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COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the document

Proposal for a Directive of the European Parliament and of the Council

amending Directive 2012/27/EU on Energy Efficiency

{COM(2016) 761 final}
{SWD(2016) 406 final}

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Glossary of acronyms and abbreviations

CA EED	Concerted Action of the Energy Efficiency Directive
CEPPI	Coordinated energy-related PPI actions for cities
CHAP	Central registry for complaints and enquiries
Commission	European Commission, unless specified otherwise
DG	Directorate-General
Directive	Energy Efficiency Directive, unless specified otherwise
EcoDesign	EcoDesign Directive (2009/125/EC)
EE	Energy efficiency
EEA	European Economic Area
EEC	Energy Efficiency Calculation Tools
EED	Energy Efficiency Directive (2012/27/EU)
EEOS	Energy efficiency obligation scheme
Energy Labelling	Energy Labelling Directive (2010/30/EU)
EPBD	Energy Performance of Buildings Directive (2010/31/EU)
ESCOs	Energy services companies
ESD	Effort Sharing Decision (DECISION No 406/2009/EC)
ESIF	European Structural and Investment Funds
ETS	Emissions Trading System
EU PDA	EU Project Development Assistance
FI	Energy agency or regulator
GRASP	Growth and sustainability policies for Europe
H2020	Horizon 2020
ICT	Information and Communication Technologies
IEM	Internal Energy Market legislation
Ktoe	kilotonnes of oil equivalent
MS	Member State(s)
MSR	Market Stability Reserve under the ETS
Mtoe	Million tonnes of oil equivalent
M&V	Monitoring and verification
NEEAP	National Energy Efficiency Action Plan
NZEB	Nearly Zero Energy Building
RAP	Regulatory Assistance Project
RES	Renewable Energy
RES Directive	Renewable Energy Directive
SME	Small- and medium-sized enterprise
SWD	Staff Working Document
TCO	Total Costs of Ownership

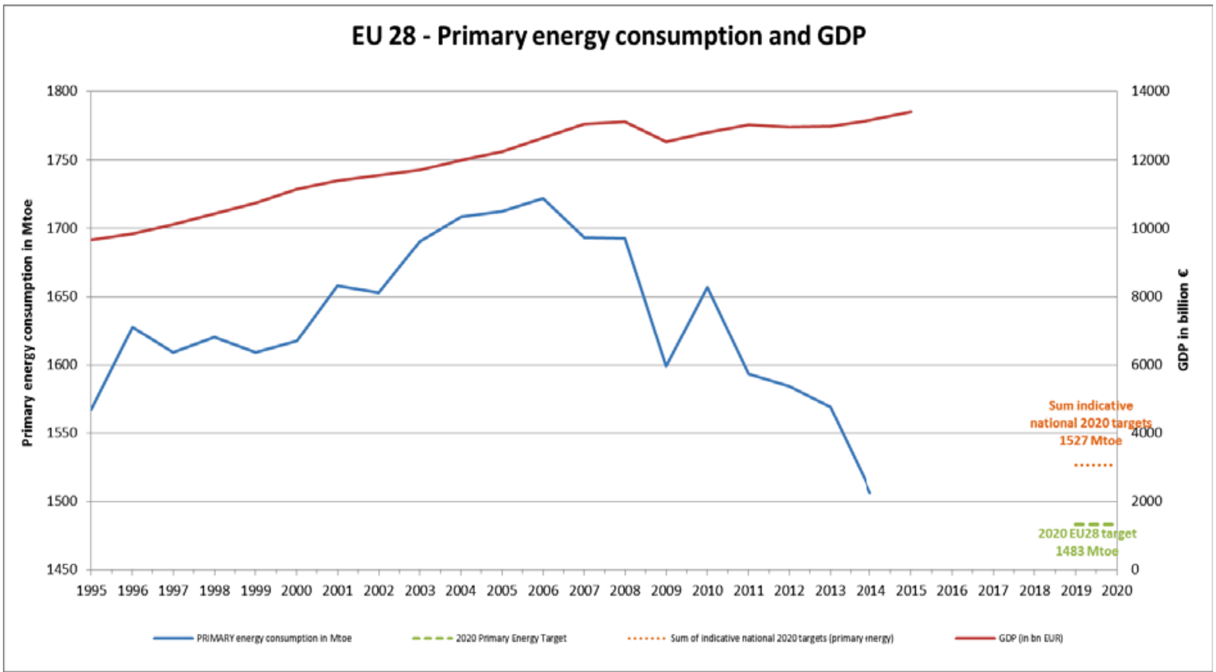
1 What is the problem and why is it a problem?

1.1 Scene setter

The Energy Union and the Energy and Climate Policy Framework for 2030 establish ambitious EU commitments to further reduce greenhouse gas emissions (by at least 40% by 2030 compared to 1990), to increase the share of renewable energy consumed (to at least 27%), and to save at least 27% energy and to review this level “having in mind an EU level of 30%”[1], to increase Europe's energy security, competitiveness and sustainability. In December 2015 the European Parliament voted for a "40% energy efficiency target; emphasised that the post-2020 EU energy efficiency target should be binding and implemented through individual national targets […]"[2].

The EU is already achieving significant energy efficiency progress. Although the decline in energy consumption can to a certain extent be attributed to the economic crisis and its aftermath of restrained production and freight transport activity, EU energy efficiency policies have played a more significant role in decoupling economic activity from energy consumption since 2006 (see decomposition analysis for the period 2005-2014 in Annex 5).

Figure 1: Primary energy consumption in EU28[3]



Source: Eurostat

A similar trend is observed on the global level. According to the International Energy Agency (IEA), energy efficiency improvements in IEA countries accelerated considerably since 2000 and generated enough energy savings to power Japan for a full year. Even in the context of

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1 EUCO 169/14, CO EUR 13, CONCL 5, Brussels 24 October 2014.
2 European Parliament P8_TA-PROV(2015)0444.
3 A graph on final energy consumption can be found in Annex 5.

lower energy prices, global energy intensity improved by 1.8% in 2015. While GDP grew by 2% in IEA countries, efficiency gains led to the flattening of growth in primary energy demand. IEA countries saved an average of 490 USD per capita in energy expenditure in 2015 as a result of energy efficiency improvements since 2000[4].

However, besides the multiple benefits of energy efficiency, the level of investment in energy efficiency in Europe is still below its economic potential[5]. Energy efficient investments with a payback time of four or five years are often not undertaken in the private and public sectors. Market and behavioural barriers (see Annexes 4 and 6) hinder consumers from taking up energy efficiency measures, which would lower their energy bills and would bring other benefits for the whole society e.g. health, environmental and economic improvements.

EU energy efficiency policies and strategies focus on correcting market and regulatory failures (see Annex 3). This serves to realise energy saving potentials by triggering economically viable investments, which do not take place because of market or regulatory barriers or failures. The current 2020 energy efficiency framework is based on mutually reinforcing instruments:

1) An overall drive for a decrease in energy consumption, via the establishment of an EU **headline target** to give public and private actors confidence that this is a sector worth investing in. An indicative EU 2020 energy efficiency target was set in 2007 underpinned by indicative national targets notified in 2013 (under Articles 1 and 3 of Directive 2012/27/EU on energy efficiency[6] (EED))[7].

2) EU policies to speed up the **rate** at which people and businesses choose to upgrade the energy performance of their buildings, systems and appliances (Article 7 of the EED and financing through European funds and assistance projects). These polices bring more energy efficient products to be traded in the **internal market**.

3) Minimum performance requirements (**depth of the upgrading**) for new buildings, buildings which undergo a major renovation, new appliances and new vehicles (Directive 2010/31/EU on the energy performance of buildings[8] (EPBD), eco-design and CO_2 standards for vehicles). Energy efficiency is an enabler for economic modernisation.

4) **Information** for consumers and industry – labels for products, certificates for buildings and consumer rights for metering and billing – to enable them to choose the

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4 International Energy Agency (2016): Energy Efficiency Market Report 2016 (see http://www.iea.org/publications/freepublications/publication/mediumtermenergyefficiency2016.pdf).

5 Energy Efficiency Financial Institutions Group (EEFIG) Final Report, February 2015 (see https://ec.europa.eu/energy/sites/ener/files/documents/Final%20Report%20EEFIG%20v%209.1%2024022015%20clean%20FINAL%20sent.pdf) and COMMISSION/DG ECFIN, Note to the Economic Policy Committee Energy and Climate Change Working Group (19 April 2016): INVESTMENT IN ENERGY EFFICIENCY BY HOUSEHOLDS.

6 Directive 2012/27/EU on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, OJ L315/1 of 14 November 2012.

7 Article 1 of the EED establishes the Union's 2020 20% headline target on energy efficiency and Article 3 of the EED specifies that this equals a primary energy efficiency consumption of not more than 1483 Mtoe or final energy consumption of no more than 1086 Mtoe in 2020.

8 Directive 2010/31/EU on the energy performance of buildings, OJ L153/13 of 18 June 2010.

efficiency level that is right for them (Energy labelling, EPBD, Articles 8 and 9-11 of the EED).

5) **Research and innovation** particularly through the Strategic Energy Technologies Plan, to bring down the cost of key technologies that are currently technically but not economically viable and to bring them to the internal market.

1.2 What is the problem?

The problem for energy efficiency policy in general is that, because of market and regulatory failures, large amounts of cost-effective investments in energy efficiency will not take place. This will lead to a **level of energy consumption in 2030** which is not in line with the agreement of the European Council of October 2014 (at least 27% reduction compared to 2007 baseline[9]) and the Energy Union ambition and which does not achieve the multiple benefits related to lower energy consumption in 2030. This level is also not in line with the EU's ambition for decarbonisation by 2050 as all decarbonisation scenarios rely on a significant share of energy efficiency[10].

This **insufficient progress in energy efficiency holds back the full benefits** of lowering Europeans' energy bills, reducing Europe's reliance on external suppliers of oil and gas, helping protect the environment and mitigating emissions with negative health impacts such as particulate matter and NO_2[11]. In addition, the full potential of positive economic and employment impacts of local energy efficiency investments and decarbonising the economy remains unexploited.

Well-documented market failures and regulatory barriers include:

- Information failures;
- Split incentives;
- Short investment horizons in both companies and households;
- Lack of awareness of the "business case behind energy efficiency investments";
- High transaction costs for small projects;
- Capital market failures[12]; and
- Lack of clear signals for companies to become actors in an energy efficiency market.

9 2007 Baseline modelled with PRIMES energy system model projected for 2030 primary energy consumption reaching 1887Mtoe and final energy consumption 1416 Mtoe.

10 COM(2011) 885 final.

11 Energy efficiency is key to lowering fuel consumption. If the heat demand in housing is reduced, less fossil fuel or biomass is required for domestic heating thus lowering direct emissions of air pollutants. If more efficient electric appliances are used, less power has to be supplied by fossil fuel or biomass fuelled power plants, thus also lowering emissions. This will help reach compliance with EU air quality limit values and National Emission Ceilings, in line with the objectives of the Clean Air Policy Package (COM(2013)918 final).

12 These have been reinforced by the short-term effects of the crisis can be summarized in two points: a progressive fragmentation of the euro area financial system, and the growing reluctance of European banks to finance high-risk investment due to the processes of deleveraging and the introduction of stricter capital and liquidity requirements.

Existing energy efficiency legislation at EU level already addresses parts of these failures. E.g. the EPBD, via Energy Performance Certificates, provides transparency with regard to the energy use of a building for a future tenant or the owner to address information failures. In addition, it provides an incentive for the owner to invest in energy saving opportunities as those investments are reflected in the rating and, often, in the rental or sale value.

Articles 7 (energy saving obligations and alternatives) and 18 of the EED create business cases for companies providing energy efficiency services. The two central failures that energy saving obligations can tackle are high transaction costs and the lack of clear signals for companies to become actors in an energy efficiency market. Without a specific regulatory signal e.g. to energy suppliers, it is difficult to imagine how one of them would be induced to help its customers to save energy and thus ultimately buy less of its services. When such an obligation is generalised and the costs of energy efficiency investments supported by the public budget/passed on to the consumer, electricity and gas suppliers can become an active agent in the transition towards a more efficient and decarbonised economy.

Against this background, this Impact Assessment tackles **three specific problems**:

1) The **need to identify the level of energy efficiency ambition for 2030** as well as its character (binding or non-binding) in order to fulfil the political mandate given by the European Council and by the European Parliament. The need for an explicit energy efficiency target for 2030 has already been agreed by the European Council and the European Parliament. The European Council of October 2014 set an "indicative target at the EU level of at least 27%" and requested the Commission to review this level by 2020 "having in mind an EU level of 30%"[13]. In December 2015, the European Parliament voted for a "40 % energy efficiency target; emphasised that the post-2020 EU energy efficiency target should be binding and implemented through individual national targets […]"[14].

   The assessment of the impact of the EU's 2020 target for energy efficiency[15] showed that the adoption of an explicit energy efficiency target played an important role as part of the policy framework for overcoming the barriers to the implementation of cost-effective energy efficiency measures. The identification of the 2030 target will lead to a revision of Articles 1 and 3 of the EED, which currently lay down only the EU 2020 energy efficiency target.

2) Article 7 has a sunset clause for 2020. However, the EED[16] also requires the Commission to assess the progress of implementation of Article 7 by 30 June 2016 and to assess whether it should be extended after 2020. Therefore, the second specific problem identified in this Impact Assessment is **the lack of long term predictability concerning provisions of Article 7 which will prevent cost-effective energy efficiency investments.** As a consequence, a substantial amount of economically viable energy savings will not be taken up.

[13] EUCO 169/14, CO EUR 13, CONCL 5, Brussels 24 October 2014.
[14] European Parliament P8_TA-PROV(2015)0444.
[15] COM(2014)520 final.
[16] Article 24(9) of Directive 2012/27/EU

3) **Persistent information failures affecting energy consumers' ability to understand and regulate their own energy consumption**.

   The EED (in Articles 9-11) and the Internal Energy Market legislation already contain provisions aimed at enabling/incentivizing energy savings through sufficiently frequent feedback to consumers about (the cost of) their energy consumption. Nevertheless many Europeans still only infrequently receive information based on their actual consumption (e.g. only once or twice a year), and often the information is unclear, incomplete or too complex/overwhelming. This is in part due to the current framework being complex and open to interpretation with regard to the nature and scope of key obligations, and in part due to the potential of new technologies in this field not being fully exploited yet.

This Impact Assessment tackles only the three above mentioned specific problems because the main transposition deadline of the EED was in June 2014, and it is considered too early to carry out a full review of the remaining provisions.

As required by Article 24(8) EED, the Commission carried out an evaluation of Article 6 on public purchasing of energy efficiency products and services. The findings showed that it is premature to review Article 6 at this stage as Member States are still putting in place the necessary measures for its implementation. Thus, it is not analysed in this Impact Assessment. The evaluation report can be found in Annex X.

The legal proposal that this Impact Assessment accompanies also includes a modification to Annex IV of the EED, revising the default coefficient applied to savings in kWh electricity – the so called Primary Energy Factor (PEF). Article 22 of the EED empowers the European Commission to review this default coefficient via a delegated act. However, in this particular occasion of the revision of other provisions of the EED through a co-decision process, the review process for Annex IV is included into the legal proposal for the sake of efficiency and reduced administrative burden. The proposed revision of the default coefficient follows three meetings with Member States and stakeholders conducted in accordance with the rules for the preparation of delegated acts. A summary of the process that concludes the revision procedure of the default coefficient can be found in Annex 9 to this Impact Assessment.

1.3 Drivers of the problem

The drivers of the problem are the market and regulatory failures that have not been fully tackled by existing energy efficiency legislation. Therefore, large amounts of cost-effective investments in energy efficiency will not take place.

a) *Regulatory barriers: incorrect/sub-optimal/delayed implementation of the 2020 policy framework might lead to insufficient savings in 2020, having a negative impact on 2030 target and the decarbonisation of the economy in 2050*

The EED has not yet been completely transposed by all Member States which might prevent energy savings to be exploited by 2020. However, positive progress can be observed in recent months, with the majority of Member States having fully transposed it. The incomplete and slow legal transposition and implementation is partly due to lack of political commitment for energy efficiency policies in some Member States as it is in particular the case for Article 7, something which might have negative implications in view of the achievement of the 2020 target. A gap towards the 2020 target has implications for the 2030 target as more savings would then have to be achieved in the period post-2020.

Delayed implementation may be partly due to missing political commitment or Member States underestimating the transposition needed for the obligations of the EED[17]. The Commission's services initiated infringement procedures for non-communication of all necessary measures of transposition against those Member States which did not declare full transposition of the Directive by the transposition deadline on 5 June 2014 to ensure that the complete legal framework enabling energy savings is in place at national level.

b) *Short-term perspective*

The expiration after 2020 of one of the key provisions in the EED, namely Article 7 on savings obligations, will deepen the uncertainty for investors and have a negative effect not only on the long-term planning of national energy efficiency policies, but also on investment decisions made by obligated parties, other market actors and public administrations. Long-term energy efficiency measures will continue to have some effect post 2020. However, without new measures required by legal obligations energy savings will diminish as time goes by. In the absence of a post-2020 framework, preference might be given to short-term measures towards the end of the existing obligation period. In particular, if the energy saving obligation is not continued, electricity and gas suppliers might not continue investing in energy efficiency projects for their customers and hence opportunity will be lost for an innovative and profitable new business segment, also for new energy efficiency service providers.

c) Current EU framework on metering and billing is complex and open to interpretation with regard to the nature and scope of certain key obligations

An evaluation of the existing EU provisions on metering and billing[18] has identified a number of problems or gaps which limit their effectiveness in guaranteeing adequate provision of information on energy consumption.

As regards electricity and gas, this notably arises from the fact that metering and billing is regulated both in the EED and in the Electricity and Gas Internal Market Directives. This could be addressed by consolidating and updating the provisions in the Internal Energy Market legislation and will be done in the context of the forthcoming proposals under the Market Design Initiative. Consequently, the present Impact Assessment only considers metering and billing of thermal energy.

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[17] Depending on their constitutional structure, some Member States have been able to transpose the Directive with secondary legislation, whilst others have used primary legislation. Countries with federal and regional structures have needed to adopt legislation at different levels. The amount of necessary new legislation also varies greatly, from 2 to 140 instruments per Member State, which means that for some Member States the sheer volume of legislation necessary has led to delays. It should be noted that very few of these cases concerned full non-transposition – in the majority of Member States a certain amount of the EED requirements had been transposed, but not all. After a dialogue with the Member States, new legislation has been adopted and the vast majority of cases have been closed, or are going to be closed.

[18] SWD (2016)/XXXX.

For thermal energy (heating, cooling and hot water), the existing EED provisions lack clarity in particular as regards their application in the case of sub-metered consumers (that occupy/use individual units in multi-apartment/purpose buildings).

d) *Technical progress in metering and billing technologies for thermal energy not reflected in the current provisions of the EED*

In addition to certain provisions lacking clarity, significant market developments over recent years resulting in cost reductions for intelligent metering systems are not adequately reflected in the current provisions, some of which date back to as far as 2006 (Article 9(1)) of the EED was copied from Article 13 of Energy Services Directive[19] (ESD)). The requirements are therefore rather conservative, and out of date, particularly in a 2030 perspective, when it comes to the promotion of individual measurement devices. There is clear empirical evidence that accurate and timely information on consumption can help trigger behavioural changes leading to additional energy savings. Most heat cost allocators being installed in multi-apartment buildings nowadays are electronic and remotely readable devices not requiring manual readings and access to individual flats, thus allowing for cost-effective provision of enhanced – and notably more frequent - consumption information. Until and unless such devices replace conventional ones requiring access to individual flats, it will in most situations be difficult or too expensive to provide all consumers with such enhanced information in line with the vision for a New Deal for Energy consumers[20].

e) *Market barriers: poor access to capital and lack of information*

Poor access to finance hinders the exploitation of cost-efficient energy efficiency potentials. In particular, the energy poor have no access to the financing needed to reduce their energy consumption.

In addition, ineffective, uncoordinated and fragmented use of public finance - with too great a focus on grants and the use of publically supported financial instruments which are set up ad-hoc, are overly subsidised and do not reach sufficient economic scale to attract private finance can impair the development of well-functioning markets for energy efficiency investments[21].

Today, there are about 200 energy efficiency financing schemes in operation across different Member States, targeting the different markets and testifying to the broad range of different circumstances. In some cases, various schemes address the same sectors and the same beneficiaries in the same Member States, with different intensity of public support and competing solutions. In the area of energy services high intensity grants sometimes crowd out private investment (e.g. in public lighting or industry sectors), which is clearly sub-optimal.

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19 Directive 2006/32/EC.

20 COM(2015) 339 final.

21 As regards the European Structural and Investment Funds, the strategic programming process and ex ante assessments for setting up of financial instruments ensures a coordinated and effective approach to address market gaps.

In 2015, the Energy Efficiency Financial Institutions Group (EEFIG) reported[22] to the Commission with an analysis of the obstacles that prevent up-scaled investment in economically viable energy efficiency projects. It identified four challenges:

1) **De-risking**: Addressing the financial community's perception, based on lack of experience with energy efficiency, of the high level of risk of investments in this sector and unclear business case (unclear benefits) at the demand side that reduces the investment appetite;

2) **Aggregation**: Enabling project promoters to bundle small, heterogeneous projects in larger packages which reduce transaction costs while enabling more effective (and profitable) investment structuring and governance;

3) **More effective use of public funding**: Reinforcing the use of public finance via financial instruments moving away from grants in favour of instruments that maximise the triggering of private capital allocation for energy efficiency;

4) **Regulatory framework**: Full implementation of existing energy efficiency legislation as well as "future concerted and consistent regulatory pressure to improve buildings efficiency". The report states that "The importance of leadership and signalling for energy efficiency investments should not be underestimated in the context of the EU's 2030 Climate and Energy package; the headline positioning of energy efficiency targets would impact how EU buildings' energy use will decrease and decarbonize from now until 2050 with intermediate milestones. If the EU wants to unlock the enormous potential for energy savings in its existing building stock then it clearly requires bold policy intervention going beyond the strong implementation of existing legislation."

The Commission is tackling these specific issues in its initiative on Smart Financing for Smart Buildings[23]. Energy saving obligations are an important complementary tool as they mobilise private money for energy efficiency investments (usually put in first by the utility and then paid back via energy bills).

1.4 Existing framework and outcome of the evaluations

1.4.1 Evaluation of progress towards the 2020 target (Articles 1 and 3)

In 2007, the EU committed itself to a 20% energy efficiency target in 2020, which means at most 1086 Mtoe of final energy consumption and 1483 Mtoe of primary energy consumption. Member States set their indicative national energy efficiency targets in 2013, which together add up to a reduction in primary energy consumption reduction of 17.6 % in 2020 and 20.6% expressed in final energy consumption.

Member States have made efforts to implement EU energy efficiency legislation, mainly the transposition of the EPBD by July 2012 and the EED by June 2014. In addition, energy

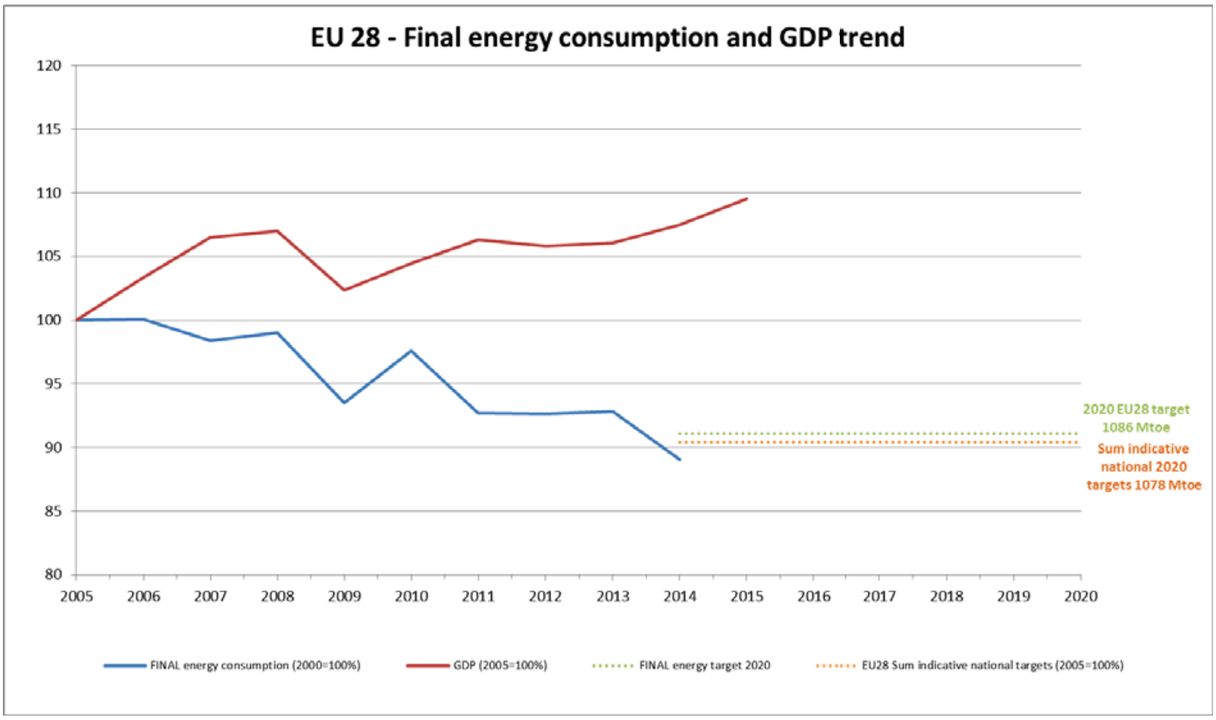
22 https://ec.europa.eu/energy/en/topics/energy-efficiency/financing-energy-efficiency .
23 COM(2016)xxx.

labelling and eco-design requirements and CO_2 light duty vehicle standards have had a considerable impact on products' performance.

In 2014 primary energy consumption fell to 1507 Mtoe and final energy consumption to 1061 Mtoe. Compared to the 2007 baseline projections for 2020, this equals a reduction of 18.7% expressed in primary energy consumption and 21.8% in final energy consumption. This means that the European Union is close to achieving its primary energy efficiency target in 2020 and has already achieved its final energy consumption 2020 target, provided this level of consumption can be kept until 2020. While more progress is expected in implementation of energy efficiency policies, economic growth and lower fossil fuel prices might boost energy consumption in the next years. However, the overall expectation is that both targets will be met.

Final energy consumption decreased from 1191 Mtoe in 2005 to 1062 Mtoe in 2014 (-11%).

Figure 2: Final energy consumption EU28 (2005=100%)



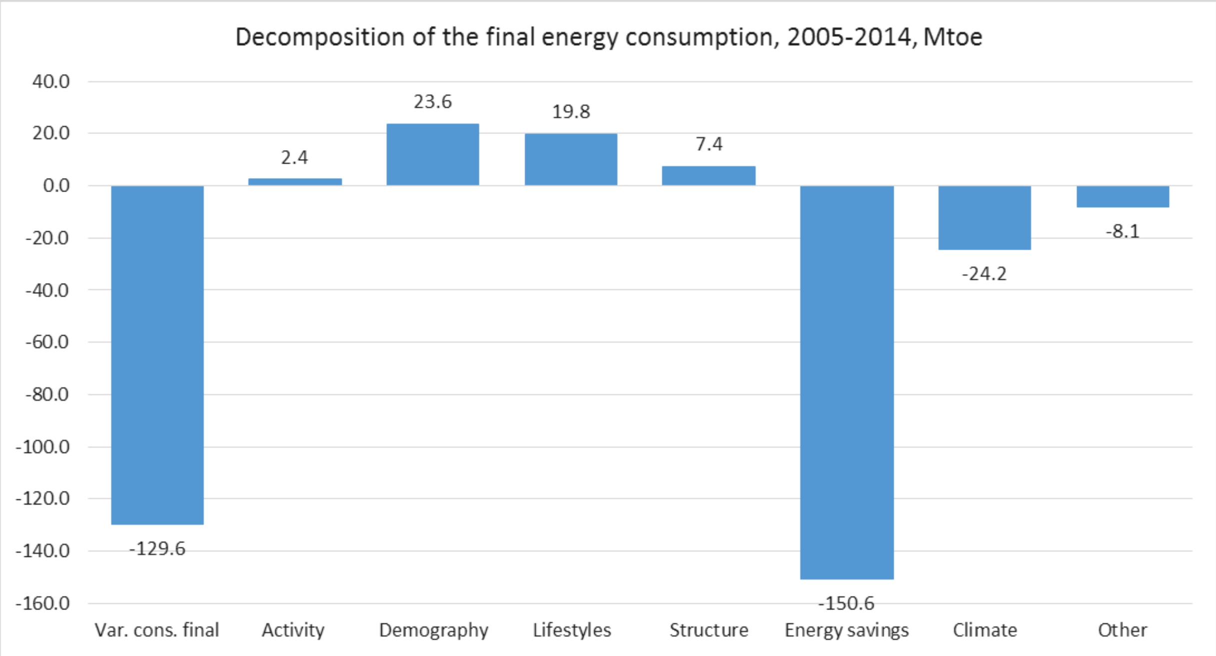
Source: Eurostat

Quantifying the saving impacts of energy efficiency measures based on a bottom-up engineering calculation is challenging for each energy efficiency measure as other external factors (e.g. weather) might overcompensate the savings effect of the measure. Furthermore, each type of measure has its own baseline and methodology for calculation of savings and thus adding up measures can only be an approximation. Another method is a top-down approach based on historical energy consumption statistics. Such a top-down calculation, called decomposition analysis, indicates how energy savings, but also other elements, such as increased activity, contribute to changes in energy consumption. Energy savings are mostly brought about by energy efficiency policies, but also by natural replacement of equipment and technological progress. The decomposition analysis does not allow singling out the impacts of each of the policies versus other drivers. However, it gives an indication of how much energy efficiency policies in total (and facilitated by normal replacement and technological progress) might have contributed to the overall downwards trend in energy consumption in the past years. In addition, at this point in time, official historical data is only available until 2014. Therefore the specific impacts of the EED, which came into force in 2014, cannot be shown yet. Nevertheless, the impacts of the other energy efficiency policies which were implemented so far can be estimated.

An analysis based on statistical data from 2012 showed that energy savings brought about a reduction of 53 Mtoe in energy consumption in the period 2008-2012 while the economic crisis (or more broadly activity level) contributed to this reduction with 33 Mtoe, structural changes with 5 Mtoe and modal shifts in transport with 3 Mtoe[24].

This analysis was confirmed by a decomposition analysis performed under the Odyssee-Mure project[25]. The analysis shows that a higher level of economic activity, demographic, structural and lifestyle changes would have led to an increase of final energy consumption in the period between 2005 and 2014. However, through the important contribution of energy savings it was possible to obtain a more-than-offsetting reduction in consumption by 151 Mtoe. The contribution of climate and other changes reduced final energy consumption together by 33 Mtoe. This shows that energy efficiency improvements were the most important factor leading to lower final energy consumption in 2014 compared to 2005.

Figure 3: Variation final energy consumption - European Union - Mtoe (2005-2014)



Source: Odyssee-Mure

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[24] Behavioural and comfort changes led to a slight increase of energy consumption by 4 Mote but this increase was counterbalanced by the other decreasing factors. See chapter 4 of https://ec.europa.eu/energy/sites/ener/files/documents/2014_report_2020-2030_eu_policy_framework.pdf

[25] See http://www.indicators.odyssee-mure.eu/decomposition.html.

To close the remaining gap towards the 2020 target expressed in primary energy consumption, the Commission indicated in its Impact Assessment on Energy Efficiency in 2014 and its Energy Efficiency Progress Report 2015 that Member States need to accelerate their efforts in implementation of European legislation and their own policies in order to achieve their national energy efficiency targets for 2020 or to go beyond them[26].

The National Energy Efficiency Actions Plans (NEEAP) submitted to the Commission in 2014 and the Annual Reports show that Member States, in addition to a range of EU policy measures (e.g. eco-design, labelling, EU ETS, light duty vehicles standards), have introduced energy efficiency measures in the industrial, residential, services, transport and power generation sectors. They indicate that most Member States have increased their effort and either strengthened existing energy efficiency measures or introduced new ones.

To achieve the 2020 primary energy consumption target of 1483 Mtoe in 2020, primary energy consumption needed to be reduced by 370 Mtoe compared to 2007 baseline projections for 2020. Primary energy consumption was 1507 Mtoe in 2014. Therefore, an additional reduction by 24 Mtoe is needed by 2020. As highlighted in the Impact Assessment on Energy Efficiency in 2014 proper implementation in the three following policy areas are key for the achievement of the 2020 energy efficiency targets:

- Article 7 of the EED: The 2011 Impact Assessment on the EED estimated that 108-113 Mtoe of primary energy savings would be delivered by the implementation of **Article 7** in 2020[27]. The Commission reassessed the figure during the negotiations down to **84.5 Mtoe** in primary energy. A preliminary analysis of the Annual Reports 2016 shows that Member States achieved 12 Mtoe of energy savings in 2014[28].

- EPBD: The estimated energy saving impact of **60 – 80 Mtoe** energy savings in 2020 of the **revised EPBD**[29] will not be fully realised unless it is properly implemented. With the current state of implementation 48.9 Mtoe of savings were achieved in 2014[30]. Therefore, proper implementation could bring an additional 15 Mtoe savings[31].

- **Ecodesign, energy labelling, Energy Star and tyre labelling measures**: The different regulations are estimated to contribute with **162 Mtoe** primary energy savings in 2020[32]. In 2014, the assessment concluded that poor compliance holds back

26 See SWD(2014) 255 and SWD(2015) 574.

27 http://ec.europa.eu/energy/sites/ener/files/documents/sec_2011_0779_impact_assessment.pdf (Annex VII).

28 http://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans. Reported 12 Mtoe also include savings stemming from early actions introduced before 2014 (Article 7(2)d).

29 Compared to the baseline PRIMES 2007. See SEC/2008/2864.

30 SWD (2016) evaluation EPBD.

31 See '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' by Fraunhofer ISI, PWC and TU Wien (2014) (see https://ec.europa.eu/energy/sites/ener/files/documents/2014_report_2020-2030_eu_policy_framework.pdf).

32 Compared to a business as usual scenario which represents the situation without measures as assessed during the first preparatory and impact assessment study for a product. Further information is provided under https://ec.europa.eu/energy/sites/ener/files/documents/Ecodesign%20Impacts%20Accounting%20%20-%20final%2020151217.pdf

the full saving potential of Ecodesign and Energy Labelling. With stronger enforcement an additional 4 Mtoe savings could be achieved[33].

These are the three most important policy areas on which Member States should focus in the next years. These policy areas contribute mainly to the 2020 target achievement, but they are also expected to bring the most significant savings in the course of the next decade as they target the sectors in which the highest cost-effective energy efficiency potential was identified in a study and modelling exercise performed in 2014[34]. As the table below shows, targeting barriers to energy efficiency with the help of moderate but targeted policies (LPI scenario) would lead to the highest cost-effective energy efficiency savings in the tertiary sector. If barriers to energy efficiency investments are almost completely removed with strong energy efficiency policies (HPI scenario), the highest cost-effective energy efficiency potentials can be realised in the residential and tertiary sector (final energy consumption in 2030 could be reduced by 25.9% in each sector compared to the baseline scenario). However, also the transport sector and industrial sector also have remaining cost-effective potentials which need to be exploited through the removal of energy efficiency barriers.

Table 1: Identification of saving potentials of sectors in 2030

Potentials in 2030 compared to the BASE_inclEA Scenario						
	Mtoe			% compared to Base_inclEA in 2030		
	LPI	HPI	NE	LPI	HPI	NE
All final demand sectors	**103**	**194**	**221**	**9.6%**	**18.2%**	**20.6%**
Residential sector	23	73	79	8.3%	25.9%	28.1%
Tertiary sector	25	47	50	13.9%	25.9%	27.7%
Transport sector	28	41	46	9.2%	13.4%	14.9%
Industry sector	26	33	46	9.5%	12.2%	16.8%

Source: Fraunhofer, PwC, TU Wien[35]

Consequently, all the measures listed above (Articles 7 and 9-11 of the EED, EPBD and ecodesign/labelling) will be analysed regarding their operation post-2020 and in view of the contribution to 2030 target. For other energy efficiency measures no revision is foreseen as the legal provisions that underpin them are fit for purpose. These measures will continue post-2020 (e.g. ESCOs, renovation of public buildings) and they form an important part of the policy mix to exploit the cost-effective energy efficiency potentials in the different sectors.

It has to be noted that the additional saving impact of the product legislation is expected to be less in the 2020s than currently, as most of the product groups which bring major additional savings are already covered by ecodesign legislation or other policy regimes or a natural limit

[33] See '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' by Fraunhofer ISI, PWC and TU Wien (2014) (see https://ec.europa.eu/energy/sites/ener/files/documents/2014_report_2020-2030_eu_policy_framework.pdf)

[34] See https://ec.europa.eu/energy/sites/ener/files/documents/2014_report_2020-2030_eu_policy_framework.pdf

[35] Ibidem.

of efficiency is achieved – although significant potential remains through reviewing these regulations.

This impact assessment focuses mainly on analysing the potentials of the first policy area, namely EED/Article 7, to deliver the 2030 target. As a part of Energy Efficiency package, a separate impact assessment for the EPBD looks at potentials of buildings renovation.

1.4.2 Outcome of the evaluation on Article 7

Overview of the existing framework and progress in implementation

Article 7 on Energy Efficiency Obligation Schemes (EEOSs) is designed to attract private investment. It requires each Member State to deliver 1.5% new end-use energy savings per year of retail energy sales over the 2014-2020 obligation period, leaving the Member State to decide whether to achieve this through an EEOS or alternative policy measures or a combination. It is also in the remit of Member States to determine the sectors in which the measures should primarily take place.[36]

Energy saving obligations regulate the outcome but leave it to the market operators to determine the most cost effective path for achieving that outcome. It is not the government that decides how the obligated parties deliver their targets. If well-designed, such schemes can address multiple market failures, as they use the knowledge of well-placed actors in the energy sector who have information about the available energy efficiency services, technologies and the behaviour of their customers. They address the challenge that households in many cases do not have the necessary capital for upfront investments, nor the knowledge of what would be technically and economically feasible in each case. They can ensure that energy efficiency investments benefit from a scale effect and hence can lower the transaction costs for energy efficiency projects. Also they provide a general incentive to invest in energy efficiency in a market environment with inflexible prices and puts energy providers at the centre of the energy sector transition. In a well-designed scheme, the market delivers the desired outcome at least-cost. Energy saving obligations can further encourage the development of an ESCO sector, which is a key element in stimulating the adoption of energy efficiency improvements. At the time of adoption of the Directive in 2012, the Commission services estimated that Article 7 and the related Annex V would be responsible for more than half of the energy savings the Member States should achieve under the EED.

In implementing this provision, Member States' subsidiarity has been respected by leaving them flexibility in how they achieve the 1.5% end-use savings as long the cumulative savings amount is achieved by 2020. For example, Member States can choose a wide range of policy measures, energy using sectors and individual energy efficiency improvement actions (in total 477 measures were notified to achieve the 250 Mtoe of end-use savings by 2020, and 16 out

[36] A detailed intervention diagram of Article 7 can be found in Annex 6.

of those are obligation schemes implemented by utilities)[37]. Finally, Member States were free to not adopt an energy savings obligation scheme if in their particular regulatory context this was not deemed to be the most cost effective way, e.g. when due to a long history of national energy efficiency legislative efforts other measures already addressed the lack of incentives for energy efficiency investments.

Given the fact that the EED has triggered the uptake of energy efficiency obligation schemes (increasing in number from 5 to 16), and the fact that some Member States use specific trading platforms at national level, the Commission services organised a stakeholder meeting on 29 February 2016[38] to discuss the feasibility of cross border tradability of documented savings. The outcome of the meeting suggests that at this stage it is not feasible to establish an EU white certificate scheme and thus the option of tradability of savings across Member States was not considered in this impact assessment (see Annex 1).

Conclusions of the Evaluation

In terms of **effectiveness**, the evaluation of the implementation of Article 7 on energy efficiency obligation schemes and alternative measures reveals that Member States are on track to achieve the required savings by 2020 (based on their current notifications), provided that the measures are effectively implemented and that robust monitoring and control systems are established to check the credibility of reported energy savings. The evaluation showed that simplification of certain requirements of Article 7 and clarification of aspects such as what savings are eligible as well as concepts such as 'materiality' would improve implementation at national level and would allow an effective and efficient achievement of the required savings by Member States.

In terms of **efficiency**, the evidence of pre-existing schemes shows that the EEOS are highly cost-effective instruments. Certain alternative policy measures also tend to be cost-effective, for example voluntary agreements, taxation measures and financing schemes and incentives. Despite initial start-up costs, the administrative costs to run EEOSs are relatively low, although they can be expected to vary between Member States. There is more evidence available on how the monitoring and verification systems work for the EEOS than for the alternative measures, including only limited evidence on the administrative costs associated with the monitoring of the alternative measures under Article 7.

In terms of **relevance**, Article 7 remains relevant as it addresses a wide range of market and regulatory failures and can, in particular, be instrumental for making energy efficiency services and investments a business case. This becomes even more relevant in the context of the new 2030 ambitious climate and energy objectives.

In terms of **coherence**, Article 7 remains coherent with other measures of the Energy Efficiency Directive. The energy savings requirement of Article 7 provides an important contribution to the EU's collective energy efficiency target as set out in Article 3. It also

[37] More detailed information on major policy measures notified under Article 7, containing examples and best practice is provided in four case studies annexed to the dedicated study on evaluating progress in implementation of Article 7 (Ricardo AEA/ CE Delft (2015): Annex 4 of the Study on evaluating the implementation of Article of the EED).

[38] For more detail see Annex 1 on stakeholder consultation.

complements other EU energy efficiency policies in two ways. Firstly, only those energy savings that exceed the minimum requirements of other EU policies are eligible and can be counted towards the Article 7 target, so overlaps are minimised. Secondly, it drives forward the application of the energy efficiency requirements of other policies. For example, the Energy Performance of Buildings Directive (EPBD) sets minimum energy requirements for new or renovated buildings, but contains no requirements as to how many buildings must be renovated, or by when. By contrast, Article 7 requires Member States to show actual energy savings, and therefore encourages the building renovations to take place in practice. The same logic applies to eco design and energy labelling, when Member States have policies under Article 7 to encourage the purchase of highly efficient boilers or household appliances. Article 7 can therefore be seen as a 'pull' factor which increases the practical application of the other EU energy efficient policies, and indeed for national energy efficiency policies.

Finally, in terms of **added value**, Article 7 allows more effective and coordinated achievement of the EU 2020 energy efficiency objectives, while respecting the subsidiarity. Article 7 allows ensuring the stability to investors that in turn helps unlock the needed financing for implementing the energy efficiency measures.

1.4.3 Outcome of the evaluation on Articles 9-11 (on metering and billing)

Overview of the existing framework and progress in implementation

EED Article 9 contains provisions on individual metering generally, on smart metering of electricity and gas and on metering of thermal energy in multi-apartment/purpose buildings. Article 10 sets requirements for consumption based billing information in general (incl. as regards minimum frequency) and requirements on consumption information from smart meters for electricity and gas, as well as general information and billing requirements pertinent to costs, consumption and payment. Article 11 ensures that metering and billing are generally free of charges and sets out the conditions for the pass-through of cost of sub-metering/billing. In addition, Annex VII sets minimum requirements for billing and billing information based on actual consumption. These requirements set out both general requirements for all energy forms and specific requirements for where smart electricity and gas meters are installed, without requiring that such meters are installed. These complement the provisions in the internal market legislation on roll-out and functionalities of smart meters. The EED also covers thermal energy forms, which are not addressed in the internal energy market legislation.

Given that provisions on metering and billing are found in both the EED and in the Internal Energy Market (IEM) legislation, the Commission services developed "thematic" cross-cutting evaluations of these. The evaluation concluded that amendments to Articles 9-11 and related Annex VII would improve effectiveness, as detailed below.

The objective of Articles 9-11 is to strengthen the empowerment of final customers as regards access to up-to-date information on their actual, individual energy consumption at a frequency enabling them to regulate their energy use. The evaluation of existing metering and billing provisions notes that it is too early to draw too many firm conclusions as regards the effectiveness of Articles 9-11 of the EED given the relatively recent deadline for EED transposition (5 June 2014) Nevertheless it is already possible to identify, as regards the thermal sector, certain gaps, problems and potential improvements and clarifications. There was an evident intention at the time of the adoption of the EED to clarify the pre-existing requirements on metering and billing that were then contained in the 2006 Energy Services Directive, and in the IEM legislation. This intention was however only partially met and the current framework remains complex and open to interpretation with regard to the nature and scope of certain key obligations. This is particularly the case regarding the rights of consumers in multi-apartment/purpose buildings with central supply of heating, cooling and/or hot water to be informed about and billed according to their own consumption and the frequency with which this must happen.

Moreover, Articles 9(2) and 10(2) of the EED specifically concern requirements for smart electricity and gas meters, the roll-out of which is regulated in the IEM Directives and covered by a partially overlapping Commission Recommendation.

Conclusions of the Evaluation

In terms of **effectiveness**, the evidence available suggests that the provisions on metering and billing in the IEM Directives and EED, to the extent they can be assessed at this time, together are likely to have made some contribution towards the achievement of their dual objectives (enabling energy savings and effective consumer choice), although it is very difficult to quantify. However, the ambiguous wording of certain provisions has substantially reduced their impact, depending on how they were interpreted in individual Member States. This not least concerns the applicability of billing/information provisions for sub-metered consumers of thermal energy.

In terms of **efficiency**, there is reason to assume that the provisions considered have generally been efficient in terms of the proportionality between impacts and resources/means deployed.

With regard to **relevance**, most provisions remain highly relevant, although parts of both the IEM and the EED to some extent have been surpassed by developments and could benefit from being revisited / updated, including in the light of technical progress made in terms of the deployment of remotely readable devices for heat measurements.

In terms of **coherence**, the evaluation pointed to a number of issues where improvements would seem possible and desirable. Most importantly it would be simpler to ensure full consistency if billing and metering for gas and electricity was regulated in only one place and not also covered by EED legislation, hence those provisions should be moved to the Electricity and Gas Market Directives in the context of the future market design proposal.

As regards the **EU added value**, the evaluation concluded that, in a single market for energy, there is a strong case for suppliers being subject to similar if not identical obligations and rules, and for consumers to enjoy the same basic rights and be provided with comparable and recognisable information. Delivering a New Deal for energy consumers as part of an Energy Union with consumers at its heart means *inter alia* providing consumers with frequent and meaningful, accurate and understandable information on their energy consumption and related costs[39]. This contributes to realising the Energy Union and meeting EU goals on energy efficiency and greenhouse gas reductions.

1.5 Why does the problem need to be tackled now?

The assessment of 2030 energy efficiency target needs to be developed now for several reasons:

1. The level of the EU wide target for energy efficiency affects the amount and type of greenhouse gas reductions achieved in the non-ETS sectors[40]. This in turn contributes to the achievement of the national green house gas (GHG) reduction targets for the non-ETS sectors in the Effort Sharing Regulation for which Commission's proposal was published on 20 July 2016[41]. The aim of the Regulation is to achieve in 2030 the EU 30% GHG emission reductions compared to 2005 in the non-ETS sectors. However, energy efficiency policies will not only contribute to the emission reduction targets for 2030, they are also helping pave the way for a cost-efficient way for 80-95% emission reductions by 2050 (see Annex 3).

2. Current uncertainty about the energy efficiency ambition for 2030 can lead to delays and lower ambition of national contributions to EU objectives under the governance process of the Energy Union. The new governance system will ensure that a transparent and reliable planning, reporting and monitoring system is in place for all 2030 climate and energy targets, based on integrated national energy and climate plans and streamlined progress reports by Member States. Therefore, a timely and clear agreement on the energy efficiency target for 2030 is important to ensure a coherent planning of climate and energy policies on a national and European level.

3. The market design and renewable energy initiatives of the Commission will cover areas which are also linked to energy efficiency policies e.g. metering, consumer rights and demand response and deployment of renewables. To ensure that the energy efficiency is seen as an energy source in its own right and to accommodate energy efficiency and its value in increasingly flexible market, the contribution of energy efficiency in 2030 needs to be fixed. The overall energy efficiency framework should be made fit for purpose for the 2030 perspective to ensure that the different pillars of the Energy Union are coherent.

4. The Commission adopted in July 2016 its Strategy for Low-Emission Mobility[42]. The transport sector has the highest share of final energy demand. It can make an important contribution to energy efficiency notably via standards for vehicles and transport management policies. Furthermore, in the transport sector, potential synergies can be exploited in terms of realising important co-benefits in terms of decrease in pollution, congestion and thus improving quality of life, especially in cities. Therefore, different levels of the 2030 energy efficiency target require efforts in the transport sector which

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[39] COM(2015) 339 final.
[40] Some EE measures that concern electricity have also impact on the ETS sector.
[41] COM(2016)/482.
[42] COM(2016) 501 final.

are analysed in this impact assessment and, in more detail, in the Staff Working Document[43] accompanying the Communication *Strategy for Low-Emission Mobility*.

As regards the metering and billing provisions in Articles 9-11, the problems identified need to be addressed now in order to contribute to the delivery of a New Deal for Energy Consumers announced as part of the Energy Union. Delivering the New Deal means providing consumers with frequent access, including in near real-time, to partially standardised, meaningful, accurate and understandable information on consumption and related costs as well as the types of energy sources not just on electricity and gas but also on heating and cooling was set out in the Heating and Cooling strategy[44].

1.6 Nature and extent of the problem

The 2016 EU Reference scenario ('REF2016')[45], reflecting a scenario based on currently implemented policies and adhering to binding 2020 targets, demonstrates that the EU objectives of sustainability, energy security and competitiveness will not be reached. It indicates that the current national and European energy efficiency framework would lead to 23.9% of primary energy reduction compared to 2007 baseline projections in 2030. In the EU Reference scenario, primary energy consumption reaches 1436 Mtoe and final energy consumption reaches 1081 Mtoe in 2030[46].

This is because without a 2030 energy efficiency framework, large amounts of cost-effective investments in energy efficiency will not take place in the different sectors. This is in itself damaging for all EU citizens because the benefits for the environment, lower energy costs for households and companies, increased jobs and economy-wide economic activity and health protection possibilities are not exploited. Insufficient energy efficiency could also increase the risk of not achieving the agreed objective of at least 40% GHG reductions by 2030 and put the 2050 long term goal to decarbonise our economy in jeopardy or outside a cost efficient trajectory. In terms of **security of supply**, high energy demand increases the dependence of the EU on energy imports, in particular of gas. Gas imports amounted to 254 Mtoe[47] in 2014 and in the Reference scenario are projected to rise to 295 Mtoe in 2030. Various Member States rely on fossil fuel imports from single providers and their dependency on single import routes create many risks, including price volatility and sudden disruptions of supply.

The evaluation of Article 7 shows that the saving obligation will play a key role in the delivery of the 2020 target thanks to its "pulling" effect as it attracts private investment in energy efficiency, thus increasing the *rate* of energy efficient renovations or uptake of energy

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[43] The same core policy scenarios (EUCO27 and EUCO30) from this Impact Assessment are used as a starting point in SWD(2016) 244 final. In addition, more ambitious scenarios are analysed, notably on more stringent light duty vehicles' CO2 standards – leading to higher energy savings in the transport sector.

[44] COM(2016) 51 final, 16.2.2016.

[45] See Annex 4 for more details.

[46] A reference scenario follows the logic of including only policy measures which have been adopted until a certain cut-off date, without including new policies not yet officially adopted. In the Reference 2016 scenario, the cut-off date was December 2014 (the EED was therefore included, although with conservative assumptions as to its implementation).

[47] In 2014, EU28 imported 257 bcm (233 Mtoe) of natural gas, 'Quarterly Gas Report on gas Market Observatory for Energy', Commission/DG Energy, Volume 8, 2015. (https://ec.europa.eu/energy/sites/ener/files/documents/quarterly_report_on_european_gas_markets_q3_2015.pdf).

efficient appliances and techniques. Therefore the expiry of Article 7 would not facilitate the realisation of sufficient savings in view of a 2030 target. It is likely that some Member States with a strong political drive for energy efficiency would continue using this instrument in the absence of EU framework, but the situation before the EED was adopted suggests that most would not.

With regard to metering and billing, the lack of clarity of certain key provisions has become evident in the course of the work with Member States to transpose and implement the provisions nationally, and dialogue with/feedback from stakeholders have confirmed that major divergences in interpretations exist, e.g. as regards the applicability of provisions for sub-metered heat consumers. The analysis presented later in this reports seeks to estimate the extent of the potential energy savings not exploited due to inadequate consumption information being given to sub-metered consumers of thermal energy.

2 Why should the EU act?

According to Article 194 of the Treaty on the Functioning of the European Union, Union policy on energy shall aim, in a spirit of solidarity between Member States, to promote energy efficiency and energy savings. The European Parliament and the Council, acting in accordance with the ordinary legislative procedure, shall establish the measures necessary to achieve the objectives.

In October 2014 the European Council requested the Commission to review the minimum 2030 energy efficiency target of at least 27% by 2020, having in mind an EU level of 30%. In December 2015, the European Parliament pointed to the need to assess the viability of a binding 40% EU energy efficiency target.

Agreeing on a common framework for energy efficiency for 2030 on the EU level as part of the overall energy and climate framework will help Member States to achieve a sustainable, secure and affordable energy system for European society as a whole and for European citizens. These challenges cannot be tackled at national level alone as climate change and security of supply are trans-boundary problems. All Member States face the same risk of increasing energy prices, which could lead to high energy bills for consumers and could weaken Europe's competiveness. The 2020 framework has been already proved to be an effective way of targeting these challenges[48].

Co-ordinated EU action helps Member States to better target national energy efficiency policies. EU-wide headline targets, coherent with other energy and climate objectives, namely the ETS, the Effort-Sharing Regulation and the EU Renewable energy target for 2030, facilitate the establishment of national policies and indicative targets. As in 2020, Articles 1 and 3 of the amended EED would again provide the appropriate legislative framework for all Member States to fix a coherent European 2030 energy efficiency level.

[48] Back in 2010 Member States agreed on the EU 2020 headline targets for energy efficiency, greenhouse gases and renewable energy. It was decided that no binding energy efficiency targets were implemented but instead binding measures were put in place.

The overall level of target will influence the level of ambition of European energy efficiency policies, notably EU standards. The role of Member State action will, however, remain crucial to delivery of the target as it is mainly national measures that contribute and ensure meeting the overall agreed EU target.

If cost-effective investments in energy efficiency are not undertaken, then other potentially more costly mitigation measures need to be taken to achieve the same GHG reduction effort. Therefore improving the business case for energy efficiencies can reduce the overall costs of GHG abatement as long as Member States have sufficient freedom to define the areas which they want to target and the policy approaches. The market and regulatory failures identified above are of relevance to all Member States alike as they are inherent to energy efficiency rather than linked to certain political and institutional set-ups. In particular all EU Member States will need to bring their energy systems on a decarbonisation path and create a framework in which there is a strong business case for energy efficiency.

One of the main articles of the EED is Article 7 which has delivered an effective contribution towards reaching the agreed indicative EU energy efficiency targets. With its binding nature, it requires Member States to address the fundamental obstacles preventing energy efficiency to take place – either through an obligation or through a set of alternative measures with similar effect. This is necessary as otherwise EU instruments only set minimum requirements, but do not fundamentally improve the attractiveness of investing in energy efficiency as such[49]. In line with the Better Regulation guidelines, Member States have significant flexibility[50] on how they implement Article 7, thus allowing all energy consumers in the EU to benefit from energy savings both directly (reduced energy consumption and lower energy bills) and indirectly (higher comfort level and better air quality, etc.). The extension of Article 7 is important in particular for the development of an energy efficiency market. It promotes investments and energy services available in the market thanks to the increased demand for energy efficiency improvements. This in turn creates new jobs, triggers innovation and the development of new technologies and techniques. In a single market for energy, there is a strong case for suppliers being subject to similar, if not identical, obligations and rules, and for consumers to enjoy the same basic rights and be provided with comparable and recognisable information. The EU needs to decide if and in which form Article 7, which would be a major contributor to the 2030 target, should continue to ensure that cost-effective energy saving measures are implemented post 2020. Updating the existing energy savings requirement of Article 7 is fully in accordance with the energy legal base introduced by the Lisbon Treaty, is in line with the conclusions of the evaluation of the EED and also fully respects the principle of subsidiarity by leaving it to the Member States to decide which policies and measures they would use to achieve the required savings in accordance with their national situation and specificities.

With respect to Articles 9-11 only the EU can act to ensure that its legal provisions are sufficiently clear and adequately reflect the possibilities offered by technological advances made. Guaranteeing certain minimum standards in terms of the frequency and content of

[49] For example the EPBD lays down minimum energy performance requirements but does not set a rate at which buildings should be renovated.

[50] Through the energy efficiency obligation schemes or alternative measures which suit national circumstances; 477 measures notified were notified under Article 7 by Member States to reach the savings requirement by 2020.

billing and billing information empowers consumers and contributes to realising the Energy Union.

This proposal is entirely in line with Article 37 of the Charter for Fundamental Rights, under which a high level of environmental protection and the improvement of the quality of the environment must be integrated into the policies of the Union and ensured in accordance with the principle of sustainable development. The proposals on metering and billing of energy for consumers will help ensure a high level of consumer protection, as required under Article 38 of the Charter. The requirement that meters or cost allocators be remotely readable respects the right to privacy of home and family life. The increased emphasis on solutions to energy poverty helps to combat social exclusion and poverty in accordance with Article 34.

Overall, the revised EED framework will help achieving the 2030 climate targets in a cost-effective way, while leaving flexibility to Member States on how to achieve the savings.

3 What should be achieved?

The **general objective** of this initiative is to ensure that energy efficiency contributes to the development of a competitive, sustainable and secure EU energy system in 2030 and beyond, as recognised by the Energy Union Strategy and in accordance with the 'energy efficiency first' principle.

The three **specific objectives** are as follows:

1. To respond to the political mandate given by the European Council and the European Parliament to determine the energy efficiency target in 2030, taking into account the multiple benefits and costs related to lower energy consumption, while respecting all other 2030 objectives. In addition, it has to be assessed whether the target should be binding or non-binding in nature.

2. To ensure that Article 7 contributes to the achievement of the energy efficiency target for 2030, as well as the overall GHG targets for 2030 and beyond by attracting private investments. In this respect, a business case for long-term energy efficiency private investments post 2020 needs to be ensured, while respecting the overall architecture of EU energy and climate change policies.

3. To empower consumers of thermal energy through better and sufficiently frequent feedback on their consumption including by taking advantage of progress in technology.

The three **operational objectives** are as follows:

1. In relation to the energy efficiency target, a legal revision of Article 1 and 3 is necessary to fix the EU 2030 energy efficiency target.

2. In relation to Article 7 it will require a legal revision of the policy framework so that it ensures that Member States achieve their required national energy savings by the end of 2030.

3. In relation to Articles 9-11 a legal revision is necessary to clarify the metering and billing requirements for consumers of heating, cooling and hot water and update them to reflect the capabilities of the technologies now available.

4 What are the various options to achieve the objective?

4.1 2030 energy efficiency target level – policy options for Articles 1 and 3

4.1.1 Level of energy efficiency target

As discussed above, the updated 2016 EU Reference scenario (REF2016) indicates that with no new policies beyond those adopted by the end of 2014, only 18.4% reduction of primary energy consumption will be achieved in 2020 (hence missing the 2020 indicative target). As the policy initiative supported by this impact assessment does not propose additional measures before 2020, the policy scenarios do not achieve the 2020 target either. In this respect, the policy scenarios are conservative. If the 2020 target is indeed achieved – and the Commission believes that it will be - less effort and investments will be needed after 2020 to achieve any given 2030 target[51].

REF2016 projects a 23.9% primary energy consumption reduction compared to the 2007 baseline projections for 2030[52]. It is assumed that national policies to achieve the required savings under Article 7 are mostly phased-out after 2020 because of the expiry of this article. Renewable energy would account for 24.3% of gross final energy consumption and GHG emissions would be reduced by 35.2% (37.7% in the ETS sectors and 23.7% in the ESD sectors) in 2030.

Different energy models have been used in order to respond to the political mandate given by the European Council and the European Parliament to determine the energy efficiency target in 2030, taking into account the multiple benefits and costs related to lower energy consumption, while respecting all other 2030 objectives.

Energy efficiency targets need to be assessed within the framework of the other targets that have been agreed by the European Council, *i.e.* an overall GHG emissions reduction (at least 40% compared to 1990), a GHG emissions reduction in ETS sector (43% compared to 2005, including the Market Stability Reserve and the proposed revision of the linear reduction factor), a GHG emissions reduction in sectors covered by the Effort Sharing Regulation (30% with respect to 2005) and renewable energy shares in final energy consumption (at least 27%). The different policy areas reinforce each other and are analysed as a package. In terms of ETS and non-ETS targets in 2030, these are met in the EUCO27 and EUCO30 scenarios, but necessarily overshoot in some of the more ambitious scenarios. In contrast to the REF2016, all policy scenarios are consistent with the EU's long term GHG reduction objective for 2050.

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[51] As set out in its Energy Efficiency Communication of 2014 and Energy Efficiency Progress Report of 2015, the Commission has strong grounds to consider that the 20% target for 2020 will be achieved with proper implementation of existing legislation, and is working intensively with Member States to achieve that.

