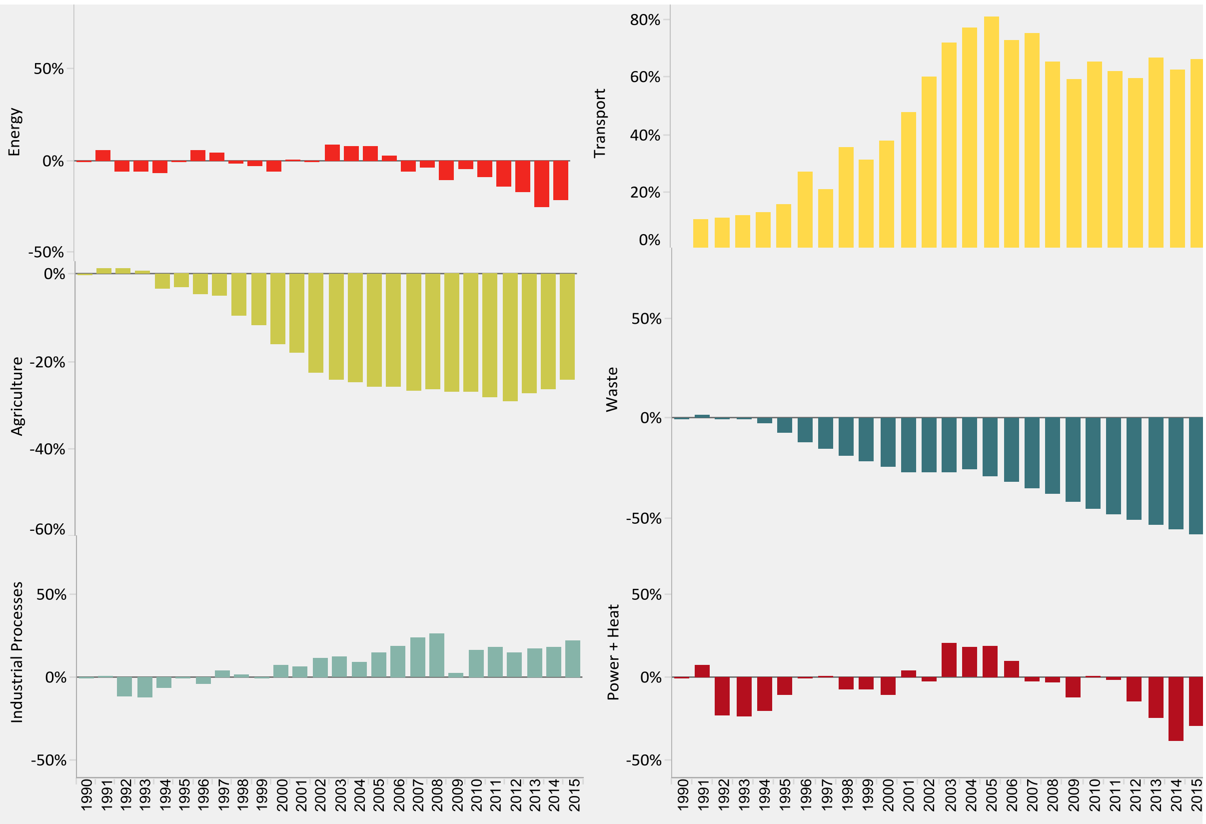
**Figure 145.** GHG emissions in AT broken down by source, 1990 (left) — 2015 (right)




Some sectors in Austria, such as agriculture and waste management, saw a fall in their GHG emissions immediately after 1991. In 2015 the absolute contribution of emissions from agriculture totalled 7.2 Mt $CO_2$-eq. Even though there was a 12.5 % decrease in emissions from that sector between 1990 and 2015, its relative share remained almost unchanged. The GHG emissions from waste management stood at 3.4 Mt $CO_2$-eq. in 2015, 76.2 % below the 1990 level. The GHG emissions from industrial processes and product use amounted to 11.5 Mt $CO_2$-eq., a fall of 53.8 % in comparison with the 1990 level. GHG emissions from public power and heat production came to 56 Mt $CO_2$-eq. in 2015, or 43 % of energy-related GHG emissions in that year.

([66]) Austria's ESD target for 2015 was 51.53 Mt $CO_2$-eq. The target for 2020 is set to 48.8 Mt $CO_2$-eq.

**Figure 146.** Changes of GHG emissions from sectors relative to 1990 — AT

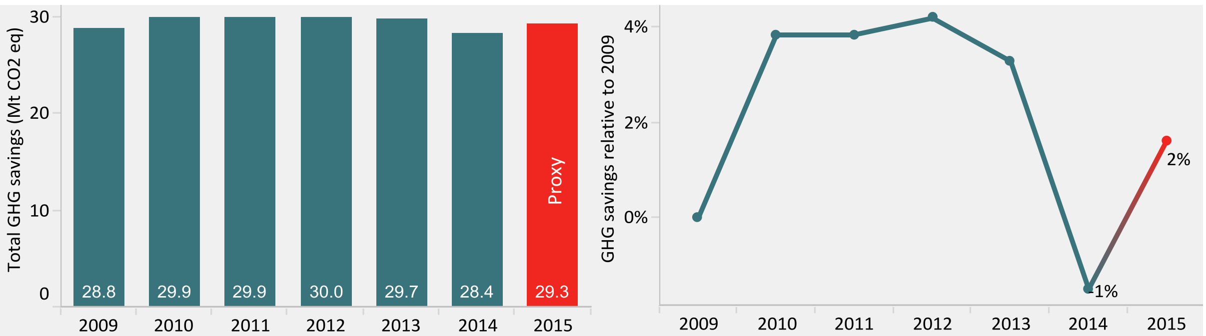



## 9.20.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Austria from the use of renewable energy in three sectors — electricity, heating/cooling and transport — fell by 1 % (or 0.4 Mt $CO_2$-eq.) over 2009-2014, reaching 28.4 Mt $CO_2$-eq. In per capita terms GHG emissions ranged from 3.5 to 3.3 t $CO_2$-eq.

Figure 147 illustrates the trend in GHG emissions savings from renewable energy use in Austria over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 147.** Trend in GHG emission savings from RES in AT (left) — Change relative to 2009 (right)




Renewable electricity was the main contributor to overall GHG emissions savings in Austria between 2009 and 2014. Its absolute contribution decreased by 6.1 % (1.1 Mt $CO_2$-eq.) over this period. Its relative share fell from 62.2 % to 59.2 %. Its contribution was estimated at 58.1 % in 2015. The contribution of renewable energy in the heating/cooling sector decreased over the years, from 37.8 % in 2009 to 33.9 % in 2014. This contribution was estimated to have reached 34 % in 2015. The contribution from savings from biofuels in the transport sector increased at 6.8 % in 2014 from its very marginal contribution in 2009. A contribution of 7.9 % was estimated for 2015.

**Figure 148.** Breakdown of GHG savings from renewables in AT, 2009-2014 and 2015 (proxy)

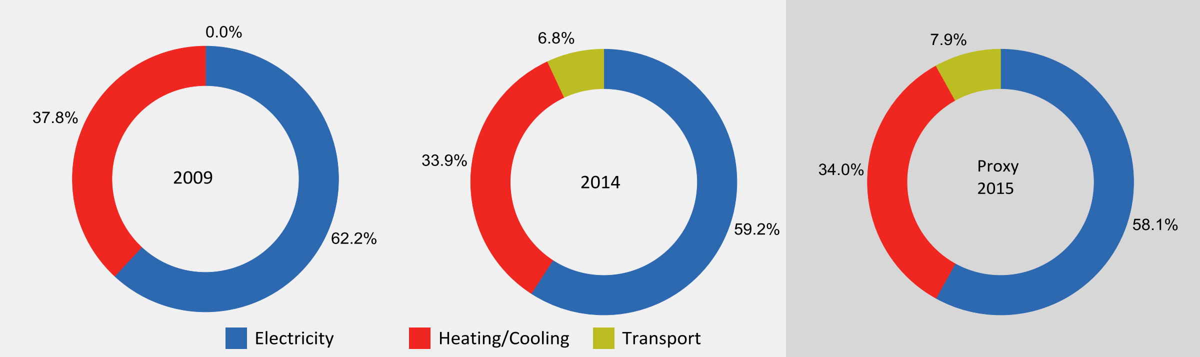



Table 26 shows how the deployment of renewable energy in Austria has helped the country to: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; (iv) its GHG emissions from transport.

**Table 26.** Emissions reduction in AT through the use of renewables, 2009-2014 and 2015 (proxy)

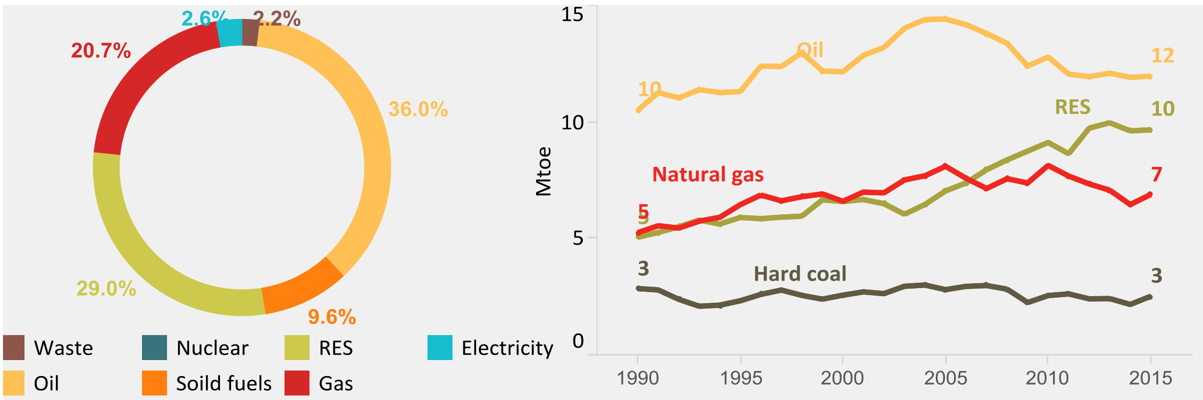
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 26.0 | 25.5 | 26.0 | 26.8 | 26.6 | 26.6 | 26.6 |
| GHG (E+Tr) emissions reduction (%) | 33.7 | 33.3 | 34.2 | 35.2 | 35.0 | 35.6 | 35.5 |
| GHG (P+H) emissions reduction (%) | 75.1 | 73.1 | 72.5 | 75.4 | 77.3 | 79.8 | 77.8 |
| GHG (Tr) emissions reduction (%) | 0.0 | 0.0 | 7.2 | 6.9 | 7.0 | 8.0 | 9.3 |

Without the current deployment of renewable energy, GHG emissions in Austria would have been 26 % higher in 2009 and 26.6 % higher in both 2014 and 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 33.7 % in 2009 to 35.6 % in 2014, remaining at this level in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 75.1 % in 2009 to 79.8 % in 2014, coming in at 77.8 % in 2015. The contribution of biofuels in the reduction of GHG emissions from transport reached around 7 % in 2011, 8 % in 2014 and 9.3 % in 2015.

## 9.20.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Austria include a higher share of petroleum products and renewables. In 2015 more than 66 % of Austria's gross inland consumption of energy was met by fossil fuels. Austria's import dependency rate was 60.7 % in 2015 remaining high for solid fuels (85.2 %), petroleum products (94 %) and gas (72.5 %). The role of renewables became more prevalent around 2005 and by 2015 it had expanded by 60 %. After 2006 the use of renewables overtook the gross inland consumption of gas and hard coal. This deployment served to displace fossil fuels — by as much as 4.6 Mtoe by 2015. Thirty-two per cent of this displacement took place in the electricity sector (1.5 Mtoe); the main fossil fuels displaced were gas and hard coal.

**Figure 149.** Breakdown of gross inland consumption in Austria, 2015 (left) — trend over 1990-2015 (right)



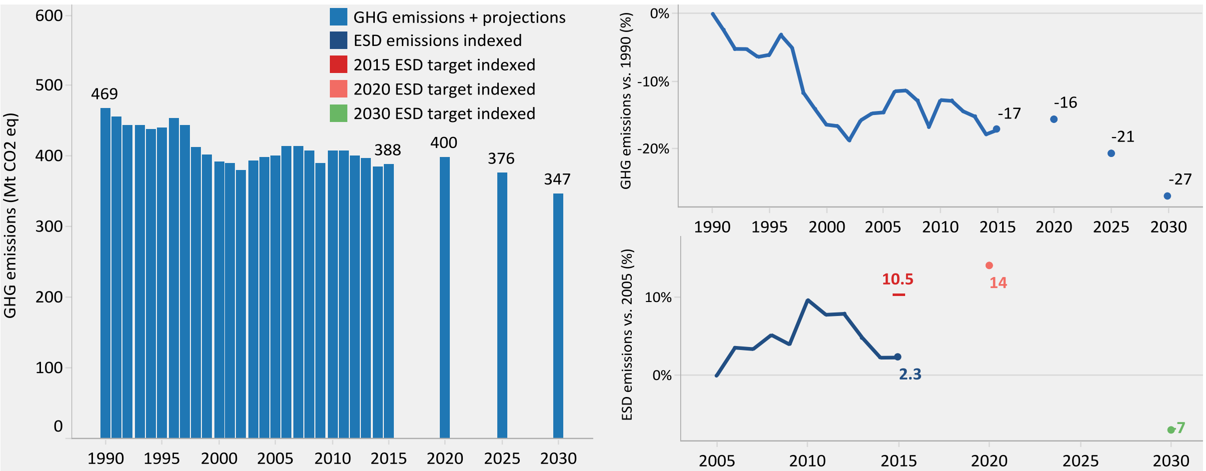
## 9.21 Poland

### 9.21.1 GHG emissions: trends & projections

In 2015, Poland emitted almost 295 Mt $CO_2$, a fall of 19 % (69 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by the ESD scheme reached almost 182 Mt $CO_2$-eq., 7.4 % (14.55 Mt $CO_2$-eq.) **below the ESD target**[67]. Total GHG emissions in Poland were 388 Mt $CO_2$-eq. in 2015, or 17 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions are projected to fall below the 1990 level by 16 % and 27 % respectively.

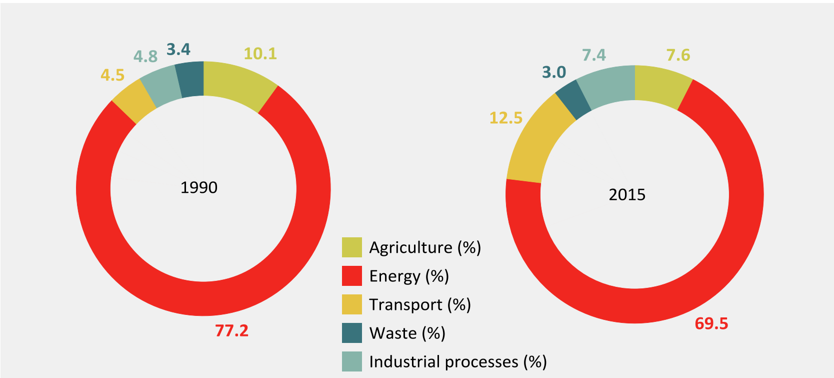
Figure 150 illustrates (i) the overall trend in GHG emissions in Poland over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 150.** GHG emissions in PL, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Poland since 1990. They totalled 269.5 Mt $CO_2$-eq. in 2015, a fall of 25.5 % in comparison with the 1990 figure. GHG emissions from the transport sector reached 48.5 Mt $CO_2$-eq. in 2015, 129.7 % higher than the 1990 figure, making it the second largest source of GHG emissions.

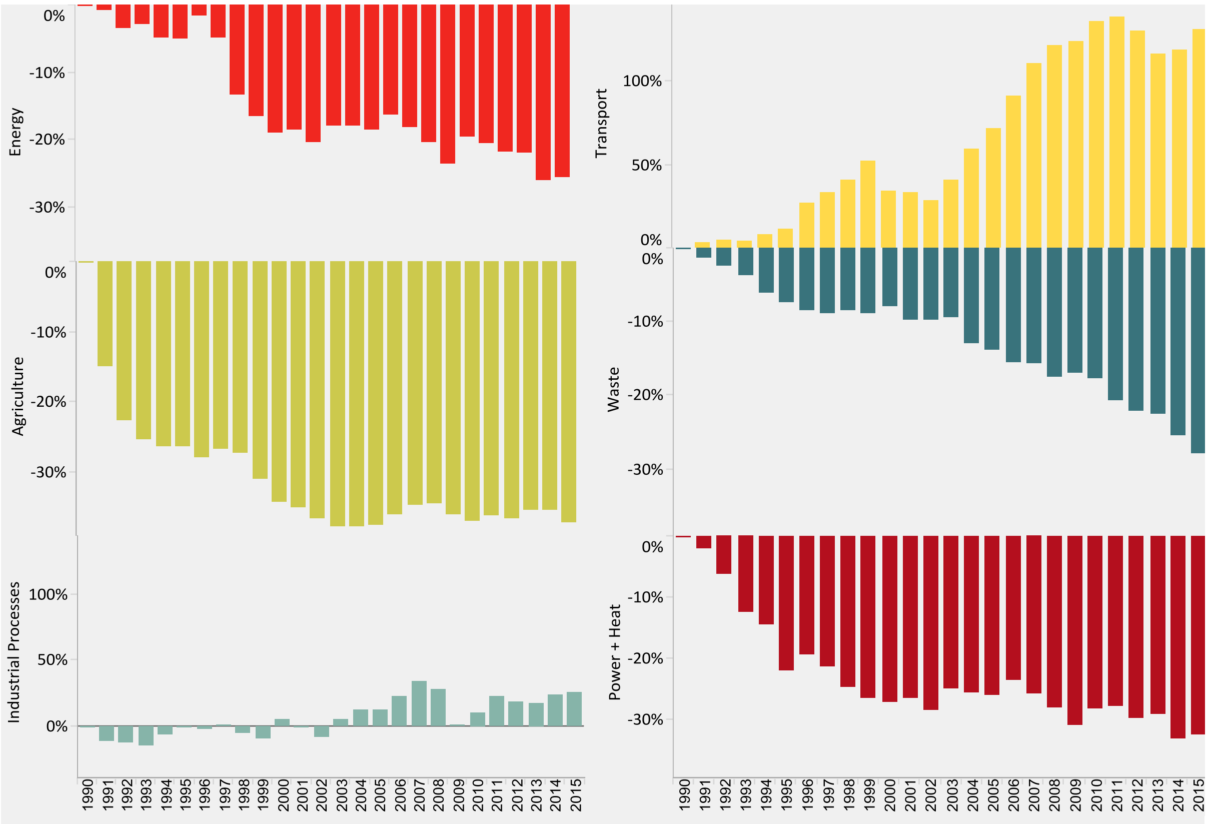
**Figure 151.** GHG emissions in PL broken down by source, 1990 (left) — 2015 (right)




Almost all sectors in Poland, except transport, saw a fall in their emissions immediately after 1990. The GHG emissions from industrial processes and product use increased around 2002. In 2015 their absolute contribution reached 28.5 Mt $CO_2$-eq., a rise of 25.7 % in comparison with the 1990 level. The GHG emissions from agriculture totalled 29.6 Mt $CO_2$-eq, a fall of 37 % in comparison with the 1990 figure. The GHG emissions from waste management stood at 11.6 Mt $CO_2$-eq. in 2015, 28 % below the 1990 level. Their relative share nevertheless remained almost unchanged, around 3 %. The GHG emissions from public power and heat production came to 154.6 Mt $CO_2$-eq. in 2015, or 57.4 % of energy-related GHG emissions in that year.

([67]) Poland's ESD target for 2015 was 196.13 Mt $CO_2$-eq. The target for 2020 is set to 202.34 Mt $CO_2$-eq.

**Figure 152.** Changes of GHG emissions from sectors relative to 1990 — PL

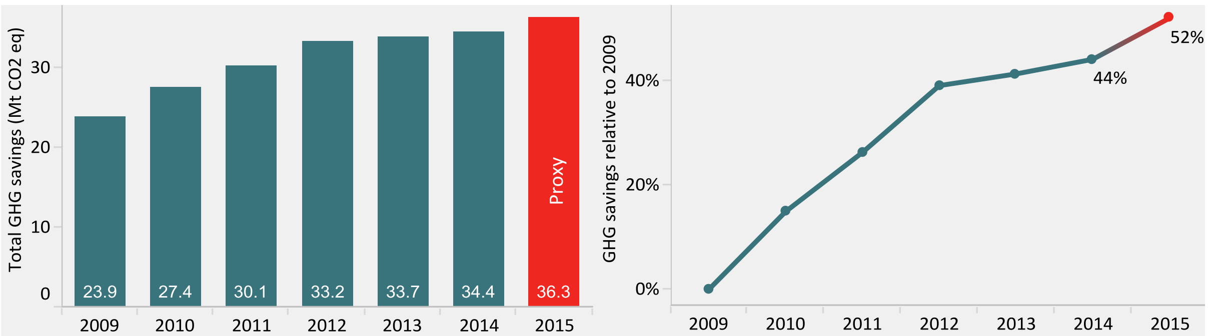



## 9.21.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Poland from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by 44 % (or 10.5 Mt $CO_2$-eq.) over 2009-2014, reaching 34.4 Mt $CO_2$-eq. In per capita terms GHG emissions ranged from 0.6 to 0.9 t $CO_2$-eq.

Figure 153 illustrates the trend in GHG emissions savings from renewable energy use in Poland over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 153.** Trend in GHG emissions savings from RES in PL (left) — Change relative to 2009 (right)




Renewable energy in the heating/cooling sector was the main contributor to overall GHG emissions savings in Poland between 2009 and 2014. Its absolute contribution rose by 17.6 %, but in relative terms it fell from 64 % to 62.3 %. This contribution was estimated at 50 % in 2015. The contribution of renewable electricity increased over the years, from 26 % in 2009 to almost 40 % in 2014. This contribution was estimated to have reached 41.8 % in 2015. The contribution from savings from biofuels in the transport sector reached 9.7 % in 2009, and then fell to 7.8 % in 2014. A contribution of 8.2 % was estimated for 2015.

**Figure 154.** Breakdown of GHG savings from renewables in PL, 2009-2014 and 2015 (proxy)

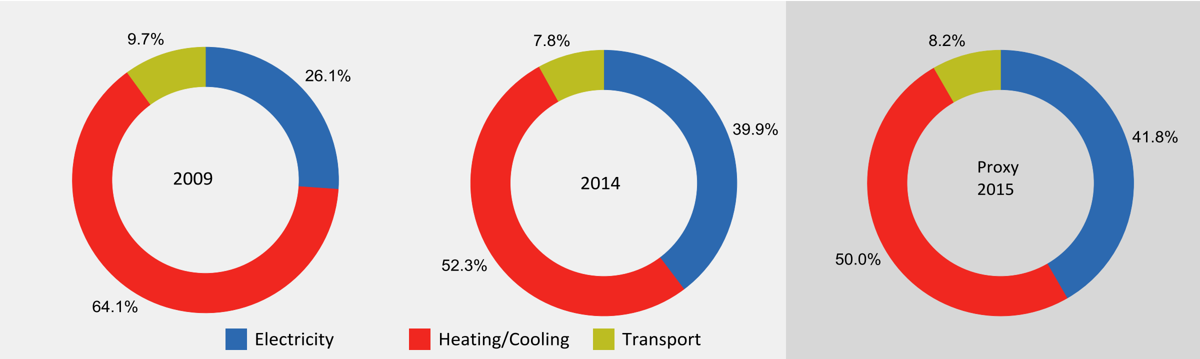



Table 27 shows how the deployment of renewable energy in Poland has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 27.** Emissions reduction in PL through the use of renewables, 2009-2014 and 2015 (proxy)

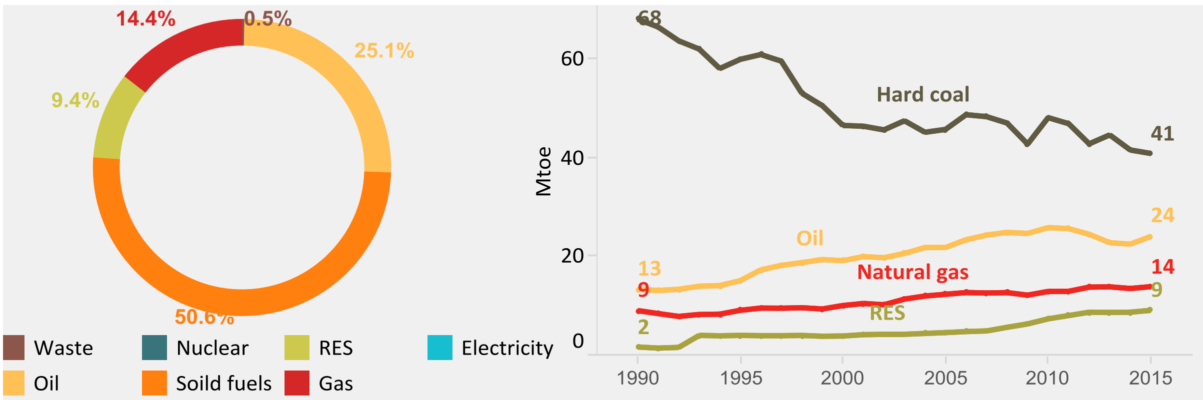
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 5.8 | 6.3 | 6.9 | 7.6 | 7.8 | 8.2 | 8.6 |
| GHG (E+Tr) emissions reduction (%) | 6.9 | 7.5 | 8.2 | 9.1 | 9.4 | 9.9 | 10.3 |
| GHG (P+H) emissions reduction (%) | 12.0 | 12.9 | 13.9 | 15.8 | 16.0 | 17.1 | 17.7 |
| GHG (Tr) emissions reduction (%) | 4.8 | 6.1 | 6.6 | 6.2 | 6.0 | 5.7 | 6.0 |

Without the current deployment of renewable energy, GHG emissions in Poland would have been 5.8 % higher in 2009, 8.2 % higher in 2014 and 8.6 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 6.9 % in 2009 to 9.9 % in 2014 and 10.3 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 12 % in 2009 to 17 % in 2014 and 17.7 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport reached around 4.8 % in 2009, 5.7 % in 2014 and 6.0 % in 2015.

