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Securing Energy Efficiency to Secure the Energy Union

How Energy Efficiency meets the EU Climate and Energy Goals

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Abstract

In line with the Energy Union strategy, the EU 2030 climate and energy policy framework sees energy saving as Europe's first fuel in 2030. Making energy efficiency the mechanism for delivering moderation of demand will enable the EU to meet its objectives in terms of security of supply, climate change, jobs, growth and competitiveness.

The decarbonisation of the EU energy system is under way. Energy-related greenhouse gas (GHG) emissions fell by 19% between 1990 and 2013. The power generation and energy-intensive industries covered by the EU Emissions Trading Scheme (ETS) are responsible for 45 % of total EU GHG emissions and for 23 % of the emissions reduction achieved between 2005 and 2013. The end-use sectors, such as buildings and transport, covered by the Effort-Sharing Decision (ESD) contributed 13 % of emissions reduction over the same period.

Emissions reduction in the EU is a result of economic restructuring, the economic crisis and the EU 2020 climate and energy policy package. With the post-2020 climate and policy package, the Energy Union is seeking to develop a more reliable and transparent governance system. Reporting on progress towards climate and energy targets will be streamlined through integrated national energy and climate plans. Indicators will be developed to ensure consistency and better interaction between the various climate and energy policy instruments.

For decarbonisation to be made cost-neutral, a strong signal is required from the 2015 Paris Climate Summit (COP21) – giving a value to the carbon saved by pricing GHG emissions, so that energy saving become the niche fuel for investors. At EU level, a framework for "De-risking Energy Efficiency Investments (DEEI)" is needed to ensure that energy saving compete on equal terms with generation capacity. The framework should include setting-up guarantees for loans related to energy efficiency investments; this would lower capital cost by reducing investors' perceived risk. Cost/benefit analysis of energy efficiency investments should consider using "Levelised Cost of Conserved Energy (LCCE)", as a financial metric given that this metric allows for risk and basic rate components to be separated. The aim is to make mitigation of the risk premium related to energy efficiency investments possible via the DEEI framework.

"It is necessary to fundamentally rethink energy efficiency and treat it as an energy source in its own right, representing the value of energy saved. As part of the market design review, the Commission will ensure that energy efficiency and demand side response can compete on equal terms with generation capacity."

A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy
Energy Union Package, COM(2015) 80 final

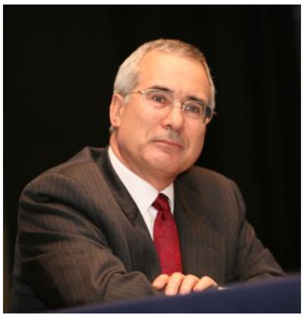
Foreword

The world has begun a great climate and energy transition towards a low-carbon economy. It provides a much cleaner, more efficient and more attractive way of consuming and living. It is the growth story of the future.

Increasingly, decision makers are realising that business-as-usual in our policies and our actions is unacceptable. I welcome Europe's Energy Union because it is necessary to re-think every aspect of energy policy and particularly those policies that can have a significant impact in the reduction of greenhouse gas emissions. First, in terms of quantitative importance, amongst those policies are those to support energy efficiency throughout the economy. While we have increased our level of ambition, we can do much more. The technologies and techniques exist; but the political will, commitment and ability to act is sometimes weak. Strong examples and clear demonstrations of ways forward can galvanise action.

Thus, I welcome this new report from the European Commission's Joint Research Centre. The report showcases the benefits of a more ambitious energy saving target for 2030. Energy efficiency is not only a cost-effective means to mitigate climate change, but improved energy efficiency combined with stringent renewable energy targets reduces Europe's energy dependency. As highlighted in the "New Climate Economy" report from the Global Commission on the Economy and Climate, of which I was co-chair, the next fifteen years are crucial in the creation of a low-carbon infrastructure across energy system and cities throughout the world. Done well, in terms of delivering cleaner, less congested, resource efficient infrastructure, the transition to a low-carbon economy can drive economic development, reduce poverty, provide great health benefits, and strengthen and empower communities.

As we continue the global deliberations at the Paris Climate Conference and beyond, we hope that the global commitment to keep global temperatures from rising more than 2 degrees Celsius can become a reality. This requires taking advantage of a full range of mitigation options. This report makes a strong case for action on energy efficiency that goes beyond Europe's borders. If we rise to the challenge of the low-carbon transition firmly and creatively, we can create a future for Europe and beyond which is much more attractive, productive and dynamic then the out-of-date and destructive energy use and sources that we will leave behind.



Lord Stern of Brentford
Chair of the Grantham Research Institute on Climate Change
and the Environment at the London School of Economics (LSE)

Prologue

The European Union entered in 2015 towards a new approach to Energy Policy, by endorsing the "Energy Union". To this end, the European Commission established a roadmap, aiming to make Europe's energy system meet the challenges of securing the Union an affordable energy supply, whilst meeting requirements for a climate policy which puts Europe at the forefront of reducing greenhouse gas (GHG) emissions within the United Nations Framework Convention on Climate Change (UNFCCC).

To this end, the Commission has proposed an action plan targeting five dimensions, of which one is energy efficiency, the other four being the decarbonisation of the EU economy, the security of energy supply, an internal energy market, and research, innovation and competitiveness.

Energy efficiency, or the reduction of energy consumption without decreasing the services energy provides, has a fundamental role to play, as any avoided consumption of energy serves all goals of a resilient energy policy.

This report is intended to quantify the impact of reducing energy demand on energy security in terms of European import dependency, as well as the possible reduction of GHG emissions.

The data are analysed also with respect to the achievements of current energy efficiency policy goal of reducing energy demand by 20% by the year 2020, and its impact on the overall CO_2 emissions reduction goal of the European Union.

An important element in this report is the assessment of the impact energy imports have on the trade balance of each Member State.

As Europe's buildings are one of the largest contributor to CO_2 emissions, more quantitative details are given regarding the energy mix, the potential of consumption reduction by renovation and new buildings, as well as the requirements of innovation in the construction sector.

In a year where a global agreement is sought to reduce CO_2 emissions to the extent of limiting global warming to 2 degrees Celsius before the end of the century, the report is also assessing which ambition energy efficiency policy must pursue, to achieve further reduction in Europe's energy demand by 2030 and beyond.

The authors hope with this report to contribute to a careful assessment of policy option, as well as to an encouragement of an ambitious policy to reduce Europe’s energy demand.

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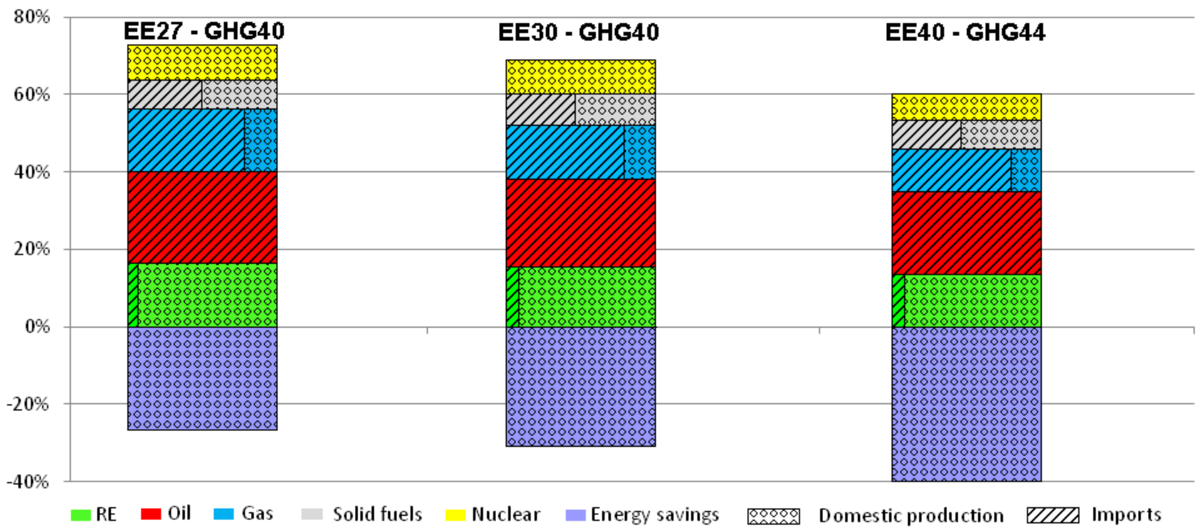
BAT	Best Available Technology
boe	Barrel of oil equivalent
CRF	Capital recovery Factor
CO_2	Carbon Dioxide
CF	Cohesion Fund
EEA	European Environment Agency
ETS	Emission Trading Scheme
ECFIN	Directorate General for Economic and Financial Affaires
EC	European Commission
EBRD	European Bank for Reconstruction and Development
EE	Energy efficiency
EEEF	European Energy Efficiency Fund
EFSI	European Fund for Strategic Investment
EIB	European Investment Bank
ELENA	European Local Energy Assistance
ERDF	European Regional Development Fund
EU	European Union (28 Member States)
GHG	Greenhouse Gas
GDP	Gross Domestic Product
GIC	Gross Inland Consumption
GIS	Geographic Information System
IEA 2 DS	International Energy Agency 2 degrees scenario
JASPERS	Joint Assistance to Support Projects in European Regions
Ktoe	Kilo tonnes of oil equivalent
LCV	Light commercial vehicle
LCCE	Levelized Cost of Conserved Energy
$MtCO_2eq.$	Millions of tonnes of CO_2 equivalent
Mtoe	Millions of tonnes of oil equivalent
MENA	Middle East and North Africa
MSR	Market Stability Reserve
N_2O	Nitrous oxide
OECD	Organisation for Economic Cooperation and Development
OM	Operational and Maintenance
PF4EE	Project Finance for Energy Efficiency
PFCs	Perfluorocarbons
PPS	Purchasing Power Standard
r	Discount Rate
TWh	Terawatt hour
toe	Tonne of oil equivalent
tCO_2eq	Tonnes of CO_2 equivalent
UNFCCC	United Nations Framework Convention on Climate Change
WACC	Weighted Average Cost of Capital

Executive summary

Energy saving will overtake oil as Europe's first fuel in 2030

In line with the Energy Union strategy, the EU climate and energy framework sees energy saving as the EU first fuel in 2030. In the 40% energy saving scenario, EE40, the sum of domestic production of energy saving and renewables will overtake the sum of imported fossil fuels (oil, gas and solid fuels) (Figure ES.1). Making energy efficiency the mechanism for delivering moderation of demand will enable the EU to meet its objectives in terms of security of supply, climate change and competitiveness. Under the EE27, EE30 and EE40 scenarios, the EU energy import dependency would not rise from its current level. The EE27 and EE30 scenarios would allow Europe to meet its 2030 climate objective by reducing greenhouse gas (GHG) emissions by 40 % as compared with the 1990 level and the EE40 scenario would lead to greater reductions (44 %). In the longer run, the decarbonisation scenarios should give EU industry a competitive advantage and end-use consumers would benefit from energy and cost savings.

Figure ES.1 EU primary energy mix in 2030 in the EE27, EE30, EE40 decarbonisation scenarios



Key point: With 40% energy saving target, domestic production of energy saving and renewable energies will overtake the sum of imported fossil fuels all together (oil, gas solid fuels) in 2030.

Source: PRIMES 2014

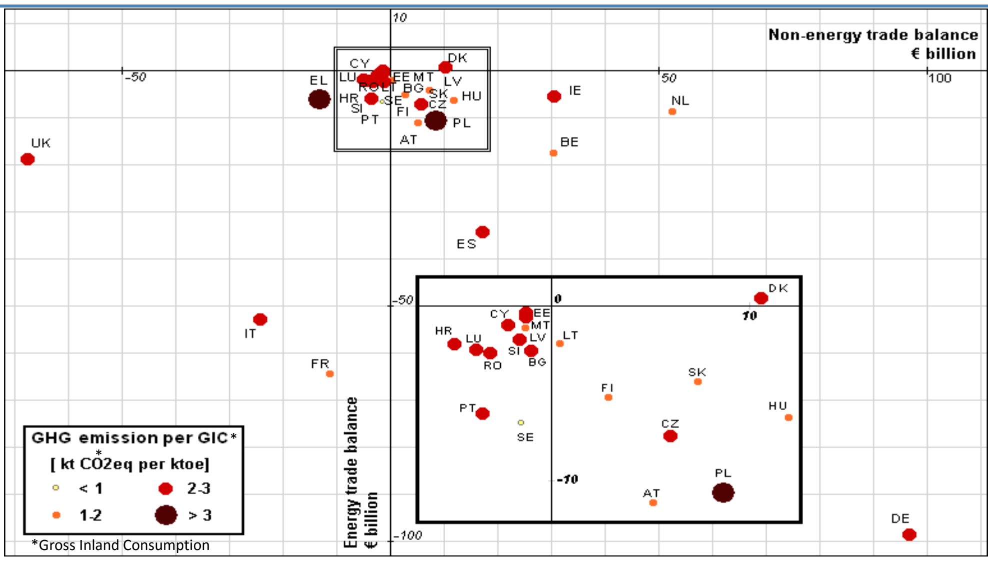
A strong policy signal is required from the 2015 Paris Climate Summit (COP21) to value the carbon saved globally by pricing GHG emissions and making energy saving the niche fuel for investors, especially when energy prices are low

Decarbonisation of the EU energy system requires significant investment. The EU Emissions Trading Scheme (ETS) is one policy instrument that provides financing opportunities, but in the absence of a binding and transparent global climate deal, carbon pricing is not practised worldwide and the ETS has been blamed for the partial relocation of energy-intensive industries to regions without climate regulations. COP21 is therefore an important step towards creating a global carbon market in which a monetary value is given to the carbon saved by pricing GHG emissions. The ETS carbon prices considered in the decarbonisation scenarios for the EU 2030 climate and energy framework vary from €39/t CO_2 eq. in the EE27 scenario to €6/t CO_2 eq. in the EE40 scenario. Such low carbon prices make the decarbonisation more challenging from a financing perspective, especially if the societal perspective is not privileged when estimating the capital cost of the decarbonised energy system.

If maintained over a period of decades, low energy prices will reduce the EU fossil fuel import bills (2.8 % of EU GDP in 2013, when fossil fuels accounted for 72 % of the EU primary energy mix) and consequently the "energy purchases" cost of total energy system. This will free up resources that could be used for investments in energy efficiency. Current energy prices are almost half those used to estimate energy purchases cost in the decarbonisation scenarios. A price signal on GHG emissions would make energy saving the niche fuel for investors, especially in a period of low energy prices.

Fossil fuel import bills have a significant impact on individual Member States' trade balances. The trade deficits of Austria, Finland, Lithuania, Poland and Spain were entirely due to energy in 2013 (Figure ES.2). With the exception of Denmark, the only EU country with an energy trade surplus, all Member States have experienced increased energy trade deficits in the past five years. In the case of Sweden, the EU country with the lowest GHG emissions per unit of energy consumed as a result of the low proportion of fossil fuels in its primary energy mix, over 80 % of the deficit is due to energy; this is equivalent to 1.5 % of the country's 2013 GDP. The highest relative expenditure on fossil fuel imports in 2013 was in Malta (9.4 % of GDP), followed by Bulgaria, Cyprus, Hungary and Lithuania (all over 6 % of their national GDP).

Figure ES.2 Net energy trade balance, non-energy trade balance and energy-related GHG emissions by Member State (2013)



Key point: Fossil fuel imports exacerbate most Member States' trade deficits and increase their contribution to global warming.

Source: Eurostat: EU trade since 1988 by SITC [DS-018995] and EEA: greenhouse gas emissions [env_air_gge]

A framework for De-risking Energy Efficiency Investments (DEEI) is needed to ensure that energy saving compete on equal terms with generation capacity

Energy efficiency investments suffer from investors' perceived risk, which increases financial cost and consequently the capital-cost of the total energy system. A guarantee fund for such investments would reduce financial cost by providing a guarantee for energy efficiency loans, thus lowering the interest rate and consequently the capital cost. Furthermore, lowering the interest rate for such investments would help energy saving to compete on equal terms with generation capacity. As regards prevailing capital costs (the most important financial parameter), connected risk and basic rate components can be separated by using the "Levelised Cost of Conserved Energy (LCCE)" as the financial metric for costs/benefits analysis. The DEEI framework could mitigate the perceived risk by providing a guarantee to lower interest rates. As a result, investors would estimate the Weighted Average Cost of Capital (WACC) on the basis of a lower risk premium and the capital cost would be reduced.

Investing in the development and deployment of low-carbon technologies should enhance the competitiveness of EU industry.

The decarbonisation of the EU energy system will lead to jobs and growth if the necessary investments are made in the development and deployment of low-carbon technologies. Innovation is needed at each stage of the transition to a low-carbon economy, from designing policy instruments to developing technologies as well as new business models, understanding impact of policies on individual choices and monitoring progress towards climate and energy targets. Major coordinated efforts to reshape skills and institutional arrangements will be required at EU, national and regional levels to ensure effective implementation of the EU climate and energy policies.

The EU is on track to meet its 2020 GHG emissions reduction target but not its energy efficiency target.

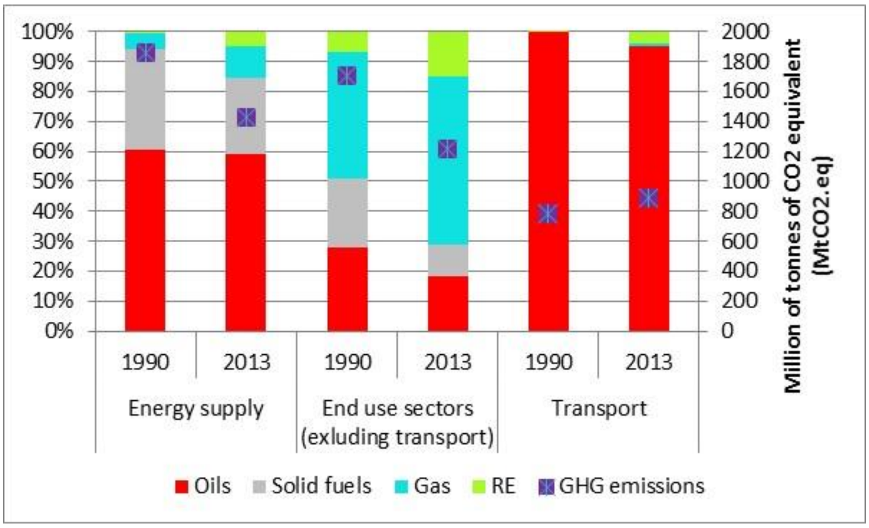
Decarbonisation of the EU energy system is well under way. The EU energy-related GHG emissions, which represented 79% of total GHG emissions in 2013, fell by 19% between 1990 and 2013. While total GHG emissions decreased by 21% over the same period. On the contrary, the EU energy efficiency target is unlikely to be met without additional measures. The sum of national indicative targets submitted by Member States to the European Commission corresponds to 17.6% primary energy saving compared to projections to 2020.

The restructuring of the EU economy (especially in eastern Member States), the recent economic crisis and the implementation of energy efficiency measures in end-use sectors resulted in total energy demand dropping back to 1990 levels. Combined with an increase in the proportion of renewables in the EU primary energy mix (almost three times more than in 1990) and the implementation of energy efficiency measures in energy supply, this accelerated the decarbonisation of power and heat generation. As a result, the EU economy improved its energy and carbon intensities while growth was decoupled from energy consumption and carbon emissions.

The power generation and energy-intensive industries covered by the ETS are responsible for 45 % of total EU GHG emissions and for 23 % of emissions reduction between 2005 and 2013 (Figure ES.3). Emissions reduction from power generation are projected to reach 58 %, 55% and 60% in the EE27, EE30 and EE40 decarbonisation scenarios as compared with the 2005 level, as a result of the implementation of renewable energy targets and energy efficiency measures. The scenarios project lower reductions from the energy-intensive industries: 32 % (EE27), 29 % (EE30) and 30 % (EE40).

The transport sector -aviation included- is characterised by an increase in GHG emissions (+12.8 %) between 1990 and 2013 (Figure ES.3). It is also the sector with the lowest emissions reduction in the decarbonisation scenarios (around 17 %). As a result, it will be the highest emitting sector in 2030 and will remain as dependent as it is today on imported oil.

Figure ES.3 Changes in primary energy mix and energy-related GHG emissions per sector



Key point: The transport sector is the only sector with almost no changes in the use of fossil fuels. It is also the sector with increased GHG emissions over the period 1990-2013.

Source: Eurostat for energy for energy and EEA for GHG emissions

Sectors covered by the Effort-Sharing Decision (ESD), which include buildings, transport, agriculture and waste, contributed 9.3 % of GHG emissions reduction between 2005 and 2013. Austria, Belgium, Ireland and Luxembourg are at risk of not meeting their national ESD targets by 2020. The buildings sector is projected to be the least emitting sector in 2030 as a result of more renovation of existing buildings and the zero-energy approach to new ones. Consequently, space heating will consume less energy and gas imports will be reduced. Emissions reduction are projected to be higher in the non-residential sub-sector than in the residential sub-sector (up to -73 % against 63 %, as compared with the 2005 level; EE40 scenario).

The EU climate and energy policy package will be streamlined to ensure better monitoring of progress towards 2020 and 2030 climate and energy policy goals.

The EU 2020 climate and energy policy package has been put together step by step, sector by sector over the past four decades. It is made up of various regulations, decisions and directives (Table ES.1). Gauging progress towards climate and energy goals is challenging, given the range of indicators used to assess implementation of individual policy measures and the inconsistency of reporting across Member States. For the post-2020 targets, the Energy Union intends to develop a more reliable and transparent governance system. Reporting on progress will be streamlined through integrated national energy and climate plans for 2021-2030. Consistent indicators need to be agreed and used to avoid duplication, ensure better interaction between policy measures and allow for progress to be monitored across Member States.