[52] 2007 Baseline modelled with PRIMES projected for 2030 primary energy consumption reaching 1436 Mtoe and final energy consumption 1081 Mtoe.

The **first policy option** is to achieve a target of 27% reduction of primary energy consumption (compared to the 2007 baseline), the minimum energy efficiency ambition level agreed by the European Council in 2014. The scenario that reflects this policy option is considered as the **baseline scenario** in this impact assessment[53] and the policy scenarios are, most often, compared to this scenario.

Four further **policy options** explore 2030 **targets of a 30%, 33%, 35% and 40%** reduction of primary energy consumption (compared to 2007 baseline). The policy options with a level above 30% energy efficiency in 2030 also include higher RES shares of 28% which makes them closer to the 2030 renewable energy target called for by the European Parliament[54].

The baseline scenario and the four policy scenarios which reflect the different policy options are called respectively EUCO27, EUCO30, EUCO+33, EUCO+35 and EUCO+40[55].

Comparing the policy scenarios against REF2016 would show the costs (notably investment expenditure) necessary to achieve the GHG, Effort Sharing Regulations and RES target all together. Likewise, if compared to REF2016, benefits shown by a policy scenario are combined benefits of achievement of all targets. If, however, the policy scenarios are compared to EUCO27 (which is considered as the baseline), they only show incremental changes in impacts due to scaling up level of energy efficiency.

The mix of energy efficiency policies assumed for the scenarios follows the logic of the current European legislation. This policy mix involves policy instruments including carbon pricing to reduce emissions in the ETS and non-CO_2 emissions in the non-ETS sectors, standards, reduction of market barriers, incentives and obligations related to energy efficiency and RES policies in a coherent manner across Member States, taking into account the current policy framework (as developed in the REF2016). A top-down modelling approach was used to show the impacts of different energy efficiency levels on the energy system (e.g. energy mix) and macro-economic impacts (e.g. GDP, employment), social, environmental and health impacts. Energy efficiency policies are, however, depicted only in an aggregated and stylised manner which does not allow quantifying the achieved savings or costs of individual policy measures (e.g. Articles 7 or 9-11 of the EED).

The link between the policy scenarios and what they mean in practice can be explained in the following way: the energy efficiency targets are achieved by simulating a mix of European and national energy efficiency policies in all sectors: residential, tertiary, industrial, transport

[53] Please see more information on the role and logic of baseline in the impact assessment accompanying the renewables initiative, Annex 4.

[54] In December 2015 the European Parliament called "for three binding energy and climate targets for 2030, in particular the 40 % energy efficiency target; emphasises that the post-2020 EU energy efficiency target should be binding and implemented through individual national targets; urges the Commission to develop various 2030 energy efficiency scenarios, including at the level fixed by Parliament of 40 %" and "least 30 % for renewables" European Parliament P8_TA-PROV(2015)0444.

[55] The PRIMES/GAINS modelling framework is used to analyse long term energy, transport and GHG emission trends in the EU. This modelling framework was used for the analysis underpinning the setting of the EU 2020 targets (including energy efficiency), the Low Carbon Economy and Energy 2050 Roadmaps, the 2030 policy framework for climate and energy and the Energy Efficiency Impact Assessment in 2014. The main difference to the energy efficiency modelling exercise performed in 2014 is that the energy efficiency policy scenarios in this Impact Assessment are based on the updated EU Reference scenario 2016. Therefore, the results are based on the latest energy projection. The discount rates used in the model have been reviewed. In addition, the policy scenarios differ slightly from the ones in 2014 in terms of policy mix.

and supply. The mix of energy efficiency policies assumed for the scenarios follows the logic of the current European legislation: the EED, the EPBD, regulations adopted under Eco-design, energy labelling and specific measures in transport (e.g. CO_2 standards for cars and vans). The stringency and intensity of the policy differs between the policy scenarios. Overall, the modelling aims to reflect a cost efficient achievement of GHG reductions in the context of different sets of GHG, energy efficiency and RES targets and existing policies[56].

The set-up of the five policy scenarios is different with respect to the intensities of the following policies:

- Standards (eco-design[57], building codes and CO_2 standards for vehicles) are intensified for all sectors in the different policy scenarios. Standards are an essential feature of a cost-effective approach. Both modelling experience and current practice show that the benefits in terms of economies of scale and overcoming market failures by using internal market rules are very important. For the most ambitious scenarios, the application of BAT (best available technology) in industry is assumed.
- Shadow Energy Efficiency Values (EEVs) were applied and scaled up representing yet to be identified policy measures aiming at achieving energy savings (notably reflecting implementation of Article 7, other national incentive and saving schemes). As EEVs apply to the entire residential, tertiary and industrial sector, they trigger the most cost-effective options in these sectors.
- The use of behavioural discount rates was adjusted with increasing energy efficiency levels in 2030. The Commission is working on improving financial instruments and other financing measures at the European level to facilitate access to capital for investment in thermal renovation of buildings. Together with further labelling policies for heating equipment and for other product groups, this can lead to a reduction of behavioural discount rates for households and the service sector.
- Some specific measures aimed at improving the efficiency of the transport system and managing transport demand are included as scenarios become more ambitious, in line with measures assumed in the scenarios presented in the Staff Working Document on Low Emission Mobility (e.g. full internalisation of local externalities on the inter-urban network, ambitious deployment of Collaborative Intelligent Transport Systems, promotion of efficiency improvements and multimodality, taxation).
- Policies were assumed which are facilitating the uptake of heat pumps for the scenarios more ambitious than EUCO27 to reflect option 3.b of the Article 7 analysis which would allow counting savings stemming from on-site renewable energies (e.g. heat pumps) within the 25% exemptions, more ambitious eco-design/labelling policies in this respect and the change of the primary energy factor.

A description of the approach and definition of the policy scenario is to be found in Annex 4.

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[56] While informative about the achieved additional emission reductions in case of coherent cost efficient actions across the EU in all policy areas to achieve all targets, these scenarios outcomes cannot be attributed to the effort sharing mechanism itself, which will sets targets differently from the cost effective outcome to allow for fairness between Member States.

[57] The modelling has shown that, with current assumptions about technology development, the potential of eco-design improvement is already exploited in the EUCO30 scenario.

As explained above, while some energy efficiency policies, notably standards for different product groups, are represented in greater detail, others are represented in an aggregated and stylised manner and the impacts of such policies are subject to higher uncertainty. Therefore the assessment regarding the level of the target would have to be complemented by specific assessments and associated analytical tools that would assess in more detail the effects of specific policy measures and instruments (but which lack a system-wide perspective). It is therefore likely that different policy mixes and specific policy instruments, different parameters of these policies (e.g. in case of CO_2 standards for cars and vans) and nature of instruments (e.g. regulation, voluntary agreement, financing, information campaign) from the ones assumed in this modelling exercise might be necessary, appropriate or desired.

4.1.2 Character and formulation of energy efficiency target

With regard to the character of the 2030 Energy efficiency target, the policy options start from the European Council Conclusions 2014 and the 2015 request from the European Parliament as described above.

Table 2: Policy options for Articles 1 and 3

Policy options	Articles 1 and 3
Option 1.1	Continuation of the current framework: Indicative EU target, indicative national pledges coupled with specific EU measures together with a governance system.
Option 1.2	Binding EU target, coupled with indicative national pledges and specific EU measures together with a governance system. This would replicate the intended approach for the renewable energy targets for 2030.
Option 1.3	Binding national targets.

With regard to the formulation of the 2030 Energy efficiency target, the options as shown in the table below are analysed.

Table 3: Policy options for Articles 1 and 3

Policy options	Articles 1 and 3
Option 2.1	Energy saving target
Option 2.2	Final and primary energy consumption target
Option 2.3	Either final or primary energy consumption target
Option 2.4	Final and primary energy intensity target

4.2 Attracting private investment – Policy options for Article 7

A set of policy options including non-legislative and legislative options are considered in order to address the drivers of the problems identified above.

Table 4: Overview of policy options for Article 7

Policy options	Article 7, Annex V (energy savings obligation)
Option 1 – No changes relating to regulatory framework	**Baseline scenario – no regulatory action at EU level; continue with guidance on regulatory framework and work on enforcement until 2020**
Option 2 – regulatory	**Extend Article 7 to 2030**
Option 3 – regulatory	**Extend Article 7 to 2030; simplify and update**
Option 4 – regulatory	**Extend Article 7 to 2030; increase the rate of savings**

4.2.1 Option 1: Baseline scenario – no regulatory action at EU level; continue with guidance on regulatory framework and work on enforcement until 2020

If pursued with this option, the regulatory framework which requires Member States to achieve annual savings of 1.5% from the annual energy sales under Article 7 of the Directive would expire after 2020. Under this option, the focus would be on continuing providing guidance to Member States on the application of the requirements of Article 7 and Annex V until 2020, such as what savings can be counted and on materiality or on the existing scope of eligibility (which were all assessed in the evaluation) in order to avoid delays in implementation and incorrect implementation.

At national level, energy efficiency obligation schemes would possibly continue in some Member States. Some alternative measures (in particular renovation of buildings) might also still be pursued although only as voluntary action and continue delivering some savings beyond 2020 and 2030 thanks to the long lifetimes of these measures. It is difficult to estimate to what extent such voluntary action would generate new savings, but it is likely that this would be minimal without EU intervention given the previous experience.

Exchange of best practice and experience through organising thematic workshops and seminars would be part of the work on enforcement. The focus would be on the annual monitoring of Member States' performance until the end of 2020, dialogue with Member States, and relevant infringement proceedings could also be taken in the context of the existing regulatory framework laid down to achieve the cumulative savings requirements by 31 December 2020 in line with Article 7(1).

While this option would reduce the risk of non-delivery of savings by 2020, it would however not address the issue of the short term perspective as Article 7 would cease to apply after 2020 and thus would not secure the needed investments to achieve savings and would not address the existing market and regulatory barriers in view of the 2030 target. This might in turn put a significant risk on the achievement of the EU 2030 energy efficiency target and also on the greenhouse gas emissions GHG target which depends strongly on energy efficiency measures (especially for non-ETS sectors) to be implemented in all Member States.

A number of respondents to the public consultation (including Member States) pointed out that guidance is needed on materiality and on which savings can be counted[58]. Many respondents stated that exchange of best practice through platforms and workshops is also needed.

The non-regulatory financial measures set out in the Smart Financing for Smart Buildings Initiative would enable a framework with greater private capital participation for in the sector. However, the necessary up-take of the opportunities offered by this framework would not be guaranteed and would be significantly lower without Article 7[59].

4.2.2 Option 2: Extend Article 7 to 2030

This option foresees the extension of Article 7 beyond 2020 while retaining the existing approach (1.5% of energy end-use savings from annual energy sales to be achieved via energy efficiency obligation schemes and/or alternative measures)[60].

Other options with a slower rate of savings are not investigated here because evidence shows that the current rate of savings is likely to be cost-effective in narrow terms, even without taking into account wider societal benefits[61].

In this option Article 7 will retain the same level of flexibility for Member States to fully or partially exclude energy sales in transport from the baseline (used by almost all Member States) or to use the four different exemptions up to 25% of the total saving requirement[62].

Besides flexibility in the calculation of savings requirement, Member States will retain their freedom how to achieve the energy savings in terms of selecting measures according to

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[58] Some also asked for more specific information on which savings may not be counted, for example under EcoDesign, the EPBD, and CO2 standards for vehicles, and also stated the need for clearer definition on lifetimes.

[59] Firstly, the injection of additional private finance as a result of the implementation of Article 7 would be missing (taking the form of finance coming from utilities driven by energy efficiency obligations; financing from firms driven by voluntary agreements; and financing from firms and individuals driven by tax incentives introduced to fulfil the requirements of Article 7). Secondly, Article 7 could not incentivise the aggregation of projects, notably through energy efficiency obligations and voluntary agreements. Thirdly, a strong regulatory framework would be missing as expressed by the Energy Efficiency Financial Institutions Group which said that "the importance of leadership and signalling for energy efficiency investments should not be underestimated in the context of the EU's 2030 Climate and Energy package; the headline positioning of energy efficiency targets would impact how EU buildings' energy use will decrease and decarbonize from now until 2050 with intermediate milestones. If the EU wants to unlock the enormous potential for energy savings in its existing building stock then it clearly requires bold policy intervention going beyond the strong implementation of existing legislation." (see https://ec.europa.eu/energy/sites/ener/files/documents/Final%20Report%20EEFIG%20v%209.1%2024022015%20clean%20FINAL%20sent.pdf).

[60] 68% respondents of the public consultation confirmed that Article 7 is an effective instrument to achieve final energy savings and 63% shared the view that Article 7 should be extended beyond 2020, as it is regarded as key contributor to the achievement of the 2030 target. The majority of NGOs and utilities and five out of ten Member States, which expressed an explicit view on effectiveness in the public consultation, considered Article 7 to be effective. The extension was supported by a majority of both participating NGOs and utilities. However, seven out of fifteen Member States, which expressed a view, did not support extending Article 7.

[61] In certain countries the cost of an average kWh delivered to final consumers has been estimated at about 14-23 times higher than the cost of saving one kWh of final energy - Rosenow, J., Bayer, E. (2016): Costs and benefits of the Energy Efficiency Obligation Schemes. Regulatory Assistance Project.

[62] This option requires no change of the existing flexibilities and exemptions under paragraph 2, as the evaluation showed significant use of the flexibilities and exemptions by Member States (see Annex 6) to continue recognising the different achievement levels and policy developments in Member States also in view of the next commitment period.

national situation and choosing the end-use sectors, including choosing how the savings are distributed over the whole commitment period as long the cumulative amount is achieved by the end of the period.

This flexibility will also be important to maintain coherence with the flexibilities foreseen for the achievement of the proposed more ambitious non-ETS GHG emissions targets in Member States under the Effort Sharing Regulation[63] in view of the 2021 to 2030 period.

Member States would be required to continue achieving new annual savings of 1,5% for ten year periods after 2030, unless review(s) by the Commission conclude that this is not necessary to achieve the Union's long term energy and climate targets for 2050.

4.2.3 Option 3: Extend Article 7 to 2030; simplify and update

As under the previous option, the extension of the period to 2030 would be in line with the general objective of aligning Article 7 with the overall 2030 framework for climate and energy. In addition to the elements analysed under option 2, this option aims at simplification and clarification of certain requirements posing most challenges in the current framework, in particular how to calculate savings.

Article 7 already allows Member States to impose requirements with a social aim, in particular related to energy poverty, on energy companies under their energy efficiency obligation schemes. The need to tackle energy poverty has been recognised politically at the EU level. Extending Article 7 to 2030 could encourage more Member States to include social aims in the measures they use to achieve their savings obligation in the next obligation period, in particular in relation to households affected by energy poverty[64]. If it were not considered appropriate to propose any regulatory action, consideration should be given to guidance, monitoring and reporting and exchange of good practice, etc.

Sub-option a) Simplification of what savings can be counted

The current Article 7 and Annex V lay down that only energy saving which are additional to those required under other EU legal requirements, can be counted for the purposes of Article 7. The evaluation shows that as it applies to savings calculated from national building codes[65], this requirement has been difficult to understand and to apply. It could be simplified by allowing Member States to count all savings stemming from energy efficiency renovations under national building codes, not only those above the cost-optimal level set in accordance with the Energy Performance of Buildings Directive, provided the materiality criterion[66] is fulfilled. This would facilitate the calculation of savings triggered by energy efficient

[63] The recent evaluation Study on the Effort Sharing Decision refers to the EEA Report (2014) pointing out that there are a number of positive synergies and that energy efficiency measures (i.e. EED and EPBD) help meeting the targets under the Effort-Sharing Decision.

[64] Four Member States have foreseen such measures (Austria, France, Ireland and the United Kingdom) under their EEOS.

[65] This is borne out by the responses of the Member States to the consultation, and in their replies to the structured dialogue with the Commission through the EU Pilot system – see Annex 3.

[66] In line with Annex V(2)(c), the activities of the obligated or participating parties must demonstrably contribute to the achievement of the energy savings claimed for the purposes of Article 7. I.e. that the actions of obligated and participating parties have actually contributed to the energy savings caused by the uptake of renovation of buildings.

renovation of buildings. This option would trigger more renovations of existing buildings, encourage long term energy saving measures and also ensure greater coherence with the EPBD.

Under this option the Commission would aim to develop a harmonised notification template (as suggested by the evaluation[67]) for Member States to submit the Article 7 notifications for measures in the 2020-2030 period, which would then be integrated in the national energy and climate plans under the governance initiative of the Energy Union.

Sub-option b) Allow counting on-building RES

This sub-option looks at whether Member States and obligated parties could be allowed to count to some extent on-building renewable energy measures[68] towards their Article 7 savings requirement[69].

4.2.4 Option 4: Extend Article 7 to 2030, increase the rate of savings

Similarly as under the previous options 2 and 3, the extension of the commitment period to 2030 would be in line with the general objective of aligning Article 7 with the overall 2030 framework for climate and energy. Two different levels of increased annual savings requirement for future obligation periods are examined while retaining the existing flexibilities and exemptions under Article 7(2).

Sub-option a) 1,75% savings per year;

Sub-option b) 2,0% savings per year.

These more ambitious levels should be looked only in conjunction with more ambitious scenarios for the energy efficiency target in 2030[70].

4.3 Empowering consumers - Policy options for Articles 9-11

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[67] See SWD (2016) Evaluation Art7.

[68] For example, installing heat pumps or solar thermal collectors etc.

[69] A large majority of stakeholders (70%) shared the view that the scope of Article 7 should be clarified, and 67% (9 Member States) out of these favoured the extension of the scope to, for example, 'savings from energy management systems' (88), 'primary energy savings from the utilisation and recovery of waste heat' (68) and 'savings from switching from fossil fuel heating and cooling to renewable energy use' (55). On the other hand, 25% stated that the scope should be only end-use energy savings, as is currently the case and 8% provided other views. Most utilities favoured extension of the scope to measures e.g. that increase efficiency of district network infrastructure and generation (which is already possible under exemption (c) of paragraph 2 subject to certain requirements under Article 14 of the EED, including from providing storage capacities). On the other hand, most NGOs considered that that the scope should only be end-use energy savings, as it is at the moment.

[70] Moreover, any decision to pursue energy savings during the next decade at a faster rate than during this one should be accompanied by a broader comparison of the merits of different measures to support this goal (see chapter 5).

This impact assessment considers options with respect to thermal energy forms only – that is, metering and billing of heating, cooling and hot water supplies. Electricity and gas aspects will be addressed in the context of the Market Design Initiative.

Given that the objectives are essentially to clarify and simplify the existing requirements in certain places (taking advantage of the fact that EED Articles 9-11 in the future would focus on thermal energy carriers only), whilst at the same time addressing some specific policy objectives already announced in the New Deal for Energy Consumers Communication and in the Heating and Cooling Strategy, only two options are considered: Non-regulatory (based on further guidance) and regulatory clarification and updating of provisions relating to thermal systems.

It should be stressed that Article 9(3) was introduced with the EED and the deadline for the application of its second subparagraph is only 31 December 2016. It is, therefore, premature to evaluate and change that particular subparagraph. However, the ongoing transposition work has already exposed challenges related to ambiguities in other provisions.

Table 5: Overview of options proposed in relation to Articles 9-11

Option	**Option 1**	**Option 2**
Short title **Component/sub-options**	**Non-regulatory guidance**	**Clarification / updating**
• Further **guidance** related to thermal energy in multi-unit buildings	✓	✓
• **Simplification and clarifications** of min. billing requirements, e.g. - Applicability to sub-metering - Simplified feasibility conditions for billing & billing info - Nature of comparisons	(✓)	✓
• **Heat meters/cost allocators must be remotely readable to enable enhanced consumption feedback** - if installed after 1 January 2020 - anywhere as of 2022 • Member States required to introduce **transparent rules on cost allocation**		✓
• **Further clarifications and simplifications** - Improving coherence & eliminating redundancy		✓

4.3.1 Option 1: Non-regulatory – Continue with the existing framework but give further guidance

Under this option, Articles 9 to 11 would not be changed with respect to thermal energy, and the focus would be on implementation and enforcement of the existing provisions based on the already issued Commission guidance note of November 2013 and on further guidance. Such further guidance is currently already under development with respect to heating, cooling and hot water in multi-apartment/purpose buildings[71]. This further guidance in particular focuses on the good practices for the application by Member States of the technical feasibility and cost-effectiveness criteria in Article 9(3), but could conceivably be expanded to include further guidance on any other issue related to the interpretation and implementation of Articles 9-11.

The key arguments in favour of this option are regulatory stability as the Directive is relatively recent.

4.3.2 Option 2: Clarification and updating of provisions relating to thermal systems

Under this option, in addition to the guidance already under development referred to under Option 1, Articles 9-11 of the EED and Annex VII would be changed to clarify, simplify and modernise with respect to thermal energy whilst they, in so far as electricity and gas are concerned, would be consolidated with the provisions in the Internal Energy Market legislation and any future changes proposed to these as part of the Market Design Initiative. More specifically, the following sub-options could be considered:

1.1. Require heat measurement devices (meters or heat cost allocators) to be remotely readable
- If they are newly installed as of 1 January 2020;

- Anywhere by 1 January 2027.

Both would aim at enabling transition to at least monthly feedback by 2022 for all buildings where meters or heat cost allocators are in place.

1.2. Require that Member States "shall" rather than "may" introduce transparent rules on cost allocation (cf. Article 9(3)).

1.3. Clarification and simplification

1.3.1. General clarification of applicability to sub-metered heat consumers (in particular clarify the extent to which obligations relating to "final customers" in Articles 9, 10 and 11 apply to consumers in multi-apartment/purpose buildings supplied with thermal energy from a central source).

[71] See draft from June 2016, "Specific guidelines for sub-metering of thermal energy in multi-unit buildings (implementation of Articles 9-11 of Directive 2012/27/EU on energy efficiency", https://ec.europa.eu/energy/en/studies?field_associated_topic_tid=45.

1.3.2. Clearer and simpler nature of obligations in Annex VII, section 1.1 (=replace "technical and cost-effectiveness" conditions for consumption and frequent billing with condition of whether or not meters/heat cost allocators are installed, and whether they are remotely readable).

1.3.3. Clarify the nature of minimum information elements (e.g. mandatory climate correction of heating and cooling comparisons and graphic comparisons).

1.3.4. Address certain overlaps between Annex VII 1.2.c and 1.3 (by deleting 1.3).

1.3.5. Clarify the respective role of the current Article 9(1) and 9(3) in respect of thermal energy forms, so that paragraph one of Article 9 is about metering (at entry of customer/building premises), and paragraph 2 is about sub-metering (in multi-unit buildings).

In the public consultation, 43% of all respondents expressed the view that the EED provisions on metering and billing are sufficient to guarantee all consumers easily accessible, sufficiently frequent, detailed and understandable information on their own consumption of energy, versus 32% who opposed this view and 25% who had no view. Most "free text" comments were provided by participants who did not think that the provisions are sufficient. Many argued that energy bills would be too complex to be properly understood by most customers. Furthermore, certain energy bills would be provided only once per year, which would not suffice to incentivise behavioural change. Yet others called attention to the possibility that suppliers are exploiting the conditionalities of the articles, so as to avoid having to provide individual metering. Finally, several participants also called for more live energy consumption data, which could be expressed in terms of Kilowatt hours and Euros.

At the stakeholder event organised in Brussels on 14 March 2016, support was expressed for both options 1 and 2.

5 Assessment of policy options

5.1 2030 energy efficiency target level

The sections below present a comparison of impacts of the different policy scenarios representing different level of ambition of the overall EU 2030 target with the baseline scenario. Each target is achieved applying a cost-effective approach within the values attributed to parameters used in the model, *i.e.* exploiting first the options with lowest costs in the targeted sectors across the countries as this is inherent feature of the PRIMES model. A multi-dimensional analysis of different levels of ambition is performed using also other models and assessments resulting in a comprehensive overview of benefits and costs of different ambition levels.

As described above, it needs to be kept in mind that a comparison of the policy scenarios against REF2016 would show the costs (notably investment expenditure) necessary to achieve the GHG, Effort Sharing Regulation and RES target all together. Likewise, if compared to REF2016, benefits shown by a policy scenario are combined benefits of achievement of all targets. If, however, policy scenarios are compared to EUCO27, they only show incremental changes in impacts due to scaling up level of energy efficiency. Therefore, EUCO27 is considered as the baseline scenario in this impact assessment.

The overall level of ambition would need to be delivered by policies at both European and national level. In order to represent the targets by scenarios, a series of assumptions was made about policies that would lead to achievement of targets (see Annex 4). The assumptions follow the logic of the current policy mix. These assumptions read together with impacts on energy consumption indicate in which sectors the highest efficiency gains lie (residential, tertiary) and indicate the broad level of ambition of the specific measures – be it standards or energy efficiency obligations. These assumptions, however, do not prejudge the policy set-up that will be put in place in order to achieve the targets in the next decade. The impacts of intensifying the current policy mix – as assumed in the policy mix of respective scenarios – are shown below.

5.1.1 Energy system impacts

5.1.1.1 Primary energy and fuel mix

Despite growth in EU GDP[72], **gross inland energy consumption and primary energy consumption**[73] are, by construction, reduced step-wise according to the increasingly ambitious options for the energy efficiency target for 2030. The absolute values for consumption and changes in consumption compared to the 2007 baseline, REF2016 projections and 2005 historical values can be found in Table 6. A target of 27% energy efficiency would equal primary energy consumption of 1369 Mtoe in 2030. When increasing the target to 30%, primary energy consumption is 1321 Mtoe in 2030. The policy scenarios demonstrate significant differences in terms of **the consumption of various primary energy sources**.

- As regards **solid fuels** (in particular coal), absolute gross inland consumption is significantly reduced in EUCO27 in comparison to REF2016. For EUCO30, EUCO+33 and EUCO+35 solid fuels consumption increases slightly compared to EUCO27 but still remains well below the solid fuel consumption in the REF2016. The highest intensity of energy efficiency measures leads to an overall reduction of solids consumption. In general lower ETS prices allow maintaining consumption of solids as the scenarios become more ambitious. Also, energy efficiency measures tend to target more specifically gas and oil consumption, as they represent the main fuel in, respectively, heating and transport energy consumption. In the most ambitious EUCO+40 scenario, GHG emission levels are reduced by more than 40% and consequently the required reduction in solid fuels consumption is stronger.
- For **oil**, the absolute reduction of consumption is closely linked with transport policies, notably CO_2 standards for light duty vehicles becoming more stringent. Additional reductions in oil consumption vary from 2% in EUCO30 to 9% in EUCO+40 compared to EUCO27.
- **Natural gas** is the fuel for which the reduction of consumption is most pronounced. The more ambitious the energy efficiency target, the higher are the reductions achieved as energy efficiency policies improve the thermal integrity of buildings

[72] The GDP growth projections are established by DG ECFIN and are 1.2% p.a. over the period 2010-2020 and 1.5% p.a. over the period 2020-2050.

[73] Gross Inland Consumption minus non-energy uses.

which reduces gas consumption. EUCO27 reduces gas consumption by 5% compared to REF2016. EUCO30 further reduced natural gas consumption by 10% compared to EUCO27. In EUCO+33, the reduction amounts to 19%. In the most ambitious scenario EUCO+40, gas consumption is reduced by 34% compared to EUCO27 baseline.

- Absolute consumption of **nuclear** decreases in 2030 in all scenarios.
- The consumption of **renewables** reflects the achievement of the target of 27% (or even overshooting it as in case of EUCO+ scenarios) of RES in gross final energy consumption[74]. As energy consumption decreases with increased energy efficiency, the shares of renewables in electricity, heating and cooling and transport "mathematically" increase. However, absolute consumption of renewables also declines (see table below) especially in heating and cooling as renovation of buildings reduces the need for all sources of heating and cooling, including renewable energy[75].
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Table 6: **Impacts on energy consumption**

Impacts on energy consumption (2030)	**Ref2016[76]**	**EUCO27**	**EUCO30**	**EUCO+33**	**EUCO+35**	**EUCO+40**
Gross Inland Energy Consumption (Mtoe)	1554	1486	1438	1377	1337	1245
Primary Energy Consumption (Mtoe)	**1436**	**1369**	**1321**	**1260**	**1220**	**1129**
Change in primary energy consumption in 2030 compared to 2007 Baseline (1887 Mtoe in 2030) (% change)	-23.9	-27.4	-30.0	-33.2	-35.3	-40.1
Change in primary energy consumption compared to REF2016 (Mtoe)		-67	-115	-176	-216	-307
Change in primary energy consumption compared to REF2016 Reference (% change)		-4,7	-8,0	-12,3	-15,0	-21,4
Change in primary energy consumption compared to historical 2005 energy consumption levels (1713 Mtoe in 2005) (% change)	-16	-20	-23	-26	-29	-34
Reduction requirement starting from the 2020 primary energy consumption target (1483 Mtoe) (Mtoe)	-47	-114	-162	-223	-263	-354
Reduction requirement starting from the 2020 primary energy consumption target (1483 Mtoe) (% change)	-3	-8	-11	-15	-18	-24
Energy Intensity (2005 = 100) (*primary energy to GDP)*	63	60	58	56	54	51
Gross Inland Consumption for REF and EUCO27 (Mtoe)	1554	1486	-3	-7	-10	-16

[74] This level was set by construction for all policy scenarios.

[75] It should be noted that increased share of RES contributes to the achievement of the energy efficiency target when it is expressed in primary energy, through increased statistical efficiency in power generation.

[76] Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency (≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

and % change from EUCO27						
- Solid fuels	185	164	4	1	2	-8
- Oil	513	470	-2	-4	-6	-9
- Natural gas	371	351	-10	-19	-24	-34
- Nuclear	187	187	-1	-2	-3	-11
- Renewables	297	314	-3	-7	-11	-15
Gross Inland Energy Consumption Shares (%) of:						
- Solid fuels	12	11	12	12	12	12
- Oil	33	32	32	33	33	34
- Natural gas	24	24	22	21	20	19
- Nuclear	12	13	13	13	14	13
- Renewables	19	21	21	21	21	21
Renewables Shares (%) in gross final consumption - Overall	24	27	27	28	28	28
- Share in heating & cooling	25	27	26	29	28	28
- Share in electricity	42	47	49	49	48	51
- Share in transport[77]	14	18	19	19	20	22
Overall RES consumption (Mtoe)	273	292	279	274	261	245
- RES consumption in heating & cooling	124	128	117	114	107	92
- RES consumption in electricity	128	143	142	140	135	133
- RES consumption in transport	39	46	48	48	49	53

Source: PRIMES

If the 2020 target is met, primary energy consumption will be 1483 Mtoe in 2020. This means that EU28 would have reduced energy consumption by **173 Mtoe over 10 years from 2010 to 2020**. To achieve a 27% energy efficiency target the EU would need to reduce its energy consumption by 114 Mtoe from 2020 to 2030. A 30% target would require the EU28 to save **162 Mtoe** in the next 10 year period between 2020 and 2030. The achievement of an almost similar energy consumption reduction could be facilitated by technological progress and experience gained in recent years. In addition, the realisation of remaining energy efficiency potentials in regions and sectors with currently low energy efficiency levels could contribute to achieve broadly the same amount of energy consumption reduction as in 2010-2020.

5.1.1.2 Final energy consumption and sectoral split

Energy efficiency policies affect final energy consumption in all four sectors: residential, tertiary, industrial and transport. As scenarios become more ambitious the reductions in energy demand become more significant across the four sectors. In the scenarios presented, energy efficiency improvements are most prominent in the residential and tertiary sectors. Energy efficiency improvements are lower in industrial and transport sectors, reflecting the current policy instruments and in the case of transport, the projected growth trend in activity.

As shown in Table 7 reductions in the **residential sector** range from 9% for EUCO30 to 37% for EUCO+40 compared to the baseline EUCO27. Similarly, reductions in the **tertiary sector** range from 9% to 35%. These reductions reflect decreasing demand for heating and cooling

[77] The share of renewables in transport is based on the definition as amended by the ILUC Directive.

due to buildings' thermal renovation, behavioural change[78], improved efficiency of heating and cooling appliances, including higher uptake of heat pumps and lower demand for electricity from other appliances.

For the **transport sector**, reductions range from 1% to 5%. The key drivers are the assumptions on CO_2 standards for light duty vehicles, which become more stringent as the scenarios become more ambitious. Other measures affect heavy duty vehicles and transport demand, but their impact is smaller.

In REF2016 there is already a reduction in energy demand in the industrial sector that reflects the increased energy efficiency embedded in newer production assets and the structural changes towards higher value added and less energy-intensive production. In the policy scenarios PRIMES modelling shows that reductions in industry range from 0.5% to 12% compared to the baseline EUCO27. They are mainly driven by the ETS and by the impact of ecodesign on performance of industrial motors. In the most ambitious scenarios horizontal energy efficiency measures and application of Best Available Technologies (BATs) have also a considerable impact[79].

Final energy consumption reduces as scenarios become more ambitious. In EUCO30 gross final energy consumption for heating and cooling demand is reduced by 7%, electricity demand by 3% and transport energy demand by 2% compared to the baseline EUCO27. The reductions increase in the EUCO+ scenarios. In order to see the effects of ecodesign, it is useful to focus on the residential sector performance in EUCO30 where heating and cooling useful energy per appliance use is reduced by 18 Mtoe, for water heating and cooking by 5 Mtoe, and for electrical appliances and lighting by 2 Mtoe compared to the REF2016 baseline EUCO27.

[78] Modelled by scaling up Energy Efficiency Values (EEVs) as scenarios become more ambitious – please see Annex 4 for more information.

[79] The energy efficiency values (EEVs), scaled up as scenarios become more ambitious, were also applied to industrial sector (in all policy scenarios except baseline EUCO27). However, lower EEVs were applied than in residential and tertiary sectors in order to reflect the fact that industrial sector is already partly exposed to ETS and that many MS have so far chosen to exempt industrial sector from energy efficiency measures. EEVs make impact only at higher levels and thus mostly in EUCO+ scenarios.

Table 7: Other energy system impacts

Other energy system impacts (2030)	Ref2016[80]	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Final Energy Demand (Mtoe)	1,081	1,031	987	929	893	825
Industry	270	269	268	259	251	237
Residential	288	267	243	213	199	169
Tertiary	179	166	152	135	127	108
Transport[81]	344	329	324	322	316	312
Reduction requirement starting from the 2020 final energy consumption target (1086 Mtoe) (Mtoe)	-5	-55	-99	-157	-193	-261
Reduction requirement starting from the 2020 final energy consumption target (1086 Mtoe) (% change)	-0,4	-5,0	-9,1	-14,4	-17,8	-24,0
Final Energy Demand in REF2016 and EUCO27 (Mtoe) and change from EUCO27 (% change)	1,081	1,031	-4.3	-9.9	-13.4	-20.0
Industry	270	269	-0.5	-3.8	-6.7	-12.0
Residential	288	267	-9.2	-20.4	-25.6	-36.9
Tertiary	179	166	-8.6	-18.5	-23.9	-35.0
Transport	344	329	-1.2	-2.0	-3.9	-5.1
Change in Final Energy Demand - compared to 2005 levels (1191.3 Mtoe in 2005) (% change)	-9,2	-13,4	-17,1	-22,0	-25,1	-30,7
Industry[82]	-17,6	-17,8	-18,2	-20,9	-23,3	-27,7
Residential[83]	-6,4	-13,1	-21,1	-30,8	-35,3	-45,2
Tertiary[84]	-2,3	-9,4	-17,1	-26,2	-31,0	-41,1
Transport[85]	-6,3	-10,7	-11,8	-12,5	-14,1	-15,2
Gross final energy consumption (Mtoe)	1,133	1,086	1,040	987	948	876
Heating and cooling	485	454	423	373	350	304
Electricity	302	302	292	286	278	260
Transport	274	256	252	250	242	239
Gross final energy consumption - REF2016 and EUCO27 (in Mtoe) and change from EUCO27 (% change)	1,133	1,086	-4	-9	-13	-19
Heating and cooling	485	454	-7	-18	-23	-33
Electricity	302	302	-3	-5	-8	-14
Transport	274	256	-2	-3	-5	-7
Residential sector: Useful energy per energy use (in Mtoe)						
- Heating and cooling	184	169	151	128	118	94
- Water heating and cooking	56	51	46	39	36	29
- Electric appliances and Lighting	48	48	46	46	45	45

Source: PRIMES

80 Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency ((≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

81 Including pipeline transportation, ground activities in airports and harbours, etc.

82 Compared to 328 Mtoe in 2005 according to PRIMES.

83 Compared to 308 Mtoe in 2005 according to PRIMES.

84 Compared to 183 Mtoe in 2005 according to PRIMES.

85 Compared to 368 Mtoe in 2005 according to PRIMES.

Box 1: Bottom-up modelling of energy efficiency in the industrial sector[86]

> In addition, a bottom up analysis using the ICF Industrial Energy Efficiency Model (IEEM) has been carried out to assess impacts in particular of a continuation and intensification of eco-design measures, the continuation of an energy efficiency obligation scheme post-2020 and better access to finance for energy efficiency actions for the industrial sector[1]. Analysis indicates that the individual saving impacts of eco-design policies are 1.8 Mtoe in the industrial sector in 2030 compared to the REF2016. Extending the energy efficiency obligation schemes would lead to 15 Mtoe saving in the industrial sector and improved access to finance to 11.8 Mtoe in 2030. The combined impact would be 28.6 Mtoe compared to the REF2016. There is limited overlap between policies on finance and energy efficiency obligation schemes, since policies are targeting different areas – either the supply side finance or the demand side of finance. The bottom-up model shows higher impacts of the three policy areas than the top-down energy model PRIMES.

Table 8 shows that all policy scenarios reduce demand for electricity in 2030 thanks to eco-design, continuation of energy efficiency obligations, other Member State energy efficiency policies and EBPD requirements. Nevertheless, the electrification of transport[87] starts to be visible in 2030 as shown by the stock of electric vehicles and consequently electricity demand in transport grows as scenarios become more ambitious. One modelling assumption was also the increase of electrification of heating in households (notably with policies facilitating the uptake of heat pumps)[88]. This will lead to an increased number of households with electric heating which drives up the demand for electricity in residential sector. The overall demand for electricity in households, however, declines in EUCO30 compared to EUCO27, and in EUCO+35 and EUCO+40 thanks to a larger impact of energy efficiency measures.

As a result of a higher share of RES in power generation, the carbon intensity of power generation decreases in baseline EUCO27 and all policy scenarios compared to the EU Reference scenario.

As the scenarios become more ambitious, thermal power generation capacity decreases (mostly gas - disadvantaged by the low ETS prices), whereas nuclear capacity remains stable. An increase of the energy efficiency target from 27% to 30% would reduce the net installed power generation capacity of thermal power plants by 10 Giga Watt and further reductions are achieved as scenarios become more ambitious. This shows that energy demand measures can

[86] ICF Draft Interim Report July 2016 (Contract ENER/C3/2016-51. modelling concrete energy efficiency measures in energy intensive industries for the review of the Energy Efficiency Directive).

[87] Electrification of transport is driven by CO_2 standards for LDVs. The standards are more stringent as the scenarios become more ambitious. In the EUCO+40 scenario, the CO_2 standards reflect the most ambitious edge of the European Parliament's proposal for 2025 CO2 standards for LDVs – such standards would lead to stronger electrification of the fleet and a visible increase in electricity demand from transport.

[88] To reflect option 3.b of the Article 7 analysis which would allow counting savings stemming from on-site renewable energies (e.g. heat pumps) within the 25% exemptions, more ambitious eco-design/labelling policies in this respect or the change of the primary energy factor.

replace energy supply investments[89]. These reduced capacity investments lead to lower electricity prices.

Table 8 indicates also the penetration of electric heating in households and of electric light duty vehicles which is result of policies assumed. It also indicates the increase of efficiency of white and black appliances brought by the policies assumed.

Table 8: Electricity indicators

Electricity indicators (2030)	Ref2016[90]	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Gross Electricity Generation (*TWh*)	3,528	3,526	3,413	3,341	3,246	3,035
- Solids Share	16.0	13.8	14.8	15.1	15.7	15.1
- Oil Share	0.5	0.5	0.36	0.37	0.39	0.36
- Natural Gas Share	17.9	15.1	12.3	11.6	11.1	9.2
- Nuclear share	22.0	22.0	22.5	22.8	23.1	22.8
- Renewable share	42.9	47.7	49.1	49.3	48.8	51.5
of which hydro share (%)	10.7	10.8	11.1	11.4	11.6	12.5
of which wind share (%)	17.2	19.6	20.3	20.2	19.8	20.6
of which Solar, tidal, etc. share (%)	6.6	8.7	9.0	9.1	9.0	9.7
of which Biomass & waste share (%)	8.0	8.4	8.5	8.4	8.2	8.5
Carbon intensity of power generation (t of CO2/toe of GIC)	0.20	0.18	0.18	0.18	0.19	0.18
Net Installed Power Capacity (in GWe)						
- Thermal power	379	369	359	354	352	347
- Nuclear	110	110	110	110	110	110
- Renewables	571	652	656	646	625	623
Electrification: number of HH with electric heating (in millions)	16	22	30	48	48	53
Electrification of transport: total stock of electrically chargeable (full electric, plug-in hybrids and fuel cells) cars and vans (in millions)	15,8	34,2	39,8	39,9	45,8	55,5
Final Energy per appliance type (ktoe)						
- Lighting	3,371	3,311	3,333	3,328	3,334	3,308
- White appliances	16,724	16,604	15,945	15,926	15,926	15,874
- Black appliances	28,068	27,623	26,256	26,255	26,238	26,195

Source: PRIMES

5.1.1.3 Energy imports

Although the import of fuels is not an energy security problem in every case, the magnitude and nature of, in particular, oil and gas imports, magnified by the projected reduced domestic production in the next decades, raise specific energy security issues. Energy efficiency policy can contribute to reducing energy imports in total – especially gas and oil imports. By reducing the overall scale of imports, energy efficiency helps lowering the magnitude of

[89] Also the IEA found that energy efficiency avoided over 1 trillion USD in investment needs in electricity generation in the past. International Energy Agency (2016): Energy Efficiency Market Report 2016 (see http://www.iea.org/publications/freepublications/publication/mediumtermenergyefficiency2016.pdf).

[90] Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency (≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

potential disruptions of the economy because of supply severance or price shocks. Policies aiming at improving thermal integrity of buildings (stricter building codes, measures accelerating renovation rates and electrification of heating) reduce gas consumption since some 65% of gas in Europe is used for heating. CO_2 standards for LDVs, additional measures aiming at more efficient transport and demand management reduce oil consumption since road transport currently depends on oil products for 94% of its energy use.

Energy efficiency policy thus plays an important role in increasing the security of supply (together with diversification of suppliers and supply points, domestic renewable energy production, ensuring proper fuel stocks and building interconnectors), which is currently a political priority and one of the five dimensions of the Energy Union Strategy.

Net energy imports in 2030 decrease significantly for all scenarios. While the reduction of net energy imports in 2030 (in comparison to the year 2005) is 14% for EUCO27 baseline, the more ambitious scenarios achieve between 18 and 31% reductions. The trend is even more pronounced in 2050 (where for all scenarios imports more than halve in comparison to the year 2005). Looking at fuels separately:

- **Solids imports** are reduced compared to the REF2016 in 2030. In 2050 imports of solids would be only 1/10 of the 2005 level in all the scenarios.

- **Imports of oil** are significantly reduced but do not vary strongly among the scenarios. In EUCO27 they are reduced by 20% compared to 2005 levels and in more ambitious scenarios the reductions range from 21 to 27%. In 2050 imports of oil would be halved in comparison to 2005.

- **Imports of gas** are significantly reduced and fall further with the overall ambition of the energy efficiency target. In EUCO27, gas imports are lower than in the REF2016 but are still 10% higher compared to 2005 levels. However, in EUCO30 gas imports could be reduced by 3% compared to 2005 levels which would decrease Europe's dependency on gas imports considerably. In the more ambitious scenarios (EUCO+) reductions (from 2005 levels) range from 16 to 36%. In 2050 imports of gas would be halved in comparison to 2005.

The net monetary cost of fossil fuel imports decreases in 2030 as scenarios become more ambitious. Comparing EUCO30 to EUCO27 the average annual net cost of imports (in period 2021-2030) is 2% lower whereas for more ambitious scenarios the reductions in net cost of imports would range between 3% and 7%. As oil prices are higher than gas prices and are projected to increase faster, the differences are well pronounced in net cost of oil imports even though imports of oil do not vary strongly among the scenarios. In addition, strong energy efficiency policies can have impacts on international fuel prices as shown in the following section.

In the period 2021-2030 the target of 30% would bring a cumulative €70 billion saving in fossil fuels import bills in comparison to a 27% target. For more ambitious scenarios, the cumulative savings would range from €147 to 288 billion. The savings would be even greater in the period 2031-50.

Table 9: Impacts on energy security

Impacts on energy security (2030)	Ref2016[91]	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Net Energy Imports Volume (2005=100)	93	86	82	77	75	69
- Solids	67	57	59	57	57	52
- Oil	88	80	79	77	75	73
- Gas	116	110	97	84	78	64
- Renewable Energy	796	848	804	803	785	762
Import Dependency[92] (% net imports to total gross inland energy consumption)	57	54	53	53	52	52
Gas imports (bcm)	327,5	309,2	272,7	236,7	220,2	181,5
Reduction compared to EUCO27 (bcm)			-36.4	-72.4	-88.9	-127.6
Reduction compared to EUCO27 (% change)			-11.8	-23.4	-28.8	-41.3
Value of Fossil Fuel Net Imports (billion €'10) *(average annual 2021-30)*	449	427	420	413	407	399
- Oil	326	309	307	303	300	296
- Gas	111	107	102	97	96	91
- Solids	12	11	12	12	12	12
Fossil Fuels Import Bill Savings compared to EUCO27 (billion € '10) (cumulative 2021-30)	4494	4274	-69.6	-147.3	-199.3	-287.5

Source: PRIMES

5.1.1.4 **Electricity, ETS and international fuel prices**

The result of the modelling of the different policy options is the projected electricity price which is one of main economic impacts directly affecting all energy consumers. The electricity price increases slightly from 158 €/MWh in REF2016 to 161 €/MWh in EUCO27 as additional investments in RES power generation and higher ETS prices have to be recuperated. Lower investments in power generation capacity, partly offset by the need to spread fixed costs over smaller amounts of electricity sold, contribute to slightly lower electricity prices in policy scenarios with higher energy efficiency levels than 27%.

[91] Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency (≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

[92] Import dependency is defined in the table as the ratio between all fossil fuel imports and total energy consumption and, in contrast to absolute import quantities, in 2030 it shows little differences between scenarios with respect to the baseline scenario. This is mostly because energy consumption and energy imports decrease hand in hand. In general, the import dependency indicator should be interpreted with caution as the denominator of the ratio (total energy consumption) decreases with the overall level of energy efficiency target. It is more illustrative to use the absolute numbers of gas and oil imports to assess the impact of energy efficiency policies on security of supply.

The model runs show that for energy efficiency targets of 30% or higher, the primary impact is to lead to extra abatement of GHG emissions in sectors outside of the EU ETS (see Table 17).

The ETS carbon price in 2030 differs substantially across the various scenarios, reflecting the effect energy efficiency measures can have on emissions in the ETS sectors (via reduction of demand for electricity) and their interactions with other target levels. In REF2016, the ETS price is projected to reach 34 €/tCO2 in 2030. In EUCO27 scenario, which requires higher reductions due to a higher linear reduction factor, it increases to 42 €/tCO2.

Higher levels of energy efficiency levels than in EUCO27 result in a corresponding reduction in electricity consumption which leads to a lower demand for ETS allowances with a given ETS cap, which in turn can also contribute to reduced demand for allowances for hedging emissions from the power sector. Overall this can impact carbon prices downward.

For instance, in EUCO30 which increases by design energy efficiency levels by 3 percentage points while keeping the GHG and ETS target constant, the substitution of other emission reduction measures by energy efficiency clearly lowers the carbon price below REF2016 levels.

In the policy scenarios with higher energy efficiency levels, notably the step up to EUCO33+, while reductions are mainly driven by specific energy savings policies, the ETS continues to contribute to the achievement of the higher energy efficiency levels. The result is a more limited carbon price impact, but further reductions in emissions by 2030.

Stronger demand side policies that address specific market failures can significantly reduce the direct CO_2 costs of businesses subject to the EU ETS, but also reduce the positive incentive the ETS gives towards low carbon investments. On the other hand, the results also show that the ETS can incentivise energy efficiency if emissions reductions are adapted consequently.

A word of caution is necessary with regard to the absolute values of the resulting carbon prices. The modelling tries to reflect some features of the Market Stability Reserve in a stylised way, but can only approximate it with its five year steps and its foresight assumptions, and the exact interactions are uncertain. The new Market Stability Reserve gradually reduces allowances on the market to counteract the over-supply of allowances under specific circumstances. In very ambitious energy efficiency conditions, reduction of energy consumption in sectors whose emissions are covered by the ETS might cause a faster reduction in emissions compared to the decline in the overall number of allowances which are taken out of the ETS market until 2030 through the new Market Stability Reserve. However, if the decline in emissions is too strong due to ambitious energy efficiency policies, this might lead to imbalances between supply and demand in the ETS which might no longer be counteracted by the new Market Stability Reserve.

The concrete impacts of energy efficiency policies on the ETS price will depend on the sectors and fuels which energy efficiency policies affect. If the focus is mainly on the non-ETS sector, the impacts on the ETS price will be smaller than if energy efficiency policies focus on the ETS sectors.

Table 10: Electricity and carbon prices

Electricity, carbon prices and ETS emissions (2030)	Ref2016[93]	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Average Price of Electricity (€/MWh)	158	161	157	158	157	159
ETS carbon price (€/t of CO2-eq)	34	42	27	27	20	14
ETS emissions (% below 2005)	-37.7	-43.1	-43.1	-44.3	-44.2	-48.3

Source: PRIMES

As in the energy efficiency Impact Assessment 2014, the impact of energy efficiency policies on international fuel prices was modelled, using the POLES model[94]. The results indicate that European energy efficiency policies would have some impact on international energy prices. This can be explained because of the significant reduction of the gas demand in the residential and tertiary sector. The results show that the international gas price in 2030 would be 1.1-.4.3% less than in the EUCO27, and the international oil price would be 0.3-1.4% less with energy consumption reductions of 30-40% in 2030 compared to EUCO27[95]. Coal prices are relatively unaffected.

Table 11: International fuel prices compared to EUCO27 (average 2020-2030)

International fuel prices compared to EUCO27 in % (average 2020-2030)	Ref2016	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
International oil prices	-	-	-0.3%	-0.6%	-1.0%	-1.4%
International gas prices	-	-	-1.1%	-2.3%	-3.0%	-4.3%
International coal prices	-	-	0.02%	0.01%	0.01%	-0.03%

Source: Poles, JRC

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93 Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency (≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

94 See Annex 4 (chapter 4.11) for further information.

95 The analysis has been produced using EU28 primary fuel demand from the scenarios analysed in this Impact Assessment (differentiated by fuel: oil, gas, coal) has been replicated in the POLES model. The modified demand affects the international fuel prices which decrease: a) the (world) oil price evolves with the (world) marginal production cost; b) the international gas price considered for the European market evolves with the new supply conditions and is partially indexed to the oil price (is thus affected not only by the decrease of gas demand but also by the decrease of oil demand) and c) the international coal price considered for the European market evolves with the average import cost to the European market. Feedbacks on non-EU countries are accounted for: they react to the lower international oil price in increasing their energy demand, which balances the decreasing EU energy demand and limits the impact on prices. These results should be further analysed, including their impact on feedback-effects on energy consumption and GDP in the EU. Elements like the missing flexibility of the gas infrastructure produces a higher price effect on the European gas markets, since the gas producers cannot easily redirect their fuel exports to other markets have not be taken into consideration.

5.1.1.5 **Competitiveness**

Lower energy consumption and decreasing energy prices due to higher levels of energy efficiency in 2030 will have a positive impact on energy related costs. The table below shows that the ratio of energy related costs (inclusive of auction payments ETS) to value added improves in EUCO30 compared to the baseline EUCO27. This indicates that energy efficiency investment efforts can, in fact, positively impact the competitiveness of energy-intensive industries. This is because any projected increase in the capital cost component is more than outweighed by the decrease in energy purchases (including auction payments). Only in the EUCO+40, the share increases slightly compared to the baseline EUCO27 which can be explained by slightly higher electricity price in EUCO+40 (see chapter above) and the high investments needs to achieve this very ambitious 2030 target.

Table 12: Energy related costs for energy intensive industries

Ratio of energy related costs inclusive auction payments ETS to value added in 2030	Ref2016[96]	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Energy intensive industries (in %)	40.3%	40.8%	40.1%	40.0%	39.8%	40.6%

Source: PRIMES

As shown in the table below, energy intensity improves considerably for the industry sector and the service sector with increasing levels of energy efficiency in 2030.

Table 13 Impacts on energy consumption

Energy intensity (2030)	Ref2016	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Energy intensity						
Industry - value added related (toe/MEuro'13)	66	66	66	64	62	58
Domestic -household income related (toe/MEuro'13)	68	63	58	50	47	40
Services -value added related (toe/MEuro'13)	69	64	59	52	49	42

Source: PRIMES

5.1.2 Macro-economic and other economy-wide impacts[97]

Macroeconomic and sectoral economic impacts are assessed using two macroeconomic models: E3ME and GEM-E3. Similar to the Impact Assessment on energy efficiency in 2014, the choice in this impact assessment has been to use two macroeconomic models that

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[96] Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency (≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

[97] Results for GDP and total employment are provided for the two versions of each of the two macro-models in order to put forward a more comprehensive picture of potential macro-benefits and constraints arising from increased investments in energy efficiency. For the rest of the economy-wide related impacts, results are often presented only for the "no crowding out" version of E3ME and the "loan-based" version of GEM-E3 in order to keep the discussion within reasonable limits.

represent two different schools of economic thought, and that have been frequently used in the macroeconomic assessment of energy and climate policies[98].

Compared to previous impact assessments, the modelling has been further developed in order to provide a more rigorous assessment of the macroeconomic effects of varying "crowding out" assumptions and different financing mechanisms for energy efficiency investments[99]. Two versions of each macro-model have been run in order to provide a more nuanced picture of potential macro-benefits and constraints. In the case of E3ME, these versions are referred to as *"no crowding out"* and *"partial crowding out"*[100]. In the case of GEM-E3, the two versions are referred to as *"loan-based"* finance and *"self-financing"*. In the former, businesses and households can borrow in the markets, whereas in the latter no borrowing is possible and economic agents finance their investments in energy efficiency by spending less on other items[101]. In both cases, the more nuanced assumption is considered more realistic.

There are three main reasons why it is useful to include different macro-models that operate with different assumptions on crowding out and financing. First, these address model uncertainty and improve the robustness of modelling results that are reported. Second, to better understand likely ranges in macroeconomic effects and the barriers and bottlenecks that restrict potential macro-benefits from investing in energy efficiency, it is important to relax critical model assumptions, such as crowding out and the availability of lending. Third, self-finance and commercial loans have been found to be the first, and respectively, the second most common financing methods of energy efficiency investments in EU countries.[102] Including these in macro-models improves the understanding of the conditions necessary for realising potential growth and jobs benefits.

98 More detail on the E3ME and GEM-E3 modelling structures is provided in Annex 4.

99 "Crowding out" effects refer typically to investments undertaken in particular sectors at the expense of other sectors (e.g. by drawing resources away from other businesses). Otherwise, with respect to households, both models assume there are crowding out effects, i.e. households spend more on energy efficiency and less on other items.

100 The "no crowding out" represents the standard approach in E3ME and its usual treatment of investment dynamics, whereby there is no maximum level imposed on production growth. Industries can grow by absorbing investments without negatively impacting other sectors (e.g. drawing on spare capacity or unutilised physical capital). The "partial crowding out" imposes a constraint on activity expansion by introducing a rule that would set a maximum amount that the sectors benefiting from energy efficiency policies would be allowed to increase by, without adversely affecting other economic activities. This rule is 5% over three years starting from 2021. For example, if in the year 2025, output is projected to increase in the construction sector by x% in EUCO27 relative to the Reference case, then in the next year (2026), the output of the respective sector is allowed to increase by a maximum of x% + (5/3)% without crowding out effects. In other words, the modelling of constrained expansion aims to implicitly mimic the effects of partial crowding out. The choice of 5% over three years starting in 2021 (translating in a 15% limit on additional / energy efficiency policy induced output growth by 2030) is arbitrary but suggests that first, firms keep enough spare capacity to cover 2-3 years of growth, and, second, that market players become aware of the increased investments in energy efficiency and try to adapt (the 3-year period allowing for the incorporation of changing expectations). Beyond that, physical and financial capital bottlenecks appear, constraining the potential for additional growth..

101 In the "loan-based" finance version, by assumption, an energy efficiency investment in 2020 would be financed via a loan which would cover 90% of total expenditure in 2020. This share is assumed to decrease after 2020, reaching 70% of total expenditure in 2035. Afterwards the percentage remains constant. The loan lasts for 10 years and repayment starts one period after it is issued. In the "self-financing" version, GEM-E3 excludes the possibility of firm and household indebtedness and assumes that all expenditures are self-financed by the sectors undertaking the energy efficiency investments, e.g. firms increase prices, households reduce other expenditures. More details on the scenario setup and model versions are provided in Annex 4.

102 See for instance the findings in OECD/IEA (2014) "World Energy Investment Outlook: Special Report".

5.1.2.1 **GDP impacts**

In both models investments in energy efficiency to reach the required energy efficiency targets for 2030 are the primary drivers for changes in GDP. The GDP impacts are likely to be positive as long as energy efficiency investments are more productive than alternative investment, there is spare capacity in the economy which is put to work, labour mobility is fluid across sectors, and financial capital is effectively mobilised towards energy efficiency investments across Europe.

The E3ME model projects positive GDP impacts as increased investment in energy efficiency makes productive use of idle resources in the economy. The net benefits remain positive at higher ambition levels but these are projected to diminish should capacity constraints limit the growth potential of economic activities benefiting from the demand of energy efficiency goods and services[103]. This shows that policies to trigger investment in energy efficiency have the potential to overcome market failures. When there is no crowding out investment is as such financed at no direct cost to the financing of investments in other sectors of the economy. In this case, GDP increases with the ambition of the target; from 0.39% in EUCO30 (which is around 70bn €) to 4.08% in EUCO+40 (relative to the baseline EUCO27). However, in the "partial crowding out" case, the E3ME model shows less (albeit still) positive GDP impacts, particularly for the more ambitious energy efficiency policy scenarios that vary from 0.39% in EUCO30 (which is around 70bn €) to 2.21% in EUCO+40 (relative to the baseline EUCO27).[104] All in all, the E3ME model simulations show that the realisation of macro-benefits from stepping up energy efficiency ambition levels will depend on the ability of economic sectors to effectively absorb the required energy efficiency investments, and expand their capacity and output accordingly without meeting significant constraints.

In the GEM-E3 model, GDP impacts can be either positive or negative depending on the extent to which economic agents have access to financial markets in order to finance their required energy efficiency investment expenditures. If third party finance for investments in energy efficiency is available so that businesses and households can access financial markets or banks ("loan-based" case), potential crowding out effects are mitigated and GDP increases in 2030. GDP increases by 0.26% in EUCO30 compared to EUCO27 (which is around 45bn €), although these increases become less positive with higher ambition levels for energy efficiency and drop to almost net zero GDP impacts in EUCO+40[105.] However, if households and businesses cannot borrow ("self-financing" case – a less realistic assumption given the

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[103] GDP gains in E3ME are mostly investment-driven. They are largely attributed to its non-equilibrium approach allowing for policy intervention to boost growth as resources are not assumed to be optimally and fully allocated under initial conditions. To get a better idea of EU GDP impacts in 2030 implied in the E3ME model versions, these can also be expressed in terms of changes in annual growth rates, i.e. they can vary in 2030 (relative to the projected annual growth rate for EUCO27) from an increase in the annual GDP growth rate by 0.11 percentage points in EUCO30 to an increase of 0.83 percentage points (the case of "no crowding out" for EUCO+ 40).

[104] The reasons why GPD impacts are the same for both "no crowding out" and "partial crowding out" in the EUCO30 case (relative to the baseline EUCO27) are attributed to the setup of the partial crowding out scenario, in the E3ME model. According to the model, output constraints imposed to reflect crowding out dampen potential production growth rates only with more ambitious energy efficiency policies, starting from EUCO+33.

[105] There are two main reasons for GDP benefits to diminish with the stringency of the energy efficiency policies, in GEM-E3. First, increasing financing requirements implied by the EUCO33, 35 and 40 scenarios increase the demand for money and hence increase lending interest rates, which in turn adversely impacts other sectors of the economy. Second, very high ambition in energy efficiency implies high marginal investment costs for incremental savings, hence diminishing expected returns on this investment.

data referred to above), this will, by construction, result in adverse impacts on other sectors of the economy and overall negative GDP impacts in 2030 (varying from -0.22% in EUCO30 to -2.12% in EUCO+ 40, when compared to the EUCO27 case). In this case, any potential positive impacts stemming from improved energy efficiency and multiplier effects of increased economic activity in sectors providing inputs to energy efficiency projects are outweighed by the negative impacts arising from higher cost of capital and relative loss in competitiveness associated with investments in other productive assets[106].