## 9.21.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Poland include a higher share of solid fuels and petroleum products. In 2015 around 90 % of Poland's gross inland consumption of energy was met by fossil fuels. Poland has a low-import dependence rate at 29.3 % due to the presence of domestic solid fuels. Nevertheless the import dependency rate remains high for petroleum products (96.8 %) and gas (76.2 %). The role of renewables became more prevalent around 2005 and by 2015 it had expanded by 117 %. This deployment served to displace fossil fuels — by as much as 7.4 Mtoe by 2015. Twenty-three per cent of this displacement took place in the electricity sector (1.7 Mtoe); the main fossil fuels displaced were gas and hard coal.

**Figure 155.** Breakdown of gross inland consumption in Poland, 2015 (left) — trend over 1990-2015 (right)



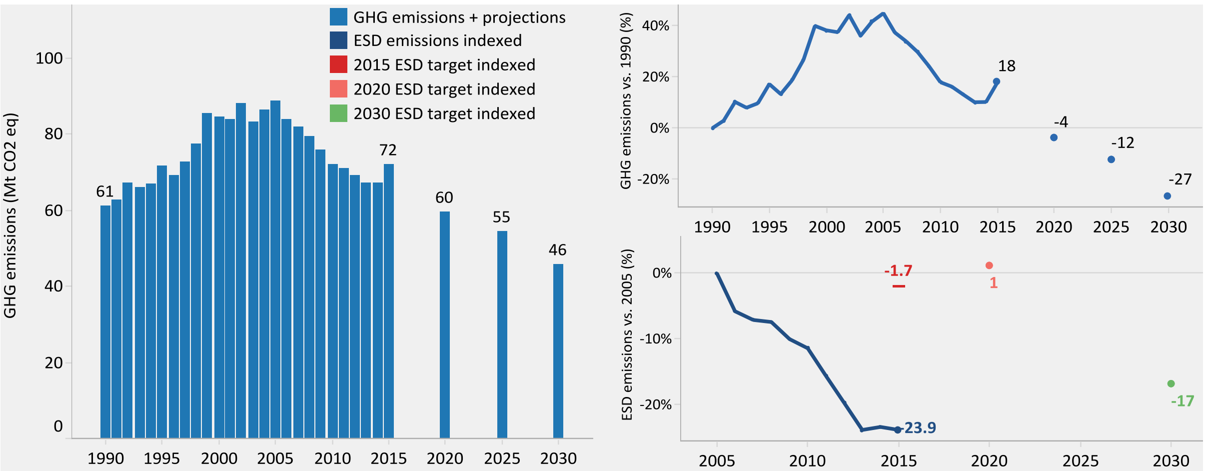
## 9.22 Portugal

### 9.22.1 GHG emissions: trends & projections

In 2015, Portugal emitted 50.8 Mt $CO_2$, a rise of 18 % (7.7 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by the ESD scheme reached 38.6 Mt $CO_2$-eq., 22.6 % (11.25 Mt $CO_2$-eq.) **below the ESD target**[68]. Total GHG emissions in Portugal were 72 Mt $CO_2$-eq. in 2015, or 18 % above the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Portugal are projected to fall below the 1990 level by 4 % and 27 % respectively.

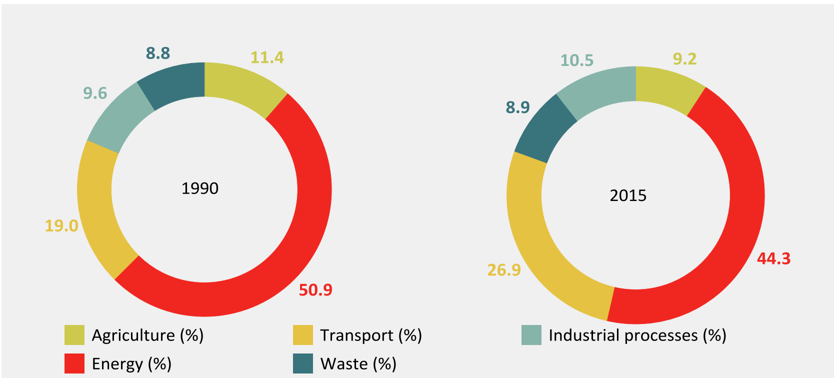
Figure 156 illustrates (i) the overall trend in GHG emissions in Portugal over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 156.** GHG emissions in PT, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Portugal since 1990. They totalled 32 Mt $CO_2$-eq. in 2015, a rise of 2.6 % in comparison with the 1990 figure, but a lower share from 50.9 % to 44.3 %. Transport sector emissions reached 10.4 Mt $CO_2$-eq. in 2015, 67 % higher than the 1990 figure, making it the second largest source of GHG emissions. They saw the largest expansion around 2006, reaching 90 % above the 1990 level.

**Figure 157.** GHG emissions in PT broken down by source, 1990 (left) — 2015 (right)




Some sectors in Portugal, such as agriculture, did not see a significant fall in their GHG emissions over 1990-2015. In 2015 their absolute contribution totalled 6.6 Mt $CO_2$-eq., a fall of only 5 % compared with the 1990 level. The GHG emissions from industrial processes and product use increased again around 1994, after falling in 1991. In 2015 these emissions came to 7.6 Mt $CO_2$-eq., 30 % above the 1990 level. The GHG emissions from waste management amounted to 6.4 Mt $CO_2$-eq., a rise of 19 % in comparison with the 1990 level. GHG emissions from public power and heat production stood at 16 Mt $CO_2$-eq. in 2015, or 50 % of energy-related GHG emissions in that year.

([68]) Portugal's ESD target for 2015 was 49.86 Mt $CO_2$-eq. The target for 2020 is set to 51.24 Mt $CO_2$-eq.

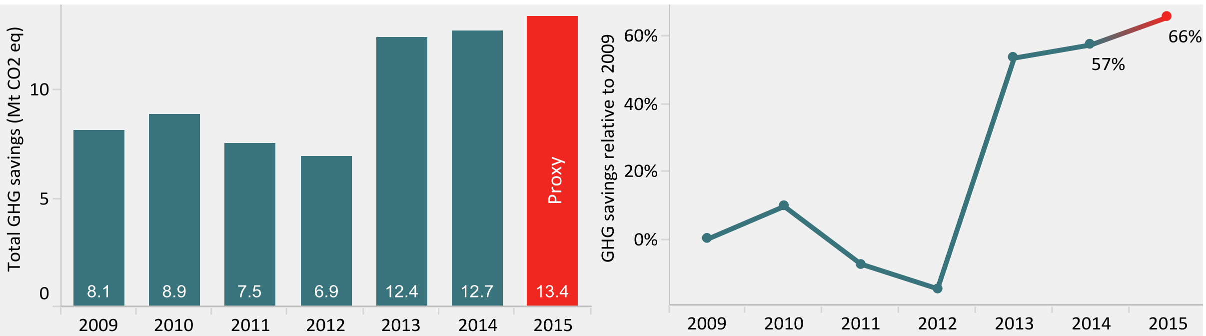
**Figure 158.** Changes of GHG emissions from sectors relative to 1990 — PT


## 9.22.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Portugal from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by 57 % (or 4.6 t $CO_2$-eq.) over 2009-2014, reaching 12.7 t $CO_2$-eq.[69] In per capita terms GHG emissions ranged from 0.8 to 1.2 t $CO_2$-eq.

Figure 159 illustrates the trend in GHG emissions savings from renewable energy use in Portugal over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 159.** Trend in GHG emissions savings from RES in PT (left) — Change relative to 2009 (right)




Renewable energy in the heating/cooling sector was the main contributor to overall GHG emissions savings in Portugal between 2009 and 2014. Its absolute contribution increased by 26 % but in relative terms it decreased from 65.3 % to 48 %. This contribution was estimated to have reached 49.3 % in 2015. The contribution of renewable electricity increased over the years, from 29.5 % in 2009 to 48 % in 2014. This contribution was estimated at 42.6 % in 2015. The contribution from savings from biofuels in the transport sector reached 5.1 % in 2009 and 3.7 % in 2014. A contribution of 8.3 % was estimated for 2015.

([69]) In both its first and second progress report Portugal reported data with a unit measure 1000 times less than the unit measure it reported in its third report. No change is reported on the coefficients used for the calculation of GHG emissions savings from renewables. This report provides the corrected data for period 2009-2012. See more in the Annex of this report.

**Figure 160.** Breakdown of GHG savings from renewables in PT, 2009-2014 and 2015 (proxy)

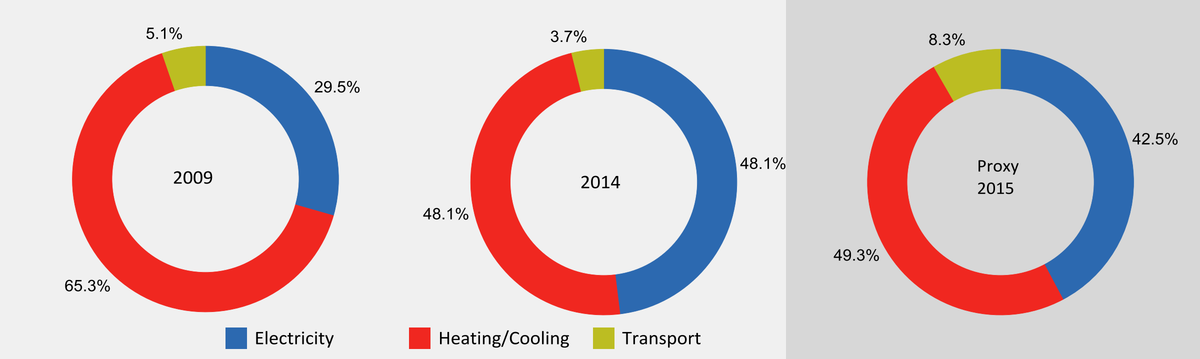



Table 28 shows how the deployment of renewable energy in Portugal has helped the country to curb: (i) the reduction of its total GHG emissions; (ii) the reduction of its GHG emissions from energy and transport; (iii) the reduction of its GHG emissions from power and heat; and (iv) the reduction of its GHG emissions from transport.

**Table 28.** Emissions reduction in PT through the use of renewables, 2009-2014 and 2015 (proxy)

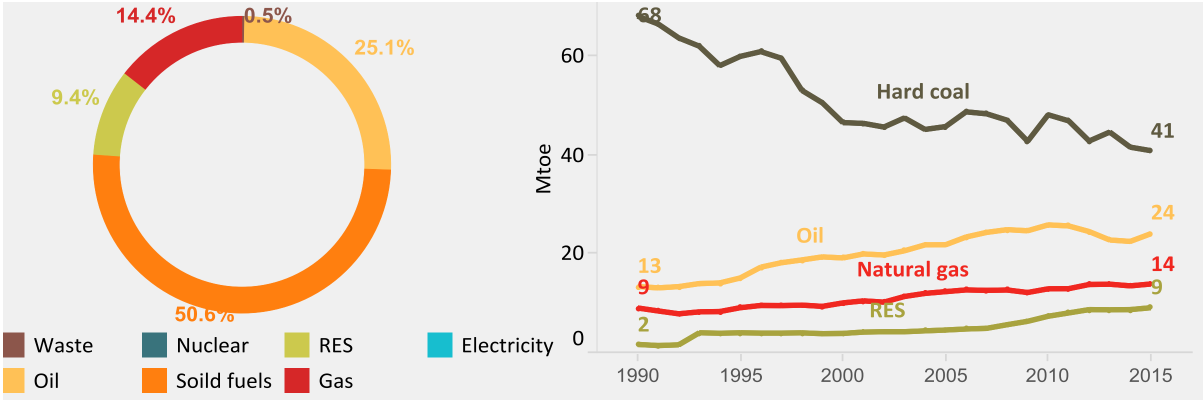
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 9.6 | 11.0 | 9.5 | 9.1 | 15.6 | 15.9 | 15.7 |
| GHG (E+Tr) emissions reduction (%) | 13.2 | 15.5 | 13.5 | 13.0 | 21.9 | 22.5 | 21.8 |
| GHG (P+H) emissions reduction (%) | 30.8 | 40.4 | 34.2 | 31.0 | 49.3 | 49.6 | 43.4 |
| GHG (Tr) emissions reduction (%) | 2.1 | 3.1 | 0.2 | 0.2 | 0.5 | 3.1 | 6.4 |

Without the current deployment of renewable energy, GHG emissions in Portugal would have been 9.6 % higher in 2009, 15.9 % higher in 2014 and 15.7 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 13.2 % in 2009 to 22.5 % in 2014, decreasing slightly to 21.8 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 30.8 % in 2009, to 49.6 % in 2014, coming in at 43.4 % in 2015. The contribution of biofuels in the reduction of GHG emissions from transport reached around 2 % in 2009, 3.1 % in 2014 and 6.4 % in 2015.

## 9.22.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Portugal include a higher share of petroleum products and renewables. In 2015 around 77 % of Portugal's gross inland consumption of energy was met by fossil fuels. Portugal's import dependency rate was 77.4 % in 2015 remaining very high for solid fuels (100 %), petroleum products (99.7 %) and gas (99.8 %). The role of renewables became more prevalent around 2005 and by 2015 it had expanded by 17 %. This deployment served to displace fossil fuels — by as much as 1.7 Mtoe by 2015. Seventy-six per cent of this displacement took place in the electricity sector (1.3 Mtoe); the main fossil fuel displaced was hard coal.

**Figure 161.** Breakdown of gross inland consumption in Portugal, 2015 (left) — trend over 1990-2015 (right)



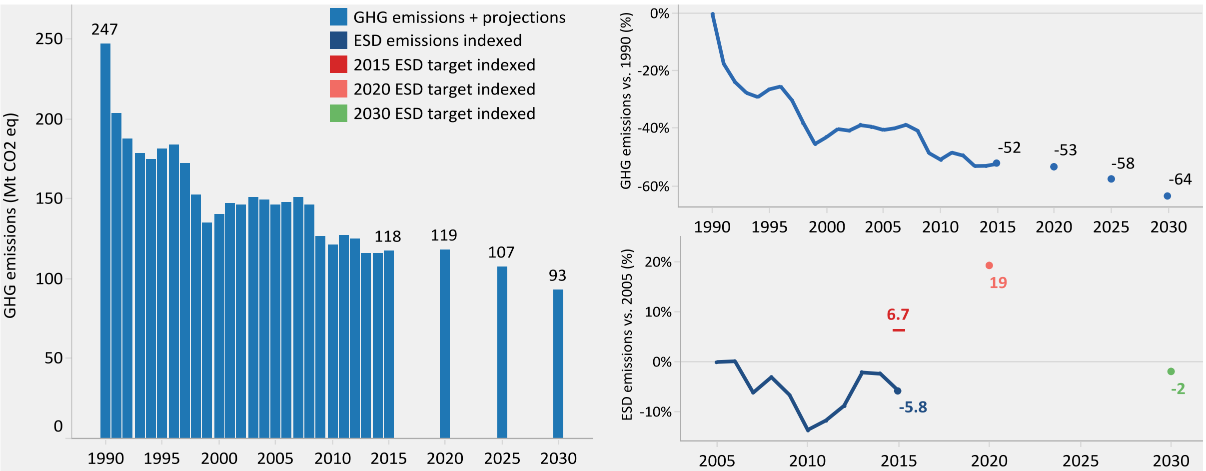
## 9.23 Romania

### 9.23.1 GHG gas emissions: trends & projections

In 2015, Romania emitted 81.2 Mt $CO_2$, a fall of 56.3 % (104.8 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by the ESD scheme reached 70 Mt $CO_2$-eq., 11.7 % (9.3 Mt $CO_2$-eq.) **below the ESD target**[70]. Total GHG emissions in Romania were almost 118 Mt $CO_2$-eq. in 2015, or 52 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Romania are projected to fall below the 1990 level by 53 % and 64 % respectively.

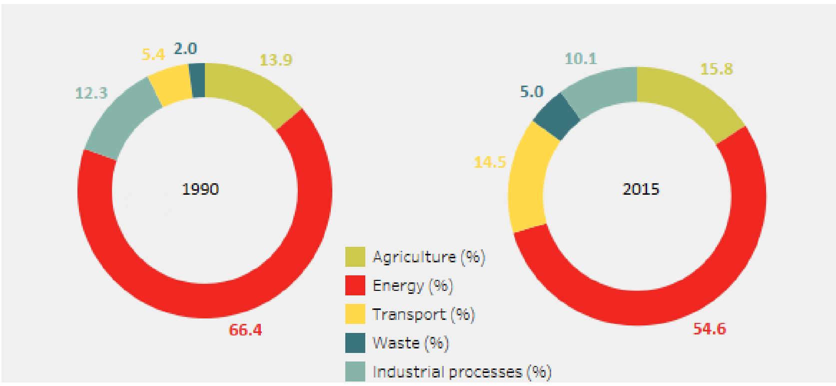
Figure 162 illustrates (i) the overall trend in GHG emissions in Romania over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 162.** GHG emissions in RO, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Romania since 1990. They totalled 64.4 Mt $CO_2$-eq. in 2015, a fall of 61 % in comparison with the 1990 figure. GHG emissions from the transport sector reached 17 Mt $CO_2$-eq. in 2015, 29 % higher than the 1990 figure, making it the third largest source of GHG emissions. These emissions decreased immediately after 1990 but started rising again around 2004.

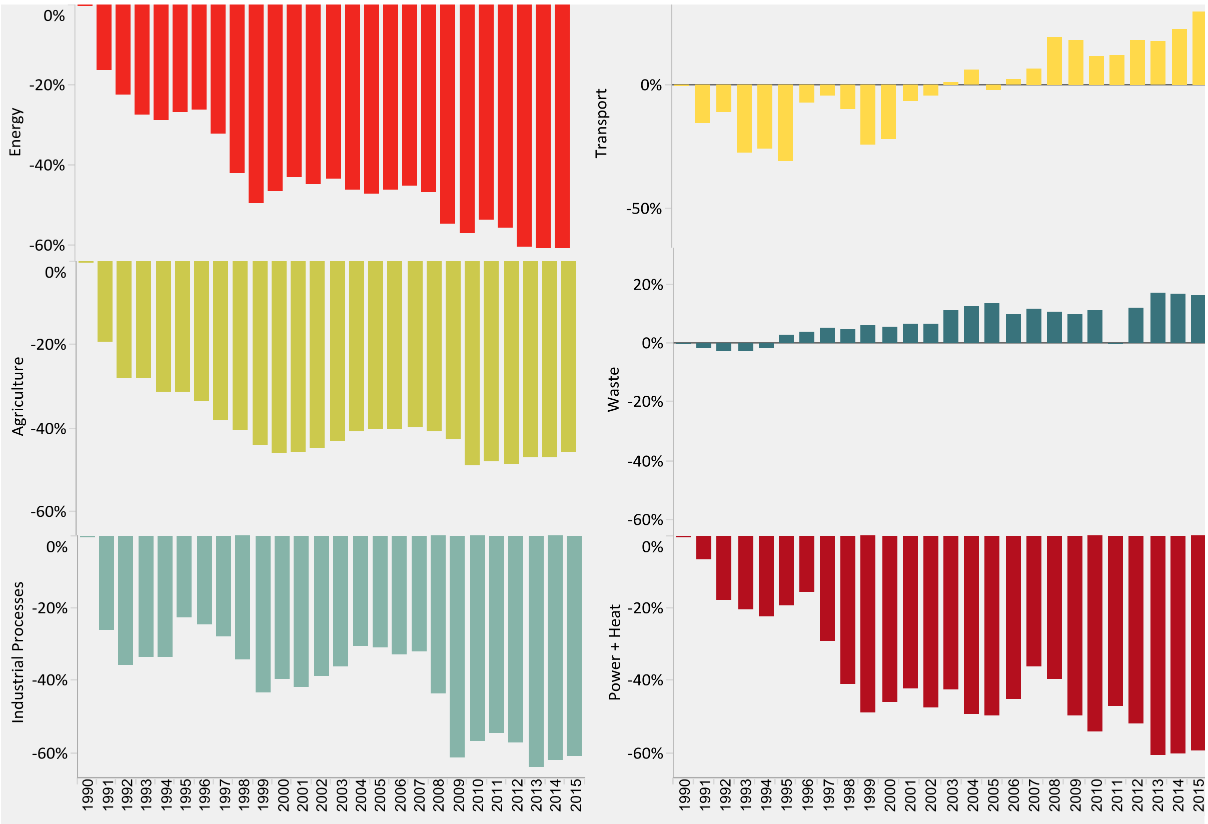
**Figure 163.** GHG emissions in RO broken down by source, 1990 (left) — 2015 (right)




Some sectors in Romania, such as transport and waste management, saw an increase in their GHG emissions after they fell in 1991. The GHG emissions from waste management started rising in 1995. In 2015 they reached 5.8 Mt $CO_2$-eq., a rise of 16.3 % in comparison with the 1990 level. The GHG emissions from industrial processes and product use came to almost 12 Mt $CO_2$-eq. in 2015, a fall of 61 % in comparison with the 1990 level. The GHG emissions from agriculture almost halved over 1990-2015. They totalled 18.6 Mt $CO_2$-eq. in 2015. The GHG emissions from public power and heat production stood at 27 Mt $CO_2$-eq. in 2015, or 42 % of energy-related GHG emissions in that year.

(70) Romania's ESD target for 2015 was 79.27 Mt $CO_2$-eq. The target for 2020 is set to 88.38 Mt $CO_2$-eq.

**Figure 164.** Changes of GHG emissions from sectors relative to 1990 — RO

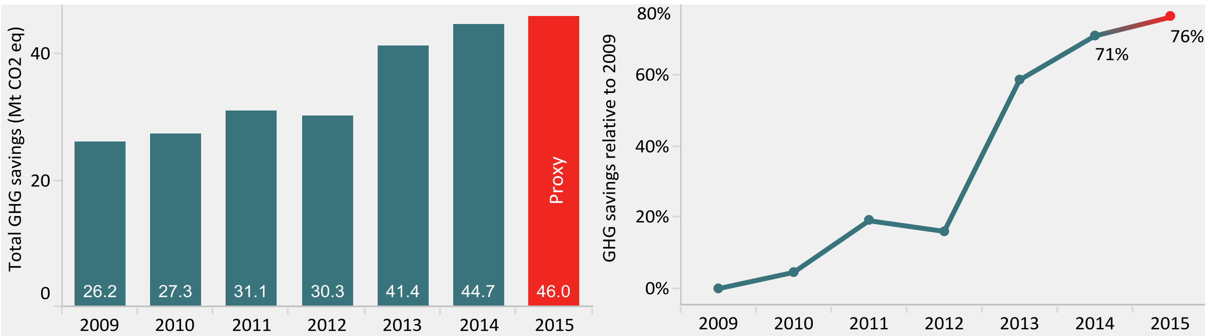



## 9.23.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Romania from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose sharply, by 71 % (or 18.5 Mt $CO_2$-eq.) over 2009-2014, reaching 44.7 Mt $CO_2$-eq. In per capita terms GHG emissions almost doubled, from 1.2 to 2.3 t $CO_2$-eq.

Figure 165 illustrates the trend in GHG emissions savings from renewable energy use in Romania over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 165.** Trend in GHG emissions savings from RES in RO (left) — Change relative to 2009 (right)




Renewable electricity was the main contributor to overall GHG emissions savings in Romania between 2009 and 2014, increasing from 58.8 % to 66 %. This contribution was estimated to have reached 67.7 % in 2015. The contribution of renewable energy in the heating/cooling sector decreased somewhat over the years, from 41.2 % in 2009 to 31.6 % in 2014. This contribution was estimated at 29.6 % in 2015. The contribution from savings from biofuels in the transport sector remained marginal at 2.2 % in 2014 and 2.6 % in 2015.

**Figure 166.** Breakdown of GHG savings from renewables in RO, 2009-2014 and 2015 (proxy)

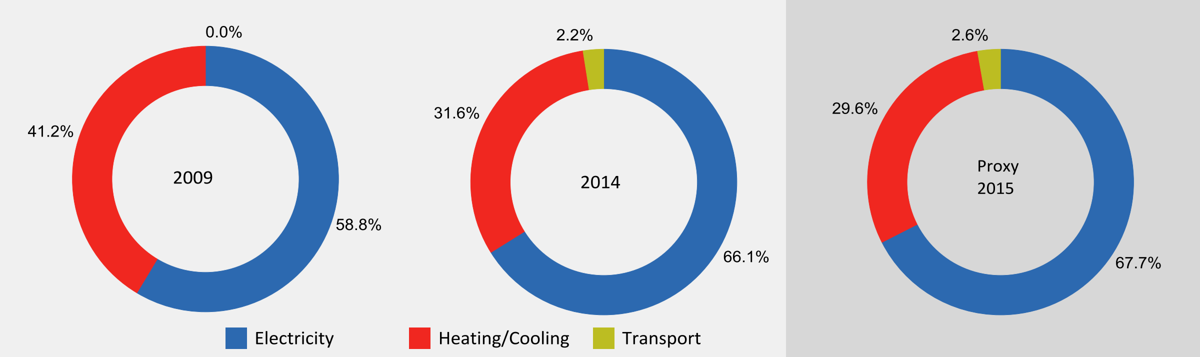



Table 29 shows how the deployment of renewable energy in Romania has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 29.** Emissions reduction in RO through the use of renewables, 2009-2014 and 2015 (proxy)

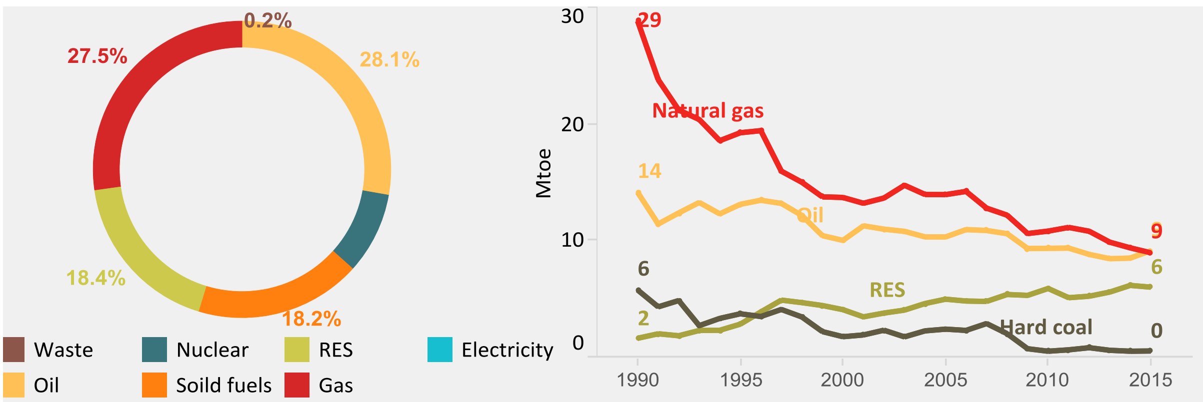
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 17.1 | 18.4 | 19.6 | 19.6 | 26.3 | 27.8 | 28.1 |
| GHG (E+Tr) emissions reduction (%) | 22.6 | 24.4 | 25.6 | 25.6 | 34.0 | 35.9 | 36.5 |
| GHG (P+H) emissions reduction (%) | 43.8 | 47.2 | 46.4 | 48.1 | 60.8 | 62.3 | 62.3 |
| GHG (Tr) emissions reduction (%) | 0.0 | 0.0 | 4.4 | 3.8 | 4.3 | 6.0 | 7.2 |

Without the current deployment of renewable energy, GHG emissions in Romania would have been 17 % higher in 2009, 27.8 % higher in 2014 and 28 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 22.6 % in 2009 to 35.9 % in 2014 and 36.5 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 43.8 % in 2009 to 62.3 % in 2014. It remained at 62.3% in 2015. The contribution of biofuels to the reduction of GHG emissions from transport reached 4.4 % in 2010, 6.0 % in 2014 and 7.2 % in 2015.