Table ES.1 The EU 2020 climate and energy policy instruments

2020 EU climate and energy targets (base year 1990, annual reporting)									
Emission Trading Scheme target (EU level) Directives 2003/87/EC and 29/2009/EC and decision 2015/1814 (base year 2005, annual reporting since 2006, covers 45% of total emissions)					**Effort Sharing Decision targets (national level)** Decision 406/2009/EC (base year 2005, annual reporting since 2013, covers 55% of total emissions)				
DG in charge	**Framework**	**Policy measure**	**Sectors**	**Reporting**	**DG**	**Framework**	**Policy measure**	**Sectors**	**Reporting**
Climate Action	*Directive 2009/29/EC*	*Maximum CO_2 emissions*	*Power generation*	*Every year*	*Climate Action*	*Decision 406/2009/EC*	*Maximum CO_2 emissions*	*Buildings*	*Every year*
			Energy intensive industries	*Every year*				*Transport*	*Every year*
						Directive 1999/94/EC	*Label for new passengers cars*	*Transport*	*NA*
						Regulation 443/2009 and 333/2014	*Maximum CO_2 emissions for new passengers cars (average fleet)*		*Every year*
						Regulation 510/2011 and 253/2014	*Maximum CO_2 emissions for new light commercial vehicles (average fleet)*		*Every year*
						Directive 2009/30/EC	*Target to reduce life cycle of GHG emissions from fuels*		*Every three years*
						Directive 2009/33/EC	*Public Procurement for clean Vehicles*		*Every two years*
						Directive 2010/75/EU	*Target for Maximum Industrial emissions*	*Industry*	*Every three years*
Energy	*Directive 2009/28/EC*	*Minimum share of renewables*	*Power and heat generation*	*Every two years*	*Energy*	*Directive 2009/28/EC*	*Minimum share of renewables*	*Transport* *Buildings*	*Every two years*
	Directive 2009/125/EC	*Minimum energy performance standard*	*Industry (energy related products)*	*NA*		*Directive 2009/125/EC*	*Minimum energy performance standard*	*Buildings and industry (energy related products)*	*NA*
	Directive 2010/30/EU	*Label*				*Directive 2010/30/EU*	*Label*		*NA*
	Directive 2012/27/EU	*Energy saving obligation*	*Energy providers*	*Every year*		*Directive 2012/27/EU*	*3% yearly renovation rates*	*Buildings (public only)*	*Every year*
		Mandatory audits	*Industry*	*NA*			*Indicative maximum primary and/or final national energy consumption*	*All sectors together*	*Every year*
						Directive 2014/24/EC	*Public procurement*	*All sectors*	*Every three years*

Key point: The EC developed a comprehensive set of policy instruments to ensure the EU 2020 climate and energy targets will be met.

Source: Compiled by the authors from various EC sources

Introduction

Improving the security of energy supply and reducing greenhouse gas (GHG) emissions are priority concerns for the Energy Union. Given that it helps to moderate energy demand and mitigate climate change, energy efficiency is one of the five pillars in the EU quest for greater energy security, sustainability and competitiveness. In its framework strategy for a resilient Energy Union with a forward-looking climate change policy (EC, 2015-a), the European Commission underlined the need to "fundamentally rethink energy efficiency and treat it as an energy source in its own right, representing the value of energy saved". Also, the Commission will ensure, in its market design review, "that energy efficiency and demand-side response can compete on equal terms with generation capacity" (EC, 2015-a).

This report documents, for the European Commission, the European Council, the European Parliament and relevant stakeholders, the prominent role that energy efficiency has played in the past and will continue to play in the future. The aim is to support policy decisions making Europe less energy dependent and more climate-resilient while also contributing to growth, jobs and innovation. The report complements previous Commission reports on the contribution of energy efficiency to energy security, the 2030 climate and energy policy framework and those related to the State of the Energy Union (EC (2013), EC (2014-a), (EC, 2014-b), (EC, 2015 a-d)). It shows how energy efficiency addresses all three strands of the "energy trilemma", i.e. security, sustainability and affordability.

The report is structured as follows:

- Chapter 1 highlights how energy efficiency measures designed to enhance security of supply have also mitigated the adverse effects of anthropogenic climate change. It analyses changes in the EU primary energy mix, energy intensity and energy dependency between 1990 and 2013. It shows how the EU strategy of diversifying its primary energy mix has contributed to reduce energy-related GHG emissions. It concludes with analysis of the progress towards the EU 2020 climate and energy targets.

- Chapter 2 refers to Commission projections related to the 2030 climate and energy policy framework. It shows that energy saving will be the EU "first fuel" by 2030. It analyses the contribution of energy efficiency in Commission President Juncker's priority areas of energy security, climate change, jobs and growth. The analysis is based on the 27 %, 30 % and 40 % energy saving scenarios used in DG ENERGY's 2014 impact assessment on energy efficiency and its contribution to energy security and the 2030 climate and energy policy framework.

- Chapter 3 examines the challenges in the path to achieve the estimated saving potential in the 27 %, 30 % and 40 % energy saving scenarios. It highlights the need for a De-risking Energy Efficiency Investment (DEEI) framework to deliver on the ambitious objective of making energy saving the EU "first fuel" by 2030. The authors propose the use of the "Levelised Cost of Conserved Energy (LCCE)'' as a financial metric when conducting costs/benefits analysis of energy efficiency projects. The aim is to ensure that energy efficiency competes on equal terms with generation capacity by reducing the perceived risk.

Chapter 1: EU energy and climate trends in figures

Highlights

- While total energy demand was 1709 Mtoe in 2013 in the EU (returning to 1990 levels), domestic energy production of fossil fuels (oil, gas and solid fuels) decreased by 16% over the 1990-2013 period and imports of fossil fuels increased by 31%. The contribution of renewable energies to total energy demand reached 11.5% in 2013 – almost triple what it was in 1990.
- The EU fossil fuels import dependency reached 53.2% in 2013, almost 10 percentage points more than in 1990. The highest increase was in the UK (from 2.4% in 1990 to 46.4% in 2013), while the largest decrease was in Denmark (from 45.8% in 1990 to 12.3% in 2013). Fossil fuels import dependency was over 90% for Malta, Cyprus and Luxembourg in 2013 and below 20% for Romania, Estonia and Denmark.
- Russia is by far the largest single supplier of fossil fuels to the EU. In 2013, Russia supplied 31% of the EU total gas and crude oil imports and 26% of its solid fuel imports. The EU total energy import bill was €385 billion, equivalent to almost 3% of its 2013 GDP.
- The EU cut its energy-related greenhouse gas emissions by 19% over the 1990-2013 period. Luxembourg was responsible for the highest emissions per capita in 2013 and Latvia for the lowest, while Poland had the highest emissions per unit of energy produced and Estonia the highest per unit of GDP. Sweden had the lowest energy-related GHG emissions per unit of GDP and per unit of energy produced.

This chapter analyses trends in the EU in terms of energy mix, consumption, domestic production, imports, and energy-related GHG emissions for the 1990-2013 period and the progress towards the EU 2020 climate and energy goals. The objective is to gain a better understanding of the EU import dependency on fossil fuels and the consequences of this dependency for EU GDP, Member States' trade balances and long-term climate goals.

This is a scene setting chapter that provides the context for the subsequent chapters dealing with energy efficiency as an energy source in its own right and the role of energy saving in improving the EU energy security and reducing GHG emissions. The aim is to identify the challenges facing the Energy Union in achieving energy efficiency targets in order to meet the EU climate and energy goals.

The graphs and maps in this chapter are based on Eurostat data for 1990-2013 and EC estimates for the progress towards the 2020 climate and energy targets.

The European Commission defines energy security as the “uninterrupted availability of energy products at a price which is affordable for all consumers (private and industrial), while respecting environmental concerns and looking towards sustainable development” (EC, 2000).

A country's energy security status is the combined result of a number of factors:

i) the diversity of energy sources in its energy mix;
ii) the extent to which it depends on imports to meet its energy needs; and
iii) the diversity of its energy suppliers, which determines how vulnerable it is to political decisions taken in other countries.

The more diverse a country's domestic energy sources (i), the lower is its dependency on imported fuels (ii); the more diverse its suppliers, the less vulnerable it is to shocks affecting a specific energy source as a result of supply disruption, decisions taken elsewhere and price volatility (EC, 2013).

Historically, because of the oil crisis (in 1973-1974), the resulting disruption of oil supplies and the related price shocks, energy security has been primarily associated to the security of oil supply. A comprehensive set of emergency oil response measures has been developed under the auspices of the International Energy Agency (IEA), the overall objective of which is to prepare better for changes in the energy landscape and patterns of the global oil trade.

The Commission has adapted the IEA measures to the EU context and implemented them as part of the EU energy security strategy (IEA, 2014). Member States have taken measures both to increase the supply of oil and reduce demand for it. They are legally required to hold emergency oil stocks equivalent to 90 days' worth of net imports. The idea is to stabilise supply even in the event of sudden changes in the supply/demand balance. Also, Member States have taken significant steps to diversify oil suppliers in the past four decades. Measures to reduce oil demand include demand restraint (primarily during a crisis) or moderation on the basis of energy efficiency policies and switching to domestic fuels such as renewable energies (IEA, 2014). These measures are coupled with investments in energy, including those relating to the decarbonisation of supply and demand, with the dual objective of diversifying the energy mix and reducing energy-related GHG emissions.

Given the increased share of gas consumption in the EU energy mix as a result of Member States' fuel-switching policies, the energy security measures developed to address supply disruptions after the oil crisis have been adapted and extended to gas security (IEA, 2014).

Box 1.1 Definitions

Total energy demand is the sum of gross inland consumption and the oil supplied to international marine bunkers, expressed in energy units.

Gross inland consumption is the sum of domestic production, imports, recovered products and stock, minus the sum of exports and fuel supplied to maritime bunkers, expressed in energy units.

Net imports are the difference between imports and exports, expressed in energy units.

Import dependency is the ratio between net imports and total energy demand, expressed as a percentage. A negative import dependency ratio indicates that the country is a net exporter of energy.

Primary energy consumption equals gross inland consumption minus non-energy uses, expressed in energy units.

Final energy consumption covers deliveries of commodities to end-use sectors (buildings, industry and transport), expressed in energy units.

Energy intensity is the ratio between gross inland consumption and GDP.

Source: Energy Statistics Manual, OECD-IEA-Eurostat, 2005
https://www.iea.org/publications/freepublications/publication/statistics_manual.pdf

EU energy mix

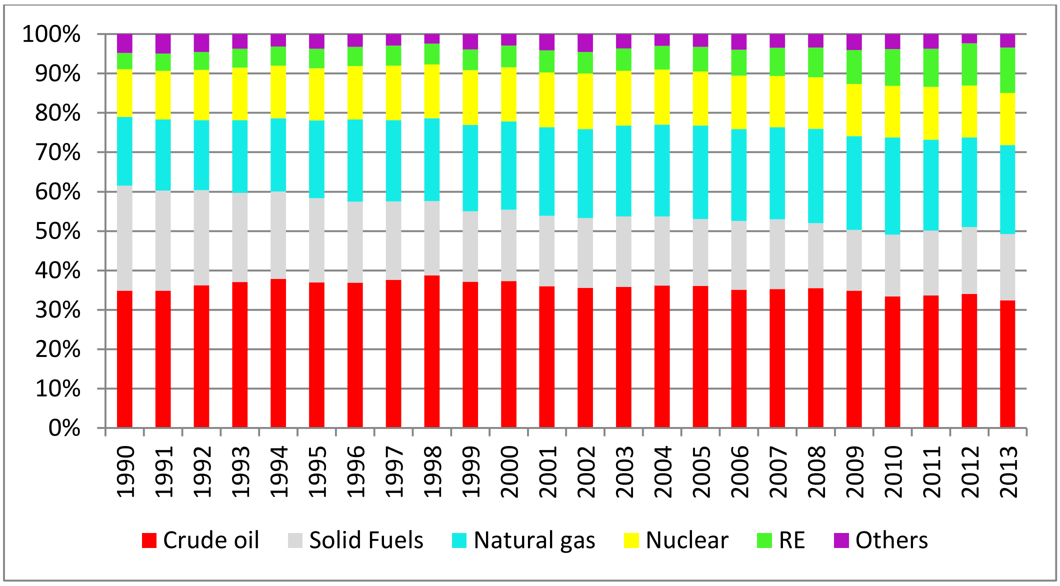
Total energy demand

Total energy demand in the EU reached a peak of 1885 Mtoe in 2006 before declining to 1709 Mtoe in 2013, almost equal to the 1990 level (1703 Mtoe). The structural changes in the EU[1] economy, especially in eastern countries, the economic downturn experienced in most Member States since 2006 and the implementation of energy efficiency policies are the main factors (Box 1.2) underlying stable energy demand over the 1990-2013 period.

On the other hand, the EU primary energy mix underwent great changes during this period (Figure 1.1) as a result of policies first on energy security and more recently on reducing GHG emissions. While the proportions of total energy demand covered by oil and nuclear power remained quite stable (32.4% and 13.2% respectively), the share of solid fuels — which include hard coal and derivatives, lignite, peat and derivatives, oil shale and oil sands — decreased from 26.7% to 16.8% and that of gas increased from 17.4% to 22.6%. The share of renewables almost tripled, to 11.5% in 2013. Overall, fuel-switching policies implemented over this period as part of the EU long-term energy security strategy had a significant impact on the EU primary energy mix.

Note: unless otherwise indicated, all figures, table and boxes derive from JRC and EC data and analysis.

Figure 1.1 Evolution of primary energy mix, 1990-2013 (EU)[2]



Key point: Fossil fuels accounted for 72% of the EU primary energy mix in 2013, six percentage points less than in 1990.

Source: Eurostat: Complete energy balances - annual data [nrg_110a]
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_110a&lang=en

1 EU refers to EU28
2 Others include industrial waste and non-renewable waste.

Despite the changes in the primary energy mix, in 2013 the EU still covered 72% of its energy demand from fossil fuels. Oil was still the dominant fuel, with 554 Mtoe consumed (three times more than renewables), followed by gas with 387 Mtoe and solid fuels with 287 Mtoe.

Box 1.2 Factors influencing the decrease of the EU energy demand

A decomposition analysis of the EU energy demand showed that primary energy consumption decreased by 102 Mtoe over the period 2008-2012 against 34 Mtoe for the period 2000-2012.

The main factor influencing the decrease of primary energy consumption was during the period 2008-2012 the decrease of the energy available for final energy consumption, followed by the efficiency improvement and structural changes in the power generation sector. On the contrary, during the period 2000-2012, the main factor behind the decrease of primary energy consumption was related to the structural changes, followed by the efficiency improvement of the power generation sector and the decrease of energy available for final energy consumption (Table 1.1).

Table 1.1 Decomposition analysis of primary energy consumption

Period	Change in primary energy consumption due to (Mtoe)	Total change	Energy available for final consumption	Distribution losses	Energy sector consumption	Structure of energy sector	Sector efficiency
2000-2012	Overall energy conversion sector	-34.12	-33.78	-0.55	-0.99	39.74	-38.55
2008-2012		-102.11	-95.90	1.31	-2.26	23.79	-29.06

Key point: Primary energy consumption decreased less in the period 2000-2012 than in the period 2008-2012.

For what regards the EU final energy consumption, the decomposition analysis showed that improved energy efficiency in end-use sectors is the main factor which contributed to the decrease of final energy consumption over the period 2000-2012. However, the efficiency improvement was offset by the increased level of activity before 2008. For the period 2008-2012, the decrease of the level of activity contributed greatly to reducing final energy consumption and efficiency improvement was lower than in the previous years (Table 1.2).

Table 1.2 Decomposition analysis of final energy consumption

Period	Change in final energy consumption due to (Mtoe)	Total change	Activity level	Structure	Model shift	Comfort/social factors	Annual climate variation	Energy efficiency
2000-2012	All sectors	-28.35	88.41	-15.89	1.45	23.32	12.77	-138.40
2008-2012		-70.67	-32.97	-5.18	-2.66	4.42	18.32	-52.61
2000-2012	Industry	-50.08	13.30	-15.89		0.00	0.00	-47.49
2008-2012		-46.46	-27.71	-5.18		0.00	0.00	-13.58
2000-2012	Residential buildings	-5.41	12.55	0.00		23.32	12.77	-54.04
2008-2012		9.42	4.78	0.00		4.42	18.32	-18.11
2000-2012	Non-residential buildings	25.94	19.43					6.51
2008-2012		3.09	2.35					0.74
2000-2012	Transport	5.23	41.64		1.45	0.00	0.00	-37.86
2008-2012		-35.58	-12.86		-2.66	0.00	0.00	-20.06

Key point: The contribution of energy efficiency improvement to the decrease of final energy consumption was higher before 2008.

Industry is the sector with the highest decrease of final energy consumption as a result of efficiency improvement and structural changes before 2008 and mainly the decrease of activity level in the period 2008-2012.

Transport sector experienced an increase of its final energy consumption over the period 2000-2012. Since 2008, the sector is the second contributor to the decrease of the overall final energy consumption mainly as a result of energy efficiency improvement.

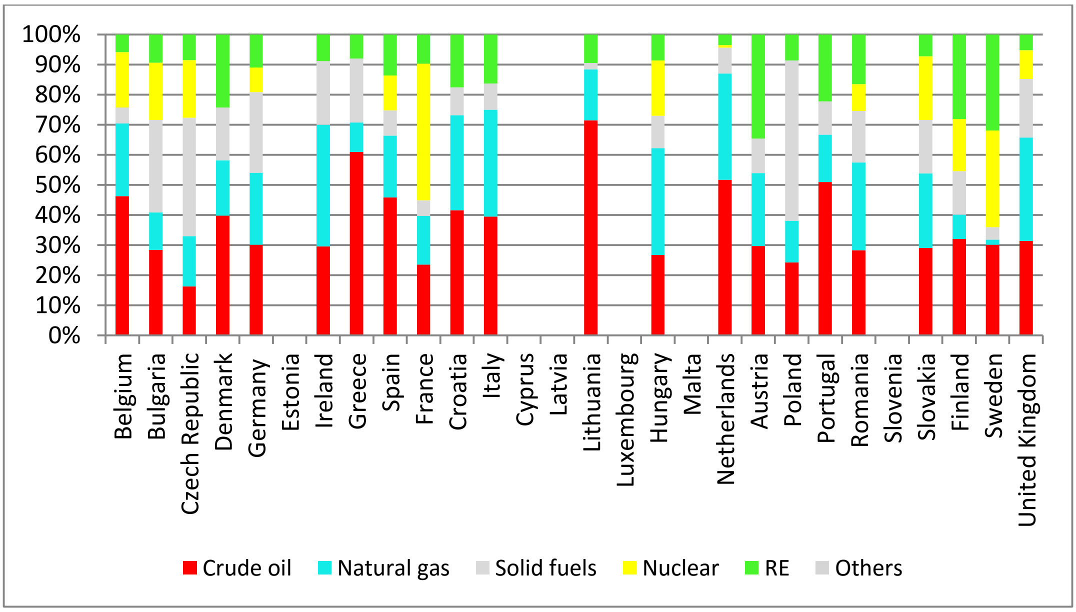
The building sector (residential and non-residential) had the lowest contribution to the decrease of final energy consumption over the period 2000-2012 as a result of the increased level of activity mainly in non-residential buildings, especially before the economic crisis. Efficiency improvement was higher in residential buildings than in non-residential ones.

Source: Study evaluating the current energy efficiency policy framework in the EU and providing orientation on policy options for realising the cost-effective energy efficiency/saving potential until 2020 and beyond (Fraunhofer ISI, 2014) https://ec.europa.eu/energy/sites/ener/files/documents/2014_report_2020-2030_eu_policy_framework.pdf

Trends per Member State

The energy mix varied widely at Member State level in 2013, with oil the dominant fuel in 11 of the 22 Member States for which a breakdown is available. Oil accounted for the highest proportion of consumption in Lithuania (70%) and the lowest in the Czech Republic (16%). Natural gas was the dominant fuel in Ireland, Hungary, Romania and Bulgaria, while its contribution to Sweden's national energy mix was less than 2%.

Figure 1.2 Breakdown of primary energy mix in selected Member States (2013)



Key point: Fossil fuels were the dominant fuels in 20 Member States among the 22 countries where breakdown was available for 2013.

Source: Eurostat: Complete energy balances - annual data [nrg_110a]
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_110a&lang=en

In 2013, solid fuels' share of total energy consumption was over 50% in Poland, over 40% in the Czech Republic and over 30% in Bulgaria. France is the country where nuclear energy was the dominant fuel, satisfying more than 45% of total energy demand, Sweden was the country for equal share of nuclear and renewables, 32% each. Renewables contributed for 35% in Austria and over

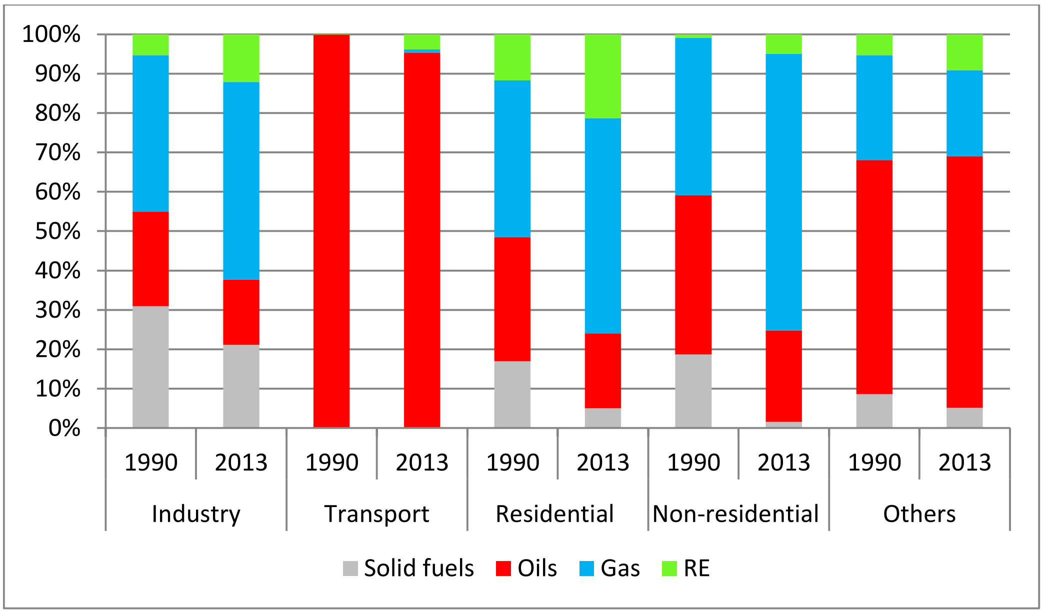
20% in Denmark, Portugal and Finland. The lowest contributions of renewables to the primary energy mix were observed in the United Kingdom, the Netherlands and Belgium (Figure 1.2).