Table 14: GDP impacts in EU28 in 2030[107]

% change from EUCO27	Ref2016[108] (bn €2013)	EUCO27 (bn €2013)	EUCO30	EUCO+33	EUCO+35	EUCO+40
E3ME (no crowding out)	17,928	18,045	0,39	1.45	2.08	4.08
E3ME (partial crowding out)	17,928	18,045	0.39	1.30	1.58	2.21
GEM-E3 (loan-based)	16,955	16,962	0.26	0.21	0.16	0.06
GEM-E3 (self-financing)	16,955	16,907	-0.22	-0.79	-1.35	-2.12

Source: E3ME, Cambridge Econometrics and GEM-E3, National Technical University of Athens

When comparing to REF2016, the modelling shows that achieving a 40% greenhouse gas reduction, a renewable target of 27% together with an energy efficiency target of 30% in 2030 could lead to an increase of up to 1% in GDP by 2030.

In essence, an important policy implication of this analysis is that relative GDP impacts vary with time and will depend on assumptions if and when borrowing takes place and loans have to be paid back[109].

The modelling exercise has shown that it is key for policy makers to continue to facilitate the flow of funds from banks to private economic agents so that businesses and households can smooth out their consumption and savings patterns and help them invest in energy efficiency goods and services. It is also essential to identify labour and capital constraints that prevent sectors potentially benefiting from energy efficiency investment to expand their capacity

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106 The reason for this is that full crowding out effects occur in the self-financing GEM-E3 model version when no money is borrowed. Sectors that expand because of energy efficiency take the investments from other sectors, leading to an increase in interest rates (capital costs). This increase in interest rates (which is greater than the loan-based case) affects capital costs and the relative loss of competitiveness.

107 Projected GDP levels in 2030 for REF2016 are different between the two models mostly because each model builds its own macro- projections (based on energy inputs they receive from the PRIMES energy system model).

108 Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency (≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

109 It is important to note that GDP impacts will also depend upon the time lag between when agents implement their energy efficiency investments and when agents need to pay for these. For instance, the GEM-E3 model which covers a projected time horizon up to 2050 shows that GDP impacts are more favourable in the 2030 horizon in the loan-based case compared to the case self-financing variant. Nonetheless, after 2030, GDP impacts tend to be more positive in self-financing case compared to the loan-based case as the economy is influenced by the repayment of debt accumulated for energy efficiency investments. In the long term, the model shows converging and positive impacts in 2050 in both financing versions. Please see Annex 4 for a discussion of GDP impacts across time and the relevance of loan financing availability and conditions using the GEM-E3 model.

accordingly. Improving access to finance could help mitigating any potential adverse effects on the economy that stem from crowding out at times of high levels of energy efficiency expenditures. Hence, crowding out of investments in other productive sectors of the economy could be avoided and the overall EU economy could be stimulated.

5.1.2.2 **Employment impacts**

In general, total employment is driven by employment-related multiplier effects[110] and interactions between sectors under the different policy-induced energy efficiency investment scenarios. These depend on the respective labour intensity of the sectors delivering inputs to energy efficiency projects (relatively high for sectors like market services, high-tech manufacturing, and construction sector) and that of the sectors negatively affected. The share of domestically produced inputs to total inputs also matters. Net employment effects also depend on the extent to which wages will adjust to changes in labour demand, and on the availability of skill formation and reorientation programs. Since energy efficiency investment requires more labour and brings more net benefits to the economy than other investment alternatives, energy efficiency is expected to reduce structural unemployment[111].

Table 15 summarises potential impacts on employment levels in the EU across the energy efficiency policy scenarios for the two macro-models. Employment impacts are likely to be on the positive side, as long as labour resources can be absorbed in the sectors projected to benefit from energy efficiency investments. In 2030, the positive employment effects of increasing the levels of ambition of energy efficiency polices (relative to the baseline EUCO27) range, in E3ME in the "no crowding out" case, between 0.17% (around 405,000 people) in EUCO30 and 2.08% (around 4.8 million people) in EUCO+40. In the "partial crowding out" case, E3ME shows lower net positive impacts on employment across particularly the more ambitious scenarios, an additional 404,000 people in EUCO30 and around 3.2 million people in EUCO+40 compared to EUCO27.

GEM-E3 shows positive or negative impacts on employment in 2030 depending on the extent to which economic agents are able to borrow the funds instead of paying for energy efficiency investments out-of-pocket and on the spot. In the "loan-based" finance case of GEM-E3, employment impacts are positive and range between 0.2% (around 434,000 people) in EUCO30 and 0.56% (approximately 1.2 million people) in EUCO+40 (relative to baseline EUCO27). In the "self-financing" case, which does not reflect the situation today or the expected situation in the future given the important enabling framework, employment impacts are projected to be negative, ranging from -0.18% in EUCO30 (around 382,000 people losing their jobs) to -1.36% (almost 2.9 million people) in EUCO+40 relative to the baseline EUCO27. This is largely attributed to the fall in GDP that is projected in the "self-financing" variant, meaning that full crowding out also negatively impacts employment, albeit to a lesser extent than output depending on the labour intensity of sectors.

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[110] Multiplier effects refer to the economy-wide ripple effects stemming from an initial change in aggregate demand. In other words, an increase in GDP is associated with an increase in income, and this extra income results in more spending, more demand, which in turn leads to higher GDP, more income and so on. The final impact on the GDP level is higher than the initial change in aggregate demand.

[111] COMBI-Project (2015) Literature review on macroeconomic effects of energy efficiency improvement actions, Deliverable 6.1 (see: http://combi-project.eu/). The project receives funding from the EU's Horizon 2020 programme (No 649724).

In E3ME, employment is determined primarily by the level/growth of economic output analysed above as well as relative labour costs/wage rates. Up to 2020 there is very little change in overall EU employment levels in the scenarios. However, once the energy-efficiency investment starts to grow quickly after 2025, employment is expected to increase substantially. In GEM-E3, employment is mostly affected by the projected changes in the activity of the more labour intensive sectors affected by energy efficiency policies. In GEM-E3, unused labour resources can be used in labour-intensive scenarios with only small effects on the equilibrium wage rates, whereas in E3ME impacts on wage rates are stronger, *i.e.* higher wage rates with increased labour demand partly counteracting the positive employment effects driven by GDP gains.

Table 15: Employment impacts in EU28 in 2030

% change from EUCO27	REF2016[112] (mln people)	EUCO27 (mln people)	EUCO30	EUCO+33	EUCO+35	EUCO+40
E3ME (no crowding out)	233.1	233.5	0.17	0.68	1.04	2.08
E3ME (partial crowding out)	233.1	233.5	0.17	0.63	0.85	1.40
GEM-E3 (loan-based)	216.4	216.6	0.20	0.28	0.36	0.56
GEM-E3 (self-financing)	216.4	216.0	-0.18	-0.51	-0.84	-1.36

Source: E3ME, Cambridge Econometrics and GEM-E3, National Technical University of Athens

When comparing to REF2016, the modelling shows that achieving a 40% greenhouse gas reduction, a renewable target of 27% together with an energy efficiency target of 30% in 2030 could create up to 900,000 new jobs.

Evidence shows that investing in energy efficiency compares favourably with investing in other energy sectors in terms of local job creation impacts.[113] Analysis by Pollin et al. (2009) evaluating different economic stimulus options, demonstrated that the employment creation from investing in energy efficiency is 2.5 to 4 times larger than that for oil and natural gas. A similar study by Wei at al. (2010) has shown that the energy efficiency industry is about twice as labour-intensive compared to the fossil fuel-based energy supply sector per unit of energy saved/produced. Cambridge Econometrics (2015) came to similar conclusions that energy efficiency investments create more employment than investments in energy generation[114]. A review of more than 20 studies concluded that for every £1 million spent on energy efficiency about 23 jobs are directly supported in the energy efficiency industry (Janssen and Staniaszek 2012). Applying this ratio to the total expenditure by energy companies in the UK, Italy,

112 Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency (≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

113 Rosenow, J., Bayer, E. (2016): Costs and benefits of Energy Efficiency Obligation Schemes. Regulatory Assistance Project.

114 https://ec.europa.eu/energy/sites/ener/files/documents/CE_EE_Jobs_main%2018Nov2015.pdf.

France, Austria and Denmark and assuming a leverage factor of 2 suggests that up to 100,000 jobs are supported by EEOSs in those countries together[115].

5.1.2.3 Other macroeconomic indicators

Annex 4 provides the results of both models for sectoral output and employment; trade; competitiveness; real disposable income; consumer expenditure; public budgets; and other macro-indicators. For instance, **exports are projected to increase** in the macro-models for the cases where these project that overall GDP growth is stimulated by energy efficiency investments. The models also indicate an **increased competitiveness in sectors** (such as engineering) benefitting from lower energy costs and learning effects on energy efficient equipment. In addition, energy efficiency investment efforts are unlikely to adversely impact the competitiveness of energy-intensive industries, as any projected increase in the capital cost component is outweighed by the decrease in energy purchases (including auction payments) that could be experienced by these sectors (see chapter 5.1.1.5).

Furthermore, in terms of **impacts on third countries** and from a macro-economic perspective, overall extra-EU imports are projected to grow. This is due to increased EU aggregate demand that is stimulated through increasing energy efficiency investment efforts. As a consequence, third countries that act as main manufacturing trade partners exporting to the EU may stand to benefit. However, from an energy perspective, energy-exporting third countries could be adversely affected due to reduced EU energy demand and energy efficiency improvements in the EU.

5.1.3 Environmental effects and health impacts

5.1.3.1 GHG emission reductions

Both EUCO27 and EUCO30 achieve the same overall GHG reductions in 2030 (as compared to to 1990): 41% but more ambitious scenarios overshoot quite significantly the minimum 40% GHG reduction target. The EUCO+40 scenario achieves 47% reduction because of the combined effect of ambitious energy efficiency policies and a renewable energy share of 28%[116].

Both EUCO27 and EUCO30 achieve by design very similar reductions in 2030 respectively ETS and non-ETS emissions: 43 and 30% – in line with the targets agreed by the European Council. More ambitious scenarios reach in 2030 between 44 and 48% reductions in the ETS sector and between 34 and 39% in sectors covered by the Effort Sharing Decision, which is coherent with overall GHG emissions reductions.

115 Rosenow, J., Bayer, E. (2016): Costs and benefits of Energy Efficiency Obligation Schemes. Regulatory Assistance Project.

116 In terms of impacts on GHG emissions, all scenarios achieve 2030 reductions of at least 40% in line with the European Council conclusions. The GHG and non-ETS/ESD emission results for the EUCO27 and EUCO30 scenarios are features/assumptions of the scenarios, while for the EUCO+ scenarios they are modelling results. Likewise, by design, all scenarios achieve the decarbonisation objective in 2050.

Table 16: Total GHG emissions

Emissions (2030)	Ref2016[117]	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Total GHG emissions (% to 1990)	-35.2	-40.7	-40.8	-43.0	-43.9	-47.2
ETS (% to 2005)	-37.7	-43.1	-43.1	-44.3	-44.2	-48.3
ESD (% to 2005)	-23.7	-30.2	-30.3	-33.7	-35.5	-38.7

Source: PRIMES, GAINS

Some differences between the scenarios are visible in sectoral GHG emission reductions. Comparing the projected 2030 emissions to historical figures of 2005, the power generation, residential and tertiary sectors are projected to experience the biggest reduction across all policy scenarios.

For power generation, for the baseline EUCO27 and the policy scenarios reductions range from 48 to 56% with the effectiveness of the energy efficiency policies in reducing energy consumption taking over ETS prices as the driving force for emission reductions in the sector as energy efficiency ambition increases. In the residential sector, reductions range from 35 to 66% and in the tertiary sector very similarly from 43 to 63%. In both sectors reductions are driven by reduced demand from heating and cooling. In industry the reductions are less differentiated among the scenarios reflecting changes already taking place in the REF2016 scenario and the fact that current energy efficiency policy set-up is not targeting industry in a first place. For the installations covered by ETS, the key driving force in emission reduction is ETS although the ETS prices are lowered by the ambitious energy efficiency policies[118]. While the industry installations and supply side (power generation, CHP, district heating) show significant declines in emissions, other sectors covered by ETS demonstrate slower decline: aviation and non-energy related, i.e. process emissions.

As indicated, ETS emission reductions in EUCO+ scenarios are mainly driven by energy savings policies and achieved with very low ETS carbon prices (see Annex 4)[119].

Comparing other policy scenarios to the baseline, it can be observed that moving from a 27 to a 30% energy efficiency target in 2030, leads to additional emission reductions of 0.1% in industry, 8.5% in residential sector, 6.8% in tertiary and 1.6% in transport.

[117] Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency (≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

[118] In transport, the emission decrease is more differentiated across the scenarios because of the assumptions that are scaled up gradually across the scenarios. In addition, the bio-fuels penetration driven by overall RES target contributes to lowering GHG emissions. The decreases range from 18 to 23% relative to 2005. In a 2050 perspective, emission reductions increase significantly across all sectors as they are all compatible with the 2050 decarbonisation objective. The power sector is almost fully decarbonised reaching in all scenarios 94% reductions compared to 2005 and it remains the sector with the highest reductions. Residential, tertiary and industrial sectors achieve deep 84-88% reductions. The transport sector sees the lowest reductions of 67% relative to 2005 for the baseline and all policy scenarios but in line with White Paper for Transport ambition of 60% GHG reduction in 2050 with regard to 1990.

[119] In the UK, the government has monetised the benefits stemming from avoided greenhouse gas emissions due to energy efficiency obligation schemes. Using guidance on the valuation of CO_2 savings from the Interdepartmental Analysts' Group the value of the avoided greenhouse gas emissions due to ECO have been estimated being worth up to €6.2 billion of non-EU ETS sector emissions and about €2 billion worth of traded EU ETS allowances. Together, the value of the greenhouse gas emission reduction is equivalent to 50% of the energy bill savings. Similar figures have been produced for the extension period of CERT with emission reduction benefits amounting to about 45% of the energy bill savings, see DECC (2010): Extending the Carbon Emissions Reduction Target to December 2012. Final Impact Assessment. DECC, London.

Table 17: Sectoral GHG emissions

Sectoral GHG emission impacts (2030)	Ref2016[120]	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Power generation, CHP and district heating GHG emissions (% change compared to 2005)	-41.0	-48.0	-49.1	-50.5	-50.5	-55.8
Industry GHG emissions (energy) (% change compared to 2005)	-40.7	-43.6	-43.5	-45.9	-47.3	-51.6
Residential GHG emissions (% change compared to 2005)	-25.5	-34.8	-40.3	-53.2	-57.2	-66.1
Tertiary GHG emissions (% change compared to 2005)	-32.5	-42.5	-46.4	-54.1	-57.2	-63.3
Transport GHG emissions (% change compared to 2005)[121]	-12.3	-17.7	-19.0	-19.8	-21.7	-23.2
Power generation, CHP and district heating HG emissions (Mt of CO2 eq) for REF2016 and EUCO27 scenarios and % change from EUCO27 for other scenarios	978	861	-2.1	-4.7	-4.8	-15.0
Industry (energy) (Mt Co2 eq), (% change)	376	358	0.1	-4.0	-6.6	-14.3
Residential (Mt Co2 eq), (% change)	361	316	-8.5	-28.3	-34.3	-48.1
Tertiary (Mt Co2 eq), (% change)	183	156	-6.8	-20.1	-25.6	-36.1
Transport (Mt Co2 eq), (% change)	947	889	-1.6	-2.5	-4.9	-6.7

Source: PRIMES

5.1.3.2 Air pollution: health impacts and air pollution control cost

Latest research results confirm that energy efficiency measures will lead to improvements in air quality[122]. Although emission reductions from large combustion plants in the European Union have been significant in the past few decades, in some countries large emission reduction potentials are still untapped[123]. The residential sector in particular has potentials for untapped energy efficiency and, as a result, air pollution abatement and the EU is supporting research projects on how to exploit this potential[124]. The size of this potential depends on the fuel choice of households and the efficiency of the heating system.

According to the European Environmental Agency, energy efficiency improvements in the transport sector (such as efficiency improvements of vehicles and modal shift from motorised to non-motorised transport) can significantly reduce air pollution, particularly in urban areas. Transport is responsible for more than half of NO_x emissions, and contributes significantly

[120] Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency (≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.
[121] Including pipeline transportation, ground activities in airports and harbours, etc.
[122] European Environment Agency (2010). Impact of selected policy measures on Europe’s air quality. Luxembourg: Publications Office. Retrieved from http://dx.publications.europa.eu/10.2800/42618.
[123] COMBI-Project (2015). Literature review on avoided air pollution impacts of energy efficiency measures, Deliverable 3.1, http://combi-project.eu. The project receives funding from the EU's Horizon 2020 programme (No 649724).
[124] For examples LIFE projects linking energy efficiency with lower emissions of air pollutants (http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=5240, http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=5002 or http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=3765).

(around 15 % or more) to the total emissions of the other pollutants. Road transport in particular makes a significant contribution to emissions of all the main air pollutants[125].

The table below shows that the different policy options all reduce emissions of $PM_{2.5}$, SO_2 and NO_X compared to the EUCO27[126]. The reductions become larger as the scenarios become more ambitious and reduce fossil fuel consumption and combustion more significantly. It has to be noted that energy efficiency policies mostly target gas and oil consumption, whereas coal consumption is mainly affected by ETS prices[127]. Therefore, the EUCO+40 scenario with very ambitious GHG reduction also significantly reduces coal consumption. The most pronounced differences between the scenarios are in gas consumption as described above.

Compared to EUCO27, EUCO30 reduces NOx emissions by 83 kton, SO_2 by 6 kton and $PM_{2.5}$ by 28 kton. The other options show higher reductions (see table below).

The reduction in air pollution has **positive impacts on human health**. The EUCO30 scenario reduces the number of life years lost due to lower $PM_{2.5}$ concentrations (a result of lower $PM_{2.5}$, SO_2 and NO_X emissions by some additional 2.5 million in 2030 compared to EUCO27). The number of life years gained increases to 8.7 million in EUCO+33, 11 million in EUCO+35 and close to 17 million in EUCO+40. Ozone mortality is also reduced more prominently. Positive impacts occur also in the **reduction of mortality due to lower ozone concentration** (cases per year), but these are small in comparison to the effect of particulate matter. The positive human health impacts are orders of magnitude larger in the options with higher energy efficiency.

The **reduction in mortality** can also be valued economically. The table shows that with a 30% energy efficiency target, health damage due to air pollution is reduced in 2030 by €2.9 to 6.6 billion compared to EUCO27. The range results from the use of a high and a low valuation of mortality (value of life year lost) also used for the Thematic Strategy on Air Pollution. These health benefits are much higher (up to €45 billion) for the more ambitious energy efficiency targets in line with higher reductions in emissions and their impacts.

Because of lower emissions, the **costs to control air pollution** are lower as well compared to EUCO27. For the EUCO30 scenario, the reduction in pollution control costs (e.g. for particle filters) is €1.7 billion. Cost savings are higher with higher energy efficiency targets. They range from €3.9 billion/year (EUCO+33) to €10.9 billion in the EUCO+40 option.

Summing up the monetized part of the health damage costs and the pollution control costs in 2030, the table below shows reductions in the costs between €4.5 and 8.3 billion for the EUCO30 scenario compared to EUCO27. This is mainly due to the reduction in mortality due to particulate matter concentrations. In the higher energy efficiency options the impacts are

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[125] http://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-air-pollutants-8/transport-emissions-of-air-pollutants-2

[126] For the analysis of reduced air pollution benefits the same methodology, based on the GAINS model, was used as in the Impact Assessment for the Roadmap to a Low Carbon Economy and IA accompanying policy framework for climate and energy in the period from 2020 to 2030.

[127] It should be noted, however, that in some Member States coal is widely used for electricity, district heating/cooling and domestic heating. Especially the latter is not affected at all by ETS prices, but energy efficiency can have a big effect on domestic coal consumption and related emissions of air pollutants.

much higher and range from a € 15.2 to 28.4 billion/year (EUCO+33) to between €30.4 and 55.9 billion per year (EUCO+40).

Forest, catchment and ecosystem areas where acidification and eutrophication exceed critical loads are reduced. For example, the size of the area **with ecosystems exposed to acidification exceeding critical loads is reduced** by around 0.4 million km^2 in the EUCO30 compared to the baseline EUCO27. In the other options the area protected against acidification increases by 1.1 million km^2 (EUCO+33), 1.8 million km^2 (EUCO+35) and nearly 3.2 million km^2 (EUCO+40). Also the area of ecosystems that are no longer exceeding critical loads for eutrophication is increased by 4.3 million km^2 in EUCO30. For the other options the impacts are more significant. The area protected increases by 12 million km^2 in EUCO+33, 14.6 million km^2 in EUCO+35 and 22.8 million km^2 in EUCO+40.

Other effects linked to pollution are also reduced i.e. morbidity (health effects), damage to crops (e.g. because of lower ground level ozone emissions), but these benefits have not been quantified in this Impact Assessment. Furthermore, damage to materials, buildings and sensitive ecosystems (due to acidification, excess nitrogen deposition and ground level ozone) are also expected to be reduced but have not been assessed.

In conclusion, all policy options analysed come with significant environmental and health benefits, which are more prominent for the more ambitious energy efficiency targets[128].

Table 18: Impacts of reduced air pollution

Change in air pollution control costs and health damage in 2030 (compared EUCO27)	**EUCO30**	**EUCO+33**	**EUCO+35**	**EUCO+40**
SO2 (kton)	-6	-44	-63	-148
NOX (kton)	-83	-221	-309	-487
PM2.5 (kton)	-28	-89	-111	-163
Health impacts (million life years gained due to less PM2.5)	2.5	8.7	11.0	16.9
Premature deaths ozone avoided (cases per year)	114	337	438	662
Reduction in monetary damage health because of PM & ozone concentration (€ billion/year). Low estimate	2.9	10.1	12.8	19.5
Reduction in monetary damage health PM & ozone concentration (€ billion/year). High estimate	6.6	23.3	29.4	45.0
Air pollution control cost savings (€2010 billion/year)	1.7	5.1	7.2	10.9
SUM of reduction in pollution control costs & health damage costs (€ billion/year)	4.5-8.3	15.2-28.4	19.9.-36.6	30.4-55.9

Source: IIASA (2016) based on GAINS for emissions, health impacts and air pollution control costs (in € of 2010). Benefit valuation uses valuation of mortality (value of life year lost) used for the Thematic Strategy on Air Pollution of €57700 to 133000 per life year lost.

128 A 2007 review of the Vermont Weatherization program determined that health and safety improvements added an additional $1,044 in project cost, while returning benefits worth $2,372, including $1,421 due to fewer illnesses. Another comprehensive evaluation of the costs and benefits of the Warm Homes Scheme in Northern Ireland concluded that for every €1 spent on energy efficiency 42 cents was recouped by the health service. Recognising the significant health benefits of improved thermal efficiency the UK government trialled the prescription of high-efficiency boilers with the result that medical appointments for those households receiving a boiler dropped by 60% (www.gmjournal.co.uk/boilers_on_prescription_scheme_reduces_gp_appointments_by_60_25769832606.aspx).

5.1.4 Social impacts including affordability issues

One important aspect is the affordability for consumers of energy including both operational costs (purchases of electricity and fuels) and capital expenditure (measured by direct investment expenditures or alternatively coupled with the cost to borrow money for energy). As demonstrated in the analysis of system costs below all policy scenarios lead to considerable shifts from operational to capital expenditure. Operational expenditure is influenced by energy prices. Energy prices (except electricity) are projected to rise in the longer term and they do not vary among scenarios[129]. However, electricity prices are impacted by the energy efficiency policies.

The table below demonstrates that the share of energy-related costs (both including and excluding transport) in household expenditure grows only slightly in 2030 in step with increasing level of ambition of the target[130]. This means that the additional expenditure related to more energy efficient equipment is almost entirely compensated by the reduced expenditure on fuels and electricity. In the 2050 perspective, the share of energy-related costs would even decrease for households with higher energy efficiency levels in 2030. However, targeted financing schemes would certainly be needed in order to incentivise the necessary investment by consumers with lowest income without increasing the overall share of energy related cost in their household expenditure. In addition, it needs to be kept in mind that the share of energy costs in household expenditures (as shown in Table 19) does not take into account the positive impacts on households stemming from a higher employment and GDP impacts which would lower the share of energy costs as the real disposable income increases (see Table 20).

Table 19: Share of energy costs in household expenditure (2030 and 2050)[131]

Share of energy costs in household expenditure (2030)	Ref2016[132]	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Share of energy related cost (excluding transport) in household expenditure in 2030 (in 2010: 6.2)	6.9	7.1	7.4	7.8	8.0	8.5
Share of energy related cost (excluding transport) in household expenditure in 2050 (in 2010: 6.2)	5.8	7.8	7.6	7.5	7.4	7.1

Source: PRIMES

[129] However, strong energy efficiency policies can have a positive impacts on international fuel prices as shown in the chapter 5.1.1.4.

[130] The modelling results presented here do neither offer a disaggregation of households among income groups nor analyse targeted financing schemes for consumers with low incomes that could serve to facilitate their access to capital to finance energy investments.

[131] These shares do not take into account an increase in real disposable income.

[132] Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency (≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

When looking at the real disposable income, it can be seen in the table below that they increase with higher energy efficiency levels as society benefits from higher employment levels and GDP which has a positive impact on the real disposable income.

Table 20: Real disposable income[133]

Real disposable income (% change from EUCO27)	Ref2016[134] (EUR)	EUCO27 (EUR)	EUCO30	EUCO+33	EUCO+35	EUCO+40
E3ME (no crowding out)	11,371.4	11,446.7	0.16	1.00	1.42	2.88
GEM-E3 (loan-based)	11,334.2	11,368.6	0.25	0.30	0.23	0.18
GEM-E3 (self-financing)	11,334.2	11,319.6	-0.14	-1.00	-1.36	-1.84

Source: E3ME, Cambridge Econometrics and GEM-E3, National Technical University of Athens

Energy efficiency has positive social impacts measured by several metrics e.g. jobs which have been discussed above. This impact assessment also examines social impacts from the perspective of skills, energy poverty and equity, with analysis indicating positive crosscutting benefits. Energy poverty is closely linked to issues of affordability of energy in residential housing for low income groups; in this context it is important to underline the interlinkages between the general energy efficiency framework and the Energy Performance of Buildings Directive. These are designed to work together in the area of building renovation, the first one providing a framework for increasing the rate of renovation in the buildings sector, the second one to ensure that renovations – when carried out – meet higher minimum standards with regard to energy efficiency than previously. Together they drive increased investment in the sector[135].

Energy costs and their social impacts are of particular relevance in the residential sector for consumers with low incomes. On the one hand, these consumers may have the keenest interest in reducing their energy expenditures. On the other hand it is widely acknowledged that capital market failures mean that many households in this category do not have access to

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133 Real disposable income results are not reported for the E3ME case of "partial crowding out". This is because of the methodological approach of E3ME in representing potential crowding out effects, which are modelled via forcing higher savings to compensate for what would have been price changes if crowding out effects were to be modelled in a tradition general equilibrium model. In other words, because of the post-Keynesian approach to simulating the possible existence of crowding out effects that are typical to economic equilibrium approaches and not to non-equilibrium models, income effects cannot be adequately captured in the "partial crowding out" version of E3ME.

134 Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency (≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

135 Research results show a positive correlation of the efficiency of a building as indicated in the certificates on the energy performance of buildings (EPCs) on the sales price of the property. This correlation affects even more the value of less energy-efficient properties, by decreasing their value by nearly 1/4. This indicates that more ambitious energy efficiency efforts in particular in the building sector could increase the value of a Member State's building stock in monetary terms. Energy efficiency investments are not stranded investments for home owners as the investments increases the value of the building. However, whereas the display of the EPC in the advertisements introduced by the EPBD plays a significant role for the sales price, the impact of energy efficiency measures on rental prices is less proven (See Jensen/Hansen/Kragh: Market response to the public display of energy performance rating at property sales (Energy Policy 93 (2016) 229–235).). This may be linked to the landlord-tenant problem and the question of whether higher rents can be compensated by the tenant by lower energy bills

the capital markets to obtain long term finance, and therefore will not be able to invest in energy efficiency. An issue of equal importance is the positive correlation between lower household income and an increasing likelihood that the household is in the rental market. In rental markets, where there is insufficient regulation or other shortfalls in the regulatory framework, the issue of capital rationing is compounded by the issue of split incentives, i.e. where the cost effective optimum is not realised due to lack of incentives for the owner to renovate. It is a challenge, but the clear positive relationship between reaching the cost effective level of investment in residential energy efficiency solutions and potential reduction in energy poverty must be further exploited.

Basic analysis has been carried out with the E3ME model to examine the distributional impacts across socio-economic groups (disaggregated by income quintiles) of implementing the energy efficiency policy scenarios. Modelling was carried out under an assumption of self-financing of energy efficiency investments by households[136]. The E3ME model supports the notion that in most countries real incomes[137] increase across all household groups, although the distributional impacts of energy efficiency measures are not uniform across all energy efficiency and lower heating bills[138].

Table 21: Distributional impacts for income by socio-economic group, % change in average real income EUCO30 and EUCO33 compared to EUCO27 in 2030[139]

(% change compared to EUCO27)		All households	Lowest Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
No Crowding out	EUCO30	0.10	0.16	0.18	0.15	0.12	0.03
	EUCO33	0.71	1.05	0.99	0.85	0.68	0.44
Partial Crowding out	EUCO30	0.10	0.15	0.17	0.15	0.12	0.03
	EUCO33	0.62	0.93	0.87	0.75	0.61	0.37

Source: E3ME, Cambridge Econometrics

Research on the multiple social effects of energy efficiency has recently gained momentum[140], but more is needed to sufficiently quantify the various social impacts of energy efficiency improvements. However, concluding from the available empirical data summarised by the COMBI project,[141] the strongest social welfare benefits can be expected in housing, transport and productivity related effects. Energy efficiency improvements in the housing sector have a positive impact in reducing energy poverty and associated negative aspects of well-being[142].

[136] Bank lending is not explicitly modelled in E3ME, although it is implicitly assumed that banks can create credit and lend to households without crowding out financial resources from other bank lending activities (i.e. no competition for loans is assumed) in the non-crowding out model run. No assumptions are made about the types of households that are most affected by the energy efficiency improvements.

[137] Income from wages, benefits and other after tax income.

[138] In many countries low-income households use a larger share of their incomes for space heating. Therefore, higher energy prices might have negative impacts. However, it is less relevant to the energy efficiency scenarios modelled here where energy prices do not change significantly between scenarios. However, it is noted that the prices of other goods may change in the scenarios due to indirect effects.

[139] EU average of the percentage changes per socio-economic group are shown, i.e. first the changes in real incomes per group are calculated; then these are averaged across Member States.

[140] IEA (2015). Capturing the Multiple Benefits of Energy Efficiency. Paris.

[141] COMBI-Project (2015) Literature review on social welfare impacts of energy efficiency improvement actions, Deliverable 5.1, http://combi-project.eu. The project receives funding from the EU's Horizon 2020 programme (No 649724).

[142] For example, a better insulated building can lead to an increase in indoor average temperatures and decrease in damp. Empirical studies suggest that energy efficiency improvements in fuel poor households are usually divided into

Energy efficiency improvements particularly in buildings thus have a positive welfare effect in the form of increasing comfort and an energy savings effect in the form of lower energy bills. For low-income households in particular, this can be a challenge. Accompanying measures, including via the use of financial instruments, are therefore necessary to make sure that households do benefit from such energy efficiency improvements. Improving the efficiency of buildings lived in by people who face fuel poverty is key in this respect as the multiple benefits. According to the IEA, positive health outcomes are strongest among vulnerable groups, including children, the elderly and those with pre-existing illnesses, as more efficient buildings improve the health and well-being for occupants[143]. A 2013 study for the European Investment Bank[144] found that the reduction of fuel bills through energy efficiency measures could mitigate energy poverty and many of the issues associated with inequality and social exclusion. Work on best practices undertaken with stakeholders in the Citizens' Energy Forum has also highlighted that energy efficiency improvements tend to be the best long-term solution to energy poverty[145].

Energy poverty alleviation is thus a function of investments in energy efficiency measures, and of the assumptions on the division of the surplus value. In the case of the building sector and energy poverty, the drivers for investment are renovation rates and energy performance standards for new buildings and for building renovations. Similar analysis has been carried out by E3ME of the impacts of increased investments in energy efficiency from increasing the ambition level in the EPBD impact assessment. While measures under Article 7 of the EED drive demand for increased energy efficiency in the housing sector, an increased ambition level is a necessary but not sufficient condition for ameliorating energy poverty. While modelling indicates that all scenarios reduce energy poverty, the results in this case are contingent on Member States implementing policies in parallel that favour the energy poor.

Welfare effects in the transport sector result particularly from modal shifts from motorised to non-motorised or collective forms of transport such as walking, cycling, public transport or a combination of these options. The most significant co-benefits of a modal shift towards active modes of transport arise from increased physical activity and may lead to lower levels of obesity, various physical and mental diseases and pre-mature mortality. Associated co-benefits would include reduced congestion and noise and air pollution to the general population. Secondary co-benefits may be located in employment and improvements in social cohesion[146].

Another potential area of benefits of energy efficiency investments is productivity benefits in commercial buildings. This is closely related to health and comfort benefits. Literature suggests a positive, significant and sizable influence of life expectancy (or some related health indicator) on the subsequent pace of economic growth. Any energy efficiency improvement

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comfort improvements (i.e. rebound effect), but also into reducing energy costs through lower energy consumption. See COMBI-Project (2015). Literature review on social welfare impacts of energy efficiency improvement actions, Deliverable 5.1, http://combi-project.eu.

143 IEA (2014): Capturing the Multiple Benefits of Energy Efficiency (see http://www.iea.org/publications/freepublications/publication/Captur_the_MultiplBenef_ofEnergyEficiency.pdf).

144 The Benefits of Energy Efficiency, http://www.eib.org/epec/ee/documents/factsheets-energy-efficiency-en.pdf

145 A New Deal for Energy Consumers, COM(2015) 339 final

146 COMBI-Project (2015). Literature review on social welfare impacts of energy efficiency improvement actions, Deliverable 5.1, http://combi-project.eu. The project receives funding from the EU's Horizon 2020 programme (No 649724).

action which has a sizeable health impact may, therefore, also impact macro-economic growth[147].

5.1.5 Energy related investments

Table 22 below describes the average annual investment expenditures projected by PRIMES across scenarios. Energy related investment expenditures can be divided into:

- Investments on the supply side (power generation), namely in grids, power generation plants and industrial boilers; and
- Investments on the demand side, which include energy equipment (covering appliances in households and tertiary sector, vehicles, industrial equipment etc.) and direct energy efficiency investments (covering renovation of buildings improving their thermal integrity).

Only a part of the costs for appliances, which is deemed to represent the cost of energy efficiency improvement, is reported. Likewise, for building renovations the cost of improving the thermal integrity of the building envelope is isolated from the total renovation costs. Moreover, only the costs of thermal renovation triggered by the policies assumed (both in REF2016[148] and policy scenarios) are reported.

Investment expenditures are, alongside energy purchases, the key components of the total system costs figures. Importantly, energy system costs reflect the entire financial flows (among others cost of finance) related to scenarios whereas investment expenditure is net of financing or other costs.

It should be noted that projections of investment expenditure, while consistent across scenarios, are difficult to compare with the investment volumes that are currently being incurred to promote energy efficiency (and are delivering energy savings) as there are no complete data on investments by households or private businesses and methodologies (notably baselines) for estimation of volume of investment differ. Still, an attempt for such a comparison is presented in Annex 8.

Looking at EUCO scenario projections of future investment expenditure, it has to be borne in mind that that an increase in total investment expenditure between them and REF2016 is due not only to the energy efficiency targets but also the achievement of other 2030 targets (GHG emission reduction and renewable energies). However, comparing policy scenarios with EUCO27 indicates expenditure increases due to energy efficiency policies only[149].

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[147] Ibid.

[148] The REF2016 investments do not include renovations which are triggered by natural stock turnover. However, in REF2016, there is already thermal renovation triggered by existing energy efficiency policies (in 2015-2020 period only) which is reported.

[149] Looking at policy scenario projections of future investment expenditure, it has to be borne in mind that that an increase in total demand-side investment expenditure between policy scenarios and baseline is due not only to the energy efficiency target but also achievement of other 2030 targets. On the other hand, comparing policy scenarios among themselves indicates expenditure increases due to energy efficiency policy only with exception of EUCO+40 scenario which also increases RES target above 30% in 2030.

Total investment expenditure increases in all scenarios - more significantly in more ambitious scenarios. Firstly, investments in REF2016 (needed for the currently adopted policies) can be compared to EUCO27 investments which are necessary to achieve all three minimum 2030 targets agreed by the European Council. The table below shows an increase of average annual investment needs of nearly €98 billion/year in the period 2021-2030 in order to reach the 27% energy efficiency target together with a 40% GHG and 27% RES target compared to the REF2016[150]. To achieve a 30% target would lead to an increase in average annual investment expenditure of €78 billion compared to a 27% target. For more ambitious scenarios an increase in average annual investments (compared to 27% target) would range from €196 to 529 billion. While the scale of the investment challenge is significant it leads to lower operational costs (energy expenditures) and is an opportunity for the European economy in terms of growth and job creation as demonstrated above.

Investment needs increase most significantly in the residential and tertiary sectors because the majority of energy efficiency policies assumed in the policy scenarios focus on these two sectors. In the residential and tertiary sectors, total average annual investments cover both increased investments in appliances and equipment as well as additional investments in the energy efficiency of the building envelope (thermal renovation). Investments are already high in the EUCO27 scenario, namely around €168 billion/year for residential (thermal renovation representing 1/4 of investments) and €40 billion/year for tertiary (thermal renovation representing 1/2 of investments). In both sectors investments would increase by €75 billion/year to achieve a 30% target and majority of this increase is due to thermal renovation of buildings. However, these sectors will benefit from reduced energy bills (see below the section on energy purchases). The average annual investments in industry and transport[151] increase slightly by €6 billion only between the two scenarios as industry is less targeted by the policy mix assumed and for transport, a strong change is assumed already for EUCO27 scenarios. On the other hand, investment in power generation and grids are constant between EUCO27 and EUCO30 and decrease for more ambitious scenarios as less energy needs to be generated, transported and distributed (as already demonstrated by a decline of net installed power generation capacity of thermal power plants (see Table 8). It has however to be noted that as energy efficiency in buildings increases, the need for additional renewables in heating and cooling is reduced. In order to reach the overall 27% RES target, additional investments in power generation thus have to be triggered in EUCO30 scenario compared to baseline.

In general, it needs to be kept in mind that there is also a high potential for policy learning by public bodies and technology cost reductions that can lower investment costs. Technological progress is essential for an early market penetration of energy efficiency technologies and

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150 Looking at policy scenario projections of future investment expenditure, it has to be borne in mind that that an increase in total demand-side investment expenditure between policy scenarios and baseline is due not only to the energy efficiency target but also achievement of other 2030 targets. On the other hand, comparing policy scenarios among themselves indicates expenditure increases due to energy efficiency policy only with exception of EUCO+40 scenario which also increases RES target above 30% in 2030.

151 For all scenarios (including REF2016) investments in transport are higher than for other sectors, this is because for transport total investments associated to the turnover of the rolling stock are reported, which are broader than (but include) those related to energy services.

contributes considerably to the achievement of higher energy efficiency targets in a cost-efficient manner[152].

Table 22: Investment expenditures

Investment expenditures: total and sectorial decomposition in billion €'10 (average annual 2021-30)	Ref2016[153]	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Total energy related investment expenditures	938	1,036	1,115	1,232	1,324	1,565
Change from EUCO27 in bn €			78	196	288	529
Households	127	168	214	286	337	455
Change from EUCO27 in bn €			47	118	169	288
Tertiary	23	40	68	119	157	257
Change from EUCO27 in bn €			28	79	117	217
Industry	15	17	19	24	29	51
Change from EUCO27 in bn €			1	6	12	34
Transport[154]	705	731	736	729	733	740
Change from EUCO27 in bn €			5	-2	3	9
Grid	34	39	36	34	31	26
Change from EUCO27 in bn €			-3	-5	-8	-13
Generation and industrial boilers	33	42	42	40	37	36
Change from EUCO27 in bn €			0	-2	-5	-6

Source: PRIMES

Energy efficiency investments necessary to implement European and national policies will increase the initial capital costs for energy consumers. However, over time, energy efficiency investments will pay back as they will reduce operating costs (energy bills for energy consumers to pay for fuels and electricity) compared to the situation without the intervention. In other words, an increase in capital costs due to up-front investments for energy efficiency improvement measures will be to a large extent compensated by lower operational costs[155]. This is demonstrated by a general shift in the structure of costs for energy consumers, i.e. diminishing energy purchases (consumer paying less for fuels and electricity) and increasing investment expenditures (consumers paying for additional energy efficiency investments)[156].

Average **energy purchases** in 2021-2030 are reduced from €1,448 billion in REF2016 to €1,415 billion in EUCO27. A further reduction of energy purchasing costs by €28 billion is

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152 See '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' by Fraunhofer ISI, PWC and TU Wien (2014) (see https://ec.europa.eu/energy/sites/ener/files/documents/2014_report_2020-2030_eu_policy_framework.pdf).

153 Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency ((≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

154 This includes investments in transport equipment for mobility purposes (e.g. rolling stock but not infrastructure) and energy efficiency. They exclude investments in recharging infrastructure. However, the electricity prices in PRIMES are calculated in order to recuperate all costs including those related to recharging infrastructure for electric vehicles.

155 For individual energy customers a long payback period of energy efficiency investments is an important factor which prevents many energy customers from investing in energy efficiency.

156 See also Annex 4 with a more detailed table on system costs.

possible in EUCO30 (compared to EUCO27). For more ambitious scenarios, a decrease in average annual energy purchases range from €52 to 86 billion compared to EUCO27. Across all scenarios, the reductions are mainly achieved in the residential and tertiary sector. In addition, a small reduction of international fuel prices due to strong European energy efficiency policies (see chapter 5.1.1.4) could have some impact on the energy purchase costs for consumers.

Table 23: Energy purchasing costs

Energy purchasing costs (2030)	**Ref2016**[157]	**EUCO27**	**EUCO30**	**EUCO+33**	**EUCO+35**	**EUCO+40**
Energy Purchases in billion €'13 *(average annual 2021-30)*	1,448	1,415	1,388	1,363	1,360	1,329
Industry	272	271	269	267	264	261
Residential	417	410	397	386	380	365
Tertiary	249	243	235	226	222	213
Transport	510	491	486	484	494	489

Source: PRIMES

5.1.6 Energy system costs

In the REF2016, the average annual total energy system costs[158] for the decade 2021-2030 are projected to be €1,928 billion. This equals a ratio of total energy system cost to GDP of 12.28%. When looking at a longer time horizon (2021-2050), average annual total energy system costs are projected to be €2,130 billion with a ratio of total energy system cost to GDP of 11.70% (a growing GDP is assumed until 2050).

In the period 2021-2030, a target of 30% would lead to an average annual increase in system costs of €9 billion compared to a 27% target. This constitutes an increase of 0.44% in total energy system costs or, expressed as share of GDP, an average annual increase in system costs of 0.05 percentage points compared to EUCO27. Taking a longer term perspective (2021-2050), the average annual system costs for the 30% scenario would be € 9 billion lower than in the EUCO27 scenario, as the benefits of investments made between 2021 and 2030 continue to pay off post-2030.

[157] Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency ((≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

[158] Energy system costs for the entire energy system include capital costs (for energy installations such as power plants and energy infrastructure, energy using equipment, appliances and vehicles), energy purchase costs (fuels + electricity + steam) and direct efficiency investment costs, the latter being also expenditures of capital nature. Capital costs are expressed in annuity payments, calculated on the basis of sector specific discount rates (see Annex 4 for further explanations on discount rates). Direct efficiency investment costs include additional costs for house insulation, double/triple glazing, control systems, energy management and for efficiency enhancing changes in production processes not accounted for under energy capital and fuel/electricity purchase costs. They do not include any disutility costs associated with changed behaviour, nor the cost related to auctioning of allowances which lead to corresponding revenues which can be used. Energy system costs are calculated ex post after the model is solved. The calculated cost is influenced by the discount rate used; capital expenditures and energy efficiency investment costs have been discounted with a financial discount rate of 10% (see further information in Annex 4).

Looking at more ambitious (than EUCO30) scenarios, they require an increase in average annual costs for the period 2021-2030, ranging from €34 to 133 billion or 0.20 to 0.80 percentage points of GDP higher compared to EUCO27.

Table 24: Energy system costs 2021-2030[159]

Energy system costs (2030)	Ref2016[160]	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Total System Costs in billion €'13 (average annual 2021-30)	1,928	1,943	1,952	1,977	2,014	2,077
Change in system costs compared to EUCO27 (in bn €'13)			9	34	71	133
Total System Costs as % of GDP (average annual 2021-30)	12.28	12.37	12.42	12.57	12.80	13.18
Total System Costs as % of GDP increase (average annual 2021-30) compared to EUCO27 in % points			0.05	0.20	0.43	0.80

Source: PRIMES

Table 25: Energy system costs 2021-2050[161]

Energy system costs (2050)	Ref2016[162]	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Total System Costs in billion €'13 (average annual 2021-2050)	2,130	2,264	2,255	2,290	2,324	2,384
Change in system costs compared to EUCO27 (in bn €'13)			-9	26	60	121
Total System Costs as % of GDP (average annual 2021-2050)	11.70	12.35	12.31	12.51	12.70	13.04
Total System Costs as % of GDP increase (average annual 2021-50) compared to EUCO27in % points			-0.04	0.16	0.35	0.70

Source: PRIMES

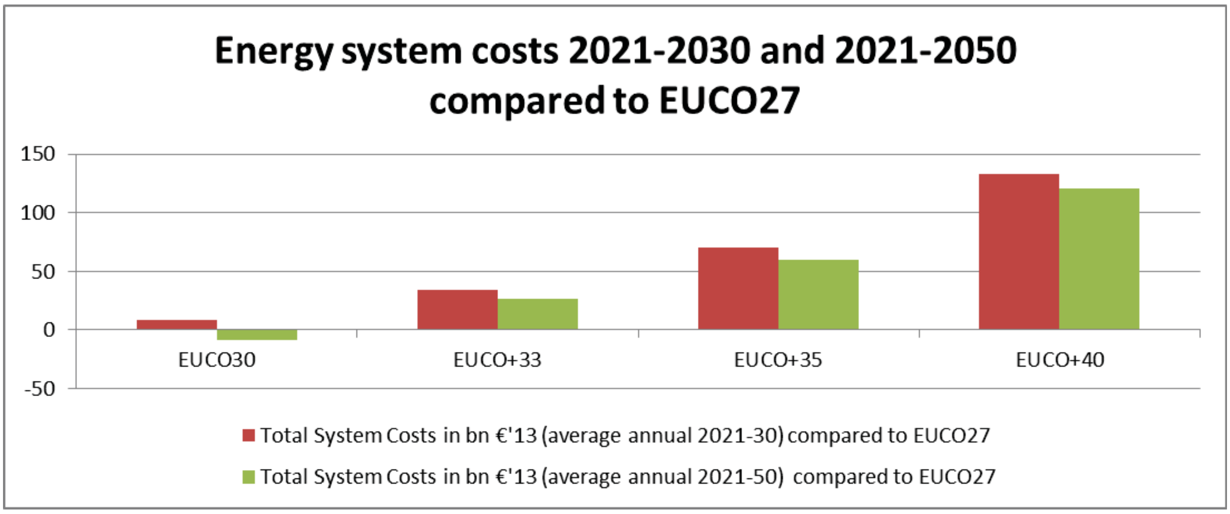
[159] The small difference between the total system costs and the summation of capital costs, energy purchase costs and direct efficiency investment costs (as shown in Annex 4) is due to the inclusion of the supply side auction payments under energy purchases, embedded in the energy prices (but not included under the reported total system costs which exclude auction payments).

[160] Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency ((≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

[161] The small difference between the total system costs and the summation of capital costs, energy purchase costs and direct efficiency investment costs (as shown in Annex 4) is due to the inclusion of the supply side auction payments under energy purchases, embedded in the energy prices (but not included under the reported total system costs which exclude auction payments).

[162] Whereas the EUCO scenarios achieve the 2030 targets for RES (≥27%), GHG (≥ 40%) and energy efficiency ((≥27%), the REF2016 does not achieve these targets. Therefore, a comparison of the results of EUCO scenarios with REF2016 should not be undertaken to identify the impacts of a higher energy efficiency level above 27% in 2030 only because this comparison would include also the impacts of a higher RES and GHG targets and the associated cost.

Figure 4: Energy system costs (2021-2030 and 2021-2050)



Source: PRIMES

In the PRIMES model, private discount rates have been used to reflect the decision-making process of economic actors. The behavioural discount rate for investments in buildings renovation of households was slightly lowered with the intensification of energy efficiency policies in more ambitious policy scenarios. A 10% discount rate was used – after the model was solved – to annualise the capital and energy efficiency investment costs reflecting opportunity costs of raising funds by the actor on a private basis. The 10% discount rate was kept unchanged among the scenarios. This rate is similar to the WACC used for supply side investments.

Energy efficiency measures are mainly financed by private capital in the form of savings from households, equity from companies, commercial debt originating from small consumer loans by retail banks and large-scale green bonds issued on the capital markets. This mobilisation of private financing is reinforced by a number of public schemes (around 200) across Europe, which primarily take the form of grants, low interest rate credit lines[163], tax rebates or guarantees[164]. To facilitate future investment expenditure from the private sector, it would be helpful to ease access to financing and bring down its costs by addressing a number of market failures, by 1) using public funding more effectively and by supporting the development of attractive financing solutions built upon the emergence of new business models (**more effective use of public funding**); 2) securing sustainable large-scale pipeline of bankable energy efficiency projects (Aggregation and assistance); 3) de-risking of energy efficiency investments which are currently still seen as risky and costly (De-risking). In that context, these three pillars of the **"Smart Finance for Smart Buildings"** Initiative come with a coherent response to the need to strengthen energy efficiency financing streams in Europe.

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[163] For example, Energy Efficiency Fund operated by VIPA in Lithuania.

[164] At the EU level, the most important financing streams for energy efficiency are the European Structural and Investment Funds (ESIF). Energy Efficiency has also been a beneficiary of the European Fund for Strategic Investments (EFSI). In addition, there are two specific EU financial instruments for energy efficiency, the European Energy Efficiency Fund which provides market-based financing to public projects and PF4EE (Private Finance for Energy Efficiency) which combines lending from the EIB to private banks together with guarantees and technical assistance.

5.2 Assessment of the character of the target

The different policy options regarding the target formulation are analysed qualitatively in relation to the following criteria: Effectiveness, efficiency, relevance, coherence, subsidiarity and proportionality. -1 is given for a high chance of not meeting the criterion, 0 for neutral and 1 for a high chance of meeting the criteria.

This analysis is done having in mind the initiative on governance of the Energy Union, which is developed in parallel as decided by the European Council in 2014. It will provide a mechanism for Member States to present their energy efficiency targets for 2030 and projections towards these targets as contributions to the EU wide energy efficiency 2030 target. This will help to track the progress towards the EU 2030 energy efficiency target.

Effectiveness[165]

In general, the **binding nature** of a target is assumed to impact on the **delivery of the target** only. Measures need to be put in place **which ensure that the agreed target is achieved** by the EU as a whole or by individual Member States. In contrast, **indicative targets** are seen to focus on **binding measures and actions** that trigger energy efficiency investments and which enable the EU28 and Member States to achieve their indicative target.

Option 1.1 (indicative EU and national targets) would be a continuation of the current approach, ensuring a continuity of a framework to which relevant stakeholders including Member States have become accustomed. However, this option does not ensure effectiveness as Member States can set their ambition level according to their national circumstances which does not necessarily lead in the sum to the overall EU target as it is the case for the 2020 targets. In addition, the indicative nature of the current target has sometimes made it difficult to mobilise the necessary policy effort. Experience with the 2020 indicative national targets under Article 3 of the EED has shown that there is only limited scope to increase Member States' efforts to ensure that all 28 indicative national targets add up to the overall EU target[166]. Effectiveness could be achieved if a review of the progress towards the 2030 target would be foreseen in legislation which would allow legislation to be adopted in time to deliver the needed additional savings by 2030[167]. Without an early review clause or even a concrete 'what if' clause in the EED if the 2030 target is at risk, the effectiveness score would be -1. However, if legislation would create a presumption for the Commission to take action in case the EU is at risk to achieve the 2030 energy efficiency target, the score can be increased to zero as this would increase the effectiveness of this option.

By contrast, **option 1.3** with binding Member States targets would be the most effective way of achieving the agreed 2030 EU energy efficiency target level as it could be assured that the sum of national targets of Member States, if defined by the Commission or the individual contributions agreed between Member States, would be in line with the overall European

[165] Effectiveness considers how successful the option is in achieving or progressing towards the set objectives.

[166] Article 3(3) EED required the Commission to review in 2014 if the European Union achieves its 2020 target. The Commission concluded that new primary legislation would be unlikely to enter into force soon enough to deliver the required savings to close the gap towards the 2020 target. Therefore, the Commission stressed the need to properly implement existing energy efficiency legislation (COM(2014) 255 final).

[167] On the other side, it is difficult to conclude many years ahead of 2030 if the EU is at risk to meet the energy efficiency target as many different factors might influence the energy consumption in the years until 2030.

energy efficiency target (effectiveness score 1)[168]. In case of binding national Member States targets, the whole EED needs to be reassessed as Member States might need to have more flexibilities. In this context, also a complete removal of Article 7 which sets requirement for Member States to save a fixed amount of final energy from energy sales every year needs to be considered in this case. Therefore, option 1.3 would require a complete reassessment of the Directive to ensure consistency of national binding targets with binding measures.

Option 1.2, a binding EU target (as will be implemented for the renewable energy framework 2030), will be effective for energy efficiency only in combination with an early review clause or a 'what-if-clause' and in combination with a strong governance system. National plans which will be introduced under the Energy Union governance would include an explicit aim of contributing to the overall EU target for energy efficiency. If a review by the Commission would show an insufficient level of ambition, an iterative process would need to take place with the aim of reinforcing the content of the plan(s) and respective Member State effort. Without such an early review clause and a strong governance framework no instruments would be available to ensure the full delivery of Member States toward the agreed 2030 EU energy efficiency target. Therefore, the score is set also at zero for option 1.2.

Efficiency

Efficiency considers the relationship between the resources used by an intervention and the changes generated by the intervention. At a national level, no proof could be found that a binding efficiency target takes more resources than an indicative target as the target finding procedure is assumed to be the same. However, experience with the 2020 targets on renewable energies and greenhouse gas emission shows that binding national targets generate more changes and efforts due to a stronger signal to relevant actors, such as investors and consumers, about the policy direction (national targets are achieved in almost all Member States)[169]. Price drops for some renewable technologies show that a binding renewable energy target in 2020 helped to reduce the costs. This binding policy framework was needed for renewable technologies to be able to compete with other technologies. A binding renewable target in 2020 gave investors the security that it is worth investing in renewables.

Most energy efficiency technologies are cost-efficient. However, many energy efficiency investments have a long payback period which hinders end-consumers to invest in energy efficient solutions. Households prefer a short payback period and commercial consumers usually within 1-4 years. The energy efficiency framework helped in the past years to bring down the costs of energy efficient solutions e.g. for windows. To further reduce the cost, e.g. for building insulation or efficient appliances, a secure policy framework with a binding national energy efficiency target for 2030 could help to incentivise more investments in this sector. As the generated changes are considered higher for binding national targets, option 1.1 is scored with zero, option 1.2 with zero and option 1.3 with 1.

Relevance

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[168] However, it needs to be kept in mind that a target in itself does not deliver any energy savings. Energy savings are delivered only through energy efficiency measures which reduce energy consumption reductions through technological improvements or a change of behaviour.

[169] See e.g. EEA Report No 4/2015: Trends and projections in Europe 2015.

Relevance looks at the relationship between the needs and problems in the society and the objectives of the intervention. The objective of an indicative or binding national energy efficiency target is the same, namely to reduce energy consumption. Also the relationship between the needs and problems of society which are tackled through an energy efficiency target remain the same, irrespective of the binding nature of the target. Therefore, all options are scored with 1.

Coherence

As described in the Energy Efficiency Impact Assessment 2014, an indicative energy efficiency 2030 target would accommodate the differences in the national/domestic markets and their energy efficiency potentials. Member States know their energy efficiency potential best to identify cost-efficient remaining potentials and market barriers. Member States would be also more flexible to adjust their indicative targets in case of considerable changes e.g. in the economy. It would also limit the risk of imposing too much rigidity on the overall energy and climate framework which includes also the GHG (ETS and ESD) and renewable targets. For example, a strong increase of the share of renewables could make it necessary to adjust the energy efficiency target expressed in primary energy consumption to update it due to the latest market projections. But also the national binding targets under the Effort Sharing Decision Member States might need flexibilities to achieve the cost-effective mix between the different policies.

However, too great a range of flexibility could risk coherence at EU level if changes towards the indicative energy efficiency are undertaken by Member States which would result in total in a lesser reduction of energy consumption for 2030 than the one agreed. Therefore, option 1.2 (binding EU target) with an early review clause or a 'what-if-clause' in legislation combined with the governance system would guarantee that the EU28 target would be met even with leaving enough flexibility to Member States in setting and adjusting their indicative national targets. The governance process also has the merit of increasing the economic efficiency of its implementation. In terms of economic efficiency the need to consult neighbouring Member States as part of the establishment of national plans would mean that decisions about managing energy demand and deciding on supply options would be better coordinated among Member States across the internal energy market. The same applies to option 1.1 (indicative targets) if combined with an early review clause. Therefore, both options are scored with 1.

Option 1.3 (binding national targets) is scored with zero. The reasons for this were already given in the Impact Assessment (2014)255 final: Experience with the Renewable Energy Directive shows that binding targets can be a strong driver for national action: a target at Member State level can ensure political accountability and commitment to deliver results while providing flexibility to choose and apply the most suitable tools to achieve the target[170]. On the other hand important synergies in policy making on EU level (e.g. common methodologies for establishing cost-optimal levels for building renovations) would be lost. Regarding coherence this approach would run counter to recent proposals on governance and might lead to increases in administrative cost linked to fragmented EU action and potential

170 The shared efforts between Member States would have to be devised, taking into account for example such factors as the energy efficiency potential, early action, the structure of the economy

harm to businesses operating across the internal market would limit the economic efficiency of this approach.

Subsidiarity and proportionality

The principals of subsidiarity and proportionality ensure that decisions are taken as much as possible at national, regional or local level, except in the areas that fall within its exclusive competence of the EU. Proportionality requires that any EU action should not go beyond what is necessary to achieve the objectives. Option 1.1 and 1.2 are scored with 1 because targets will be set by Member States. However, the score of option 1.3 would depend largely on the decision that will set the target. In case the targets are defined at EU level, the score of the subsidiarity and proportionality criteria would be -1. In case the national binding targets would be set at national level, the score would be 1 as well. For that reason, a score of zero is applied.

Table 26: Comparison of policy options for the character of the 2030 target

	1.1 Indicative EU and national targets with review/what-if-clause and governance system	1.2 Binding EU target with review clause/what-if-and governance system	1.3 Binding MS targets
Effectiveness	0	0	1
Efficiency	0	0	1
Relevance	1	1	1
Coherence	1	1	0
Subsidiarity and proportionality	1	1	0
SUM	**3**	**3**	**3**

Combining the different criteria assessments, no option could be identified as a preferred option. However, as described above, if option 1.1 or 1.2 is chosen, an early review clause or a 'what if' clause needs to be stipulated in the EED. If option 1.2 is chosen, the governance system will be of major importance.

5.3 Assessment of the formulation of the target

The European Council conclusions in 2014 used the same formulation while referring to the energy efficiency 2030 as the one used for the 2020 target. The 2014 Commission's Communication, however, proposed that in the framework of the governance, "[…] the Commission will explore the use of additional indicators, to express and monitor progress towards the energy efficiency target, such as energy intensity, which better take account of underlying changes in and projections for GDP and population growth". In the public consultation (see Annex 1) stakeholders also commented on the formulation of the energy efficiency target. 23% of the respondents, the biggest group after those in favour of maintain the current formulation (for the 2020 framework) asked for an energy intensity target.

The formulation of the target will be analysed below based on effectiveness, efficiency, relevance, coherence, as well as the transparency and ease of monitoring.

Policy option 2.1 (final energy savings) is discarded for the following reason: a saving target was included in the former Energy Services Directive 2006/32/EC[171] which was repealed by the EED. Such a target does not necessarily translate into an energy consumption reduction (e.g. when the economic activity level increases at the same time, due to a very cold winter or rebound effects). Therefore with a final energy saving alone there is no guarantee that energy consumption is reduced to ensure decarbonisation in 2050. Second the monitoring of achieved savings is more difficult. The achievement of the target cannot easily be monitored through official statistics. Therefore a political decision was taken in 2012 to move away from a saving target towards an energy consumption reduction objective. Also the coherence with other 2030 EU climate and energy goals might not be achieved. This is confirmed by the public consultation in which only 8% of the respondents asked for a change towards a final energy saving target for 2030.