## 9.23.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Romania include a higher share of petroleum products and gas. In 2015 around 74 % of Romania's gross inland consumption of energy was met by fossil fuels. Romania import dependency rate was 17 % in 2015 remaining relatively high for petroleum products (53.5 %). Renewables expanded by 277 % over 1990-2015 overcoming the gross consumption of hard coal after 1995. This deployment served to displace fossil fuels — by as much as 5 Mtoe by 2015. Thirty per cent of this displacement took place in the electricity sector (1.5 Mtoe); the main fossil fuel displaced was hard coal.

**Figure 167.** Breakdown of gross inland consumption in Romania, 2015 (left) — trend over 1990-2015 (right)



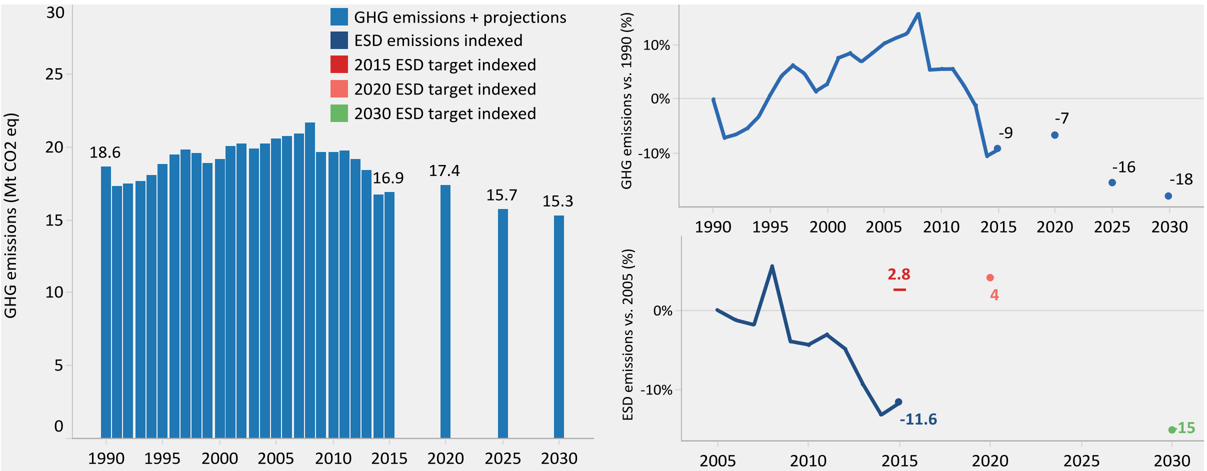
## 9.24 Slovenia

### 9.24.1 GHG emissions: trends & projections

In 2015, Slovenia emitted 15.6 Mt $CO_2$, a rise of 1.4 % (0.2 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, the GHG emissions covered by the ESD scheme reached 10.7 Mt $CO_2$-eq., 14 % (1.7 Mt $CO_2$-eq.) **below the ESD target**[71]. Total GHG emissions in Slovenia were almost 17 Mt $CO_2$-eq. in 2015, or 9 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Slovenia are projected to fall below the 1990 level by 7 % and 18 % respectively.

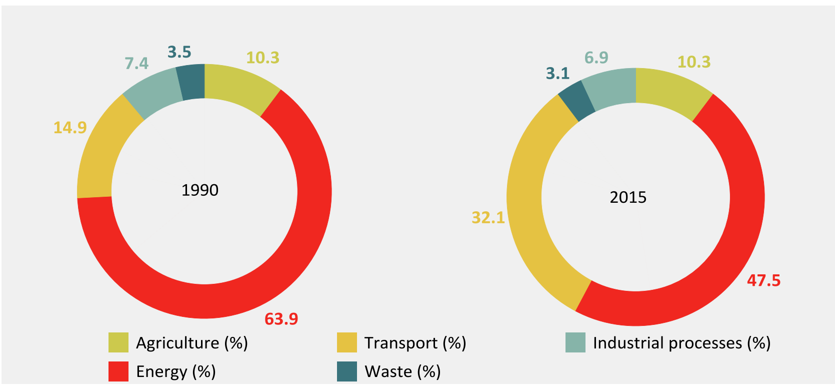
Figure 168 illustrates (i) the overall trend in GHG emissions in Slovenia over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 168.** GHG emissions in SI, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Slovenia since 1990. They totalled 8.0 Mt $CO_2$-eq. in 2015, a fall of 32.6 % in comparison with the 1990 figure. GHG emissions from the transport sector reached 5.4 Mt $CO_2$-eq. in 2015, 95.3 % higher than the 1990 figure, keeping the second place among sources of GHG emissions. These emissions saw their largest expansion around 2008, at 125 % over the 1990 figure.

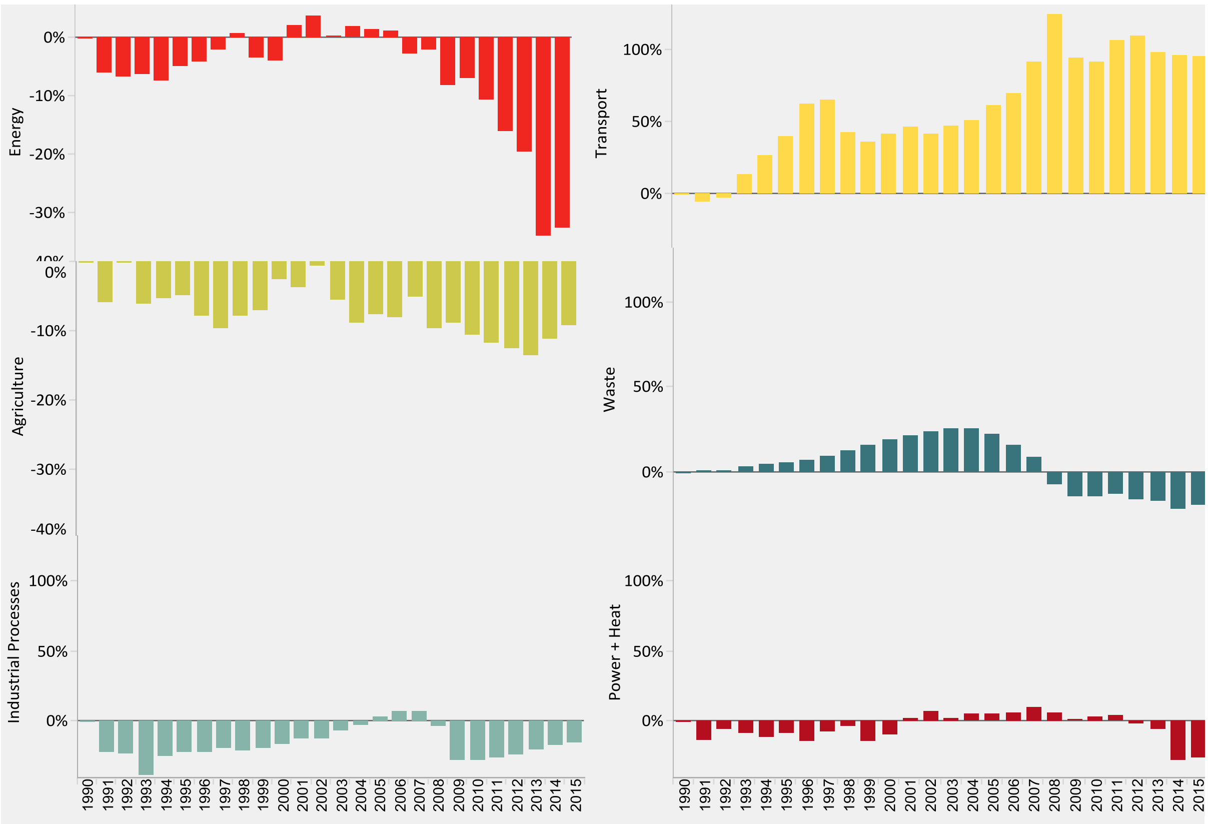
**Figure 169.** GHG emissions in SI broken down by source, 1990 (left) — 2015 (right)




Some sectors in Slovenia, such as waste management, did not see a fall in their GHG emissions immediately after 1990. The decrease happened only after 2007. These emissions totalled 0.5 Mt $CO_2$-eq. in 2015, 19.2 % below the 1990 figure. The GHG emissions from industrial processes and product use came to 1.2 Mt $CO_2$-eq. in 2015, a fall of 14.8 % in comparison with the 1990 level. The GHG emissions from agriculture totalled 1.7 Mt $CO_2$-eq. in 2015, only 9.3 % below the 1990 level. The GHG emissions from public power and heat production stood at 4.6 Mt $CO_2$-eq., or 56.7 % of energy-related GHG emissions in that year.

([71]) Slovenia's ESD target for 2015 was 12.38 Mt $CO_2$-eq. The target for 2020 is set to 12.53 Mt $CO_2$-eq.

**Figure 170.** Changes of GHG emissions from sectors relative to 1990 — SI

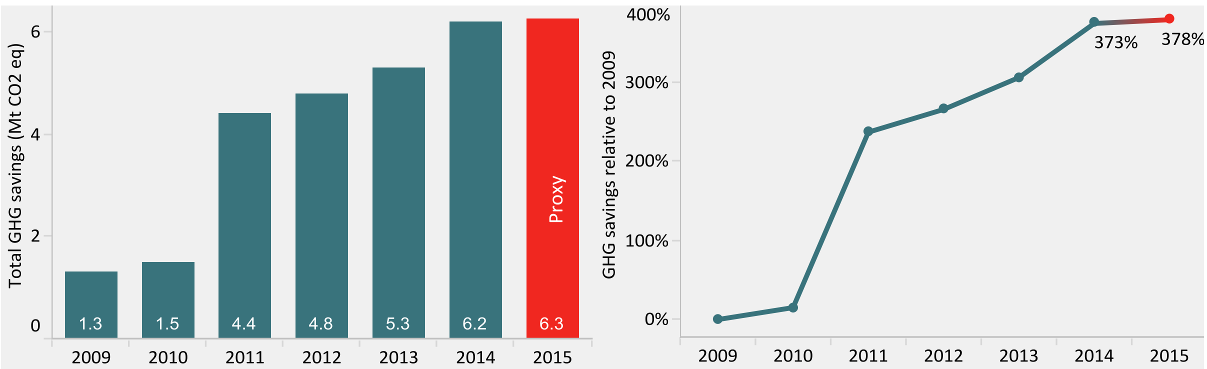



## 9.24.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Slovenia from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose sharply, by 373 % (or 4.9 Mt $CO_2$-eq.) over 2009-2014, reaching 6.2 Mt $CO_2$-eq. In per capita terms GHG emissions increased from 0.6 to 3.0 t $CO_2$-eq.

Figure 171 illustrates the trend in GHG emissions savings from renewable energy use in Slovenia over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 171.** Trend in GHG emissions savings from RES in SI (left) — Change relative to 2009 (right)




Renewable energy in heating/cooling was the main contributor to overall GHG emissions savings in Slovenia in 2009, while the role of renewable electricity was very marginal. However, over the period 2009-2014 renewable electricity was to become the main contributor to overall GHG savings, reaching 76 % by 2014. This contribution was estimated at 74.3 % in 2015. The contribution of renewable energy in the heating/cooling sector accounted for 22.6 % in 2014 and was estimated to have reached 24.7 % in 2015. The contribution from savings from biofuels in the transport sector was at 8.2 % in 2009. This contribution was marginal in 2014, at 1.4 %, falling to an estimated 0.9% in 2015.

**Figure 172.** Breakdown of GHG savings from renewables in SI, 2009-2014 and 2015 (proxy)

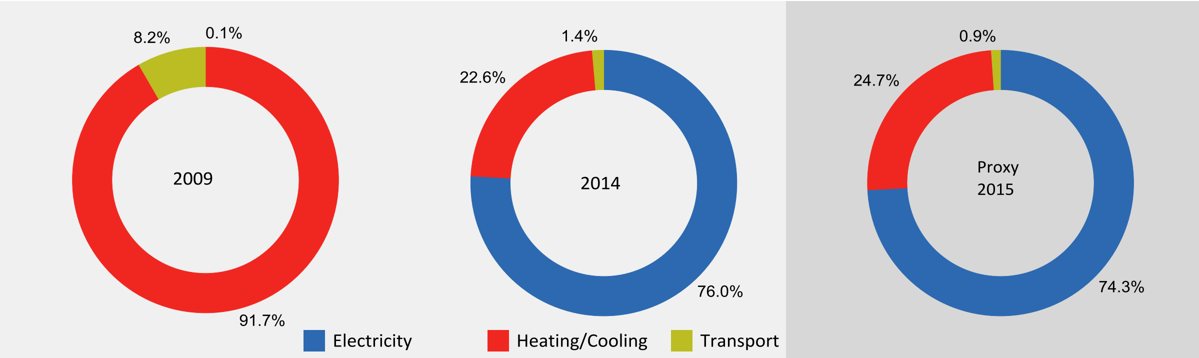



Table 30 shows how the deployment of renewable energy in Slovenia has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 30.** Emissions reduction in SI through the use of renewables, 2009-2014 and 2015 (proxy)

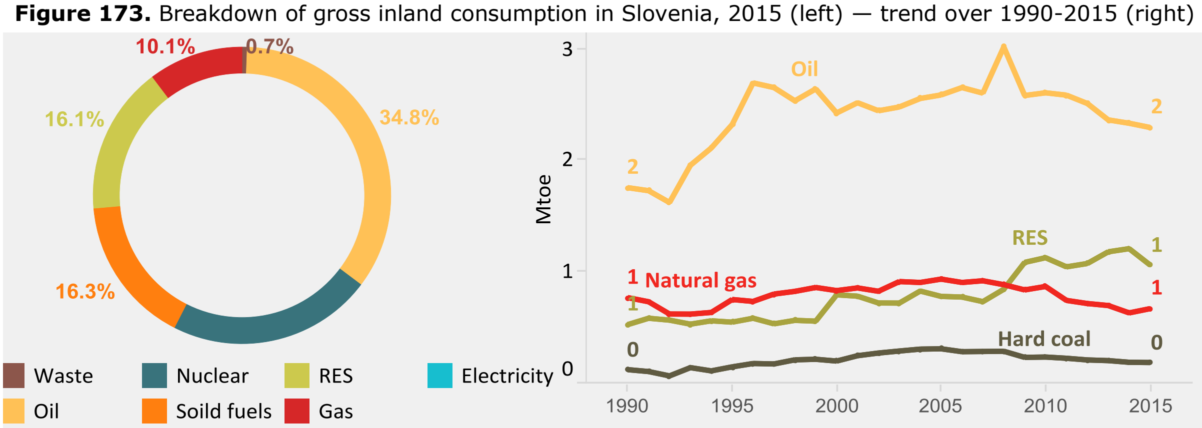
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 6.2 | 7.1 | 18.3 | 20.0 | 22.4 | 27.1 | 27.0 |
| GHG (E+Tr) emissions reduction (%) | 7.4 | 8.4 | 21.2 | 23.2 | 26.1 | 31.8 | 31.8 |
| GHG (P+H) emissions reduction (%) | 16.2 | 17.6 | 40.6 | 43.6 | 47.3 | 57.9 | 57.6 |
| GHG (Tr) emissions reduction (%) | 2.0 | 2.8 | 1.1 | 1.6 | 2.1 | 1.5 | 1.1 |

Without the current deployment of renewable energy, GHG emissions in Slovenia would have been 6.2 % higher in 2009 and 27 % higher in 2014 and 2015 alike. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 7.4 % in 2009 to 35.9 % in both 2014 and 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 16.2 % in 2009 to 57.9 % in 2014, coming in at 57.6% in 2015. The contribution of biofuels to the reduction of GHG emissions from transport reached 2.0 % in 2009, 1.5 % in 2014 and 1.1 % in 2015.

## 9.24.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Slovenia include a higher share of petroleum products and solid fuels. In 2015 more than 61 % of Slovenia's gross inland consumption of energy was met by fossil fuels. Slovenia import dependency rate was 48.7 % in 2015 remaining very high for petroleum products (99.6 %) and gas (99.6 %). The role of renewables became more prevalent around 2005 and by 2015 it had expanded by 48 %. This deployment served to displace fossil fuels — by only 0.6 Mtoe by 2015. Fifteen per cent of this displacement took place in the electricity sector (0.09 Mtoe); the main fossil fuels displaced were gas and hard coal.

**Figure 173.** Breakdown of gross inland consumption in Slovenia, 2015 (left) — trend over 1990-2015 (right)



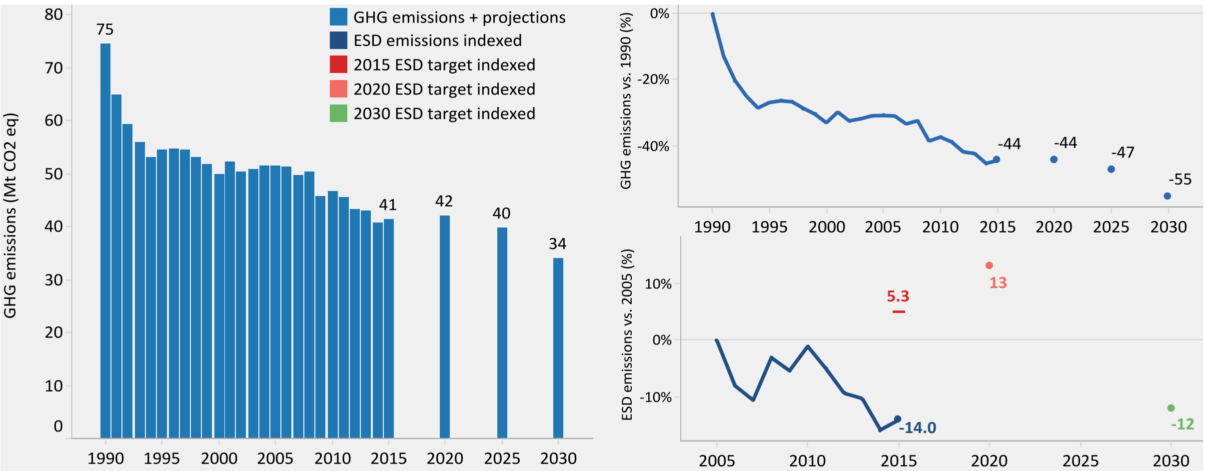
## 9.25 Slovakia

### 9.25.1 GHG emissions: trends & projections

In 2015, Slovakia emitted 36.2 Mt $CO_2$, a fall of 40.2 % (24.3 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, the GHG emissions covered by the ESD scheme reached 20.2 Mt $CO_2$-eq., 18.4 % (4.6 Mt $CO_2$-eq.) **below the ESD target**[72]. Total GHG emissions in Slovakia were 41 Mt $CO_2$-eq. in 2015, or 45 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Slovakia will fall below the 1990 level by 44 % and 55 % respectively.

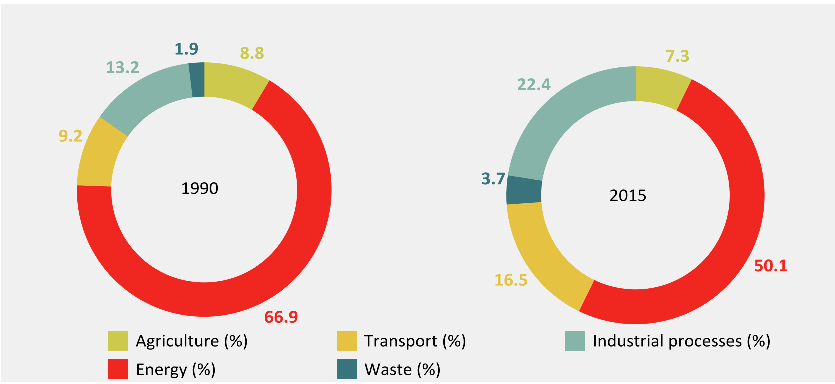
Figure 174 illustrates (i) the overall trend in GHG emissions in Slovakia over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 174.** GHG emissions in SK, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Slovakia since 1990. They totalled 20.7 Mt $CO_2$-eq. in 2015, a fall of 58.4 % in comparison with the 1990 figure. GHG emissions from the transport sector totalled 6.9 Mt $CO_2$-eq. in 2015, almost equal with the 1990 figure. These emissions saw their largest expansion around 2008, at 125 % over the 1990 figure. The GHG emissions from industrial processes and product use increased only in the period 2004-2008. They came to 9.3 Mt $CO_2$-eq. in 2015, 5.4 % below the 1990 level, keeping the second place among sources of GHG emissions.

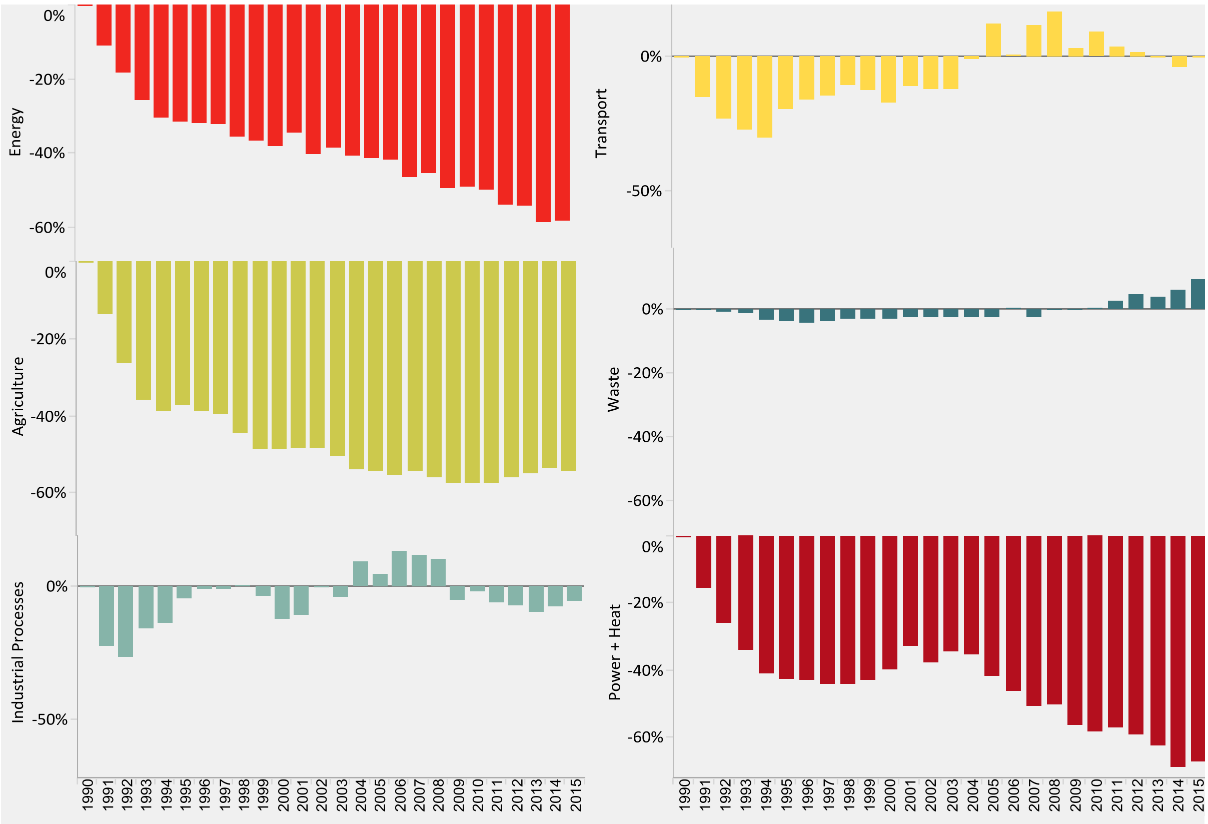
**Figure 175.** GHG emissions in SK broken down by source, 1990 (left) — 2015 (right)




Emissions from some sectors in Slovakia, such as waste management and transport increased around 2004 after their sudden fall in 1991. The GHG emissions from waste management reached 1.5 Mt $CO_2$-eq. in 2015, 9.5 % above the 1990 figure. The GHG emissions from agriculture totalled 3.0 Mt $CO_2$-eq. in 2015, a fall of 54.2 % compared with the 1990 level. The GHG emissions from public power and heat production stood at 4.9 Mt $CO_2$-eq. in 2015, a fall of 67.2 % from the 1990 figure. They accounted for 23.7 % of energy-related GHG emissions in that year.

([72]) Slovakia's ESD target for 2015 was 24.74 Mt $CO_2$-eq. The target for 2020 is set to 26.54 Mt $CO_2$-eq.