Oil consumption declined in 13 countries over the 1990-2013 period. The biggest drops were observed in the UK and France (23%), followed by Italy (19%). Poland stands out as the country in which oil consumption almost doubled. The general decline is the result of fuel-switching policies whereby some Member States have promoted the use of gas and, more recently, renewables in power generation, but also of refinery closures (EC, 2014-a).

Trends per end-use sectors

Final EU energy consumption was 1104 Mtoe in 2013, 20 Mtoe more than in 1990. Buildings (residential and non-residential) and transport accounted for almost three quarters of this, up from 61% in 1990. Over the period, the proportion accounted for by the buildings sector rose from 35.4% to 37.7%, making it the largest single energy consumer in Europe, while industry's share of final energy consumption fell from 34% to 25%. Transport was responsible for 78% of oil products consumption, while buildings (residential and non-residential) used the most gas (62%), electricity (60%), heat (68%) and renewables (57%). Industry had the highest use of solid fuels (73%).

Figure 1.3 Breakdown of EU final energy consumption by end-use sectors



Key point: Residential and non-residential buildings used the most gas (62%), industry the most solid fuels (73%) and transport the most oil products (78%).

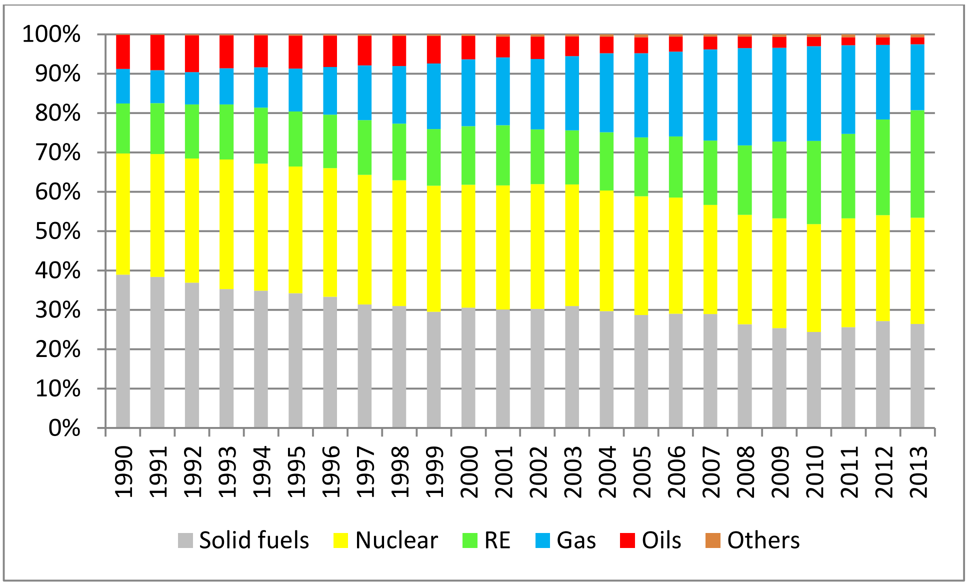
Source: Eurostat: Complete energy balances - annual data [nrg_110a]
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_110a&lang=en

Bulgaria, Estonia, Latvia, Lithuania and Romania experienced more than a 40% decrease of their final energy consumption over the period 1990-2013 as a result of the structural changes of their economies which led to more than 70% drop in final energy consumption of industry in Bulgaria, Estonia, Lithuania and Romania. Ireland, Spain, Cyprus, Malta and Austria experienced an increase of more than 40% of their final energy consumption as a result of the increased consumption by more than 50% in the building sector (residential and non-residential) in Spain, Cyprus, Malta and Austria as well as the increased consumption by more than 70% of the transport sector in Ireland and Austria. Final energy consumption remained stable in the United Kingdom while it varied by less than 6% in Denmark, Croatia, Germany, Poland and Sweden over the same period.

Trends in power generation

Among final forms of energy, electricity production saw the highest increase (26%), to reach 3262 terawatt hours (TWh) by the end of the period. Over 50% of the EU gross electricity production was solid fuels and nuclear-based in 2013, although their contributions to the power generation energy mix had decreased from 39% to 26% and 31% to 27% respectively. The contribution of renewables to gross electricity production saw the highest increase (from 13% to 27%), followed by gas (from 9% to 17%). The contribution of oil products to electricity generation fell from 9% to 1% (Figure 1.4).

Figure 1.4 EU primary energy mix in power generation, 1990-2013



Key point: Over 50% of the electricity produced in the EU was solid fuels and nuclear-based, while 27% was from renewable energy sources in 2013.

Source: Eurostat: Complete energy balances - annual data [nrg_110a]
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_110a&lang=en

The share of solid fuels in electricity production decreased in all Member States, with the largest drop (-56%) in Malta. This was offset by an increase in the share of oil (+54%). The proportion of nuclear-based electricity production remained stable in France, at around three quarters; the biggest decrease was observed in Lithuania (-60%) and the highest increases in Romania (+20%) and the Czech Republic (+19%). The share of renewables in electricity production increased in almost all Member States. The highest increase (over 40%) was observed in Denmark and the lowest (less than 1%) in Malta. As regards the share of gas, the largest increase was observed in the UK (+25%), followed by Lithuania (+23%) and Ireland (+19%), and the biggest decrease in Austria (-4.4%).

As for electricity consumption, the changes in the structure of the EU economy, the high penetration of household appliances and consumer electronics in the buildings sector and the penetration of industrial electrical equipment led to a 28% increase over the 1990-2013 period. The increase was more pronounced in countries with substantial growth in economic activity in the non-residential sector, e.g. Ireland, Malta and Cyprus, where consumption has doubled. In contrast, countries where heavy-industry closures were not offset by activities in the non-residential sector experienced a decrease in electricity consumption. Lithuania saw the biggest drop (-25%), followed by Bulgaria (-22%) and Latvia (-21%). Overall, the highest increase (+10%) was observed in the non-residential sector and the biggest decrease (-10%) in industry.

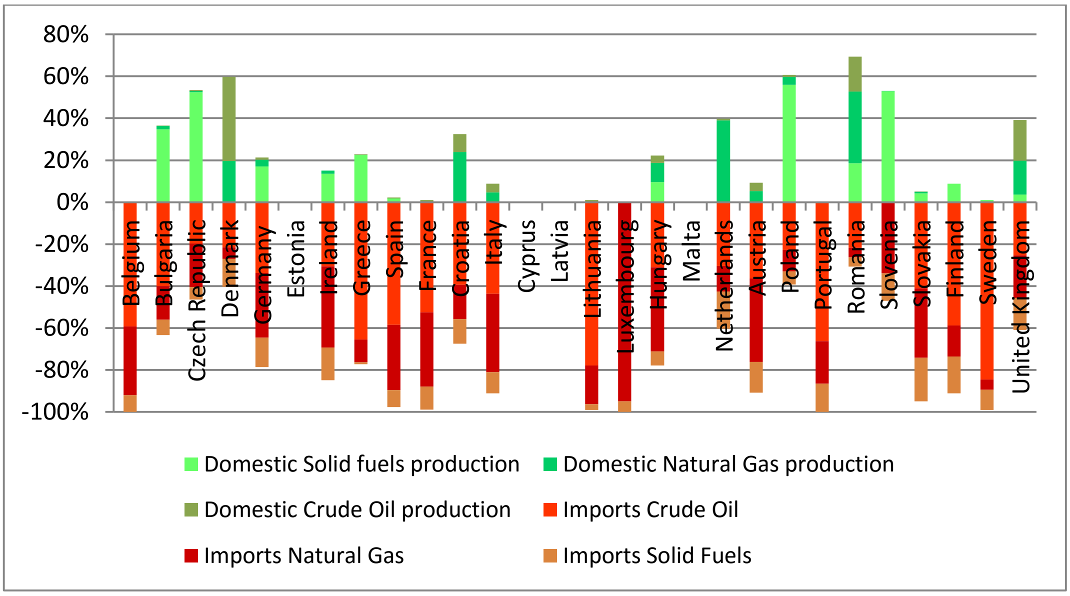
EU energy dependency

Domestic production and imports of fossil fuels

Domestic production of fossil fuels (oil, gas and solid fuels) decreased by 16% over the 1990-2013 period, with production of crude oil dropping by 47%, natural gas by 20% and solid fuels by 58%. As a result, total fossil-fuel imports increased by 31%. Gas imports doubled, while those of solid fuels increased by 30% and oil imports remained stable. The decrease in the domestic production of fossil fuels would have boosted fossil-fuel imports even more if total energy demand had not been kept stable and production from renewable energy sources not tripled (see above).

Crude oil production was 66 Mtoe in 2013, almost half of the 1990 figure. A peak of 166 Mtoe was reached in 1999. The UK was by far the largest producer of crude oil in the EU, with 60% of total EU domestic production, but its production dropped by 56%. Denmark and Italy were the two other countries with a significant contribution to EU oil production (13% and 8% respectively). Total oil imports were 530 Mtoe in 2013, 7 Mtoe less than in 1990. Germany had the highest share (17%), while Italy, France, Spain and the UK each imported 10% of the total.

Figure 1.5 Share of fossil-fuel imports and domestic production in national energy demand, 2013



Key point: At EU level, domestic production of fossil fuels decreased by 16% while imports increased by 31% between 1990-2013.

Source: Eurostat: Complete energy balances - annual data [nrg_110a]
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_110a&lang=en

EU gas production was 132 Mtoe in 2013, the lowest level in the whole period. The Netherlands and the UK were by far the largest contributors, with over 70% of the total. However, the Netherlands experienced a 13% increase in its production, while the UK saw a 20% decrease. Germany and Romania contributed 6% each to total EU gas production in 2013. Gas imports were 341 Mtoe that year, which is one of the highest volumes over the period. Germany had the highest share of EU gas imports (24%), followed by Italy (15%) and the UK (12%) (Figure 1.5).

Solid fuel production was 156 Mtoe in 2013, less than half of what it was in 1990. Poland made the highest contribution, with 36% of the total, followed by Germany (29%) and the Czech Republic (11%). Like most Member States, these three major producers experienced mine closures during the period (EC, 2014-a) and production dropped by 42% in Poland, 63% in Germany and 51% in the Czech Republic. Solid fuel imports were 165 Mtoe in 2013, the highest level over the period. In 2013, Poland imported 16 times more solid fuels than in 1990, while Germany and the UK imported three times more and the Netherlands in 2013 twice as much.

Fossil fuels import dependency

The EU overall fossil fuels import dependency ratio (Box 1.1) reached 53.2% in 2013, nine percentage points higher than in 1990. The main factors are the high proportion of fossil fuels in the energy mix and the decline of domestic fossil-fuels production (see previous section), due to the depletion of reserves and the closure of uncompetitive sources (EC, 2014-a) not being offset by a threefold increase in renewable energy production. Malta had the highest import dependency ratio for all fossil fuels combined, followed by Luxembourg, Cyprus and Ireland. Denmark had the lowest fossil fuels dependency ratio (12.3%), as it is a net exporter of oil and gas.

In 2013, the EU oil import dependency ratio was 87.4%, while the gas import dependency ratio was 65.3%, 20 percentage points above the 1990 level. The increased gas dependency made the EU (especially Member States relying on a single supplier) more vulnerable to gas supply insecurity, which is why oil emergency response mechanisms have recently been adapted to cover gas (IEA, 2014). The EU import dependency ratio for solid fuels was 44.2% in 2013; while less than that for oil and gas, it should still be noted that this is 26 percentage points higher than the 1990 level.

At Member-State level, Bulgaria, Ireland, Latvia, Luxembourg, Malta, Finland and Sweden are 100% oil dependent, while the UK became oil dependent in 2006 and its dependency reached 40% in 2013. Belgium, Estonia, the Czech Republic, Latvia, Lithuania and Portugal are 100% gas dependent, while Romania had the lowest gas dependency (11.9%) and Denmark and the Netherlands are net gas exporters. Croatia and the Netherlands are 100% solid-fuel dependent, while Poland and the Czech Republic are net exporters of solid fuels.

The sensitivity of end-use sectors and power generation to fossil-fuel supply disruptions varies across Member States. Countries such as Denmark, Ireland, Croatia, the Netherlands and Portugal, with solid-fuel import dependency ratios of over 70% and where over 20% of heat and power generation is solid-fuel-based, would be most affected by disruption to the supply of solid fuels. Countries such as Belgium, Ireland, Spain, Italy, Latvia, Lithuania, Luxembourg, Hungary and Portugal, with gas dependency of over 70% and where over 20% of heat and power generation is based on gas, would be most affected by disruption to the supply of gas. Countries such as Cyprus and Malta, with almost 100% oil dependency and where oil makes the highest contribution to power generation and heating, would be most affected in the event of oil-supply disruption. As regards end-use sectors, the buildings sector is highly sensitive to gas-supply disruption in most Member States (JRC, 2015), while the transport sector is highly sensitive to oil-supply disruption in all Member States.

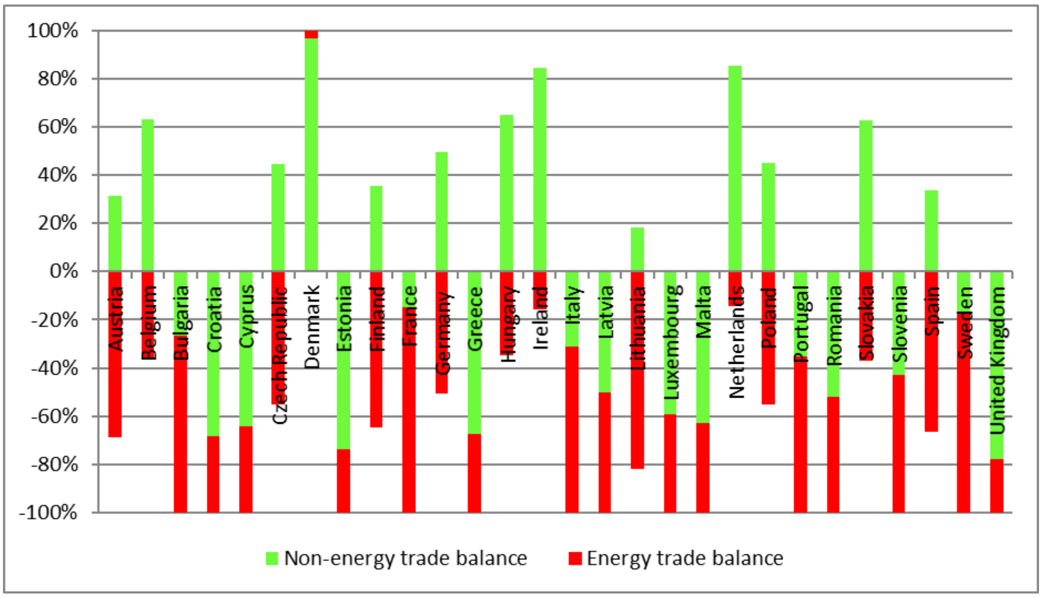
Impact of energy dependency on the EU economy

The EU high fossil fuels import dependency ratio resulted in an overall energy import bill of €385 billion in 2013, which was equivalent to 2.8% of its GDP. The EC developed a set of indicators to assess the impact of fossil fuels import bills on national economies (Box 1.3).

Energy imports had a significant impact on individual Member States' trade balances, making them more vulnerable to energy price shocks and dragging on investment in jobs and growth. Austria's, Finland's, Lithuania's, Poland's and Spain's negative trade balances were entirely due to their energy trade deficit (Figure 1.6). Denmark is the only country with a positive energy trade balance, thanks to its net exports of oil and gas. Energy imports were responsible for 85% of France's trade deficit, 73% of Bulgaria's and 65% of Italy's trade deficit (Figure 1.6).

Moreover, energy import bills as a proportion of national GDP reached 9.4% in Malta, which is almost 100% fossil fuels dependent, more than 6% in Bulgaria, Cyprus, Hungary and Lithuania, and more than 5% in Croatia, Latvia, Luxembourg, Slovakia and Slovenia. The proportion was lowest in the UK (0.9%), followed by Sweden and the Netherlands (both 1.5%), all of which have low fossil fuels dependency ratios.

Figure 1.6 Net energy and non-energy trade balances per Member State (2013)



Key point: Energy trade deficits exacerbate the total trade deficit in most Member States.

Source: Eurostat: EU trade since 1988 by SITC [DS-018995]
http://appsso.eurostat.ec.europa.eu/nui/show.do

Box 1.3 EC indicators to assess the contribution of energy products to trade

The Directorate General for Economic and Financial Affairs (DG ECFIN) of the EC developed indicators to identify the most vulnerable Member States to energy price shocks resulting from their energy trade deficits and account imbalances.

DG ECFIN organises the analysis of the contribution of energy products to trade around one key indicator (**the net energy trade balance**) and three indicators (**relative energy trade balance, share of energy trade in total trade, macro trade openness**) which result from a decomposition of the key indicator.

The (net) energy trade balance expressed as a percentage of GDP. All other things being equal, the more negative this balance, the higher the likelihood that the current account is vulnerable to energy price shocks, and hence the bigger the contribution of trade in energy products to an external imbalance.

Relative energy trade balance in terms of the size of total cross border energy trade (i.e. the sum of energy exports and imports). All other things being equal, the more energy imports outstrip energy exports relative to total trade in energy, the larger the energy trade deficit becomes and hence the more vulnerable the country is to energy shocks related to trade.

Share of energy trade in total trade; all other things being equal, the larger the share of energy in a country's international trade, the larger the impact of the relative energy trade balance is on the net energy trade balance.

Macro trade openness: the relative size of a country's international trade vis à vis the size of its economy. This indicator is not energy-related. It expresses the notion that a higher macro trade openness amplifies the effects of the previous two factors.

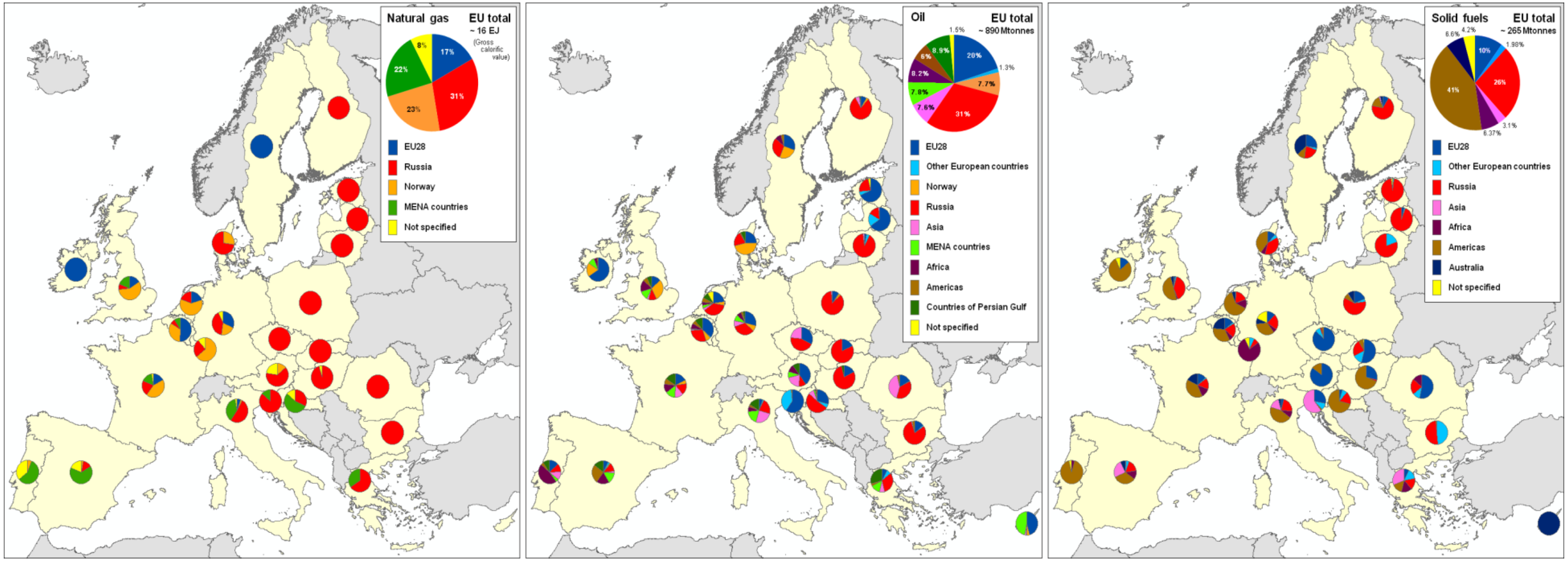
Source: Member States' Energy Dependence: An Indicator-Based Assessment, occasional papers 145 & 196
http://ec.europa.eu/economy_finance/publications/occasional_paper/2013/pdf/ocp145_en.pdf
http://ec.europa.eu/economy_finance/publications/occasional_paper/2014/pdf/ocp196_en.pdf

Diversification of energy suppliers

Russia was by far the EU main partner in terms of fossil-fuels supply in 2013. It was the source of 31% of the EU total imports of oil and gas, making it the top supplier of both. It was the second biggest supplier of solid fuels, with 26% of total imports (Figure 1.7). After the 1973-1974 oil crisis, the EU Member States successfully pursued a strategy of diversifying oil suppliers, importing from states in the Middle East and North Africa (MENA) and the Gulf countries, as well as Russia. Crude oil from these other countries accounted for 23% of total oil imports. In comparison, gas suppliers were not so diverse: Russia, Norway and MENA countries are the EU main partners for gas supply, each contributing around 23% of its total gas imports. Suppliers of solid fuels are more diverse, but the Americas were the main source, with a 41% share of total EU imports (Figure 1.7).