The remaining options are 2.2 primary and final energy consumption, 2.3 either primary or final energy consumption and 2.4 primary or final energy intensity: ***Final energy consumption targets*** address energy efficiency in industry, residential, transport, services and other final sectors. Whereas ***primary energy consumption targets*** address energy efficiency in all those sectors and, in addition, also in the generation sector and energy networks. ***Energy intensity*** is defined as primary or final energy consumption divided by the gross domestic product[172].

Effectiveness

As described in SWD(2014) 255 final or primary energy consumption targets are the most straightforward options. However a reduction of energy consumption can be caused by energy efficiency measures but also because of a change in temperature (which causes a lower energy demand), a change in the economic structure, a change in the generation mix or other factors. In particular, future economic developments of the economy need to be anticipated correctly when setting long-term energy consumption targets. If growth turns out to be higher than anticipated, achieving the target will require additional energy efficiency measures, potentially making them no longer cost-effective. If on the other hand growth is lower than anticipated, the target can be met without the energy efficiency improvements that were originally envisaged and therefore some of the cost-effective potential will not be realised. From this angle, option 2.2 and 2.3 can, by construction, be defined with the aim of reaching a certain energy consumption level in 2030, **but without actually targeting the underlying causes to the changes**.

An important difference between final and primary energy consumption targets is that most of the energy efficiency measures target energy consumption reduction in end-users sectors. A final energy target would make it easier to break down the level of efforts by sub-sector (residential, industry, transport) and therefore it would become easier to monitor progress in the different sectors. However, energy efficiency measures also target the supply side which would not be covered by a final energy efficiency target only. Some Member States have put in place several measures to increase the efficiency of their power plants which would not be

[171] The energy efficiency target of the Energy Service Directive 2006/32/EC was based on proving 9% end use energy savings in 9 years against the average of a five year base period.
[172] To monitor trends, GDP is in constant prices to avoid the impact of inflation.

counted then. Therefore, it was decided on a political level in 2012 that the EED should contain both targets, a final and primary energy consumption target for EU28.

According to Article 2 of the EED '*energy efficiency*' means the ratio of output of performance, service, goods or energy, to input of energy and '*energy efficiency improvement*' means an increase in energy efficiency as a result of technological, behavioural and/or economic changes. This means that also economic changes, e.g. a switch from energy intensive industries towards a more service oriented economy, count towards the energy efficiency target in case the target is defined for the whole economy and not per each sector. Economic cycles should not, however, be counted. Decrease of energy consumption due to an economic crisis is taken into account under option 2.2 and 2.3 even if this is not related to a technical energy efficiency improvement and this represents a weakness of these metrics.

When setting absolute energy consumption targets using the PRIMES or any other partial equilibrium energy model **economic developments, changes in economic structure, changes in the energy mix etc. until 2030 and beyond are taken into account**. This **ensures that e.g. economic growth is not supressed when setting the energy efficiency headline targets**. However, if the one of the factors is projected wrongly this would lead to an overly stringent or overly lax 2030 energy efficiency target if it is formulated as an absolute energy consumption target. Therefore, these options are given a score of zero.

The risk of setting an energy efficiency target not in line with the real economic developments would be lower under option 2.4 (energy intensity indicator). Energy intensity indicators account for economic cycles. The main reason for observing closely this indicator is that historically, economic growth led to higher energy consumption. In the future, higher consumption of energy due to economic growth is to be expected. What the energy efficiency policies aim at is not to cap the absolute amount of energy consumed in a manner that could turn out to be prohibitive in times of high economic growth or a very lax target in times of economic slowdown. Instead, energy should be used in a more efficient way (i.e. using less energy per unit of economic output). This indicator identifies to what extent there is decoupling between energy consumption and economic growth. While economic growth assumptions are likely to be different from the real-life trend, the following situations can be envisaged: If 1) in 2030 the economic growth is smaller than assumed in current PRIMES runs, the energy intensity ratios will have a smaller denominator. In order to meet the target the energy consumption will have to be smaller as well (reflecting that some part of energy consumption reduction will happen automatically due to reduction in activity) but if 2) conversely, economic growth is bigger than assumed in PRIMES, the energy intensity ratios will have a higher denominator. In order to meet the target the energy consumption can be bigger as well (reflecting that some increase in energy consumption will happen due to an increase in activity). However, when setting an intensity target there is also the risk that the numerator is projected wrongly (as for options 2.2 and 2.3). Nevertheless, as energy intensity accounts better for changes in economy, this option is scored with 1.

Efficiency

Efficiency considers the relationship between the resources used by an intervention and the changes generated by the intervention. No evidence could be found that the different options require different resources. However, regarding the changes generated, option 2.2 (primary **and** final energy consumption target) will be more efficient as the concept of having a target expressed in primary and final energy consumption incentivises **changes in all sectors**. The same applies to option 2.4, if expressed in final **and** primary energy intensity. Whereas option

2.3 will generate changes if expressed in final energy consumption in in industry, residential, transport, services and other final sectors only but not in the generation sector and energy networks. Member States could achieve their target without generating any savings in the final energy consumption sectors (e.g. in buildings) if the target is expressed in primary energy consumption only. Member States could e.g. focus on a shift towards more renewable energies only, instead of aiming for energy efficient housing. Therefore options 2.2 and 2.4 will be scored with 1, and option 2.3 with -1.

Relevance

Relevance looks at the relationship between the needs and problems in society and the objectives of the intervention. High energy bills and energy poverty are a major problem in many Member States, With 11% of European citizen unable to keep their houses warm in the winter. Companies also suffer from high energy bills due to competitive disadvantages, in particular energy intensive industries (large and small) but also in the service sector. Therefore, energy efficiency policies should in particular target end consumer sectors to improve their situation. Option 2.2 which include a final energy consumption target is therefore scored with 1, whereas option 2.3 is scored with 0 which would only include one of the two targets only and would not cover all relevant sectors (in case of a final energy efficiency consumption target the generation sector and energy networks would not be covered where also huge energy efficiency potentials exist).

The relevance of a final and primary energy intensity target is not obvious for all sectors as energy consumption is not always closely linked to the development of the economy in some sectors. The **correlation between energy consumption and economic growth is low in the residential, services, passenger transport and generation sector**. However, **energy consumption is highly correlated with economic developments in industry and freight transport**. An analysis of these correlations is included in Annex IV of SWD(2014)255. However, even if both indicators are considered, option 2.4 is scored with zero only, as the correlation with economic growth is not given for all sectors covered by both indicators.

Coherence

All options are in line with the other climate and energy 2030 targets, namely the RES and GHG targets. Policies targeting those two areas will also contribute towards energy efficiency (see Annex 4). In terms of coherence with other targets, all options are scored with 1.

Transparency and monitoring

The administrative costs for all policy options can be estimated to be low or even close to zero as these targets can be monitored through official statistics (primary energy consumption, final energy consumption, energy intensity) which are readily available at national level and from Eurostat.

The contribution of each Member State is difficult to measure if the targets are expressed at EU level as a primary or final energy intensity target. For stakeholders and citizens it is more difficult to understand what a Member State needs to contribute to the EU level and if a Member State is on track to achieve its own target. Therefore, options 2.2 and 2.3 are scored with one, whereas option 2.4 is scored with zero.

Table 27: Comparison of policy options for the nature of the 2030 target

	2.2. Primary **and** final	2.3 **Either** primary **or**	2.4. Primary and final

	energy consumption	final energy consumption	energy intensity
Effectiveness	0	0	1
Efficiency	1	-1	1
Relevance	1	0	0
Coherence	1	1	1
Transparency and monitoring	1	1	0
SUM	**4**	**1**	**3**

Source: DG ENER assessment

In the public consultation 31% of respondents expressed the view that the new EU energy efficiency target for 2030 should be expressed in both primary and final energy consumption in 2030, followed by energy intensity (23%), and primary energy consumption in 2030 only (10%). 'Other' included a wide range of different proposals.

In the past, the 2020 energy efficiency targets were set based on energy consumption projections using the energy model PRIMES. For these energy consumption projections for 2020, different assumptions had to be made regarding economic growth and other factors. These EU Reference scenario projections are updated on a regular basis taking into account the latest policy developments and other economic trends[173]. However, the 2020 targets still refer to the projections made in 2007 which assumed a high economic growth and an increase of energy consumption in the long term. However, the latest reference projections in 2013 and 2016 show that the energy consumption projection will drop considerably by 2020 and 2030 due to energy efficiency measures, economic changes and other factors (see

[173] See Annex 4 for the description of the latest update in 2016 on the EU reference scenario.

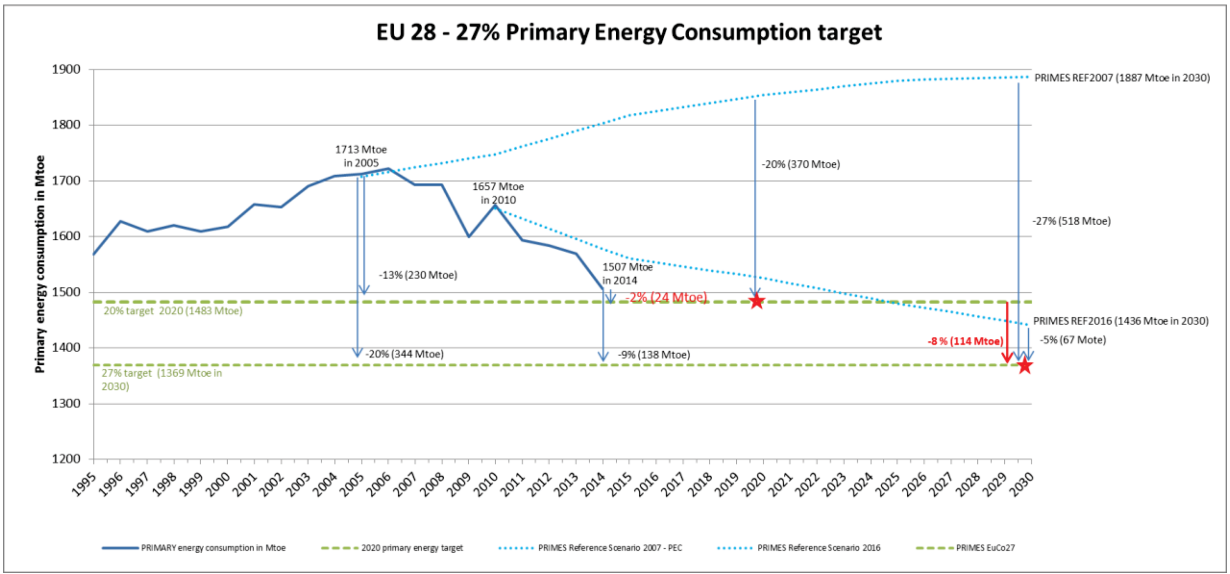
Figure 5).

The EU Reference projections 2007 projected a primary energy consumption in 2030 to be 1887 Mtoe of primary energy consumption and 1416 Mtoe of final energy consumption[174]. However, the new REF2016 projects a primary energy consumption of 1451 Mtoe and a final energy consumption of 1082 Mtoe in 2030 only. The figure below visualises the differences between the EU reference projections performed in 2007 and 2016. The latest projections take into account the implementation of the EED but also the impacts of the economic crises from 2009/2010, changes in economic structure, changes in fuel prices etc.[175].

[174] In PRIMES 2007 the primary energy consumption in 2020 was projected to be 1854 Mtoe of primary energy consumption and 1357 Mtoe of final energy consumption.

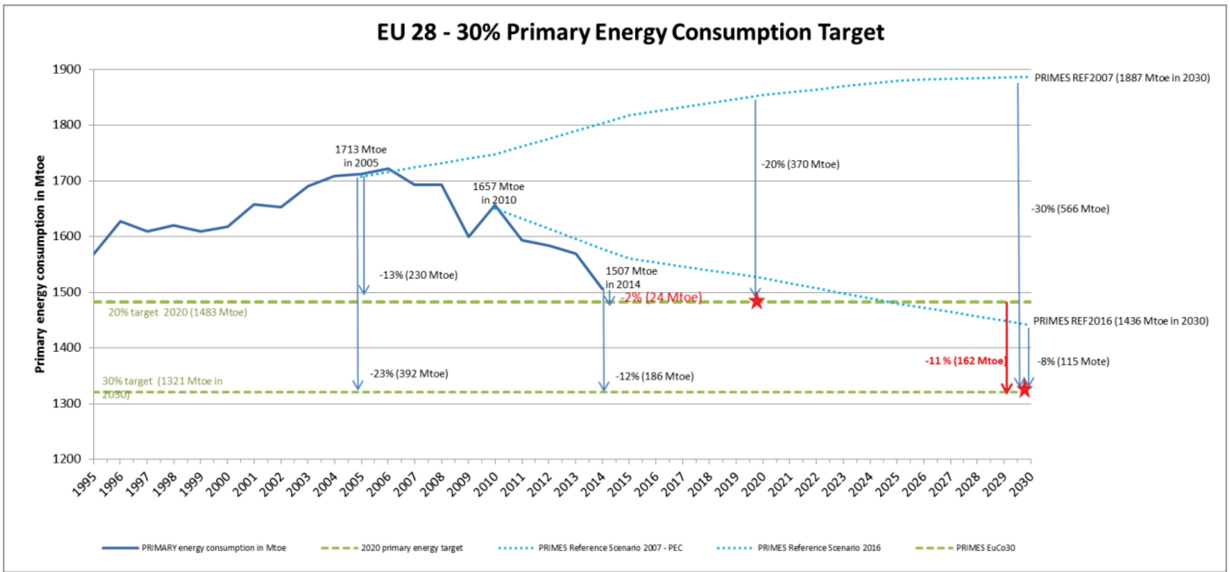
[175] Please, see further details in Annex 4.

Figure 5: 27% Primary energy consumption target



Source: PRIMES and Eurostat

Figure 6: 30% Primary energy consumption target



Source: PRIMES and Eurostat

For stakeholders and European citizens, it is difficult to understand how the energy efficiency targets are set. A definition of energy efficiency targets against an outdated projection made in 2007 can cause confusion and makes it difficult to assess the progress towards these targets.

The other energy and climate targets for 2020 and 2030 are based on historic levels of GHG emissions or can be easily related to historical years, as in the case of RES. Possible targets assessed with EU Reference projections should be translated into energy efficiency improvements or energy reduction targets compared to 2005 levels. Therefore, the Commission proposes to translate the defined energy reduction target into a reduction target compared to **2005 as the reference year for energy efficiency** for consistency reasons with the other climate and energy targets. This should be done for the 2030 energy efficiency target expressed in both final and primary energy consumption as this would increase the transparency of the target setting and facilitates the assessment of the targets.

Table 28: Alternative formulation of the targets – PEC in 2030 compared to 2005 levels

	REF2016	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Change in primary energy consumption compared to 2005 levels (1713 Mtoe in 2005) (% change)	-16	-20	-23	-26	-29	-34

Source: PRIMES and Eurostat

5.4 Impacts of policy options for Article 7

This chapter assesses specific impacts of the policy options of Article 7. It is based on a bottom-up engineering approach for estimating levels of energy savings in view of the 2030 framework[176].

5.4.1 Impacts of option 1: No action at EU level – continue with guidance on regulatory framework and work of enforcement until 2020

Reduction of energy consumption

The analysis shows that the impact of Article 7 will not cease after 2020 due to long lifetimes of some of the measures notified by Member States, e.g. renovation of building envelope or certain elements of the building, installation of technical building systems (see more detail in Annex 6).

As the Commission does not have information on post-2020 saving levels of Member States in the absence of EU regulatory intervention, it is assumed that no new savings will be generated even though it is likely that some Member States will continue putting in place measures also without Article 7[177].

In the EU Reference scenario it is assumed that Article 7 obligations end in 2020 and therefore does not trigger any new savings post 2020. Given that savings stemming from energy efficiency measures under Article 7 implemented before 2020 cannot be precisely quantified, the bottom-up engineering calculation was used[178]. The annual energy savings are estimated to reach 61 Mtoe in 2020 due the policy implemented during the 2014-2020 period. From 2020 onwards, the annual energy savings from Article 7 will decline, as this policy will no longer be a stimulus for triggering 'new' savings each year. It is estimated that some 49

[176] There is a range of economic, social and environmental impacts thanks to the measures implemented under Article 7. These Article impacts constitute a fraction of the overall energy consumption reduction impacts which were analysed in the chapter 5.1 for the different energy efficiency target level. The respective impacts of Article 7 measures are difficult to quantify for due to the recent implementation of energy efficiency obligation schemes under Article 7 in Member States. Nevertheless, impacts of Article 7 were quantified where possible.

[177] Most probably those Member States with a long history of EEOSs, which have become already a part of their national economic model – will continue with energy saving measures beyond 2020.

[178] As recognised by Ricardo AEA/ CE Delft in its study on evaluating the implementation of Article 7, this figure is based on engineering bottom-up modelling on basis of the notified savings and does not take into account the reality check.

Mtoe savings will continue to be delivered in 2030 as a result of the long term measures introduced in the 2014-2020 period[179].

Administrative burden

With the expiry of the savings obligation under Article 7, there would be no reporting requirements for this policy post 2020. This would reduce the administrative burden to some extent. The reporting of progress in view of the achievement of the 2030 energy efficiency target would continue under the new governance instrument only. To this end, even though the administrative burden would be taken away just for one provision of the EED, it would not liberate the Member States from the overall reporting on tracking progress towards the achievement of the 2030 energy efficiency target.

However, the benefit from a reduced administrative burden would be low compared to the missed opportunities associated with the link of Article 7 with other energy efficiency policies. Article 7 is a cross-cutting policy which has links with other legislation including the EPBD and Ecodesign. It works as a pull-mechanism (e.g. for the EPBD) and triggers investments for renovation of buildings stemming from the obligation to achieve new savings each year.

5.4.2 Impacts of option 2: Extend Article 7 to 2030

In this chapter the impacts of the extension of Article 7 are compared with the impacts of policy option 1 – baseline scenario.

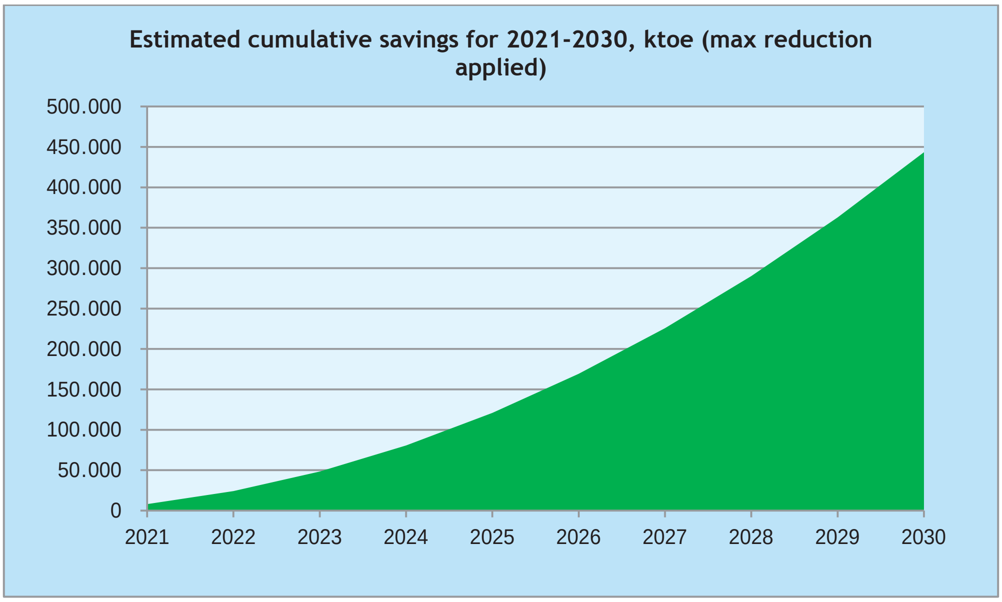
Reduction of energy consumption

The extension of Article 7 to 2030 will allow securing, on a purely engineering calculation, a maximum of 81 Mtoe[180] of new savings in 2030 (see

[179] In addition, there is a need to factor in potential overlaps between the different policies and also the rebound effect which is not reflected in these estimations.
[180] Description of the calculation of the amount of savings is provided in Annex 6.

Figure 7) on the basis of the same 1.5 % savings rate per year. In cumulative terms these savings are estimated to amount to 443 Mtoe by 2030 (for the whole period 2021 – 2030). This figure needs, however, to be adjusted to take into account overlaps with other policy measures also contributing to the energy efficiency target, and rebound effects (see Annex 6). This is a conservative estimate based on PRIMES reference scenario 2016 on how final energy consumption would evolve over the next years. In reality Member States might have higher reduction levels in final energy consumption which would thus result in lower amount of energy savings required by 2030.

Figure 7: Estimated amount of energy savings (ktoe), engineering calculation, with 1.5% rate[181]



Source: Ricardo AEA/CE Delft (2016)

As mentioned above under option 1, some of the energy saving measures (e.g. roof insulation) put in place by the Member States in the 2014-2020 period have long lifetimes and will continue to deliver energy savings after 2020. As pointed out under policy option 1, the effect of these long term savings will diminish with time and it is difficult to quantify it precisely for 2021-2030[182]. The effect of these savings has been estimated to amount to 49 Mtoe in 2030. Any contribution from measures that have already been put in place will be a useful, additional contribution towards the achievement of the 2030 target into addition of the new energy savings generated during the period 2021-2020. It should be noted that savings obtained after 2020 may not count towards the Member State's current savings requirement for 2014-2020.

Analysis of the current period shows that Article 7 has triggered the implementation of energy efficiency obligation schemes (EEOS) in many Member States. In the past, this has proven to be an effective tool for energy savings. Sixteen countries have notified EEOSs[183], an increase from five EEOSs which existed before the introduction of Article 7. The extension of the period would confirm the new schemes, consolidate the learning effects of the implementing public authorities and obligated parties and ensure that they would continue to deliver. The notified cumulative savings under EEOSs amount to 86 Mtoe by 2020. This represents 34% of the total savings to be achieved under Article 7 by 2020. The evaluation also suggests that 19 % or 49 Mtoe of the savings are triggered by the financing schemes or incentives. This

[181] Calculation is based on the projected final energy consumption averaged over 2015-2020 (2016 PRIMES reference scenario).

[182] As recognised by Ricardo AEA/ CE Delft in its study on evaluating the implementation of Article 7 this figure is based on engineering bottom-up modelling described in Annex 6, and does not take into account the reality check.

[183] This figure is subject to changes as one Member State will replace the EEOS by alternative measures, while some Member States are considering introducing an EEO scheme in addition to the alternative measures; and in four Member States the scheme is not operational yet.

shows the important role of Article 7 as a "financing instrument", which *inter alia* contributes to the increase of the renovation rates.

The effect on energy demand depends also on the application of the flexibilities (excluding sales in transport) and exemptions under Article 7(2) which have a direct impact on the national savings contributions and were used by Member States to the large extent in the current obligation period 2014-2020 (analysed in Annex 6).

Economic impacts

Energy efficiency policy in general provides macroeconomic benefits in the form of GDP growth and indirect and induced jobs. In addition, consumers can reduce their energy bills, and invest the savings in goods and services which creates additional jobs as described in chapter 5.1.1.5[184]. It is estimated that the extension of Article 7 to 2030 would contribute with extra savings to the macro-economic benefits. Article 7 is one of the policies that are needed to achieve energy efficiency levels above the EU Reference Scenarios.

Costs and benefits

Because Article 7 is new, there is limited data on the costs and benefits of most of the measures which Member States have selected to implement Article 7[185]. Better data are available on energy efficiency obligation systems because some Member States had introduced monitoring schemes already before Article 7 was enacted under the EED[186]. Member States always have the choice to use either energy efficiency obligations or – where they find them more cost-effective - alternative measures. Therefore, an assessment of the cost-effectiveness of energy efficiency obligation schemes is a good basis for assessing the cost-effectiveness of Article 7 as a whole.

Studies show that obligated companies pay from 0.4 eurocents in France to 1.1 eurocents respectively per kWh of energy saved through energy efficiency obligations in selected Member States[187]. For other Member States these are similar – 0.5 eurocents/kWh in Denmark, 0.7 eurocents/kWh in Italy and 0.5 eurocents/kWh in Austria. So is the weighted cost of supplying energy to the sectors covered by the obligations – 13 eurocents/kWh in Denmark, 9 eurocents/kWh in Italy and 8 eurocents/kWh in Austria (see Table 29). Overall, the European energy efficiency obligations seem to represent a good level of cost-effectiveness as compared to the cost of supplying energy as shown in the table below.

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184 These 'ripple effects' of capital expenditure can be estimated using multipliers along the whole supply chain. An illustration of this effect can be found in a recent paper assessing investment in building fabric insulation. See Rosenow, J., Platt, R., Demurtas, A. (2014): Fiscal impacts of energy efficiency programmes - the example of solid wall insulation investment in the UK. Energy Policy 74, pp. 610-620.

185 Start of the obligation period was on 1 January 2014.

186 Assessed Member States are: Austria, Denmark, France, Italy and the United Kingdom.

187 Including administrative costs, which are estimated at 0.2%-1.4% of the costs for the obliged companies.

Table 29: Comparison of costs of EEOSs across selected countries (unit cost of saved energy)

	Time period	Weighted average EEOS cost of lifetime energy savings (Eurocent / kWh)[188]	Weighted average retail prices of comparable energy supply for relevant sectors (Eurocent / kWh)
UK	2008-2012	1.1	10
Denmark	2015	0.5	13
France	2011-2013	0.4	9
Italy	2014	0.7	9
Austria	2015	0.5	8
Vermont, U.S.	2012-2014	3.2*	11.57
California, U.S.[189]	2009-2011**	2.1	12.24

Source: Regulatory Assistance Project

** Includes both electricity and natural gas and fuel oil savings; may not fully account for longer-lifetimes of non-electricity savings measures.*

*** Data for a different set of years; the cost to the energy companies not available for the 2010-2012 period.*

Looking at the costs and benefits of Article 7 from a narrow 'private cost' perspective, as well as from a societal cost perspective, it could be concluded that the programme leverages additional investment attaining the societal costs by consumers on average 2-3 times the cost to the obligated parties. For example, the societal costs in the United States reach to 2.4 billion Euro per year for the programme that costs utilities 1 billion€ per year. In Europe, the leverage effect is a bit lower and range from 1.4 to 2 times of the investment cost to the obligated parties. Recent studies show that the proportion of the investment costs paid by the obligated companies is in France is 72% and in the UK 69%. In other Member States the share is even lower[190]. The complete data including both energy company costs and contributions from the beneficiaries are available only for the British and French EEOS and are shown in Table 30[191].

188 The figures for the U.S. are generally higher because costs in the US are generally higher than those in the EU due to: shorter measure life assumptions, more 'aggressive' or 'deeper' savings, also targeting energy poverty which is more costly; costs are levelised whereas in the EU not all countries discount energy savings, the higher depth of savings than in most of the EU examples.

189 https://emp.lbl.gov/sites/all/files/cse-report-summary-overview-presentation_0.pdf

190 Rosenow, J., Bayer, E. (2016): Costs and benefits of the Energy Efficiency Obligation Schemes. Regulatory Assistance Project (data are for 2008-12 (UK), 2015 (Denmark), 2011-13 (France), 2014 (Italy) and 2015 (Austria)). The share of the private cost contributed by the consumers depend on the design and objectives of the programme. In the UK, the average annual cost for the period of 2005 to 2008 was 1.97 Bn €; but for 2008-2012 this figure was 1.51 Bn € for the household sector, as the programme also covered the cost accrued to energy poor households and vulnerable consumers. In Denmark the share paid by the obligated parties was much lower and reached 30% in industry sector.

191 Rohde C. Rosenow J. Eyre N. (2014) Energy Saving Obligations. Cutting the Goardian Knot of leverage (2).pdf.

Table 30: British and French energy efficiency obligation schemes [192]

	Energy efficiency investments: annual cost to energy companies (€ billion)	Energy efficiency investments:, overall annual cost for society including to consumers (€ billion)	Energy savings per year (ktoe)
UK	1.05	1.51	237
France	0.39	0.54	377

Source: Regulatory Assistance Project

As regards alternative measures put in place by Member States it could be concluded that public funding attracts additional private investment for energy efficiency through the different financing and fiscal instruments and which in turn allows achieving certain level of leverage in the implementation of energy efficiency projects. The level of leverage of private investment though differs from country to country. For example, in Germany one of the KfW programmes designed for energy efficiency renovations attracted 19.4 billion€ (i.e. 78 %) in private investment of the total annual investment of 25 billion €, while in Lithuania the share of private investment for the Renovation programme of the multi-apartment buildings was considerably lower and reached around 37 % in private investment (55 million € in private funding per year in addition to 145 million € of public investment). The total annual investment for the tax incentive in Ireland "Accelerated Capital Allowance" reached 10.6 million Euro where 9.5 million € of private investment per year was attracted in addition to 1.1 million € of public investment through the tax incentive[193].

Costs have decreased over time in the established schemes, thanks to the expertise gained by the obligated parties and improved quality of installation of the measures[194] and thanks to innovative financing models such as white certificate trading. Evidence shows that costs to the energy companies vary significantly depending on the country ranging from 185 million € per year in Denmark to more than 1 billion €o per year in the UK[195], depending on the size of the scheme and the target to be achieved, and also on the specific actions financed through the EEOS. The obligated parties usually pass on to their customers the costs of achieving the savings obligation through increased energy bills; however, this may vary (e.g. in fully liberalised markets obligated parties can pass on the costs at their own discretion and may spread the cost unevenly across customers). On the other hand, customers benefit from the energy efficiency improvement measures undertaken by the obligated parties in the form of reduced energy consumption and reduced energy bill.

Article 7 could also have a distributional effect. Consumers with higher incomes are most likely to take up opportunities offered by the EEOSs because they can afford to contribute to the investment. On the other hand, the availability of the financing contribution and the willingness of utilities (i.e. obligated parties) to take over the burden to organise the

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192 Energy savings indicated are relevant for the household sector in the UK covering 2008-2012; in France, energy savings are depicted for all sectors covering 2011-2013.

193 The level of private investment and number of projects is calculated as average of investment/projects in ACA equipment by companies between 2009 -2012.

194 eceee (2012) Briefing for DG Energy, EU Experience of Energy Efficiency Obligations/White Certificates & their Importance in Meeting Climate Change Challenges.

195 Rosenow, J., Bayer, E. (2016): Costs and benefits of Energy Efficiency Obligation Schemes. Regulatory Assistance Project.

installation of the energy efficiency measures could trigger investment decisions among lower income groups.

If Member States are concerned about the distribution effect they can address it through the design of the scheme to ensure that the measures reach energy poor households as priority. This is already done by some Member States (e.g. Ireland and the UK). The reduced energy demand as a result of the energy saving actions under the EEOS will contribute to lower energy prices (see chapter 5.1.1.4) and to some extent offsetting the costs of the EEOS. In particular, lower energy prices would be beneficial for all consumers. Social aspects are analysed from a broader energy efficiency perspective in chapter 5.1.4.

Since all Member States already have Article 7 measures in place[196], no additional budgetary consequences for the public authorities of Member States might be expected if the same intensity of 1.5% per year is retained for the new period 2021-2030. For example, the final evaluation of the obligation period 2008-2012 for the Carbon Emissions Reduction Target (CERT)[197] in the UK provides data on the cost of the EEOSs to the obligated energy suppliers. It shows that the average costs per year to the energy companies were significantly (33%) lower than originally estimated in the impact assessment. This is in line with historical precedence as through innovative delivery and economies of scale, energy savings are consistently delivered by energy suppliers cheaper than anticipated.

There is limited evidence for alternative measures due to the recent implementation, and therefore it is difficult concluding about the cost consequences specifically related to Article 7 implementation. According to the evaluation it could be expected that the costs to public authorities carrying out the alternative measures will depend on the type of measure and the savings level to be achieved, only the source of financing will differ and how the costs are recovered[198].

As indicated above, it is also likely that a positive impact will continue to take place for the **energy poor** as this is already being addressed by some Member States under Article 7 (Austria, France, Ireland and the United Kingdom). Ireland has set a binding sub-target for suppliers that 5% of savings should be achieved in energy poor households. The UK also decided to achieve a certain amount of savings in low income areas and vulnerable households[199]. In this regard, UK provisional figures provided in the recently submitted EED Annual Report show that by the end of January 2016 there were 1.7 million measures installed under its ECO[200].

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196 At the time of drafting this report, some Member States have notified changes as regards the measures they intend to use for achieving savings under Article 7.

197 Ipsos MORI, CAG Consultants, University College London and Energy Saving Trust (2014).

198 SWD(2016) Evaluation EED article 7

199 Of these, around 978 000 measures were installed in 767 000 low income and vulnerable households, or households in specified low income areas. Measures installed included: cavity wall insulation (37 %), loft insulation (26 %), and boiler upgrades (21 %).

200 Energy Company Obligation, introduced in January 2013. Under ECO, energy suppliers are obligated to achieve carbon saving targets in the domestic sector and energy bills reductions in low income and vulnerable households. See https://ec.europa.eu/energy/sites/ener/files/documents/UK%202016%20Energy%20Efficiency%20Annual%20Report_en.pdf.

Administrative burden and compliance costs

It is not expected that the extension of the obligation period under Article 7 as such would result in additional administrative burden and compliance costs for Member States as no new obligations or additional reporting would be required from the Member States.

Indeed it is very likely that thanks to the new integrated governance system in view of the 2030 framework[201] administrative burden associated with reporting and monitoring obligations could be reduced. Expertise gained in administering the obligation schemes and alternative measures could also contribute to this. The evaluation report shows that administrative and compliance costs related to monitoring and verification of energy savings, are relatively low for energy efficiency obligation schemes. They currently range from 0.2-1.4% of the programme cost (see table below) but this depends on the specific scheme in question. The extension of Article 7 would imply a continuation of the recurrent compliance costs, i.e. the monitoring and verification of the savings created as well as the reporting of those to the Commission.

Although certain reporting requirements under Article 7 and Article 24(1) may be assumed to pose additional administrative burden to Member States, the stakeholders' replies to the public consultation of the EED revealed that monitoring is an effective and efficient way to track progress of achieved savings on an annual basis. The flexibility given by this policy in terms of measures pursued and calculation methodology applied should be balanced with robust monitoring and verification mechanisms which require reporting by Member States (including participating parties at national/regional level depending on the programme).

Administrative and compliance costs have a negligible effect on consumer energy bills compared to the cost consumers need to pay for the supplied energy including charges and levies associated with supply. The EEOS create almost no extra costs for governments as they are financed through energy prices or grid charges, or - if certificate trading is part of the scheme - by a charge per certificate issued.

[201] The governance framework in view of the 2030 framework intends to streamline and simplify the existing planning and reporting energy and climate obligations.

Table 31: Annual company cost and compliance cost of EEOSs[202]

	Time period	Energy company costs (million Euro/ year)	Energy company costs (Euro/ capita/ year)*	Administrative costs (% of overall program costs)
UK	2008-2012	1,052	16	0.2%
Denmark	2015	185	33	0.3%
France	2011-2013	390	6	0.4%
Italy	2014	700	12	1.4%
Austria	2015	95	11	not available
Vermont	2012-2014	39	62	<0.3%**
California	2010-2012	742[203]	19	not available

Source: Regulatory Assistance Project

** shown on per capita basis solely for the purpose of allowing for comparison; this does not indicate the amount of money paid by individuals.*

*** This is an estimate, based on the monitoring and evaluation expense of the Vermont Department of Public Service as a percentage of total operating expenses for state-wide energy efficiency programmes.*

Other impacts

The extension of Article 7 to 2030 would send a positive signal to investors and the energy market in general which in turn would have a positive impact on the uptake of innovative technologies, techniques and services, as it will stimulate demand for energy efficiency improvement measures. Greater demand for energy efficiency improvement measures is likely to positively stimulate the **energy services market** and also the manufacturing of energy efficient products. Competition in the markets is therefore likely to somewhat increase in the long term. This could reduce prices for products and services offered and encourage enterprises to innovate and develop more energy efficient products.

At least half of the Member States use some sort of IT tool for monitoring and verification of reported savings which allows them to effectively address the risk of double counting and which increases the efficiency in processing the data and reduces the cost due to the growing demand for these technologies. It is expected that further uptake of **digitalisation** related to the implementation of the energy efficiency measures could take place post 2020.

The extension of Article 7 would continue to have a positive impact on the further development of **innovative business models** – notably energy performance contracting especially due to the greater uptake of EEOS whereby energy suppliers very often make use of energy services companies (ESCOs) as third parties[204]. Some Member States, for example France and Italy, have put in place White Certificate Schemes enabling bidding for the best market price for white certificates issued following the installation of energy efficiency improvement actions. Evidence from these schemes suggests that trading systems have helped

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202 The obligated parties in most of the cases pass on to their customers the costs of achieving the savings obligation.

203 Total program expenditure over 3 years ($2.5 billion) / 3, converted into Euros. Source: CPUC 2015 report on IOU programs, http://switchboard.nrdc.org/blogs/lettenson/2015-03_10-12%20EM%26V%20Report_CPUC.pdf.

204 RAP (2012): Best practices in designing the EEOSs.

aggregating investments for small projects, creating new business models, especially energy performance contracting and ESCOs which are often SMEs. In Italy, for example, 967 ESCOs have been actively involved in the White Certificate scheme to install energy efficiency measures as of 2015[205]. ESCO activities range from heating/cooling solutions to energy services for buildings and industry. The energy services market in Europe is undergoing changes that are stimulating growth, with a corresponding increase in the revenues of ESCOs; these changes, are achieving sales for products and services in the billions of euros range. This is happening for example in France where the growth in the energy services market is also expected at annual rates of 3% to 4%[206].

This in turn has a positive spill over effect on the growth of **small and medium enterprises (SMEs)** due to the higher demand for these services which is likely to grow even further. Studies show that SMEs are key actors for upscaling energy efficiency[207]. Especially in households 70% of these measures are carried out by SMEs[208].

5.4.3 Impacts of option 3: Extend Article 7 to 2030; simplify and update

All impacts related to the extension of Article 7 that are assessed under option 2 remain valid for option 3. This chapter will analyse the impacts of a simplification of what savings can be counted and the consideration of renewable energy produced by buildings for own use.

Reduction of energy consumption

The simplification proposed under **sub-option 3.a** on what can be counted under Article 7 will not change the impact in terms of end use energy savings to be achieved in 2030. However, it will facilitate the achievement of the expected savings (81 Mtoe in 2030 as referred to in chapter 5.4.2) as the requirement of what can be counted under the EPBD will be fully relaxed by allowing taking full credit of savings from the energy efficient renovation of buildings.

Analysis on impact on energy consumption is carried out for the **sub-option 3.b** that considers allowing on-building renewables under the Article 7 savings requirement for the new period 2021-2030.

According to the assessment of the notified cumulative savings by Member States under Article 7 to be achieved by 2020, at least 3% (8.5 Mtoe) of the expected savings could be associated with renewable energy in buildings as the primary action. This number might be slightly higher (5%) for measures targeting multiple actions, for example under the EEOSs in France, Italy and the UK. In addition, it could be assumed that some 25% of the cumulative energy savings notified (62.5Mtoe) are to be generated from actions that are partially linked to the renewable energy installation in buildings (for example, installation of heat pumps or solar

205 http://www.gse.it/it/CertificatiBianchi/Pages/default.aspx.
206 IEA Energy efficiency market report, 2015.
207 JRC European ESCO Market report 2013.
208 International Union of property Owners (UIPI).

thermal collectors as part of measures targeting the renovation of the heating system of the building)[209].

Studies show that around 63 Mtoe of thermal energy and around 9 Mtoe of electricity would be generated by buildings in 2020 (2 Mtoe of electricity will be self-consumed by the buildings, the rest being fed into the grid)[210].

Renewables will help reduce the energy dependence on imported fossil fuels and mitigate the carbon emissions, which is in line with the Energy Union strategy and the 2050 Energy Roadmap. Recent data[211] demonstrate that around 380 Mt CO_2 emissions have been avoided in 2014 as a result of the use of renewable energy[212], which is comparable with the annual emissions of Poland.

Recent estimates suggest that renewables used for producing energy at building level will increase in parallel with other renewable generation, driven by substantial cost-reduction and an enabling framework, which already today allows these technologies to compete with fossil fuel technologies[213]. Estimates[214] of overall cost of support per kWh generated in the EU-28 (see Table 32) shows that certain renewable technologies have benefitted from variable range of support, sometimes higher (for solar PV), and sometimes lower (heat pumps) than the cost of energy efficiency measures which ranges between 0.4 – 1.1 Eurocent/ kWh saved energy for some EU Member States having an EEOS (see above). Therefore, it is likely that some renewable technologies would be able to compete with energy efficiency measures targeting energy efficiency in buildings, if allowed under Article 7.

Table 32: Overall cost per kWh generated per RES technology[215]

Total cost of deploying RES (€ct/kWh)	2008	2009	2010	2011	2012	2008-2012
Solar	46	46	41	32	22	**31**
Heat pumps	0.081	0.052	0.047	0.014	0.000	**0.03**

Source: Commission services' estimate

Cost reduction is observed for efficient technical building systems (such as solar technologies or geothermal heat pumps) which are getting cheaper and more effective every day (see Figure 8 and Figure 9).

209 Only limited information is available to the Commission on the specific actions to calculate the exact amount.

210 Interim results of the Study on on Renewable Energy Progress, based on PRIMES EUCO27 and EUCO30 scenarios, 2016, Öko Institut.

211 EEA Report (2016): http://www.eea.europa.eu/publications/renewable-energy-in-europe-2016.

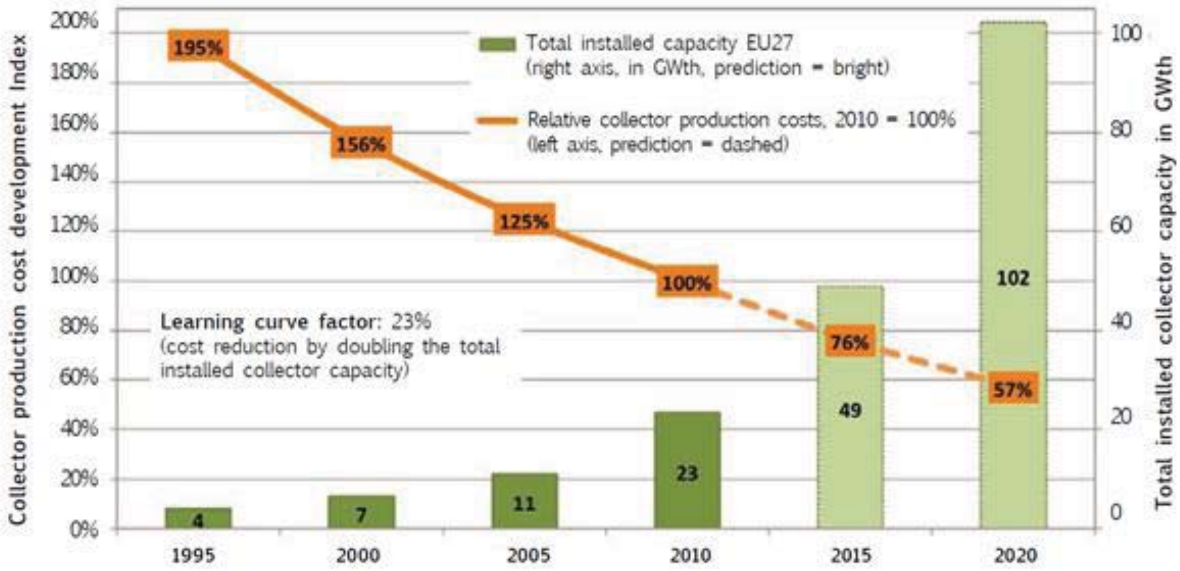
212 Fossil fuels use has also been reduced by an estimated 114 Mtoe (megaton oil-equivalent) the same year, comparable to the fossil fuel consumption of France.

213 Interim results of the Study, on Renewable Energy Progress, based on PRIMES EUCO27 and EUCO30 scenarios, 2016. Öko Institut.

214 Based on the total energy generated divided by the overall support (investment and operational) every year. It is not discounted and doesn't take into account the lifetime of the installation. Based on interim results of the Study on Subsidies and costs of energy, European Commission (2014) and Öko-Institut, aggregated from Eurostat SHARES 2014.

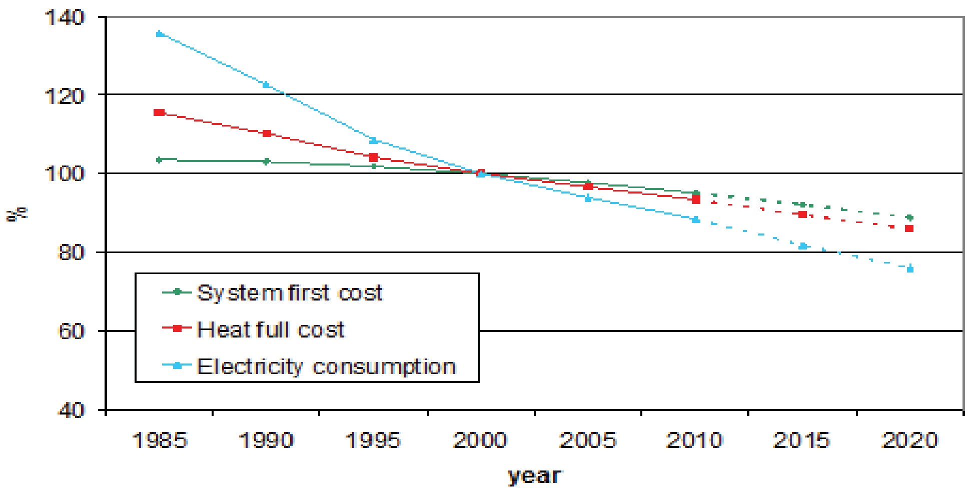
215 Costs are not discounted and do not take into account the lifetime of the installation.

Figure 8: Costs for high-efficient flat plate solar collector panel (of about 2.2 to 2.5 m² gross collector area) manufactured in Europe[216]



Source: Solrico & Trenkner consulting

Figure 9: Development of geothermal heat pump system first cost, heat full cost, and electricity consumption of geothermal heat pump systems in the residential sector in Central Europe (Germany, Austria, Switzerland, Luxembourg)



Source: European Technology Platform on Renewable Heating and Cooling, "Strategic Research and Innovation Agenda for Renewable Heating & Cooling")

In the U.S. eight States have experience with the integrated approach of energy efficiency and renewable obligations, called 'renewables portfolio standards' (RPS)[217]. They allow energy

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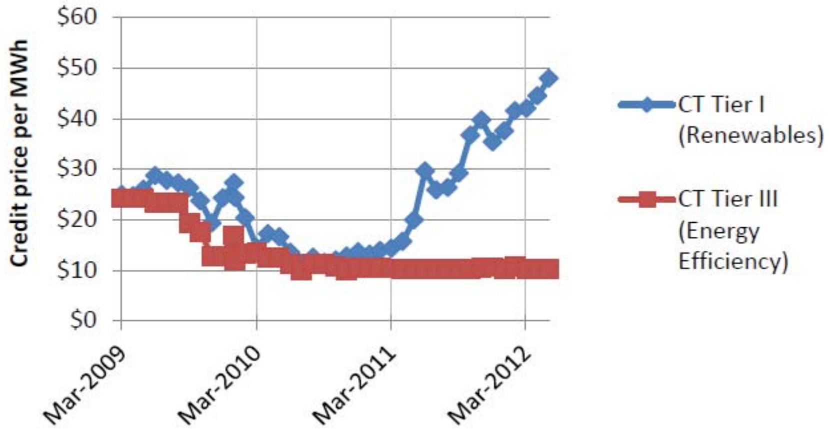
[216] Based on a learning factor of 23%, derived from these historical data, cost reduction projections are calculated up to 2020 based on market expectations of the National Renewable Energy Action Plans (NREAPs).

[217] U.S. NREL (2012): Technical Report: http://www.nrel.gov/docs/fy13osti/55979.pdf.

efficiency as one of the non-renewable resources that count towards compliance. Including energy efficiency in an RPS target lowers the effective amount of renewable energy that must be procured if energy efficiency is not capped. Capping the level of energy efficiency at a certain percentage ensures that both renewable energy and energy efficiency are utilised and provides a level of certainty to market participants. In the two States which directly compare costs of meeting the combined targets with renewables versus energy efficiency, the cost of energy efficiency is well below the cost of renewables. For example, the Michigan PUC assessed that the weighted average energy optimization cost of conserved energy was $15.82/MWh, compared to a life cycle cost of $91.19/MWh for renewable energy.

In Connecticut, Tier III credits (energy efficiency credits) have historically seen credit prices at least slightly lower than Tier I (renewable energy certificates) as shown in the figure below. Prices tracked closely in 2009 and 2010 but in 2011 this trend changed. By mid-2012, Tier I renewable energy certificates increased up to nearly $50/MWh, while energy efficiency credits remained in the $10/MWh range[218].

Figure 10: Efficiency and renewable credit trading prices in Connecticut[219]



Source: Spectron 2012; indicative pricing only

Hawaii no longer has a combined standard and the majority of states with ambitious energy efficiency policies drive them through EEOSs, rather than the combined EE/RES mechanisms. In fact, even Connecticut, which has a combined RES/EE policy, delivers most energy efficiency through EEOS, rather than this combined policy.

The Danish energy efficiency obligation scheme already contains this element by allowing energy distributors to count certain end-use renewable technologies such as heat pumps and solar thermal solutions (except for biomass). This approach is combined with the increased national energy savings target of 3% (while for the purposes of Article 7 Denmark counts only energy efficiency under its annual 1.5% savings requirement)[220]. Denmark also permits

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218 It is probable that the increase in Tier I pricing was due to a shortage of eligible supply of renewables.

219 NREL (2012): Technical Report: http://www.nrel.gov/docs/fy13osti/55979.pdf.

220 Gives a prioritisation factor of 1.5 to energy companies if they promote measures with long term effect (e.g. insulation of walls, roof etc.).

energy generated from the local renewable energy plants which reduce the need for non-renewable energy input to a specific consumer (or a closed circle of consumers, i.e. block heat) to be counted as savings[221]. The overall objective of the Danish scheme is to ensure the cost-effectiveness of the measures so the obligated parties (energy companies) should aim at minimizing the cost per kWh saved. Therefore, energy companies will implement only those measures which make economic sense and benefit the consumer. For example, the Danish scheme allows energy companies to count towards their savings requirement the difference between the actual oil or gas consumption and the electricity consumption by the heat pump. Therefore, energy taken from the air or the ground is not counted. The evidence shows that heat pumps are a relatively cost effective solution both for the consumer and society and reduces the need for supplied fossil fuel.

Given the analysis above, it could be concluded that from the technical point of view it would be an effective way of promoting on-building renewables[222] by counting them to some extent under Article 7 in the new period post-2020 as a way of reducing the delivered energy consumed by the buildings. This would allow increased coherence with the EPBD to some extent (which takes into account the overall energy performance of buildings) and potentially with the reviewed RES Directive. Such integrated approach would help Member States to achieve both objectives in a facilitated way.

Even though this approach would trigger a positive effect in principle, such a combination would not be appropriate without a firm link to an equivalent and proportioned increase of level of ambition of Article 7, to ensure that the end-use energy savings can be achieved to contribute to the energy efficiency target. Therefore, it would best fit as part of the options allowed under Article 7(2) by adding it to the already existing exemptions capped to maximum application of 25%. This would allow Member States to exploit these possibilities by keeping the same level of flexibility under Article 7(2).

Administrative burden and compliance costs

The simplification proposed in sub-option 3.a would have a positive impact as it would reduce administrative burden for Member States and undertakings (i.e. obligated parties). With the proposed simplification of the rules on what savings can be counted under Article 7, Member States would be able to use the calculation methodologies already used under the EPBD. Similarly, sub-option 3.b on on-building RES would not result in additional administrative burden as the calculation approach under the EPBD could be used.

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[221] In buildings that are connected to district heating systems, effects of local solar heating systems may not be included, unless these are included as a part of the district heating plant's supply strategy. See Annex 1(8) of the Agreement with the energy companies, of 13.11.2012.

[222] Although the definition of 'nearly zero –energy building' in the Energy Performance of Buildings Directive refers to energy from renewable sources produced on-site or nearby, it was decided to restricted this new possibility to renewable energy generated on or in buildings to respect the overall objective of Article 7 of achieving end-use energy savings as a result of reduced energy consumption by buildings.

5.4.4 Impacts of option 4: Extend Article 7 to 2030; increase the rate of savings

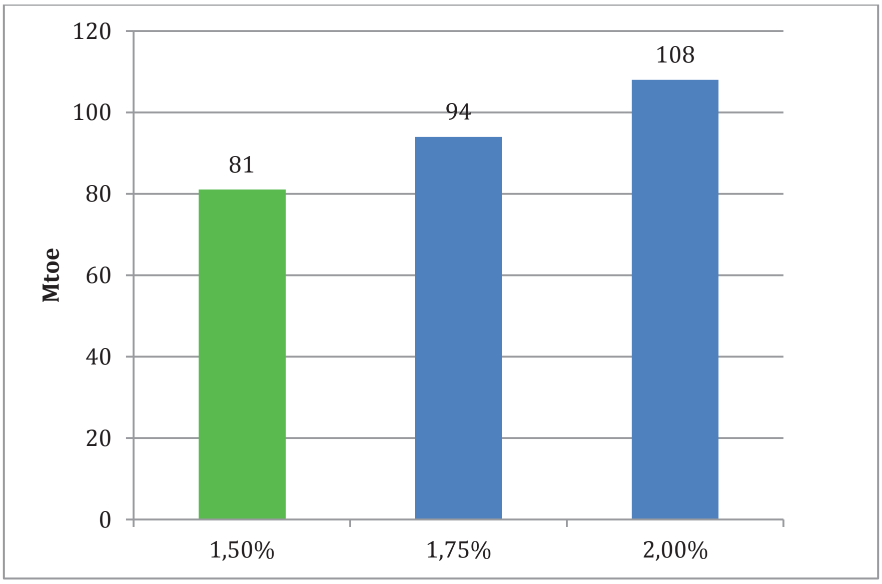
Higher levels of energy savings of 1.75% and 2.0% are closely linked with more ambitious policy scenarios analysed for the 2030 energy efficiency target and should be looked at in this context and not as a self-standing element.

It could be assumed that the increase in the level of savings would result in comparable economic benefits and environmental benefits described under the previous options 2 and 3. In terms of costs, there is limited evidence of the costs associated with the higher levels of ambition for Article 7 including the degree to which low cost savings would take place before the high cost energy savings.

Reduction of energy consumption

As indicated under option 2, the extension of Article 7 to 2030 will allow securing a maximum of 81 Mtoe of savings in 2030 (in cumulative terms 443 Mtoe over the whole obligation period)[223]. With higher rates than 1.5% an impact on the energy demand would increase accordingly. Figure 11 depicts possible scenarios for three levels of rates (1,5%; 1,75% and 2,0%) based on the bottom-up engineering estimation of the potential amount of savings that could be reached in year 2030.

Figure 11: Estimated energy savings in year 2030, maximum reduction applied (Mtoe)[224]



Source: Commission services' estimate

223 Description of the calculation of the amount of savings is provided in Annex 6 (on analytical approach).
224 Calculation based on the final energy consumption averaged over 2015-2020 (PRIMES ref. scenario).

Administrative burden and compliance costs

It is unlikely that the higher rates of savings requirement would automatically result in a linear increase of administrative burden and compliance costs. This is due to the fact that Member States have already put in place the regulatory framework for implementing Article 7 to achieve savings due by the end of this period (2014–2020) including the calculation methodologies (for example, catalogue of standardised measures which is widely used for carrying out measures under the EEOSs) and systems for monitoring and verification of claimed savings by the obligated or participating parties.

5.5 Empowering consumers - impacts of policy options for Article 9-11

The options considered in relation to Articles 9-11 differ mainly with respect to the following aspects:

- Support to new (= remotely readable) technologies;
- Legal clarity;
- Regulatory stability / ability to enforce existing rules in coming years.

In Table 33 the options are assessed qualitatively with regard to these aspects. Subsequently, impacts in terms of energy savings, costs and administrative burdens are assessed before the options are compared in chapter 6.5.

Table 33: Assessment of options with respect to main differences (from "---" to "+++")

Option	Support to new technologies	Legal clarity	Regulatory stability	Comments
1 non regulatory	+	--	+++	COM guidance could recommend take-up of remotely readable devices for delivering feedback and provide further interpretive advice, but with no guarantee of this being taken-up in practice. It would give no legal clarity, so whilst it would allow focusing on implementation in the foreseeable future, the existing challenges identified in that respect would not go away
2 Clarification and updating	+++	+++	++	Only with legislative changes all the issues identified in the existing legislation can be fully addressed, and remotely read devices can be promoted with a guaranteed effect. If changes to the legislation are limited to obvious clarifications and a few distinct "new policy" points (cf. points 1.1. and 1.2 in the option description), regulatory stability should still remain.

5.5.1 Reduction of energy consumption

The energy savings to be expected from the different options are difficult to assess. An attempt has made to quantify first the full technical potential and thereafter the share of this which each option might be able to realise.

The analysis focuses on heating and hot tap water; collective cooling systems are still rare, at least in the residential sector. There is a good base of evidence for savings accruing from sub-metering in space heating. In the absence of dedicated studies of savings in hot tap water made when cost-allocation and consumption information measures are introduced, it is assumed that the proportional behavioural effects on hot tap water usage are similar in magnitude to those for space heating. The methodological approach is detailed in Annex 6.

The results indicate that the total remaining potential energy savings in EU-28 that might be achieved through individualised metering and billing (i.e. consumption based cost allocation) in multi-apartment buildings compare to around 25% of the residential sector's expected contribution to the overall reduction of final energy consumption under the EU 2020 energy efficiency target. Additionally, savings from introducing consumption information service could reach an amount corresponding to around 8% of the 2020 reduction target for the residential sector in EU-28[225].

Figure 12: Savings potential expressed as contribution to the 2020 energy efficiency target

Source: Empirica estimations based on Guidelines for good practice[226]

As stated earlier, the actual impact to be expected from each option is difficult to assess. The impact mainly stems from three effects:

1. **Improved implementation of current heat cost allocation requirements**: this effect is in principle minor as none of the options involve changing the current conditionalities for individual metering. However, option 2 which ensure more transparency for final consumers about how costs in multi-unit buildings are allocated (cf. point 1.2 in option description) will likely have a positive effect on implementation due to less opposition from tenants or co-owners not understanding or considering the allocation as unfair.

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[225] Known limitations in the data used/needed to perform the above analysis include: 1) Due to lack of data, no correction has been applied for buildings in which occupants have no control over temperature or ventilation; 2) Conversion from savings in building's energy demand to savings in the resulting final energy consumption assumes 85% heating system efficiency (compare Enerdata (2011) Quantitative evaluation of explanatory factors of the lower energy efficiency performance of France for space heating compared to European benchmarks);; 3) Variation across Member States in the proportion of building elements (e.g. walls, windows) in a 'typical' multi-family building was not taken into account.

[226] empirica (2016) Guidelines on good practice in cost-effective cost allocation and billing of individual consumption of heating, cooling and domestic hot water in multi-apartment and multi-purpose buildings, Available at https://ec.europa.eu/energy/sites/ener/files/documents/MBIC_Guidelines20160530D.pdf.

2. **Improved implementation of current provisions on sub-annual (2-4 times per year) billing/consumption information services**: This is a key part of the effect since a key issue addressed by the options is the applicability of Articles 10 and Annex VII to sub-metered flats.

3. **Further enhancing feedback**: options which help promote remotely readable meters or heat cost allocators (HCAs) can be expected to trigger additional savings by enabling more complete and more frequent (at least monthly) consumption feedback than what is currently required by the EED. Near-real time feedback on smart phone apps, websites etc. could also be enabled and more widely applied by this scenario.

The total potential of the first two effects has been estimated as explained above. Even in the baseline scenario and non-regulatory option 1, a considerable share of this is expected to be realised as a result of implementation of the existing EED provisions.

In contrast, the effect of further enhanced feedback is enabled by and dependent on more consistent roll out of remotely readable sub- devices and their use to provide more frequent and useful feedback than is currently required by the EED. This could for example be monthly consumption information provided by email or paper, but also information closer to real time (weekly or even daily values) made available via a secure web site or a smartphone application. The effect of such enhanced feedback depends on a lot of factors and is difficult to estimate at EU level. A recent meta-analysis of existing studies in this field shows a range of observed savings of up to 14% in heat related studies, with an average of 4%[227]. The analysis also shows significant variations depending on the medium used to convey the information, with bills having a relatively smaller average effect (4%) than for example in-home displays (7%), cards (7%) or PC/Web access (10%). It concludes i.a. that "…*feedback can reduce the households' energy consumption up to realistic 5 to 10%*" and that it works best when it is delivered regularly and with high frequency and, as regards billing, is made through enhanced billing versus standard billing. For the purposes of this analysis, it is conservatively assumed that enhanced feedback enabled by increased deployment and use of remotely readable devices would trigger additional savings of the same scale as the estimated potential for the more basic consumption information service reflected in the current EED minimum requirement, i.e., an additional total of 4,4 Mtoe. Specifically, an average saving of 3% from current EED feedback requirements is assumed together with a potential for an additional 3% from enhanced, more frequent feedback enabled by remotely readable devices.