**Figure 176.** Changes of GHG emissions from sectors relative to 1990 — SK

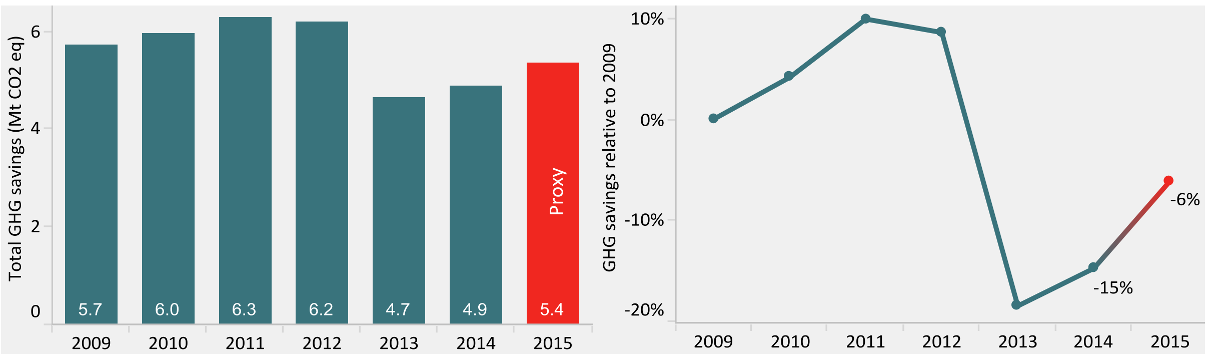



## 9.25.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Slovakia from the use of renewable energy in three sectors — electricity, heating/cooling and transport — decreased by 15 % (or 0.8 Mt $CO_2$-eq.) over 2009-2014, falling to 4.9 Mt $CO_2$-eq. In per capita terms GHG emissions remained almost unchanged, at around 1.0 t $CO_2$-eq.

Figure 177 illustrates the trend in GHG emissions savings from renewable energy use in Slovakia over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 177.** Trend in GHG emissions savings from RES in SK (left) — Change relative to 2009 (right) — SK




Renewable electricity was the main contributor to overall GHG emissions savings in Slovakia between 2009 and 2014. This contribution decreased by 21 % over this period. The relative contribution of this sector fell from 64.1 % to 59.5 %. This contribution was estimated at 54.9 % in 2015. The contribution of renewable energy in the heating/cooling sector increased slightly over this period, from 32.6 % in 2009 to 36.3 % in 2014. This contribution was estimated to have reached 40.9 % in 2015. The contribution from savings from biofuels in the transport sector remained marginal at 3.3 % in 2009, rising to 4.2 % in 2014. It remained at 4.2% in 2015.

**Figure 178.** Breakdown of GHG savings from renewables in SK, 2009-2014 and 2015 (proxy)

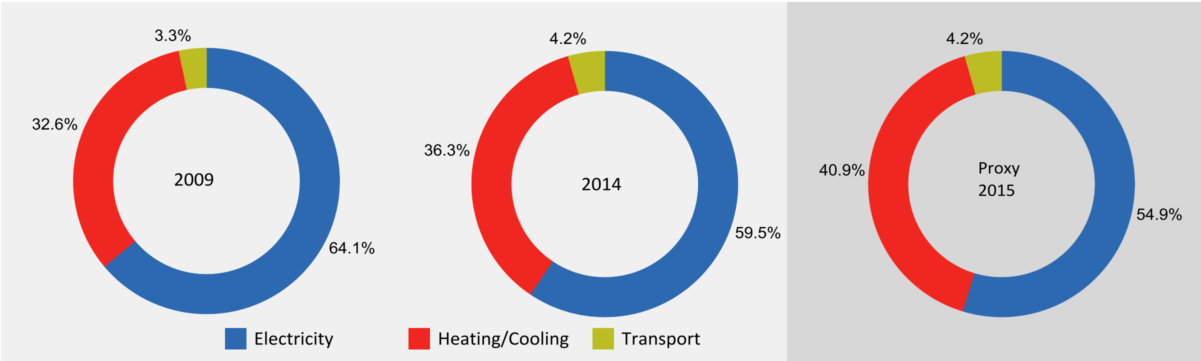



Table 31 shows how the deployment of renewable energy in Slovakia has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 31.** Emissions reduction in SK through the use of renewables, 2009-2014 and 2015 (proxy)

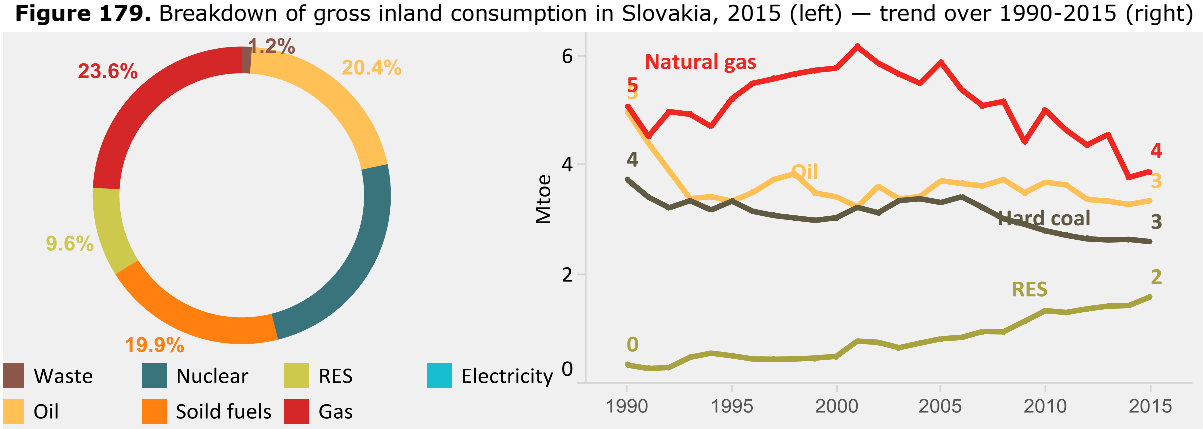
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 11.1 | 11.3 | 12.1 | 12.5 | 9.8 | 10.7 | 11.5 |
| GHG (E+Tr) emissions reduction (%) | 15.1 | 15.4 | 16.4 | 17.2 | 13.6 | 15.2 | 16.4 |
| GHG (P+H) emissions reduction (%) | 45.9 | 47.8 | 48.8 | 49.8 | 44.4 | 50.0 | 51.2 |
| GHG (Tr) emissions reduction (%) | 2.6 | 3.3 | 2.5 | 2.0 | 2.2 | 3.1 | 3.3 |

Without the current deployment of renewable energy, GHG emissions in Slovakia would have been 11 % higher in 2009, 10.7 % higher in 2014 and 11.5 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 15 % in 2009 to 15.2 % in 2014. It reached at 16.4 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 45.9 % in 2009 to 50 % in 2014 and 51.2 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport reached 2.6 % in 2009, 3.1 % in 2014 and 3.3 % in 2015.

## 9.25.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Slovakia include a higher share of gas, petroleum products and solid fuels. In 2015 almost 64 % of Slovakia's gross inland consumption of energy was met by fossil fuels. Slovakia import dependency rate was 58.7 % in 2015 remaining high for gas (95 %), petroleum products (89.4 %) and solid fuels (84.6 %). The role of renewables became more prevalent around 2005 and by 2015 it had expanded by 144 %. This deployment served to displace fossil fuels — by as much as 1.2 Mtoe by 2015. Almost 30 % of this displacement took place in the electricity sector (0.3 Mtoe); the main fossil fuel displaced was hard coal.

**Figure 179.** Breakdown of gross inland consumption in Slovakia, 2015 (left) — trend over 1990-2015 (right)



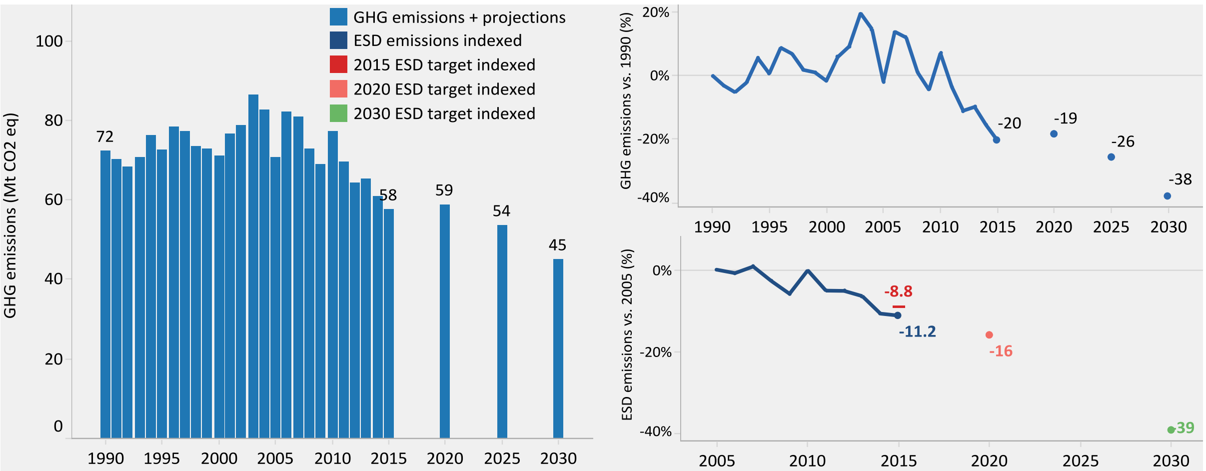
## 9.26 Finland

### 9.26.1 GHG emissions: trends & projections

In 2015, Finland emitted 48.5 Mt $CO_2$, a fall of 14.3 % (8.1 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, the GHG emissions covered by the ESD scheme reached 30 Mt $CO_2$-eq., 2.6 % (0.8 Mt $CO_2$) **below the ESD target**[73]. Total GHG emissions in Finland were 58 Mt $CO_2$-eq. in 2015, or 20 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Finland are projected to fall below the 1990 level by 19 % and 38 % respectively.

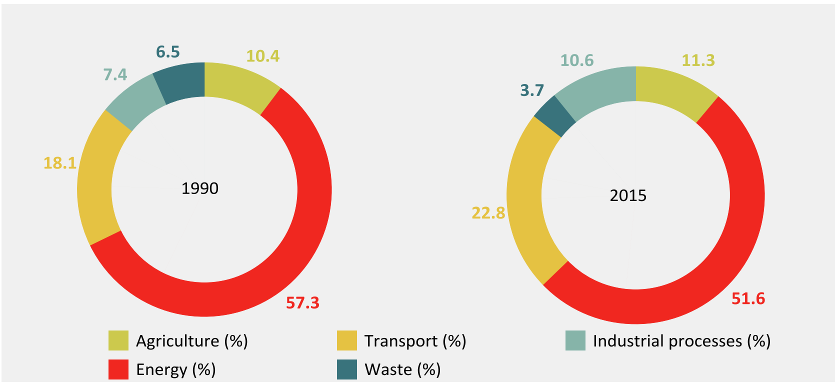
Figure 180 illustrates (i) the overall trend in GHG emissions in Finland over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 180.** GHG emissions in FI, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Finland since 1990. They totalled 29.7 Mt $CO_2$-eq. in 2015, a fall of 28.3 % in comparison with the 1990 figure. The GHG emissions from the transport sector reached 13 Mt $CO_2$-eq. in 2015, almost equal with the 1990 figure. Their relative share increased from 18 % to 22.8 % keeping the second place among sources of GHG emissions.

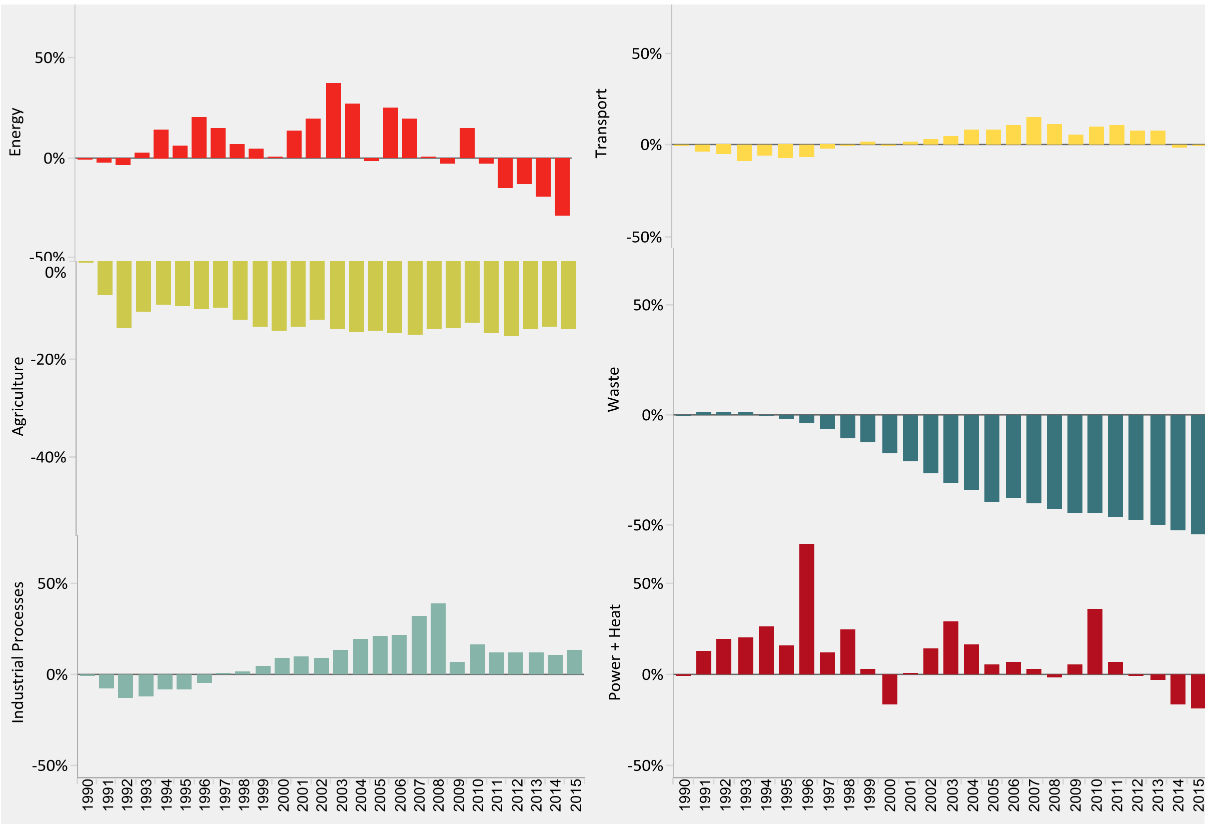
**Figure 181.** GHG emissions in FI broken down by source, 1990 (left) — 2015 (right)




Some sectors in Finland, such as transport and industrial processes and product use, saw an increase in their GHG emissions around 1997 after their sudden fall in 1991. The GHG emissions from industrial processes and product use came to 6.1 Mt $CO_2$-eq. in 2015, 13 % above the 1990 level. The GHG emissions from waste management came to 2.1 Mt $CO_2$-eq. in 2015, a fall of 54.3 % in comparison with the 1990 figure. The GHG emissions from agriculture totalled 6.5 Mt $CO_2$-eq. in 2015, 14 % below the 1990 level. The GHG emissions from public power and heat production stood at 6.4 Mt $CO_2$-eq. in 2015, a fall of 18.6 % from the 1990 figure. They accounted for 21.6 % of energy-related GHG emissions in that year.

([73]) Finland's ESD target for 2015 was 30.8 Mt $CO_2$-eq. The target for 2020 is set to 28.36 Mt $CO_2$-eq.

**Figure 182.** Changes of GHG emissions from sectors relative to 1990 — FI

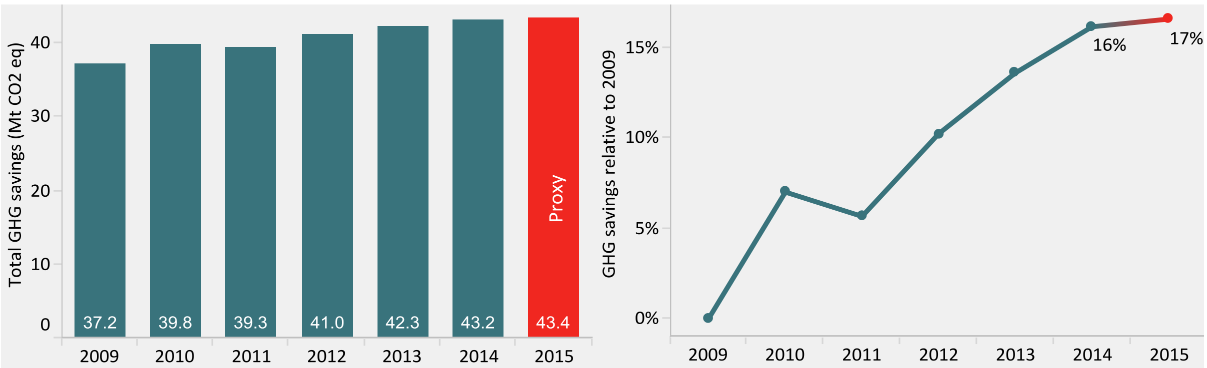



## 9.26.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in Finland from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by 16 % (or 6.0 Mt $CO_2$-eq.) over 2009-2014, reaching 43.2 Mt $CO_2$-eq. In per capita terms GHG emissions ranged from 7.0 to 7.9 t $CO_2$-eq.

Figure 183 illustrates the trend in GHG emissions savings from renewable energy use in Finland over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 183.** Trend in GHG emissions savings from RES in FI (left) — Change relative to 2009 (right)




Renewable energy in the heating/cooling sector was the main contributor to overall GHG emissions savings in Finland between 2009 and 2014, increasing from 54.8 % to 57.9 %. This contribution was estimated at 57.3 % in 2015. The contribution of renewable electricity decreased over the years, from 44.4 % in 2009 to almost 40 % in 2014. This contribution was estimated at 40.4 % in 2015. The contribution from savings from biofuels in the transport sector remained marginal at 0.8 % in 2009 and at 2.3 % in 2014 and 2015 alike.

**Figure 184.** Breakdown of GHG savings from renewables in FI, 2009-2014 and 2015 (proxy)

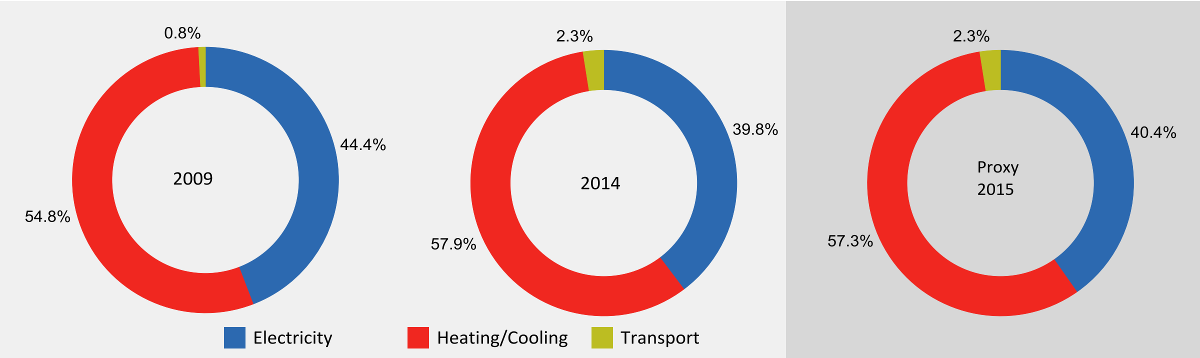



Table 32 shows how the deployment of renewable energy in Finland has helped the country to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 32.** Emissions reduction in FI through the use of renewables, 2009-2014 and 2015 (proxy)

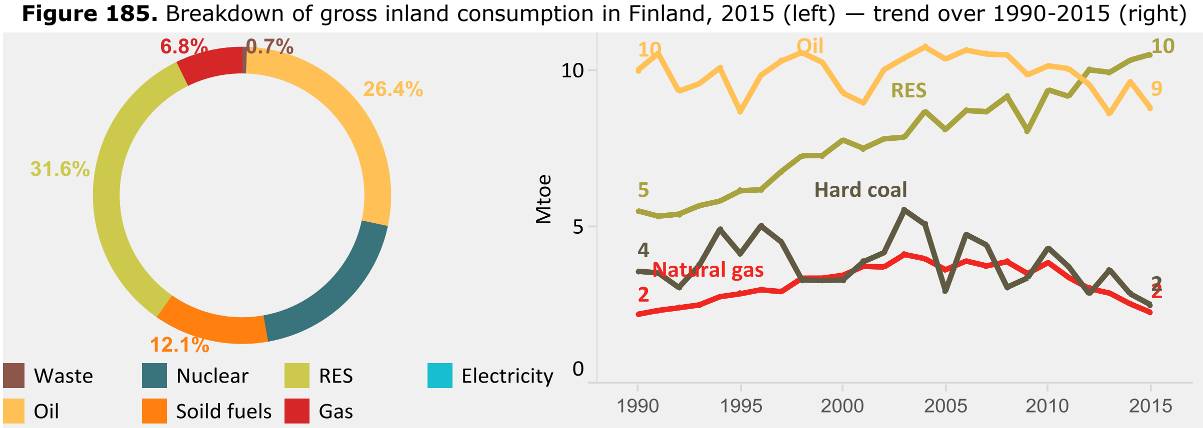
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 35.0 | 34.0 | 36.1 | 38.9 | 39.3 | 41.4 | 43.0 |
| GHG (E+Tr) emissions reduction (%) | 41.4 | 39.8 | 42.7 | 46.3 | 46.6 | 49.3 | 51.5 |
| GHG (P+H) emissions reduction (%) | 81.7 | 78.7 | 82.2 | 83.8 | 84.6 | 86.5 | 86.9 |
| GHG (Tr) emissions reduction (%) | 2.4 | 2.3 | 3.1 | 3.9 | 3.6 | 8.1 | 8.1 |

Without the current deployment of renewable energy, GHG emissions in Finland would have been 35 % higher in 2009, 41.4 % higher in 2014 and 43 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 41.4 % in 2009 to 49.3 % in 2014 and 51.5 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 81.7 % in 2009 to 86.5 % in 2014 and 86.9 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport reached 2.4 % in 2009 and 8.1 % in 2014 and 2015 alike.

## 9.26.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Finland include a higher share of renewables. In 2015 only 45 % of Finland's gross inland consumption of energy was met by fossil fuels. Finland's import dependency rate was 46.8 % in 2015 remaining very high for gas (99.7 %) and petroleum products (100 %). The role of renewables became more prevalent around 2005 and in 2012 they overtook the gross inland consumption of each fossil fuel. Over the period 1990-2015 the role of renewables expanded by 91 %. This deployment served to displace fossil fuels — by as much as 5.0 Mtoe by 2015. Almost 26 % of this displacement took place in the electricity sector (1.3 Mtoe).

**Figure 185.** Breakdown of gross inland consumption in Finland, 2015 (left) — trend over 1990-2015 (right)



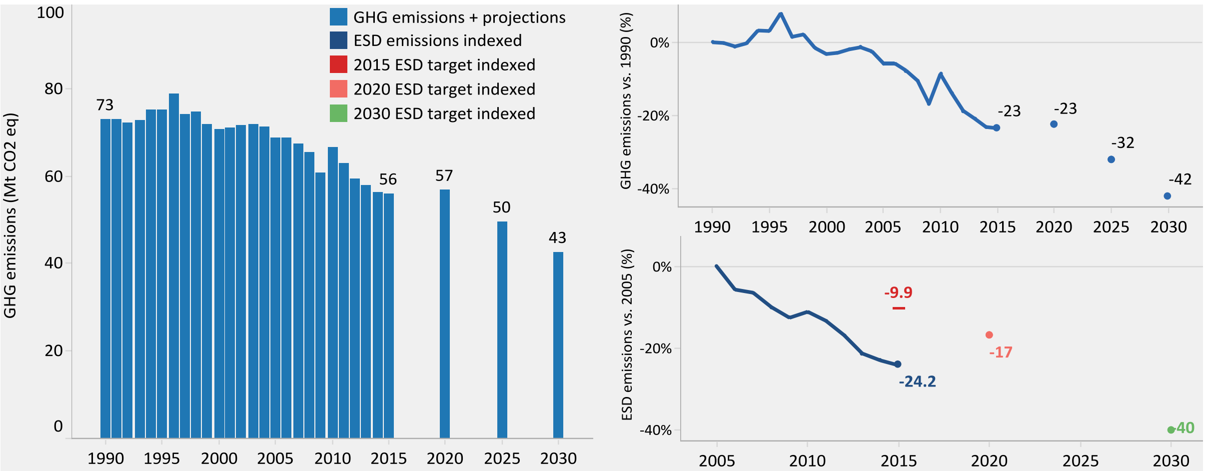
# 9.27 Sweden

## 9.27.1 GHG emissions: trends & projections

In 2015, Sweden emitted 42.5 Mt $CO_2$, a fall of 26 % (15 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by the ESD scheme reached 34 Mt $CO_2$-eq., 16 % (6.4 Mt $CO_2$-eq.) **below the ESD target**[74]. Total GHG emissions in Sweden were almost 56 Mt $CO_2$-eq. in 2015, or 23 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in Sweden are projected to fall below the 1990 level by 23 % and 42 % respectively.

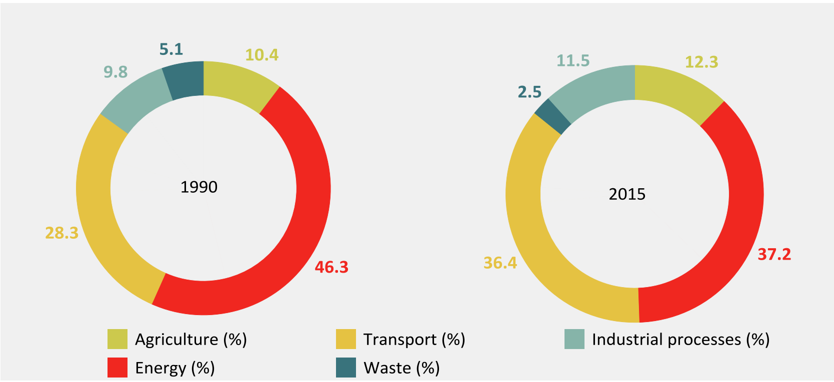
Figure 186 illustrates (i) the overall trend in GHG emissions in Sweden over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 186.** GHG emissions in SE, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in Sweden since 1990. They totalled 20.8 Mt $CO_2$-eq. in 2015, a fall of 38.4 % in comparison with the 1990 figure. The GHG emissions from the transport sector totalled 20.4 Mt $CO_2$-eq. in 2015, only 1.6 % below the 1990 figure, keeping the second place among sources of GHG emissions.