Bulgaria, the Czech Republic, Estonia, Latvia, Lithuania, Poland, Romania and Finland have diversified least as regards their gas imports: in 2013, they all sourced 100% from Russia. On the other hand, 100% of the gas imported by Ireland and Sweden came from within the EU. For oil, Bulgaria and Slovakia were the only Member States to rely 100% on a single supplier (Russia). However, over 80% of Hungary's, Lithuania's, Finland's, Poland's and Croatia's oil imports came from Russia, while MENA and Gulf countries supplied more than 50% of the total imported oil by Greece and over 40% of the total imported oil by Italy and France. As regards solid-fuel imports, Estonia and Latvia relied on Russia for more than 90%, while Portugal relied on the Americas for 92% of its total imports.

Figure 1.7 Origin of fossil-fuel imports by Member State (2013)



Key point: The origins of EU oil and solid-fuel imports are more diverse than those of gas imports, but Russia remains the EU main partner overall for fossil-fuel imports.

Source: Eurostat, supply, transformation, consumption — all products — annual data [nrg_100a]
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_100a&lang=en

Trends in GHG emissions

The demand restraint measures under the EU energy security strategy have had a positive impact in terms of reducing overall GHG emissions. While aimed at improving energy security, energy efficiency and fuel-switching policies contributed to the reduction of the carbon-intensity of the overall energy system in a cost-effective manner, thereby mitigating climate change.

The fall of GHG emissions in the EU cannot be ascribed only to the economic downturn since the financial crisis. In fact, total GHG emissions fell by 21.2% (EEA, 2015-a), which is equivalent to the improvement in energy intensity, while GDP increased by 45% over the period 1990-2013. Obviously, the EU climate policy instruments (Box 1.4) had a direct impact in terms of reducing GHG emissions. Also, the shift to a low-carbon economy has been accelerated by energy efficiency policies implemented over the past four decades (Box 3.1) and the climate and energy policy package adopted in 2009, with its integrated approach based on:

- a binding target of 20% reduction of GHG emissions by 2020 compared with 1990 levels;
- a binding target of a 20% share of renewables by 2020 in the energy mix; and
- an indicative target of 20% decrease of primary energy consumption by 2020 compared with a 2007 baseline.

Box 1.4 EU climate policy instruments

The two major EU climate policy instruments are the Emission Trading Scheme(ETS) and the Effort Sharing Decision (ESD).

The **Emissions Trading Scheme (EU-ETS)** was introduced by the **Directive 2003/87/EC** to deliver on the EU commitments under the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC). The objective is to reduce domestic anthropogenic GHG emissions, in a cost-effective manner, by 20 % by 2020 (as compared with 1990 levels) and by 80-95 % by 2050. The Directive was substantially revised in 2009, **Directive (29/2009/EC)**, in order to strengthen the EU-ETS from 2013.

The EU-ETS covers 45 % of domestic GHG emissions. It provides for **reduced emissions of:**

- **carbon dioxide (CO_2) from civil aviation, power and heat generation**, and energy-intensive industries such as oil refineries, steel works and the production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, acids and bulk organic chemicals;
- **nitrous oxide (N_2O) from nitric, adipic, glyoxal and glyoxlic acids**; and
- **perfluorocarbons (PFCs)** from the production of aluminium.

Participation in the scheme is **mandatory** for all companies operating in these sectors, but Member States can exempt small installations if they take alternative measures to cut their emissions. The EU-ETS is based on a **"cap and trade"** principle: each sector has an annual GHG emissions limit subject to an **EU-level cap**. Within this volume, companies receive or buy emission allowances that they can trade. Companies can also buy credits generated from projects recognised under the Kyoto Protocol **Clean Development Mechanism (CDM**) or the **Joint Implementation Mechanism (JIM**).

The development of the EU-ETS can be broken down into four phases:

i. 2005-2007: this was a learning phase in which the EU-ETS became established **as the world's biggest carbon market**, but the carbon price felt to zero in 2007 due to the high number of allowances issued;
ii. 2008-2012: in response to the collapse in the price of carbon, the number of allowances was reduced by 6.5 %. However, the financial and economic crisis led to a fall in energy demand, and thus in GHG emissions, which produced a surplus of unused allowances on the market and again reduced the price of carbon. This period saw the inclusion of the civil aviation sector and Iceland, Norway and

Liechtenstein. As in the first phase, governments issued the vast majority of allowances for free;

iii. 2013-2020: in this phase, auctioning has become the main method for allowances. As a result of the imbalance between the supply of, and demand for, allowances (see phase ii), the initial surplus of 2 billion allowances is expected to reach 2.6 billion by 2020. This imbalance is due to the mismatch between a very rigid auction supply of allowances and demand fluctuations determined by economic cycles and energy prices. The Commission has proposed short- and long-term measures to address the imbalance and preserve the incentives for low-carbon investments. The short-term measures include **postponing the auctioning of 900 million allowances** in the early part of the period; and

iv. 2021-2028: the main long-term measure would be to introduce a M**arket Stability Reserve** (MSR), mechanism from 2019 to adjust auction volumes automatically if the number of allowances in circulation falls outside a predefined range (**Decision 2015/1814**). The mechanism should help to stabilise the market by transferring allowances to the reserve from future auction volumes if the surplus exceeds 8 333 million and releasing allowances from the reserve if it falls below 400 million allowances.

The **Effort Sharing Decision (ESD) (406/2009/EC)** is the **Member States's agreement on binding annual targets** until 2020 for cutting GHG emissions compared to 2005. The targets differ according to national wealth. From a 20% cut for the richest Member States to a maximum of 20% increase for the least wealth ones. Member States report to the European Commission annually on the progress made on ESD. The first reporting is from 2013.

The **ESD covers 55 %** of domestic GHG emissions. It includes housing, agriculture, waste and transport (excluding aviation). To achieve emissions reduction various climate and energy policy instruments target each sector individually.

1. The building sector is regulated under the Energy Performance Building Directive (EPBD), the Energy Efficiency Directive (EED), the Ecodesign Directive and the Labelling Directive (see box 3.1) and to some extent the Renewable Energy Directive (RED).

2. The industry sector with industrial emissions that are not covered by the EU ETS is regulated by the **Industrial Emissions Directive, IED, (2010/75/EU).** The directive sets out the main principles for the permitting and the control of installations based on an integrated approach. The objective is to achieve a high level of environmental protection as a whole. The IED promotes energy efficiency and fuel switching.

3. The transport sector is targeted by the following regulations, directives, and decisions.

- **Regulations 443/2009 to limit CO_2 emissions of new passenger cars to a fleet** average of 130 g/km by 2015 and 95 g/km by 2021. The 2015 and 2021 targets should lead to 18% and 40% emissions reduction compared to the 2007 fleet average. This regulation has been complemented in 2014 by the **regulation 333/2014** on modalities for reaching the 2021 targets for new passenger cars.

- **Regulation 510/2011** to limit CO_2 emissions of new light commercial vehicles to a fleet average of 175 g/km by 2017 and 147 g/km by 2021. The 2017 and 2021 targets should lead to 14% and 28% emissions reduction compared to the 2007 fleet average. This regulation has been complemented in 2014 by the **regulation 253/2014** on modalities for reaching the 2021 targets for new light commercial vehicles.

- **Fuel Efficiency Directive (1999/94/EC)** which requires manufacturers to provide consumers with information on the fuel economy and CO_2 emissions of new passenger cars offered for sale or lease in the Community, by:
  - attaching a fuel consumption and CO_2 emissions label to the windscreen of each vehicle at the point of sale; this must be clearly visible and meet certain requirements. It must give estimates of fuel consumption (litres/100 km, km/l or mpg) and CO_2 emissions;
  - producing a fuel consumption and CO_2 emissions guide;
  - displaying posters in car showrooms; and
  - including fuel consumption and CO_2 emissions data in promotional material.

The Fuel Efficiency Directive is an important complementary measure designed to help car industry to meet its specific emission targets as set under regulation 443/2009.

- **Fuel Quality Directive (2009/30/EC)** introduced a binding target for fuel suppliers to reduce life-cycle GHG emissions per unit of energy from fuel and energy supplied by 6% by 2020 compared to 2010. The reduction is to be obtained through the use of biofuels, alternative fuels, electricity in road transport and/or reduction in upstream emissions such as from flaring and venting at production sites. The calculation methods and the reporting requirements have been specified in the **Directive 2015/652.**

- **Clean Vehicles Directive (2009/33/EC)** requires that energy and environmental impacts related to the operation of vehicles over their whole lifetime, including CO_2 emissions, are considered in public procurement, including public transport operators.

- **Renewable Energy Directive (2009/28/EC)** which sets a mandatory 10% minimum target to be achieved by all Member States for the share of biofuels in transport petrol and diesel consumption by 2020.

- Furthermore, several **Environmental and safety directives and regulations** such as **regulation 661/2009,** which aims at increasing the fuel efficiency of motor vehicles by introducing tyre pressure monitoring systems and gear shift indicators, contribute indirectly to CO_2 emissions reduction.

Source: summarised by the authors from various EC documents

Primary energy mix composition and its impact on GHG emissions

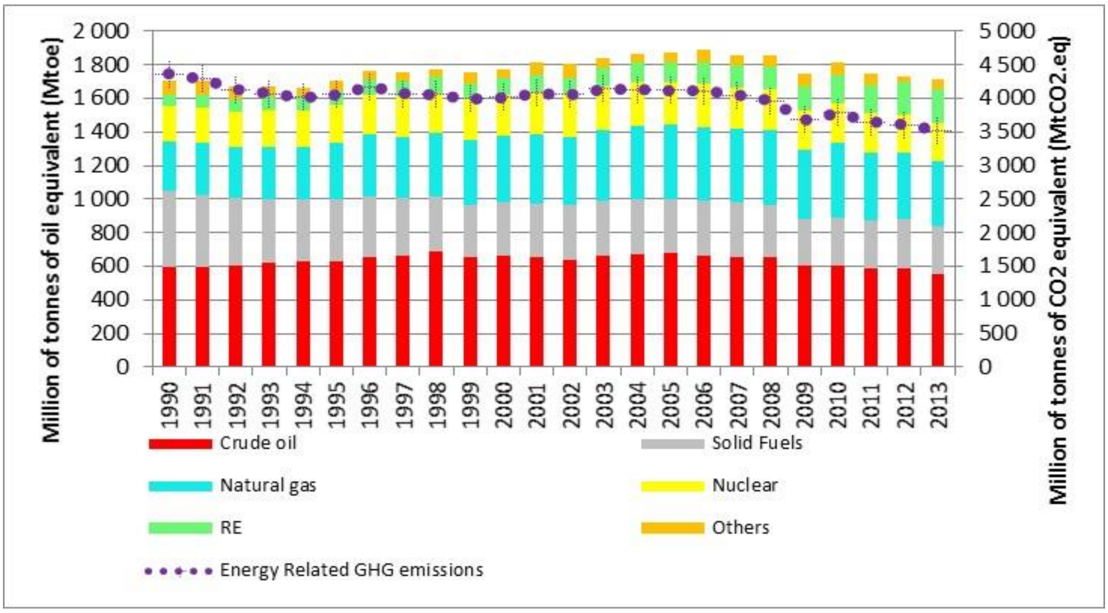
The EU total GHG emissions were 4477 $MtCO_2eq$ in 2013, 21.2% below the 1990 level (EEA, 2015-a). On the one hand, structural changes in the EU economy, the economic downturn of recent years and the implementation of energy efficiency policies over the past four decades (Box 3.1) stabilised energy demand. On the other hand, the shift from carbon-intensive to low-carbon heat and electricity production contributed to decarbonisation of the supply side. As seen above, the share of solid fuels in the total energy mix decreased by 37% over the period, while the share of gas increased by 30% and the contribution of renewables almost tripled.

However, the overall decrease in GHG emissions for the EU as a whole hides big differences among Member States. Malta and Cyprus had the highest increase, +50% and +33% respectively over the 1990-2013 period, this could be due to the increase of their energy demand (mainly oil). The biggest fall in GHG emissions was in Lithuania and Romania, -58% and -56% respectively, which also had the sharpest drop in total energy demand as a result of the structural changes of both economies. Furthermore, Romania experienced the biggest shift from solid fuels to gas. Slovenia and France are the two countries that cut GHG emissions least, -5.3% and -10.7% respectively between 1990 and 2013.

Energy-related GHG emissions include emissions from energy supply (public electricity and heat production, petroleum refining and manufacturer of solid fuels) and end use sectors (buildings, transport, manufacturing industries and construction). These sectors all together were responsible for 79% of total EU emissions in 2013, as fossil fuels made up 72% of the EU primary energy mix that year. Between 1990 and 2013, energy-related GHG emissions fell by 19.1% as a result of stable energy demand and fuel-switching policies (Figure 1.8). Emissions of EU-ETS sectors decreased by

20% while sectors covered by ESD decreased their emissions by 9.3% between 2005-2013 (EEA, 2015-b).

Figure 1.8 Impact of changes in the EU primary energy mix on energy-related GHG emissions, 1990-2013



Key point: Energy efficiency and fuel switching measures contributed to reducing energy-related GHG emissions, but such emissions still represent 79% of total EU emissions, as fossil fuels still account for 72% of the EU energy mix.

Source:
Energy mix: Eurostat, supply, transformation, consumption — all products — annual data [nrg_100a]
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_100a&lang=en
GHG emissions: Greenhouse Gas Emissions (source: EEA) [env_air_gge]
http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

The power sector is by far the largest single source of energy-related GHG emissions (40%), despite having cut these by 23.6% as compared with 1990 as a result of the fuel-switch policies and the implementation of energy efficiency measures in power generation. However, 46% of the EU electricity is still generated from fossil fuels. Countries with a high share of renewables or nuclear power, such as Sweden, Austria, Denmark and France, have the least carbon-intensive power sectors. It is in countries with a high share of electricity production from solid fuels, such as Poland, that power generation makes the biggest contribution to energy-related GHG emissions.

Transport, mainly dominated by the use of oil products, is the most carbon-intensive end-use sector, with emissions reaching 887 $MtCO_2eq$ in 2013. This represent an increase of 12.9% compared to 1990 level, making the share of transport's emissions reaching 19.8% of the total EU emissions in 2013 (EEA, 2015-a). Most of the transports' emissions are due to road transport which experienced an increase in all Member States (EEA, 2015-a).

Emissions from buildings, manufacturing industries and construction contributed by 34% to the EU energy-related GHG emissions in 2013, five percentage points less than in 1990. Emissions in these sectors fell by 28.8% in 2013 compared to 1990 level (EC, 2015-c).

GHG emissions per capita, per unit of GDP and per unit of energy

Per capita GHG emissions were 8.86 tCO_2eq in 2013, with highest (20.48 tCO_2eq) in Luxembourg followed by Estonia (16.66 tCO_2eq) and Ireland (12.85 tCO_2eq) and lowest (3.43.53 tCO_2eq) in Latvia followed by Croatia, Hungary, Romania and Sweden (less than 6 tCO_2eq). They were lower than the EU average in 15 Member States (Bulgaria, Denmark, Spain, France, Croatia, Italy, Lithuania, Hungary, Malta, Austria, Latvia, Portugal, Romania, Slovakia and Sweden) and above it in the other 13 (Belgium, the Czech Republic, Germany, Estonia, Ireland, Greece, Cyprus, Luxembourg, the Netherlands, Poland, Slovenia, Finland and the UK) (Figure 1.9).

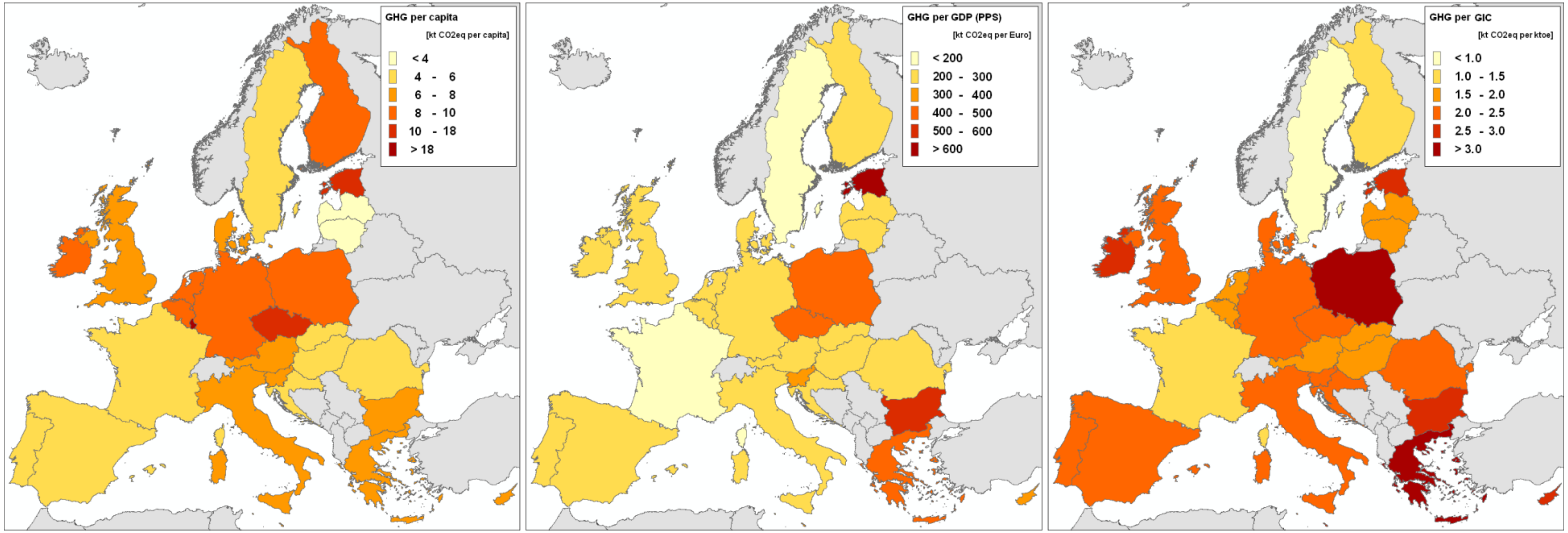
After a period of recession, the EU economy has experienced slow growth since 2011. In 2013, GDP increased by 0.2% as compared with the year before, while energy-related GHG emissions decreased by 2%. Sweden had the lowest GHG emissions per unit of GDP (132 tCO_2eq/€), followed by France (189 tCO_2eq/€), while Estonia had the highest (678 tCO_2eq/€), followed by Bulgaria (452 tCO_2eq/€). Per GDP emissions were below the EU average in 20 Member States (Belgium, Denmark, Germany, Ireland, Spain, France, Croatia, Italy, Latvia, Lithuania, Luxembourg, Hungary, the Netherlands, Austria, Portugal, Romania, Slovakia, Finland, Sweden and the UK) and above the average in eight Member States (Bulgaria, the Czech Republic, Estonia, Greece, Cyprus, Malta, Poland and Slovenia) (Figure 1.9).

Energy-related GHG emissions per unit of energy consumed were 2.06 tCO_2eq/toe in 2013. Poland had the highest (3.27 tCO_2eq/toe), followed by Greece, due in both cases to the high proportion of solid fuels used in power generation (over 80% and 40% respectively). Sweden had the lowest levels (0.85 tCO_2eq/toe), as a result of the high proportions of renewables and nuclear is used in power generation (54% and 43% respectively), followed by France (1.86 tCO_2eq/toe), due to its 74% use of nuclear power. Bulgaria, the Czech Republic, Estonia, Ireland, Cyprus and Malta had over 2 tCO_2eq/toe, due mainly to their use of solid fuels and oil for electricity production. GHG emissions per unit of energy consumed are higher in countries with energy-intensive industries such as the Czech Republic, Bulgaria, Romania and Ireland.

The EU is on track to meet its 2020 GHG emissions reduction target while decoupling growth and GHG emissions. The improvement of GHG emissions intensity is due for more than 80% to the intensity improvements in heat and power generation. With the exception of the transport sector, all other sectors experienced a decrease of their GHG emissions. The implementation of energy efficiency measures and the increased share of renewable energies in the EU primary energy mix, in order to meet the EU 2020 climate and policy targets, played an important role in the moderation of the energy demand in the end-use sectors and the use of decarbonised fuels in the supply side.

Furthermore, the EU 2020 climate and energy policy package introduced a reporting requirement on the progress towards the three 2020 targets (GHG emissions, primary energy consumption, share of renewables). The aim is to assess the progress made so far and the projected progress towards 2020 targets. These projections give a signal for further policy intervention if needed.

Figure 1.9 Energy-related GHG emissions per capita, per unit of GDP (Purchasing Power Standard) and per GIC (Gross Inland Consumption)



Key point: Per-capita and per-GDP energy related GHG emissions are lower in Member States with low share of energy intensive industries while emissions per unit of energy consumed are lower in Member States where power generation is low carbon intensive.