The assumed contribution in terms of the percentage of delivery of the full potential and the resulting total approximate savings are set out in table below. Even for option 2 the full potential estimated above of the existing requirements is not assumed to be 100% realised since Member States will retain the possibility to make exceptions for reasons of technical feasibility and cost-effectiveness. Nevertheless, the estimated effect of option 2 is substantially higher than of option 1 which is not estimated to result in significant savings

[227] "Energy Feedback Systems: Evaluation of Meta-studies on energy savings through feedback", Joint Research Centre, 2015 (http://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/energy-feedback-systems-evaluation-meta-studies-energy-savings-through-feedback).

compared to business as usual. As for option 2, the improvement is in the order of 50% over business as usual[228].

Table 34: Assumed contributions of individual measures to the savings effect of each policy option

	Heat cost allocation implementation of EED requirements		**Informative billing implementation of EED requirements**		**Enhanced feedback**		**Total potential/ effect**
Total potential	100%/13,4 Mtoe		100% / 4,4 Mtoe		100%/4,4 Mtoe		100%/22,3Mtoe
	Assumed contribution (% of total) of each option / resulting saving						
Baseline/business as usual	85%	11,4	20%	0,9	25%	0,9	13
Option 1	90%	12,1	25%	1,1	25%	1,1	14
Option 2	95%	12,8	90%	4,0	100%	4,0	21

5.5.2 Costs

A consideration of potential cost implications of the different options requires a discussion of the detailed clarifications or other elements that are envisaged/possible under the policy options considered.

Remotely readable requirement (Option 2)

Option 2 would add a new requirement for newly installed sub-metering devices (be it meters or HCAs) to be remotely readable as of 2020, and all non-readable devices to be turned into or replaced by remotely readable devices by 2022. The advantage is that data can be read without access to the individual flats, either by so-called "walk-by" technology or via a dedicated data network infrastructure installed in the building. Remotely readable devices are marginally more expensive than the simplest devices available on the market implying some increased costs, part of which is for the data network infrastructure if such is installed[229]. On the other hand they generate costs savings and additional consumer benefits by eliminating the need for meter readers to access every single building unit in sub-metered buildings. For frequent information services, such cost savings are critical.

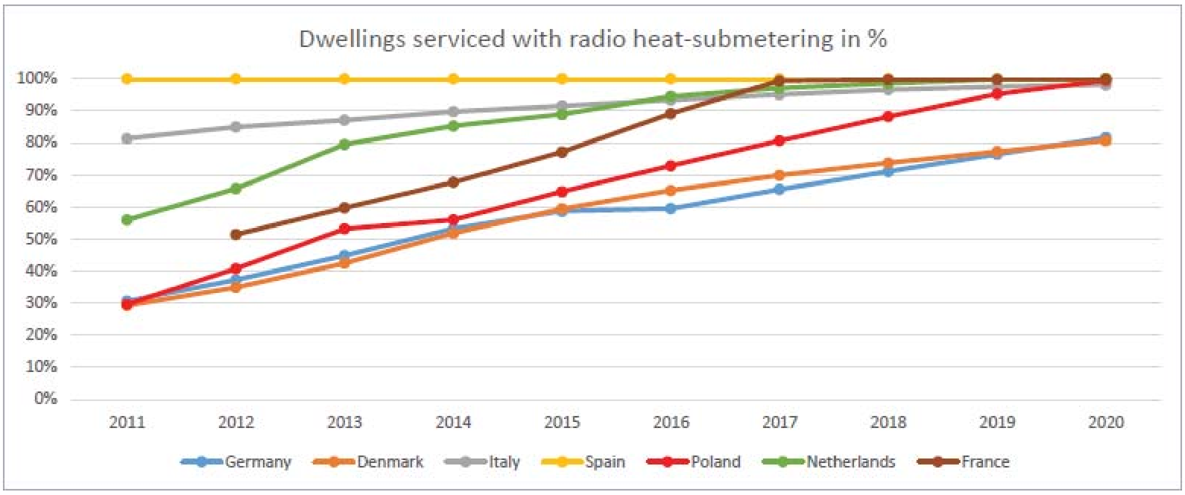
It is emphasised that neither option 1 nor option 2 would change the existing cost-effectiveness criteria for the deployment of individual meters or HCAs. The unchanged cost-effectiveness criterion would therefore ensure that any cost increases would not be disproportionate to the increased benefits.

Moreover, the transition towards remotely readable devices is already occurring in the market. The vast majority of HCAs installed in recent years are remotely readable and this requirement would support or accelerate this trend and ensure it continues. Figure 13 is based on data obtained from providers of heat cost allocation services. It shows the trends in recent years and industry estimates of the expected developments in the next few years.

[228] It is emphasised that the estimates must be considered to indicate orders of magnitude rather than precise figures, given the difficulty of predicting behavioural changes of this kind in widely varying circumstances and with limited statistical data available.

[229] Whilst there is little cost data available in the public domain and pricing policies vary between service providers, information from the industry suggests that typical additional monthly costs per dwelling for a heat cost allocator installation and related web service capable of providing access to monthly consumption information is in the order of 1-2 euros, although this may be higher in certain markets or buildings.

Figure 13: Share of sub-metered dwellings serviced with remote readings (not requiring access to flats) in selected European countries.



Source. EVVE (The European Association for Energy Cost Allocation), May 2016.

Focusing the future market on remotely readable devices could very well increase competition in this market segment and put downwards pressure on prices, which in turn would further reduce the already fairly marginal price difference. The overall effect of this requirement is principally expected to be a consolidation of the ongoing trend and a signal to manufacturers and service providers about focusing investments exclusively on "future proof" digital technologies.

Competition in the provision of these services would be facilitated by ICT focused technologies. Final consumers would benefit from deployment of modern devices not having to face recurring manual readings for which they have to be at home. Giving some time for fully phasing in the remote reading functionality would prevent buildings recently having installed non-remotely readable HCAs (to the extent such cases even exist) from incurring significant sunk costs. Indeed, both meters and heat cost allocators are in any case typically replaced on a regular basis (typically at most 10 years) due to technical or legal requirements. Recently installed meters without this functionality might be retrofitted with optical sensors or add-on modules at modest additional costs.

Simplified criteria for application of consumption based billing and frequent information (Option 2)

As regards the current conditionalities for the mandatory application of consumption based billing and frequent billing information (Article 10(1)), option 2 would replace these with two simpler and more operational but largely equivalent conditions:

- **Technically feasible** ≈ "where meters or heat cost allocators are installed"
- **Economically justified** ≈ "where remotely readable individual meters or heat cost allocators are installed"

Regarding **"technically feasible",** the availability of individual measurement devices is clearly a good indicator and reasonable and simpler substitute for "technical feasibility" when it comes to consumption based billing on an annual basis. However, for producing sub-annual billing information the availability of sub-annual (e.g. quarterly) cost data might also be a constraint. To this end option 2 envisages allowing the sub-annual information to be consumption information only, which it is feasible to produce as long as individual measurement devices are available.

Regarding the "**economically justified**" condition, the key determinants are the availability of sub-annual cost-data and corresponding individual measurements/readings, respectively. The cost of providing/communicating sub-annual information is very marginal, especially if it is done electronically[230]. As regards the cost data, the same remarks as above apply. As regards sub-annual availability of individual measurements or readings, this is not problematic where remotely readable devices are installed. Where this is not the case, sub-annual consumption information will require manual meter reader access to each flat in the buildings concerned. The cost of this may in some cases be justified by the additional benefits, in others not. Conservatively, it is here assumed that sub-annual manual meter readings in most cases will cost more than the value of the additional savings triggered.

In conclusion, the simplification/reformulation of the conditions for the mandatory application of consumption based billing and "frequent" billing or consumption information is not expected to entail any cost increases. It will however make it much simpler for consumers and landlords/building owners to determine at a building level where these services must be offered.

Improved comparisons in billing/consumption information (Option 2)

Comparisons with previous consumption periods as well as with "average normalised or benchmarked final customer consumers in the same user category" are already requirements under Annex VII of the EED. However, there is currently some ambiguity about the extent to which they are mandatory for sub-metered consumers, and the use of such comparisons is not generalised.

Comparisons with consumption periods in preceding years are relatively straightforward. Presenting them in the format of a graph should not pose any significant challenges or additional costs. As regards climate-correction, this also ought already to be incorporated in any year-to-year comparison relating to heat since such comparisons are otherwise of little value in terms of understanding the evolution in consumption. Nevertheless, under option 2 climate correction would be expressly required to ensure that this is done and that the information provided to consumers is meaningful. This kind of calculation is rather straightforward as long as data for heating (or cooling) degree days are available. It should not impose any significant additional costs apart from perhaps an initial software adjustment for sub-metering service or district heating/cooling providers that do not already make such adjustments.

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[230] Whilst handling of complaints or enquiries may trigger some additional costs, these are unlikely to be significant if the sub-annual information concerns consumption alone (as opposed to billing/cost information).

5.5.3 Administrative burden

Given that all options are formulated with the objective of simplification and clarification in mind, they should generally help reduce administrative burdens at all levels, in particular for Member States.

For building owners/managers, the transition to monthly billing or consumption information as of 2022 for buildings where remotely readable equipment is installed could conceivably increase the administrative burden in relation to provision of such information. However, a number of factors mitigate, counter-act or justify this risk/effect:

1. The adjusted requirements envisaged under option 2 would provide that heating and cooling information need not be provided monthly outside the heating/cooling seasons.
2. If managers opt for consumption information only, this is unlikely to trigger significant additional burdens in terms of complaints handling, etc.
3. Once sub-metering has been introduced for a building and the necessary infrastructure in terms of equipment and software is in place, the additional effort to make available frequent *consumption* information is very marginal, especially if done electronically.
4. It is compensated by a more significant savings effect due to a better informed consumer.
5. In the absence of monthly consumption information, sub-annual billing relies on estimates which can result in significant corrections once a year following the actual meter/HCA readings, sometimes entailing big unexpected payment requests of consumers. This is known to cause confusion and frustration and be a common source of complaints. Such problems are likely to be substantially reduced if consumers can follow their actual use month by month. This will reduce the administrative burden related to complaints and back-payments.

Indeed the advantages in terms of potential reductions in administrative costs deserve to be explored in a bit more detail. In the electricity and gas sector, the single biggest source of complaints from household customers are concerns related to "Invoicing / billing and debt collection"[231] which in reality often is about annual statements and back-billing of "debt" caused by too low estimated inter-annual bills.

For heating new data available to the Commission confirm a similar pattern. From an analysis of real customer data from a sample of 27.000 sub-metered buildings in an EU Member State, made available to the Commission by a provider of cost-allocation services, it transpires that 90% of all complaints received from sub-metered consumers were from households whose annual settlement bill required an extra, unforeseen payment. The data in other words shows a strong correlation between the net-position of a household's heating bill, the point of annual settlement, and the propensity to complain. The data also shows that 50% of the consumers in the buildings analysed face annual billing corrections (extra-payments or reimbursements) which are bigger than 32% of the total annual heating bill. This analysis suggests that more frequent/monthly billing or consumption information based on actual consumption rather than

[231] ACER/CEER Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2014, November 2015, section 3.2.2.

estimates likely could reduce the number of complaints and the associated administrative costs very significantly.

As regards the mandatory obligation for Member States to introduce transparent rules on cost allocation rules envisaged under option 2, this would be expected to facilitate the work of building managers/owners and sub-metering service providers. With transparent, public rules and principles it should be easier for these actors to explain and justify cost allocation to sub-metered consumers. An initial effort would be associated for Member States with introducing these rules, but many of them have done so already with reference to the current EED provisions or even before that[232].

5.6 Interaction between energy efficiency policies

As described in the problem definition, this impact assessment is intended to serve as the basis for the Commission to identify the EU target for energy efficiency in 2030. In this respect, it is also necessary to analyse the contribution of existing and planned EU measures in the field of energy efficiency could make to these targets. Therefore, before concluding on the preferred options, the links between the EED with the energy efficiency EU measures which are part of Energy Efficiency Package 2016 are analysed:

- The set of revisions to the EPBD that is identified as the preferred option in the EPBD impact assessment that forms part of this package;

- The revision of the EED, in particular the extension of Article 7 but also the clarification/updating of metering and billing provisions (Articles 9-11);

- The Commission's proposal to amend the framework legislation for energy labelling of products, the ecodesign and labelling measures that form part of the first and second ecodesign working plans and have not yet been finalised; and an estimation of the ecodesign and labelling measures that may form part of a third ecodesign working plan.

It should be noted that these measures are all considered to be "cost-effective" even in the narrow, private-cost sense of the term. Savings under the EPBD are constrained by the Directive's "cost-optimal" methodology for setting building standards. Member States have the full flexibility to decide which measures they implement under an energy efficiency obligation scheme or alternative measures to deliver the required final energy savings under Article 7 of the EED, and the evidence quoted above shows that obligation schemes are cost-effective. It is therefore assumed that Member States choose cost-effective measures only. Ecodesign measures are required by the Directive to be set at the level of Least Lifecycle Cost.

As described above, the impact of a single policy measure on the 2030 target level cannot be quantified by the partial equilibrium energy system model that has been used. A **simplified calculation** can be, however, performed to estimate the individual contribution of each of the

[232] Such rules have been identified in at least 12 MS, and others are considering introducing them (source: empirica).

proposed changes in this Energy Efficiency Package 2016 to the overall 2030 energy efficiency target bearing in mind that each of these estimations uses different baseline.

In order to do so, use is made of the results of the engineering analysis of the maximum impact of each set of measures considered in isolation (Article 7 EED, Articles 9-11 EED, EPBD and Ecodesign/Labelling). Second, overlaps between the four initiatives are considered where possible. Third, an estimation of the rebound effect of these sets of measures is undertaken and fourth, these savings will be compared against the results of the policy scenarios modelled with the partial equilibrium energy system model (PRIMES).

1. The maximum impact of extending Article 7 beyond 2020 would result in 81 Mtoe energy savings in year 2030. Given the cross-cutting nature of Article 7, some savings might overlap with some other provisions of the EED to some extent. The Commission services have estimated that this overlap amounts to around 24% of the total energy savings stemming from the measures notified under Article 7 for the period 2014-2020[233]. If applying the same pattern of overlap for the next period 2021-2030, it would reduce the estimated impact of 'pure' Article 7 savings.

   The EPBD and Article 7 are also complementary and reinforce each other. As described above, EPBD sets e.g. minimum requirements for new buildings, building undergoing a major renovation or building elements whereas Article 7 mainly accelerates the renovation rate of buildings or building elements. The 'cost optimal level' of the EPBD is intensified every 5 years by 5%. Therefore, it is assumed that the 10% (2x 5% in 2020-2030) of the required savings can be attributed to the strengthening of the 'cost optimal levels'.

   There are also overlaps between Article 7 and ecodesign measures as some of the measures which were notified for the saving obligation period 2014-2020 also incentivise the uptake rate of more efficient products. However, no data are available to quantify this impact.

   Combining the overlaps with other EED articles and the 'cost optimal level' of the EPBD would reduce the estimated impact of 'pure' Article 7 savings to 53 Mtoe in 2030.

2. The maximum impact of the **changes to Articles 9-11** considered in respect of thermal energy has been estimated to be in the order of **8 Mtoe** compared to business as usual. Overlaps with the other polices are likely to be minimal since this estimate only covers the residential sector and essentially relies on an extrapolation of empirical observations of typical actual savings brought about by *behavioural changes* in the use of centrally provided heat.

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[233] The Commission services have undertaken a rough estimate of the overlaps of the policy measures notified by Member States under Article 7 for the period 2014-2020 with other obligations stemming from the EED. Measures which fully or partially overlap with Articles 5, 6, 8, 14, 15 and 17 of the EED. The total amount of savings subject to such overlap amount to 59.457 ktoe which is 24% of the total energy savings from policy measures notified under Article 7 (251.813 ktoe). The exact amount of savings attributed to the ‘partial’ overlap could not be quantified due to lack of information as regards individual actions envisaged under the policy measures notified. The maximum overlap thus was assumed even though it would not depict the situation accurately. .

3. The engineering analysis in the respective Impact Assessment shows that the maximum impact of **the preferred option of the revisions to the EPBD** would lead to final energy savings of **28 Mtoe** in 2030.

4. The anticipated annual maximum impact of the energy labelling and Ecodesign measures is final savings of **30 Mtoe** in 2030. Ecodesign and labelling pull improved technical building systems into the market and influence the 'depth' of the renovation. They deliver synergies with the EPBD. Overlaps between the two should not be double counted[234]. It is assumed that Ecodesign and energy labelling advance the frontier of renovations that are considered as "cost optimal" for the purposes of the EPBD (every 5 years by 5%). Therefore, it is assumed that the overlaps are 10% (2x 5% in 2020-2030). Taking this factor into account reduces the **combined estimated impact of these two policies** from 60 Mtoe to **52 Mtoe**.

The three sets of measures are therefore estimated to have a combined maximum impact, once overlaps are eliminated, of around **113 Mtoe** in 2030.

By reducing energy bills, energy efficiency measures give consumers more money to spend on energy-consuming goods and services. By reducing the price of energy services, consumers might increase their demand for energy-intensive goods and services at the expense of less energy-intensive ones. These effects offset the maximum estimated energy savings. Together they constitute the rebound effect. Barker et al. (2009) estimated that this effect would reduce the impact of a range of policies introduced over the period 2013-2030 by 31% by 2020 and 52% by 2030. The policies under consideration here would largely take effect in the period 2020-2030. An intermediate value – 43% – is therefore used, reducing the estimated savings to 65 Mtoe in 2030. However, Cambridge Econometrics (2015) estimated, following a literature review, that the rebound effect would be lower – 21%. That would imply reducing the estimated savings to 90 Mtoe in 2030.

It is thus estimated that, with the overlapping impacts of the different policies and rebound effects taken into account, the final saving impact of **the different sets of measures, taken together, will be in the range of 65-90 Mtoe in 2030.**

Taking possible higher saving rates under Article 7 into account would bring higher final energy savings in 2030 as shown in the table below.

[234] Overlaps between ecodesign and Article 7 (e.g. boiler replacements) have not been taken into account due to lack of data.

Table 35: Impacts of assessed policies

Energy efficiency policy mix	Article 7		
	1.5% = 81 Mtoe	1.75% = 94 Mtoe	2% = 108 Mtoe
Article 7 savings after a 34% deduction of savings stemming from other EED articles (24%) and overlaps with the strengthening of the cost-optimal level of the EPBD (10%) in Mtoe	53	62	71
Final energy savings in 2030 for preferred option of EPBD review and Ecodesign/Labelling	52	52	52
Final energy savings for preferred option of Art. 9-11 EED review	8	8	8
Savings from all policies taking a conservative rebound effect of 43% into account	**65**	**70**	**75**

Energy efficiency policy mix	Article 7		
	1.5% = 81 Mtoe	1.75% = 94 Mtoe	2% = 108 Mtoe
Article 7 savings after a 34% deduction of savings stemming from other EED articles (24%) and overlaps with the strengthening of the cost-optimal level of the EPBD (10%) in Mtoe	53	62	71
Final energy savings in 2030 for preferred option of EPBD review and Ecodesign/Labelling	52	52	52
Final energy savings for preferred option of Art. 9-11 EED review	8	8	8
Savings from all policies taking a conservative rebound effect of 21% into account	**90**	**97**	**104**

Source: Commission calculations

REF2016, among other things, includes existing measures in transport, the EPBD in its current form and eco-design and labelling implementing measures[235]. It also includes the EED in its current form, under which the provisions of Article 7 cease to apply in 2020, while the rest of the EED would continue to be in force. In this setting there are projected primary energy savings of 23.9% in 2030, while final energy consumption would be 1081 Mtoe in 2030[236].

To achieve more ambitious targets for energy efficiency in 2030, energy consumption would have to be further decreased. The table below shows by how much final energy consumption would need to be lower than REF2016:

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235 Ecodesign and labelling implementing measures which were adopted up to 2014.

236 Statistical cross-effects with certain types of renewable energy can make the interpretation of detailed savings figures expressed in primary energy confusing. The analysis is therefore made in terms of final energy.

Table 36: Final energy consumption in Mtoe in 2030

Final energy consumption in Mtoe in 2030	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Final energy demand	1031	987	929	893	825
Reduction compared to reference scenario	50	94	152	189	256

Source: PRIMES

The modelling results provide an outline of how these additional savings could be achieved. The EU Reference scenario assumes a continuation and implementation of the energy efficiency framework beyond 2020 e.g. the renovation of public buildings under Article 5 or the further development of the ESCO market according to Article 18. However, as described above, Article 7 will not be obligatory post-2020.

To achieve a level of at least 27% of energy efficiency, the policy scenarios assume for the transport sector, policies and measures under consideration at European level. For the other final demand sectors, eco-design/labelling, building standards were intensified in the model to reflect the proposals of the parallel initiatives and general incentives for a thermal improvement of buildings were gradually intensifies - as described above and in Annex 4 – to reflect current policies and the proposed policy changes to achieve different energy efficiency levels in 2030.

The table above shows the required energy consumption reductions from all sectors under the different policy scenarios. It need to be kept in mind that these are **savings which are needed in addition to the energy efficiency framework which is already in place and which delivers savings**. These additional savings in 2030 compared to the business-as-usual baseline will need to be compared with the anticipated impacts of the proposed, new energy efficiency policies.

In a simplified manner, combining the bottom-up engineering results for the different packages with the modelling results shows the contribution of each measure towards the different target levels.

Figure 14: Energy efficiency policy mix 2030 - Conservative rebound effect

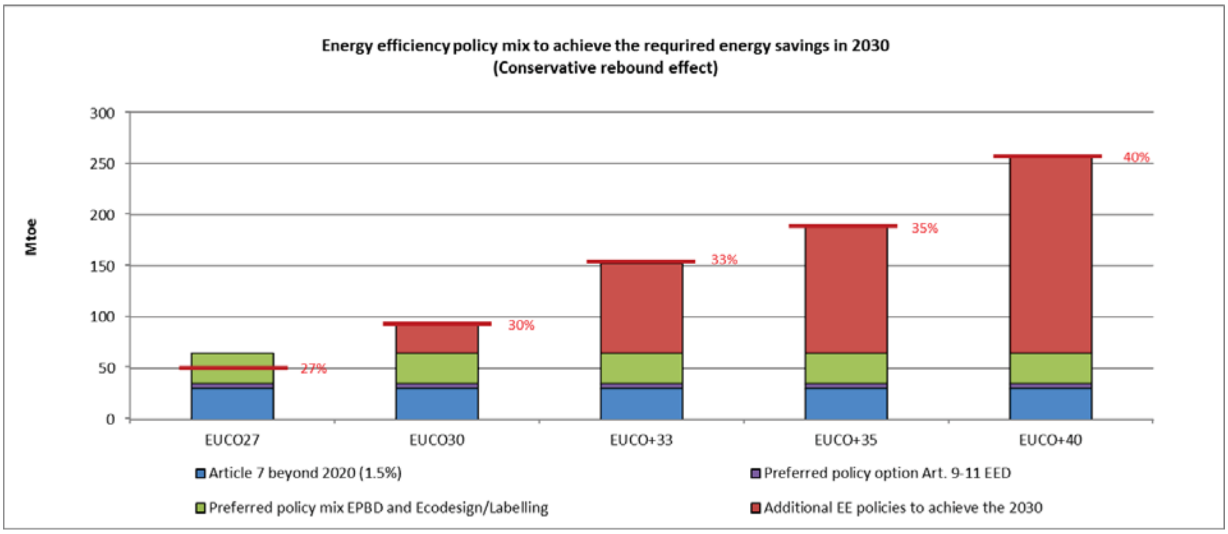
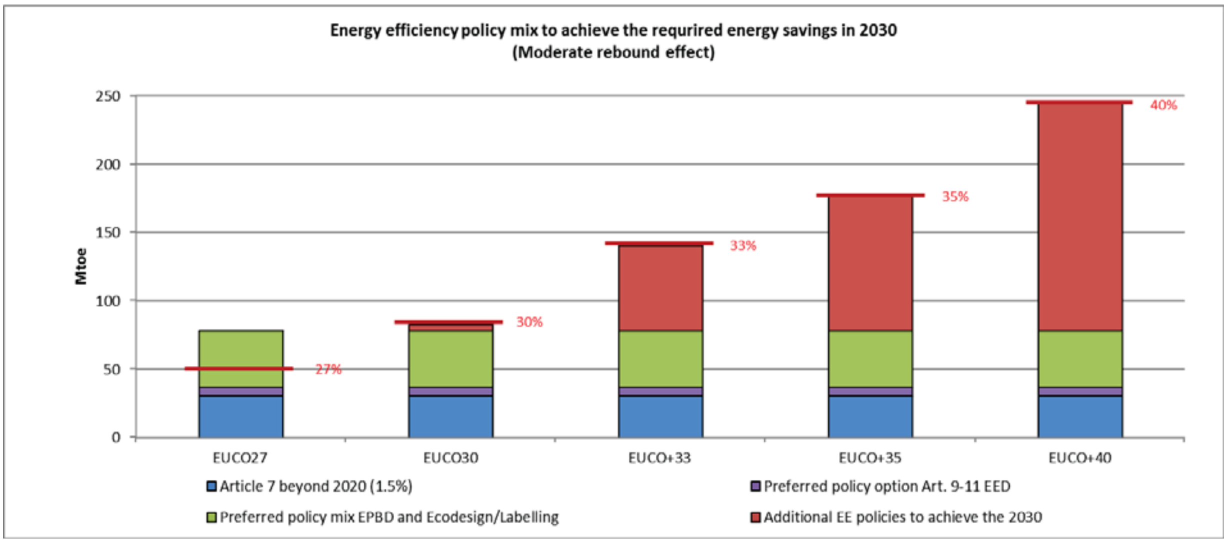


Figure 15: Energy efficiency policy mix 2030 - Moderate rebound effect



Comparing the different energy efficiency 2030 targets which are based on the modelling exercise with the engineering results, it can be seen that the extension of Article 7 to 2030 would contribute considerably to achieve an EU target above 27% in 2030. The changes to the EPBD would contribute together with the changes on metering and billing, various eco-design and energy labelling initiatives also to a large extend (see graphs above).

To achieve a 30% target the following would therefore be needed at EU level:

1. Extension of Article 7 post 2020;
2. Change of EPBD as indicated in the Impact Assessment to deliver additional energy savings in the buildings sector by 2030.
3. Ambitious implementation of the Ecodesign Working Plan and the review of the Labelling Directive to deliver additional energy savings by 2030.
4. Timely adoption of the proposed changes to the ETS and Effort Sharing Regulation to ensure a reduction of GHG emissions of at least 40% in 2030.

5. Enforcement of renewables policies necessary to achieve a renewable target of at least 27% in 2030.
6. Further strengthening of CO2 standards for cars and vans, measures on management of transport demand.
7. Continued improvement of financial instruments and other financing measures at European and national level lowering the cost of capital for investment in thermal renovation of buildings are needed to increase the rate of renovation and depth of renovation as well as the uptake of efficient products. Facilitating smart financial framework for energy efficiency investments is part of the accompanying Communication. It is considered that the impact of this framework will be to enable and enhance the required investments and hence act as a complement to the policy framework.

To achieve a 30% target the following would also be needed at Member States, regional and local level:

1. Assessment of cost-efficient energy efficiency measures in order to set national 2030 energy efficiency targets. These targets may take into account national circumstances affecting primary and final energy consumption but should contribute sufficiently to the EU 2030 energy efficiency target.
2. Continued effort to implement the other EED requirements and measures to achieve the required savings in 2030;
3. Continuation of national measures which increase the rate and depth of renovation and the uptake of energy efficient products;
4. Continuation of national measures which increase the uptake of energy efficiency measures in the industrial, service and agricultural sector which is also an enabler for economic modernisation and competitiveness;
5. Further tackling of market barriers to energy efficiency investments;
6. Further empowering of energy consumers.

6 Comparison of the policy options

6.1 Preferred option for the level and formulation of the 2030 target

In terms of economic impacts on energy sector, energy system costs increase as scenarios become more ambitious. In the period 2021-30, a target of 30% would lead to an increase in average annual system costs of € 9 billion compared to a 27% target (or, expressed as share of GDP, an increase in average annual system costs of 0.05 percentage points compared to 27% target). However, taking a longer term perspective (2021-50), the average annual system costs for 30% scenario would be € 9 billion lower than in the 27% scenario, as the benefits of early investments continue to pay off post-2030.

In addition to overall system costs a general shift in the structure of costs for energy consumers has to be considered, i.e. diminishing energy purchases (consumer paying less for fuels and electricity) and increasing investment expenditures (consumers paying for additional energy efficiency investments). Total energy efficiency investment expenditure increases in all scenarios – more significantly in more ambitious scenarios and again mostly in the residential and tertiary sectors. In the period 2021-30, a target of 30% would lead to an average annual increase in investment expenditure of €78 billion compared to 27% target. At the same time energy purchases visibly decline. In the period 2021-30 a target of 30% would lead to an average annual decrease in energy purchases of €28 billion compared to 27% target. In addition, the reduction in energy purchases continues after 2030.

The following impacts associated with energy efficiency improvements have been identified:

- Energy efficiency has a strong beneficial impact on security of supply and the level of gas imports in particular. For example, increasing the level of ambition from 27% to 30% would reduce gas imports by 12%, i.e. 36 bcm. The additional savings in oil imports would be marginal only. Decreases in net energy imports translate into savings in the fossil fuel imports bill and over the period 2021-30 the target of 30% energy efficiency would bring about a cumulative reduction in the fossil fuels imports of €70 billion in comparison to the 27% energy efficiency target.

- Investments in power generation and grids are constant or decrease as the scenarios become more ambitious and this reflects less need for additional generation capacity. Lower electricity demand and lower investments in power generation capacity contribute to lower electricity prices. Electricity price reductions range from 1% to 2% in the year 2030 (compared to 27% target).

- All policy scenarios reduce the demand for electricity in 2030 as eco-design and energy savings obligation and national energy efficiency incentive scheme are assumed to continue. In the longer term, it is assumed that the combination of climate, energy efficiency, renewable and transport policies also trigger electrification which could counterbalance the decreasing trend of electricity demand.

- Energy efficiency targets and policies interact with the EU Emissions Trading System which is the main European instrument to ensure the achievement of the -43% target. The ETS carbon price in 2030 differs substantially across the various scenarios, reflecting the important effect of energy efficiency measures on emission reductions in the ETS sectors (via reduction of demand for electricity, partly offset by energy efficiency measures supporting electrification in heating and transport). As their ambition grows, energy efficiency policies reduce both costs and incentives from the ETS itself for GHG abatement. The ETS Market Stability Reserve (MSR) adopted in 2015 will respond to major changes in the demand of allowances, regardless of whether these are the result of economic factors or due to policy developments, for example in relation to improved energy efficiency. The architecture of the reserve is such that it automatically and in a gradual manner reduces the auction supply if there is a significant oversupply of allowances. For very ambitious levels of 2030 energy efficiency targets, this might pose risks to the overall coherence in delivering the climate objective. Therefore, it might need to be considered as part of the first review of the Market Stability Reserve parameters foreseen by 2021 whether this justifies a change to the parameters (e.g. the MSR feeding rate) in case of ambitious energy efficiency targets to preserve the overall policy coherence in delivering the climate objective in a cost effective manner, as agreed by European leaders.

- All policy options analysed come with very significant air quality, environmental and health benefits, which are more prominent for the more ambitious energy efficiency targets. Summing up the monetized impacts of the reduced health damage and pollution control costs in 2030, a 30% target leads to a reduction in combined costs between €4.5 and 8.3 billion compared to a 27% target (depending on low or high valuation). This is mainly due to the reduction in mortality due to particulate matter.

- More ambitious energy efficiency measures in particular in buildings help to improve the living standards of EU citizens. In particular, targeted energy efficiency measures in buildings can help households with lower incomes to reduce their energy bills and improve their living conditions. This can be reinforced if targeted measures are put in place to help them making the necessary investments.

- In terms of the macro-economic impacts, stepping up the level of energy efficiency efforts is expected to have moderate positive impacts on economic growth. GDP impacts are likely to be on the positive side and relate to the positive impacts of boosting domestic investments, most importantly in the construction sector and in the engineering and transport equipment. These macro-benefits would accrue across Europe, as long as the scale of the required energy efficiency investments does not act as a constraint on the overall economy. Mitigating measures to ensure that physical capital bottlenecks and private lending deployment constraints are effectively addressed can reinforce this effect. Two methodologically different macro-economic models are used in this Impact Assessment. They show that there can be potentially net positive impacts on GDP from investing in energy efficiency. As the stringency of the energy efficiency target increases the marginal net benefits diminish[237]. It is important to note that any potential GDP and macro-economic benefits will vary post-2030 depending on financing arrangements, the repayment conditions of the private debt for energy efficiency investments accumulated before 2030, and long-term energy efficiency gains.

- A higher level of energy efficiency creates employment opportunities. Employment impacts are likely to be positive, as long as labour resources can be absorbed in the sectors expected to benefit from energy efficiency investments. However, employment opportunities from more ambitious energy efficiency efforts could be created particularly if banks facilitate lending to economic actors to finance their energy efficiency investments and if labour inputs required for energy saving activities are not sourced from other growing sectors of the economy. In addition, the magnitude and sectorial distribution of employment impacts depend on the labour intensity of sectors and on the responsiveness of wages to labour demand. Overall, employment tends to increase in sectors that provide inputs to energy efficiency projects and/or have significant forward and backward linkages with other sectors of the economy (e.g. construction sector, engineering, certain basic manufacturing sectors). Sectoral employment is projected to decrease in energy supply-related activities in line with the projected fall in output in these sectors. Accompanying measures targeting skill

[237] The drivers of these results are mostly threefold. First, they depend on whether the magnitude of energy efficiency investments will "crowd out" investment resources from other productive sectors of the economy (higher "crowding out" negatively impact the macro-economy). Second, GDP impacts will depend on whether existing unemployed and underutilised labour and capital resources can be effectively deployed in economic sectors providing energy efficiency investment goods and services (higher deployment of unutilised resources positively impact the macro-economy). Third, potential macro-benefits can be better realised if access to the required private finance is facilitated and economic agents are able to cover upfront costs and smoothen their investment, saving and consumption patterns.

matching and labour mobility will be critical to effectively reaping potential employment benefits.

In general, the analysis at the economy-wide level showed that energy efficiency policies should be designed in such a way that possible crowding-out of investments in other economic sectors is limited, the private financing of energy efficiency investments is encouraged, and unnecessary market distortions and negative macroeconomic effects are avoided. To tackle some of these issues, the review of the EED is accompanied by a 'Smart Finance for Smart Buildings' initiative.

Accompanying policies should address inhibiting factors that prevent spare capacity and capital to flow into energy efficiency investments and unemployed people to fill the vacancies created by energy efficiency. Labour skills shortages and barriers to labour and financial and physical capital mobility need to be addressed. Stimulus to higher investments, leading to a "virtuous cycle" with higher growth and more savings needs to be given to the market.

Most important is the confidence of the banking system and investors who react to credible and lasting signals and incentives, such as stepping up an ambitious political commitment for a 2030 energy efficiency target, and helping prove the case for the business opportunity of investment in energy efficiency goods and services.

The provision of macroeconomic benefits of a more stringent energy efficiency target would also depend on the success of EU's Capital Market Union (insuring greater capital mobility and unlocking funding for Europe's growth) and on the effectiveness of EU's aim within Europe **for private capital to finance** profitable investments **without a need for direct public funding interventions**, as well on EU's Industrial Policy (aiming to increase the share of manufacturing in the economy) that could support key economic sectors in the effective provision of energy efficiency equipment, goods and services.

Table 37: Summary table

2030 results unless indicated otherwise (PRIMES results/features unless indicated otherwise)	REF2016	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Main features scenarios						
Primary Energy Consumption (Mtoe)	1,436	1,369	1,321	1,260	1,220	1,129
Change in primary energy consumption in 2030 compared to PRIMES 2007 Baseline levels (% change)	-24	-27	-30	-33	-35	-40
Change in primary energy consumption compared to historical 2005 energy consumption levels (% change)	-16	-20	-23	-26	-29	-34
Final Energy Consumption (Mtoe)	1,081	1,031	987	929	893	825
GHG emmissions with regard to 1990 (% change)	-35	-41	-41	-43	-44	-47
GHG emissions in ETS sectors with regard to 2005 (% change)	-38	-43	-43	-44	-44	-48
GHG emissions in non-ETS sectors with regard to 2005 (%)	-24	-30	-30	-34	-36	-39
RES share in final energy consumption (% change)	24	27	27	28	28	28

Security of supply						
Gas Net Energy Imports Volume (2005=100)	116	110	97	84	78	64
Fossil Fuels Import Bill (for REF2016 and EUCO27) and savings compared to EUCO27 (for other scenarios) (cumulative 2021-30) (billion € '13)	4494	4274	-69.6	-147.3	-199.3	-287.5
Environmental impacts and health						
Carbon intensity of power generation (t of CO2/toe of GIC)	0.20	0.18	0.18	0.18	0.19	0.18
Residential and tertiary GHG emissions compared to 2005 (% change)	-28	-38	-43	-54	-57	-65
Sum of reduction in pollution control costs & health damage costs (billion € '10 /year) compared to EUCO27 [GAINS model]			4.5-8.3	15.2-28.4	19.9.-36.6	30.4-55.9
Competitiveness						
Ratio of energy related costs (inclusive ETS auction payments) to value added in 2030 for energy intensive industries (%)	40.3%	40.8%	40.1%	40.0%	39.8%	40.6%
GDP impacts (billion € '13 for REF2016 and EUCO27 and % change relative to EUCO27 for other scenarios) [E3ME model, no crowding out]	17,928	18,045	0,39	1.45	2.08	4.08
GDP impacts [E3ME model, partial crowding out]	17,928	18,045	0.39	1.30	1.58	2.21
GDP impacts [GEM-E3 model, loan-based]	16,955	16,962	0.26	0.21	0.16	0.06
GDP impacts [GEM-E3 model, self-financing]	16,955	16,907	-0.22	-0.79	-1.35	-2.12
Employment						
Employment impacts (million workplaces for REF2016 and EUCO27 and % change relative to EUCO27 for other scenarios) [E3ME model, no crowding out]	233.1	233.5	0.17	0.68	1.04	2.08
Employment impacts [E3ME model, partial crowding out]	233.1	233.5	0.17	0.63	0.85	1.40
Employment impacts [GEM-E3 model, loan-based]	216.4	216.6	0.20	0.28	0.36	0.56
Employment impacts [GEM-E3 model, self-financing]	216.4	216	-0.18	-0.51	-0.84	-1.36
Electricity, ETS and international fuel price prices						
Net Installed Power Capacity - Thermal power (GWe)	379	369	359	354	352	347
Average Price of Electricity (€ '13/MWh)	158	161	157	158	157	159
ETS carbon price (€ '13/t of CO2-eq)	34	42	27	27	20	14
International oil prices compared to EUCO27 (average annual 2020-2030) (% change) [POLES model]			-0.3%	-0.6%	-1.0%	-1.4%
International gas prices compared to			-1.1%	-2.3%	-3.0%	-4.3%

EUCO27 (average annual 2020-2030) (% change) [POLES model]						
International coal prices compared to EUCO27 (average annual 2020-2030) (% change) [POLES model]			0.02%	0.01%	0.01%	-0.03%
Investments and system cost impacts						
Total energy related investment expenditures (bn €'13) (average annual 2021-30)	938	1036	1115	1232	1324	1565
Energy Purchases (bn €'13) (average annual 2021-30)	1448	1415	1388	1363	1360	1329
Total System Costs (bn €'13) (average annual 2021-30)	1928	1943	1952	1977	2014	2077
Total System Costs (bn €'13) (average annual 2021-50)	2130	2264	2255	2290	2324	2384

Source: PRIMES, GAINS, E3ME, GEM-E3, Eurostat

6.2 Comparison of the policy options for the character of the 2030 target

No preferred option could be identified in the assessment of whether the energy efficiency target for 2030 should be indicative as in 2020, binding on EU level as the RES target for 2030 or binding on national level. As for the 2020 energy efficiency target, this is a political decision. However, as shown in the assessment of the options, all would require a timely review of the progress towards the 2030 target and an effective governance system.

6.3 Comparison of the policy options for the formulation of the 2030 target

With regard to the formulation of the target, the analysis showed that a continuation approach chosen for the 2020 energy efficiency target is the preferred option. Therefore, the 2030 target should be expressed on EU level as maximum primary and final energy consumption in 2030.

The defined energy reduction targets should be translated into reduction targets compared to **2005 as the reference year for energy efficiency** for consistency reasons with the other climate and energy targets. This should be done for both the energy efficiency target 2030 expressed in final and primary energy consumption as this would increase the transparency of the target setting and facilitates the assessment of the targets.

6.4 Comparison of the policy options for Article 7

The proposed policy options for Article 7 are compared with the baseline scenario on the basis of the better regulation criteria: 1) **Effectiveness**: The extent to which proposed options would achieve the objectives; 2) **Efficiency**: Analysis of benefits versus the costs; and 3) **Coherence**: Coherence of each option with the overarching objectives of EU policies.

As regards **effectiveness** - option 1 would fail to achieve the objective of this initiative of attracting private financing and thus securing the economically viable energy savings in view of the 2030 energy efficiency target. By contrast, options 2 and 3 foreseeing the extension of Article 7 to 2030 would attain the objective of attracting private financing for energy efficiency by continuing this key instrument accounting for more than half of energy savings from the EED and thus contributing to the achievement of the energy efficiency target for 2030. Even though option 4 would allow securing the fixed level of the savings, it would go beyond the objectives and thus is deemed not effective in this context. Furthermore, option 3 would be more effective as it aims at simplification of the key requirement of what savings can be attributed to the measures put in place, which was interpreted inconsistently by Member States, in particular for calculating savings from the national building codes. Clarification of this requirement would also contribute to the achievement of the savings by 2020 and secure the needed contribution towards the 2030 target.

In addition, option 3 would be more effective in terms of ensuring greater 'pulling effect' on other EU energy efficiency policies in particular the implementation of the Energy Performance of Buildings Directive (given that the simplified requirement of eligibility would encourage increasing the rate of renovation).

Allowing the counting of on-building renewables under Article 7 would be effective in helping Member States to achieve both energy efficiency and renewable objectives and would also increase coherence between these instruments, it would risk undermining the end-use energy efficiency objective unless the level of ambition is sufficiently high or the contribution of renewables is capped.

In terms of **efficiency**, the evaluation shows that measures taken under the EEOSs are a cost effective way of achieving the existing ambition level of 1.5% per year. Therefore keeping the same level of ambition (1.5% per year) as proposed in policy options 2 and 3 would imply a similar pattern of costs and benefits for the next obligation period if Member States continue with the same instruments as in the current period. Simplification and clarification of the key requirements proposed in option 3, notably that of what savings can be counted (i.e. “additionality”), will facilitate the calculation of savings triggered by renovation of buildings, and it would also reduce the administrative burden for Member States. This option would also be more efficient for utilities as integrated approach would reduce the costs of achieving RES and EE objectives by implementing certain measures at buildings level.

By contrast, there is limited evidence on the efficiency of option 4 - on whether higher rates proposed by this option would not result in increased compliance costs and administrative burden for Member States and obligated parties.

Option 1 would not be coherent with other EU energy and climate policies as it does not foresee the regulatory action to extend the Article 7 after 2020. On the other hand, options 2-4 are **coherent** with the overarching EU policies; however, **option 3** would ensure greater synergies with other policies, notably the EPBD and to some extent the RES Directive.

Table 38: Overview of comparison of the policy options for Article 7

Policy option	effectiveness	efficiency	coherence
Option 1	Limited effectiveness due to limited contribution to the 2030 target as Article 7 expires post 2020 and limited attraction of private capital without regulatory action at EU level	No changes in costs and benefits to obligated parties (in Member States retaining the EEOS or alternative measures)	Not coherent as Article 7 expires after 2020
Option 2	The required level of savings for 2030 would be achieved in view of the overall EE target for 2030	Efficient as mechanisms and structures have already been established by the Member States	Coherent with the EU 2030 energy target and the energy and climate framework for 2030
		No additional costs since 1.5% savings rate retained	Integrated reporting and monitoring under the new governance
Option 3	Effective as the extension would attract the private investment to help securing the required level of savings in view of the overall EE target for 2030	Efficient as mechanisms and structures have already been established by the Member States	Coherent with the EU 2030 energy target and the energy and climate framework for 2030
3.a	Achievement of savings will be facilitated by the simplification of what savings can be attributed to the EPBD	No additional compliance costs and administrative burden since 1.5% savings rate retained	Integrated reporting and monitoring under the new governance
	Increased effectiveness of the EPBD (more renovations) as Member States would be allowed to take full credit	Will facilitate calculation of savings related to building renovation due to the simplification of what savings could be attributed to the EPBD	
3.b	Effective of achieving EE and RES objectives, but would undermine the EE element if the savings rate 1.5 % is retained	Efficient for utilities as integrated approach would reduce the costs of achieving RES and EE objectives by implementing certain measures at buildings level	Coherent in helping achieve both EE and RES objectives
Option 4	Effective as the more ambitious policy would help securing the needed level of savings (and attracting more private capital) in view of the overall EE target for 2030	Limited evidence on whether higher rates would result in increased compliance costs and administrative burden	Coherent with more ambitious EU 2030 energy efficiency target

The principle of **subsidiarity** is respected in all options, given that Member States will retain the same flexibility in terms of selecting their policy mix and the approach to achieve the required savings by 2030, including how the savings are phased over the whole commitment period. The 477 different energy saving measures notified to the Commission so far show that Member States have taken full advantage of this flexibility.

In terms of the **proportionality** principle, the following aspects were assessed:

- Overall, option 1 would not be appropriate in terms of what is necessary to achieve the Union's objectives (energy reduction requirement by 2030) in this policy context, if the current approach of the formulation of the EU energy efficiency target for 2030 is retained which is selected as preferred option (different options on the nature of the target are discussed in chapter 5.2 on the formulation of the target).
- Options 2-3 would be in line with what is necessary to achieve the Union's objectives if the same rate of 1.5% per year is retained also for the new commitment period (2021-2030). By contrast, as indicated above, option 4 would go beyond what is necessary to achieve the Union's objectives. The scope of the elements proposed in options 2 and 3 is limited only to those aspects that require the action by the Union (setting the savings requirement and putting in place the framework to ensure that these savings are achieved in a credible way).
- Options 2 and 3 would allow reaping significant benefits that outweigh the costs to the end-consumers. These are direct benefits (i.e. reduced energy bills thanks to the reduced energy demand) and indirect benefits (higher disposable income and comfort level along with the positive impacts on health etc. and environment, higher asset value of a renovated building, increased productivity for industry, reduced burden on public budget for public administrations, a greener image, etc.) as a result of the energy efficiency improvement measures taken by obligated or participating, entrusted parties. This is especially the case concerning energy poor households[238] as these options allow them to further benefit from the renovation of their buildings that reduces energy bills and thus reduces the energy consumption and also the health risks of consumers affected by energy poverty. Given that both options will retain the same level of flexibility as in the existing approach, the level of costs related to measures will depend on each measure, and its design, as indicated under the section on impacts. By choosing to achieve the 1.5% savings through the EEOS associated costs are placed on end-consumers (who can benefit from economic savings associated with measures that can outweigh their costs) and on economic operators (energy suppliers and distributors who can attract new customers and benefit from increased customer loyalty following the implementation of measures), without placing burden on the public finances. Such evidence is not available though for option 4 which proposes higher savings rates than 1.5% per year.
- The instrument is simple as it proposes amending the existing Directive 2012/27/EU on energy efficiency to ensure the achievement of the required savings under Article 7

[238] It is up to the Member States to identify which end-use sectors and consumers should be targeted under Article 7, but it is well proven in some Member States that energy efficiency measures can help effectively address energy poverty.

and contribute to the energy efficiency target for 2030, and would ensure the effective enforcement of the updated Article 7.

The preferred option is **option 3** thanks to the simplification and clarification elements proposed under sub-option 3.a, which would facilitate the achievement of savings by 2030 if the current pattern is to continue in the next commitment period (in fact, the majority of savings are generated in the buildings sector). This option also would ensure overall clarity in terms of requirements applicable to the energy efficiency obligation schemes and alternative measures.

As regards allowing on–building renewable measures to count towards the Article 7 energy savings requirement, this approach is recommended in principle but would not be appropriate without a firm link to an equivalent and proportioned increase of level of ambition for energy efficiency.

6.5 Comparison of the policy options for Article 9-11

Based on the analysis in Chapter 5.5 the proposed policy options for Article 9-11 are compared using the better regulation criteria.

Table 39: Overview of comparison of the policy options for Articles 9-11

Policy option	**Effectiveness**	**Efficiency**	**coherence**
Option 1 **Non-regulatory.**	Unlikely to significantly contribute to the key objectives (clarification & adjustment to technology /market progress)	Will not impose any new costs but is also unlikely to ensure that the existing framework delivers what was expected, even if administrative efforts by authorities, COM and market players would still be needed.	Unlikely to improve coherence with IEM legislation and proposal in the context of the Market Design Initiative
Option 2 **Clarification/ updating (regulatory)**	Allows clarification of identified issues, as well as promotion of more effective services exploiting remotely readable devices.	Would deliver objective efficiently. Does not entail significantly more (if any at all) net-costs when account is taken of additional savings triggered and reduction in admin. burden related to back-payments and complaints handling, and in any case these would be better directed at clearer ends/purposes (because obligations would be clearer and simpler)	Coherence would be achievable

Overall, the **preferred option is option 2** as it is deemed most likely to deliver on the dual objectives of ensuring clarity and alignment with technological/market realities and does not have major disadvantages compared to option 1. Regulatory stability can be safeguarded by not changing the key provisions relating to deployment of metering and heat cost allocation in the first parts of current EED Article 9(3), and rely on further guidance with respect to the application of cost-effectiveness and technical feasibility conditions in that article.

7 Monitoring and evaluation

7.1 Monitoring the progress towards the 2030 target

To ensure that the agreed EU energy efficiency 2030 target is achieved in 2030 requires a constant monitoring of progress towards this agreed target. This assessment needs to be based on robust indicators which are easy to understand and which measure progress with regard to energy efficiency in a meaningful way.

For many years, Member States have adopted several energy efficiency policies and programmes as demonstrated in the National Energy Efficiency Action Plans (NEEAPs) which were already required under the previous Energy Services Directive 2006/32/EC. The NEEAPs have gradually improved the strategic planning of energy efficiency policies in most of the Member States, including the evaluation of existing policies and informs the European Commission and other Stakeholders of the developments and planned energy efficiency activities in a country.

In its Energy Efficiency Progress report 2015[239], the Commission suggested fifteen indicators to measure the progress of Member States towards their 2020 targets:

1. Long-term indicator: Comparison of primary energy consumption trends 2005-2013 with the rate of decrease that would be needed in 2005-2020 to reach the indicative national target;
2. Long-term indicator: Comparison of final energy consumption trends 2005-2013 with the rate of decrease that would be needed in 2005-2020 to reach the indicative national target;
3. Short-term indicator: 2012 compared to 2013 primary energy consumption;
4. Short-term indicator: 2012 compared to 2013 final energy consumption;
5. Energy intensity indicator for the whole economy 2005-2013;
6. Energy intensity indicator for industry 2005-2013;
7. Final energy consumption per capita 2005-2013;
8. Final energy consumption per m^2 2005-2013;
9. Energy intensity of the service sector 2005-2013;
10. Total final energy consumption of the transport sector 2005-2013;
11. Share of collective passenger transport means 2005-2013;
12. Share of railway and inland waterway freight transport 2005-2013;
13. Heat generated from CHP plants 2005-2013;
14. Transformation output of district heating plants 2005-2013;
15. Transformation output/input ratio for thermal generation 2005-2013.

Those indicators should be used to monitor progress per Member State as the historical data for all indicators (except indicator 8) are available from Eurostat. This enables stakeholders to track progress based on official data.

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[239] COM(2015) 574 final. In addition, the Commission highlighted some of these indicators in its State of the Energy Union report COM(2015) 572 final.

In particular final and primary energy consumption, energy intensity for the economy, industry and the service sector should be one of the main metrics to be monitored in governance process. However, appropriate indicators covering each sector should be monitored in any case.

To better distinguish between energy efficiency improvements and other factors such as a change in the energy mix, in the economic structure, in the economic development, of climate conditions or other factors the Commission will make use of a decomposition analysis. The Commission has supported for many years the Odyssee-Mure project which already gives insight on the impacts of energy efficiency measures. In parallel, the Commission is working on the development of its own decomposition analysis.

The EED includes already provisions that enable the Commission to assess the progress of Member States. Article 24 of the EED requires Member States to publish a National Energy Efficiency Action plan every three years which includes all major developments and planned initiatives with regard to energy efficiency[240]. In addition, Member States need to send an Annual Report to the Commission providing information on the reasons for a constant or increasing energy consumption in the previous year, an update of the mayor legislative and non-legislative measures implemented in the previous year, the renovated and not renovated floor area of public buildings (over $250m^2$) according to Article 5(1) and the achieved energy savings according to Article 7.

In October 2014 – when agreeing on the 2030 Framework for climate and energy – the European Council called for a reliable and transparent governance system meant to guarantee that the EU meets its common climate and energy policy goals. On 19 March 2015, the European Council concluded that the governance system will build on existing building blocks such as national climate programmes, national plans for renewable energy and energy efficiency. As described in chapter 5.3, a strong governance system is needed to ensure that a target expressed as indicative targets or an EU binding target is met. Therefore, the above mentioned reporting requirements will be assessed in more detail in the dedicated governance impact assessment.

The planned governance system will allow the Commission to assess the collective efforts presented in Member States' national plans in view of delivering on the agreed EU 2030 energy efficiency target. If the sum of the national energy efficiency targets of all Member States is not sufficient to achieve the EU energy efficiency 2030 target, additional measures at EU level will be needed to complement national efforts to ensure the target delivery by 2030. This will ensure insufficient collective efforts by Member States will not risk meeting the EU 2030 target on energy efficiency. In addition, to ensure the coherence of energy and climate policies and to avoid potential overlap between climate and energy objectives, changes to energy consumption and their impacts on other energy and climate objectives should be reported and monitored. This will allow the interaction between climate and energy policies to be identified and provide evidence to inform how to address potential issues related to the coherence between such policies. As described in chapter 5.3, a timely review of the progress

[240] More details on the required information can be found in Annex XIV of the EED and in the Guidance for National Energy Efficiency Action Plans SWD(2013) 180 final.

towards the 2030 target is also needed and a corresponding clause should be included in the EED.

7.2 Monitoring and evaluation of Articles 7 and 9-11 of the EED

The 2011 Impact Assessment supporting the EED[241] addressed four aspects of monitoring arrangements:

1. Overall progress on energy savings and expected progress;
2. Progress with individual measures;
3. Review of overall energy efficiency progress in 2013;
4. Legal transposition and implementation of the new Directive/Regulation.

The follow up of these four points was and continues to be Articles 3, 7 and 24 of the Directive contain detailed requirements on reporting and monitoring. The requirement on Member States to notify an Annual Report[242] (and a detailed National Energy Efficiency Action Plan every three years) on progress achieved towards their national energy efficiency targets allowed the Commission to comply with its obligation to assess progress towards the EU's 2020 target, in its 2014 Energy Efficiency Communication[243] in which it concluded that the EU would achieve energy savings of around 18-19% in 2020 rather than the 20% target.
The Member States were required to notify to the Commission already by 5 December 2013 their detailed plans on how they would achieve the savings required under Article 7. Updated notifications were received in 2014 from a number of Member States[244].

The transposition and implementation of the Directive was followed up by the Commission after the transposition deadline of 5 June 2014, at which point only 4 Member States had declared full transposition. Infringement procedures for non-communication are still on-going against 18 Member States, but as the last pieces of transposing legislation are adopted, the cases are being closed. The Commission has also engaged in structured dialogue with the Member States through the EU Pilot tool with respect to their implementation of Article 7, as well holding meetings on the implementation of Article 7 at technical level with all Member States that so requested.

At a more detailed level, Article 7 of the Directive requires Member States to monitor and verify the energy savings they claim and this was explored in the structured dialogue mentioned above and followed up with a specific workshop on sharing of best practice in monitoring and verification.

Under the current proposal, no change is made to the current reporting obligations but as indicated above the new governance initiative will ensure that a transparent and reliable planning, reporting and monitoring system will be put in place, based on integrated national energy and climate plans and streamlined progress reports by Member States regularly

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241 SEC(2011) 779 final.
242 http://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans.
243 COM(2014) 520 final: https://ec.europa.eu/energy/sites/ener/files/documents/2014_eec_communication_adopted_0.pdf.
244 http://ec.europa.eu/energy/en/topics/energy-efficiency-directive/obligation-schemes-and-alternative-measures.

assessing the implementation of national plans along the five dimensions of the Energy Union. This will ease the administrative burden on Member States but still allow the Commission to monitor Member States' progress towards their energy efficiency targets and that of the EU. Indicators of success in line with the preferred option once the proposal is adopted would be:

- Correct transposition and implementation of the changes to the Directive;
- Increased progress towards the national and EU energy efficiency targets;
- Improved ability of consumers to know about their thermal energy consumption;
- Reduction of administrative burden on Member States and improved reporting on the savings claimed under Article 7 by the Member States.

Member States are required to report annual energy efficiency statistics, allowing the Commission to evaluate their progress towards their national energy efficiency targets, as well as collectively towards the EU target.

The achievement of the operational objectives will be monitored in a number of ways. The amending Directive will contain a transposition deadline and the Commission will check whether the Member States have notified their legal transposition measures as required. The Commission will also examine the conformity of the national measures with the new requirements under the EED. If a Member State has not transposed the changes to the EED, or not done so fully, or has done so incorrectly, the Commission will initiate a dialogue with the Member State in question, which can result in infringement procedures.

Under the new Energy Union governance system Member States will have to submit to the Commission Integrated National Energy and Climate Plans which will allow the Commission to track their progress towards greater energy efficiency.

Monitoring of progress under the new governance system will be key to track progress on how Member States achieve their national energy savings requirements due by the end of 2030. The Commission's role is therefore incremental to continue assisting Member States in their implementation by providing guidance to Member States on the regulatory framework and fostering exchange of best practice via workshops and other fora.

The information received from the Member States will allow the Commission to assess what energy savings Member States claim under Article 7 of the EED. The changes proposed give more prominence to monitoring and checking of savings by the Member States, both in terms of materiality (was the policy measure actually responsible for the energy savings), eligibility (are the savings additional to what would have happened anyway?) and calculation (how has double counting been avoided, on what has the "lifetime" of the measure been based etc.).

In terms of improving the ability of consumers to know about their thermal energy consumption, a first key indicator would one which indicates how many people in multi-apartment buildings actually have meters or cost allocators in accordance with the existing requirements of Article 9(3). The shares of buildings/building units equipped with individual and collective metering respectively is one of the indicators selected for the future *EU Building Stock Observatory*, so as and when data becomes available for this indicator. This will provide useful information on the matters analysed here. Moreover, industry associations of providers of heat cost allocation services may be requested to help provide data on the amount of buildings serviced and the kind of service provided, including possibly the frequency with which consumption is provided to consumers, the share of remotely read dwellings as well as samples of the billing information provided.

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SWD(2016) 405 final

PART 2/3

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the document

Proposal for a Directive of the European Parliament and of the Council amending Directive 2012/27/EU on Energy Efficiency

{COM(2016) 761 final}
{SWD(2016) 406 final}

Table of Contents of the Annexes

1. Annex - Procedural issues

1.1 Lead DG and associated DGs

The preparation of the Impact Assessment started at the end of 2015. The inter-service group meetings on this document were held on 27 April 2016. The lead Directorate-General is DG Energy. The services invited to the ISG were Agriculture and Rural Development; Budget; Communications Networks, Content and Technology; Climate Action; Competition; Economic and Financial Affairs; Employment, Social Affairs and Inclusion; Enterprise and Industry; Environment; Eurostat; Justice; Joint Research Centre; Mobility and Transport; Regional and Urban Policy; RTD and Secretariat-General.

The Impact Assessment is supported by:

- Analysis of impacts on the energy system using the PRIMES partial equilibrium model, developed and used by the National Technical University of Athens (NTUA). A number of energy efficiency scenarios were modelled to analyse the impacts of different level of energy efficiency in 2030;
- Macroeconomic modelling using GEM-E3, a general equilibrium model, maintained and used by NTUA; and macroeconomic modelling using E3MG, a macro-econometric model run by Cambridge Econometrics – both building on PRIMES results;
- Analysis of air quality impacts by the GAINS model operated by IIASA – building on PRIMES results.
- Industrial Energy Efficiency Model (IEEM) operated by ICF.
- The POLES model operated by the JRC to quantify impacts on international fuel prices.

This energy efficiency package forms part of a full set of 2016 proposals for climate and energy policy under the Energy Union. It is assumed that all the other policies are to be implemented in line with the conclusions of the European Council of October 2014.