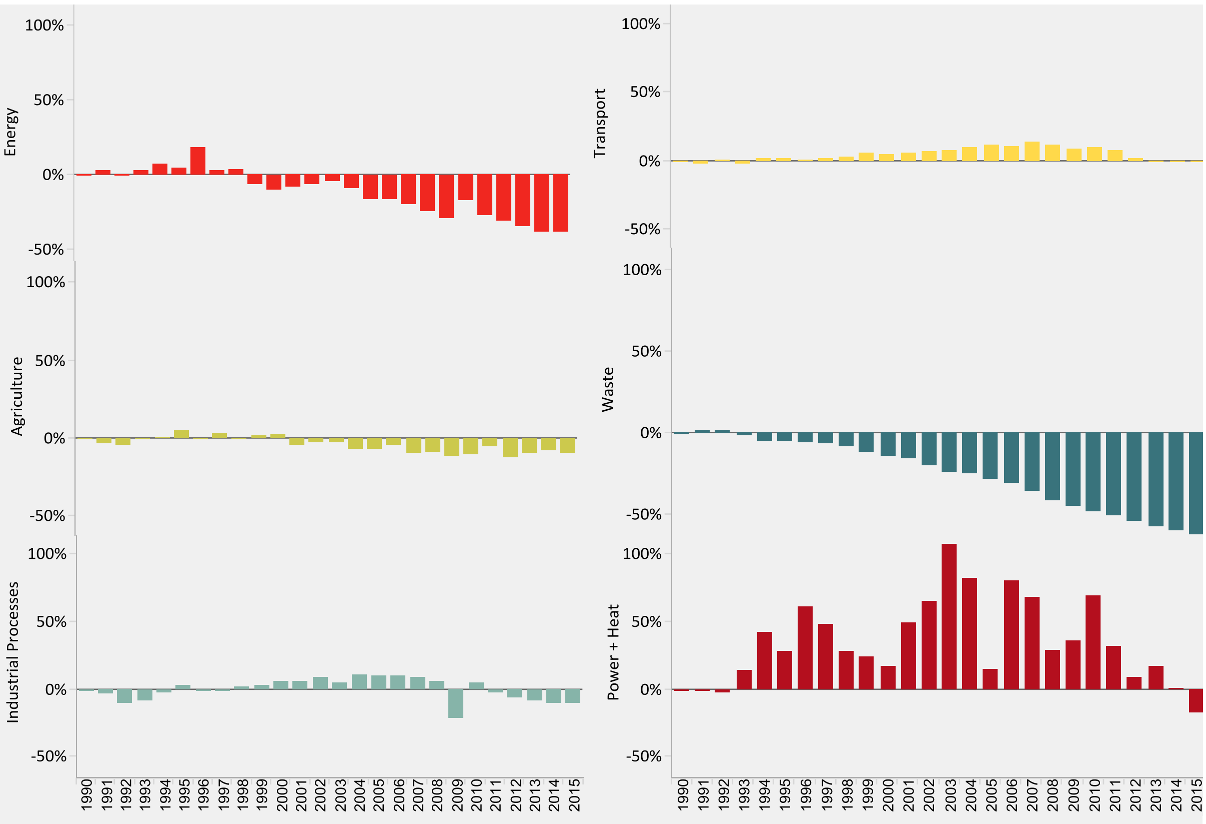
**Figure 187.** GHG emissions in SE broken down by source, 1990 (left) — 2015 (right)




Some sectors in Sweden, such as energy and waste management, did not see a fall in their GHG emissions immediately after 1990. The GHG emissions from waste management started falling around 1994. They totalled 1.4 Mt $CO_2$-eq. in 2015, a fall of 62.5 % in comparison with the 1990 figure. The GHG emissions from industrial processes and product use came to 6.4 Mt $CO_2$-eq. in 2015, 10.4 % below the 1990 level. The GHG emissions from agriculture totalled 6.9 Mt $CO_2$-eq. in 2015, 9.5 % below the 1990 emissions. The GHG emissions from public power and heat production stood at 13.7 Mt $CO_2$-eq. in 2015, a fall of 17.6 % from the 1990 figure. They accounted for 65.6 % of energy-related GHG emissions in 2015.

(74) Sweden's ESD target for 2015 was 40.4Mt $CO_2$-eq. The target for 2020 is set to 37.2 Mt $CO_2$-eq.

**Figure 188.** Changes of GHG emissions from sectors relative to 1990 — SE

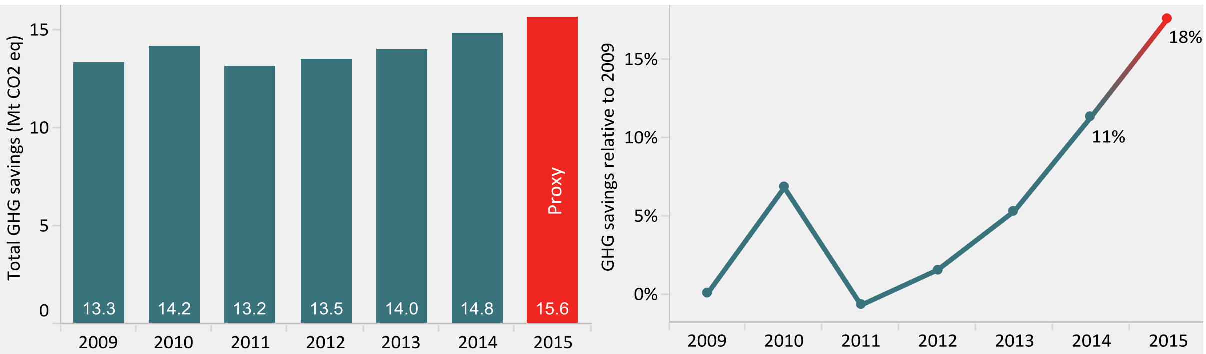



## 9.27.2 GHG emission savings: role of renewables

Overall GHG emissions savings in Sweden from the use of renewable energy in three sectors — electricity, heating/cooling and transport — rose by 11 % (or 1.5 Mt $CO_2$-eq.) over 2009-2014, reaching 14.8 Mt $CO_2$-eq. In per capita terms GHG emissions ranged from 1.4 to 1.5 t $CO_2$-eq.

Figure 189 illustrates the trend in GHG emissions savings from renewable energy use in Sweden over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 189.** Trend in GHG emission savings from RES in SE (left) — Change relative to 2009 (right)




Renewable energy in the heating/cooling sector was the main contributor to overall GHG emissions savings in Sweden between 2009 and 2014. Its absolute contribution remained almost unchanged over this period but its share decreased from 82.7 % to 74.3 %. This contribution was estimated at 72.4 % in 2015. The contribution of renewable electricity decreased slightly over the years, from 11.3 % in 2009 to 10.1 % in 2014 and 2015 alike. The contribution from savings from biofuels in the transport sector more than doubled, from 6.0 % in 2009 to 15.5 % in 2014. This contribution was estimated to have reached 17.6 % in 2015.

**Figure 190.** Breakdown of GHG savings from renewables in SE, 2009-2014 and 2015 (proxy)

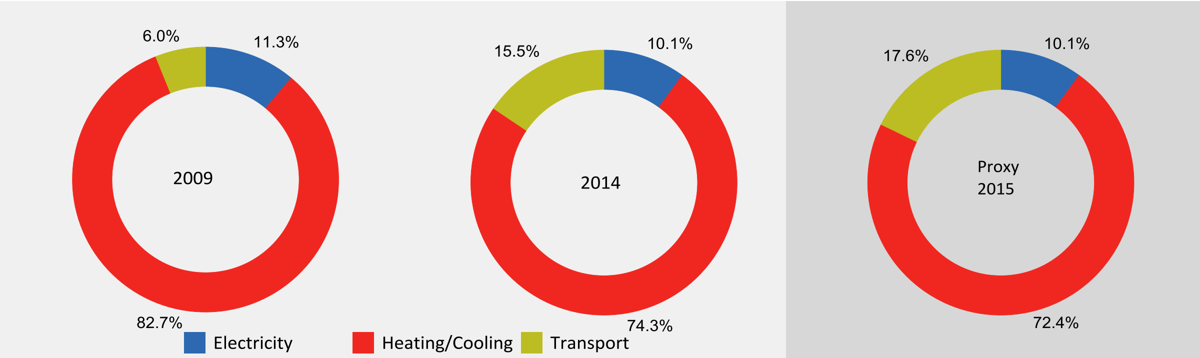



Table 33 shows how the deployment of renewable energy in Sweden has helped to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 33.** Emissions reduction in SE through the use of renewables, 2009-2014 and 2015 (proxy)

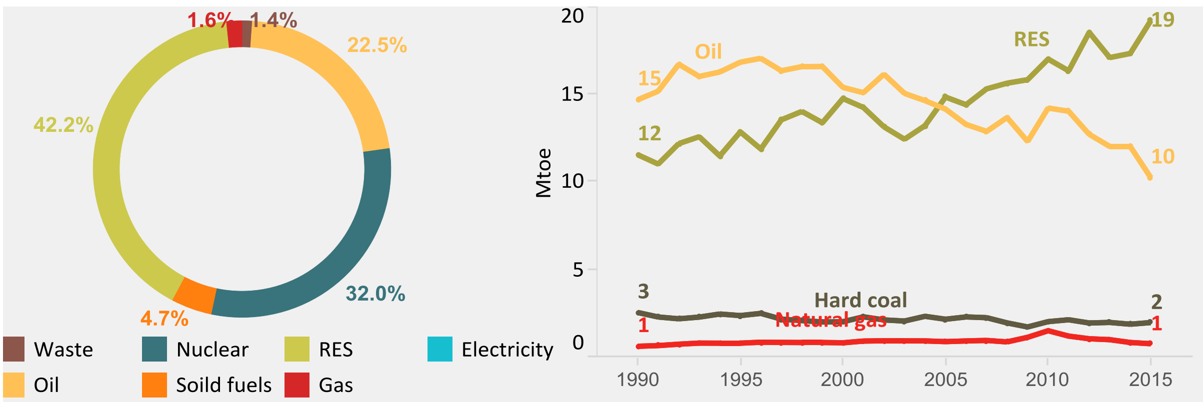
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 18.0 | 17.6 | 17.4 | 18.5 | 19.5 | 20.9 | 21.9 |
| GHG (E+Tr) emissions reduction (%) | 23.1 | 22.7 | 22.9 | 24.3 | 25.7 | 27.5 | 28.6 |
| GHG (P+H) emissions reduction (%) | 35.6 | 32.2 | 35.9 | 40.9 | 38.4 | 42.8 | 48.6 |
| GHG (Tr) emissions reduction (%) | 3.8 | 4.2 | 4.8 | 5.0 | 9.4 | 11.2 | 13.1 |

Without the current deployment of renewable energy, GHG emissions in Sweden would have been 18 % higher in 2009, 20.9 % higher in 2014 and 21.9 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 23.1 % in 2009 to 27.5 % in 2014 and 28.6 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 35.6 % in 2009 to 42.8 % in 2014 and 48.6 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport reached 3.8 % in 2009, 11.2 % in 2014 and 13.1 % in 2015.

## 9.27.3 Fossil fuels displacement: role of renewables

The features of the energy mix in Sweden include a higher share of renewables. In 2015 only 7 % of Sweden's gross inland consumption of energy was met by fossil fuels. Sweden's import dependency rate was 30 % in 2015 remaining high for solid fuels (92.3 %), gas (99.1 %) and petroleum products (105.4 %). The role of renewables became more prevalent after 2005 when it overtook the gross inland consumption of each fossil fuel. Over period 1990-2015 the role of renewables expanded by 66 %. This deployment served to displace fossil fuels — by as much as 7.6 Mtoe by 2015. Almost 32 % of this displacement took place in the electricity sector (2.4 Mtoe).

**Figure 191.** Breakdown of gross inland consumption in Sweden, 2015 (left) — trend over 1990-2015 (right)



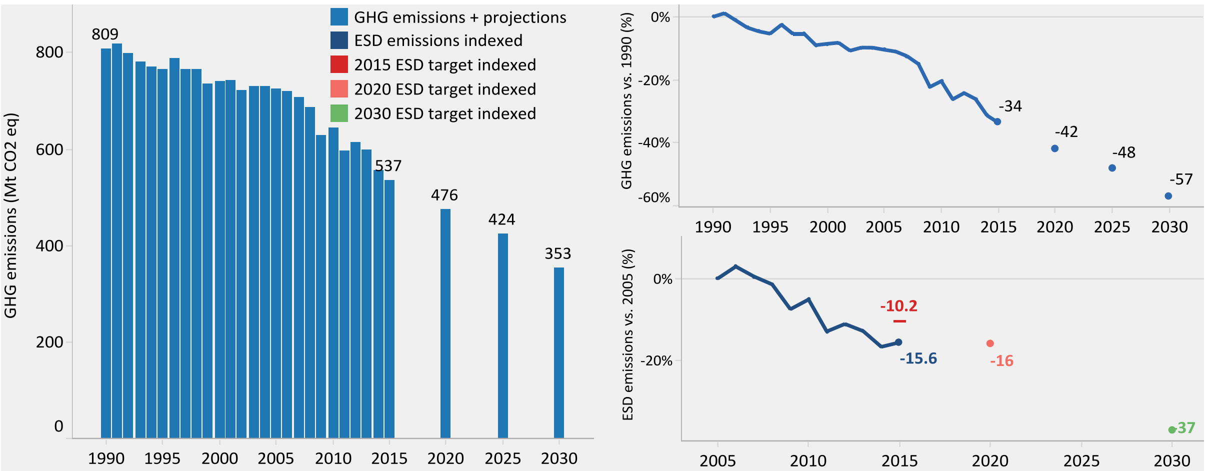
## 9.28 United Kingdom

### 9.28.1 GHG emissions: trends & projections

In 2015, the UK emitted 398.5 Mt $CO_2$, a fall of 31.3 % (18.2 Mt $CO_2$) in comparison with its $CO_2$ emissions in 1990. In the same year, GHG emissions covered by the ESD scheme reached 328.7 Mt $CO_2$-eq., 6 % (21 Mt $CO_2$-eq.) **below the ESD target**[75]. Total GHG emissions in the UK were 537 Mt $CO_2$-eq. in 2015, or 34 % below the 1990 figure. Under the EUCO27 scenario, by 2020 and 2030 the GHG emissions in the UK are projected to fall below the 1990 level by 42 % and 57 % respectively.

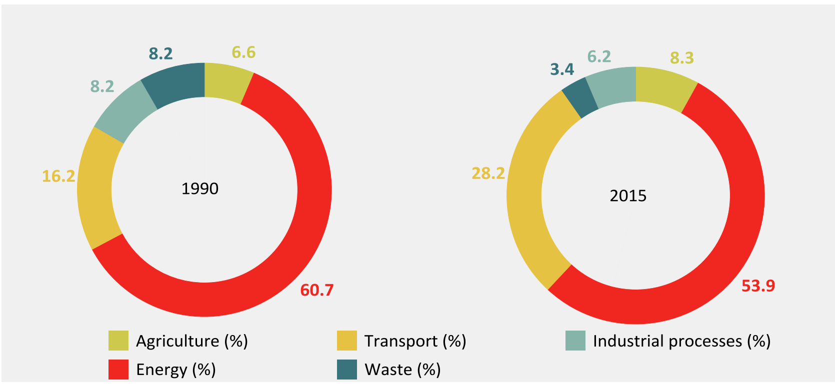
Figure 192 illustrates (i) the overall trend in GHG emissions in the UK over 1990-2015; (ii) the projected GHG emissions under the EUCO27 scenario until 2030; (iii) the relative changes in GHG emissions as compared with 1990; (iv) the relative changes in ESD GHG emissions as compared with 2005, the base year; and (v) the 2020 and 2030 ESD targets.

**Figure 192.** GHG emissions in UK, (1990-2015), targets and projections — Relative change vs 1990




Energy-related GHG emissions have remained the main source of total GHG emissions in the UK since 1990. They totalled 289.4 Mt $CO_2$-eq. in 2015, a fall of 41 % in comparison with the 1990 figure. The GHG emissions from the transport sector reached 151.2 Mt $CO_2$-eq. in 2015, 15 % above the 1990 figure, keeping the second place among sources of GHG emissions. The relative share rose from 16.2 % in 1990 to 28.2 % in 2015.

**Figure 193.** GHG emissions in the UK broken down by source, 1990 (left) — 2015 (right)

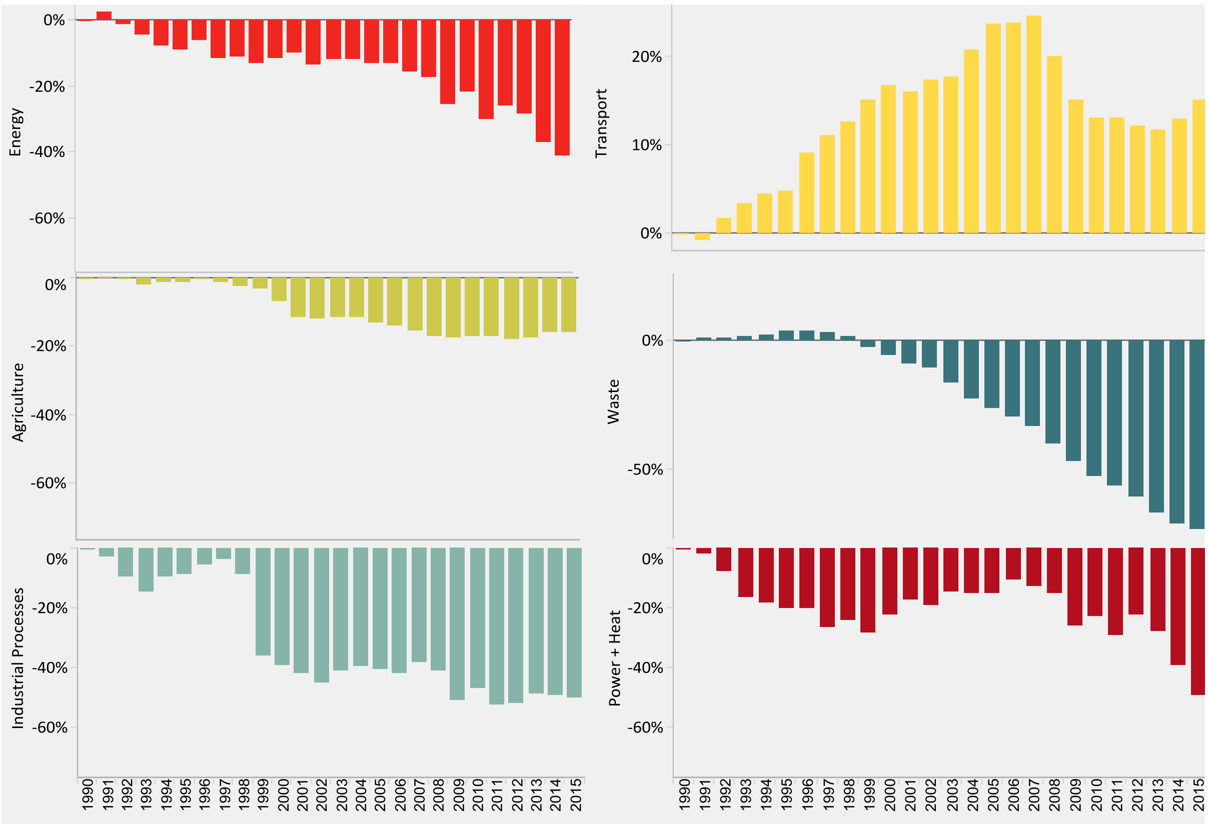



Some sectors in the UK, such as waste management, did not see a fall in their GHG emissions immediately after 1990. The emissions from this sector started to fall after 1999. They totalled 18.7 Mt $CO_2$-eq. in 2015, a fall of 72.7 % in comparison with the 1990 figure. The GHG emissions from industrial processes and product use came to 33.5 Mt $CO_2$-eq. in 2015, 49.7 % below the 1990 level. The GHG emissions from agriculture totalled 44.6 Mt $CO_2$-eq. in 2015, 16 % below the 1990 level. The GHG emissions from public power and heat production stood at 104 Mt $CO_2$-eq. in

(75) UK's ESD target for 2015 was 349.7 Mt CO2-eq. The target for 2020 is set to 327.1 Mt $CO_2$-eq.

2015, a fall of 49 % from the 1990 figure. They accounted for 36 % of energy-related GHG emissions in that year.

**Figure 194.** Changes of GHG emissions from sectors relative to 1990 — UK

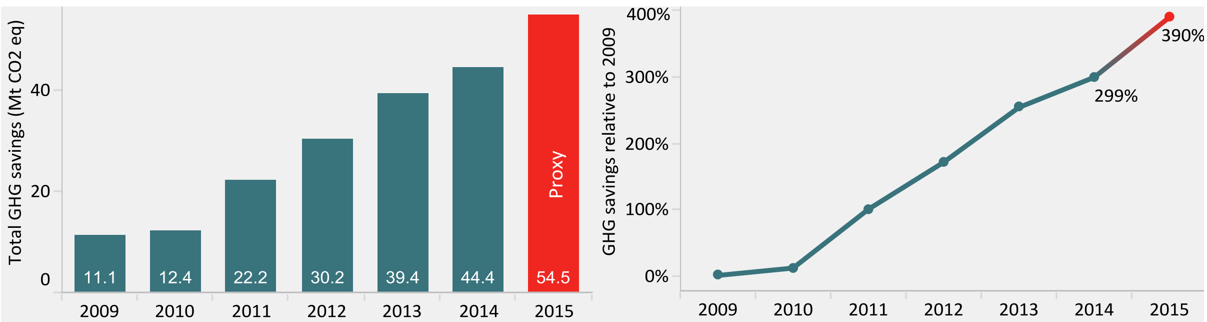



## 9.28.2 GHG emissions savings: role of renewables

Overall GHG emissions savings in the UK from the use of renewable energy in three sectors — electricity, heating/cooling and transport —rose by 90 % (+5.4 Mt $CO_2$-eq.) during the period 2009-2014 reaching 11.4 Mt $CO_2$-eq. In per capita terms GHG emissions almost doubled from 0.56 t $CO_2$-eq. to 1 t $CO_2$-eq.

Figure 195 illustrates the trend in GHG emissions savings from renewable energy use in the UK over 2009-2014 and the estimated GHG emissions savings for 2015.

**Figure 195.** Trend in GHG emissions savings from RES in UK (left) — Change relative to 2009 (right)




Renewable electricity was the main contributor to overall GHG emissions savings in the UK [76] between 2009 and 2014, increasing from 83.4 % to 93.4 %. In absolute terms this contribution increased by 346 % (32.2 Mt $CO_2$-eq.). This contribution was estimated at 95.7 % in 2015. The contribution from savings from biofuels in the transport sector decreased from 16.4 % in 2009 to 6.6 % in 2014. In absolute terms their contribution increased by 61 % (1.1 Mt $CO_2$-eq.). A contribution of 4.3 % was estimated for 2015.

([76]) UK did not report on GHG emissions savings from the use of renewables in the heating/cooling sector.

**Figure 196.** Breakdown of GHG savings from renewables in UK, 2009-2014 and 2015 (proxy)

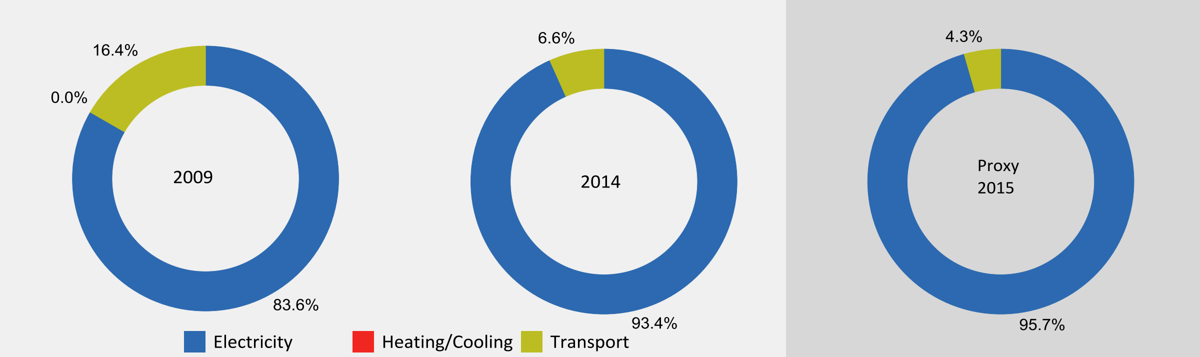



Table 34 shows how the deployment of renewable energy in the UK has helped it to curb: (i) its total GHG emissions; (ii) its GHG emissions from energy and transport; (iii) its GHG emissions from power and heat; and (iv) its GHG emissions from transport.

**Table 34.** Emissions reduction in UK through the use of renewables, 2009-2014 and 2015 (proxy)

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| GHG emissions reduction (%) | 1.7 | 1.9 | 3.6 | 4.7 | 6.2 | 7.4 | 9.2 |
| GHG (E+Tr) emissions reduction (%) | 2.2 | 2.4 | 4.6 | 5.9 | 7.8 | 9.5 | 11.8 |
| GHG (P+H) emissions reduction (%) | 5.8 | 6.2 | 12.2 | 15.1 | 19.9 | 25.0 | 33.4 |
| GHG (Tr) emissions reduction (%) | 1.5 | 1.6 | 1.9 | 1.7 | 2.2 | 2.5 | 2.0 |

Without the current deployment of renewable energy, GHG emissions in the UK would have been 1.7 % higher in 2009, 7.4 % higher in 2014 and 9.2 % higher in 2015. The reduction of GHG emissions in the energy sector (including transport) from the deployment of renewable energy rose from 2.2 % in 2009 to 9.5 % in 2014 and 11.8 % in 2015. Over the same period emissions from power and heat recorded the largest falls from the deployment of renewable energy sources in the electricity and heating/cooling sectors, from 5.8 % in 2009 to 25 % in 2014 and 33.4 % in 2015. The contribution of biofuels to the reduction of GHG emissions from transport reached 1.5 % in 2009, 2.5 % in 2014 and 2.0 % in 2015.

## 9.28.3 Fossil fuels displacement: role of renewables

The features of the energy mix in the UK include a higher share of petroleum products and gas and a lower share of renewables. In 2015 more than 81 % of the UK's gross inland consumption of energy was met by fossil fuels. The UK's import dependency rate was 37.4 % in 2015 remaining relatively high for solid fuels (65.4 %) and gas (41.8 %). The role of renewables became more prevalent around 2005 and by 2015 it had achieved the fastest expansion, at 445 %. This deployment served to displace fossil fuels — by as much as 13.7 Mtoe by 2015. Almost 50 % of this displacement took place in the electricity sector (6.7 Mtoe); the main fossil fuel displaced was hard coal.