Source:
Energy mix: Eurostat: Supply, transformation, consumption — all products — annual data [nrg_100a]
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_100a&lang=en
GHG emissions: Greenhouse Gas Emissions (source: EEA) [env_air_gge]
http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do
Population: Eurostat: Population on 1 January Code:tps00001
http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tps00001&plugin=1
GDP: Eurostat: GDP and main components - Current prices [nama_gdp_c]
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_gdp_c&lang=en

Progress towards the EU 2020 climate and energy targets

The EU is on track to meet its 2020 GHG emissions target. Emissions reduction in 2013 were 21.2% below the 1990 level (EEA, 2015-a, EC, 2015-c), which is above the 20% reduction target set for 2020. Projections made by Member States, based on the current policies and measures, show that the EU may achieve 24% emissions reduction by 2020 compared to 1990 level (EEA, 2015-b). More than 60% of the emissions reduction between 2013-2020 are expected to take place in the ETS sectors, especially in heat and power generation. The transport sector is the only sector expected to increase its GHG emissions in 2020, 13% above the 1990 level (EC, 2015-c). Emissions reduction in the industry sector is projected to be in 2020 above the 1990 level by 29% (EC, 2015-c). As regards the national targets set under ESD, GHG emissions were in 2013 and are expected to remain in 2020 below the national annual ESD targets in 24 Member States. Projections of emissions covered by ESD in Austria, Belgium and Ireland show that they will be higher than the 2020 ESD target if no additional measures are implemented. GHG emissions covered by ESD were in Luxembourg above the 2013 national target.

The EU is unlikely to meet its 2020 energy efficiency target despite the progress made in moderating energy demand in recent years. In fact, the sum of indicative national targets reported by Member States in their 2014 National Energy Efficiency Action Plans (NEEAPs) corresponds to 17.6% primary energy saving compared to 2020 projections (JRC, 2015-c). Additional measures are therefore needed to achieve the EU 2020 energy saving target. Energy consumption reductions, both primary and final, have to be stepper in all Member States in the period 2014-2020 compared to the period 2005-2013 (EC, 2015-b). Efforts to be made to achieve national energy saving targets vary widely among Member States. Extra efforts are needed in Bulgaria, Estonia, Lithuania, Slovakia and Spain to reduce their final energy consumption, while Malta and Netherlands need to focus more on reducing their primary energy consumption and Austria, Belgium, Germany, France, Sweden and the United Kingdom need to target a reduction of energy consumption in both final and primary energy (EC, 2015-d).

The EU is on track to meet its 2020 renewable energy target of 20% share of renewables in its final energy consumption (EEA, 2015-b). However, this might be challenging in some Member States given the recent development of national policies supporting the development of renewable energy projects.

The progress made towards the 2020 climate and energy targets is encouraging, especially for what regards GHG emissions reduction and the increased share of renewables in the EU final energy consumption. However, 2020 is only an intermediate step in the EU path towards a competitive and secure low-carbon economy. To ensure the EU will meet its long-term goal of reducing its GHG emissions by 80%-95% in 2050 compared to 1990 level, in a cost effective manner, the European Council endorsed, in October 2014, climate and energy targets for 2030. As regards energy security, the European Council has accepted that moderating energy demand through enhanced energy efficiency will mitigate the EU energy dependency (EC, 2015-a), as described in the following chapter.

Chapter 2: Energy saving – the EU "first fuel"

Highlights

- Energy saving is projected to be the "first fuel" of Europe in each of the 2030 decarbonisation scenarios. In the Commission's "40% energy saving", EE40, scenario, the sum of energy saving and renewables overtake the sum of imported fossil fuels all together (oil, gas and solid fuels).
- Policy intervention is needed to finance the decarbonisation of the EU energy system. A framework for De-risking Energy Efficiency Investment (DEEI) is required. It should provide a guarantee for energy efficiency loans, thus reducing the capital cost of energy efficiency investments.
- The decarbonisation scenarios mitigate the EU import dependency. Domestic production of energy saving, renewables and the unexploited fossil fuels available in the EU could lead in the longer term to Europe being energy self-sufficient.
- The GHG emissions reduction target in EE40 is almost 6% more than the 2030 target. It is in the same order of magnitude than the IEA estimates in the "two-degrees" scenario for Europe's contribution to limiting global warming under two degrees.
- The building sector is projected to be the least emitting sector by 2030. Converting the EU building stock from being an energy consumer to being an energy producer by insulating existing buildings and integrating renewables will transform the EU building and energy landscape. The transport sector is projected to be the highest emitter in 2030.
- The decarbonisation of the EU energy system is projected to drive growth and jobs. There will be positive job creation. Job losses in utilities and energy extraction industries are projected to be largely offset by jobs to be created in end-use sectors and the sectors manufacturing efficient goods and products.

Chapter 1 presented analysis of changes in the EU energy mix in 1990-2013 and their impact on energy dependency, trade balances and each Member State's GDP. It included analysis of energy-related GHG emissions per capita, per unit of GDP and per energy unit and the progress towards the EU 2020 climate and energy targets.

This chapter analyses the impact of energy efficiency in three of the six decarbonisation scenarios considered for the 2030 climate and energy framework; the scenarios are:

i) EE27 – as adopted by the European Council (27% energy saving target);

ii) EE30 – to be borne in mind for the 2020 revision (30% energy saving); and

iii) EE40 – as called for by the European Parliament (40% energy saving) in October 2014.

The objective is to feed into the upcoming climate and energy debate a comprehensive picture of the prominent role of energy saving, as the "first fuel" of the Energy Union, in energy security, climate mitigation, jobs and growth in each of the scenarios.

The chapter is illustrated with graphs and tables based on the PRIMES, GEM-E3 and E3ME modelling results used for the impact assessment on energy efficiency and its contribution to energy security and the 2030 framework for climate and energy policy:
https://ec.europa.eu/energy/sites/ener/files/documents/2014_eec_ia_adopted_part1_0.pdf

The framework strategy for a resilient Energy Union with a forward-looking climate-change policy called for a fundamental rethinking of energy efficiency and for energy saving to be valued by treating energy efficiency as an energy source in its own right (EC, 2015-a). Furthermore, the objective of the Energy Union is to provide EU citizens and businesses with secure, sustainable, competitive and affordable energy, thus reducing the scale of the "energy trilemma" (i.e. the difficulty of finding secure energy supplies and catering to rising demand without prices becoming unaffordable, at the same time as reducing greenhouse gas emissions). Energy efficiency is one of the policy instruments needed to shift the EU economy from one driven by imported fossil fuels to one based on domestic low-carbon and climate-friendly energy sources. The impact of energy saving in making the EU economy low-carbon is amplified when combined with an increased share of renewables in the EU primary energy mix, as described in the following sections.

Energy efficiency is the ratio between an energy service delivered and the energy input used to deliver it. The less energy consumed in delivering an energy service, the more efficient is the technology and/or energy system used. One can improve efficiency with or without changes to the fuel and/or technology used. For example, fluorescent lamps can be replaced by LEDs, or a conventional boiler by a condensing boiler, using the same fuel. Similarly, efficiency can be improved by better energy management of industrial processes. Replacing an oil-fired boiler by a heat pump or a combustion engine car by an electric one are examples of efficiency improvement as the combined effect of fuel and technology shifts (IEA, 2012).

Energy saving could also come from changes in economic activity and other socio-economic parameters, such as population growth and the level of end-user's prices. For the purpose of this report, energy saving generated by fuel and technology shifts are considered brought about by energy efficiency policies. Those driven by socio-economic changes are assumed to be the same across the three scenarios considered in the study.

The analyses presented in this chapter are based on the modelling results used for the impact assessment accompanying the Commission's Communication to the European Parliament and the Council on *Energy efficiency and its contribution to energy security and the 2030 framework for climate and energy policy* (EC, 2014-b). However, while the impact assessment included six decarbonisation scenarios with energy saving projections to 2030 and 2050, this report includes the projections to 2030 only, under the following three scenarios:

- EE27: 27% energy saving, which corresponds to the current efficiency target set by the European Council in October 2014;
- EE30: 30% energy saving, which is the possible target to be considered when the climate and energy policy framework is reviewed in 2020; and
- EE40: 40% energy saving, as called for by the European Parliament when the impact assessment was presented in October 2014.

The analyses show the contribution of each decarbonisation scenario to reducing the scale of the "energy trilemma" by limiting the rise in the EU energy dependency, reducing GHG emissions and limiting the impact of energy price fluctuations on businesses and households. Where possible, a monetary value is placed on the energy saving.

The analyses of the energy system are based on an update of the PRIMES 2013 "EU energy, transport and GHG emissions — trends to 2050" reference scenario. Policy measures adopted between spring 2012 and January 2014 have been taken into account in the update. It is assumed that existing energy efficiency measures will remain in place until 2020 and be intensified between 2020 and 2030. Energy saving in 2030 are calculated, in the reference scenario as well as in the decarbonisation ones, relative to the energy consumption projected in PRIMES 2007 for that year. For each scenario, the model simulates a new equilibrium in the energy market, taking into account the impact of lower energy demand on GHG emissions and consequently on the emissions trading scheme (ETS), energy prices and the need for new power plants. The economic analyses are based on an assessment of the overall economic impact of each scenario using two different models, E3ME (post-Keynesian) and GEM-E3 (general equilibrium) (Box 2.1).

Box 2.1 Analytical framework

The analyses of the three scenarios are based on the results of various models:

- as regards the impact of energy efficiency measures on the overall energy system, GHG emissions, investment needs and overall energy system costs: the **PRIMES** model (a partial-equilibrium model of the energy system) was used. For each scenario, PRIMES offers consistent projections (not forecasts) based on the reference scenario. It was used for setting the 2020 targets, the low-carbon economy and energy 2050 roadmaps and the 2030 framework for climate and energy;

- for the macro-economic impacts of the implementation of energy efficiency measures:

    - **E3ME**: a post-Keynesian model based on the assumption that investment in one sector does not automatically lead to a crowding effect on investment in other sectors was used. Energy efficiency measures are financed by ETS allowances;

    - **GEM-E3**: a general equilibrium model which assumes that capital markets operate in an optimal manner, so that additional investments in energy efficiency imply lower capital availability in other sectors was used. Governments use ETS revenues to lower employers' social security charges.

The projections analysed are those to 2030. Each scenario involves a strengthening of current energy efficiency policies, including the Energy Efficiency Directive, the Energy Performance of Buildings Directive (EC, 2010-a) and the measures under the Ecodesign (EC, 2009) and Labelling Directives (EC, 2010-b). For the transport sector, the measures considered are those included in the 2011 White Paper (EC, 2011-b).

The non-policy assumptions are similar to those made for the 2030 Communication. The model assumes GDP growth of 1.6% a year and population growth of 0.2% per year in 2020-2030. Degree days are kept constant at the 2005 level. GHG emissions reduction target was 40% and the share of renewables in the energy mix put at 27%.

Fossil-fuel prices are as used for the 2030 Communication, i.e. €93/boe for oil, €65/boe for gas and €24/boe for coal.

The scenarios are set in enabling conditions. In each case, the policy assumptions are those that are economically viable for each sector (see Table 2.1).

The system cost is calculated using standard (un-lowered) private discount rates (8% for public transport, 9% for power generation, 12% for industry, trucks and inland navigation and 17.5% for passenger cars).

Table 2.1 Policy and financial assumptions by scenario and sector

Policy assumptions	EE27	EE30	EE40
Buildings: - annual renovation rate	• 1.48% (2015-2020) • 1.84% (2021-2030)	• 1.61% (2015-2020) • 2.21% (2021-2030)	• 1.65% (2015-2020) • 2.42% (2021-2030)
- discount rate reduction	• from 12% to 10.5% (residential sector) • from 10% to 9.2% (non-residential sector)	• from 12% to 10% (residential sector) • from 10% to 9% (non-residential sector)	• from 12% to 10% (residential sector) • from 10% to 9% (non-residential sector)
- % of households connected to district heating in 2030	• 11%	• 12%	• 14%
Products:	Increased uptake of: • advanced technologies; • BAT in industry	Increased uptake of: • advanced technologies; • BAT in industry	Increased uptake of: • advanced technologies; • BAT in industry
Transport • passenger cars • LCVs	• 75gCO2/km • 110 gCO_2/km	• 72gCO_2/km • 110 gCO_2/km	• 70gCO_2/km • 110 gCO_2/km
Grid	Measures limiting losses	Measures limiting losses	Measures limiting losses

Source: Impact assessment accompanying the document from the Commission to the European Parliament and the Council Energy efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy. https://ec.europa.eu/energy/sites/ener/files/documents/2014_eec_ia_adopted_part1_0.pdf

EU energy mix by 2030

Per fuel

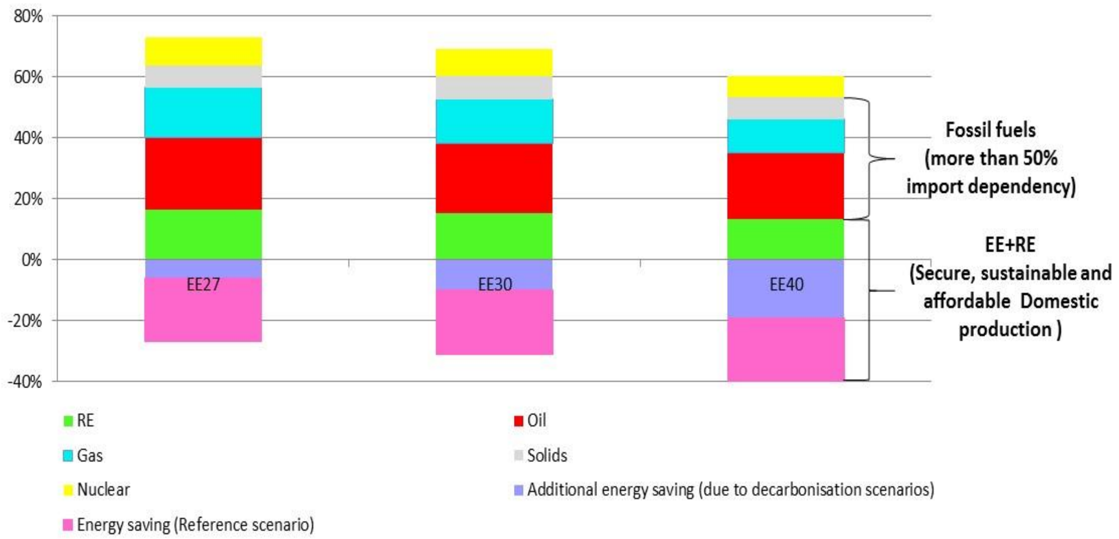
The projected intensification of energy efficiency policies after 2020 would reduce the growth of primary energy demand in absolute terms, as compared with the reference scenario, by 7.6% in EE27, 13% in EE30 and 24% in EE40, making energy saving the “first fuel” of the EU in 2030 in each of the three scenarios (Figure 2.1). In the EE40, the sum of energy saving and renewables will overtake the sum of imported fossil fuels all together (oil, gas and solid fuels). This would reflect:

- increasing renovation rates accelerating the improvement of building envelopes;
- the penetration of efficient appliances and equipment (as the least efficient are gradually phased out under ecodesign measures);
- the use of more efficient vehicles;
- more efficient power generation and fuel switch;
- reduced losses; and

In each scenario, oil is projected to be Europe's second fuel in 2030 in absolute terms, followed by renewable energies and gas. Compared with the reference scenario, oil demand is projected to decrease in absolute terms by 7.3% in EE27, 10.6% in EE30 and 14.8% in EE40, reflecting the stringency of CO_2 standards for LCVs. Gas is the fossil fuel that should see the biggest drop in absolute terms, reflecting the decrease in heating demand due to higher building renovation rates.

As compared with the reference scenario, gas demand falls, in absolute terms, by 15.5% in EE27, 25.6% in EE30 and 43% in EE40.

Figure 2.1 Primary energy mix in 2030 in the EE27, EE30 and EE40 scenarios



Key point: Energy saving is projected to be, in absolute terms, the EU "first fuel" in all three scenarios in 2030. In EE40, the sum of energy saving and renewable energies overtake the sum of imported fossil fuels all together (oil, gas and solid fuels).

Source: PRIMES results included in the impact assessment accompanying the communication from the Commission to the European Parliament and the Council on energy efficiency and its contribution to energy security and the 2030 framework for climate and energy policy
https://ec.europa.eu/energy/sites/ener/files/documents/2014_eec_ia_adopted_part1_0.pdf

The share of renewables in each scenario is based on the binding target considered in the 2030 Communication, i.e. 27.7% in EE27 and EE30, and 27.4% in EE40. However, in absolute terms, the contribution of renewables to the primary energy mix depends on the energy saving target: the more ambitious the energy saving target, the lower is the contribution in absolute terms of renewables.

The share of solid fuels is projected to decrease, in absolute terms compared to the reference scenario, by 15.5% in EE27, 8.70% in EE30 and 13% in EE40, due to the low ETS prices when energy saving increase. Nuclear is the second fuel projected to see a big drop in EE40 – 32% in absolute terms as compared with the reference scenario, against 6% in EE27 and 12.4% in EE30 – reflecting the reduced need to use nuclear power for decarbonisation when stringent energy efficiency targets are implemented (EC, 2014-b).

In the EE27 and the EE30 scenarios, the sum of imported fossil fuels, in absolute terms, is projected to exceed the sum of energy saving and renewables by 143 Mtoe and 56 Mtoe respectively. On the contrary, in the EE40 scenario, the sum of imported fossil fuels all together (oil, gas and solid fuels) is projected to be 172 Mtoe lower than the sum of energy saving and renewables.

The projected reduction of primary energy demand described above would have a positive impact on the energy intensity of the EU economy. The improvement of energy intensity over the 1990-2013 period (see Chapter I) is projected to accelerate if the energy efficiency measures considered in the decarbonisation scenarios are implemented in full. The intensity improvement is projected to exceed that in the reference scenario by 4.9% in EE27, 7.8% in EE30 and 14.7% in EE40.

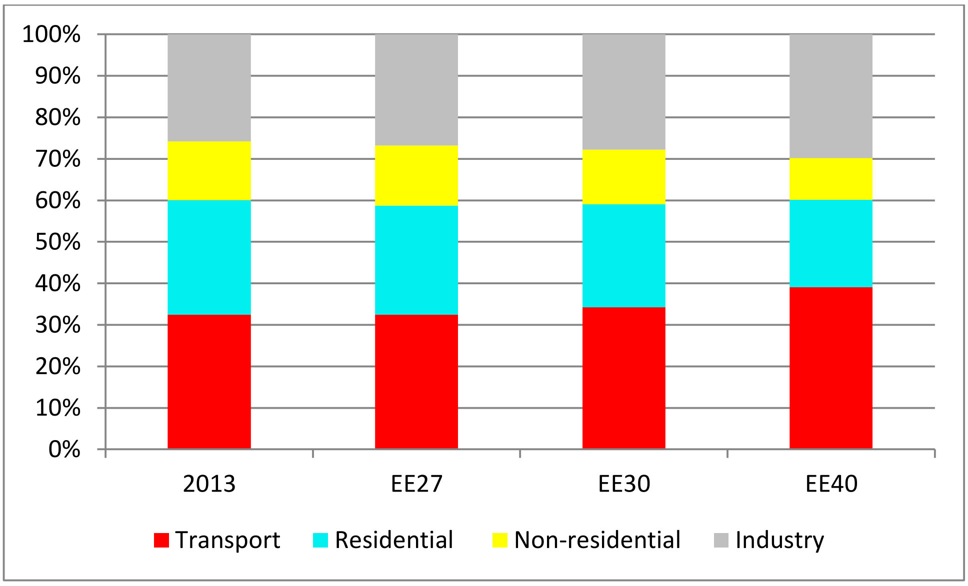
Per sector

End-use sectors

In 2013, final energy consumption in the buildings sector (residential and non-residential) reached 448 Mtoe, which was equivalent to 41% of the EU total. Given the projected rise in building renovation rates and the implementation of "nearly zero" energy requirements for new buildings after 2021, final energy consumption in the sector (and its share of the total) is projected to fall in each of the three decarbonisation scenarios. Compared with the reference scenario, the absolute final energy consumption of residential buildings is projected to fall by 2030 by 8% in EE27, 18% in EE30 and 39% in EE40, while for non-residential buildings the projected decrease, as compared to the reference scenario, is 10% in EE27, 23% in EE30 and 48% in EE40.

The second sector projected to experience a sharp decrease in its final energy consumption is industry, with a drop in absolute terms compared with the reference scenario of 9.4% in EE27, 11% in EE30 and 17% in EE40. Transport is the sector projected to experience the smallest decrease compared to the reference scenario: 4.5% in EE27, 4.8% in EE30 and 5% in EE40.

Figure 2.2 End-use sectors' shares of final energy consumption, 2013 and 2030 (EE27, EE30 and EE40 scenarios)



Key point: The building sector's share of total final energy consumption in 2030 is projected to be 41% in EE27 (as in 2013), 38% in EE30 and 31% in EE40.