1.2 Consultation of the Regulatory Scrutiny Board

The Regulatory Scrutiny Board of the European Commission received the draft impact assessment report on 3 May 2016, and issued its positive opinion on 7 June 2016. The Regulatory Scrutiny Board made several recommendations. These are taken into account in this version of this impact assessment report as follows:

- The separate impact assessment reports on Articles 3 and 7 and 9-11 have been merged into a single document. The issue of metering and billing, in so far as electricity and gas is concerned, is referred to the upcoming impact assessment on market design and the present report only considers policy options in respect of thermal energy, regulated solely in the EED.
- It has been clarified (in Annex 3) how energy efficiency achievements contribute to the Effort Sharing Decision.
- The potential contribution of existing energy efficiency policies to the 2020 and 2030 target has been expanded and clarified in chapter 1.4.1 and chapter 5.6.
- More detail has been provided on the key policy areas for the achievement of the 2020 and 2030 targets in chapter1.4.1.
- The discussion of the relationship between the appropriate mix of policy measures and the energy efficiency target for 2030 has been expanded, in chapter 5.6.

- Chapter 4.1 describes in more detail how the policy mixes considered in this Impact Assessment represent a cost-effective approach.
- A discussion on the trade-offs between imposing targets and unified measures and the appropriate level of cost efficiency and flexibility for Member States has been developed in chapter 5.2.
- Energy poverty was further assessed in chapters **Error! Reference source not found.**
- The link between the EU target and the 1.5 % energy savings requirement of Article 7 of the EED has been explained further in chapter 5.4 and 5.6, and it has been made clear in chapter 5.2 that binding measures of this type would need to be looked at again if it was decided to adopt binding national energy efficiency targets.
- An analysis of the policy option of an energy intensity target for 2030, which was raised by stakeholders, has been added in chapter 5.3.
- Chapters 5.1.2, 5.1.5, 5.1.6 and Annex 8 have been adapted to better show the required levels of investments and to explain how the required investments for the different scenarios would need to be generated.
- Chapter 5.1.2 has been clarified to better describe possible crowding out effects.
- It has been clarified that the EED does not legally require the installation of smart meters.
- A discussion of sensitivities has been added in Annex 4.
- More explanation on monitoring and evaluation has been given in chapter 7.

The Board asked for the Reference scenario to be used as the baseline against which the impact of energy efficiency policy options would be assessed. The results of the Reference scenario 2016 are indeed consistenly reported in the impact assessment. A specific baseline assuming no additional energy efficiency efforts and policies while achieving the other 2030 targets for GHG and RES was not modelled. However, since all the policy scenarios need to include – in addition to energy efficiency policies – the 2030 greenhouse gas (GHG) and renewable energy policies as agreed by the European Council in October 2014, the EUCO27 scenario has been chosen as a baseline to assess the impacts of energy efficiency policies only. The reason for choosing EUCO27 baseline is explained in chapter 4.1.1 and in Annex 4 of the impact assessment accompanying the renewable energy initiative.

1.3 Public consultation[1]

A public consultation was launched on 4 November 2015 to collect views from stakeholders via on-line survey for the review of the Energy Efficiency Directive. It accepted responses for over 12 weeks and closed on 29 January 2016.. It focused on certain aspects of the EED, namely Articles 1, 3, 6, 7, 9-11, 20 and 24 , as outlined in the review's Evaluation and Inception Impact Assessment Roadmaps[2]. In line with the Better Regulation requirements and to assure transparency, submissions were published on the consultation website, unless confidentiality was requested[3].

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[1] Full report available on DG ENER website: http://ec.europa.eu/energy/en/consultations/consultation-review-directive-201227eu-energy-efficiency.

[2] http://ec.europa.eu/smart-regulation/roadmaps/docs/2015_ener_062_evaluation_energy_efficiency_eed_en.pdf.

[3] https://ec.europa.eu/energy/en/consultations/consultation-review-directive-201227eu-energy-efficiency.

The online survey was divided into two parts, the first covered more general questions, the second covered more technical ones (on Articles 6 and 7). Respondents were invited to answer all questions deemed relevant. A functional email address was created so as to assure additional guidance for participants, if required. The introduction of the consultation was translated into all 24 EU languages, which were published on the consultation website. To assure transparency both preliminary contributions as of 26 January 2016, and final contributions as of 29 January 2016 were made publicly available as Excel files[4]. The survey received 332 submissions, and an additional 69 documents were submitted to the functional email address, either complementary to or *in lieu* of survey-based submissions. The greatest number of contributions were submitted by industry associations (140), followed by private companies (47) and NGOs (33). A total of 18 central public authorities submitted contributions, including 17 from within the EEA. Of the 17 central public authorities from within the EU, 4 requested to remain anonymous. The remaining 13, all of which represented Member States, were from Austria, Belgium, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Hungary, Latvia, Lithuania, the Netherlands and Slovakia.

Main findings on the general questions related to the EED and the energy efficiency target 20303:

- Member States expressed the view that the EED, ETS and the ESD are instruments that work together to meet the EU's overall energy and climate objectives. It was seen by one Member State as positive that the EED had led to additional energy efficiency actions and to establishing a common framework for energy efficiency at EU level. Views highlighted the complexity of the existing legislation, and some Member States expressed a view that there were benefits to be gained from possible simplifications of the legislation. Several Member States underlined the centrality of articles 3, 7 and 24, and in combination, for the working of the Directive. The issue was raised in one case that the Member States have had little time to implement the EED and that it would have been an advantage to have more time and in consequence progress with respect to implementation was partial.
- One Member State raised the question of the benefits of the EED for driving energy savings compared to the Energy Services Directive. In another case a Member State expressed the view that to avoid situations where Member States curtail efforts to improve energy efficiency because they consume less energy than planned (for instance due to exogenous economic shocks or structural changes in the economy), it could be considered to make energy efficiency efforts mandatory regardless of the economic situation of a country.
- The view was expressed by one Member State that legislation should take into consideration both differences across Member States in terms of past experience with Energy Efficiency Obligation Schemes and the same yearly saving requirement may not be appropriate for all Member States.
- One Member States saw the EED's main contribution to be to the achievement of wider GHG reduction target. This Member State expressed the view that the importance that reductions in GHG emissions from non-energy activities due to changes in the production chain were not taken into proper consideration in this context.

4 https://ec.europa.eu/energy/en/consultations/consultation-review-directive-201227eu-energy-efficiency.

- Most stakeholders agreed that the EED has successfully established a comprehensive energy efficiency framework for the EU. Several also expressed the view that the EED has been a key driver of initiatives in Member States, as evidenced, for example, by the extent to which Energy Efficiency Obligation Schemes (EEOSs) have been implemented across the Union. Respondents also underlined, however, that the present framework remains complex, and that Member States require additional guidance. Respondents requested the Commission to focus more on the transport sector, monitor Member States' progress, and, if necessary, sanction non-compliance.
- 31% of the respondents shared the view that the 2030 target should be expressed as both primary and final energy consumption, versus 23% who wanted it to be presented in terms of energy intensity. A large majority (73%) shared the view that energy consumption should be targeted irrespective of its source (i.e. that savings in renewable energy, for example, should continue to be taken into account).
- A variety of views were expressed on which factors should be taken into account for determining the target for 2030.
    - Several stakeholders expressed the view that when setting a new target for 2030 one should take into considerations that the current framework based on an indicative EU-level target and a mix of binding EU measures and national action had proved to be effective in reaching the 2020 EU objectives.
    - Many stakeholders expressed that the target should be ambitious.
        - Some saw an ambitious energy target as a cost-effective means to contribute to the achievement of the energy and climate goals of the EU.
        - Several stakeholders highlighted the agreement at the COP21. The EU needs to live up to the Paris agreement and increase its climate and energy targets for 2030 accordingly.
        - Representatives from industry that supported an ambitious goal for 2030 underlined the importance of a commitment at EU level to competitiveness.
        - It was also expressed that the current low ETS prices increased the need for a high energy efficiency target, to achieve all the goals the EU energy and climate policy.
    - A further argument was that many Member States will not of their own accord go beyond the minimum European legislation, and the EU should therefore set a sufficiently ambitious target to be confident of meeting its goals. In this regard some stakeholders highlighted the varying intensity of national implementation across Member States. In one instance the stakeholder referred to interviewed experts who claimed that the EED had been the sole driver for the introduction of energy efficiency measures in certain Member States.
    - Some stakeholders' experience with Member States' implementation of measures to reach the current EU 28 2020 target is that an overall non-binding European efficiency target will not be met unless the targets and associated measures set down in EU legislation are not sufficiently ambitious from the beginning.
    - A recurring theme from some stakeholders was that in their view energy efficiency is a policy that has general welfare benefits through contributing to value added, investment and jobs. As the energy efficiency gap is considerable there is an associated potential for substantial gains.
    - Interaction with other goals: Several stakeholders expressed the importance of policy coherence with the other energy and climate goals.
        - One factor that should be taken into account when setting an energy efficiency target is that barriers to energy efficiency in part cannot be effectively dealt with by market instruments. An energy efficiency target

        complements the ETS. On the other hand, other stakeholders' view was there was room for reducing policy overlap between ETS and EE.
        - The EED should be seen as a tool to help achieving the goals of the effort sharing decision and there is a potential for positive synergy which could be further developed.
        - Interaction with RES target: one should take into consideration that it will be easier to achieve the RES target by reducing final energy consumption.
    - Stakeholders in general agreed that efficiency was an important criterion for setting the target.
    - The target is also seen as important to raise awareness among stakeholders across Europe.
    - Representatives from industry focused among other things on cost-effectiveness when designing the target, and in particular on the importance for industry's competitiveness of minimising the administrative burden.
    - A view expressed by several stakeholders was that the European Commission should propose a target that takes into consideration the EU principles of subsidiarity and proportionality. Furthermore, when defining a target allowances should be made for differences between Member States. The main rationale for energy efficiency can vary between Member States with a different emphasis on competitiveness, security of supply and reduced impact on the climate and the environment. Some others focused on the interactions between the target and the measures necessary to reach it, and that the design of the target would to some extent determine the mix of cost-effective measures.
    - Stakeholders highlighted also that the target set should serve to drive national energy efficiency policies and to provide a good mix between providing flexibility for Member States and the need to achieve the target.

Main findings on the stakeholder's views related to Article 7 (energy savings obligations) and Articles 9-11 (metering and billing) of the EED:

- *Article 7: Energy Efficiency Obligation Schemes (EEOSs)*

A large majority (68%) thought that Article 7 is an effective instrument for achieving final energy savings, versus 32% who opposed this view. Article 7 was seen as significantly stimulating the European energy efficiency service market, while simultaneously granting Member States valuable legislative flexibility. The three main barriers identified by participants to implementing Article 7 effectively were:

- A 'limited timeframe (2014-2020) that makes it hard to attract investment for long term measures' (115);
- A 'high administrative burden' associated with certain measures (113); and
- 'Ensuring sound and independent monitoring and verification of energy savings' (104).

Amongst those who favoured the extension of the policy, several argued that as savings could only be calculated up to 2020, the current scheme would discourage long-term measures towards the end of the legislative period. This contrasted with the assessment of 71% who thought that most measures introduced to-date under Article 7 have long lifetimes, and corresponded with the view of 63% who stated that the policy should continue beyond 2020.

More than half (57%) disagreed (39%) or even strongly disagreed (18%), however, that the current 1.5% energy savings target is adequate, versus 26% who either agreed (23%) or strongly agreed (3%). Some explained that savings could not increase linearly, and that logarithmic – that is, marginally decreasing gains – would be more realistic. Others made the case that energy suppliers are the wrong target group, as they neither primarily generate nor consume energy. Yet others pointed out that a 1.5% target is only marginally above the 1% natural rate of energy efficiency gains, and that the target would have to be more ambitious to comply with the new climate goals ratified during the 21st Conference of the Parties of the United Nations Framework Convention on Climate Change (COP21) to reduce global greenhouse gas emissions and stabilise global warming at 1.5-2 °C.

Participants were divided on whether EEOSs should have specific rules for vulnerable consumers, with 35% opposing such rules and 30% being in favour of them.

54% either strongly disagreed (36%) or disagreed (18%) that the option of establishing an EU-wide 'white certificate' scheme for energy efficiency gains should be considered for the post-2020 period; 25% had no view, while 21% were in favour of such a scheme.

- *Articles 9-11: Metering and billing*

43% shared the view that the EED's provisions on metering and billing are sufficient to guarantee consumers easily accessible, sufficiently frequent, detailed and understandable information on their energy consumption; 32% opposed this view and 25% had no specific view on this. Nearly half (47%) did not think that conditions such as technical feasibility or cost effectiveness should be harmonised across the EU, as such conditions would vary too greatly between Member States. The greatest obstacles identified to a large scale roll out of smart meters were cost effectiveness and consumer acceptance. Regarding the latter, many noted that smart meters would raise a number of data protection and cyber security issues. One Member State was cited several times as an example of how to address such concerns: citizens are entitled to 'opt out' of the smart meter scheme, but if they withdraw they may not track their energy consumption online. They would nevertheless be required to provide accurate data to their respective utility.

1.4 Overview of Member States' positions on Article 7 (to Public Consultation)

17 Member States (MS) including Norway (referred to as a MS for the case of simplification in the following) expressed a view on Article 7 in the Public Consultation relating to the review of the EED. Three of these MS asked not to be identified.

General effectiveness of the provision

Out of 17 MS that participated in the public consultation relating to article 7, eleven MS expressed an explicit opinion on the effectiveness of Article 7. Six MS considered the Article to be effective and five Member States considered that Article 7 is not an effective instrument to achieve final energy savings.

Six other MS considered Article 7 either to be of some limited effectiveness or refrained from answering the question. One MS, while not expressing a stance on the general effectiveness of Article 7, estimates that the current rules exclude certain effective measures, while allowing ineffective ones. Another MS considers specifically Energy Efficiency Obligation Systems (EEOS) to be an effective tools.

Potential benefits of EEOS

Respondents were asked to express agreement / disagreement on a list of defined potential benefits of EEOS.

Out of 12 Member States that expressed their opinion, most consider EEOS to have the following potential benefits:

- Better awareness of energy efficiency potential by consumers (10 MS agree, 2 MS disagree)
- Development of new financial models (8 MS agree, 2 MS disagree)
- Stimulation of energy efficient potential of buildings (7 MS agree, 3 MS disagree)
- Improved business and administrative environment for upcoming innovative services (7 MS agree, 2 MS disagree).

Furthermore, a relative majority of MS that responded considers EEOS to have the following potential benefits

- Increased competitiveness in energy markets (5 MS agree, 3 MS disagree)
- Better relationship between energy suppliers, distributors and customers (5 agree, 3 MS disagree).

In contrast, a relative majority the of Member States that responded do **not** share the view that EEOS have the following benefits:

- Lower energy bills for consumers (6 MS disagree, 5 MS agree)
- Aggregation of small – scale investments (5 MS disagree, 2 MS agree)
- Lower energy generation (and transmission) costs for utilities (4 MS disagree, 3 MS agree).

In the free text comments, one MS pointed to the favourable contribution of EEOS to GHG Emission Reductions.

One MS, while considering that EEOS generally lowered consumers' energy costs and tend to cost suppliers less than originally anticipated, noted the regressive effect of EEOs costs on consumers compared to taxes: The MS noted that low income households would contribute more financially to an EEOS obligation scheme than to tax-financed efficiency measures.

Similarly, another MS expressed views about negative impact of having an EEOS which would translate into higher energy prices, and sees the suppliers' claim that EEOSs would lead to increased bills to consumers as a challenge.

Nine MS consider that most measures triggered by EEOS have long lifetimes and will have an impact beyond 2020 and two MS think that *some* measures have such a long term-impact. The long – term impact of measures relating to buildings was highlighted by some MS in their free text answer.

Eight MS think it is inappropriate to design a system where EEOs include elements for increasing the share of renewables. However one MS is in favour and one expresses an intermediate view.

Major barriers to implementing Article 7[5]

Most participating MS identified as major challenges/barriers to implementing Article 7:

- High administrative burden[6]
- Developing the calculation methodology in line with the requirements of Article V[7]
- Ensuring sound and independent monitoring and verification of energy savings[8]

Potential for simplification

Eleven out of the 16 MS that responded to the public consultation considered the current rules related to Article 7 in their free text reply *generally* as too complex and/or posing a high administrative burden and mostly asked for the simplification of the rules and two further MS ask for simple, easily understandable rules for any future amendments to be adopted.

Six MS highlighted the administrative burden/complexity and costs specifically related to *Monitoring and Verification;* one MS pointed to the administrative burden for enterprises.

Three MS called in their free text contributions explicitly to reduce/streamline the reporting burden of M S and three MS consider that the calculation requirements applying to savings is too complex. MS should have more leeway to calculate savings (three MS). One MS regrets the absence of a *standardised calculation tool* and another MS suggested introducing a reporting and monitoring tool relating to Eurostat data. Three Ms consider Article 7 or pivotal provisions thereof to be unclear. However, with regard to the provisions of Annex V, three other MS see no need for clarification.

In contrast, clarification was asked on:

- Explaining better materiality (2 MS)
- Which price elasticities can be used (one MS)
- How to deal with confidential information from enterprises which needs to be reported to the Commission (one MS)
- More guidance on how to calculate savings (two MS), in particular scaled savings and savings from soft measures (one MS).
- Which renewables are eligible (one MS)

More flexibility vs harmonisation

Five MS considered in their free text comments the architecture of Article 7 overall as too restrictive, and ask for more flexibility for Member States to achieve their savings and one MS asks to be able to use the tools they have already in place. One MS considers the rules on eligibility of measures already now as too restrictive. One MS asks that the current degree of flexibility is maintained.

In their free text replies, two MS warn against limiting the number of eligible alternative measures in the future.

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[5] The public consultation ask to tick up to five options for identifying main challenges or barriers to implanting Article 7 in the respective countries.

[6] 8 out of 13 MS

[7] 10 out of 13 MS

[8] 10 out of 13 MS

Participants were asked to express their views on the harmonisation of a defined list of the requirements of Article 7 in order to allow more consistent implementation in Member States. The 13 MS expressed rather divergent views on harmonisation. Four MS are against any harmonisation of the requirements indicated above. In contrast three three MS asked for a harmonisation of all indicated requirements.

All in all Member States' Pro and Cons for more harmonisation are as indicated below:

- Calculation methods (6 MS yes, 7 MS no)
- Materiality definition (7 MS yes, 6 MS no)
- Additionality (7 MS yes, MS 6 no)
- Lifetimes (7 MS yes, 5 MS no)
- Price demand elasticities for taxation measures in real terms (6 MS yes, 5 MS no)
- Indicative list of eligible energy saving measures (5 MS yes, 5 MS no)
- Monitoring and verification procedures (5 MS yes, 8 MS no)
- Reporting (6 MS yes, 6 MS no)

Clarifying and expanding the scope of the eligible measures beyond end-user savings

Three out of 12 MS see no need to clarify the scope of the eligible measures, one MS fears that a clarification would curtail the flexibility of MS. However, nine out of 12 Member States ask for expanding the scope of admissible measures beyond end-user savings with regard to the following measures:

- Measures to switch fossil fuel heating and cooling fully or partially to renewable energy (e.g. through individual appliances, district heating and cooling, centralised distributed units supplying larger building complexes or groups of buildings) (8 MS)
- Savings from energy management systems (7 MS)
- Primary energy savings from the utilisation and recovery of waste heat (e.g. in district networks) (7 MS)
- Measures to increase efficiency of district network infrastructure and generation, including through thermal storage facilities (7 MS)
- Measures to make energy generation from small scale generation more efficient, below the ETS threshold (7 MS)
- Switch to self-consumption, auto-generation and energy positive buildings (7 MS)
- Participation in demand response, including from providing storage capacities (3 MS)

Furthermore, MS ask in the free text replies to expand the scope of eligible measures to:

- All measures (one MS),
- To more measures (one MS)
- Use of electric vehicles (one MS)
- All on-site generation of energy (one MS)
- Use of renewables (one MS)

Each of the expansion of eligible measures is asked for by one Member State.

Request to relax the rule on the 'additionality' requirement

Nine MS see in their free text comments the requirement of additionality critically, i.e. the requirement that allows measures only to be counted if they are not demanded by existing EU legislation.

Of these, three Member States ask explicitly to remove the additionality requirement completely); two other MS want to remove it with regard to buildings and products. Two MS are concerned with the additionality specifically relating to the EPBD and ask for a "Review on the interaction of EPBD and EED" (one MS) or suggest merging both directives (another MS). Three MS consider the rules on additionality generally to be unclear. In contrast, two MS see positive synergies between the EED and EPBD.

Review the concept of Materiality

In their respective free text comments, five MS ask to review or clarify the concept of materiality, one MS suggests to abandon the materiality criterion altogether.

Is the 1.5% savings rate in Article 7 adequate?

Seven MS suggest that the current level of energy savings of 1.5% defined in Article 7 is adequate. Of these, 3 MS ask not increase the ambition of the savings requirement.

Four MS consider the savings requirement to be too high. Among these, the following comments were made:

- National GDP and growth should be taken into account for target definition;
- Climatic conditions should be taken into account;
- The savings requirement of 1.5% used to be ok at a time when the Directive was agreed upon but has turned out to be too ambitious;

Four MS expressed the following intermediate views, such as:

- The savings requirement might be considered to be appropriate but is too high in the light of the Commission's interpretation of the rules.
- The savings requirement should be defined at national level
- One MS ticked the box for considering the savings requirement to be inappropriate, but considered in its free text response the target to be at the upper [acceptable] limit.
- Another MS expressed and ambiguous view

Lifting the Sunset Clause under Article 7

15 Member States expressed views on continuing the current framework of Article 7 beyond 2020 with a view of the new energy efficiency target of 2030 ("Lifting the sunset clause").

Four Member States express themselves in favour of lifting the sunset clause: The following views were put forward:

- The size of the reduction should depend on the overall indicative target and the contributions from other energy efficiency measures;
- Payback time should be taken into account when setting savings requirement;
- The possibility of excluding sales in transport from the baseline should be excluded;
- All exemptions under Article 7 (2) should be excluded;
- Possibility for banking and borrowing energy savings should be kept.
- The savings requirement should be decided in light of the Commission’s Impact Assessment
-

Seven MS are against lifting the sunset clause; and another MS is reluctant to support lifting the clause.

Among these MS the following comments were made

- Indicative target for 2030 sufficient, as Article 7 is complex and burdensome.
    - However, if sunset clause if lifted, eligible measures should not be further restricted.
- The Council Conclusions of 2014 agreement stated that there will not be nationally binding targets: lifting the sunset clause would constitute such a target.
- Better to set targets at sector level, while taking macroeconomic indicators into account.
- Reluctant to lift the clause, due to restrictive current rules of energy savings calculations, lack of promotion of cost-effective measures and insufficient focus on GHG reductions

<u>Three MS express intermediate views.</u>

- Lifting of the sunset clause to be discussed, in particular in the view of the bureaucratic burden;
- Level of ambition to be reviewed in the light of lower energy prices and the positive impact of efficiency measures already in place;
- Another MS ticked the box of being not in favour of lifting the sunset clause. On the other hand this MS but expressed in its free text reply mostly a preference for a continuation of the status quo: MS should continue to have the [current] choice between EEOS and alternative measures, which allows MS to have the most efficient mix of energy efficiency measures.

<u>White Certificates, Transfer of savings between MS</u>

Two MS expressed a preference for considering the introduction of an EU-wide white Certificate Scheme, eight MS are against, three MS express intermediate or indifferent views.

<u>Retail Price regulation</u>

In its free text comment, one MS emphasizes the adverse effect of price regulation on energy efficiency.

1.5 General Issues Raised with Member States in the EU Pilots on Article 7

This chapter gives a brief overview of the issues clarified with Member States related to the implementation of Article 7 since 2014.

1. Eligibility/materiality:

- do measures have to be primarily aimed at energy efficiency?
- or is it sufficient that there is a (measurable) energy efficiency gain?
- do the measures have to result in a reduction of sales of energy to final customers?
- free riders – how do Member States work out what would have happened anyway?
- How are lifetimes proved?

2. Additionality:

- What should be considered the "EU Norm" under the EPBD?
- how does additionality work in relation to directly applicable ecodesign measures?
- How do MS show that a measure speeded up the up-take of a compulsory norm?

3. Monitoring and verification:

- What is a "statistically significant proportion and representative sample"?

- How is the independence of the checking system ensured?

4. Calculation of saving requirements

- Discrepancies with Eurostat data
- Use of exemptions leading to more than 25% reduction
- Own energy use
- Art 7(2)d) – how to show that "early actions" continue to have an effect after 2020?
- How to avoid double counting?
- Article 7(7)c) and "banking and borrowing"

5. Calculation of savings:

- Final/primary energy?
- Use of elasticities in taxation measures
- Use of climatic variations

6. Energy Efficiency Obligation Schemes

- Relationship with National Energy Efficiency Fund?
- Publication of savings of obligated parties
- Social aims?
- Are savings by 3rd parties allowed?

7. Alternative measures:

- How to prove energy savings from "behavioural" measures such as information campaigns?
- What if progress towards savings is not satisfactory?
- How to ensure that only one party claims the savings?
- How does the requirement to have penalties work in relation to alternative measures set in place by the State? Should it punish itself?

1.6 Other consultations

More targeted consultation with Member States took place through the EED Committee of 2 February 2016 and Concerted Action meeting of 17-18 March 2016.

Further stakeholder inputs were collected through the organisation of thematic workshops, notably on Monitoring and Verification (of 3 February) and on trading of energy savings under Article 7 (of 29 February).

Findings of the workshop on trading of energy savings under Article 7 (29 February):

12 Member States and 15 stakeholders attended the workshop. The discussion was preceded by presentations on the existing national White Certificate Schemes in France, Italy, Ireland, and on Energy Efficiency Obligations in some US States.

Overall, no support was expressed as regards establishing an EU trading system for energy savings or an EU White Certificates Scheme at this stage. The following arguments were mentioned by the participants as major impediments for cross-border trade:

  - Complexity of rules that a EU-wide trading system would imply;

- The divergent and incompatible national Monitoring and Verification systems to account properly the traded savings, which would hinder a cross- border clearing of trades;
- Incompatibility of specific national policy objectives and
- Political necessity to see national savings efforts translated in material efficiency gains at a national level (dilemma between - who pays and who benefits from the trading).

Conclusions of the stakeholder event on the EED Review (14 March 2016):

A dedicated stakeholder event on the policy options took place on 14 March 2016 and the discussion fed into the impact assessment process. Some 282 representatives from Member States and Stakeholders' European umbrella organisations gathered on 14 March 2016 in Brussels to react to the evaluations, problem definitions, and policy options raised in the framework of the review processes of the Energy Efficiency Directive (EED) and of the Energy Performance of Buildings Directive (EPBD). The event was organised as a consultation in the framework of the Better Regulation Initiative.

As regards the energy efficiency target for 2030, there was considerable interest from stakeholders in the target and many stakeholders expressed views on both design, in particular whether it should be a binding or non-binding target and the level of ambition for 2030.

Analysis of energy efficiency levels up to 40% in 2030 was supported by the majority of stakeholders who expressed their views, while views differed with regard to the binding character of the 2030 target and on the expression of the target in terms of final and/or primary energy consumption. Some of the participants asked for an explicit analysis of options in case indicative targets or national plans for 2030 would not deliver the required level of energy savings in 2030. In addition, it was highlighted that the EED framework needs to be coherent with the ETS, the Effort Sharing Decision and the RES Directive.

On Article 7 on energy efficiency obligation schemes stakeholders did not express the view that the clause should not be extended. Stakeholders expressed different views on whether the scope should be broadened to also take into account savings from additional use of renewables.

Concerning Articles 9 to 11 on metering and billing, there was considerable response from the stakeholders on these articles, with discussion also focusing on interaction with the internal energy market. Views from stakeholders varied on the need to re-open the articles.

2 Annex - Who is affected?

2.1 Article 1 and 3

The entire economy, including households, the public sector and various economic sectors are affected by the above mentioned problem:

- Member States authorities at national, regional and local levels, as they are responsible for planning and implementing necessary energy efficiency policy and legislation. Member States can benefit from lower energy bills, economic growth, employment impacts and improved energy security of supply.
- Households, in particular low income households, might be affected if remaining cost-efficient energy saving potentials are not exploited as high energy bills affect their well-being e.g. if those households cannot keep their houses warm or cool in the summer.
- European companies might improve their competitiveness by further developing energy efficiency, particularly as it better protects them against energy price differentials. This also holds for small and medium size industries which have high share of energy costs related to total production costs and would benefit from investing in energy efficiency to lower their energy purchasing costs.
- Producers of energy efficient equipment and appliances will benefit from increased demand for their products, while energy suppliers will be affected by reduced demand.
- European citizens should benefitfrom a better environment.

Stakeholders outside the EU are also affected as climate change is a global problem, which goes beyond the boundaries of the European Union. In this context, ambitious and successful EU energy policies can be replicated by third countries.

2.2 Article 7 and 9-11

- Member States' authorities at national, regional and local levels, as they are responsible for planning and implementing necessary energy efficiency policy and legislation.
- Consumers who could benefit from energy savings and reduced energy bills as a result of lower energy consumption and accurate, clearer additional billing and consumption information.
- Industry in general, which equally benefits from reduced energy costs.
- Non-SMEs as they are subject to energy audits every four years.
- SMEs as Member States are encouraged to offer voluntary energy audits or energy management systems to them.
- Obligated parties (energy distributors or retail energy sales companies), participating and entrusted parties (enterprises or public authorities involved in carrying out the energy efficiency measures) affected by Article 7 of the EED.
- Investors who may obtain greater investment security and stable investment return.
- Other financial actors, such as commercial banks, which may benefit from increased business opportunities.

Table 1: An overview of the stakeholder groups affected by this initiative

Stakeholder group	Article 1 and 3	Article 7	Articles 9-11
Member States authorities	Will be responsible for planning and implementing necessary energy efficiency policy to achieve the energy efficiency target 2030, they can benefit from lower energy bills, economic growth, employment impacts and improved energy security of supply etc.	Will be responsible for planning and implementing necessary energy efficiency policy in view of the next obligation period; Will benefit from the coherence and complementarity with the other legislation as Article 7, e.g. will contribute to the achievement of more ambitious GHG emission reduction targets under the Effort Sharing Decision for 2030;	Will be responsible for planning and implementing necessary energy efficiency policy.
Obligated parties (energy distributors or retail energy sales companies), and participating and entrusted parties (enterprises or public authorities)	X	Will be carrying out the energy efficiency measures and work with the consumers, including auditing the savings ensuring reporting to the implementing public authority; Will benefit from lower administrative burden as a result of simplification of what savings can be counted under Article 7, especially those targeting the energy efficiency renovations; Obligated parties will benefit from the improved reputation and better relationship with consumers thanks to consumer oriented business approach; Utilities will benefit from lower energy generation (and transmission) costs for the utilities	District heating/cooling companies as well as owners or managers of multi-apartment/purpose buildings or service providers will have to be involved in implementing the new billing and metering rules and adjust their processes.
Consumers	With an ambitious energy efficiency commitment of Member States, consumers benefit from an improved energy efficiency	Consumers will bear some costs of energy efficiency measures, and will benefit from reduced energy bills as a result of energy efficiency improvement measures and	Consumers of centrally provided thermal energy will benefit from more frequent, accurate, clearer additional billing and

	framework/measures which will help consumers to bear the costs of the energy efficiency measures, and they will benefit from the reduced energy bills, higher living standards, health benefits etc.	lower energy consumption; The energy poor will benefit from the continued policy as Art. 7 targets mostly energy efficiency renovations of existing buildings. Consumers will benefit from increased awareness of the benefits of energy efficiency, and possibly better – customer oriented service by the energy providers.	consumption information.
Businesses including SMEs	Will benefit from increased business opportunities and innovation with an ambitious 2030 energy efficiency target	Will benefit from increased business opportunities and innovation (energy performance contracting) and competitiveness related to the more developed energy services market; Demand for energy services would require more skills and jobs to perform the renovations and installation of the energy efficiency measures.	Will benefit from increased business opportunities and innovation.
Investors and financial actors	Play a crucial role to provide smart financing solutions for energy efficiency investments in order to exploit energy efficiency potentials to achieve the 2030 energy efficiency target	Investors will have greater investment security and stable investment return and may benefit from increased business opportunities; Financial actors such as commercial banks will benefit from increased business opportunities.	

3 Annex - Interactions with other elements of the 2030 energy climate framework

3.1 EED interaction with the EPBD, ecodesign and labelling

The 2012 Energy Efficiency Directive establishes a set of binding measures to help the EU reach its 20% energy efficiency target by 2020. The EED sets the overall energy efficiency framework which requires Member States to ensure that energy is used more efficiently at all stages of the energy chain from its production to its final consumption. New national measures have to ensure major energy savings for consumers and industry alike. These have to be achieved by taking into account the existing requirements set by the relevant legislation:

a) Minimum standards for new/renovated buildings (EPBD) and new products (ecodesign), so that when consumers do invest they take into account existing European and national standards and the set of investments available to them excludes those which have a weak case once the costs and benefits are looked at over the life cycle;

b) Information requirements for buildings (EPBD) and products (energy labelling) so that consumers which invest can reliably identify the energy performance of the building or product.

It also complements the implementation of other aspects of the EU's energy efficiency policy. For example the Energy Performance of Buildings Directive (EPBD) sets minimum energy requirements for new or renovated buildings but contains no requirements as to how many buildings must be renovated, or by when. By contrast Article 7 requires actual energy savings, and therefore encourages building renovations to take place in practice. Likewise, energy labelling requirements inform consumers of the efficiency of appliances, but a government information campaign will actively encourage consumers to buy those more efficient appliances. The EED, and in particular Article 7, can therefore be seen as a 'pull' factor in terms of increasing the take up of the linked policies.

Studies show that: (i) minimum standards and information requirements are having a good effect on the *quality* of investment; (ii) the *rate* of investment continues to be a problem, and this has been worsened by the recession.

3.2 Effort Sharing Decision / Regulation

Energy efficiency targets have a link with climate targets and in particular the Effort Sharing Decision (ESD) that defines GHG emission reduction targets for Member States for the years to 2020. This is because the level of the target for energy efficiency influences the amount of GHG reduction achieved in sectors covered by the ESD. Energy efficiency policies contribute significantly to the take-up of energy saving technologies in buildings, industry and transport and energy efficiency measures are a cost-effective way of helping Member States achieve the effort sharing targets. Assessing the level of energy efficiency for 2030 is therefore closely linked to the Commission's proposal for a new Effort Sharing Regulation (ESR)[9] on how to

9 COM(2016)482.

achieve a 30% reduction in GHG emission in the non-ETS sectors (comprising effort sharing sectors and LULUCF) in 2030 compared to 2005.

The European Council has agreed on a non-ETS target (comprising ESD and LULUCF) for 2030 of -30% below 2005 levels, the latter to be implemented by national binding targets. The European Council also concluded that the national reduction targets for the non-ETS sectors should be set based on GDP per capita differentiation, keeping them in a range from 0% to -40% compared to 2005. However the targets for Member States with a GDP per capita above the EU average should be relatively adjusted to reflect cost-effectiveness in a fair and balanced manner. As the cost-effective energy efficiency potential differs significantly between Member States, the different energy efficiency levels for 2030 can affect emission reduction potentials and costs in Member States to a different extent. Therefore two different levels of the 2030 energy efficiency target are also taken into account in the analysis underpinning the Commission's proposal for the new Effort Sharing Decision (27% and 30%)[10], and the analytical underpinning of this impact assessment and the impact assessment for the ESR[11] are based on the same two scenarios.

The post 2020 non-ETS targets will no longer allow any Member State to have growing GHG emissions (as in the current period), hence the effort required from every Member State will be bigger. Setting national binding emission reduction targets for each Member State, however, does not contradict the overall energy efficiency target for 2030 or specific energy efficiency measures set under the EED, e.g. the saving target of 1.5% under Article 7. Energy efficiency measures help to reduce GHG emissions in transport, buildings and smaller industrial installations. Importantly, energy efficiency policies ensure that market barriers are tackled in a targeted manner and existing saving potentials are exploited (which would not necessarily happen under a GHG effort sharing-only system). They ensure that all Member States improve energy efficiency and thus facilitate achievement of the ESR targets. The reason for the complementarity between the two policy areas is that European energy efficiency measures are only adopted where action is more effective at European than at national level. Thus these measures do some of the work that Member States would otherwise have to do in fulfilling their obligations under the ESD/ESR – and do it more effectively.

In the EUCO27 scenario, Member States increase their energy efficiency level starting from national energy efficiency efforts as depicted in the EU Reference scenario 2016. This leads to a reduction of primary energy consumption in 2030 of between 1 and 7% for all Member State, with the reduction at the EU28 level of 4.7%. With higher energy efficiency levels (than 27% in 2030) some Member States are projected to overachieve and some to underachieve their ESR target. Member States can use their flexibility provided in the ESR, which would allow a transfer of annual emission allocations (AEAs) in case they achieve higher energy efficiency

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[10] Member States have significant differences in economic strength and investment capacity as well as in emission reduction potentials and costs. As the 2030 framework impact assessment (SWD(2014)15) has shown, applying cost-effectiveness as sole criterion for the distribution of efforts would lead to considerable variations in the necessary national economic effort and would imply (on average) relatively higher efforts and costs per unit of GDP for lower income Member States. The current ESD and the proposed ESR address the differences in economic capacity by differentiating national targets according to relative differences in GDP per capita. However, setting targets based solely on GDP per capita may result in large differences in the costs per ton reduced emissions between Member States if the reductions have to be achieved domestically, and might induce very costly efforts for those higher income Member States with more limited remaining mitigation potentials.

[11] SWD/2016/247.

improvements than required for their national ESR target. Overall, this reflects a cost efficient achievement of GHG reductions.

Energy efficiency measures play an important role for all sectors covered by the ESD/ESR. However, EU measures on energy efficiency do not restrict Member States' freedom to choose the measures they wish to implement to attain their national GHG reduction targets. The EED already offers substantial freedom to Member States as regards how to implement different obligations and how to achieve their indicative national targets. Member States can decide e.g. with regard to Articles 5 and 7 between default and alternative approaches. Other articles leave enough room for Member States to consider their national circumstances and on which sectors they want to focus. Constraining the freedom of Member States would risk increasing costs for them. All instruments under the ESD/ESR and energy efficiency policies complement each other.

Ambitious national and European energy efficiency policies leading to a level of 33% of energy efficiency in 2030 or higher would result in more emission reductions (34%-39% in 2030) in the non-ETS sectors than agreed in the European Council conclusions in October 2014.

The 2014 Report of the European Environmental Agency confirmed that progressing towards several climate and energy targets has created a number of positive synergies. Energy efficiency measures help meet the national 2020 ESD targets. The latter can be an additional incentive to implement more ambitious efficiency policies[12].

3.3 EU Emissions Trading System

The European Council agreed on an EU ETS target of -43% emission reductions compared to 2005. Energy efficiency targets and policies interact with the EU Emissions Trading System (ETS). ETS acts on the failure of prices to internalise external costs; energy efficiency policies address non-price barriers such as lack of information, bounded rationality and split incentives.

The current policies and targets linked to the 2030 climate and energy framework were designed in a way that climate and energy efficiency targets are consistent and enable the ETS and energy efficiency measures to be mutually reinforcing instruments. Energy efficiency policies benefit from the fact that carbon prices created by the ETS open up new markets and applications for energy efficient products and technologies (notably in industrial installations and transport modes covered by ETS and in all equipment consuming electricity).

Savings in electricity consumption or in other energy forms used in industrial sectors covered by the ETS have an impact on the demand for allowances in the ETS[13]. The ETS Market Stability Reserve (MSR) adopted in 2015 will respond to major changes in the demand of allowances, regardless of whether these are the result of economic factors or due to policy developments, for example in relation to improved energy efficiency. The architecture of the reserve is such that it automatically and in a gradual manner reduces the auction supply if there is a significant oversupply of allowances. For very ambitious levels of 2030 energy efficiency targets, this poses risks to the overall coherence in delivering the climate objective. Therefore, it might need

12 Trends and projections in Europe 2014: Tracking progress towards Europe's climate and energy targets: http://www.eea.europa.eu/publications/trends-and-projections-in-europe-2014.

13 SWD(2014) 16 final.

to be considered as part of the first review of the Market Stability Reserve parameters foreseen by 2021 whether this justifies a change to the parameters (e.g. the MSR feeding rate) in case of ambitious energy efficiency targets to preserve the overall policy coherence in delivering the climate objective in a cost effective manner, as agreed by European leaders.

3.4 Renewable energies

Energy consumption reductions help to ensure progress towards higher shares of renewables, as lower energy consumption means a lower denominator in the ratio between consumption of renewables and gross final energy consumption. Non-thermal renewable energy typically has lower transformation losses than conventional energy sources, lowering the primary energy consumption for any given final energy consumption. Higher shares of renewable energy can therefore help to make progress towards the energy savings target, as the target relates to primary energy consumption.

All policy scenarios assessed in this Impact Assessment achieve RES shares of 27-28% in 2030 by assumption (more ambitious EUCO+ scenarios are overshooting 27% share). However to test the implications of ambitious energy efficiency policy with a renewable energy share of 30%, for example as a result of a high level of ambition on renewable energy across a range of Member States, and reflecting the call from the European Parliament, the impact of a scenario with 30% energy savings and 30% renewable energy on the energy system was assessed in addition.

As shown in Annex 4, GHG emissions decrease by 43.2% overall in this scenario; in the ETS sector by 48.1% and non-ETS by 30.7%. This is due to the fact that this scenario achieves mostly additional GHG reductions in the power generation sector, where additional renewable capacity would be installed. The increase in RES-E share is quite significant. Mostly driven by the shift to RES in the power sector, primary energy consumption decreases (compared to 2007 baseline) by an additional 0.8 percentage points (-30.8% instead of -30% in EUCO30), while final energy consumption remains constant, due to identical energy efficiency policies mix as in EUCO30. Due to the higher rate of RES deployment, import dependency is reduced compared with EUCO30. Average annual energy system costs in the period 2021-30 increase marginally compared to EUCO30, by 0.23% (€5 billion) driven by higher investment in grid as well as power generation. In a 2021-50 perspective, average annual energy systems costs are only slightly higher (€3 billion) than for EUCO30.

As regards the interaction of Article 7 with the RES Directive, allowing renewable actions to be counted under Article 7 will result in changing the energy mix through the integration of renewable energy targeting the residential sector.

3.5 Internal energy market

Europe's energy markets are in a period of transition to a low carbon economy. To deliver the needed investment, allow for the free flow of electricity across borders, deliver on the new deal for consumers, ensure security of electricity supply and allow for an increased share of (variable) renewables in the system, the Commission intends to make a proposal on how to reform Europe's energy markets organisation and regulation. All this means delivering a market with the consumers – households and businesses – at its core which is fit for renewables and which is mutually reinforcing with energy efficiency policies.

Energy markets providing effective price signals are a key condition for mobilising the required capital for the transition of the energy sector while maintaining a high level of security of supply. Meeting the 2030 energy and climate goals will require significant investment flows into the energy sector. Therefore, the Commission's Energy Market Design Initiative will take into account the impacts of the moderation of energy demand on the necessary investments in the energy sector (generation, networks, storage and the demand side). As the analysis in this Impact Assessment has shown, a lower demand of energy in 2030 could reduce the need for investments in additional power generation and grid capacities. Lower investments in power generation capacity contribute to lower electricity prices.

Energy efficiency policies, e.g. the requirement for individual meters for consumers or rules on demand response ensure that consumers benefit from the new framework by better integrating wholesale and retail markets and ensuring better information for consumers. These energy efficiency policies empower and encourage consumers to become active players in the future energy market as they can manage their energy consumption more easily. However, the current design of the electricity market and regulated energy prices in some Member States mean that many consumers have no incentive to change their consumption in response to changing prices on the market. Price signals in real time are currently not passed on to final consumers, resulting in inflexible demand patterns. Real time pricing would make electricity demand more flexible (smart white electronics, electric vehicles deployment as well as heat pumps in insulated buildings are examples of new flexible load shifting demand able to take advantage of such price differentials). Two aspects are relevant here: improving consumer access to fit-for-purpose smart systems as well as electricity supply contracts with dynamic prices linked to the spot market; and removing the primary market barriers for independent demand response service-providers (i.e. aggregators), creating a level playing field for them. As the current design of the retail market prevents consumers from being able to fully profit from these possibilities to participate in the energy market fully, this Impact Assessment tackled the barriers related to metering and billing for thermal energy and the new market design initiative will address these remaining barriers to exploit the full potentials of energy efficiency policies.

4 Annex - Analytical models and model-based scenarios used

4.1 Description of analytical models used

The model suite used for the key scenarios presented in this Impact Assessment has a successful record of use in the Commission's energy and climate policy impact assessments – it is the same model suite as used for the 2020 climate and energy package as well as for the 2030 climate and energy policy framework. The models and their linkages are briefly described in the following subsections. Detailed model descriptions can be found on the DG CLIMA website[14].

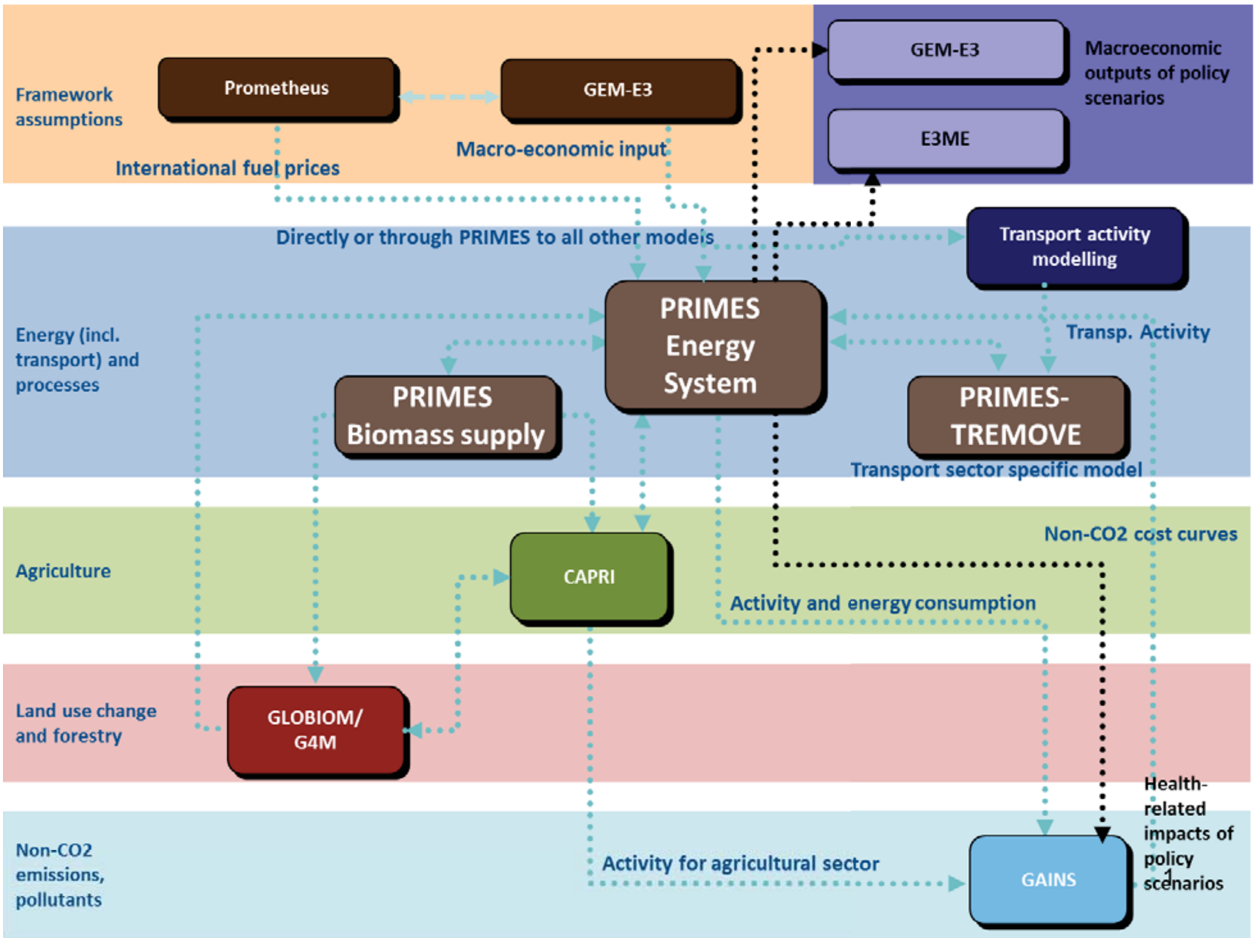
The model suite covers:

- **The entire energy system** (energy demand, supply, prices and investments to the future) and all GHG emissions and removals.
- **Time horizon:** 1990 to 2050 (5-year time steps)
- **Geography:** individually all EU Member States, EU candidate countries and, where relevant Norway, Switzerland and Bosnia and Herzegovina
- **Impacts:** on energy, transport and industry (PRIMES and its satellite models on biomass and transport), agriculture (CAPRI), forestry and land use (GLOBIOM-G4M), atmospheric dispersion, health and ecosystems (acidification, eutrophication) (GAINS); macro-economy with multiple sectors, employment and social welfare (E3ME and GEM-E3).

The models are linked with each other in formally-defined ways to ensure consistency in the building of scenarios, as shown graphically in Figure 1. These inter-linkages are necessary to provide the core of the analysis, which are energy, transport and GHG emissions trends.

[14] http://ec.europa.eu/clima/policies/strategies/analysis/models/index_en.htm.

Figure 1: Inter-linkages between models



Source: DG CLIMA based on E3MLab/ICCS15

The results of these energy-system scenarios can serve as input for the two macroeconomic models (GEM-E3 and E3ME) used to assess the macroeconomic implications of various energy efficiency targets. In addition, the energy-system scenarios also serve as input for assessing the health implications of the scenarios, via the model GAINS.

4.1.1 PRIMES

The PRIMES model is an EU energy system model which simulates energy consumption and the energy supply system. It is a partial equilibrium modelling system that simulates an energy market equilibrium in the European Union and each of its Member States. This includes consistent EU carbon price trajectories.

Decision making behaviour is forward looking and grounded in micro-economic theory. The model also represents in an explicit way energy demand, supply and emission abatement technologies, and includes technology vintages.

The core model is complemented by a set of sub-modules, of which the transport sector module and the biomass supply module are described below separately in more detail. Industrial non-

15 http://ec.europa.eu/clima/policies/strategies/analysis/models/index_en.htm

energy related CO2 emissions are covered by a sub-module so that total CO2 emissions can be projected. The model proceeds in five year steps and is for the years 2000 to 2010 calibrated to Eurostat data.

The PRIMES model is suitable for analysing the impacts of different sets of climate, energy and transport policies on the energy system as a whole, notably on the fuel mix, CO2 emissions, investment needs and energy purchases as well as overall system costs. It is also suitable for analysing the interaction of policies on combating climate change, promotion of energy efficiency and renewable energies. Through the formalised linkages with GAINS non-CO_2 emission results and cost curves, it also covers total GHG emissions and total ESD sector emissions. It provides details on the Member State level, showing differential impacts across Member States.

The PRIMES model represents energy efficiency by simulating different measures with different techniques. These modelling techniques will affect the context and conditions under which stylized agents per sector, make their decisions on energy consumption.

PRIMES has been used for the analysis underpinning the Commission's proposal on the EU 2020 targets (including energy efficiency), the Low Carbon Economy and Energy 2050 Roadmaps, the 2030 policy framework for climate and energy and the energy efficiency Impact Assessment in 2014.

PRIMES is a private model and has been developed and is maintained by E3MLab/ICCS of National Technical University of Athens[16] in the context of a series of research programmes co-financed by the European Commission.

The model has been successfully peer reviewed[17], most recently in 2011[18].

4.1.2. PRIMES -TAPEM & PRIMES-TREMOVE

PRIMES-TAPEM, operated by ICCS/E3MLab is an econometric model for transport activity projections. It takes GEM-E3 projections (GDP, activity by sector, demographics and bilateral trade by product, and by country) as drivers, to produce transport activity projections to be fed into PRIMES-TREMOVE. The econometric exercise also includes fuel prices coming from PROMETHEUS, as well as transport network infrastructure (length of motorways and rail-ways), as drivers. The PRIMES-TAPEM model provides the transport activity projections for the Reference scenario.

The PRIMES-TREMOVE Transport Model projects the evolution of demand for passengers and freight transport by transport mode and transport mean. It is essentially a dynamic system of multi-agent choices under several constraints, which are not necessarily binding simultaneously. The model consists of two main modules, the transport demand allocation module and the technology choice and equipment operation module. The two modules interact with each other and are solved simultaneously.

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16 http://www.e3mlab.National Technical University of Athens.gr/e3mlab/.
17 http://ec.europa.eu/clima/policies/strategies/analysis/models/docs/primes_model_2013-2014_en.pdf.
18 https://ec.europa.eu/energy/sites/ener/files/documents/sec_2011_1569_2.pdf'.

The projection includes details for a large number of transport means, technologies and fuels, including conventional and alternative types, and their penetration in various transport market segments. It also includes details about GHG and air pollution emissions, as well as impacts on external costs of congestion, noise and accidents.

PRIMES-TREMOVE has been used for the 2011 White Paper on Transport, Low Carbon Economy and Energy 2050 Roadmaps as well as the 2030 policy framework for climate and energy.[19]

The PRIMES-TREMOVE is a private model that has been developed and is maintained by E3MLab/ICCS of National Technical University of Athens [20], based on, but extending features of the open source TREMOVE model developed by the TREMOVE[21] modelling community. Part of the model (e.g. the utility nested tree) was built following the TREMOVE model.[22] Other parts, like the component on fuel consumption and emissions, follow the COPERT model.

In the transport field, PRIMES-TREMOVE is suitable for modelling *soft measures* (e.g. eco-driving, deployment of Intelligent Transport Systems, labelling), *economic measures* (e.g. subsidies and taxes on fuels, vehicles, emissions; ETS for transport when linked with PRIMES; pricing of congestion and other externalities such as air pollution, accidents and noise; measures supporting R&D), *regulatory measures* (e.g. CO_2 emission performance standards for new passenger cars and new light commercial vehicles; EURO standards on road transport vehicles; technology standards for non-road transport technologies), *infrastructure policies for alternative fuels* (e.g. deployment of refuelling/recharging infrastructure for electricity, hydrogen, LNG, CNG). Used as a module which contributes to a broader PRIMES scenario, it can show how policies and trends in the field of transport contribute to economy wide trends in energy use and emissions. Using data disaggregated per Member State, it can show differentiated trends across Member States.

4.1.3. PRIMES Biomass Supply

The biomass system model is linked with the PRIMES energy system model for Europe and can be either solved as a satellite model through a closed-loop process or as a stand-alone model.

It is an economic supply model that computes the optimal use of biomass/waste resources and investment in secondary and final transformation, so as to meet a given demand of final

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19 The model can be run either as a stand-alone tool (e.g. for the 2011 White Paper on Transport) or fully integrated in the rest of the PRIMES energy systems model (e.g. for the Low Carbon Economy and Energy 2050 Roadmaps, and for the 2030 policy framework for climate and energy). When coupled with PRIMES, interaction with the energy sector is taken into account in an iterative way.

20 http://www.e3mlab.National Technical University of Athens.gr/e3mlab/.

21 http://www.tmleuven.be/methode/tremove/home.htm.

22 Several model enhancements were made compared to the standard TREMOVE model, as for example: for the number of vintages (allowing representation of the choice of second-hand cars); for the technology categories which include vehicle types using electricity from the grid and fuel cells. The model also incorporates additional fuel types, such as biofuels (when they differ from standard fossil fuel technologies), LPG and methane fuels. In addition, representation of infrastructure for refuelling and recharging are among the model refinements, influencing fuel choices. A major model enhancement concerns the inclusion of heterogeneity in the distance of stylised trips; the model considers that the trip distances follow a distribution function with different distances and frequencies. The inclusion of heterogeneity was found to be of significant influence in the choice of vehicle-fuels especially for vehicles-fuels with range limitations.

biomass/waste energy products, projected to the future by the rest of the PRIMES model. The biomass supply model determines the consumer prices of the final biomass/waste products used for energy purposes and also the consumption of other energy products in the production, transportation and processing of the biomass/waste products. The model also reflects the sustainability criteria currently in place and can be used for reflecting policies facilitating the use of renewable energy sources. After cross check of input data and draft results, results of the biomass supply model are used to ensure consistency between PRIMES, CAPRI and GLOBIOM bioenergy modelling.

The PRIMES biomass supply model is private and has been developed and is maintained by E3MLab/ICCS of National Technical University of Athens[23].

4.1.2 GAINS

The GAINS (Greenhouse gas and Air Pollution Information and Simulation) model is an integrated assessment model of air pollutant and GHG gas emissions and their interactions. GAINS brings together data on economic development, the structure, control potential and costs of emission sources and the formation and dispersion of pollutants in the atmosphere.

In addition to the projection and mitigation of GHG emissions at detailed sub-sectorial level, GAINS assesses air pollution impacts on human health from fine particulate matter and ground-level ozone, vegetation damage caused by ground-level ozone, the acidification of terrestrial and aquatic ecosystems and excess nitrogen deposition of soils.

Model uses include the projection of non-CO2 GHG emissions and air pollutant emissions for EU Reference scenario and policy scenarios, calibrated to UNFCCC emission data as historical data source. This allows for an assessment, per Member State, of the (technical) options and emission potential for non-CO2emissions. Health and environmental co-benefits of climate and energy policies such as energy efficiency can also be assessed.

The GAINS model is accessible for expert users through a model interface[24] and has been developed and is maintained by the International Institute of Applied Systems Analysis[25]. The underlying algorithms are described in publicly available literature. The source code is not disclosed. GAINS and its predecessor RAINS have been peer reviewed multiple times, in 2004, 2009 and 2011.

4.1.5. GLOBIOM-G4M

The Global Biosphere Management Model (GLOBIOM) is a global recursive dynamic partial equilibrium model integrating the agricultural, bioenergy and forestry sectors with the aim to provide policy analysis on global issues concerning land use competition between the major land-based production sectors. Agricultural and forestry production as well as bioenergy production are modelled in a detailed way accounting for about 20 globally most important crops, a range of livestock production activities, forestry commodities as well as different energy transformation pathways.

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23 http://www.e3mlab.National Technical University of Athens.gr/e3mlab/
24 http://gains.iiasa.ac.at/models/.
25 http://www.iiasa.ac.at/.

GLOBIOM covers 28 (or 50) world regions. The disaggregation of the EU into individual countries has been performed only recently.

Model uses include the projection of emissions from land use, land use change and forestry (LULUCF) for EU Reference scenario and policy scenarios. For the forestry sector, emissions and removals are projected by the Global Forestry Model (G4M), a geographically explicit agent-based model that assesses afforestation-deforestation-forest management decisions. GLOBIOM-G4M is also used in the Impact Assessment for agriculture and LULUCF to assess the options (afforestation, deforestation, forest management, cropland and grassland management) and costs of enhancing the LULUCF sink for each Member State.

The GLOBIOM-G4M is a private model and has been developed and is maintained by the International Institute of Applied Systems Analysis[26].

4.1.6. Prometheus

PROMETHEUS is a fully stochastic world energy model used for assessing uncertainties and risks associated with the main energy aggregates including uncertainties associated with economic growth and resource endowment as well as the impact of policy actions. The model projects endogenously the world energy prices, supply, demand and emissions for ten world regions.

World fossil fuel price trajectories are used as import price assumptions for EU Reference scenario and for policy scenario modelling.

The Prometheus model is private and has been developed and is maintained by E3MLab/ICCS of National Technical University of Athens[27]

4.1.7. CAPRI

CAPRI is an open source economic partial equilibrium model developed by European Commission research funds. Operational since more than a decade, it supports decision making related to the Common Agricultural Policy and Environmental policy related to agriculture based on sound scientific quantitative analysis.

CAPRI is only viable due to its pan-European network of researchers which based on an open source approach tender together for projects, develop and maintain the model, apply it for policy impact assessment, write scientific publications and consult clients based on its results. It has been the basis of numerous peer reviewed publications.

The model has been used to provide consistent agricultural activity projections for the EU Reference scenario 2016s. It is also used in the LULUCF impact assessment. The CAPRI model is an open source model which has been developed and is maintained by Eurocare GmbH[28], JRC, and other partners of the CAPRI network.

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26 http://www.iiasa.ac.at/
27 http://www.e3mlab.National Technical University of Athens.gr/e3mlab/
28 http://www.eurocare-bonn.de/

4.1.3 Macroeconomic models (E3ME and GEM-E3)

Macroeconomic models have played a role in two stages of the preparation of the modelling scenarios for this Impact Assessment. First, GEM-E3 is used to provide the EU Reference scenario macroeconomic assumptions, particularly in terms of sectoral value added projections. Second, the macroeconomic and sectoral economic impacts of various ambition levels in energy efficiency are assessed using two versatile macroeconomic models: E3ME and GEM-E3[29].

Similar to previous relevant Impact Assessments[30] the choice in this Impact Assessment has been to use two macroeconomic models that represent two main different schools of economic thought, which dominate the literature and have been frequently used in the macroeconomic assessment of energy and climate policies. This helps to effectively manage current model and theoretical uncertainties and reflect the best way of assessing the corresponding impacts. The application of two different macro-models enables not only to establish a range of possible impacts, but also to identify the conditions necessary for realising potential benefits.