**Figure 197.** Breakdown of gross inland consumption in UK, 2015 (left) — trend over 1990-2015 (right)

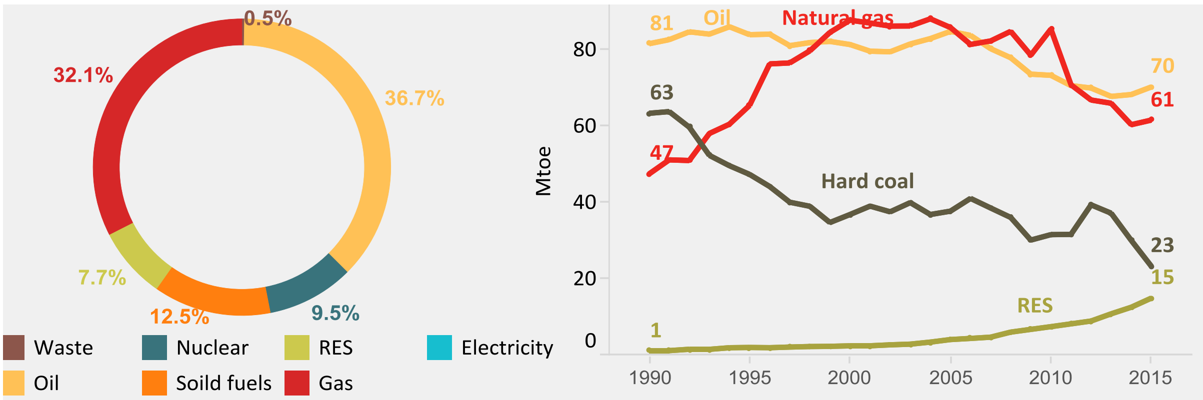


**Figure 198.** GHG emission savings in the EU countries, 2014

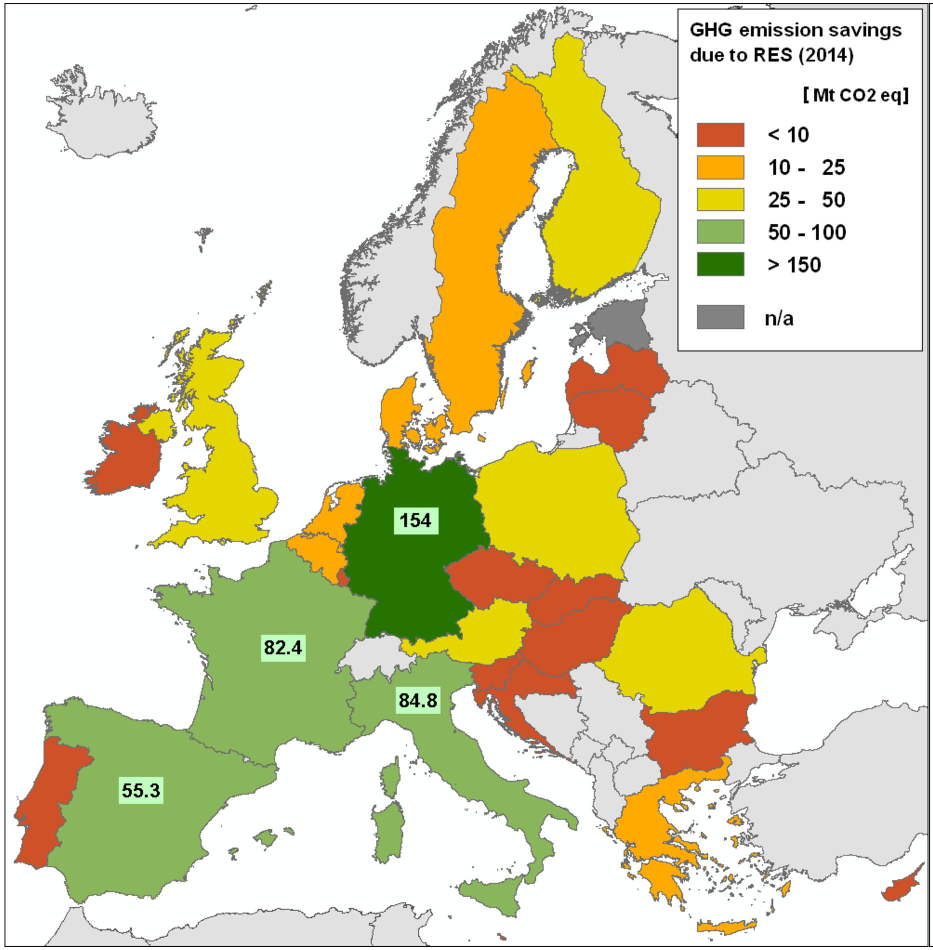



**Figure 199.** EU countries contribution in the total GHG emission savings from RES, 2014

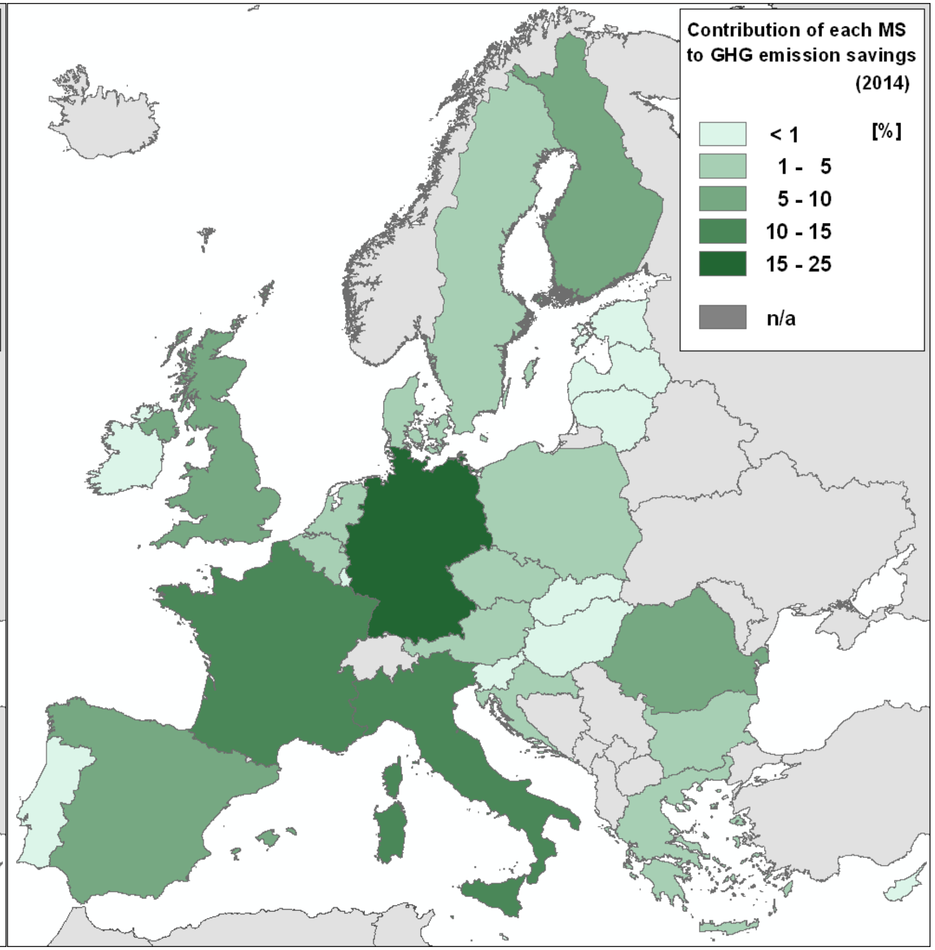


**Figure 200.** GHG emission savings in the EU countries electricity sector, 2014

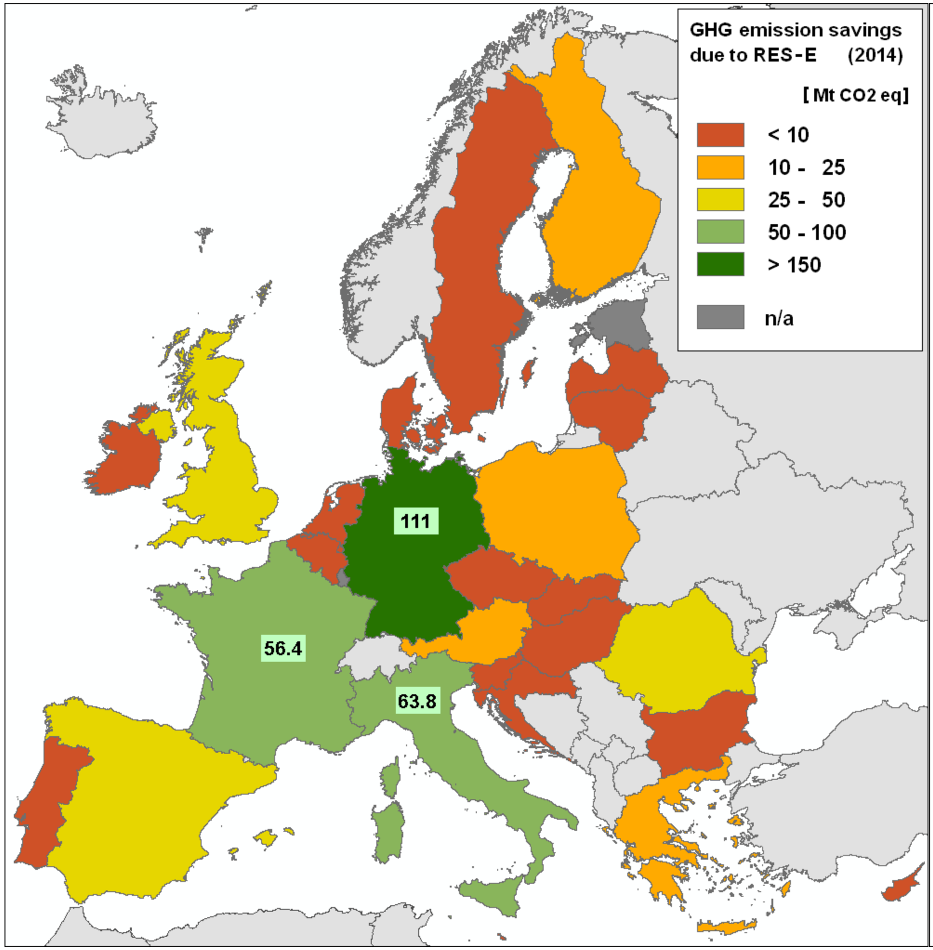



**Figure 201.** EU countries contribution in GHG emission savings from RES-E, 2014

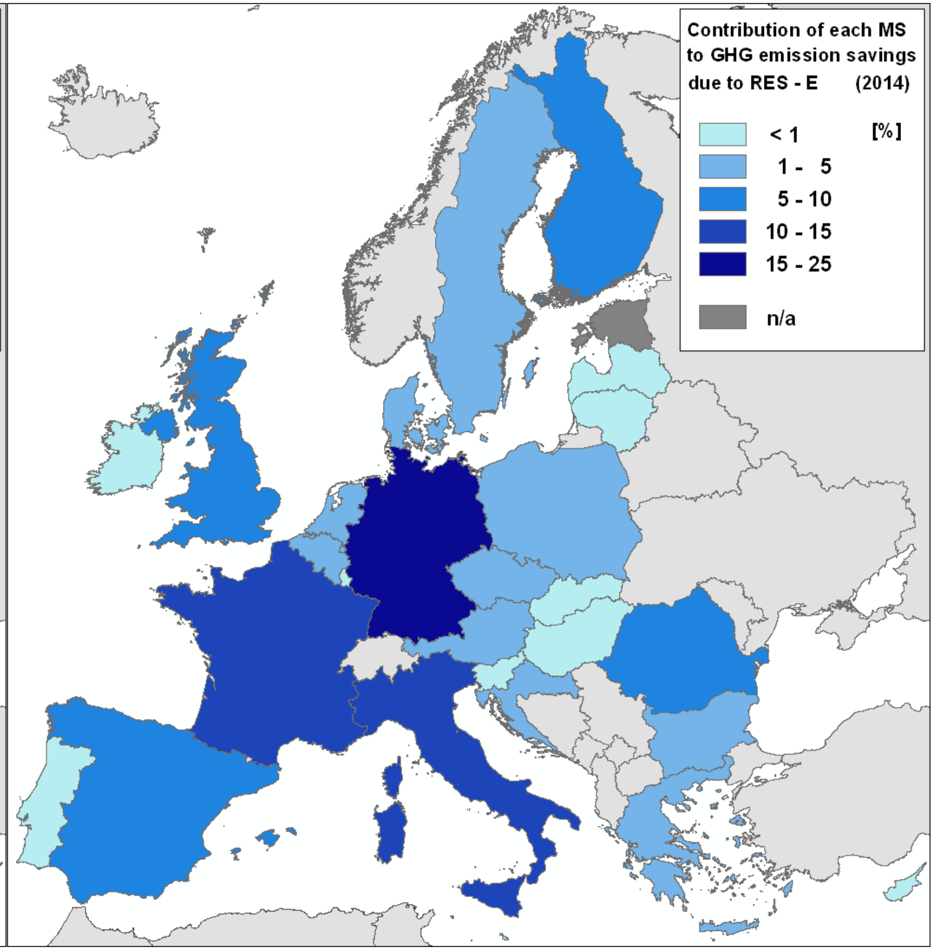


**Figure 202.** GHG emission savings in the EU countries heating/cooling sector, 2014

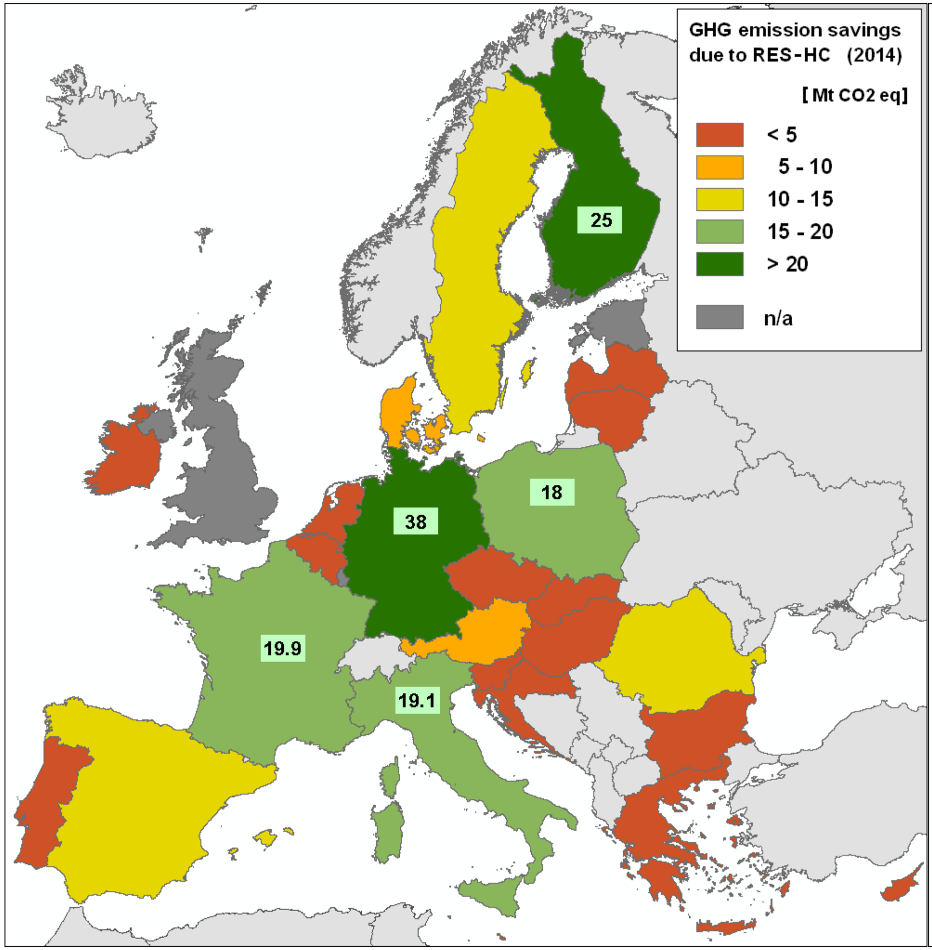



**Figure 203.** EU countries contribution in the GHG emissions savings from RES-HC, 2014

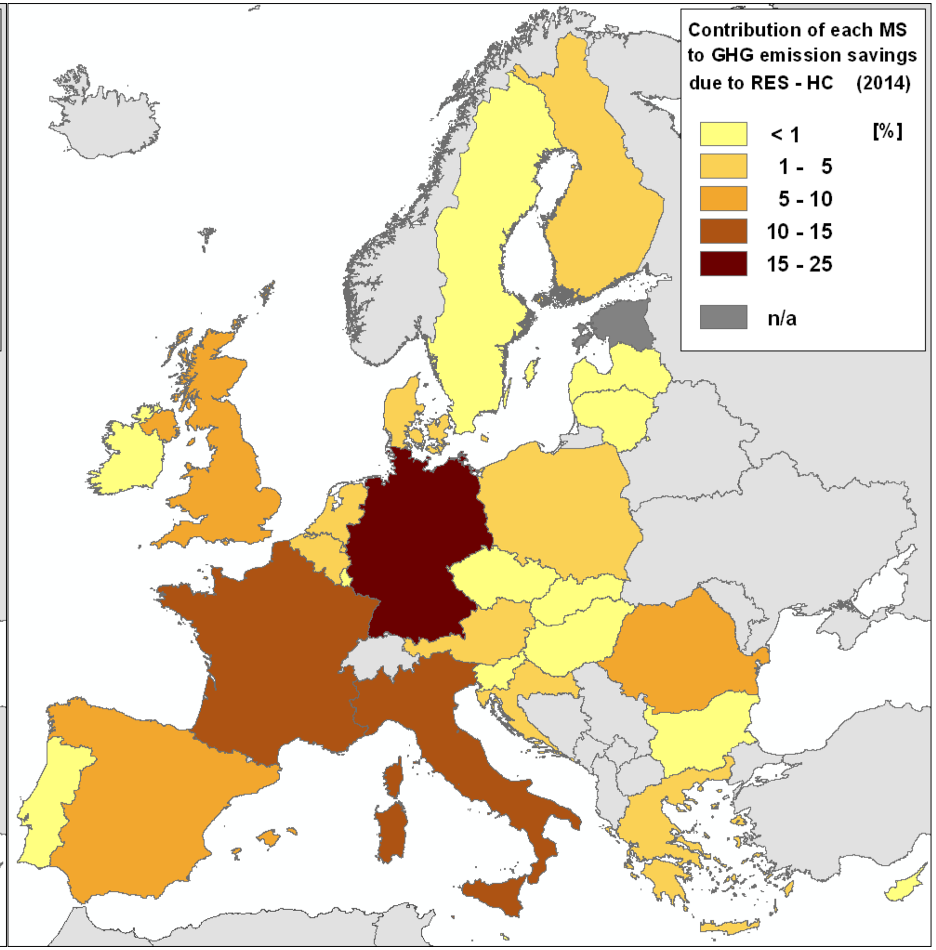


**Figure 204.** GHG emission savings in the EU countries transport sector, 2014

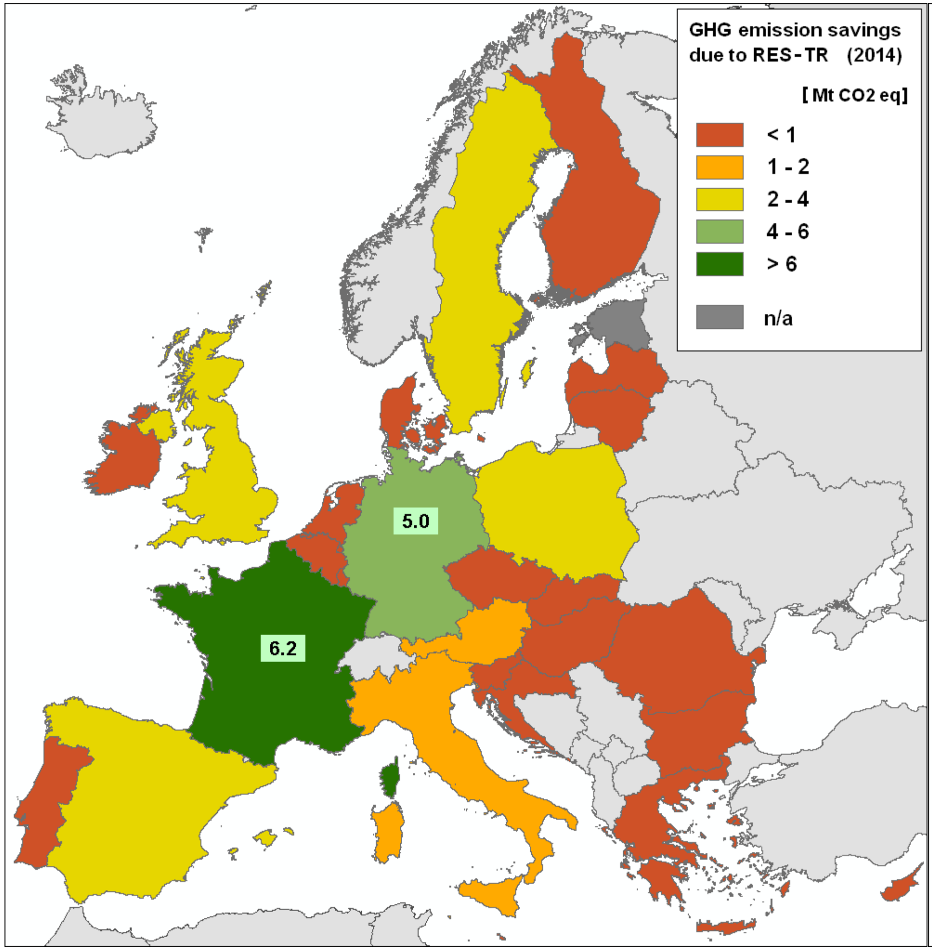
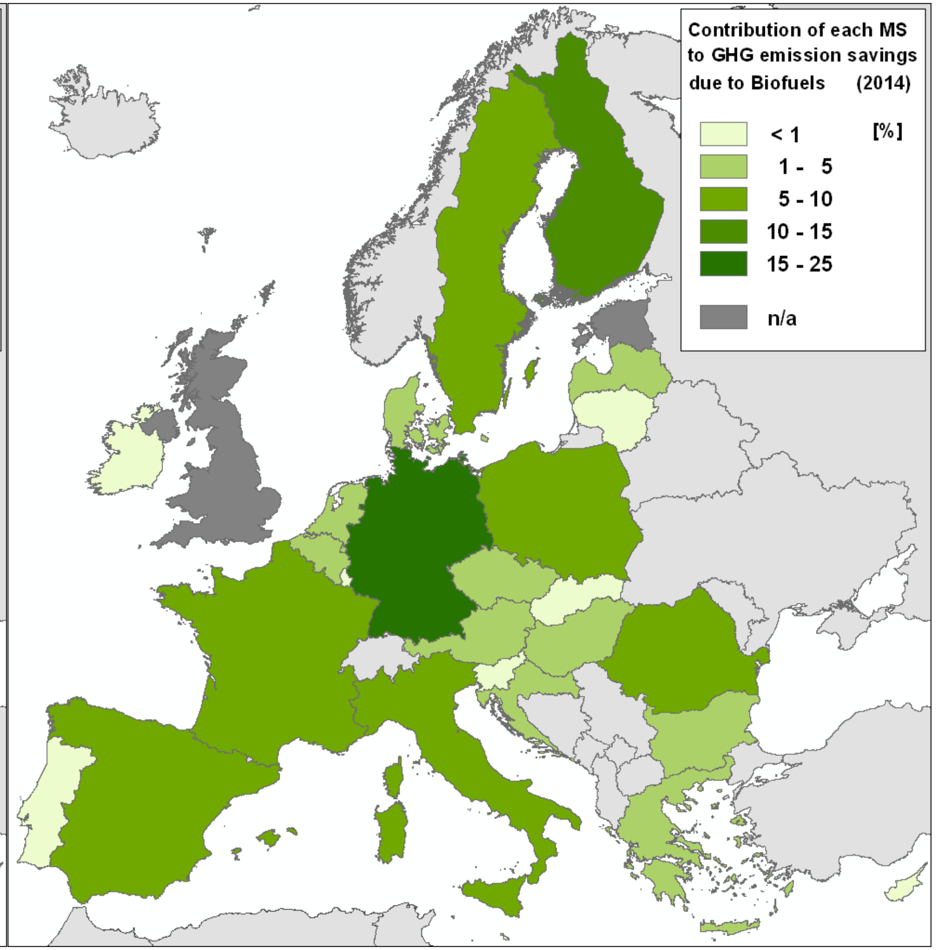



**Figure 205.** EU countries contribution in the GHG emission savings from biofuels, 2014



# References


[1]. Conclusions on 2030 Climate and Energy Policy Framework https://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145356.pdf

[2]. Clean Energy for All Europeans COM (2016) 860

http://eur-lex.europa.eu/resource.html?uri=cellar:fa6ea15b-b7b0-11e6-9e3c 01aa75ed71a1.0001.02/DOC_1&format=PDF

[3]. Trends in global $CO_2$ emissions: 2016 JRC Science for Policy Report, 103428, http://edgar.jrc.ec.europa.eu/news_docs/jrc-2016-trends-in-global-co2-emissions-2016-report-103425.pdf

[4]. EEA, 2017, "Trends and projections in Europe 2016 - Tracking progress towards Europe's climate and energy targets", http://www.eea.europa.eu/themes/climate/trends-and-projections-in-europe

[5]. EUCO27 scenario - https://ec.europa.eu/energy/en/data-analysis/energy-modelling

[6].Renewable energy progress reports, http://ec.europa.eu/energy/en/topics/renewable-energy/progress-reports

[7]. National Renewable Energy Action Plans (NREAPs) https://ec.europa.eu/energy/en/topics/renewable-energy/national-action-plans

[8]. Szabó M., Jäger-Waldau A., Monforti-Ferrario F., Scarlat N., Bloem H., Quicheron M.,

Huld Th., Ossenbrink H., "Technical assessment of the renewable energy action plans 2011", EUR 24926 EN, http://iet.jrc.ec.europa.eu/remea/technical-assessment-renewable-energy-action-plans-2011