Source:
For EE27, EE30 and EE40 scenarios: Primes results included in the impact assessment accompanying the communication from the Commission to the European Parliament and the Council on energy efficiency and its contribution to energy security and the 2030 framework for climate and energy policy
https://ec.europa.eu/energy/sites/ener/files/documents/2014_eec_ia_adopted_part1_0.pdf

For 2013: Eurostat: Complete energy balances - annual data [nrg_110a]
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_110a&lang=en

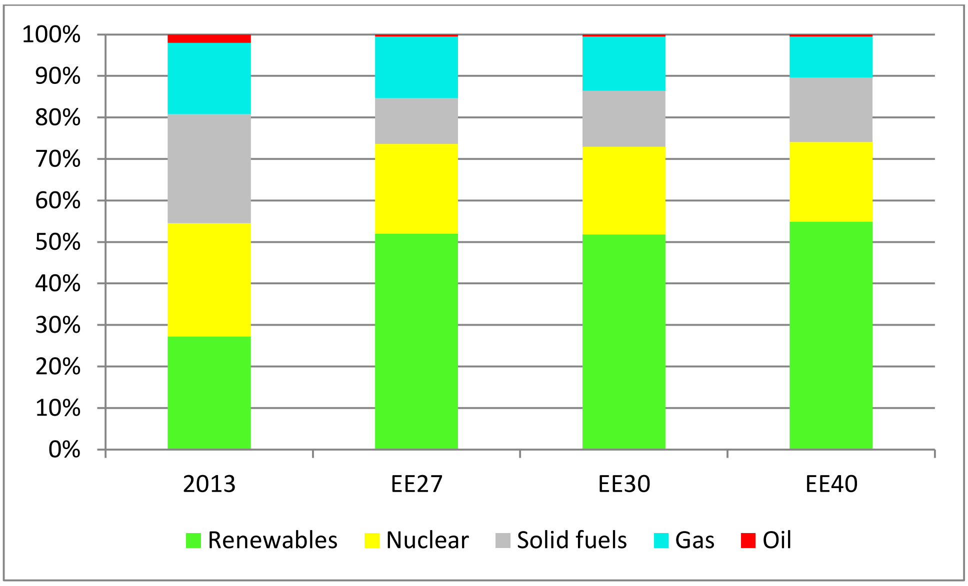
As a result, the end-use sectors' respective shares of final energy consumption in 2030 should differ from those in 2013 (Figure 2.2). Transport has the highest share of the total, 39.1%, in EE40. The building sector's share is 41% in EE27 (as in 2013), 38% in EE30 and 31% in EE40. Compared with 2013, industry will see its share increase slightly, but it will remain the smallest, with 26.8% in EE27, 27.8% in EE30 and 29.8% in EE40.

Power generation

Growth in the demand for electricity is slowing as a result of the use of energy-efficient appliances, lighting and industrial equipment, combined with automation, such as active controls for lighting, motors and cooling products. As a consequence, the need to expand power generation capacity is reduced in absolute terms as compared with the reference scenario, by 5% in EE27, 9% in EE30 and 23% in EE40.

Also, the strategy of decarbonising power generation makes renewable energies the first fuel in the electricity generation in each of the decarbonisation scenarios by increasing their share from 27% in 2013 to 51.7% in EE27, 51.5% in EE30 and 54.6% in EE40 (Figure 2.3). Among renewable energy sources, wind power is projected to have the highest share (between 24.8% in EE27 and 25.2% in EE40), followed by hydro (11.5% in EE27 and 13.9% in EE40). Nuclear is projected as the second fuel for power generation (21.5% in EE27, 21% in EE30 and 19.1% in EE40).

Figure 2.3 Primary energy mix in power generation in 2013 and 2030 (EE27, EE30 and EE40 scenarios)



Key point: Renewables are projected to be the first fuel for power generation, with a share of over 50% of the primary energy mix in power generation in 2030 in each scenario.

Source:
For EE27, EE30 and EE40: PRIMES results as used in the impact assessment accompanying the Commission's Communication to the European Parliament and the Council on *Energy efficiency and its contribution to energy security and the 2030 framework for climate and energy policy*.
https://ec.europa.eu/energy/sites/ener/files/documents/2014_eec_ia_adopted_part1_0.pdf
For 2013: Eurostat: Complete energy balances - annual data [nrg_110a]
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_110a&lang=en

Compared with 2013, the main shift is between renewables and solid fuels. While renewables' share in power generation is projected to increase to minimum 51.7%, that of solid fuels is projected to decrease from 26% in 2013 to 10.9% in EE27, 13.4% in EE30 and 15.5% in EE40. The higher figures for solid fuels in EE30 and EE40 could be explained by the low carbon prices 25€/tCO_2eq. and 6€/ tCO_2eq. respectively compared to 39€/ tCO_2eq. in the EE27. The share of gas is projected to decrease in all scenarios - to 14.8% in EE27, 13% in EE30 and 9.8% in EE40 while it was at 17% in 2013; in absolute terms, the contribution of gas is almost equal to what it was in 2013 in EE27, but projected at half that level in EE40.

Investments needs to decarbonise the EU energy system

Investments needs are the sum of technology and financial costs. Technology costs such as insulation and efficient equipment and cars have felt over the past decades. Ambitious energy saving targets and effective implementation of those targets could further reduce technology costs. This is particularly true in sectors such as the building one if an industrialised process of energy renovation is implemented, energy renovation kits are developed and skills are upgraded (JRC, 2015-a). The challenge of scaling-up the transition towards a decarbonised energy system in Europe is not related to technology costs. It is mainly related to securing long-term affordable finance. Financing cost is the main parameter that boosts or hinder energy efficiency investments (JRC, 2015-b).

The overall estimates of investment needs resulting from PRIMES for the period 2011-2030 range from an annual average of 2069 € billion in the EE27 to 2181 € billion in the EE40. This cost includes the capital cost, the direct energy efficiency investment and the energy purchases cost.

- Capital cost includes the financing cost of debt and equity. The higher is the interest rate considered, the higher is the capital cost and the less attractive is the investment for investors (JRC, 2015-a-b; ECOFYS, 2015-a-b).
- Direct energy efficiency investment represents the technology cost. It includes the cost related to investment in insulation and efficient equipment for buildings and industry. Investment needs for efficient transport are included only in the capital cost.
- Energy purchases cost includes energy cost and the capital cost for investment on power and gas infrastructure, refineries and fossil fuel extraction.

Achieving the projected cuts in energy demand and CO_2 emissions in each of the decarbonisation scenarios, as described above, will require additional average annual direct energy efficiency investments compared to the reference scenario of €17 billion in EE27, €54 billion in EE30 and €181 billion in EE40 (Table 2.2). Two thirds of the additional investment would be allocated to the building sector, as energy saving scenarios focus mainly on reducing energy demand in that sector by increasing renovation rates so as to cut the demand for heating and reducing electricity demand through the faster deployment of more efficient appliances. However, as shown in previous analysis the affordability of energy renovation by the EU citizens is questionable (JRC, 2015-a). Policy instruments such as energy performance contracts and third party financing are needed to finance the up-front cost and financial instrument such as a loan-guarantee will be required to lower the financing cost of energy renovation (JRC, 2015-a).

The decrease of energy purchases cost compared to the reference scenario range from 32€ billion in the EE27 to 89 € billion in the EE40 scenario (Table 2.2) as a result of reduced energy demand. However, given that the PRIMES results include in the energy purchases the capital cost due to infrastructure, the cost savings resulting cannot be used to conduct costs/benefits analysis. Analysis of the increase of the capital costs cannot be used either as the information provided do not allow to separate the cost of investment from the financing cost.

Table 2.2 Additional investment needs in the EE27, EE30 and EE40 scenarios compared to the reference scenario

Average annual 2011-2030 (€ billions)	EE27	EE30	EE40
Capital cost	+17	+19	+15
Direct energy efficiency investments	+17	+54	+181
Energy purchases	-32	-53	-89

Key point: The amount of additional investment needs compared to the reference scenario require policy intervention to finance the decarbonisation of the EU energy system.

Source: PRIMES results as used in the impact assessment accompanying the Commission's Communication to the European Parliament and the Council on *Energy efficiency and its contribution to energy security and the 2030 framework for climate and energy policy*.
https://ec.europa.eu/energy/sites/ener/files/documents/2014_eec_ia_adopted_part1_0.pdf

Costs-benefits analysis of the decarbonisation scenarios

Energy efficiency is not an end. It is a mean to achieve governmental policy targets in terms of climate change mitigation, security of energy supply, competitiveness, innovation and growth. Like for education, health and security of citizens, investing in the decarbonisation of the EU energy is a societal responsibility tough individuals have a role to play in the use of a decarbonised energy system when it is in place.

The scale of additional investment needs, compared to the reference scenario, (Table 2.2) estimated in the impact assessment for the decarbonisation of the EU energy system makes it clear that private finance must be at the forefront. However, given the perceived risk by investors, financing costs of energy efficiency investments is higher than financing energy supply. Financing cost (debt and equity) is the main determinant of the competitiveness of energy efficiency investment versus investment in power and heat generation. It reflects the existing and/or perceived barriers (see Chapter III) and their associated risks by investors. Policy and financial de-risking instruments are therefore needed to leverage public-private finance, reduce the perceived risk by investors and overcome the identified barriers to energy efficiency investments (see chapter III).

Costs-benefits analysis, based on the methodology developed by DG REGIO (EC, 2014-f), of the decarbonisation scenarios is needed to assess the opportunity cost. The aim would be to better estimate the potential gain from the most ambitious energy saving scenarios compared to the less ambitious ones. The EC methodology allows to value the social opportunity costs given that the return on investment is considered as a proper measure of the projects' contribution to the long-term social welfare (EC, 2014-f). It recommends to adopt the long-term perspective, set a proper time horizon and adopt appropriate discount rates to calculate the present value of futures costs and benefits (EC, 2014-f).

Given the lack of availability of input data used by PRIMES, conducting a proper costs-benefits analysis of the decarbonisation scenarios is currently not possible. For the purpose of this report the only input data used for costs-benefits analysis, without taking a risk of confusing the readers, are those related to the average annual direct energy efficiency investment, the average annual fossil fuels import bill savings and the ETS carbon prices considered in each of the three decarbonisation scenarios (Table 2.3).

As demonstrated in previous sections, primary energy demand is projected to fall by 7.6% in EE27, 13% in EE30 and 24% in EE40, as compared with the reference scenario. As a result, fossil-fuel imports are reduced, as compared to the reference scenario by 11% in EE27, 15.2% in EE30 and 23.1% in EE40, and the corresponding import bills savings by €14 billion in EE27, €20 billion in EE30 and €27 billion in EE40 (Table 2.3). Similarly, gross electricity generation is projected to fall. Consequently, less investment is needed in energy supply and infrastructure, thus reducing the overall cost of energy purchases compared to the reference scenario by €32 billion in EE27, €53 billion in EE30 and €89 billion in EE40. However, given that energy purchases cost include the capital cost related to investments in infrastructure, it is difficult to consider energy purchases costs savings for the purpose of costs-benefits analysis as the financial cost is embedded in the overall energy purchases costs.

Table 2.3 Costs/benefits analysis in the EE27, EE30 and EE40 scenarios

Average annual 2011-2030 (€ billions)	EE27	EE30	EE40
Direct energy efficiency investments	+15	+54	+181
Fossil fuel import bill savings	-14	-20	-27
ETS carbon price considered for the impact assessment analysis (€/t CO_2 eq.)	39	25	6
Total carbon revenues (€ billions)	68	43	113
ETS carbon price to make direct energy efficiency investments cost-neutral (€/t CO_2 eq.)	96	96	96
Total carbon revenues (€ billions) with ETS price at a price making energy efficiency investments cost-neutral	166	166	182

Key point: Higher carbon prices could offset the direct energy efficiency investments.

Source: PRIMES results as used in the impact assessment accompanying the Commission's Communication to the European Parliament and the Council on *Energy efficiency and its contribution to energy security and the 2030 framework for climate and energy policy*. https://ec.europa.eu/energy/sites/ener/files/documents/2014_eec_ia_adopted_part1_0.pdf

In the EE27 scenario, saving on fossil-fuel import bills would offset the additional direct energy efficiency investments needed to decarbonise Europe if financial mechanisms to allocate the cost savings from fossil fuel imports bills to energy efficiency investments are put in place. In fact, the costs savings come after the investment on energy efficiency is made and the cost savings benefit actors different than those who have to invest.

Regarding direct energy efficiency investments needed to finance projected energy saving in the EE30 and the EE40 scenarios, they would not be offset by fossil fuels import bill savings except if low energy prices experienced since 2014 are maintained for decades. Carbon revenues through the EU

ETS could offset the direct energy efficiency investment only if the tonne of carbon if at 96€. Making the decarbonisation of the EU energy system cost-neutral by considering higher carbon prices than those practised today is of a high risk in the absence of a binding and transparent global climate deal (OECD, 2015). Without a worldwide ambitious agreement at the 2015 Paris Climate Summit (COP21), aligning energy saving policies with carbon prices is unlikely to happen.

While taking advantage of external factors such as low-energy prices and a possible ambitious agreement at the Paris Climate Summit (COP21) should be considered, the decarbonisation of Europe cannot rely on factors under the control of third parties. The only option left to make the decarbonisation of the EU energy system cost neutral is to design an EU framework for De-risking Energy Efficiency Investments (DEEI). This framework should include i) policy de-risking instruments to remove the identified institutional and technical barriers to energy efficiency investments and ii) financial de-risking instruments to transfer the perceived risk by investors to public body and to make the cost of removing this risk shared by all actors (see Chapter III).

Energy efficiency to secure the Energy Union

Moderating energy demand reduces the need to import primary energy sources (EC, 2015), given that domestic reserves of fossil fuels have been diminishing over time (see Chapter I) and the trend is expected to continue (EC, 2014-b), except for solid fuel when ETS prices are low:

- EE27: -11% for solids, -5% for oil and -10% for gas;
- EE30: +3% for solids, -6.6% for oil and -20% for gas; and
- EE40: +0.6% for solids, -9% for oil and -38% for gas.

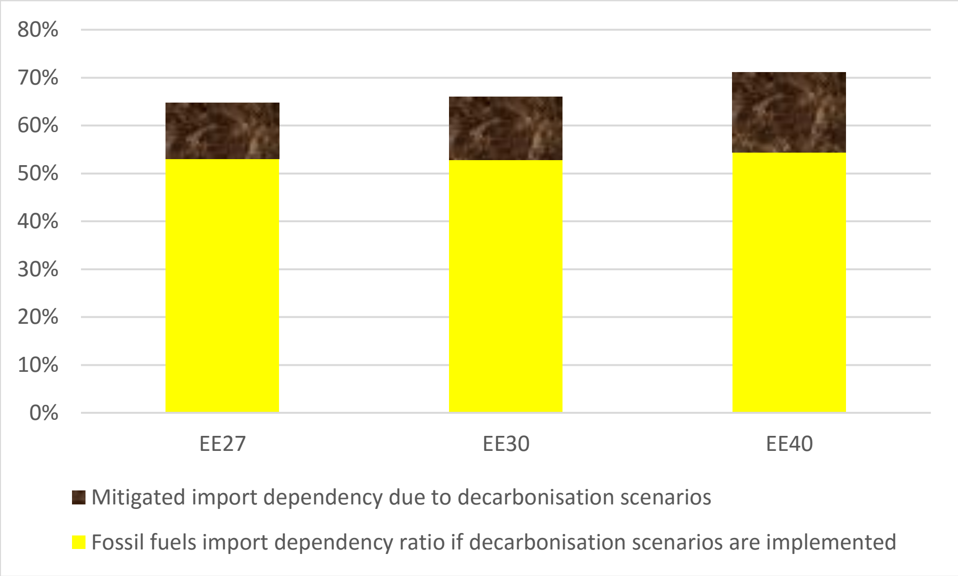
Fossil fuels are displaced by the combined increase of energy saving and renewable energies in the EU primary energy mix. However, the need to import fossil fuels is projected to increase in absolute terms compared with the reference scenario:

- EE27: +16% for solids, +7.3% for oil and +15.6% for gas;
- EE30: +7.5% for solids, +9.7% for oil and +24.9% for gas; and
- EE40: +11.6% for solids, +13.6% for oil and +42.2% for gas.

Consequently, the EU energy import dependency ratio for all fossil fuels combined will remain in 2030 at the 2013 level (53.2%). It is projected at 53% in EE27, 52.8% in EE30 and 54.4% in EE40. However, without the projected energy saving or if the full saving are not realised, it would reach 64.7% in EE27, 66.1% in EE30 and 71.1% in EE40 (Figure 2.4).

The projected decrease in fossil-fuel imports would cut energy import bills and free up resources to invest in green jobs and growth. The average annual saving in fossil-fuel import bills, as compared with the reference scenario, is projected to reach €14 billion in EE27, €20 billion in EE30 and €27 billion in EE40 (Table 2.3). Import bill savings have been calculated based on energy prices practised in 2013. The current energy prices are almost half of those of 2013. If these prices are maintained over decades, energy imports bill savings would be higher and more resources would be available for investments in energy efficiency project. However, this would be possible only if financial mechanisms to reallocate savings from imports bills to energy efficiency investments are put in place.

Figure 2.4 **Effect of EE27, EE30 and EE40 scenarios on fossil-fuels import dependency in 2030**



Key point: Decarbonisation scenarios mitigate fossil fuels import dependency.

Source:
For dependency if EE scenarios are implemented: PRIMES results as used in the impact assessment accompanying the Commission's Communication to the European Parliament and the Council on *Energy efficiency and its contribution to energy security and the 2030 framework for climate and energy policy*.
https://ec.europa.eu/energy/sites/ener/files/documents/2014_eec_ia_adopted_part1_0.pdf
For mitigated import dependency due to decarbonisation scenarios: own calculations based on Primes results mentioned above.

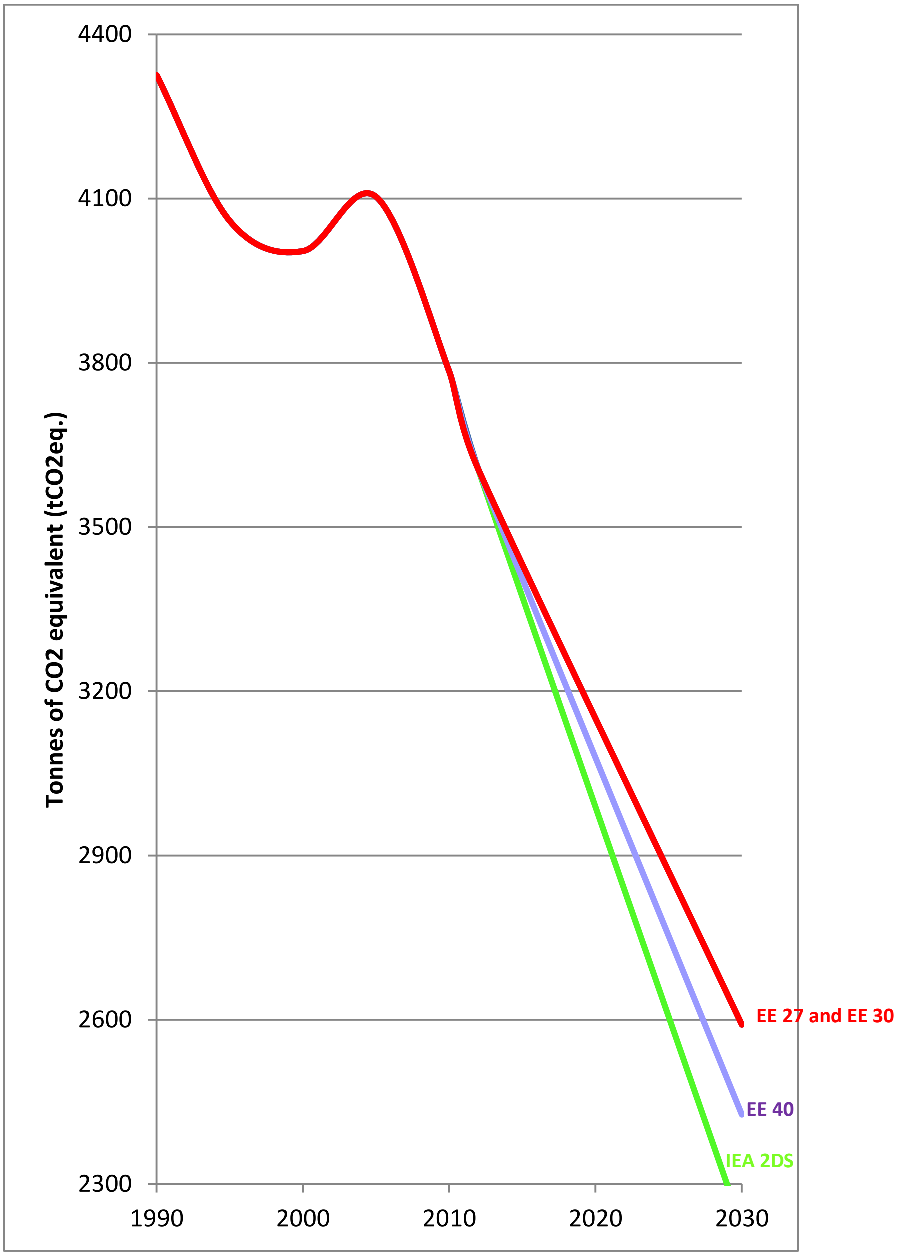
Other aspects of energy security discussed in Chapter I, such as the diversification of energy suppliers, the increase in the number of supply points, fuel stocks and building interconnectors are outside the scope of this study.

Energy efficiency to mitigate climate change

Reductions in GHG emissions as a result of energy efficiency measures can lead to direct and indirect emissions saving. The direct saving come from using less fossil fuels for the same energy service, while indirect saving are the emissions in power generation avoided due to lower heat and electricity demand in the building and industry sectors (IEA, 2012). The overall reduction of final energy demand in those sectors by reducing the heating needs of existing buildings and electricity demand through the faster deployment of best available technology (BAT) in both sectors would be reflected in a reduction of energy-related CO_2 emissions.

GHG emissions reduction in the EE27 and the EE30 scenarios are in line with the objective of a 40% reduction in GHG emissions set in the 2030 framework for climate and energy policy. In EE40, such reductions are projected to reach 44% as compared with 1990 levels, i.e. almost 6% more than the 2030 target. This is in the same order of magnitude than the International Energy Agency (IEA) estimates for the contribution of the EU to keep global warming under the two degrees Celsius (IEA, 2015). Although the modelling methodologies and the assumptions behind PRIMES model and the IEA-Energy Technology Perspectives (ETP) model are not fully comparable. The level of ambition in emission reduction resulting from the IEA modelling confirms that the proposed EU emissions reduction is the path towards the decarbonisation of the EU economy (Figure 2.5).