There are important differences between the two models that arise from their underlying assumptions and respective structures. E3ME is a macro-econometric model, based on a post-Keynesian demand-driven non-optimisation non-equilibrium framework; GEM-E3 is a general equilibrium model that draws strongly on supply-driven neoclassical economic theory and optimising behaviour of rational economic agents who ensure that markets always clear[31]. GEM-E3 assumes that capital resources are optimally allocated in the economy (given existing tax "distortions"), and a policy intervention to increase investments in a particular sector (e.g. energy efficiency) is likely to take place at the expense of limiting capital availability, as a factor of production, for other profitable sectors ("crowding out" effect). In other words, in GEM-E3, the total effect on the economy depends on the net effect of core offsetting factors, particularly between positive improved energy efficiency and economic expansion effects (Keynesian multiplier), on one hand, and negative economic effects stemming from crowding out, pressures on primary factor markets and competitiveness losses, on the other hand. Nonetheless, the GEM-E3 version used in this Impact Assessment has significantly advanced and substantially departs from standard CGE models, in that it captures involuntary unemployment, myopic expectations, and avoids instantaneous crowding out effects (i.e. static savings-investments closure) through the inclusion of the banking sector, amongst others (explained in more detail below).

E3ME does not adhere to the ‘general’ equilibrium rule; instead demand and supply only partly adjust due to persistent market imperfections and resulting imbalances may remain a long-run feature of the economy. It also allows for the possibility of non-optimal allocation of capital,

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29 The GEM-E3 version of the model used in this Impact Assessment is enhanced with an explicit representation of the banking system and financial flows (see for instance, Capros P., Karkatsoulis P., Paroussos L., "Modelling the financial sector in GEM-E3", E3M-Lab technical report, National Technical University of Athens, May 2016.

30 The Impact Assessment on energy and climate policy up to 2030 and the Impact Assessment accompanying the 2014 Energy Efficiency Communication (SWD(214)255 final).

31 Market clearance in GEM-E3 is achieved through the full adjustment of prices which allow supply to equal demand and thus a ‘general’ equilibrium is reached and maintained throughout the system.

accounting for the existing spare capacity in the economy[32]. Therefore, the level of output, which is a function of the level of demand, may continue to be less than potential supply or a scenario in which demand increases can also see an increase in output.

Having said this, the two macroeconomic models have many similarities, such as the inclusion of substantial sectorial detail, the assessment of complex interactions between the different sectors of an economy, markets and agents, as well as the simulation of inter-linkages between world economic and energy systems and the environment. Furthermore, in both models, additional effects are associated with a reduction in energy demand due to energy efficiency investments, including reduced import demand for energy inputs and a reduced need for energy generation within the EU28. A change in energy prices and of energy efficiency expenditures due to energy efficiency measures could result in the substitution of imported fuels with domestically produced goods and services. Both models also allow for the existence of unemployment.

Most importantly, in this Impact Assessment, the approaches have converged to some extent compared to previous analytical work. Notably, GEM-E3 has improved its modelling approach by incorporating an explicit representation of the financial sector at the global level and across countries. This changes the dynamics of crowding out effects as opposed to standard CGE models without a banking sector (more described below). E3ME, on the other hand, has explored the issue of "crowding out" and the possibility of capacity constraints limiting investment-driven output expansion particularly relevant in scenarios involving ambitious energy efficiency investment requirements.

4.1.3.1 E3ME

E3ME is a computer-based model of Europe's economies, linked to their energy systems and the environment. The model was originally developed through the European Commission's research framework programmes in the 1990s and is now widely used in collaboration with a range of European institutions for policy assessment, for forecasting and for research purposes. Only the main E3ME model features and mechanisms relevant for this Impact Assessment are presented, as a detailed description of the model is available in the E3ME manual[33].

The figure below shows the main modules in E3ME. The economy and energy demand are closely linked; economic activity creates the demand for energy, but energy consumption also affects the economy through output in the energy production and distribution sectors (e.g. electricity sector, oil and gas sector). Most environmental emissions are caused by fuel combustion (modelled as a fixed coefficient) but there are also direct economy-emission linkages through process emissions.

Technology, which is endogenous in E3ME, can affect many of these relationships. For example, the use of energy-efficient vehicles allows an increase in economic production without

[32] The degree of adjustment between supply and demand and the resulting imbalances are derived from econometric evidence of historical non-optimal behaviour based on the extensive databases and time-series underpinning the E3ME macro-econometric model.

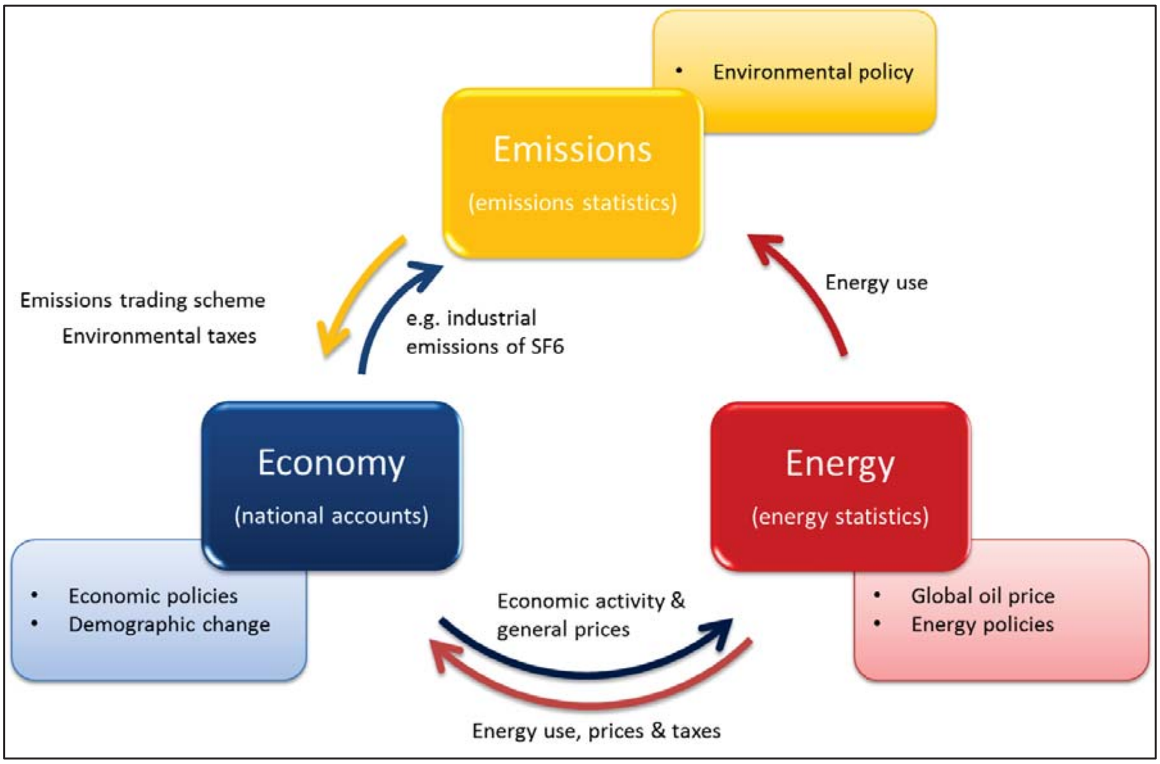
[33] Detailed information on model mechanisms are available in the E3ME manual at: http://www.camecon.com/EnergyEnvironment/EnergyEnvironmentEurope/ModellingCapability/E3ME/E3MEManual.aspx.

an increase in energy consumption and emissions. Some particular technologies like CCS or renewables allow energy consumption to increase without increasing emissions

The main dimensions of the model are:

- 33 countries (limited in scope to the EU28 Member States for this study)
- 69 economic sectors, defined at the NACE (rev2) 2-digit level, linked by input-output relationships;
- 43 categories of household expenditure;
- 13 types of household, including income quintiles and socio-economic groups such as the unemployed, inactive and retired, plus an urban/rural split;
- 22 different users of 12 different fuel types;
- the 6 Kyoto GHGs; other emissions where available.

Figure 2: E3ME modules

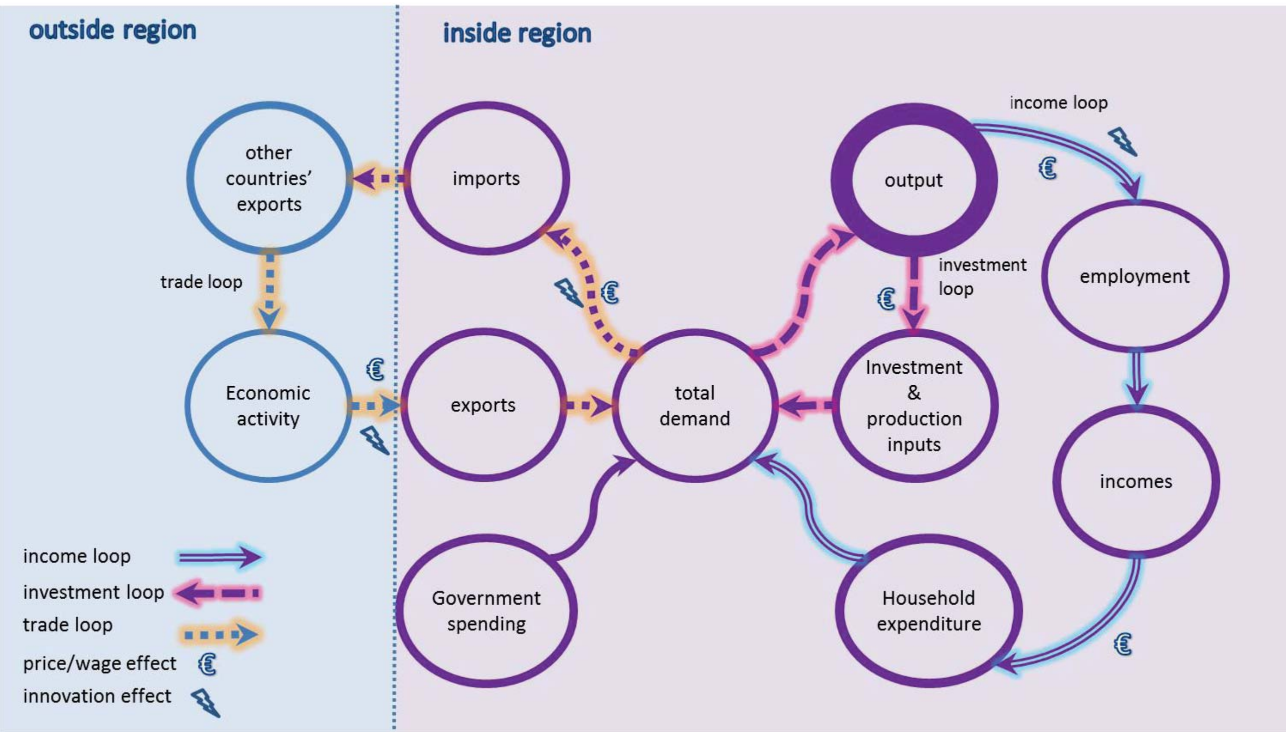


Source: E3ME, Cambridge Econometrics

The economic structure of E3ME is based on the system of national accounts, as defined by ESA95 (European Commission, 1996). The labour market is also covered in detail, with estimated sets of equations for labour demand, supply, wages and working hours. In total there are 33 sets of econometrically estimated equations, also including the components of GDP (consumption, investment and international trade), prices, energy demand and materials demand. Each equation set is disaggregated by country and by sector.

Figure 3 provides a summarised graphical representation of the main economic flows for a single European country. It displays the income loops, investment lops, trade loops, price/wage effects and innovation effects as captured in E3ME. Short-term multiplier effects occur through the various interdependencies and feedback loops that are present in the model structure.

Figure 3: E3ME's basic economic structure



Source: E3ME, Cambridge Econometrics

4.1.3.2 GEM-E3

The GEM-E3 model has been developed and is maintained by E3MLab/ICCS of National Technical University of Athens[34], JRC-IPTS[35] and others. It is documented in detail but the specific versions are private. The version of the GEM-E3 model used for this Impact Assessment is the one of E3MLab/ICCS.

The GEM-E3 model is a multi-regional, multi-sectoral, recursive dynamic computable general equilibrium (CGE) model which provides details on the macro-economy and its interaction with the environment and the energy system. It is an empirical, large scale model, written entirely in structural form. GEM-E3 allows for a consistent comparative analysis of policy scenarios since it ensures that in all scenarios, the economic system remains in general equilibrium. In addition it incorporates micro-economic mechanisms and institutional features within a consistent macro-economic framework and avoids the representation of behaviour in reduced form. The model is built on rigorous microeconomic foundations and is able to provide in a transparent way insights on the distributional aspects of long-term structural adjustments. The GEM-E3 model is extensively used as a tool of policy analysis and impact assessment.

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[34] http://147.102.23.135/index.php?option=com_content&view=category&id=36%3Agem-e3&Itemid=71&layout=default&lang=en.
[35] https://ec.europa.eu/jrc/en/gem-e3/model

It is updated regularly using the latest revisions of the GTAP database and Eurostat statistics for the EU Member States. This version of the GEM-E3 model used for this Impact Assessment simultaneously represents 38 regions and 29 sectors linked through endogenous bilateral trade flows. Most importantly new databases have been added compared to previous versions of the model: i) the GEM-E3 model has been calibrated to GTAP 9, year 2011 (this is the most recent available complete dataset for global IO tables) ii) The EU28 GTAP 9 IO tables have been replaced with EUROSTAT IO tables where possible[36] iii) A new split of EUROSTAT IO energy transactions has been made so as to be consistent with energy volumes as reported in EUROSTAT energy balances iv) To support the explicit representation of the financial sector in the new version of the GEM-E3 model a complete database regarding agents financial transactions has been developed. The financial database includes the following key financial instruments: i) bonds (corporate and public), ii) time deposits and iii) deposits.

Its scope is general in two terms: it includes all simultaneously interrelated markets and represents the system at the appropriate level with respect to geography, the sub-system (energy, environment, economy) and the dynamic mechanisms of agent's behaviour.

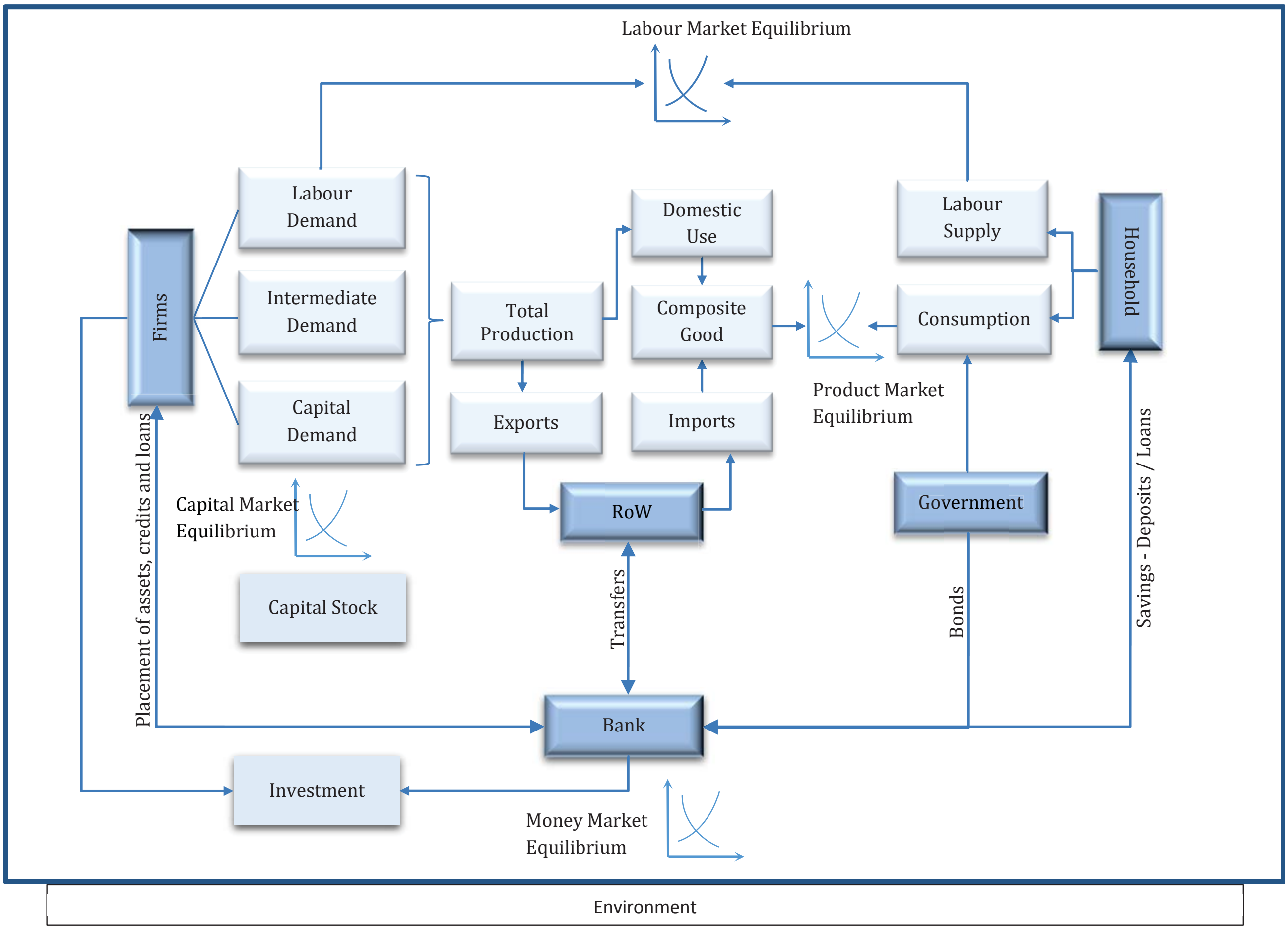
The GEM-E3 model includes projections of full Input-Output tables by country/region, national accounts, employment by economic activity, unemployment rate, balance of payments, public finance and revenues, household consumption, energy use and supply, GHG emissions and atmospheric pollutants.

GEM-E3 formulates separately the supply or demand behaviour of the economic agents who are considered to optimise individually their objective while market derived prices guarantee global equilibrium, allowing the consistent evaluation of distributional effects of policies. It also considers explicitly the market clearing mechanism and the related price formation in the energy, environment and economy markets: prices are computed by the model as a result of supply and demand interactions in the markets and different market clearing mechanisms, in addition to perfect competition, are allowed.

Total demand (final and intermediate) in each country is optimally allocated between domestic and imported goods, under the hypothesis that these are considered as imperfect substitutes (the "Armington" assumption). Institutional regimes, that affect agent behaviour and market clearing, are explicitly represented, including public finance, taxation and social policy. Figure 4 illustrates the overall structure of the GEM-E3 model.

[36] Austria, Belgium, Bulgaria, Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Netherlands, Slovakia, Slovenia, Sweden, Romania, UK. For the rest of EU28 countries the GTAP IO tables have been used as there were no symmetric IO tables available from EUROSTAT.

Figure 4: GEM-E3 model structure



Source: GEM-E3, E3M-Lab, National Technical University of Athens

The model formulates production technologies in an endogenous manner allowing for price-driven derivation of all intermediate consumption and the services from capital and labour. In the electricity sector, a bottom up approach is adopted for the representation of the different power producing technologies. For the demand-side, the model formulates consumer behaviour and distinguishes between durable (equipment) and consumable goods and services.

GEM-E3 is dynamic, recursive over time, driven by accumulation of capital and equipment. In other words, the properties of the model are mainly manifested through stock/flow relationships, technical progress, capital accumulation and agents' (myopic) expectations. Technology progress is explicitly represented in the production function, either exogenous or endogenous, depending on R&D expenditure by private and public sector and taking into account spill-over effects. Moreover, it is based on the myopic expectations of the participant agents. In other words, the uptake of advanced technologies accelerates learning making them cheaper and more efficient. As higher volumes of advanced technologies are chosen by consumers, their production moves further on the learning curve hence efficiency improvements occur faster. At the same time the investment cost in advanced technologies increases with increasing efficiency performance. GEM-E3 includes learning curves that reduce capital costs depending on accumulated capacity (learning by doing).

New model features: explicitly capturing finance

Compared to the version of the GEM-E3 model used in previous similar analyses[37], and in addition to the data updates mentioned above, a series of methodological advancements have been introduced in the model. These relate in particular to the modelling of interactions between financial flows and the real economy. In other words, this version of GEM-E3 is a financial CGE model that explicitly represents the full-scale detailed financial sector for each country and at the global level.

The modelling of the interactions between finance and the real economy draws from Capros and Karadeloglou (1991 and 1996)[38], Bourgignon et al (1989)[39] and Dixon et al. (2015)[40]. It deviates from the standard CGE framework, mainly by introducing a dynamic inter-temporal financial closure in contrast with the static savings-investment closure that standard CGE models use. The CGE models with financial modelling are relatively sparse in empirical policy analysis applied to energy-climate issues. The version of GEM-E3 used in this Impact Assessment includes a detailed financial sector country-by-country, where institutional sectors (government, private and foreign) raise and repay debts financed by commercial banks, which take leverage from a central bank. The commercial banks collect the savings of economic agents and issue loans at interest rates. Governments and firms issue bonds to cover their financing needs. Agents' decision to lend or borrow depends on the interest rates. Two leading interest rates, one for the market of public debt, the other for the market of private debt, are determined from market clearing conditions.

Money supply can either be fixed with endogenously determined interest rates (money multiplier theory) or be adjustable (endogenous money theory) at given interest rate (i.e. bank reserves adjust as needed to accommodate loan demand at prevailing interest rates). In the version used in this study, the money multiplier approach has been used. In the model the base year net lending/borrowing position of the agents is calculated[41] in detail according to the institutional transactions[42] that have been collected from EUROSTAT. Dynamically the net credit position of each agent depends on a number of endogenously determined variables like the households' disposable income, firms' sales, consumption, saving and investment. The financial assets considered in the model are: public bonds, corporate bonds, household loans, deposits and time deposits.

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37 For instance, in the Cambridge Econometrics (2015) study on social and employment impacts of energy efficiency or the 2014 energy efficiency Impact Assessment SWD(2014)255 final.

38 Capros Pantelis, Pavlos Karadeloglou & Gregory Mentzas (1991), 'Market imperfections in a general equilibrium framework: An empirical analysis', Economic Modelling, Volume 8, Issue 1, January 1991, Pages 116–128; Capros Pantelis and Pavlos Karadeloglou (1996) "Structural Adjustment and Public Deficit: A Computable General Equilibrium Modelling Analysis for Greece", in P. Capros and D. Meulders (editors) "Budgetary Policy Modelling: Public Expenditure", Routledge Publ. Co., Chapman and Hall, London.

39 Bourguignon François, William H. Branson, J. de Melo (1989), 'Macroeconomic Adjustment and Income Distribution: A Macro-Micro Simulation Model', Technical report, ECD Development Centre Working Papers 1.

40 Dixon Peter, Maureen Rimmer, L. R. (2014), 'Adding financial flows to a CGE model of PNG'(No. G-242, ISBN 978-1-921654-50-3), Technical report, Centre of Policy Studies.

41 The net lending position of each economic agent has been built from bottom up data (all sources of income including dividend payments, interest rates, debt payments, bond interest rates etc.). Data regarding the structure of the bilateral debt by agent (domestic-foreign) and country (who owns to whom) have been constructed according to current account and cumulative bilateral trade transactions.

42 Full sequence of National Accounts that include all secondary transactions (property income, income from deposits, interest rates, etc.) of all economic agents.

The model is based on a matrix of flows of funds, involving, all economic agents, namely the household, government, firms, banks and foreign, as displayed in

Table 2.

Table 2: Simplified Flow of Funds matrix in GEM-E3

	Private	Banks	Government	Foreign
Assets	Placement of assets	Supply of loans and credit		Transfers and financing of foreign debt
Liabilities	Credits and Loans	Deposits	Bonds	

Source: GEM-E3, E3M-Lab National Technical University of Athens

The financial behaviour of households is based on a portfolio model which is derived by maximising expected utility. Households allocate their disposable income to consumption and financial assets on the basis of expected yields. The behaviour of firms and the public sector in the financial model is represented only with respect to the financing of their deficit. Total public and private debts are updated dynamically by accumulating deficits or surpluses. The level of the debts in relation to the leverage of commercial banks as defined by central banks influence the interest rates. Cross-country financing is also modelled. Options in the model allow defining possible financial closures at multi-country regional level, versus financial closing at global level. Risk premium factors influencing cross border financing are also introduced. The global economy financial closure is inter-temporal (in essence it is an extension of the Walras law) and leads to a world interest rate of equilibrium, or alternatively to regional interest rates of equilibrium depending on modelling options.

The banking[43] and private sectors are represented following an "assets-liabilities balance" approach. On the assets side of the private sector, total wealth is evaluated, dynamically, by private net savings, a variable coming from the real part of the model. In the banking sector the assets-liabilities balance serves to evaluate the capacity of banks to lend the private sector, which depends also on lending from central bank.

Interest rates are derived from the equilibrium of financial supply and demand flows. The model determines endogenously two equilibrium prices: i) Demand/supply equilibrium in financing public deficits serves to determine the rate of interest of government lending, i.e. interest rates of bonds ii) Demand/supply equilibrium of the capital flows addressed to the private sector serves to determine the private lending interest rate.

The inclusion of the financial sector in the model improves its simulation capabilities in the following respects:

- Creates loan repayment schedules that span over several periods and can also combine with cross-border lending thus mitigating considerably the crowding out effect.
- Book keeping of stock/flow relationships of debt accounting (domestic and external Private and Public debt) which influences the dynamic properties of the real economies.
- Endogenous computation of interest rates depending on alternative uses of financial resources by the agents (deposits, bonds, household and business financing, etc.).

[43] The banking system, as defined in this model comprises commercial banks and the central bank.

- Income availability by sector is adjustable depending on borrowing behaviour.
- Lending capabilities depend on accumulated debt and on leverage assumptions. Thus demand and supply of money/deposits, bonds and securities determine interest rates.
- Option for financing can be: i) From own resources – self finance (savings, reduced consumption) or ii) Borrowing from other agents (domestic or/and from abroad), iii) combination of i) and ii).

4.2 The EU Reference scenario 2016[44]

4.2.1 Scenario design, consultation process and quality assurance

Building an EU Reference scenario is a regular exercise by the Commission. It is coordinated by DGs: ENER, CLIMA and MOVE in association with the JRC, and the involvement of other services via a specific inter-service group.

The Reference Scenario 2016 (REF2016) has been developed building on a modelling framework including as core models PRIMES (PRIMES-TREMOVE for transport), GAINS and GLOBIOM-G4M and as supporting models GEM-E3, PROMETHEUS, PRIMES Biomass supply and CAPRI (see prior section for details).

For the REF2016, the model was calibrated on energy data up to year 2013 from Eurostat and other sources, and for agriculture and non-CO_2 emission data up to the year 2015.

Member States were consulted throughout the development process through a specific Reference scenario expert group, which met three times during the development of REF2016. Member States provided information about adopted national policies via a specific questionnaire, key assumptions have been discussed and in each modelling step, draft Member State specific results were sent for consultation. Comments of Member States were addressed to the extent possible, keeping in mind the need for overall comparability and consistency of the results.

Quality of modelling results was assured by using state of the art modelling tools, detailed checks of assumptions and results by the coordinating Commission services as well as by the country specific comments by Member States.

REF2016 projects EU and Member States energy, transport and GHG emission-related developments up to 2050, given current global and EU market trends and adopted EU and Member States' energy, transport, climate and related relevant policies.

"Adopted policies" refer to those that have been cast in legislation in the EU or in MS (with a cut-off date end of 2014[45]). Therefore, the binding 2020 targets are assumed to be reached in the projection. This concerns GHG emission reduction targets (both for the EU ETS as well as ESD sectors) as well as RES targets, including RES in transport.

However, policies which are not yet legally implemented, e.g. those necessary to implement the 2030 energy and climate framework, are not part of REF2016[46]. On this basis, REF2016 can help identify areas where the current policy framework falls short of reaching the EU's climate and energy objectives[47]. Notably, REF2016 shows that current policy and market conditions will

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[44] Please see complete publication at: https://ec.europa.eu/energy/en/news/reference-scenario-energy.

[45] In addition, amendments to two Directives only adopted in the beginning of 2015 were also considered. This concerns notably the ILUC amendment to the RES directive and the Market Stability Reserve Decision amending the ETS Directive.

[46] For the period after 2020, policies are included that are part of the EU *acquis*, as well as important investments that are part of Member States' national energy plans. For instance, ETS with the Market Stability Reserve is included in REF16, but not the Commission's proposal for a change in the linear reduction factor post-2020. New near-zero energy buildings after 2020 - as defined in the Energy Performance of Buildings Directive - continue to be built, as well as energy labelling continues. Member States also gave input on planned energy investments, particularly in nuclear energy.

[47] Each new update of the Reference scenario models the projected impact of policy adopted up to the relevant cut-off date. Therefore, differences between two consecutive Reference scenarios, e.g. between the one

deliver neither the 2030 targets nor the long-term 2050 80-95% GHG emission reduction objective.

REF2016 provides projections, not forecasts. Unlike forecasts, projections do not make predictions about what the future will be. They rather indicate what would happen if the assumptions which underpin the projection actually occur. Still, the scenario allows for a consistent approach in the assessment of energy and climate trends across the EU and its Member States.

The report "EU Energy, Transport and GHG Emissions Trends to 2050 - Reference Scenario 2016" (available at https://ec.europa.eu/energy/en/news/reference-scenario-energy) describes the inputs and results in detail. This section summarises the main messages derived from it, especially those relevant for the Energy Union framework.

4.2.2 Main assumptions

The projections are based on a set of assumptions, including on population growth, macroeconomic and oil price developments, technology improvements, and policies.

4.2.2.1 Macroeconomic assumptions

In REF2016, the population projections draw on the European Population Projections (EUROPOP 2013) by Eurostat. The key drivers for demographic change are: higher life expectancy, convergence in the fertility rates across Member States in the long term, and inward migration. The EU28 population is expected to grow by 0.2% per year during 2010-2030 (0.1% for 2010-2050), to 516 million in 2030 (522 million by 2050). Elderly people, aged 65 or more, would account for 24% of the total population by 2030 (28% by 2050) as opposed to 18% today.

GDP projections mirror the joint work of DG ECFIN and the Economic Policy Committee, presented in the 2015 Ageing Report. The average EU GDP growth rate is projected to remain relatively low at 1.2% per year for 2010-2020, down from 1.9% per year during 1995-2010. In the medium to long term, higher expected growth rates (1.4% per year for 2020-2030 and 1.5% per year for 2030-2050) are taking account of the catching up potential of countries with relatively low GDP per capita, assuming convergence to a total factor productivity growth rate of 1% in the long run.

Sectoral activity projections are derived in a consistent way from these macroeconomic assumptions, using the macro-economic modelling tool GEM-E3 as well as econometric estimates for global demand for energy intensive industries.

4.2.2.2 Fossil fuel price assumptions

Oil prices have fallen by more than 60% since mid-2014, to an average of around 40 $/barrel for Brent crude oil in the first four months of 2016. The collapse of oil prices has been driven by low demand and sustained oversupply, due in particular to tight oil from North America and to the decision of Organization of Petroleum Exporting Countries (OPEC) countries not to cut their output to rebalance the market. REF2016 considers a gradual adjustment process with reduced investments in upstream productive capacities by non-OPEC countries. Quota discipline is assumed to gradually improve among OPEC members. Thus, oil price is projected to reach 87

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from 2013 and REF2016, can be explained by the implications of policies adopted in the meantime as well as by changed economic and technological trends.

$/barrel in 2020 (in year 2013-prices). Beyond 2020, as a result of persistent demand growth in non-OECD countries driven by economic growth and the increasing number of passenger cars, oil price would rise to 113 $/barrel by 2030 and 130 $/barrel by 2050. This price trend resulting from PROMETHEUS modelling is in line with other reference sources such as the 2015 IEA World Energy Outlook.

No specific sensitivities were prepared with respect to oil and gas price developments. Still, it can be recalled that lower fossil fuel price assumptions tend to increase energy consumption and CO_2 emissions not covered by the ETS. The magnitude of the change would depend on the price elasticities and on the share of taxation, like excise duties, in consumer prices. For instance, for transport, the changes would be limited (depending on the magnitude of the change in the oil price) due to the high share of excise duties in the consumer prices but they are still expected to lead to some higher energy consumption and CO2 emissions. They also tend to lead to lower overall energy system costs, as the increase in consumption is more than compensated by lower prices. Conversely, costs for emission mitigation could slightly increase.

4.2.2.3 Technoeconomic assumptions

In terms of technological developments, input assumptions are based on a wide range of sources, with estimates on technological costs across main types of energy equipment, from power generation to heating systems and appliances. In addition, it should be recalled that the PRIMES model (and other models where relevant) take into account technological progress.

In terms of technological developments relevant to the transport sector, battery costs for electric vehicles and plug-in hybrids are assumed to go down to 320-360 $/kWh by 2030 and 270-295 $/kWh by 2050; further improvements in the efficiency of both spark ignition gasoline and compression ignition diesel are assumed to take place. In addition, the market share of internal combustion engine (ICE) electric hybrids is expected to increase due to their lower fuel consumption compared to conventional ICE vehicles.

For the techno-economic assumptions in the projection of non-CO_2 GHG emissions, see the detailed technical documentation. In general, technological progress in this domain is strongly linked to regulation; hence EU Reference scenario assumptions are conservative.

Technology assumptions are based on extensive literature review and have been peer-reviewed by the Joint Research Centre of the European Commission.

4.2.2.4 Specific policy assumptions

Following the above described policy modelling approach, the key policies included in the REF2016 are:

- The EU Emissions Trading System (Directive 2003/87/EC and its amendments) is fully reflected in the modelling, including the linear reduction factor of 1.74% for stationary installations and the recently adopted Market Stability Reserve.
- The Effort Sharing Decision (406/2009/EC) is assumed to be implemented, i.e. ESD GHG emission reductions at EU level in 2020 need to reach at least -10% compared to 2005 levels. It turned out that no specific policy incentives in addition to adopted EU and national policies were needed to achieve the EU level target. National ESD targets need not be achieved domestically given the existing flexibilities (e.g. transfers between Member States).

- The Energy Efficiency Directive (EED) and the Energy Performance of Buildings Directive (EPBD) are reflected, including Member States' specific obligations as regards energy savings obligation and buildings codes.
- Eco-design and Energy Labelling Directives and Regulations are also reflected.
- CO_2 standards for cars and vans regulations (Regulation (EC) No 443/2009, amended by Regulation EU No 333/2014 and Regulation (EU) No 510/2011, amended by Regulation EU 253/2014); CO2 standards for cars are assumed to be 95gCO2/km as of 2021 and for vans 147gCO2/km in line with current legislation. Standards are assumed constant after 2020/2021.
- The Renewable Energy Directive (Directive 2009/28/EC) and Fuel Quality Directive (Directive 2009/30/EC) including ILUC amendment (Directive (EU) 2015/1513): achievement of the legally binding RES target for 2020 (including 10% RES in transport target) for each MS, taking into account the use of flexibility mechanisms when relevant as well as of the cap on the amount of food or feed based biofuels (7%). Member States' specific renewable energy policies for the heating and cooling sector are also reflected where relevant.
- Directive on the deployment of alternative fuels infrastructure (Directive 2009/30/EC).
- The Waste Management Framework Directive (Directive 2008/98/EC) and in particular the Landfill Directive (Directive 1999/31/EC) which contribute to a significant reduction of emissions from waste.
- The revised F-gas Regulation (Regulation 517/2014) strengthens existing measures and introduces a number of far-reaching changes, notably limiting the total amount of the most important F-gases that can be sold in the EU from 2015 onwards and phasing them down in steps to one-fifth of 2014 sales in 2030, and banning the use of F-gases in many new types of equipment where less harmful alternatives are widely available.
- The impacts of the Reforms of the Common Agricultural Policy are taken into account, e.g. the milk quota abolition.
- Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP) for maritime transport.
- Relevant national policies, for instance on the promotion of renewable energy, on fuel and vehicle taxation or national building codes, are taken into account.

4.2.3 The modelling of energy efficiency policies in the EU Reference scenario

The EU Reference Scenario reflects policies that were adopted by the end of 2014 regarding energy efficiency in the EU and in Member States, including the Energy Efficiency Directive (EED) and the Energy Performance of Buildings Directive (EPBD). In the following, modelling instruments that reflect these policies in the PRIMES model are described.

The PRIMES model can simulate different energy efficiency policies with different modelling instruments. These instruments affect the context and conditions under which individuals - in the modelling represented by stylized agents per sector - make their decisions on energy consumption and the related equipment. The following are the main instruments:

- Modification of model parameters in order to mirror technology performance or building codes that are determined in the process of calibrating the interdependent model output to the observations from the relevant statistical year (in this exercise: 2015).
- Modification of assumptions about technical and economic performance of future technologies that are available for future choices by consumers.
- Modification of perception of costs of technologies by economic agents.
- Modelling instruments for capturing the effects of measures that promote or impose efficiency performance standards (BAT, ecodesign, CO2 standards for cars and vans). Such modelling instruments relate to individual technologies or groups of technologies and modify the perception of associated costs by the modelled agents or influence the portfolio of technologies that will be available for consumer choice.
- Another type of policy measures are those which improve consumer information through education, labelling, correct metering and billing, energy audits and technology support schemes aiming at inciting consumers to select more efficient technologies. Such measures are represented by the modelling instruments that modify the perception of costs of technologies by economic agents or are directly reflected in the modelling mechanisms, where economic agents are per-se informed correctly about the prevailing and to some extent future prices. This depends on the sector as there is less foresight in final demand sectors with shorter equipment lifetimes than in power generation sector.
- The penetration of ESCOs as explicitly incited by the EED leads to an environment with reduced risks for the consumers engaging in energy efficiency renovations, which can include both changes in the building structure and changes in the energy equipment. This is represented in the modelling by reduced discount rates for certain sectors, mirroring the changes in the decision making conditions and constraints of e.g. households and services. In addition, these measures also induce lower technical and financial risk, hence reducing the perceived costs of new technologies and saving investments (see also point above on perception of costs).
- Another key modelling tool are energy efficiency values (EEVs) – which are modelled as shadow values of virtual energy saving constraints optionally applying by energy demand sector. In the model, the EEVs influence the behaviour of consumers acting as a marginal cost to penalise energy consumption and stimulate energy savings. For houses and office buildings the EEVs mainly promote improvement of thermal integrity of building cells by inciting renovation, in industrial sector they incentivise broad range of energy efficiency. Essentially using the EEVs in the model is a way of representing non-identified policy measures, which aim at achieving energy savings in order to achieve a pre-defined target level of primary energy consumption in 2030. Instead of modelling one-by-one the broad range of energy efficiency policy measures, a practical way is to assume a non-zero value of EEVs and increase it until the non-identified measures induce an assumed amount of energy savings.

  In the context of the REF2016, one of the key elements which PRIMES depicts with EEVs are the energy efficiency obligation schemes required under Art 7 of EED (which by themselves according to current legislation can be implemented through a range of alternative policy instruments with a similar effect), but EEVs can also reflect some additional Member States' policies. Because of the diversity of approaches, implementation and intensity of polices, EEVs are differentiated between Member States.

The EEVs are measured in EUR/toe saved. A non-zero EEV is added to the unit cost of energy and therefore an additional amount of energy saving investments become cost-efficient. The use of a non-zero EEV has no financial implications for the consumers except the incurrence of additional investment expenditures which allow in the future lowering the expenditures for purchasing of fuels and electricity. The investment undertaken by the consumer is counted for e.g. in the energy system costs. In other words, an EEV is not a subsidy and is not a tax, as it has no direct implications on the consumer's budget.

The EU energy efficiency 2020 and 2030 targets are mainly measured in terms of primary energy consumption, which depends on several factors, including energy demand but also fuel mix in power generation, the efficiency of thermal conversion and loss rates in all supply sectors. The EEVs act only by inciting lower use of final energy in demand sectors and does not influence directly the fuel mix in these sectors. To achieve a certain energy efficiency objective in terms of primary energy, the model iterates with varying EEVs to influence demand for energy. At the same time, other model parameters also vary to represent other policies and targets. The model calculates in each iteration a projection of energy balances, investments, prices and emissions, forming a scenario.

The EEV have a national component that represents national policies as defined in the REF2016 and an EU-wide component, which also applies nationally. This EU-wide component is harmonised across the EU to ensure harmonisation of additional incentives across the MS and to ensure overall achievement of the target as defined by the specific policy scenarios.

- A multiplier effect is used to reflect the public procurement provisions, as the public sector assumes an exemplary role, i.e. private consumers are imitating the public sector energy efficiency actions.
- Other measures that foster energy efficiency relate to taxation, in particular excise type taxes (including those reflecting emissions); they are directly modelled in PRIMES by Member State and type of fuel, allowing for the full reflection of the effects of energy taxation and other financial instruments on end user prices and energy consumption.
- Also on supply side, energy efficiency policies can be modelled (promotion of CHP, district heating, limiting grid losses) – such policies were not, however, modelled in the scenarios presented in this Impact Assessment in comparison to the Impact Assessment SWD(2014)255.
- Improvements in the network tariff system and the regulations regarding the design and operation of gas and electricity infrastructure are also required in the context of the EED; moreover, the EED requires MS and regulators to encourage and promote participation of demand side response in wholesale and retail markets. In this context, the REF2016 assumes that intelligent metering is gradually introduced in the electricity system. This enables consumers to more actively manage their energy use. It allows for demand responses so as to decrease peak and over-charging situations, which generally imply higher losses in the power grids. Thus, efficiency is also improved as a result of the intelligent operation of systems.

- Finally, some policies and measures that do not target energy efficiency directly lead to significant additional energy efficiency benefits. Among these policies are the ETS Directive, the Effort Sharing Decision (ESD) – they are reflected by consideration of carbon market and the national ESD targets.

- Policies on promoting RES also indirectly lead to energy efficiency gains; in statistical terms many RES, such as hydro, wind and solar PV, have an efficiency factor of 1; thus, the penetration of RES in all sectors, in particular in power generation, induces energy savings. These policies are reflected by RES targets (modelling constraints) and RES shadow values (see explanations below).

The PRIMES model is based on individual decision making of agents demanding or supplying energy and on price-driven interactions in markets. The modelling framework includes two distinct stages: a) a first stage models decision-making behaviour of agents, hence investment and technology choices; b) a second stage calculates total costs for the entire energy system in order to support comparisons across scenarios.

In the first stage, agents take decisions considering the time dimension of money flows. Private discount factors can be defined as reflecting opportunity costs of raising funds by the actor on a private basis. The opportunity costs of an investment decision also vary with the degree of market distortions and non-market barriers as well as with the degree of risk associated with the decision options. The opportunity costs differ hence by sector and by type of agent.

The aim is to assess policy impacts as close as possible to reality and to avoid under- or over-estimation of the costs, and thus the difficulties, of transformation required to meet targets and transition objectives (i.e. transition towards a low carbon economy). Therefore, in line with the impact assessment guidelines the modelling is based on private discount rates[48].

For determining the values of discount rates to be applied, the model follows different approaches by sector. Decisions by firms are based on the weighted average cost of capital (WACC) to determine the discount rates. The EU Reference scenario applies different WACC rates by business sector, by type of technology (mature versus emerging), by scale level (e.g. industrial or decentralised versus utility scale) and for companies subject to regulation by the state. WACC rates vary between 7.5% and 11% as shown in the two tables below.

Table 3: Decision making discount rates in energy supply sectors (2020-2050)[49]

Assumptions for REF2016	Discount rates
Regulated monopolies and grids	7.5%
Companies in competitive energy supply markets	8.5%
RES investment under feed-in-tariff	7.5%
Investment under contract for differences	7.5%
RES investment under feed-in premium, RES obligation, Quota systems with certificates	8.5%
RES investment in competitive markets	8.5%
Risk premium specific to immature or less accepted technologies	1-3 %
Risk premium specific to investment surrounded by high regulatory or political uncertainty	No
Country-specific risk premiums	No

Source: PRIMES

48 This is different from the perspective of a social planner who optimises the whole system from a societal perspective. In such a perspective social discount rates could play a role for determining normative inter-temporal choices.

49 The assumptions shown in the table are similar to those of the Reference 2013 exercise.

Table 4: Decision making discount rates of firms in energy demand sectors (2020-2050)[50]

Assumptions for REF2016	Discount rates
Energy intensive industries	7.5%
Non energy intensive industries	9%
Services sectors	11%
Public transport (road and conventional rail)	7.5%
Public transport (advanced technologies, e.g. high speed rail)	8.5%
Business transport sectors (aviation, trucks, maritime)	9.5%
Country risks	No

Source: PRIMES

Decisions by individuals are modelled based on a subjective discount rate, annualizing investment costs following the equivalent annuity cost method. Literature surveys[51] find high implicit discount rates for households, because of various factors, such as lack of information, uncertainties, different income levels, lack of sufficient funding, agency costs, transaction and hidden costs. By varying the discount rates applied in the model, it is therefore possible to reflect, for instance, the effects of energy efficiency policy instruments, mainly ESCOs, campaigns and labelling programs, by lowering the discount rates when these policies are implemented. Therefore, the EU Reference scenario uses discount rates for individuals reflecting both existing barriers for investment decisions (which have an upward effect on discount rates) and the impact of existing energy efficiency policies, such as energy-labelling, energy performance certificates for buildings, or the promotion of energy service companies (ESCOs), which are reflected by lower discount rates compared to default values. As such, discount rates for investment decisions used in the Reference scenario are comprised between 9.5% and 12% depending on the consumer good subject that is purchased.

Table 5: Decision making discount rates of individuals in energy demand sectors (2020-2050)

	EU Reference scenario 2016	
	Default discount rates	Modified discount rates due to EE policies
Private cars	11%	11%
Households for renovation of houses and for heating equipment	14.75%	12%
Households for choice of appliances	13.5%	9.5%

50 The assumptions shown in the table are significantly lower than those used for the Reference 2013 exercise.

51 For instance: Mundaca Luis, Lena Neiz, Ernst Worell and Michael McNeil (2010) "*Evaluating energy efficiency policies with energy-economy models*", Ernest Orlando Lawrence Berkeley National Laboratory. For a full list of references, please refer to the Reference scenario publication (https://ec.europa.eu/energy/sites/ener/files/documents/REF2016_report_FINAL-web.pdf).

Note: the discount rate assumptions are significantly lower in Reference 2015 compared to Reference 2013

As described above, in a second stage the model analyses the resulting energy system costs. Here, the crucial element is the amount of money that energy consuming agents (households and firms, grouped into the sectors services and industry, transport and agriculture) are required to pay in order to get the energy services they need. Energy services are provided by using energy commodities purchased by end-consumers, which depend on energy efficiency at the consumption level. The PRIMES report aggregates capital or investment expenditures (CAPEX) and purchasing costs for fuels and other energy commodities or operational expenditures (OPEX) of end-consumers to show a single total cost figure. OPEX for end-users already incorporates through pricing of energy commodities the CAPEX and OPEX costs incurred by the energy supply and trading sectors (calculated using the above mentioned WACC rates for those sectors). For making costs comparable, the CAPEX figures related to investments by final energy demand consumers also need to be annualised, and a flat discount rate of 10% is used for this purpose[52].

As in previous modelling exercises, comparability across the scenarios is of key importance and implies that the discount rates used in the cost accounting must not vary between scenarios. Consequently, the flat discount rate of 10% used for annualising CAPEX of end-consumers in the cost reporting of PRIMES and the reporting discount rates used for the Reference scenario is kept unchanged in all scenarios.

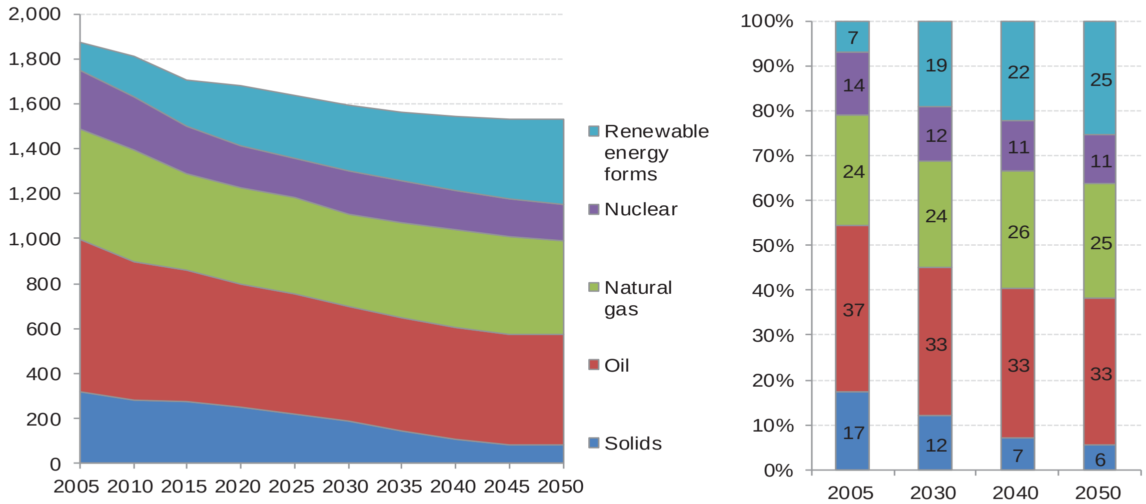
[52] The approach adopted in the 2016 Reference scenario and the present Impact Assessment accounts for the costs associated with CAPEX for final energy demand consumers using a flat rate (10%) across all end consumers, a lower rate than in the past that is more in line with the WACC used for the supply sector. This means that high perceived discount rates, which may be the result of market failures not related to financing (such as lack of information, split incentives), are no longer used for cost accounting.

4.3 Summary of EU Reference scenario 2016 main results

4.3.1 Gross inland consumption

The graphs below present the projected evolution of EU Gross Inland Energy Consumption. After the 2005 peak, energy consumption is projected to steadily decline until 2040, where it stabilises. Oil still represents the largest share in the energy mix, mostly because of transport demand. Solid fuels see a significant reduction in their share of the energy mix, while the biggest increase is for renewable energy. Natural gas and nuclear energy keep relatively stable shares in the energy mix.

Figure 5: EU28 Gross Inland Consumption (Mtoe, left; shares (%), right)

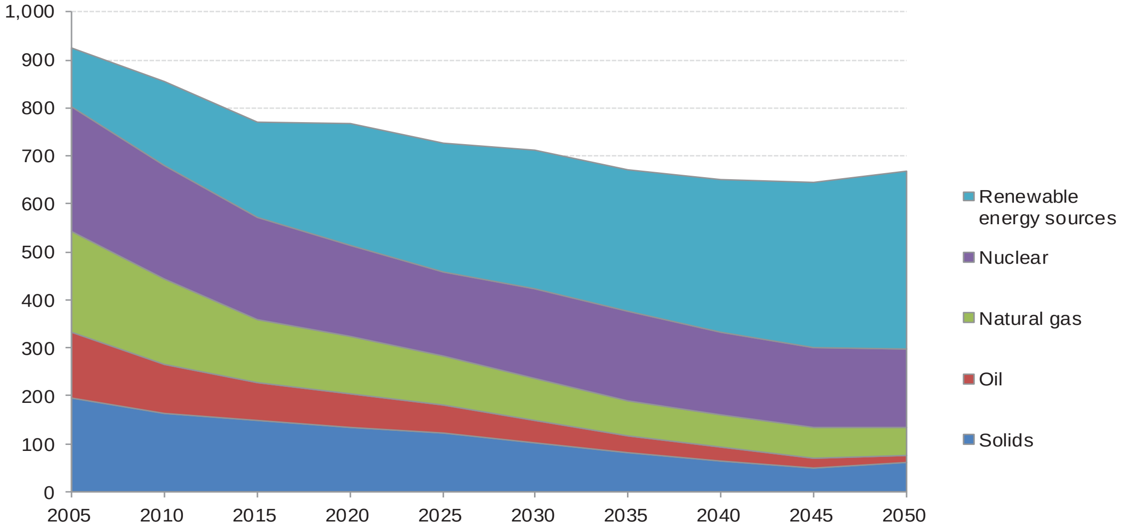


Source: PRIMES

4.3.2 Energy security

EU energy production is projected to continue to decrease from around 760 Mtoe in 2015 to around 660 Mtoe in 2050. The projected strong decline in EU domestic production for all fossil fuels (coal, oil and gas) coupled with a limited decline in nuclear energy production is partly compensated by an increase in domestic production of renewables. Biomass and biowaste will continue to dominate the fuel mix of EU domestic renewable production, although the share of solar and wind in the renewable mix will gradually increase from around 17% in 2015 to 36% in 2050.

Figure 6: EU28 energy production (Mtoe)



Source: PRIMES

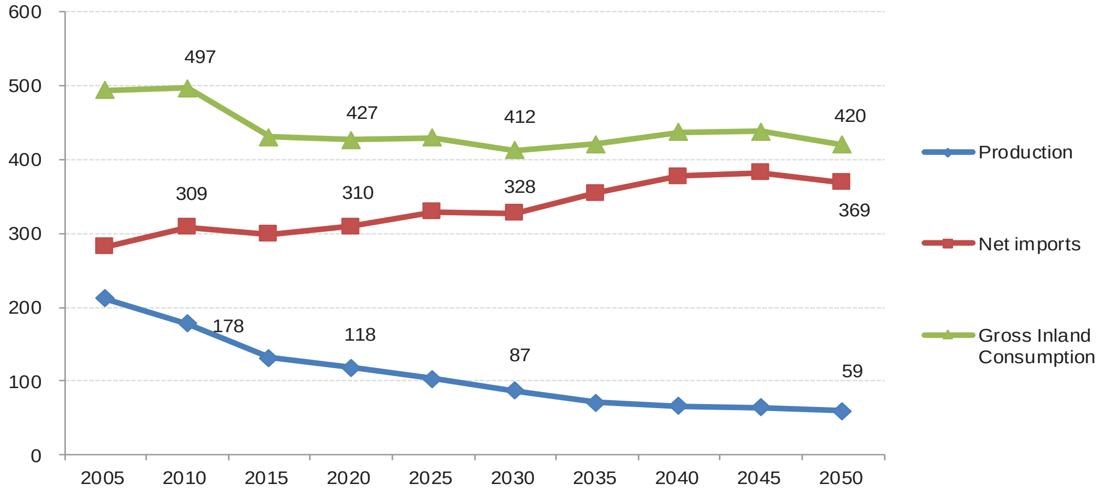
EU's import dependency shows a slowly increasing trend over the projected period, from 53% in 2010 to 58% in 2050. RES deployment, energy efficiency improvements and nuclear production (which remains stable) counteracts the strong projected decrease in EU's fossil-fuel production.

Solid imports as well as crude oil and (refinery) feedstock decline throughout the projection period, while oil products imports slightly increase. Natural gas imports increase slightly in the long term reaching approximately 370 bcm[53] net imports in 2050. Biomass remains mostly supplied domestically, although the combination of increased bioenergy demand and limited potential for additional EU domestic supply leads to some increases in biomass imports post-2020 (from 11% of biomass demand in 2020 to about 15% in 2030 and beyond).

Up to 2020, the consumption of gas is expected to remain stable at around 430bcm in gross inland terms. Post 2020, a slight decrease in gross inland consumption of gas (412 bcm in 2030) is projected, as well as further reductions in indigenous production of gas. Net import dependency of natural gas registers an increase as domestic gas production continues its downward trend. The imported volumes of gas are projected to increase between 2015 and 2040 and then to stabilise in the long term, 15% above the 2010 net import level (from 309 bcm in 2010 to 369 bcm in 2050).

53 The conversion rate of 1 Mtoe = 1.11 bcm was used for natural gas, based on the BP conversion calculator.

Figure 7: Gas - production, net imports and demand (volumes expressed in bcm)



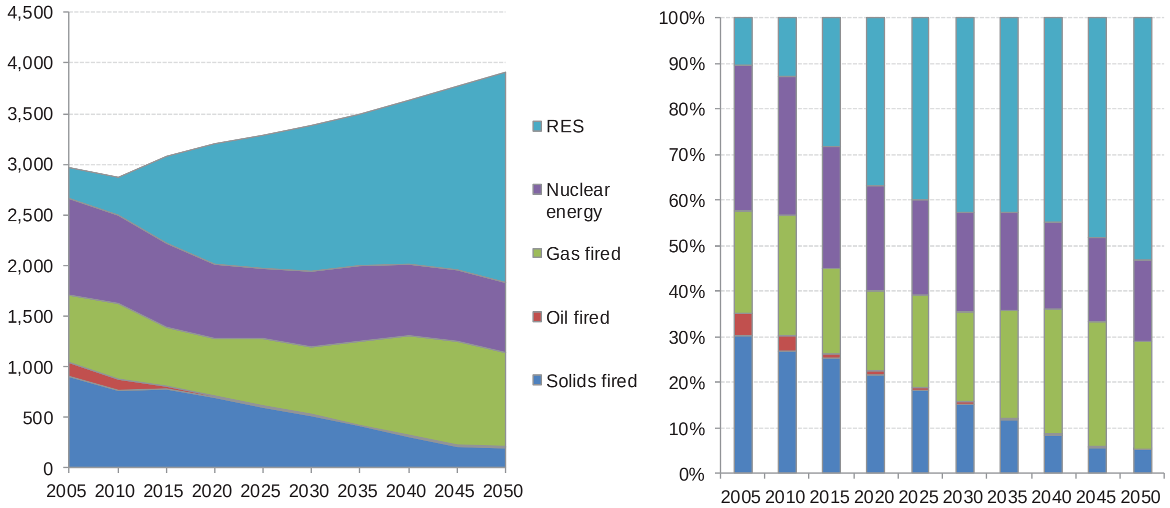
Source: PRIMES

4.3.3 Internal energy market and investments

The EU power generation mix changes considerably over the projected period in favour of renewables. Before 2020, this occurs to the detriment of gas, as strong RES policy to meet 2020 targets, very low coal prices compared to gas prices, and low CO_2 prices do not help gas to replace coal. After 2020, the change is characterised by further RES deployment, but also a larger coal to gas shift, driven mainly in anticipation of increasing CO_2 prices.

Gas therefore maintains its presence in the power generation mix in 2030 (at slightly higher levels in the long term compared to 2015). The share of solids/coal in power generation significantly declines, but not before 2020, to 15% in 2030.

Figure 8: EU power generation (net) by fuel (Mtoe – left, shares – right)



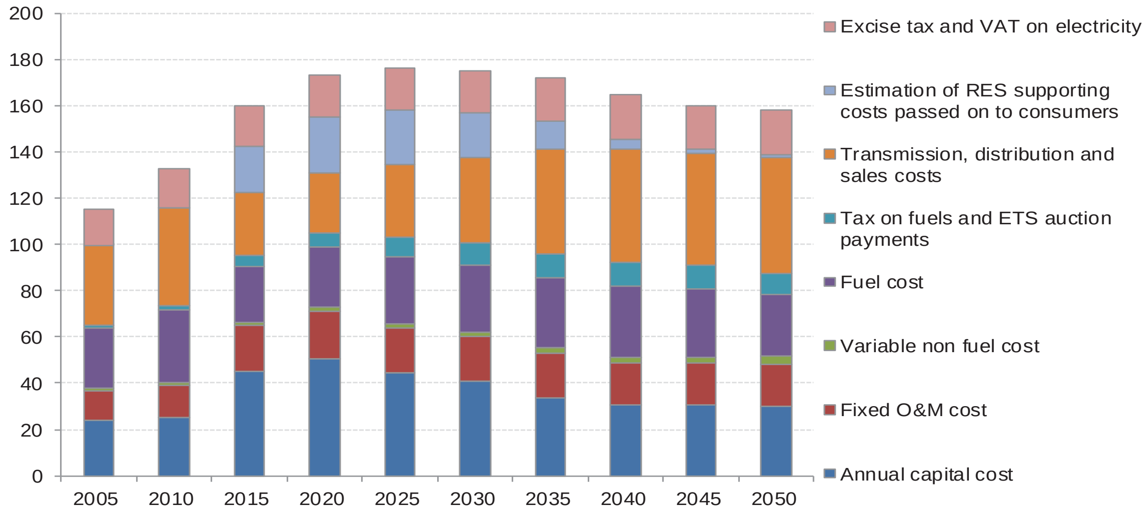
Source: PRIMES

Variable RES (solar and wind) reach around 19% of total net electricity generation in 2020, 25% in 2030 and 36% in 2050, demonstrating the growing need for flexibility in the power system. Wind onshore is expected to provide the largest contribution. Solar PV and biomass also increase over time. Hydro and geothermal remain roughly constant. The share of nuclear decreases gradually over the projected period despite some life time extensions and new built, from 27% in 2015 to 22% in 2030.

REF2016 shows increasing volumes of electricity trade over time. The flow between regions increases from 17% in 2015 to 26% in 2020, 29% in 2030 and then stays almost stable for the remainder of the projection period reaching 30% in 2050. Main drivers are intermittent RES power generation and the resulting balancing requirements. Trade is facilitated by the assumed successful development of the ENTSO-E Ten-Year Network Development Plan 2014[54] as well as pan-European market coupling and sharing of reserves and flexibility across Member States.

Average retail electricity prices[55] steadily increase up to 2030 by about 18% relative to 2010 levels, stabilising around 20% during 2030-2040, after which they start to gradually decrease. The structure of electricity costs changes over time, with the capital cost component (generation and grid costs) increasing significantly in the short term up to 2020, but decreasing afterwards in the longer term. From 2030, the fuel cost component remains stable despite the increase in fuel prices, due to a decreasing share of fossil-fuel combustion. Transmission and distribution costs increase significantly in the longer term, post-2030, partly linked to the need to cater for the increased presence of RES in the power generation mix.