[9]. Banja M., Scarlat N., Monforti-Ferrario F., "Review of technical assessment of national renewable energy action plans", 2013, EUR 25757 EN, http://iet.jrc.ec.europa.eu/remea/sites/remea/files/national-renewable-energy-action-plans.pdf

[10]. Banja M., Scarlat N., Monforti-Ferrario F., "Renewable energy development in EU-27 (2009-2010)", (2013), EUR 26166 EN, http://iet.jrc.ec.europa.eu/remea/sites/remea/files/reqno_jrc84626_online_final.pdf

[11]. Scarlat N., Banja M., Monforti-Ferrario F., Dallemand JF., (2013) "Snapshots of renewable energy developments in European Union. Status in 2010 and progress in comparison with national renewable energy action plans", EUR 26338 EN http://iet.jrc.ec.europa.eu/remea/sites/remea/files/reqno_jrc85377_snapshots_res_final_print.pdf

[12]. Banja M., Scarlat N., Monforti-Ferrario F., Dallemand JF., "Renewable energy progress in EU-27 (2005-2020)", (2013), EUR 26481 EN,

http://iet.jrc.ec.europa.eu/remea/renewable-energy-progress-eu-27-2005-2020

[13]. Banja M., Monforti-Ferrario F., Scarlat N., Dallemand JF., Ossenbrink H., Motola V., "Snapshots of renewable energy developments in the EU-28, Volume 2. Current status and progress in comparison with National Renewable Energy Action Plans", (2015), EUR 27182 EN http://iet.jrc.ec.europa.eu/remea/snapshot-renewable-energy-development-eu-28-volume-2

[14]. Banja M., Monforti-Ferrario F., Bódis K., Motola V., Ossenbrink H., (2015), "Renewable Energy in Europe for Climate Change Mitigation", EUR 24253 EN, http://iet.jrc.ec.europa.eu/remea/renewable-energy-europe-climate-change-mitigation-ghg-emission-savings-due-renewable-energy-2009-12

[15]. Banja M., Monforti-Ferrario F., Bódis K., (2015), "Renewable energy technologies/sources path within EU 2020 strategy, EUR 27447 EN

http://iet.jrc.ec.europa.eu/remea/renewable-energy-technologiessources-path-within-eu-2020-strategy

[16]. Banja M, Monforti-Ferrario F, Bódis K, Jäger Waldau A, Taylor N, Scarlat N, Dallemand JF, (2017), Renewable energy in the European Union - Renewable energy in the EU further to Renewable Energy Directive reporting – Volume 3", JRC Science for Policy Report, EUR 28512 EN http://skp.jrc.cec.eu.int/skp/publications/showList?&instituteId=3415&categoryId=10020

[17]. 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 and amending and subsequently reapealing Directives 2001/77/EC and 2003/30/EC

http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN

[18]. UN Climate Change Conference Paris 2015, http://www.un.org/sustainabledevelopment/cop21/

[19]. The Paris Agreement 2015, http://unfccc.int/paris_agreement/items/9485.php

[20]. International Energy Agency, 2015, "Energy and Climate Change – World Energy Outlook Special Report", https://www.iea.org/publications/freepublications/publication/WEO2015SpecialReportonEnergyandClimateChange.pdf

[21]. World Resources Institute, Paris Agreement Tracker http://www.wri.org/faqs-about-how-paris-agreement-enters-force

[22] Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC to enhance cost-effective emission reductions and low carbon investments COM (2015) 337

https://ec.europa.eu/transparency/regdoc/rep/1/2015/EN/1-2015-337-EN-F2-1.PDF

[23]. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: "Accelerating Europe's transition to a low-carbon economy" COM (2016) 500 https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/1-2016-500-EN-F1-1.PDF

[24]. A Roadmap for moving to a competitive low carbon economy in 2050, COM(2011) 112 final, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0112&from=en

[25]. The EU Emissions Trading System (EU ETS), https://ec.europa.eu/clima/policies/ets_en

[26]. Decision No 406/2009/EC of the European Parliament and of the Council " 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", 23 April 2009, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009D0406&from=EN

[27]. 2020 EU Climate and Energy Package, https://ec.europa.eu/clima/policies/strategies/2020_en#tab-0-0

[28]. 2030 Climate and Energy Policy Framework, EUCO 169/14, http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145397.pdf

[29]. The EU Emissions Trading System (EU ETS) Factsheet, https://ec.europa.eu/clima/sites/clima/files/factsheet_ets_en.pdf

[30]. Clean Energy for All Europeans COM (2016) 860, http://eur-lex.europa.eu/resource.html?uri=cellar:fa6ea15b-b7b0-11e6-9e3c01aa75ed71a1.0001.02/DOC_1&format=PDF

[31]. IPCC 2014, *Climate Change 2014: Mitigation of Climate Change. Contribution of WorkingGroup III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[32]. "The state of European Cities 2016 - Cities leading the way to a better future", EC, UN HABITAT, http://ec.europa.eu/regional_policy/en/information/publications/reports/2016/state-of-european-cities-report-2016

[33]. C. Rosenzweig, W. Solecki, S. A. Hammer, and S. Mehrotra, "Cities lead the way in climate-change action," *Nat. Comment*, vol. 467, pp. 909–911, 2010

[34]. C. Rosenzweig, W. Solecki, P. Romero-Lankao, S. Mehrotra, S. Dhakal, T. Bowman, and S. Ali Ibrahim, "ARC3.2 Summary for City Leaders," New York, 2015

[35]. "An EU Strategy on adaptation to climate change", COM /2013/ 216 http://ec.europa.eu/transparency/regdoc/rep/1/2013/EN/1-2013-216-EN-F1-1.Pdf

[36]. Kona A, Melica A, Iancu A, Koffi B, Zancanella P, Rivas Calvete S, Bertoldi P, Janssens-Maenhout G, and Monforti-Ferrario F, "Covenant of Mayors: Greenhouse Gas Emissions Achievements and Projections." EUR 28155 EN. Publications Office of the European Union, 2016, Luxembourg:, 2016 https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/covenant-mayors-greenhouse-gas-emissions-achievements-and-projections

[37]. Kona A, Melica G, Bertoldi P, Rivas Calvete S, Zancanella P, Koffi B, Iancu A, Janssens-Maenhout G, Dallemand JF. "Covenant of Mayors in Figures: 8-year Assessment". EUR 28723 EN. Luxembourg: Publications Office of the European Union, 2017; doi: 10.2760/64731 http://publications.jrc.ec.europa.eu/repository/bitstream/JRC106725/kjna28723enn.pdf

[38]. Climate Analytics (2017). A stress test for coal in Europe under the Paris Agreement, www.climateanalytics.org/publications

[39]. Energy prices and costs in Europe, Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM (2016) 769, http://ec.europa.eu/energy/sites/ener/files/documents/com_2016_769.en_.pdf

[40]. Global Trends in Renewable Energy Investment 2016, Frankfurt School-UNEP Centre/BNEF, http://fs-unep-centre.org/publications/global-trends-renewable-energy-investment-2016

[41]. Global Trends in Renewable Energy Investment 2017, Frankfurt School-UNEP Centre/BNEF, http://fs-unep-centre.org/publications/global-trends-renewable-energy-investment-2017

[42]. Quarterly report on European gas markets, Volume 9 - Directorate-General for Energy, Market Observatory for Energy, 2016, https://ec.europa.eu/energy/en/data-analysis/market-analysis

[43]. Quarterly report on European electricity markets, Volume 9 - Directorate-General for Energy, Market Observatory for Energy, 2016, https://ec.europa.eu/energy/en/data-analysis/market-analysis

[44]. Foster E. et al, 2016, "Challenges for Widespread Renewable Energy Deployment: Fossil Fuel Price Responses" https://www.kapsarc.org/wp-content/uploads/2016/05/KS-1640-DP034A-Challenges-for-Widespread-Renewable-Energy-Deployment-Fossil-Fuel-Price-Responses-.pdf

[45]. BP Statistical Review of World Energy June 2017, https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf

[46]. European energy industry investments, 2017- http://www.europarl.europa.eu/studies

[47]. "Projected cost of generating electricity", 2015, IEA, NEA, OECD, https://www.iea.org/publications/freepublications/publication/projected-costs-of-generating-electricity-2015-edition.html

[48]. H2 2016 Global LCOE outlook – Bloomberg NEF 2016

[49]. IRENA (2016), "The Power to Change: Solar and Wind Cost Reduction Potential to 2025", http://www.irena.org/DocumentDownloads/Publications/IRENA_Power_to_Change_2016.pdf

[50]. Agora Energiewende and Sandbag (2017): Energy Transition in the Power Sector in Europe: State of Affairs in 2016. Review on the Developments in 2016 and Outlook on 2017, https://www.agora-energiewende.de/fileadmin/Projekte/2017/EU_Jahresauswertung_2016/Agora_State_of_Affairs_EU_2016_WEB.pdf

[51]. Report from the Commission to the Council and the European Parliament on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling (COM(2010) 11. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0011:FIN:EN:PDF.

## List of abbreviations

COP – Conference of Parties

EDGAR - Emission Database for Global Atmospheric Research

EEA – European Environment Agency

ESD – Emissions Sharing Decision

ETS - Emissions Trading System

GIC – Gross Inland Consumption

GHG - Greenhouse Gas

H/C - Heating/Cooling sector

Ktoe – kilo tonnes of oil equivalent

Mtoe – Million tonnes of oil equivalent

MS - Member States

NREAPs - National Renewable Energy Action Plans

PR - Progress reports of renewable energy

PV - Solar photovoltaic

PJ - Petajoule

RED – Directive 2009/28/EC on renewable energy

RES - Renewable Energy Sources

RES-H/C – Renewable Energy Sources in the Heating/Cooling sector

RES-E - Renewable Energy Sources in the Electricity sector

RES-T - Renewable Energy Sources in the Transport sector

UNFCCC - United Nations Framework Convention on Climate Change

## Units

1 Mtoe = 41.868 PJ = 11.63 TWh

1 ktoe = 41.868 TJ = 11.63 GWh

1 PJ = 0.278 TWh = 0.024 Mtoe

1 TWh = 3.6 PJ = 0.086 Mtoe

1 TJ = 277.8 MWh

## List of boxes

## List of figures

# List of tables

# Annex

## Description of Member States methodology applied to calculate the GHG emission savings due to the use of renewable energy

According to Article 22 (1) (k) of Renewable Energy Directive (RED) each Member State should report on the estimated net GHG emission savings due to the use of renewable energy sources in its territory. While no methodology is suggested for estimating GHG savings arising from wind, solar, hydro, geothermal and tidal/waves sources, in the case of biomass, biofuels and bioliquids some standard methodologies are suggested in the RED.

In the case of greenhouse gas performance of solid and gaseous biomass used in electricity and heating/cooling sectors the suggested methodology is provided in the report on sustainability requirements of solid biomass and biogas used in electricity and heating/cooling sectors [51] briefly referred hereafter as "COM (2010) 11 methodology".

In the case of biofuels and bioliquids in the transport sector, Articles 17, 18, 19, 21 and Annex III and V of RED establish both a sustainability scheme and rules for the calculation of the biofuels impact on GHG emission savings, briefly referred hereafter as "Annex V methodology".

If a Member State chooses not to use the suggested RED methodology, it should describe what other methodology has been used to estimate these savings. Most Member States decided to develop and apply their own methodology for the calculation of biomass related net GHG emission savings in electricity (18 Member States out of 28) and heating/cooling (16 out of 28) sectors. In the case of biofuels, only 12 Member States developed a different methodology of what was suggested in the RED.

One Member State (Sweden) applied both methodologies (own methodology and suggested RED methodology) and therefore reported two values for one sector. In such cases, the analysis for Sweden presented in this report used the methodology recommended by the RED.

In several cases, the Member States did not report which methodology they applied: seven Member States did not report the methodology applied for electricity, heating/cooling and eight Member States did not report the methodology applied for biofuels.

Table A-1 shows which Member States followed the recommendations of the RED in order to calculate the biomass related GHG emission saving and whether they applied a different method. The table shows whether a description of the Member State's methodology was made available in the progress reports, as required.

The following section provides a short description of the methodologies applied by each Member State to calculate their net GHG emission savings in electricity, heating/cooling and transport as reported in their biennial progress reports, where such methodologies were made available.

The editing of this report includes also the description of methodologies used by each Member State to calculate the net GHG emission savings from the use of renewable energy in electricity, heating/cooling and transport sectors. Nevertheless these methodologies remained the Member States original one and authors cannot take any responsibility for the content of these descriptions.

Table A- 1 Member State methodologies applied to calculate the net GHG emission savings from RE

| | ELECTRICITY | | HEATING/COOLING | | TRANSPORT | | DESCRIPTION | | |
|---|---|---|---|---|---|---|---|---|---|
| | COM(2010) 11 | MS METHOD | COM(2010) 1 1 | MS METHOD | ANNEX V | MS METHOD | 1st PR | 2nd PR | 3rd PR |
| BE | √ | | √ | | √ | | N | N | N |
| BG | | √ | √ | | √ | | Y | Y | Y |
| CZ | | | | | | | N | N | N |
| DK | | √ | | √ | | √ | Y | Y | N |
| DE | | √ | | √ | | √ | N | N | N |
| EE | | | | | | | Y/N | N | Y/N |
| IE | | √ | | √ | | √ | Y | Y | Y |
| EL | | √ | | √ | √ | | Y | Y | Y |
| ES | | | | | | | N | N | N |
| FR | | √ | | √ | | √ | Y | Y | Y |
| HR | | √ | | √ | | √ | n.a | Y/N | Y/N |
| IT | | √ | | √ | | √ | Y | Y | Y |
| CY | | √ | | √ | √ | | Y | Y | Y |
| LV | | √ | √ | | √ | | Y | Y | Y |
| LT | | | | | | | N | N | N |
| LU | | √ | | √ | | √ | N | N | N |
| HU | √ | | √ | | √ | | Y | Y | Y |
| MT | | | | | | | N | N | Y |
| NL | | √ | | √ | | √ | N/Y | Y | Y |
| AT | | √ | | √ | | √ | N | N | N |
| PL | √ | | √ | | √ | | Y | Y | Y |
| PT | | √ | | √ | | √ | Y/N | Y/N | Y/N |
| RO | | √ | | √ | | √ | N | Y | Y |
| SI | | | | | | | N | N | N |
| SK | √ | | √ | | √ | | Y/N | Y/N | Y/N |
| FI | | √ | | √ | √ | | Y | Y | Y |
| SE | √ | √ | √ | √ | √ | | Y | Y | Y |
| UK | | √ | | √ | √ | √ | Y/N | Y/N | Y/N |

Y — the methodology is described

N — the methodology is not described

Y/N — the methodology is partially described

## Belgium

Belgium followed fully the methodology suggested in Article 22(2) of the RED applying the typical values from Annex V for transport and data from COM (2010) 11 for heat and cooling and electricity.

## Bulgaria

**Electricity sector**: The net reduction in GHG emissions attributable to the use of electricity from renewable sources were estimated by applying a carbon emission factor for electricity calculated on the basis of the fuel types, their calorific values and their contribution to the annual electricity output in 2013 and 2014. The calculated values for the emission factors for 2013 and 2014 were respectively 0.50658 $tCO_2$-eq./MWh and 0.5423828 $tCO_2$-eq./MWh. Using renewable energies to produce electricity reduced GHG emissions by 3 530 863 $tCO_2$-eq. in 2013 and 3 837 358 $tCO_2$-eq. in 2014. In percentage terms, the savings were 15.80 % in 2013 and 15.13 % in 2014.

**Heating/Cooling sector**: Reductions in GHG emissions attributable to the use of heat/cold from renewable sources (solid and gaseous biomass) were estimated by applying comparative values, validated across the EU, for emissions generated by the use of fossil fuels (fossil fuel comparators) in the production of heat and electricity, as specified in the Report on sustainability requirements for the use of solid and gaseous biomass sources in electricity and heating/cooling. Reductions in GHG emissions attributable to the replacement of fossil fuels with solid biomass in the production of heat/cold are calculated according to the following formula:

$$\textit{Reductions (savings)} = (ECF(h,el,c) - ECF(h,el,c)_{biomass}) / ECF(h,el,c),$$

- $ECF(h,el,c)_{biomass}$ - is the overall emissions value for the generation of a quantity of heat energy, cooling energy or electricity using biomass;

- ECF(h, el,c) - is the overall emissions value for the generation of the relevant quantity of heat energy, cooling energy or electricity based on mineral fuels.

In this case, the recommended value of the fossil fuel comparator is ECF (h,el,c) equal to 87 $gCO_2$-eq./MJ. Traditionally, tree species with a typical default value 1 $gCO_2$-eq./MJ are used as an analogue for biomass in Bulgaria. The comparative calculations were made for two scenarios, each with a different percentage of fossil fuel contribution to the production of heat (as per the table below) in order to estimate the reduction in GHG emissions due to the replacement of these fuels with biomass.

**Table A- 2.** Proportion of fossil fuels used in the overall production of heat

| | 2009 | | 2010 | | 2011 | | 2012 | |
|---|---|---|---|---|---|---|---|---|
| | | % | | % | | % | | % |
| Heating/cooling ($gCO_2$-eq./MJ) | 87 | | 87 | | 87 | | 87 | |
| Biomass ($gCO_2$-eq./MJ) | | 17.16 | | 19.90 | | 24.59 | | 27.21 |
| Electricity ($tCO_2$-eq./MWh) | 0.580 | 9.38 | 0.632 | 9.69 | 0.711 | 13.48 | 0.672 | 16.57 |
| Transport ($gCO_2$-eq./MJ) | 83.8 | n.a | n.a | n.a | n.a | n.a | n.a | n.a |

The percentage reduction of GHG emissions attributable to replacing fossil fuels with biomass in the production of energy for heating/cooling purposes was 28.87 % in 2013 and 27.99 % in 2014.

**Transport sector**: For biofuels, Bulgaria followed the methodology suggested in Annex V to the RED. In 2013 and 2014 there was a tangible increase of the proportion of biofuels in the transport sector compared to previous years, which leads to a considerable reduction in GHG emissions due to the use of renewable sources in transport. There was only negligible growth in the amount of electricity from renewable sources and, therefore, the reductions in GHG emissions were close to the 2011 levels.

## Czech Republic

The Czech Republic did not provide a description of the methodology applied in its first, second and third progress reports.

## Denmark

The calculation of GHG emission savings due to the use of renewable energy in Denmark is based on the following assumptions:

- In the case of renewable energy used for heating, the calculated net saving is 0.065 Mt $CO_2$ per PJ renewable energy used, corresponding to the renewable energy replacing a mixture of natural gas and oil typical of the Danish market;
- In the case of renewable energy used for electricity, it was assumed that electricity generation by wind, water and solar panels displaces 2.4 units of fossil fuel, while one unit of biomass/biogas displaces 1 unit of fossil fuel. It was estimated that the quantity of fuel displaced would have given rise to $CO_2$ emissions of 0.08 Mt per PJ;
- In the case of transport, it was assumed that one unit of biofuel displaces 1 unit of fossil fuel. It was estimated that the displaced quantity of fuel would have produced emissions of 0.0733 Mt $CO_2$/PJ.

No description was provided in the third progress report of Denmark. Due to this only fossil fuels comparators for period 2009-12 are reported in Table A-3.

**Table A- 3.** Comparators used to calculate GHG emission savings in Denmark, 2009-12

| | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|
| Heating/cooling (Mt$CO_2$-eq./PJ) | 0.065 | 0.065 | 0.065 | 0.065 |
| Electricity (Mt$CO_2$-eq./PJ) | 0.08 | 0.08 | 0.08 | 0.08 |
| Transport (Mt$CO_2$-eq./PJ) | 0.0733 | 0.0733 | 0.0733 | 0.0733 |

## Germany

The methodology, data sources used and the technology-specific results for GHG avoidance through renewable energy are described in detail in 2011, 2013 and 2015 reports issued by the German Environment Agency (UBA[77]). The GHG avoidance factors used in the calculations are given only in the German first progress report.

**Table A- 4.** Comparators used to calculate GHG emission savings in Germany, 2009-2010

| Mt $CO_2$-eq./PJ | 2009 | 2010 |
|---|---|---|
| Electricity | | |
| Hydropower | 0.221 | 0.221 |
| Wind power | 0.204 | 0.204 |
| Photovoltaic | 0.189 | 0.189 |
| Biogenic solid fuels | 0.216 | 0.216 |
| Biogenic liquid fuels | 0.167 | 0.167 |
| Biogas | 0.164 | 0.162 |
| Deep geothermal | 0.136 | 0.136 |
| Heating | | |
| Biogenic solid fuels | 0.084 | 0.083 |
| Biogenic liquid fuels | 0.076 | 0.073 |
| Biogas | 0.048 | 0.046 |
| Solar thermal | 0.062 | 0.062 |
| Deep geothermal | 0.018 | 0.018 |
| Heat pumps | 0.023 | 0.023 |
| Transport | | |
| Biodiesel | 0.038 | 0.038 |
| Vegetable oil | 0.049 | 0.049 |
| Bioethanol | 0.040 | 0.040 |

## Estonia

Estonia reported data on GHG emission savings in its first progress report delivered in 2011, but not in its second and third reports. In the first 2011 report, Estonia stated that a detailed calculation of GHG emission savings due to the use of energy from renewable sources had yet to be conducted in compliance with the RED. More specifically, Estonia at that time had has not yet conducted any of the required studies required for developing a method of assessment that takes into account the whole life-cycle (or at least part of it) and under the conditions prevalent in Estonia. For this reason, estimates provided in the 2011 report are based on the amounts of fuel used, their emission factors and data on the amounts of heat and electricity produced. Therefore, Estonia took into account neither the priority order for entering the electricity market with respect

([77]) Emissionsbilanz erneuerbarer Energieträger 2013 - http://www.umweltbundesamt.de/publikationen/emissionsbilanz-erneuerbarer-energietraeger to fossil fuels nor the GHGs emitted during the life-cycle with respect to biomass were taken into account. It is worth noticing that 85% of non-renewable electricity produced in Estonia in 2010 originated from shale oil, a low efficiency resource that resulted very high GHG emissions per unit of electricity produced.

In Estonia, most electricity (85 % in 2010) is produced from shale oil, which emits large quantities of carbon when burnt — the specific emissions as carbon dioxide amount to 99.4 t $CO_2$/TJfuel. As shale oil is also a low-efficiency method of generating electricity, the average specific emissions regarding electricity generated from oil shale are very high: 1085 kg CO2/MWhe. Emissions from shale oil accounted for 94 % of Estonia's total CO2 emissions from electricity generation. The emission factors for shale oil were determined as weighted average factors, taking into account the two combustion methods used: pulverised combustion and circulating fluidised bed combustion. As the proportion of other fuels used to generate electricity was rather small, the overall average specific emissions were high: 980 kg CO2/MWhe; if only fossil fuels were taken into account, the figure would be 1066 kg CO2/MWhe.

In its third progress report stated that the combined emissions margin for the period 2003-2005 was 1.10156 t CO2/MWh. As of 2014, that value was 0.91241 t CO2/MWh. Therefore there has been a noticeable reduction in the quantity of greenhouse gases over that ten-year period. The CO2 emissions margin depends to a large extent on the fuel burning technology and the properties of the fuel in question. Regarding the technical parameters of fuels, there have been consultations with the Balti and Eesti thermal power plants, VKG Energia Põhja Jaam [Northern Station] Iru Power Plant and Sillmaäe Thermal Power Plant. In addition to these plants, three recent CHP plants (Fortum Eesti, Anne Soojus, Tallinna Elektrijaam [Tallinn Power Plant]) that use renewable sources such as chips, sawdust and bark have been included in the calculations. Together these 8 plants made up 98% of total electricity production in the years 2011-2013. To calculate the quantity of emissions, one may use the simple operating margin (OM) method, i.e. the weighted average level of emissions for all production units, from which low-cost or must-run sources have been deducted. On this basis, the emission margin has changed as follows over the last three years:

EFgrid,OM,simple,2011 = 0.95893 t CO2/MWh

EFgrid,OM,simple,2012 = 0.86364 t CO2/MWh

EFgrid,OM,simple,2013 = 0.92634 t CO2/MWh

# Ireland

In its first, second and third progress reports, Ireland provided a detailed description of the methodology it applied to calculate GHG emission savings due to the use of renewable energy in the three sectors. The carbon intensity of electricity dropped to a new low of 457 g $CO_2$/kWh. The estimate of avoided $CO_2$ emissions associated with biofuels usage in transport assumes 100 % displacement of emissions from conventional fuels. The emissions from biofuels production are accounted for in this analysis in accordance with the United Nations Framework Convention on Climate Change reporting guidelines. Therefore, the $CO_2$ avoided from bioethanol in transport is supposed equal to the amount of $CO_2$ emissions that would have arisen from petrol consumption. Similarly, $CO_2$ avoided from biodiesel and pure plant oil (vegetable oil) is computed on the basis of the equivalent equated with diesel consumption.

# Greece

For the calculation of net greenhouse gas emission savings from the use of renewable energy other than solid and gaseous biomass and biofuels (i.e. hydro, wind, PV, solar thermal, geothermal and heat pumps), the methodology used was based on the emission factors that were presented in the national Annual Inventory Report, submitted in 2015 under the Convention and the Kyoto Protocol for greenhouse and other gases for the years 1990-2013. The estimation of GHG emissions in the aforementioned report was based on the methods described in the Intergovernmental Panel on Climate Change (IPCC) Guidelines, the IPCC Good Practice Guidance, the Land use, Land Use Change and Forestry (LULUCF) Good Practice Guidance and the European Monitoring and Evaluation Programme/European Environment Agency CORINAIR methodology.