Figure 2.5 GHG emissions in the EE27, EE30 and EE40 scenarios compared with the IEA "two-degrees" scenario (2DS)



Key point: Emissions reduction in the EE40 are in the same order of magnitude than those estimated by the IEA-2DS (two degrees scenarios)

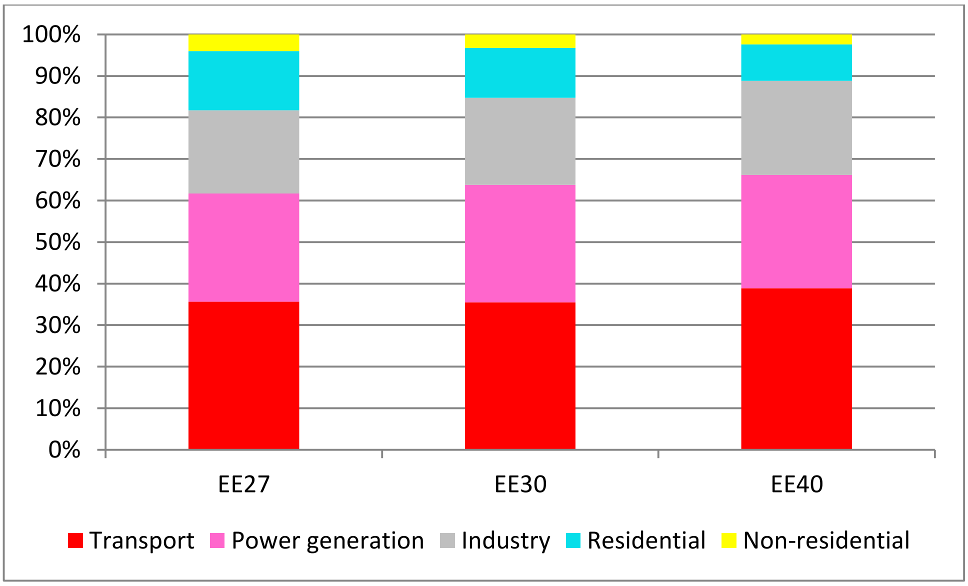
Source: For EE27, EE30 and EE40 scenarios: Source: PRIMES results as used in the impact assessment accompanying the Commission's Communication to the European Parliament and the Council on *Energy efficiency and its contribution to energy security and the 2030 framework for climate and energy policy*.
https://ec.europa.eu/energy/sites/ener/files/documents/2014_eec_ia_adopted_part1_0.pdf
For IEA 2DS: Energy Technology Perspectives, 2015
http://www.iea.org/etp/etp2015/

Reductions in GHG emissions from 2005 levels are projected to be greater in the ETS sectors than in the non-ETS sectors. In the ETS sectors, projected reductions are between -46% (EE40) and -42% (EE30), while in the non-ETS sectors they are between -35% (EE40) and -28% (EE27).

Transport is the sector projected as having the lowest emissions reduction by 2030: between-5.1% (EE27) and -5.8% (EE40), as compared with the reference scenario. Similarly, the sector is projected to have the lowest emissions reductions, as compared with 2005 emission levels: between -16.7% (EE27) and -17.4% (EE40). Industry is the second sector with projected low emissions reduction: between -31.5% (EE27) and -28.6% (EE30), as compared with 2005 and between -9.1% (EE27) and -6.1% (EE30), as compared with the reference scenario. The non-residential sector is projected to have the highest emissions reduction. Compared with the reference scenario, projected reductions in the non-residential sector range between -10.4% (EE27) and -32.9% (EE40). Compared with 2005 levels, the projected reductions are even higher, ranging from -50.5% (EE27) to -73% (EE40). In the EE40 scenario, the residential sector is projected to be the second sector in terms of emissions reduction, with -62.9%, as compared with 2005 levels, followed by power generation, with -60%. In the EE27 and EE30 scenarios, the projected reductions from power generation are greater than those in the residential sector: between -57.9% (EE27) and -54.6% (EE30), as compared with 2005, as against -33.8% (EE27) to -53.1% (EE30).

Overall, in 2030, transport will be the largest contributor to the EU GHG emissions followed by power generation and industry, while the buildings sector (residential and non-residential) is projected to be the least GHG emitter (Figure 2.6). This would reflect the policy effort to transform the EU building stock from being an energy consumer to being an energy producer.

Figure 2.6 Share of GHG emissions in EE27, EE30 and EE40 scenarios, by sector in 2030



Key point: The buildings sector is projected to be the least GHG emitting sector, while transport is projected to be the highest GHG emitter in each scenario in 2030.

Source: PRIMES results as used in the impact assessment accompanying the Commission's Communication to the European Parliament and the Council on *Energy efficiency and its contribution to energy security and the 2030 framework for climate and energy policy.* https://ec.europa.eu/energy/sites/ener/files/documents/2014_eec_ia_adopted_part1_0.pdf

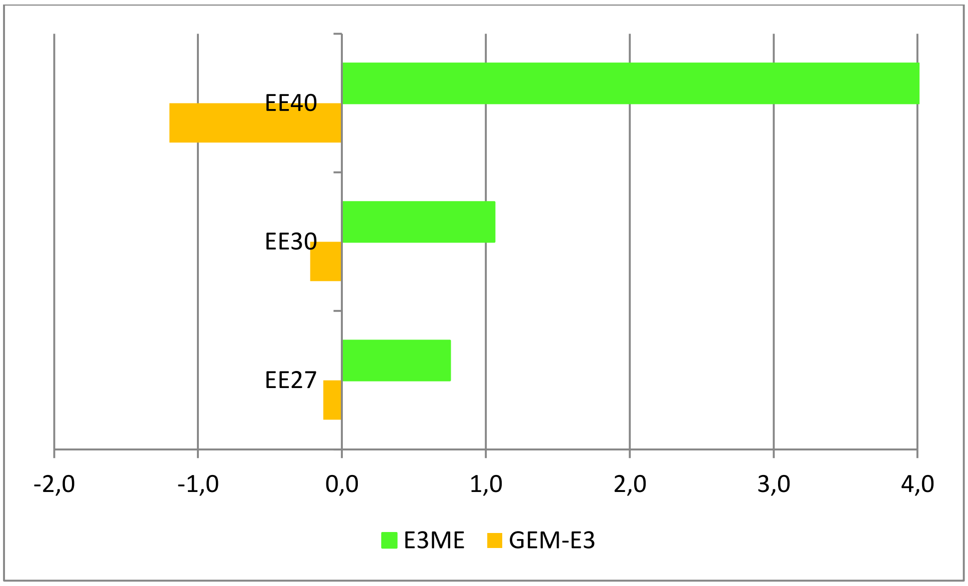
Energy efficiency to drive growth, create jobs and enhance competitiveness

The broader economic impact of the decarbonisation scenarios is assessed on the basis of the E3ME and GEM-E3 macroeconomic models (Box 2.1). E3ME is based on a post-Keynesian framework which assumes that the increased investment needed for the implementation of energy efficiency policies would not automatically lead to a reduction in investments in other sectors. GEM-E3 is a general equilibrium model which assumes that the increased investment would limit the funds available for other investments. As a result, interest rates will go up, thus raising the cost of capital and making the EU economy less competitive. In the E3ME model, the energy efficiency investment is funded from ETS revenues and increased taxation, while ETS revenues are used in GEM-E3 to lower social security charges, which would in theory boost employment.

Growth effects

The two models differ in terms of structure and the projected GDP impacts of energy efficiency measures in the decarbonisation scenarios differ accordingly. With the E3ME model, the projected GDP impacts (in terms of percentage change compared with the reference scenario) are positive in all three scenarios, but with GEM-E3 they are negative (Figure 2.7). With GEM-E3, the more ambitious the energy saving target, the lower the GDP growth projections; with E3ME, the opposite applies. Overall, both models project growth, but the more ambitious the energy saving target, the more pronounced is the difference between the two models as regards GDP impact.

Figure 2.7 Percentage change of GDP growth projections in EE27, EE30 and EE40 compared to the reference scenario using the E3ME and GEM-E3 models



Key point: The more ambitious the energy saving target, the more pronounced the difference between the GDP projections using GEM-E3 and E3ME.

Source: GEM-E3 and E3ME results included in the impact assessment accompanying the communication from the Commission to the European Parliament and the Council on energy efficiency and its contribution to energy security and the 2030 framework for climate and energy policy
https://ec.europa.eu/energy/sites/ener/files/documents/2014_eec_ia_adopted_part1_0.pdf

The structural differences between the two models could explain the variation described above. While GEM-E3 assumes that policy-makers will allocate ETS revenues to employment via a reduction in employers’ social security costs, E3ME allocates ETS revenues to the financing of additional energy efficiency investment, thus generating more economic activity. The use of the ETS revenues is a policy decision that goes beyond energy efficiency policies, but it has a direct impact on governments' capacity to overcome the barriers to energy efficiency.

Employment effects

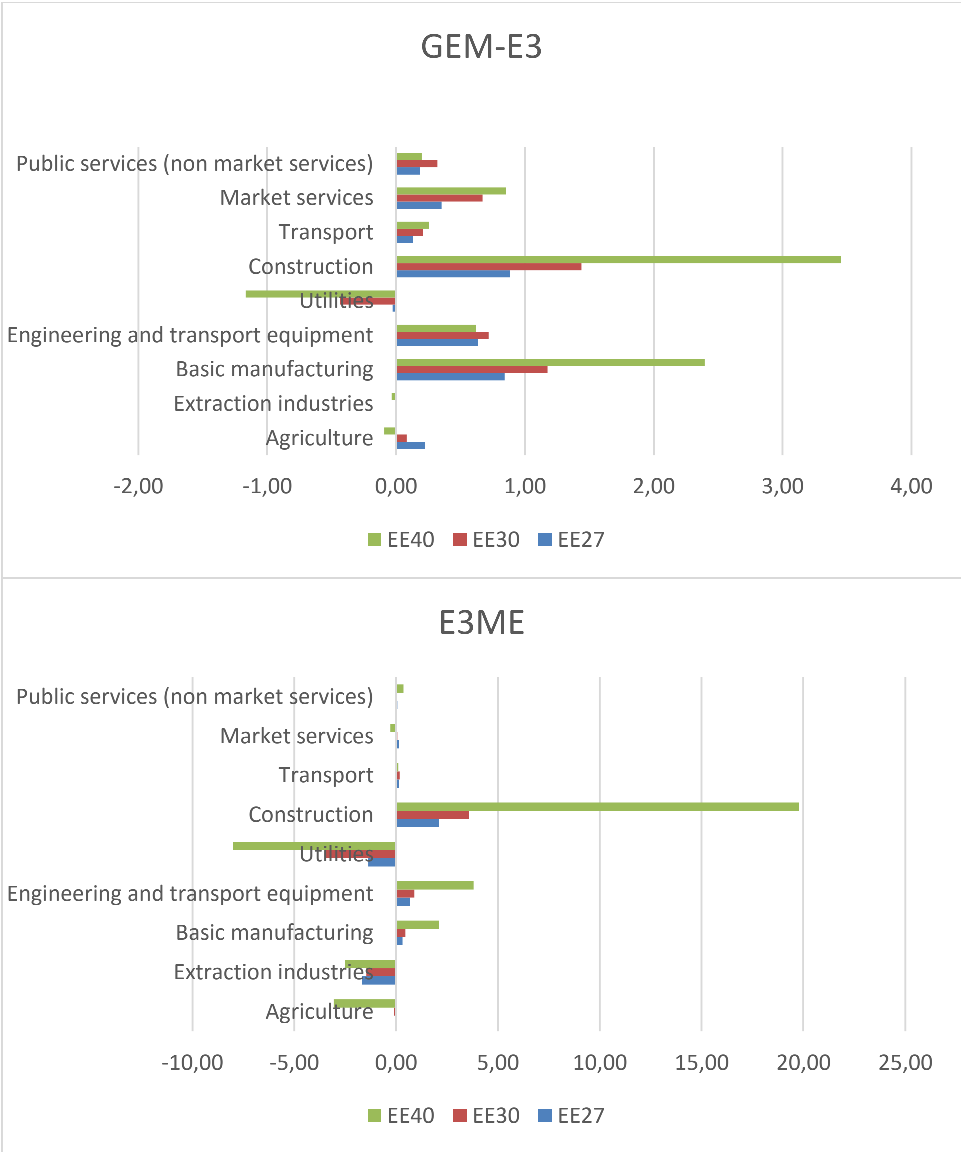
One of the direct effects of the EE27, EE30 and EE40 decarbonisation scenarios is increased demand for energy-efficient goods, as households and businesses change their spending patterns. As a result, more such goods are produced and new jobs are created to satisfy demand. On the other hand, the moderation of energy demand reduces the need for power generation and distribution, resulting in job losses in supply-side sectors.

As regards net employment impact, GEM-E3 and E3ME both show an increase - job losses on the supply side are projected to be largely offset by new jobs in end-use sectors and in the production of efficient equipment (Figure 2.8). As compared with the reference scenario, the employment effect is more pronounced in GEM-E3, ranging from a 1.47% increase in EE27 to 2.96% in EE40, while in the E3ME model the increase ranges from 0.3% in EE27 to 1.5% in EE40. This is due to the expected employment impact in GEM-E3 of the assumed allocation of ETS revenues to lowering social charges for employers (see previous section).

With both models, GEM-E3 and E3ME, higher renovation rates result in each of the decarbonisation scenarios in job creation in the building sector as well as sectors involved in the production of efficient building material, equipment and appliances. Employment in utilities and energy extraction industries falls as a result of reduced energy demand. As the effective implementation of energy efficiency measures requires public intervention, jobs are also created in the public sector. The same occurs in services providing input to energy efficiency projects, such as banks, insurance and engineering.

Overall, the decarbonisation scenarios will bring monetary flows back into the internal market and boost higher expertise and innovation. However, achieving energy saving projected in each of the three decarbonisation scenarios will require policy intervention to reshape the skills and boost breakthrough technology and innovation in basic science, material research and cross-disciplinary research and development.

Figure 2.8 Millions of persons employed by sector in EE27, EE30 and EE40 scenarios compared to the reference scenario using the GEM-E3 and E3ME models



Key point: The GEM-E3 model and E3ME models both show that job losses in energy supply industries will be largely offset by jobs created in the implementation of energy efficiency measures in end-use sectors and the production of efficient equipment.

Source: GEM-E3 and E3ME results as used in the impact assessment accompanying the Commission's Communication to the European Parliament and the Council on *Energy efficiency and its contribution to energy security and the 2030 framework for climate and energy policy*.
https://ec.europa.eu/energy/sites/ener/files/documents/2014_eec_ia_adopted_part1_0.pdf

Competitiveness and affordability effects

The IEA outlook for industrial energy and competitiveness showed that the OECD countries accounted in 2012 for two-thirds of the export market of energy-intensive goods. About half of those exports were originated from within the EU, which made Europe the largest exporter of energy-intensive goods. Based on the IEA projections, the EU share in global exports of energy-intensive goods, especially for chemicals, due to high energy prices, relatively high wages and the longer shipment distances to major consumers in Asia, is expected to decrease. However, based on the same projections, the EU would remain the leading exporter of energy-intensive goods. In 2035, the EU would be exporting more than the United States, China and Japan combined (IEA, 2013). Moreover, the IEA-OECD estimates showed a shift in the production of iron and steel from least developed countries to the United States, the European Union and India as a result of savings on production costs due to policy intervention (OECD, 2014) and despite the on-going decarbonisation of the EU energy system.

The assessment of the impact of the decarbonisation scenarios on the competitiveness of the EU industry would require a detailed analysis of each industrial sub-sector to better assess the saving potential (ECOFYS, 2014) and a hybrid modelling approach that combines PRIMES and a global model, such as the OECD-ENV-Linkages (IEA, 2013, OECD, 2014 and 2015). The OECD-ENV-Linkages is a dynamic neo-classic general equilibrium model that describes disaggregated sectoral and regional economic activities and how they are linked within a global context. It also links economic activities with their corresponding GHG emissions. When combined with an energy model it would allow for a better assessment of medium and long-term implications of the decarbonisation scenarios on global trade flows and the reallocations of primary factors and consumption of goods and services across sectors and countries/regions (OECD, 2014, 2015).

The share of energy costs in the value added of energy intensive industries is projected to increase compared to the reference scenario by 5% in the EE27 and the EE40 scenarios and by 4% in the EE30 scenario. This increase reflects the investment on energy efficiency goods and services that businesses would have to make in order to take a full advantage of energy efficiency measures in the future.

However, the increase of energy-related costs in energy intensive industries' value added does not allow drawing conclusions on the loss in competitiveness of the EU industry. Given that the geographic and scope coverage of the PRIMES model is energy in the EU28, the impact of the decarbonisation scenarios on the competitiveness of the EU industry is not possible to assess with the data available, especially for industries competing in global markets. As mentioned earlier further analysis combining PRIMES with a global economic model, such as OECD ENV-Linkages briefly described above, would be needed to assess the medium and long-term impact of the decarbonisation scenarios on the competitiveness of the EU industry. Furthermore, to limit carbon leakage, the Commission's new ETS revision proposal (for post-2020) encourages Member States to use auction revenues to provide financial compensation in line with state aid rules to sectors and sub-sectors exposed to reallocation to countries and regions without carbon regulations.

The EE27, EE30 and EE40 scenarios would encourage households to change their spending patterns towards more energy efficient goods. Thus, reduce the share of energy costs in their total expenditures. However, prior to achieving this reduction, households will need to invest in energy efficient goods and services which would result in an increase of capital costs. As a result, energy-related cost in households' expenditures excluding transport are projected to increase by 2% in the EE27 scenario, 8.6% in EE30 scenario and 42% in the EE 40 scenario, as compared to the reference scenario.

Chapter 3: Realising the saving potential

Highlights

- Making energy saving the EU "first fuel" by 2030 will require an unprecedented economic and technological transformation of the entire energy system. The EU may fall short in meeting this target if the necessary measures are not put in place right away to overcome obstacles to energy efficiency investments.
- Existing EU funding will not be sufficient to transform the EU economy from one based on fossil fuels to a low-carbon one. It needs to be blended with funding from Member States and leveraged with private finance.
- Various policy and financial instruments have proved effective in overcoming barriers to energy efficiency investments. The challenge for policy-makers is to combine the most effective ones into a long-term framework for De-risking Energy Efficiency Investments (DEEI).
- To make energy efficiency investments attractive to investors and financial institutions, governments need to minimise the financial risk by guaranteeing to cover first-risk losses and the technical risk by guaranteeing long-term energy saving.
- "Levelised Cost of Conserved Energy (LCCE)" is the indicator that allows to separate connected risk from basic rate component. Using LCCE for the assessment of energy efficiency investments would allow the DEEI to better address the perceived risk by investors. As a result energy efficiency would compete on equal terms with power generation.

Chapter 1 analysed the EU progress in moderating energy demand, limiting energy dependency and reducing GHG emissions in 1990-2013 and the progress towards the 2020 climate and energy goals. Chapter 2 analysed scenarios based on three 2030 energy saving targets: EE27 (the current agreed target), EE30 (the possible target after revision in 2020) and EE40 (as called for by the European Parliament in October 2014). In each scenario, energy saving will be Europe's "first fuel" by 2030 and provide a boost to the EU economy.

This chapter first examines the barriers that may discourage households and businesses from investing in efficient low-carbon technologies and services. It then outlines best practice policy and financial instruments for overcoming the barriers and scaling-up private investments in efficient goods and services. The analysis shows that a comprehensive and long-term framework for De-risking Energy Efficiency Investments (DEEI) would be needed to shift the EU economy from one based on fossil fuels to one based on the sustainable domestic production of energy saving and renewables.

The chapter is based on a review of the literature on barriers to energy efficiency and how they are overcome around the world, and on green growth and investments.

Setting an energy saving target is a necessary first step to tapping energy efficiency potential, but in itself it is no guarantee of success. For example, a target of 20 % energy saving by 2020 has been set, but the sum of indicative national targets reported by Member States in their 2014 National Energy Efficiency Action Plans (NEEAPs) corresponds to 17.6% primary energy saving compared to 2020 projections (JRC, 2015-c).

Bridging the 2020 energy saving gap is crucial if the EU is to reduce its GHG emissions by 80-95 % by 2050 as compared with 1990 levels. The 2020 milestone is important in the implementation of the EU roadmap to a competitive low-carbon economy (EC, 2011-b) and meeting the 2020 target would send a clear signal to market actors as regards the EU long-term strategy to deliver energy and carbon savings. It is also necessary to the achievement of the 2030 climate and energy targets. Commission analyses suggest that it will depend on better implementation of current legislation and policies (EC, 2014-a).

Moving forward and making energy saving Europe's "first fuel" by 2030 will require a paradigm shift in policy design that goes beyond energy and climate policies. Investment in the decarbonisation of the EU energy system will be scaled up only if the ambitious climate and energy policy framework is complemented by a long-term investment framework (OECD, 2012). The aim is to channel the necessary resources to removing barriers in order to attract private investment in energy-efficient projects (OECD, 2012). The overall objective is to stimulate demand for more energy-efficient and low-carbon goods and services.

It would also boost growth by creating 0.3-3 % additional jobs in 2030 (as compared with the reference scenario), while reducing the overheads linked to the use of energy. In sum, the scenarios would all mean an economic and societal "win-win" if a range of private and public actors come up with the additional investment needs.

Various energy efficiency policy instruments have been developed in the EU over the past four decades (Box 3.1). As shown in Chapter 1, they have helped to moderate energy demand, limit energy dependency and reduce GHG emissions. However, implementation has not been straightforward and neither will it be easy to strengthen existing policies to meet the 2030 climate and energy targets. A number of barriers discourage market actors from investing in energy-efficient goods and services. Governmental intervention is needed to remove the barriers to energy efficiency investments.

Box 3.1 Four decades of EU energy efficiency policies

Community energy efficiency legislation dates back to the 1973-1974 oil crisis. On 17 September 1974, the Council adopted a resolution calling for a slowdown in the growth of energy consumption as part of the **EU energy security strategy**. This was followed by the launch of a Community action programme on the rational use of energy. Heating systems were the first end-use to be targeted: Council **Recommendation 75/493/EEC** was about reducing the energy consumption of heating systems in existing buildings.

The first Council **Directive (78/170/EC),** adopted on 13 February 1978, required Member States to take the necessary measures to ensure that all new heat generators for space heating and/or the production of hot water in new or existing non-industrial buildings comply with **minimum performance requirements.** This was the predecessor of the **Ecodesign Directive (2009/125/EC),** which established a framework for setting Ecodesign requirements for energy-related products. So far, implementing directives have been adopted for air conditioners and comfort fans, circulators, computers, domestic cooking appliances, electric motors, external power supplies, household dishwashers, tumble driers and washing machines, industrial fans, lighting products in the domestic and tertiary sectors, local space heaters, heaters and water heaters, power transformers, professional refrigerated storage cabinets, refrigerators and freezers, simple set-top boxes, solid fuel boilers, standby- and off-mode electric power of household and office equipment and network standby, televisions, vacuum cleaners, ventilation units and water pumps.

The second Council **Directive (79/530/EEC)**, adopted on 14 May 1979, sought to harmonise national regulations on **energy consumption labelling on household appliances** (water heaters, ovens, refrigerators and freezers, washing machines, television sets, dishwashers, tumble driers and irons). This was the predecessor of the **Labelling Directive (2010/30/EU)**. The **Implementing Directive for ovens (79/530/EC),** which was adopted immediately, was the predecessor of the current implementing directives under the combined Ecodesign and Energy Labelling Directives.

When a **resolution on improving energy efficiency in order to stabilise the Community's CO_2 emissions** at the 1990 level by 2000 was adopted on 29 October 1990, it was the first time energy efficiency had been considered as a policy instrument to combat climate change. **Council Directive 93/76/EEC (the SAVE Directive**) was the predecessor of the **Energy Efficiency Directive (2012/27/EU)** and to some extent the **Energy Performance of Buildings Directive (EPBD; 2002/91/EC)**. It required Member States to implement programmes on the **energy certification of buildings, the billing of heating, air conditioning and hot water on the basis of actual consumption, third-party financing for energy efficiency investments in the public sector, thermal insulation of new buildings, regular inspection of boilers and energy audits**.

The European Parliament and the Council adopted the EPBD in 2002, after the building sector had been recognised in 2000 as the largest contributor to the EU's final energy consumption. One of its main requirements was that the **minimum energy performance of existing buildings must be set when they undergo major renovation** (similar requirements were already in place for new buildings in all Member States). The EPBD was repealed by **the EPBD recast (2010/31/EC),** which requires **'nearly zero' energy consumption for new buildings by 2021** and obliges Member States to develop **national plans to promote the conversion of renovated buildings into 'nearly zero' energy buildings.** Member States were also required to **set minimum energy performance requirements with a view to achieving cost-optimal levels**. On 16 January 2012, a **Delegated Regulation (EU/244/2012)** on the energy performance of buildings was adopted which established a comparative methodology framework for calculating cost-optimal levels of minimum energy performance for buildings and building elements. Member States were required to report to the Commission all input data and assumptions used for the calculations and the results of the calculations.

In 2012, in an attempt to ensure that the **2020 energy and climate targets** would be met, the European Parliament and the Council adopted the **Energy Efficiency Directive (2012/27/EU)**, which requires Member States to:

- ensure that energy distributors and retail companies achieve 1.5 % energy saving per year by implementing energy efficiency measures;
- ensure that the public sector purchases energy-efficient buildings, products and services;
- develop national renovation roadmaps involving the renovation every year of 3 % of the total floor area owned and occupied by central governments;
- strengthen existing regulations on individual metering to empower energy consumers to manage their consumption better;
- monitor the efficiency levels of new power plants;
- provide incentives for SMEs to undergo energy audits; and
- require large companies to conduct energy audits and identify ways to reduce their energy consumption.

In addition, energy-intensive industries have to comply with the EU-ETS. They have made progress in the past 10 years and will have to comply with changes to the EU-ETS to 2020 (already adopted) as described in Chapter I.

For what regards the transport sector, it is mainly regulated through climate policy instruments as described in box 1.4.

Source: summarised by the authors from various EC documents.

Categorising barriers to energy efficiency

The energy saving potential identified in the decarbonisation scenarios may remain untapped unless more conducive conditions are created for investment in energy efficiency goods and services. The literature refers to the untapped potential as the “energy paradox”, or the “efficiency gap” between identified cost-effective saving potential and realised saving (York *et al.*, 1978; Blumstein *et al.*, 1980; Stern, 1984; Stern, 1992; Jaffe and Stavins, 1994; Sorrell *et al.*, 2000, 2004; Gillingham and Palmer, 2013).

The efficiency gap stems from the existence of barriers (a “postulated mechanism”) that inhibit investment in technologies that are both energy and economically efficient (Sorrell *et al.*, 2004). To design appropriate policy instruments and measures, governments need to identify the barriers, understand how they function and examine the role of each actor in the decision-making process. The ultimate objective is to overcome the obstacles and to allow fair competition between energy saving and traditional energy sources.

In the past, barriers to energy efficiency investment were analysed on the basis of neo-classical economic theory (Jaffe & Stavins, 1994; Sutherland, 1996), whereby consumers make fully rational investment decisions. This assumes that investors have sufficient information to assess whether energy efficiency investments are cost-effective and appropriate. However, empirical studies (Sorrell *et al.*, 2004) suggest that economic agents may lack sufficient information to make economically efficient decisions.

The failure of neo-classical economic theory to capture fully how the market really functions led academics to consider behavioural (Stern, 1984; Sanstad & Howard, 1994) and organisational factors (Cebon, 1992). Behavioural theory emphasised the role of “bounded rationality”, organisational routines and the human dimension in inhibiting energy efficiency investment. Organisational theory views energy managers' lack of power as a major barrier. Most organisations delegate energy management to their (generally lowly) maintenance departments and do not assign a specific budget to energy efficiency.

More recent literature (Thollander *et al.*, 2010; Gillingham and Palmer, 2013) argues for a multidisciplinary approach to better assess the contributions that the economic, behavioural and organisational perspectives can make to address the barriers.

In the end, each of the barriers (Table 3.1) has all three dimensions described above (Weber, 1997).

Table 3.1 Taxonomy of barriers to energy efficiency investments

Perspective	Barrier	Description	Remedial policy instrument
Economic	Heterogeneity	A given technology or measure could be cost-effective on average while it may not be for some individuals and firms.	Energy audits
	Hidden costs	Include the costs associated to overheads costs for management, disruption, inconvenience, staff replacing and training and the costs related to gathering, analysing and applying information.	Better assessment of the additional costs associated to energy efficiency measures by engineering-economic models
	Perceived risk	• Technical risk due to uncertainties about the long-term saving in operating costs. • Financial risk due to uncertainties on future energy prices and future economic conditions. As a result, short paybacks and higher return on investments are required for energy efficiency investments.	• Energy performance contracting to guarantee the long-term saving • Governmental guarantee of energy efficiency investments • Use of appropriate indicators and appropriate discount rates for costs-benefits analysis
	Limited access to capital	• In the public sector, additional borrowing may be inhibited by public sector rules • In the private sector, the financial risk inhibit companies from borrowing to invest on energy efficiency measures	• Adaptation of procurement procedures • Governmental guarantee of energy efficiency investments
	Imperfect, asymmetric information and adverse selection	• Lack of adequate information on technology characteristics, their energy performance and running cost • Lack of adequate information on energy performance of products and services during the use phase	• Energy performance Labels and/or certificates • Better assessment of real usage conditions of efficient technologies in measurement protocols, test procedures and efficiency metrics • Compliance checking and enforcement of energy performance by third independent party
	Market entry rules	In monopolistic or oligopoly markets incumbent can block energy efficiency investments or the entry of new investors	• Transparent competition rules

	Split incentives	Occur when the investor on energy efficiency improvement is not the direct beneficiary of the implementation	Better assessment of costs-benefits of energy efficiency investment for each party
	Principal-agent relationships	Occur when the interest of one party (the principal) depend on the actions of another (the agent). As a result the principal may impose strict investment criteria to compensate for imperfect information	
Behavioural	Bounded rationality	Imprecise and/or outdates routines and rules of thumb due to constraints on time, attention and the ability to process information	Bundling energy efficiency projects
	The human dimension	• Inadequate and/or untimely information • The source of the information is not credible nor trustable • Some agents may favor the status quo because they are committed to what they are doing	• Making information simple, effective and provide it close in time to the relevant decision-maker • Independent third party organizations to provide information on cost-effectiveness of energy efficiency investments and to monitor energy saving • Training and capacity building at all levels
Organisational theory	Power	Energy managers may lack status and authority	• Awareness raising about cost-effectiveness of energy efficiency targeting top management in order to empower energy managers and allocate resources for energy efficiency investments

Key point: Various policy and financial de-risking instruments have proven their effectiveness in overcoming the identified barriers if public funding is allocated to this purpose

Source: adapted by the authors from:
- Understanding barriers to energy efficiency (Sorrell, 2000): http://www.sussex.ac.uk/Units/spru/publications/reports/barriers/finalsection3.pdf
- Categorising barriers to energy efficiency: an interdisciplinary approach (Thollander & all, 2010): http://cdn.intechopen.com/pdfs/11463/InTech-Categorizing_barriers_to_energy_efficiency_an_interdisciplinary_perspective.pdf

Overcoming the challenge of financing energy efficiency investments

The ambition level of the EU 2030 energy saving target requires an unprecedented economic and technological transformation of the overall energy system. Private investments will flow to energy efficiency projects only if the identified barriers in the previous section are removed. Policy intervention is therefore, needed to tackle the barriers to energy efficiency investments and trigger private investments. Public finance should be used mainly to remove the policy and financial risks by establishing the appropriate de-risking financial instruments such as guarantees, to boost innovation as well as to build the technical capacity needed to develop, implement and monitor energy efficiency policies and measures.

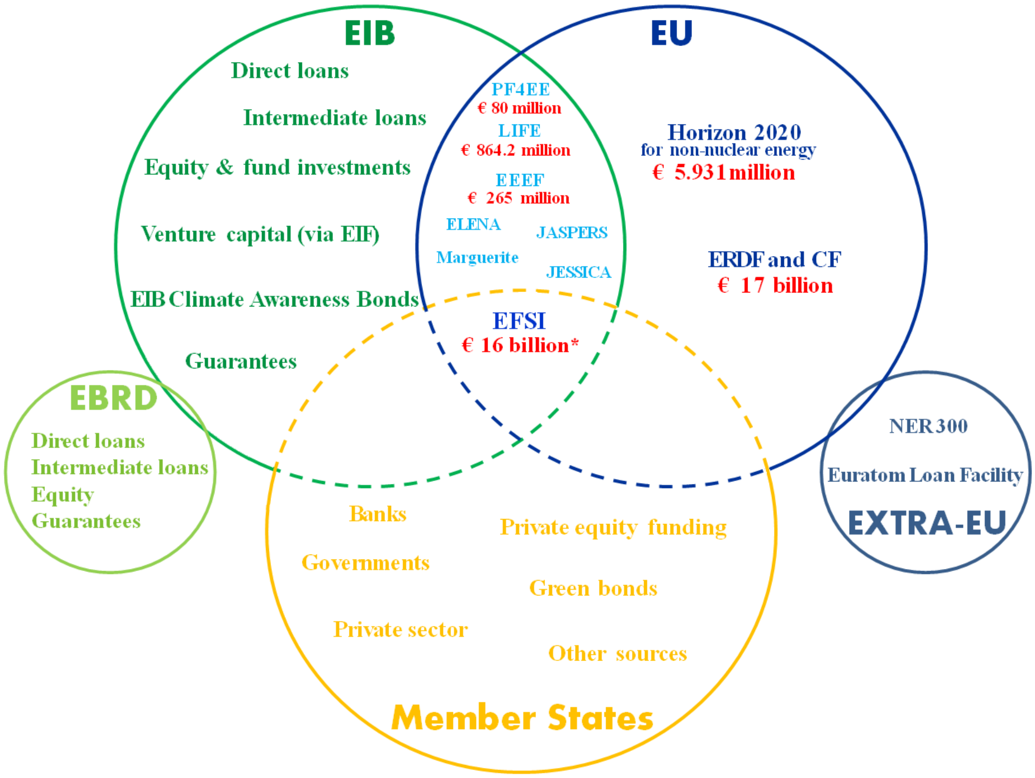
Investment on energy efficiency projects was identified as one of the priority areas to strengthen Europe's competitiveness (EC, 2014-c). Therefore, the EC developed instruments combining the existing EU funds with those from the European Investment Bank (EIB) and the European Bank for Reconstruction and Development (EBRD). Separately, over the period 2014-2020, 17 € billions from the European Regional Development Fund (ERDF) and the Cohesion Fund (CF) will be dedicated to energy efficiency investments either as grants for investment and project development assistance or as loans, guarantees and equity.

Moreover, the Investment Plan for Europe considers the partial use of the European Fund for Strategic Investment (EFSI) for loans, equity and guarantees (EC, 2014-d). A guarantee of 16 € billions is being created, for the period 2014-2020, with an expected leverage factor of 15 (EC, 2014-d). Furthermore, under Horizon 2020 programme for secure, clean and efficient energy, 5.931 € millions will be dedicated for non-nuclear energy research over the same period. However, there is no guarantee specifically dedicated to energy efficiency investments and the share of research funding dedicated to energy efficiency is not yet known. Likewise, the existing EU funds under the European Energy Efficiency Fund (EEEF), the European Local Energy Assistance (ELENA), the Joint Assistance to Support projects in European regions (JASPERS) and the Environment and Climate Action Fund (LIFE) will continue to support Member States in their capacity building efforts as well as project development assistance (Figure 3.1).

It is clear that the existing EU funding will not be sufficient to transform the EU economy from a fossil fuel based economy to a low-carbon economy unless they are blended with funding from Member States and private financial institutions. Several Member States have already announced their contributions to the Investment Plan for Europe. However, the full amount of public funding available to support energy efficiency investments is still not known.

The investment plan needed to make energy saving the first fuel of Europe in 2030 requires also a paradigm shift in the assessment of the profitability of energy and carbon savings as well as a better alignment of various climate and energy policies. As part of the implementation of the Energy Union strategy, the EU climate and energy policy package will be streamlined to ensure better monitoring of progress towards the 2020 and 2030 climate and energy goals. The Energy Union intends to develop a more reliable and transparent governance system (EC, 2015-b).

Figure 3.1 EU funds available for support energy efficiency investments over the period 2014-2020



Key point: EU funding available for energy efficiency investments will not be sufficient to transform the EU energy system unless they are blended with funding from Member States and leverage with private investments

Source: adapted by the authors from: Energy Renovation: the Trump card for the New start for Europe (JRC, 2015) http://iet.jrc.ec.europa.eu/energyefficiency/system/tdf/eur26888_buildingreport_online.pdf?file=1&type=node&id=9069

De-risking Energy Efficiency Investments (DEEI)

Energy efficiency investments suffer from the assumption that energy saving do not last long. As a result, investors lack confidence on the long-term return of their investments. Consequently, energy efficiency investments are regarded as unattractive and short time horizons as well as high interest rates are considered when assessing the opportunity to invest and/or to finance energy efficiency projects.

The investors' response to the perceived risk of energy efficiency investments has been recognised by policy-makers since a long time as one of the threats to the implementation of energy efficiency policies (Jaffe & Stavins, 1994; Sutherland, 1996; Sorrell & all, 2004; Thollander & all, 2010; Gillingham and Palmer, 2013). De-risking Energy Efficiency Investments (DEEI) requires policy intervention to remove the policy and financial risks perceived by investors.

Policy risks could be removed by i) encouraging the use of energy performance contracting to remove the perceived technical risk by investors, ii) unlocking the utility data to establish more accurate baselines, iii) developing instruments that allows for bundling small projects, iv) upgrading skills, v) boosting innovation; and vi) assessing energy saving by third independent parties (Table 3.1).

Financial risks could be mitigated by developing risk sharing facilities to provide loans guarantees thus reduce the perceived financial risk through governmental guarantee of first-loss risks (Table 3.1). The objective is to encourage the deployment of private finance in energy efficiency projects and to enhance public-private finance leverage by engaging more financial institutions in the energy transition and the decarbonisation path. As a result, the cost of capital is reduced and the long-term perspective required by energy efficiency projects become possible. The guarantee of 16€ billion established jointly by the EC and EIB as part of the EFSI could help unlocking investment in energy efficiency if part of it would be dedicated to energy efficiency projects.

The long-term perspective required by energy efficiency projects needs also to be reflected in the performance indicators used to assess the cost-effectiveness of energy efficiency investments. Payback time, calculated as a ratio between the cost of the project and the annualised cash flows, is usually the preferred economic indicator used by investors. This attraction is considered from the bounded rationality perspective as a type of routine that results in investments in low hanging fruits which usually lock the saving potential. In fact, some agents favour to continue using the same calculations because they are simple, easy to communicate and intuitive (Stern, 1984). This allows them to economise on managerial effort in examining investment proposals across a wide range of operations. An alternative to payback time calculations would be the "Levelised Cost of Conserved Energy (LCCE)" (Box 3.2) as this indicator allows to separate connected risk and basic rate components. The risk sharing facility could mitigate the perceived risk by providing a guarantee to lower interest rates. As a result, investors would estimate the Weighted Average Cost of Capital (WACC) on the basis of a lower risk premium and the capital cost would be reduced. Furthermore, the LCCE is a well-known indicator by energy supply sector. Using the same indicator for all energy sources to assess the cost-effectiveness of each investment is a way to ensure energy efficiency competing on equal terms with generation capacity (EC, 2015-a).

Box 3.2 Levelised Cost of Conserved Energy (LCCE)

The Levelised Cost of Conserved Energy should be calculated based on the following formula:

$$LCCE = \frac{\propto \Delta I + \Delta OM - \Delta F}{\Delta E}$$

- *LCCE* is the net levelised cost of conserved energy
- *α* is the capital recovery factor (CRF); $\propto = \frac{r}{1-(1+r)^{-L}}$
- *r* is the discount rate
- *ΔI* is investment costs difference between the reference and the energy saving scenario, $I = c(1+i)^{p}$
- *c* is the capital costs, *i the interest rate and p the construction period*
- *ΔOM* is the annual operational and maintenance costs difference between the reference scenario and the energy saving scenario
- *ΔF* is the difference of the annual energy costs between the reference scenario and the energy saving scenario $\Delta F = FC * \Delta E$

  FC is the fuel costs per unit of energy.
- *L* is the project duration (in operation) –usually economical lifetime
- *ΔE* is the difference in energy use between the reference scenario and the energy saving scenario

Source: Assessment of option-specific cost and potential estimates
IPCC, 2013, http://www.ipcc.ch/report/ar5/wg3/

Conclusions and future research work

Considering energy efficiency as ''an energy source in its own right'' and making it the ''first fuel'' of Europe in 2030 is certainly an ambitious target. But it is a target that Europe needs given the impact of fossil fuels on climate change and the decrease of the availability of domestic production of fossil fuels. This report shows that a paradigm shift in energy and climate policy with respect to energy efficiency is underway in the EU. The next step is to stimulate and scale-up private investments in the transition of the EU economy from a fossil fuels based one to a low-carbon one.

Policy-makers have long experience in designing and implementing individual policy and financial instruments aiming to overcome each barrier to energy efficiency investments. Today, the challenge is not about inventing new instruments. It is more about combining those that have demonstrated their individual effectiveness into a comprehensive long-term framework for De-risking Energy Efficiency Investments (DEEI). The decarbonisation scenarios, made by DG ENERGY, showed that making energy saving the ''first fuel'' of Europe is technically feasible and economically viable. However, the road to achieve this target is far from being straightforward and easy, if appropriate policy and financial de-risking instruments are not implemented. Policy intervention is therefore needed to ensure that in 2030, the EU does not fall short in meeting its climate and energy targets.

The main areas of improvement identified in this report include:

- *Ensuring that the 2020 target is met*: a gap of 2.4% relative to the 2020 energy efficiency target was identified by recent EC analysis (JRC, 2015-c). This gap needs to be closed by ensuring effective implementation of the current policies. Meeting the 2020 target will give a clear signal to market actors about the 2030 targets. More targeted and ambitious policy intervention together with more effective implementation are needed to address the identified barriers and achieve the expected impact.
- *Setting-up a comprehensive investment policy framework at the ambitious level of the 2030 energy saving targets*: The aim is De-risking Energy Efficiency Investments (DEEI). The DEEI framework should take into account the social and political costs of energy dependency and climate change. Its objective would be to value energy saving and to give the opportunity to energy efficiency to compete on equal terms with generation capacity. The DEEI framework should combine existing effective de-risking policy and financial instruments into one framework. The aim is to reduce the policy and financial risks perceived by investors and to make energy efficiency investments attractive and bankable. It should allow for a guarantee of energy efficiency investments to reduce the capital cost of the EU energy transition and for building the technical capacity needed to transform the EU economy from a fossil fuel based economy to an economy fueled with energy saving and renewables.
- *Complementing the EU top-down models with a bottom-up model and a global one*: The bottom-up modelling would allow to better assess technological innovation needs to transform the end-use sectors from being energy consumers to being energy producers. To ensure the effectiveness of bottom-up modelling, there is a need for better data collection. The global model would allow for an assessment of decarbonisation scenarios' impact on the competitiveness of the EU industry, particularly for those sectors competing in the global market.

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