**Table A- 5.** Comparators used to calculate GHG emission savings in Greece, 2009-2014

| | CO2 (t/TJ) | | CH4(kg/TJ) | | N2O(kg/TJ) | |
|---|---|---|---|---|---|---|
| **Electricity and heat production** | 2009-2012 | 2013-2014 | 2009-2012 | 2013-2014 | 2009-2012 | 2013-2014 |
| Liquid fuels | 75.48 | 75.60 | 3 | 3 | 0.6 | 0.6 |
| Solid fuels | 126.12 | 123.43 | 1 | 1 | 1.5 | 1.5 |
| Gaseous fuels | 55.1 | 55.62 | 1 | 1 | 0.1 | 0.1 |
| **Manufacturing industries and construction** | | | | | | |
| Liquid fuels | 67.51 | 83.91 | 1.024 | 1.816 | 0.73 | 3.555 |
| Solid fuels | 97.13 | 94.32 | 1.156 | 1 | 1.43 | 1.5 |
| Gaseous fuels | 55.24 | 55.57 | 1 | 1 | 0.735 | 0.091 |
| **Other sectors** | | | | | | |
| Liquid fuels | 72.97 | 72.44 | 3.109 | 3.171 | 5.733 | 2.28 |
| Solid fuels | 99.18 | 99.18 | 1.156 | 1 | 1.5 | 1.5 |
| Gaseous fuels | 55.24 | 55.57 | 1 | 1 | 0.1 | 0.1 |
| Transport | | | | | | |
| Liquid fuels | 70.72 | 73.17 | 13.37 | 13.544 | 2.925 | 2.70 |
| Gaseous fuels | 55.38 | 55.65 | 69.826 | 65.539 | 2.633 | 2.56 |

# Spain

Spain did not provide a description of the methodology it applied to estimate the net GHG emission savings in its three sets of progress reports.

# France

France applied its own methodology to calculate net GHG emission savings from the use of renewable energy. A detailed description is available in both its first, second and third progress reports. The methodology used for the 2009-2010 calculations differs slightly from that used for 2011-2014, and this influenced the results obtained for these periods. To calculate the GHG emission savings from biomass in electricity sector the reference mixes taken into account for the various sources of renewable energy are those used for the SceGES (scénarisation des émissions de gaz à effet de serre) modelling tool in 2012. Moreover a conservative saving of 60% against the fossil fuel comparator25 has been assumed – in line with the discussions at European level on the issue of solid and gaseous biomass. For other sources of electricity, both renewable and non-renewable, the LCA emission values are taken from ADEME's 'Carbon database' and records (version 1.01 of 30 June 2013). Owing to insufficient data available to establish a reference mix, the GHG emission savings attributable to geothermal energy have not been estimated.

# Croatia

The reduction in GHG emissions in Croatia was determined by considering the production of electricity from renewable energy sources, renewable energy use in transport and the use of renewable energy for heating/cooling in 2011 and 2014.

To determine the contribution of renewable energy sources, reducing GHG emissions, an estimate of what are called the avoided $CO_2$ emissions due to the use of renewable energy instead of fossil fuels. The avoided emissions are determined in such a way that the amount of electricity from renewable energy, energy, renewable energy for heating/cooling and energy from renewables in transport, replaced fossil fuels and for them a certain $CO_2$ emissions The sectoral perspective, in the production of electricity from RES, a comparison is made with fossil fuel power plants. For the budget is taken specific emissions from thermal power plants HEP-s. Avoided $CO_2$ emissions from transport are determined by the consumption of gasoline and diesel fuel. $CO_2$ emissions from the heating/cooling assume the use of fuel oil instead of renewable energy sources.

# Italy

In its third progress report Italy described in detail the methodology applied to calculate the GHG emission savings due to the use of renewable energy in period 2009-14. Italy reported also the contribution of each renewable energy technology/source in the final net GHG emission savings over this period.

**Electricity sector**: The method used to estimate the emission savings from RES generation is an emission balance based on the following formula:

*Emissions savings = Emissions avoided (SFF substituted fossil fuels) – Emissions produced (RES)*

The emissions from fossil sources avoided and those produced by RES are calculated by means of the following formulas:

$$\text{Emissions avoided from fossil sources} = \Sigma SFF\ (FE_{SFF} \times SF_{SFF}) \times \text{Gross electricity generation}$$

$$\text{Emissions produced} = EFRES \times \text{Annual RES production}$$

$$\text{Emissions produced}_{LCA} = \text{Emissions}_{operation} + \text{Emissions}_{construction} + \text{Emissions}_{upstream}$$

where SFF are the replaced fossil fuels , $SF_{SFF}$ is the substitution factor of each fossil fuel technology [%], $EF_{SFF}$ is the emission factor of each marginal fossil fuel technology, calculated as the emissions needed to produce a gross electricity unit [g/kWh], and $EF_{RES}$ are the emission factors of the possible RES source-technology per unit of energy produced (g/kWh). This balance was calculated for each phase of the lifecycle of the energy source, including the following phases: upstream, plant construction and plant operation. Annual RES generation is recorded in the statistical reports produced by GSE- Energy Services Operator[78], supplemented by the statistics published by TERNA- the National Transmission Grid Operator[79]. The electricity production considered is normalised gross production for wind and hydropower, and actual gross production for the other sources. The production of electricity from bioliquids only considers the share from sustainable bioliquids. The emission factors of greenhouse gases in the different phases of the lifecycle of renewable and fossil sources were acquired from the GSE's database of LCA emission factors, collated from a broad range of databases, legislation and technical literature, including RSE's databases of emission factors ISPRA's databases of emission factors, Ecoinvent databases, NREL databases, IPCC 2006, EMAS Declarations, NEEDS Project, UNI-TS-11435, Directive 2009/28/EC, Communication COM 2010 (11).

The $CO_2$ released in the bioenergy operation phase has been considered to be zero, while the other GHGs (CH4, N2O) have been assigned values on the basis of emission factors taken from the above-mentioned database. The emission factors of the upstream phase of bioenergies have been obtained from the standard values shown in Annex V to Directive 2009/28/EC for the different types of bioliquids (including biofuels) and from the standard values listed in UNI-TS-11435 for the different types of biogas and for solid biomass[80]. The data on electricity generation from bioenergies have been broken down and shown by supply chains of the raw materials linked to the upstream emission factors. The supply chains of the biogas and bioliquids used in electricity production are taken from the statistics on operating plants supplied by Terna with additional information from GSE. Where detailed data on the origin of the bioenergies were not available some conservative assumptions were made to assign the specific upstream emission factor (e.g. solid woody biomass for electricity was assumed to come from wood chips from short rotation forestry, sourced at a distance of 71-200km).

Determination of the substituted mix of fossil fuel technologies is based on the determination of a specific substitution factor for each RES-E, which takes into account the technology mix of the national marginal fossil fuel sources on the wholesale electricity market, at the production times and in the production zones of the specific RES analysed. This factor was calculated for each RES by GSE on the basis of the hourly and zonal electricity production data from the main RES (source: Terna[81]) and on the basis of the hourly zonal marginal technology index (statistical data supplied by GME - the Energy Market Operator[82]). By making a weighted average of the zonal hourly marginal technology index on the basis of the hourly and zonal production of each RES source[83], it

(78) http://www.gse.it/it/Statistiche/RapportiStatistici/Pagine/default.aspx
(79) http://www.terna.it/en-gb/sistemaelettrico/statisticaldata.aspx
(80) For solid biomass from waste, the emission factor was considered to be null, since it is assigned to the waste supply chain
(81) http://www.terna.it/en-gb/sistemaelettrico/transparencyreport/generation.aspx
(82) http://www.mercatoelettrico.org/It/Tools/Accessodati.aspx?ReturnUrl=%2fit%2fdownload%2fDatiStorici.aspx
(83) The hourly and zonal production of bioliquids was considered to be equal to that of thermal plants, based on the consideration that these plants share a similar production and market logic; for solid biomass ad biogas, instead, the substitute mix was evaluated on the basis of the national base load marginal technology index, assuming that the

is possible to estimate the mix of sources which have likely been replaced by the production of each source considered. It was assumed that the marginality of renewable sources and of imports was not representative of substitution of these sources by the RES[84]; accordingly, the substituted mix was normalised considering solely the national fossil sources. The conversion performances of RES and fossil-fuel plants were obtained from the annual statistics provided by Terna on the thermoelectric plants in operation.

**Table A- 6.** Comparators used to calculate GHG emission savings in Italy, 2009-2014

| Emission Factors [g$CO_2$-eq./kWh] | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LCA | Direct | LCA | Direct | LCA | Direct | LCA | Direct | LCA | Direct | LCA | Direct |
| Biogas | 621 | 502 | 592 | 471 | 575 | 453 | 591 | 469 | 591 | 469 | 591 | 469 |
| Bioliquids | 635 | 516 | 600 | 479 | 578 | 456 | 588 | 465 | 588 | 465 | 588 | 465 |
| Biomass | 621 | 502 | 592 | 471 | 575 | 453 | 591 | 469 | 591 | 469 | 591 | 469 |
| Wind | 674 | 557 | 627 | 505 | 599 | 478 | 621 | 501 | 621 | 501 | 621 | 501 |
| Geothermal | 610 | 490 | 583 | 462 | 575 | 453 | 598 | 476 | 598 | 476 | 598 | 476 |
| Hydropower | 604 | 485 | 578 | 455 | 563 | 441 | 590 | 467 | 590 | 467 | 590 | 467 |
| Solar | 613 | 490 | 574 | 450 | 559 | 436 | 599 | 477 | 599 | 477 | 599 | 477 |
| **RES-E** | **615** | **496** | **587** | **465** | **570** | **447** | **596** | **474** | **596** | **474** | **596** | **474** |

**Heating/Cooling sector**: RES penetration in the heating/cooling sector is helping to avoid increasing amounts of emissions in the processing and end-use sectors (industrial, services, residential, other end uses). The main contributor to emission savings is the spread of heat pumps and biomass in the residential sector. The calculation method and data sources for estimating GHG emissions in the thermal sector are similar to those applied for electricity production, with the following differences. The balance of the emissions associated with the use of RES in the thermal sector is assessed individually for each consumption subsector. This assessment is made by sector because RES penetration differs in the end-use sectors according to the different use of RES, (supply chains, technologies), the fossil fuel mix and the fossil technologies used which are presumably replaced by the RES. The substituted fossil fuel mix was determined on the basis of the fossil mix used annually in each sector (Eurostat balance) taking into account certain indicative energy conversion performance values of RES and fossil sources59. In the processing sector, instead, it was assumed that the renewable source would replace the fossil technology with lowest emission impacts (current BAT), which is a natural gas boiler. Bioenergy's were associated with raw material supply chains in each consumption sector, on the basis of the following statistics and assumptions:

- Processing sector - CHP and heat-only plants: similarly to the assumption made for the electric sector, solid biomass has been assumed conservatively to be ‘wood chips from short rotation forestry - SRF’, while sustainable bioliquids have been assigned to be pure palm oil and rapeseed oil, other bioliquids (from plant or animal waste) and biodiesel, in shares taken from Terna’s and GSE’s statistics on the plants in operation. Biogas has also been broken down into different types (agricultural, from sludge etc.) based on the Terna data on CHP plants in operation. The calculations and assumptions have been made so as to ensure, for CHP plants, consistency between the heat and the electricity sector. The RES plants serving district heating networks have been assumed to use the same bioenergy supply chains as CHP plants.
    - Final uses - Industrial, services, other end uses: biogas consumption is associated with specific supply chains (agricultural, sludge, landfills, etc.) taken from GSE statistics. Bioliquid and biodiesel consumption is almost negligible, while solid biomass consumption has been assumed to consist as to 50% of unprocessed generic residue and as to the remaining 50% of woodchips from forestry residue.

operators of these sources tend to operate these plants for the greatest number of hours available. For other sources no assumptions were necessary as their specific hourly zonal production data was available.

([84]) Hydroelectric plants are considered to be marginal for the purpose of optimising production on the basis of appropriate market strategies; the other RES are almost never marginal and import volumes do not seem to be decreasing yet as a consequence of increase in RES electricity production

- Final uses - Residential: solid biomass consumption consists of firewood sourced nationally or in Europe and pellets, in shares taken from GSE's annual statistics (about 90% and 10% respectively).

The $CO_2$ released in the bioenergy operation phase has been considered to be zero, while the other GHGs (CH4, N2O) have been assigned values on the basis of emission factors taken from GSE's LCA database. The difference between emissions in the construction phase of bioenergy-fuelled and fossil fuel-fuelled boilers has been considered to be negligible, whereas it was assigned a value for solar collectors, heat pumps and geothermal plants.

## Cyprus

GHG emission savings in Cyprus from the use of renewable energy in *electricity and heating/cooling* were calculated by the Department of the Environment of the Cypriot Ministry of Agriculture, Natural Resources and Environment, using its own methodology.

The net GHG emission savings due to the use of biofuels in road transport were calculated as the difference between the emissions produced if the biofuel quantity was diesel and if the said quantity was a biodiesel mixture in specific proportions. The calculation was based on the typical GHG emission reduction values listed in parts A and B of Annex V to the RED.

A very detailed description of the methodology applied by Cyprus to calculate GHG emission savings due to the use of renewable energy is presented in Annex I to Cyprus's first, second and third progress reports.

## Latvia

In its three sets of progress reports Latvia provides a description of the methodology used to calculate the GHG emissions savings from the use of renewables. In order to calculate GHG emission saving due to the use of biofuels in transport, Latvia followed the "Annex V methodology".

When calculating GHG emission savings from the use of renewable energy in heating/cooling, Latvia used a fossil fuel comparator of 87 g $CO_2$/MJ, as suggested in COM (2010) 11. For electricity, Latvia assumed that the GHG emission factor for electricity from solar collectors, solar power plants and hydropower plants was zero. For GHG emission savings for energy from heat pumps, the quantity of electricity used to ensure the functioning of heat pumps (not reported separately) was also taken into account. The $CO_2$ emission factor for gross consumption of electricity from fossil fuels considering the cogeneration correction, was estimated at 0.235 t $CO_2$/MWh in 2010.

## Lithuania

Lithuania did not provide any description of the methodology applied in its progress reports.

## Luxembourg

Luxembourg did not provide any description of the methodology applied in its three progress reports and GHG emission savings from renewable electricity and heat were not split, but reported together. The reports indicate the Environment Agency's inventory of GHG emissions the data source for the calculations. No data were reported for 2014.

## Hungary

Hungary fully followed the methodology suggested in Article 22(2) of the RED, applying typical values from Annex V for transport and data from COM (2010) 11 for heating/cooling and electricity.

## Malta

Malta did not provide any description of the methodology applied in its two sets of progress reports. The methodology is described in the Annex I of its third progress report. Biomass imports are normally attributed with household usage. It is assumed that the use of renewable biomass and other renewable energy sources are contributing to the replacement of a distributed portion from the overall share of fuel in residential heating. The substitution factors used to calculate the GHG emission savings are presented in Table A-7.

**Table A- 7.** RES substitution factors in $MTCO_2eq$ per MWh

| | RES Substitution (mT CO2e per MWh) | 2013 | 2014 |
|---|---|---|---|
| 1 | RES-E replacing Electricity | 0.7912 | 0.7899 |
| 2 | SWH replacing Electricity | 0.3956 | 0.3950 |
| 3 | Biomass replacing Heating share in Residential | 0.5426 | 0.5419 |
| 4 | Biogas replacing Gasoil in Industry | 0.2955 | 0.2955 |
| 5 | Biofuel replacing Gasoil in Industry | 0.2955 | 0.2955 |
| 6 | CHP heat replacing Gasoil in Industry | 0.2955 | 0.2955 |
| 7 | HP replacing Heating share in Services and Industry | 0.6655 | 0.6645 |
| 8 | HP replacing Heating share in Residential | 0.5426 | 0.5419 |
| 9 | Transport biofuel replacing Diesel | 0.2239 | 0.2239 |

Factors for fossil fuels found in the heating mix and Table 3 have been sourced from Table 1c of the report prepared by Defra titled '2012 greenhouse gas conversion factors for company reporting'[85]. The national GHG avoidance factors are based on the below assumptions:

- For Ref. 1 and 2, a unit of renewable energy produced is replacing one unit of energy 'sent out' from the power station;
- For Ref. 4, 5 and 6, it is assumed that one unit of renewable energy from biogas/biofuel/CHP is replacing gasoil in industry;
- The substitution of biomass and heat pumps RES in residential and industry/services is explained in Tables 1 and 2;
- In the transport sector, savings from a unit of renewable energy from biofuel sourced from waste cooking oil is equivalent to the default 83% GHG emissions of diesel fuel[86].

# Netherlands

The Netherlands applied its own methodology to calculate net GHG emission saving for 2009-2014. The greenhouse gas emission savings due to the use of **renewable electricity and heat** have been calculated according to a substitution method in accordance with the Protocol Monitoring Hernieuwbare Energie[87]. The reference technology for electricity is a national mix of natural gas, coal and nuclear power stations with emissions of 0.59 kg CO2 per KWh in 2012 and 0.62 kg of CO2 per kWh in 2013 and 2014.

The deployment of renewable electricity is relatively important in terms of prevented greenhouse gas emissions compared with heating/cooling and transport. In terms of gross final consumption, the relative contribution of electricity is far smaller. The reason for this is that far more primary fossil fuel is required to make 1 joule of electricity than for making 1 joule of heat; this is related to the high conversion losses in the thermal production of electricity. In addition, in the reference situation, the Netherlands uses far more coal with relatively high $CO_2$ emissions per unit of energy when generating electricity than is the case with heat. The emissions of greenhouse gases that have been prevented as a result of using bioethanol and biodiesel for **transport** have been calculated from a combination of data from the energy statistics of CBS and data from the Dutch Emissions Authority (NEA) on greenhouse gas performance of bioethanol and biodiesel that are on the market. The NEA received these data from companies that supply bioethanol and biodiesel within the scope of the legislation and regulations on renewable energy for transport and the legislation and regulations on fuels and air pollution.

(85) https://www.gov.uk/government/publications/2012-greenhouse-gas-conversion-factors-for-company-reporting
(86) RED Article 19(1)(a)
(87) RVO and CBS (2015) Protocol Monitoring Hernieuwbare Energie, Revision 2015

# Austria

Austria reported on GHG emission savings in three sets of progress reports but it did not provide a description of its methodology. The data on the GHG emission reduction reported in the second progress report were based on the studies carried out by BMLFUW[88].

# Poland

Poland fully followed the methodology suggested in Article 22(2) of the RED, applying typical values from Annex V for transport and data from COM (2010) 11 for heating/ cooling and electricity.

# Portugal

In its three sets of progress reports, Portugal reported only the coefficients used to calculate its GHG emission saving from the use of renewable energy in electricity, heating/cooling and transport.

**Electricity:** the emission factor used was different from the figure recommended by the Commission at COM (2010) 11 - (56.1 g $CO_2$-eq./MJ);

**Heating/cooling:** the emission factor recommended by the Commission was used - (87 g $CO_2$-eq./MJ);

**Transport sector:** a diesel emission factor different from the Annex V recommended figure was used - (74.1 g $CO_2$-eq./MJ).

In its first and second progress reports Portugal reported a unit measure $10^3$ less than the unit measure reported in its third progress report.

# Romania

In its first progress report, Romania did not provide a description of the methodology applied to calculate the net estimated reduction of GHG emissions. In its second and third report, Romania provided net GHG emission savings for 2011-2014 based on the Romanian National Institute of Statistics' Energy Balances Sheets that are sent by Romania to the EUROSTAT/IEA/UNECE international institutions in 2015. The $CO_2$-eq.uivalent emission savings for the production of electricity and of heat for heating/cooling were estimated using solid fuel (brown coal) as a comparator while savings obtained from using biomass in transport were estimated using diesel fuel as a benchmark. The efficiency used to determine the energy consumption is the average of the values reported in the Energy Balance, for electricity and heat generation, for the appropriate type of fuel, in particular brown coal: in the generation and self-generation of electricity (main activity and co-generation) – 30 %; in generating heat (main activity and co-generation) – 65 %; in heat self-generation (main activity and co-generation) – 40 %; in generating heat for heating/cooling in industry and in other sectors, the estimate of the $CO_2$ emission savings was calculated based on energy consumption. For **electricity** from hydro and wind sources, the actual quantities generated in 2013 and 2014 were used, and not the normalised quantities. The estimation of GHG emission savings by using biomass in transportation was made considering that it replaced the diesel oil.

The emission factors used are specific to Romania, taken from the national inventory of GHG emissions (INEGES), sent in January 2014 and 2015 to the European Environmental Agency and to the European Commission, for 2012 and 2013, in particular 87.7 CO2 [t/TJ] for brown coal and 73.56 CO2 [t/TJ] for diesel fuel.

# Slovenia

Slovenia did not provide in its three sets of progress reports a description of the methodology applied to calculate the GHG emission savings resulting from the use of renewables.

([88]) BMLFUW (Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management) https://www.bmlfuw.gv.at/english/environment/energytransition.html

## Slovakia

Slovakia calculated its net GHG emission savings from the use of energy from renewable sources for electricity and heating using reference values for fossil fuels for the whole of the EU. This was in line with COM (2010) 11. The value used to calculate net greenhouse gas emissions savings for electricity came from the voluntary international Biograce scheme[89], which uses the emission factor 128 gCO2ekv/MJ to calculate greenhouse gas emission savings for biofuels.

## Finland

Finland applied the methodology recommended in Article 22(2) of the RED (Annex V) in its estimates of net GHG emission savings due to the use of renewable energy in transport.

To estimate the GHG emission savings due to the use of renewable energy in the electricity and heating/cooling sectors, Finland applied its own methodology as follows:

- For separate electricity production (hydro power, wind power, photovoltaic electricity and separate electricity production from bioenergy), the net savings were estimated using an emission coefficient of 0.0951 Mt $CO_2$-eq./PJ, which corresponded to the average emission coefficient of Finland's separate condensate production based on fossil fuels. The consumption ratio of hydro power, wind power and photovoltaic electricity was assumed to be 2.4.
- For bioenergy, the fuel consumption ratio used in calculations was 1. In assessing the emissions reduction provided by bioenergy, biomass emissions were accounted for in accordance with Annex II to COM(2010) 11.
- In the calculation, heat pump energy and solar heat were replaced by separate fossil heat production. Net savings were estimated using an emission coefficient of 0.075 Mt $CO_2$-eq./PJ, which corresponded to the average emission coefficient of Finland's separate heat production based on fossil fuels.
- For separate heat production based on bioenergy, the net savings were estimated using an emission coefficient of 0.074 Mt $CO_2$-eq./PJ, which corresponded to the average emission coefficient of Finland's separate heat production based on fossil fuels and peat. The coefficient included the reduction in net savings by biomass emissions, for which a default value of 0.001 Mt $CO_2$-eq./PJ was laid down in Annex II to COM(2010) 11.
- For combined electricity and heat production, the net savings were estimated using an emission coefficient of 0.081 Mt $CO_2$-eq./PJ, which corresponded to the average emission coefficient of Finland's combined electricity and heat production based on fossil fuels and peat, minus biomass emissions as laid down in Annex II to COM(2010) 11.

## Sweden

Sweden estimated its net GHG emission savings from the use of renewable energy in electricity and heating/cooling sectors in two different ways:

**Case 1**. GHG emission savings compared with a reference scenario where all renewable sources are replaced by fossil fuels. Potential theoretical savings were estimated by calculating the difference between emissions from the renewable energy sources[90] and their fossil comparators, where emission factors for the fossil comparators were based on the Commission's recommendations, which correspond to the fossil marginal production of electricity and heating.

**Case 2**. GHG emission savings compared with a reference scenario where renewable sources for electricity and heating production are replaced with the average energy mix for electricity and heating production in 2009. The net savings were estimated by calculating the difference between the emissions from the renewable energy sources (as in Case 1) and the emissions for the fossil comparators represented by the emission factors[91] for Swedish electricity and district heating production mixes for 2009 (instead of emission factors for fossil production, as in Case 1).

(89) Biograce scheme http://www.biograce.net/home

(90) Gode, J et al., Environmental Fact Book 2011. Estimated emission factors for fuels, electricity, heating and transport in Sweden [Miljöfaktaboken 2011 — Uppskattade emissionsfaktorer för bränslen, el, värme och transporter], Värmeforsk (Thermal Engineering Research Institute).

(91) Approximately 25 g $CO_2$ equivalent/KWh for electricity and approximately 120 g $CO_2$ equivalent/KWh for heating. These emission factors come from: Martinsson, F and Gode, J 2011. Emission factors for the Swedish electricity mix and Swedish district heating in 2009 [Emissionsfaktorer för svensk elmix och svensk fjärrvärmemix år 2009]. IVL Swedish Environmental Research Institute. Report produced for Article 22 reporting. Available from the Swedish Energy Agency.

For *biofuels*, the Commission's recommendations, i.e. the emission savings specified in Annex V to the RED,[92] were used in both cases. For Case 1, only values for the fossil comparators were obtained from the Annex to which the RED refers. The emission factors for net emissions of GHGs from renewable fuels were obtained from elsewhere.[5] These emission factors were compiled from a life-cycle perspective and include all material emissions — from raw materials recovery and production of the fuel to use and distribution. However, emissions from the use of the biofuel were set to zero. For all cases, the actual values (not normalised) for hydro and wind power were used in the estimates.

For Case 2, the emission factor for the district heating mix was used as the fossil comparator for all heat production (that is, even for heat pumps and solar heating, etc.), which is a very simplified assumption. The emission factors used in this case represented the total GHG emissions (i.e. using the life-cycle perspective). The emission factors for the Swedish electricity and district heating production mix for 2009 would not be the same if, say, hydropower did not exist, but they give a picture of how the different calculation methods affect the results. We used the data in Case 1 for the analysis in our report.

## United Kingdom

The UK has used the methodology set out in the Renewable Energy Directive for estimating greenhouse gas (GHG) savings from the use of renewable sources of energy. Action on renewable energy alone will not be enough to meet the UK's ambitious target on emissions for 2050. Wider action is needed to reduce GHG emissions through well-functioning emissions trading scheme and the UK Government's system of Carbon Budgets.

The United Kingdom calculated its net GHG savings from *electricity* using the average $CO_2$ emissions factor for the fossil fuel mix for that year, as published in Table 5C in Chapter 5 of the *Digest of UK Energy Statistics, 2013*.[93]

Net direct GHG savings for *transport* were calculated using the carbon intensity data reported by suppliers for the fuel supplied. This includes a mix of RED Annex V default values and actual data calculated by fuel suppliers using guidance published by the Department of Transport in line with Annex V.

([92]) For those biofuels whose production pathways are not specified in Annex V, assumptions were made concerning which value in Annex V best represents this pathway. Ethanol produced from pulp production and wine production residues was assumed to have the same value as ethanol from sugar cane. For ethanol from wheat, the highest typical value for ethanol from wheat was used.

([93]) https://www.gov.uk/government/publications/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes

KJ-NA-28677-EN-N

## JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

**EU Science Hub**
ec.europa.eu/jrc

@EU_ScienceHub

EU Science Hub - Joint Research Centre

Joint Research Centre

EU Science Hub

Publications Office

doi:10.2760/6520

ISBN 978-92-79-70479-6