Figure 9: Decomposition of electricity generation costs and prices (€'2013 MWh)



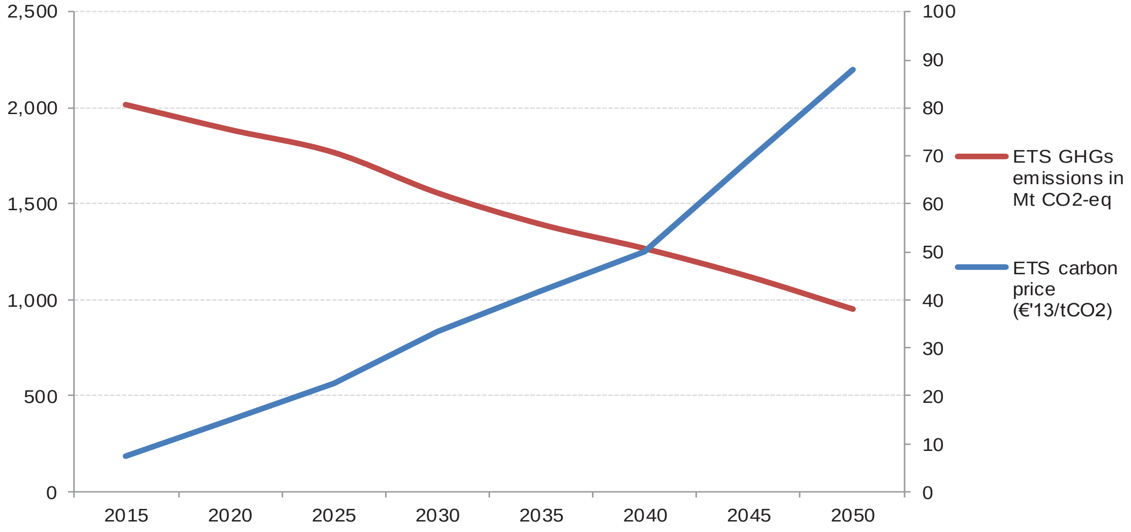
Source: PRIMES

As a result of the modelling, the carbon price is projected to increase, reflecting both the steadily decreasing ETS cap and the stabilising effect of the Market Stability Reserve. However, the increase in electricity prices due to ETS remains limited despite the significant increase in CO_2 price, as the share of carbon-intensive power generation decreases.

[54] Source: https://www.entsoe.eu/major-projects/ten-year-network-development-plan/ten%20year%20network%20development%20plan%202016/Pages/default.aspx

[55] In the PRIMES model, prices differ per type of end-user.

Figure 10: ETS emissions and carbon prices over time

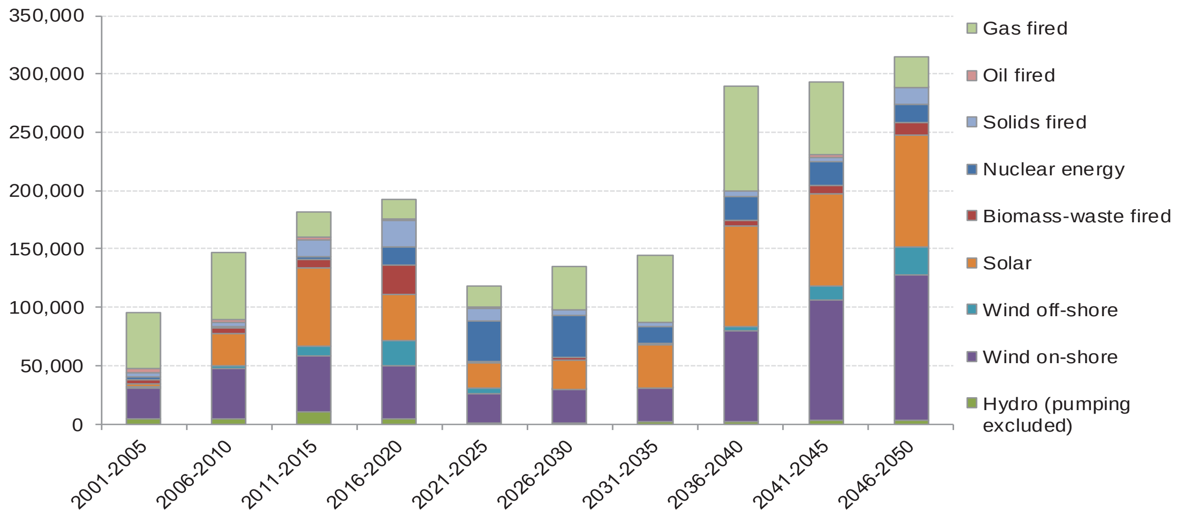


Source: PRIMES, GAINS

Electricity prices for households and services are projected to increase moderately in the medium term and to decrease slightly in the long term. Prices for industry on the contrary are stable or decrease over time as energy intensive industry maintains an electricity demand profile compatible with base-load power generation and bears a small fraction of grid costs and taxes. Taxes apply mainly on prices for households and services.

Investment expenditures for power supply increase substantially until 2020 driven by RES targets and developments, but slow down thereafter, until 2030, before increasing again from 2030 onwards notably due to increasing ETS carbon prices reflecting a continuously decreasing ETS cap based on the current linear factor. New power plant investment is dominated by RES, notably solar PV and wind onshore. Nuclear investment mostly takes place via lifetime extensions until 2030 and in the longer term via new built, such as projected in, for instance, the UK, Finland, Sweden, France, Poland, and other Central European Member States. New thermal plant investment is mainly taking place in gas-fired plants.

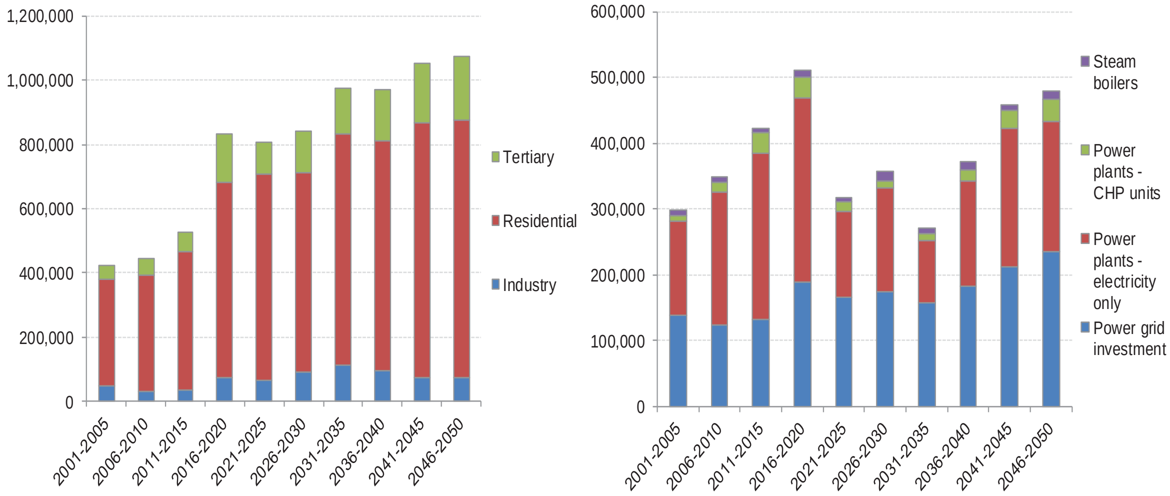
Figure 11: Net power capacity investments by plant type (MWh – for five year period)



Source: PRIMES

Investment expenditures in demand sectors (figure below – left hand side) over the projected period will be higher than in the past. They notably peak in the short term up to 2020, particularly in the residential and tertiary sectors, as a result of energy efficiency polices. Post-2020 they slightly decline until 2030, before increasing again to 2050. On the supply side (figure below – right hand side), investments peak towards 2020, followed by a decrease, notably explained by a decline in power generation investments.

Figure 12: Investment expenditures (5-year period) - demand side, million €'2013 (left, excluding transport) and supply side, million €'2013 (right)



Source: PRIMES

Transport investments (expenditures related to transport equipment) steadily increase over time but maintain a relatively stable share of GDP (i.e. between 4% and 4.5% of GDP over the projection period).

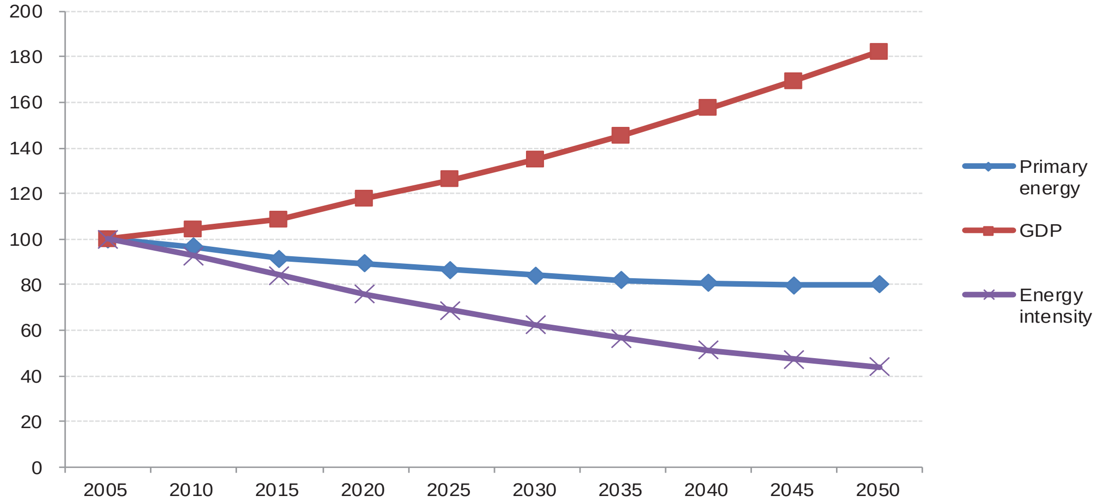
The relative weight of energy-related spending in households' expenditure[56] increases in 2020 compared to 2015 (7.5% compared to 6.8%), stabilising until 2030 before decreasing again until 2050 (6.1%).

4.3.4 Moderation of energy demand

In 2020, primary energy consumption decreases by 18.4% (relative to the 2007 baseline, i.e. how the energy efficiency target is defined), more than the sum of national Member States' indicative energy efficiency targets but still falling slightly short of the 2020 indicative EU energy efficiency target of 20%. In 2030, energy consumption is projected to decrease (again relative to 2007 baseline projections) by 23.9%. Primary energy demand and GDP continue to decouple which is consistent with the trends observed since 2005. Energy efficiency improvements are mainly driven by policy up to 2020 and by market/technology trends after 2020.

56 Share of energy system costs for the residential sector (fuel costs and annualised capital costs of energy related investment expenditures) in total households' consumption

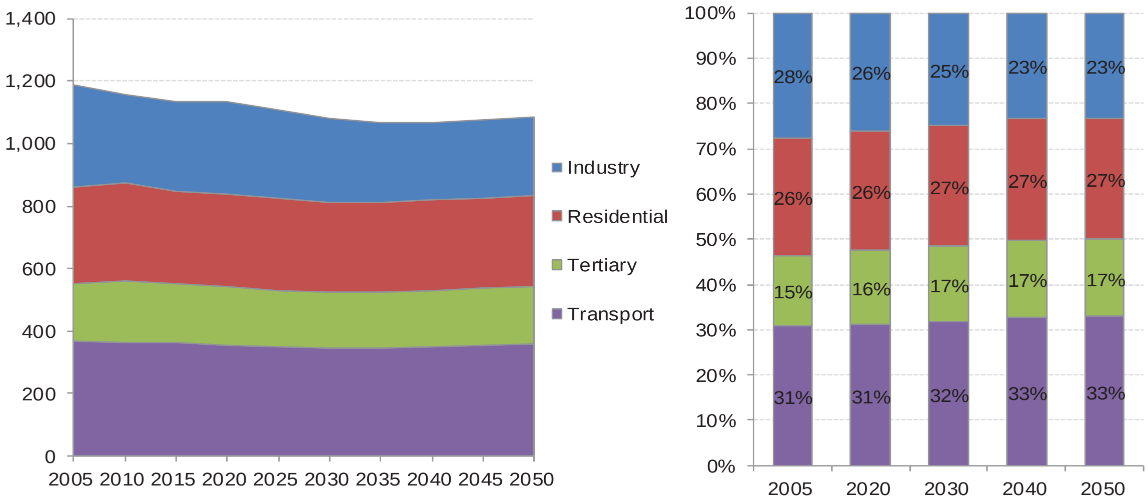
Figure 13: Decoupling of EU energy use and intensity from GDP (2005=100)



Source: Commission calculations based on PRIMES and GEM E3

The distribution of final energy consumption across sectors remains broadly similar to the current picture, all the way to 2050, with transport and the residential sector comprising the lion's share of final energy consumption (32% and 27% of final consumption, respectively, in 2030). Industry sees its share in final energy demand slightly decreasing, from 28% in 2005 to 23% in 2050, mostly due to improved energy efficiency in non-energy intensive industries. The tertiary (services and agriculture) sector keeps a stable share of about 17%.

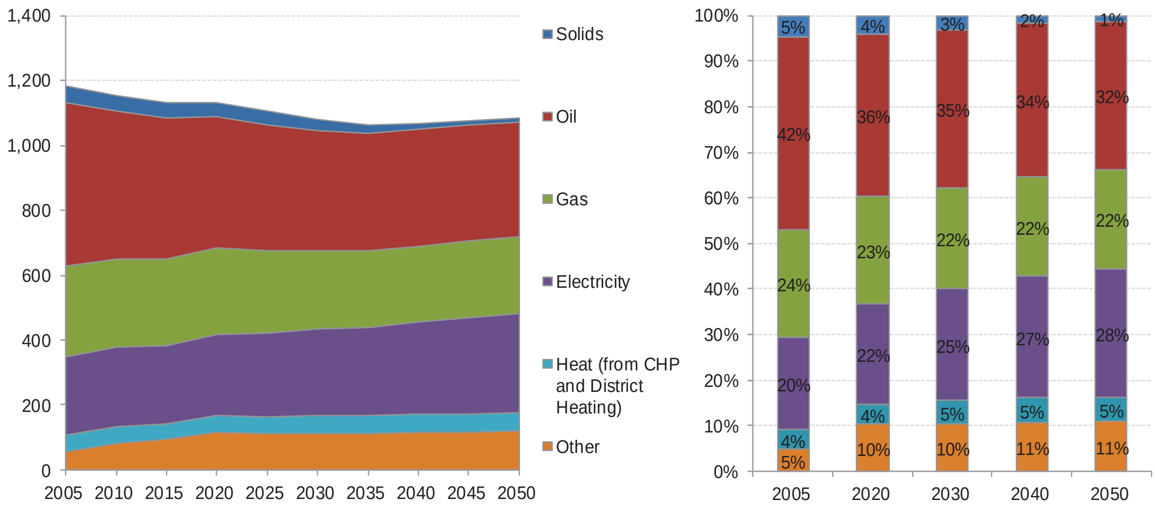
Figure 14: Evolution of final energy demand by sector (Mtoe – left, shares – right)



Source: PRIMES

With regard to the fuel mix in final energy demand, there is a gradual penetration of electricity (from 20% in total final energy use in 2005 to 28% in 2050). This is because of growing electricity demand as compared to other final energy use and to some electrification of heating (heat pumps) and to a limited extent of the transport sector.

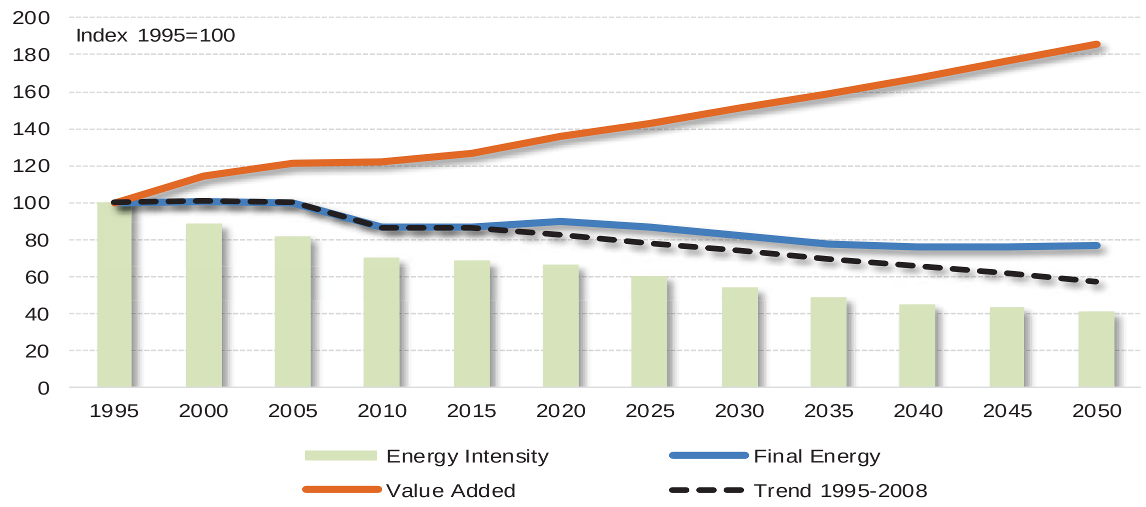
Figure 15: Evolution of final energy demand by fuel (Mtoe – left, shares – right)



Source: PRIMES

Energy intensity of the industrial sectors remains approximately constant in the medium term, as additional energy demand is due to the increase in production activity. In the long term however energy demand decreases, even though activity in terms of value added progresses. This is due to the energy efficiency embedded in the new capital vintages which replace old equipment and structural changes towards higher value added and less energy-intensive production processes, such as in iron and steel or non-ferrous metals.

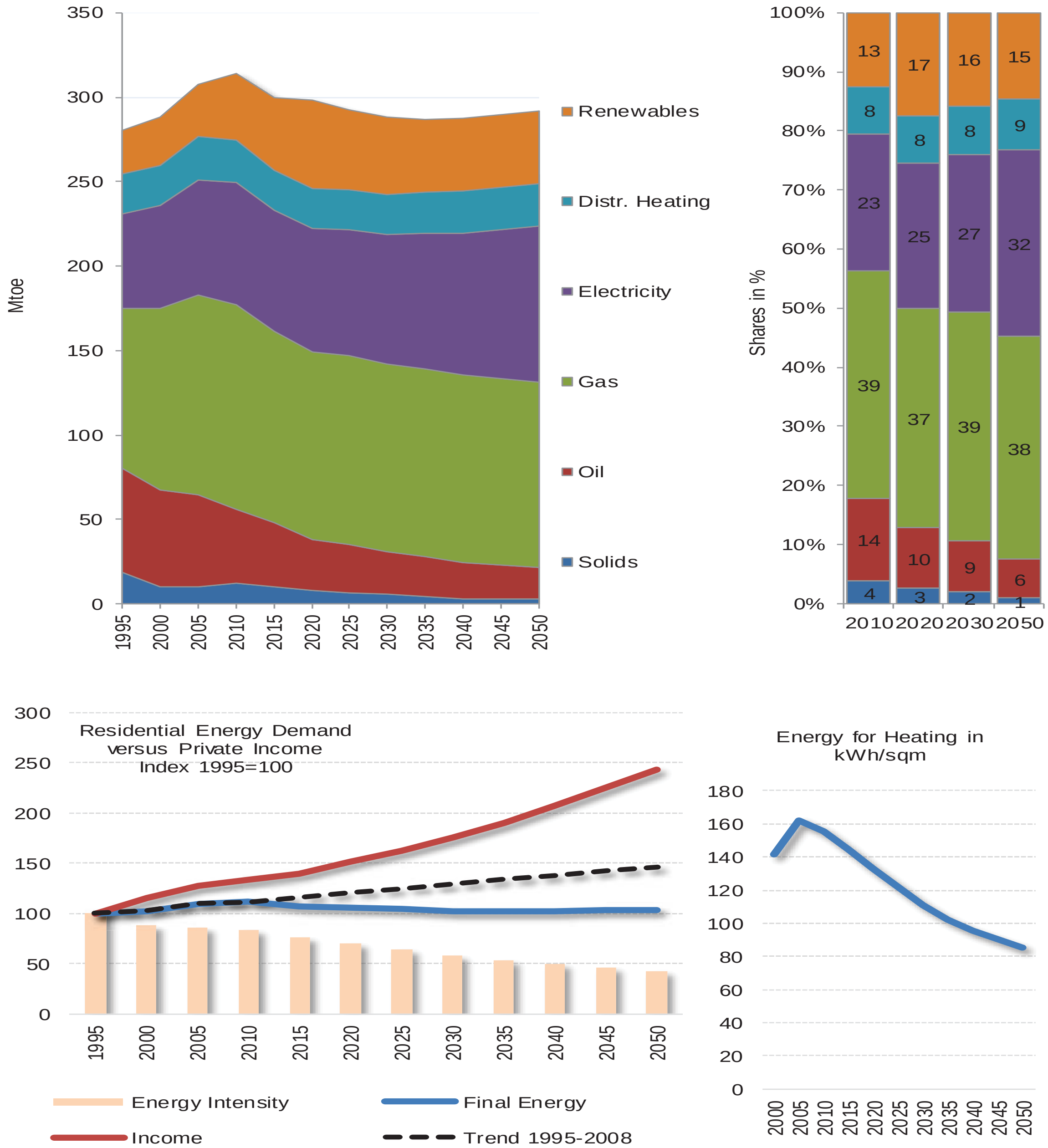
Figure 16: Industrial energy demand versus activity (value added)



Source: PRIMES

In the residential sector, energy demand remains below 2015 levels throughout the projection period. Energy demand decouples from income growth more than would be suggested by a simple extrapolation of past trends as the efficiency policies drive energy intensity improvements faster in the medium term; in the long term however the rate of improvements decreases due to the absence of additional policies.

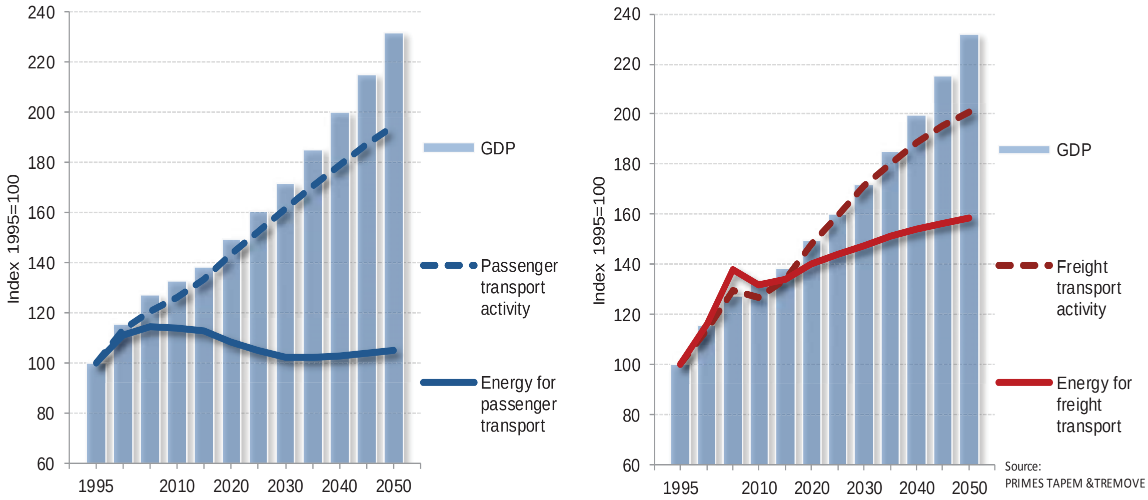
Figure 17: Final energy demand in the residential sector



Source: PRIMES

The activity of the transport sector shows a significant growth (**Error! Reference source not found.**4), with the highest increase in 2010 to 2030, driven by developments in economic activity. Historically, the growth of final energy demand in the transport sector has shown strong correlation with the evolution of transport activity. However, a decoupling between energy consumption and transport activity has been recorded in the past years. The decoupling between energy consumption and activity is projected to continue and even to intensify in the future.

Figure 18: Trends in transport activity and energy consumption



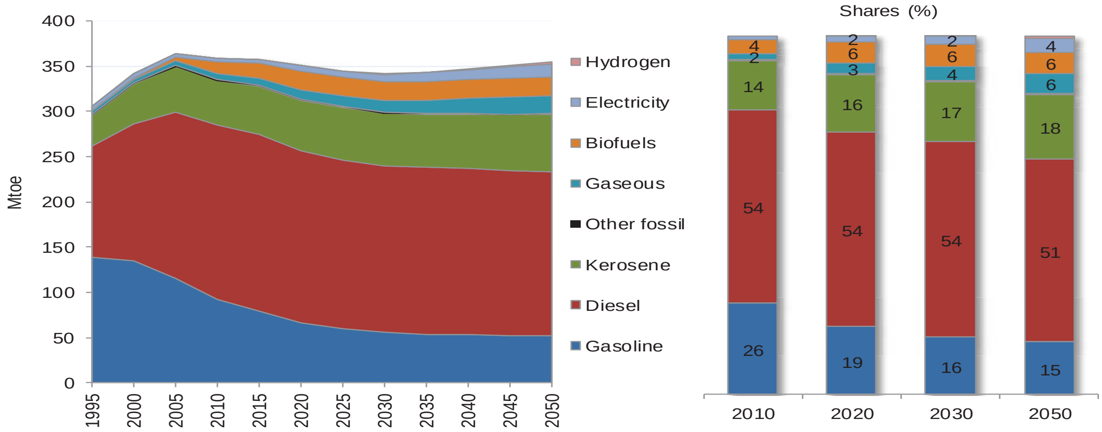
Source: PRIMES and GEM-E3; For aviation, passenger transport activity includes domestic, international intra-EU and international extra-EU aviation.

Electricity use in transport is expected to increase steadily as a result of further electrification of rail and the uptake of alternative powertrains in road transport. However, its share is projected to remain limited in the Reference scenario, increasing from 1% currently to 2% in 2030 and 4% in 2050. The uptake of hydrogen would be facilitated by the increased availability of refuelling infrastructure, but its use would remain low in lack of policies adopted beyond the end of 2014.

Liquefied natural gas becomes a candidate energy carrier for road freight and waterborne transport, especially in the medium to long term, driven by the implementation of the Directive on the deployment of alternative fuels infrastructure and the revised Trans-European Transport Network (TEN-T) guidelines which represent important drivers for the higher penetration of alternative fuels in the transport mix. However, the potential of gas demand developments in the transport sector do not fully materialise in the Reference scenario, suggesting that additional policy incentives would be needed to trigger further fuel switching.

Diesel is projected to maintain its share in total final energy demand in transport by 2030, slowly decreasing its share only during 2030-2050. Consumption of gasoline declines considerably until 2030, continuing the declining trend from 1995 and stabilizes from thereon to 2050. Consumption of jet fuels in aviation increases steadily by 2050 due to the strong growth in transport activity and despite improvements in energy efficiency.

Figure 19: Final energy demand in transport by fuel type



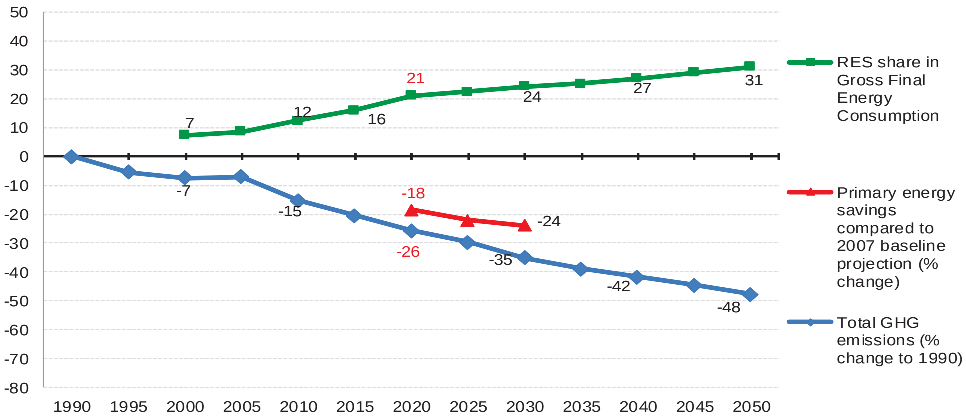
Source: PRIMES-TREMOVE; Biofuels include biomethane used in transport.

Oil products would still represent about 90% of the EU transport sector needs (including maritime bunker fuels) in 2030 and 86% in 2050, despite the renewables policies and the deployment of alternative fuels infrastructure which support some substitution effects towards liquid and gaseous biofuels, electricity, hydrogen and natural gas.

4.3.5 Decarbonisation

The EU Reference scenario 2016 is set up to meet the binding energy and climate targets for 2020, the latter being achieved as a result of existing policies. However, it shows that current policies and market conditions will deliver neither the agreed 2030 targets nor our long-term 2050 objective of 80 to 95% GHG emission reductions. In addition, as mentioned above, based on current market trends and adopted policies, the energy efficiency 2020 non-binding target is not met in REF2016, the scenario projecting a reduction in primary energy savings (relative to the 2007 baseline) of 18% in 2020, and, respectively, 24% in 2030. GHG emissions from sectors covered by the Effort Sharing Decision are projected to decrease by 16% in 2020 and by 24% in 2030 below 2005 levels, less than emissions in sectors covered by the EU Emission Trading System. The latter continue to decrease significantly after 2030.

Figure 20: Projection of key policy indicators: GHG, RES, (EE)



Source: PRIMES, GAINS

4.3.6 Renewable Energy

In 2020, the RES share in gross final energy consumption reaches 21% in 2020, while in 2030, it increases slightly further, reaching 24%.

Renewable electricity is projected to increase (as a share of net power generation) from around 28% in 2015 to 36% in 2020, which implies an acceleration compared to observed trends today, in particular in a number of countries that are currently facing difficulties to meet their target. Further RES share increases are more limited until 2030, reaching 43%, as RES policies are phased out in REF2016 after 2020 and only the most competitive RES technologies are projected to emerge.

The RES share in heating and cooling (RES-H&C) increases from 17% in 2015 to 22% in 2020, reaching 25% in 2030. The use of RES in final demand for heating and cooling is the main driver of RES-H&C increase in the short term, but its contribution stagnates in the long term. In the long-term, RES in CHP and heat plants (e.g. district heating), as well as some deployment of heat pumps, drive further increase of the RES-H&C share. Energy efficiency, implying lower demand for heat in all sectors, is also an important driver in the medium and long term.

The RES share in transport (RES-T) reaches 11% in 2020. The development of biofuels is the main driver in the short term, but their contribution stagnate in the long term. The biofuel penetration is mainly driven by the legally binding target of 10% renewable energy in the transport sector. Projections also take into consideration specific Member State mandatory blending obligations and tax incentives, as well as the Indirect Land Use Change (ILUC) amendment of the Renewables and Fuel Quality Directives, and corresponding changes in RES-T target accounting rules. Higher share of RES in electricity, combined with the relative increase of electricity use in transport (albeit modest in share terms), is the main contributor to RES-T in the long term.

4.3.7 CO_2 emission reduction

In REF2016, the binding energy and climate targets for 2020 will be met by assumption. However, current policy and market conditions will not deliver achievement of either the EU 2030 targets or the EU long-term 2050 decarbonisation goal.

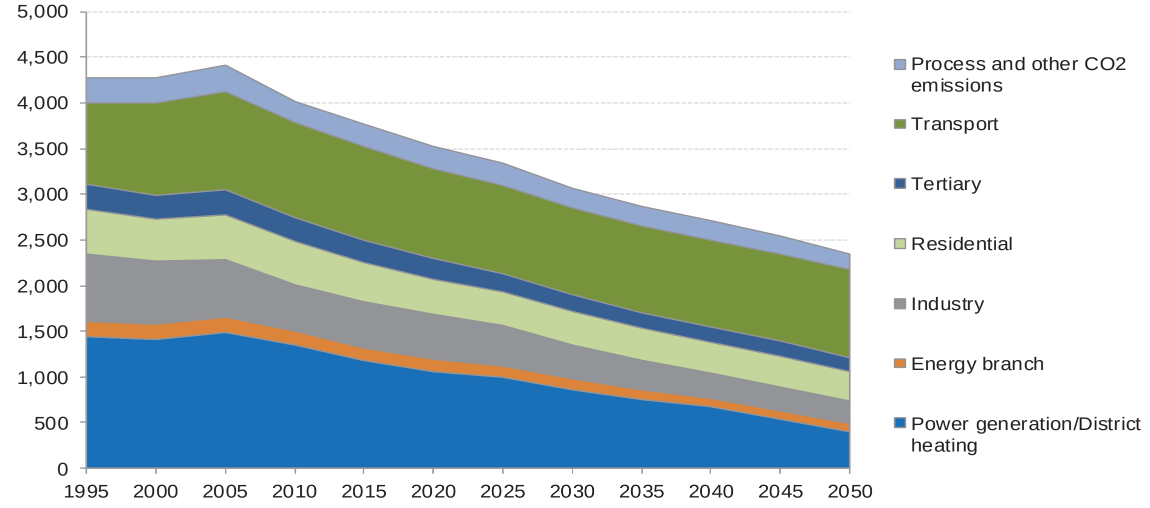
Total CO_2 emissions are projected to be 22% below 1990 levels by 2020. In 2030, CO_2 emissions reduce (relative to 1990 levels) by 32%. Most of these emissions are energy related, and this part also determines the overall trends. Non-energy related CO_2 emissions mainly relate to industrial processes, and remain rather stable. Land-use related CO_2 emissions are discussed below in the LULUCF section.

Emission reductions in the ETS sectors are larger than those in sectors covered by the Effort Sharing Decision (ESD) as current legislation implies a continuation of the reduction of the ETS cap with 1.74% per year over the projected period leading to a carbon price driving long term emission reduction. In the ESD sectors there are no further drivers beyond market forces (e.g. rising fossil future fuel prices) and the continued impact of adopted policies such as CO_2 standards for vehicles or energy performance standards for new building to further reduce energy and consequently emissions. Around two thirds of ESD sector emissions are CO_2 emissions, the rest are non-CO_2 emissions.

CO_2 emissions can be decomposed in the following components GDP, Energy Intensity of GDP and Carbon Intensity of Energy. The Energy Intensity of GDP component declines due to structural changes in the economy and increasing energy efficiency in all sectors. The decrease of carbon intensity of energy supply becomes an increasingly significant component over the period. This is mainly due to Renewable Energy policies in the short term and the ETS in the medium to long term.

On a sectoral level, CO_2 emissions decrease in all sectors between 2010 and 2050. The figure below shows a steep decrease in power generation, whereas emissions in the field of transport decrease at much slower pace, and the transport sector becomes the largest source of CO_2 emissions after 2030. Non-energy and non-land use related CO_2 emissions (e.g. industrial processes) reduce only slowly throughout the projection period; however they only represent a small share of total CO2 emissions.

Figure 21: Evolution of CO_2 emissions (Mt) by sector



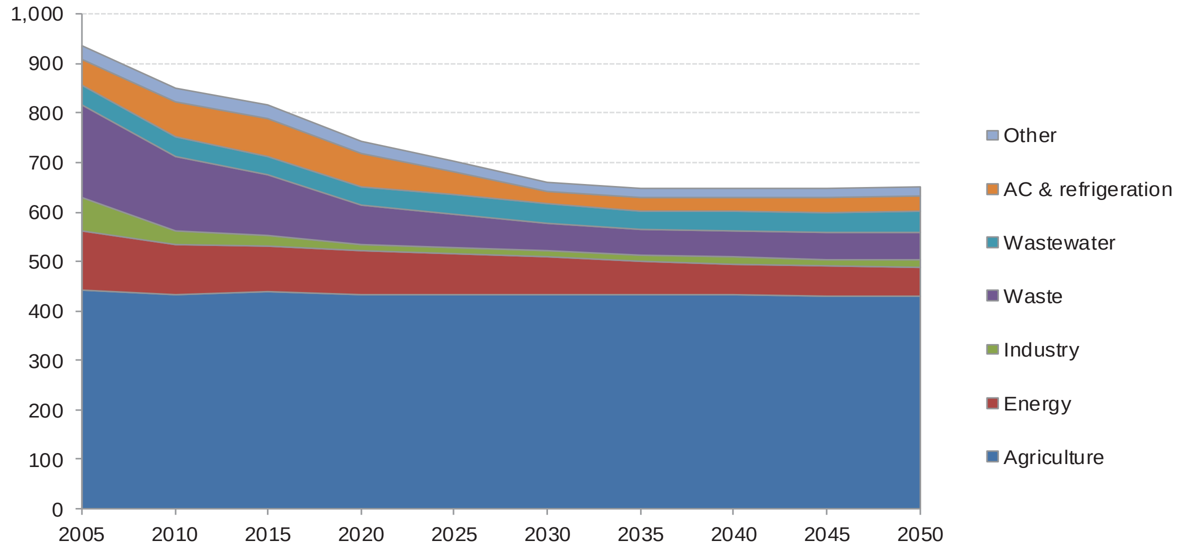
Source: PRIMES

4.3.8 Non-CO_2 GHG emission reductions

Non-CO_2 emissions (CH_4, N_2O and F-gases), accounted in 2013 for 18% of total EU GHG emissions (excluding LULUCF). They have decreased significantly (32%) between 1990 and 2013. They are expected to further decrease by 29% below 2005 levels in 2030 (-46% compared to 1990 levels), and to stagnate later on. CH_4 emissions – which have the largest share in this aggregate - are projected to decrease above average (33% due to declining trends in fossil fuel production, improvements in gas distribution and waste management) and N_2O emissions fall less than average (17%) until 2030, both remaining flat thereafter. F-gases would reduce by half between 2005 and 2030, largely driven by EU and Member State's policies (i.e. the 2014 F-gas regulation and Mobile Air Conditioning systems directive); F-gases would increase somewhat between 2030 and 2050 in line with economic developments. Except for a very minor fraction from some specific industries, non-CO_2 emissions fall under the ESD.

The non-CO_2 emission trends and their drivers vary by sector. **Agriculture** is responsible for about half of all non-CO2 emissions and is expected to increase its share in total non-CO_2 until 2030. While the agricultural non-CO_2 emissions have reduced by 22% between 1990 and 2013, they are projected to roughly stabilize at current levels as a result of different trends which compensate each other, such as decreasing herd sizes (both of dairy cows and of non-dairy cattle) but increasing milk yields. Slightly reduced use of mineral fertilizer through improved efficiency (2% less in 2030 than in 2005) leads to corresponding reductions in N_2O emissions from soils. Improved manure management (e.g. through anaerobic digestion) also delivers minor emission reductions. The Common Agricultural Policy influences, inter alia, livestock numbers/intensities and the Nitrogen Directive and the Water Framework Directive impact on the use of fertilizer.

Figure 22: Non CO2 GHG emissions



Source: GAINS

Waste is currently the second most important sector emitting non-CO2. There, a substantial reduction between 2005 and 2030 is expected (70%), strongly driven by environmental legislation, such as the Landfill directive and improvements in waste management as well as an update in inventory methodology of historic landfills that results in increased historic emissions and subsequent increased reductions of these emissions in the near to mid-term future. Also an increasing amount of CH_4 is recovered and utilised, thereby impacting on these trends towards lower emissions. After 2030, however, a moderate increase is projected, reflecting trends in economic development.

CH_4 and N_2O emissions from the **energy** sector (including transport) are expected to decrease by 36% from 2005 to 2030, and by 26% between 2030 and 2050. The main reductions come from less coal-mining and crude oil production in the EU, together with reduced emissions from power generation using fossil fuels. On the other hand, transport is expected to generate an increasing share of energy sector non-CO_2 emissions (N_2O from road transport being the most important contributor), growing from 12% in 2005 to 15% in 2030 and 20% in 2050 within the energy aggregate.

Emissions from **air conditioning and refrigeration** decrease by half from 2005 until 2030, also thanks to existing legislation (i.e. the new 2014 F-gas Regulation and the Mobile Air Conditioning systems Directive).

Most of the non-CO_2 emissions from **industry** – overall a minor non-CO_2 sector - are covered by the EU ETS (production of adipic and nitric acid, and of aluminium). The resulting incentives in combination with relatively cheap abatement options and existing national legislation cut emissions quite rapidly, to only a fifth in 2030 of those in 2005. For the period after 2030 slight increases are projected in line with economic trends.

Emissions from the **wastewater** sector and remaining **other sectors** are projected to increase moderately in line with economic development over the whole period covered.

4.3.9 LULUCF emissions and removals

The EU28 Land Use Land Use Change and Forestry (LULUCF) sector is at present a net carbon sink which has been sequestering annually on average more than 300 Mt CO_2 over the past decade according to the UNFCCC inventory data[57]. In REF2016, the LULUCF sink is expected to decline in the future to -288 Mt CO_2 eq in 2030 from -299 Mt CO_2 eq. in 2005 and decreases further after 2030. This decline is the result of changes in different land use activities of which changes in the forest sector are the most important. These changes are driven partly by the increase in timber demand (itself partially a result of the increase in bioenergy demand that is expected in order to reach the RES targets in 2020). The figure blow shows the projection of the total EU28 LULUCF sink in REF2016 and the contribution from different land use categories.

At present, the carbon sink in managed forest land (-373 Mt CO_2 eq. in 2010 without applying any accounting rules[58]) is the main component of the LULUCF sink. The managed forest land sink is driven by the balance of forest harvest and forest increment rates (accumulation of carbon in forest biomass as a result of tree growth). Forest harvest is projected to increase over time from 516 million m^3 in 2005 to 565 million m^3 in 2030 due to growing demand for wood for material uses and energy production. Along with the aging of EU forest – which reduces the capacity of forest to sequester carbon – the forest increments are projected to decrease from 751 million m^3 in 2005 to 725 million m^3 in 2030. As a consequence, the rate of accumulation of carbon (i.e. the sink) in managed forest land declines by 32% until 2030. This is partially compensated by a continuation of increasing trend in carbon sink from afforestation and decreasing trend of emissions from deforestation which decline from 63 Mt CO_2 in 2005 to 20 Mt CO_2 eq. in 2030. Carbon sequestration from afforested land increases steadily to 99 Mt CO_2eq. by 2030, as new forests continue, albeit at slower rate, to be established. In addition, young forests that were established over the last 20 years get into a phase of high biomass production.

Activity in the agricultural sector (on cropland and grassland) has a smaller impact on the total LULUCF sink than the forest sector. Still, net carbon emissions from cropland are projected to decline by some 18% by 2030 compared to 2005 as soils converge towards soil carbon equilibrium over time. In addition, perennial crops (miscanthus, switchgrass and short rotation coppice) that typically sequester additional carbon in soil and biomass contribute to decreasing cropland emissions. By 2030, 0.9 Mha of perennial crops are expected to be cultivated. The grassland sink increases to around -19 Mt CO_2 eq. in 2030 as land continues to be converted to grassland e.g. through cropland abandonment while at the same time the total grassland area slightly declines over time due to afforestation and the expansion of settlements.

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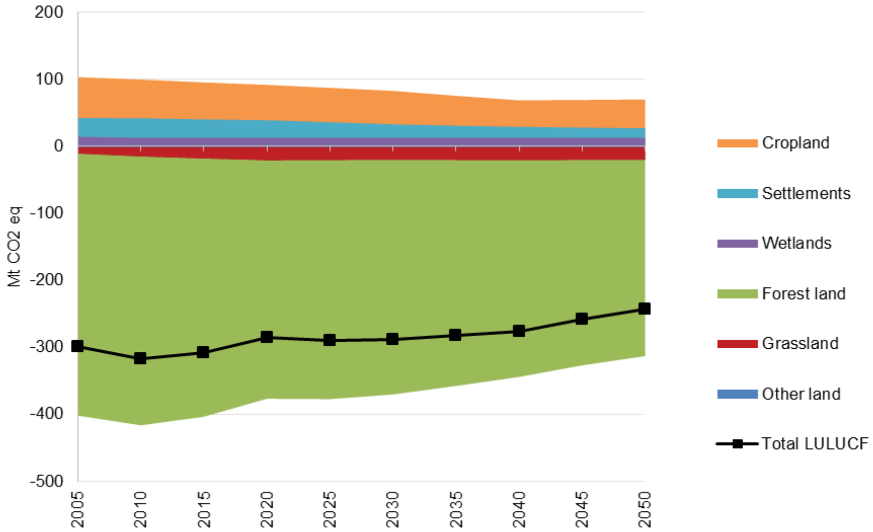
[57] See: http://unfccc.int.

[58] The GHG accounting approach for LULUCF differs from other emission sectors. Notably, forest management is not accounted compared to historic emissions, but against a so called Forest Management Reference Level. This means that the accounted removals from the LULUCF sector are much smaller than the reported removals seen by the atmosphere.

Figure 23: EU28 emissions/removals in the LULUCF sector in Mt CO2 eq. until 2050[59]



Source: GLOBIOM-G4M

4.3.10 Research, innovation and competitiveness

Although REF2016 does not deal explicitly with research and innovation, it does tackle directly the penetration of new technologies. The approach is in two steps. First, assumptions are made on techno-economic characteristics and technological learning curves based on latest scientific evidence[60]. Figure 20 presents an illustration of the RES power technologies assumptions used in REF2016. Second, the model endogenously selects the most economically viable technologies at each point in time, leading to further technological cost reduction as technologies are deployed at increasingly larger scales.

The development of solar photovoltaics (PVs) starts from lower costs than in the previous Reference Scenario and has a positive learning curve throughout the projection period. This translates into significant deployment of solar PVs in REF2016, especially in Southern Europe.

Although wind onshore costs are already competitive with many conventional technologies, the remaining potential for learning is estimated to be small, but costs can decrease due to the size of turbines and their height; very small scale wind is the only exception and still has high learning potential.

There remains large uncertainty about the costs for offshore wind and there have been cost increases due to previously unforeseen difficulties and logistics. Surveys have identified significant potential of cost decrease due to economies of scale and possibilities of improvement in logistics, but these cost decreases are likely to occur only towards 2030. As such, offshore wind developments in REF2016 are more conservative than in past exercises.

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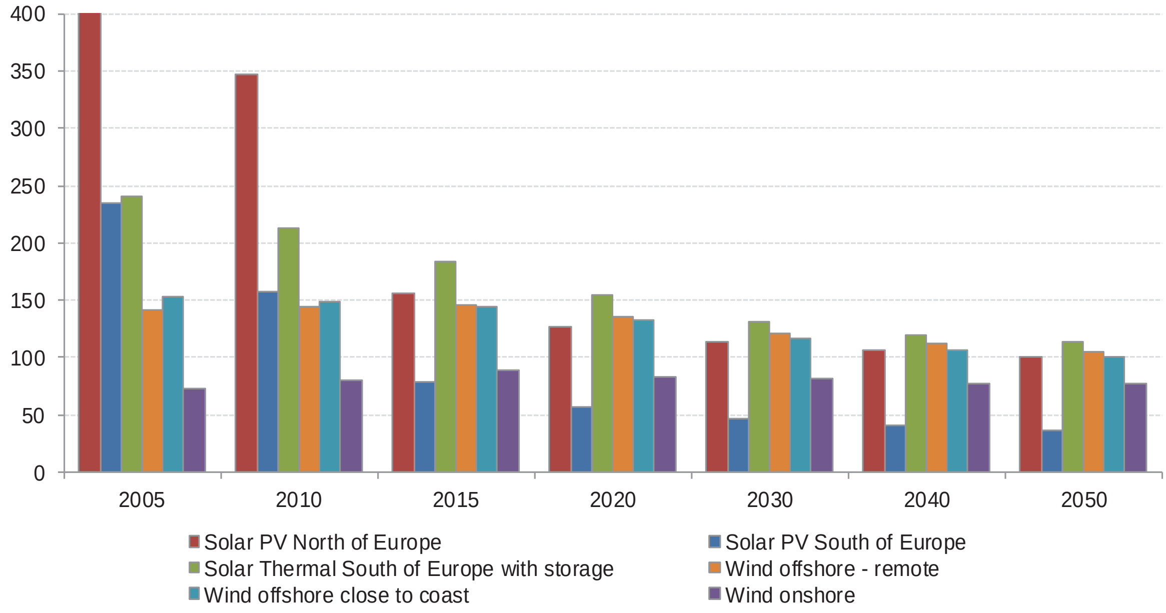
[59] Emissions from deforestation and harvested wood products are included in "Forest land" in contrast to UNFCCC inventories.

[60] See notably the European Commission's Joint Research Centre ETRI 2014 report, available at: https://setis.ec.europa.eu/publications/jrc-setis-reports/etri-2014

Figure 20: Illustrative levelized cost of electricity for selected RES technologies (expressed in €'2013/MWh-net)



Source: NTUA based on PRIMES

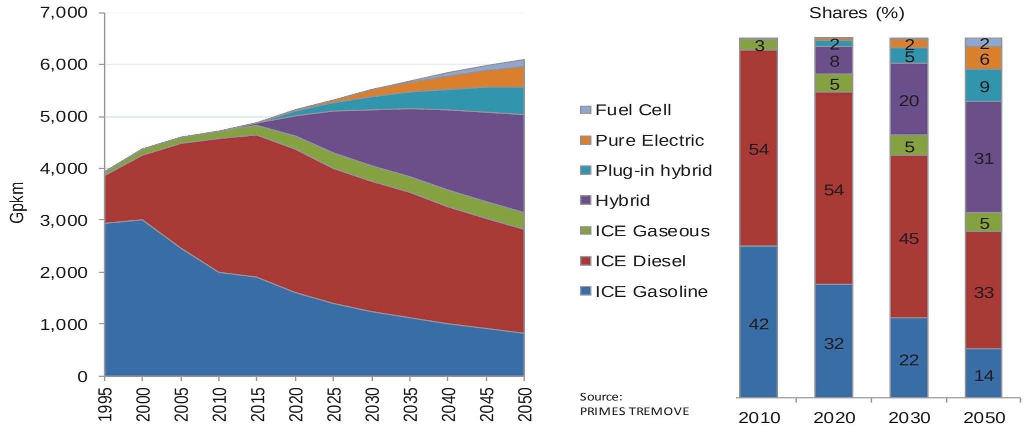
Compared to the previous Reference scenario, the costs of nuclear investment have increased and also the costs for nuclear refurbishments have been revised upwards. Although lifetime extensions of nuclear power plants remain economically viable in most cases, investments in new built plants are lower compared to previous projections.

The construction of power plants equipped with carbon capture and storage (CCS) technologies is developing at a very slow pace, and is dependent on public support (e.g. EEPR and NER300). Geological restrictions as well as current political restrictions on storage are also reflected. For these reasons, CCS costs are assumed higher than in previous Reference scenarios. Uptake of carbon capture and storage (CCS) in power and industry beyond supported demonstration plants remains very slow and occurs only towards the end of the projection period, driven by increasing ETS carbon prices.

On the demand side, demand for electric appliances continues to increase. However, there is an uncoupling between appliance stock and energy consumption due to the technological progress facilitated by ecodesign regulations.

Car manufacturers are expected to comply with the CO_2 standards by marketing vehicles equipped with hybrid system, which are becoming more appealing to the consumers thanks to lower costs. Electrically chargeable vehicles emerge around 2020 and are kick-started by existing EU and national policies as well as by incentive schemes aiming to boost their penetration. The share of activity of total electric vehicles in the total activity of light duty vehicles reaches 15% in 2050. Fuel cells would add an additional 2% by 2050. Other energy forms such as liquefied petroleum gas (LPG) and natural gas maintain a rather limited share.

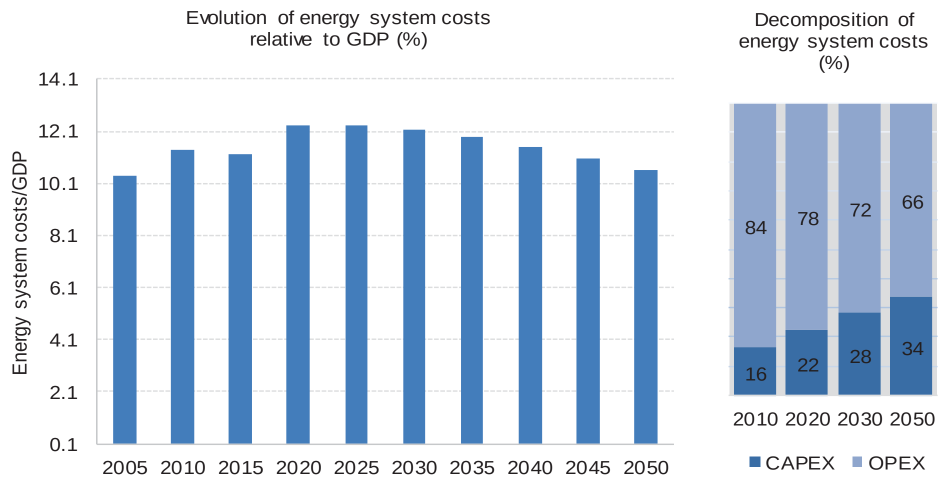
Figure 24: Evolution of activity of light duty vehicles by type and fuel[61]



Source: PRIMES-TREMOVE

Energy system costs increase up to 2020. Large investments are undertaken driven by current policies and measures. Overall, in 2020 energy system costs constitute 12.3% of the GDP, rising from 11.4% in 2010 and 11.2% in 2015, also driven by projected rising fossil fuel prices[62]. Despite further fossil fuel price increases, between 2020 and 2030 the share remains stable and decreases thereafter, as the system reaps benefits from the investments undertaken in the previous decade (notably via fuel savings). In this period, the share of energy system costs in GDP is gradually decreasing, reaching levels close to 2005 by 2050.

Figure 25: Projected evolution of energy system costs



Source: PRIMES, Energy system costs exclude ETS auction payments, given that they result in corresponding auction revenues.

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[61] Light duty vehicles include passenger cars and light commercial vehicles.

[62] Total system costs include total energy system costs, costs related to process-CO_2 abatement and non-CO_2 GHG abatement.

4.4 Overview of model-based policy scenarios

Two central policy scenarios reflecting the 2030 targets and main elements of the 2030 climate and energy framework agreed by the European Council in 2014[63] have been developed: EUCO27 and EUCO30. This recognises that for the energy efficiency target a review will still be undertaken to set the level of ambition. These scenarios also aim to provide consistency across a number of impact assessments underpinning 2016 Energy Union policy proposals. Using two central scenarios increases the robustness of policy conclusions.

All policy scenarios build on the REF2016, as described in the section above, and add the targets and policies described in detail in section below.

In addition, coordination policies are assumed which enable long term decarbonisation of the economy. Coordination policies replace the "enabling conditions" which have been modelled in 2030 framework IA and the 2014 Impact Assessment on 2030 energy efficiency targets.

4.4.1 EUCO27 policy scenario

In October 2014, the European Council decided on the energy and climate 2030 framework[64]. The following was agreed among the heads of states and governments:

- Substantial progress has been made towards the attainment of the EU targets for GHG emission reduction, renewable energy and energy efficiency, which need to be fully met by 2020.
- Binding EU target is set of an at least 40% domestic reduction in GHG emissions by 2030 compared to 1990.
- This overall target will be delivered collectively by the EU in the most cost-effective manner possible, with the reductions in the ETS and non-ETS sectors amounting to 43% and 30% by 2030 compared to 2005, respectively.
- A well-functioning, reformed Emissions Trading System (ETS) with an instrument to stabilise the market in line with the Commission proposal will be the main European instrument to achieve this target; the annual factor to reduce the cap on the maximum permitted emissions will be changed from 1.74% to 2.2% from 2021 onwards.
- An EU target of at least 27% is set for the share of renewable energy consumed in the EU in 2030. This target will be binding at EU level.
- An indicative target at the EU level of at least 27% is set for improving energy efficiency in 2030 compared to projections of future energy consumption based on the current criteria. It will be delivered in a cost-effective manner and it will fully respect the effectiveness of the ETS-system in contributing to the overall climate goals. This target will be reviewed by 2020, having in mind an EU level of 30%.
- Reliable and transparent governance system is to be established to help ensure that the EU meets its energy policy goals, with the necessary flexibility for Member States and fully respecting their freedom to determine their energy mix.

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63 http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145397.pdf.

64 http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145397.pdf.

These requirements are reflected in the scenario called the European Council (EUCO) scenario with a minimum 27% energy efficiency target for 2030: EUCO27.

The table below summarises the assumptions on climate, renewable energy and specific energy efficiency policies in the EUCO27 baseline scenario that have been modelled.

Table 6: Policy assumptions in EUCO27 scenario

EUCO27	This scenario is designed to meet **all 2030 targets set by the European Council:** • At least 40% GHG reduction (wrt. 1990). • 43% GHG emissions reduction in ETS sectors (wrt. 2005). • 30% GHG emissions reduction in Effort Sharing Decision sectors (wrt. 2005). • At least 27% share of RES in final energy consumption. • **27% primary energy consumption reduction** (i.e. achieving 1369 Mtoe in 2030) compared to PRIMES 2007 baseline (1887 Mtoe in 2030). This equals a reduction of primary energy consumption of 20% compared to 2005 primary energy consumption (1713 Mtoe in 2005). **Main policies and incentives additional to REF2016:** **Revised EU ETS** • Increase of ETS linear factor to 2.2% for 2021-30. • After 2030 cap trajectory to achieve -90% emission reduction in 2050 in line with Low Carbon Economy Roadmap. **Renewables policies** • Renewables policies necessary to achieve 27% target, reflected by RES values applied in electricity, heating&cooling and transport sectors. **<u>Energy efficiency policies:</u>** **Residential and services sector** • Increasing energy efficiency of buildings via increasing the rate of renovation and depth of renovation. In this model, better implementation of EPBD and EED, continuation of Art 7 of EED and dedicated national policies are depicted by the application of energy efficiency values (EEVs). • Financial instruments and other financing measures on the European level facilitating access to capital for investment in thermal renovation of buildings. This, together with further labelling policies for heating equipment, is depicted by a **reduction of behavioural discount rates for**

	households from 12% to 11.5%. • More stringent (than in REF2016[65]) ecodesign standards banning the least efficient technologies. **Industry** • More stringent (than in REF2016) ecodesign standards for motors. **Transport** • CO_2 standard for cars: 85g/km in 2025; 75g/km in 2030 and 25 gCO_2/km in 2050[66]. • CO_2 standards for vans: 135g/km in 2025; 120g/km in 2030; 60g/km in 2050[67]. • 1.5% average annual energy efficiency improvements for new conventional and hybrid heavy goods vehicles between 2010-2030 and 0.7% between 2030-2050. • Measures on management of transport demand: - recently adopted measures for road freight, railways and inland navigation[68]; - gradual internalisation of transport local externalities[69] as of 2025 and full internalisation by 2050 on the inter-urban network. **Non-CO2 policies** • In 2030, carbon values of €0.05 applied to non-CO2 GHG emissions in order to trigger cost-effective emissions reductions in these sectors including in agriculture. • After 2030, carbon values set at EU ETS carbon price level.

In the EUCO27 scenario, energy efficiency delivers a large part of GHG emissions reduction in the ESD sectors. This reduction is complemented by cost-effective reductions in non-CO_2 emissions – mostly in agriculture. This approach reflects the Commission's 2013 analysis of 2030 targets (SWD(2014) 15 final), where a certain amount of non-CO_2 emissions reduction was necessary to achieve 40% GHG reduction.

Reductions of non-CO_2 emissions in the 2030 perspective can be (up to a certain extent) cost-effective. To achieve those cost-effective reductions in the agricultural sector would require a political commitment for corresponding EU or national measures. This option is, however, only explored in the baseline EUCO27 scenario, as in the additional policy scenarios more ambitious energy efficiency policies deliver all necessary reductions in ESD sectors.

65 The Reference scenario 2016 does not include the revisions of existing eco-design measures that are required by their implementing regulations or any future measures under this directive which are currently under discussion.

66 On NEDC test-cycle.

67 On NEDC test-cycle.

68 Directive on Weights & Dimensions, Fourth railway package, NAIADES II package, Ports Package.

69 Costs of infrastructure wear & tear, congestion, air pollution and noise.

4.4.2 EUCO30 policy scenario

The EUCO30 scenario is constructed similarly to the EUCO27 scenario, but raises the ambition level of the specific energy efficiency policies in a cost effective way. It implements the European Council guidance of having in mind 30% for the review of the Energy Efficiency Target. A relevant implication is that more ambitious energy efficiency policies deliver all necessary reductions in ESD sectors, and no reductions in non-CO2 sectors such as agriculture beyond REF2016 take place.

<table>
<tr><td>EUCO30</td><td>This scenario is designed to meet all 2030 targets set by the European Council:

At least 40% GHG reduction (wrt. 1990).
43% GHG emissions reduction in ETS sectors (wrt 2005).
30% GHG emissions in Effort Sharing Decision sectors (wrt 2005).
At least 27% share of RES in final energy consumption.
30% primary energy consumption reduction (i.e. achieving 1321 Mtoe in 2030) compared to PRIMES 2007 baseline (1887 Mtoe in 2030). This equals a reduction of primary energy consumption of 23% compared to 2005 primary energy consumption (1713 Mtoe in 2005).

Main policies and incentives additional to REF2016:

Revised EU ETS

Increase of ETS linear factor to 2.2% for 2021-30.
After 2030 cap trajectory to achieve -90% emission reduction in 2050 in line with Low Carbon Economy Roadmap.

Renewables policies

Renewables policies necessary to achieve 27% target, reflected by RES values applied in electricity, heating&cooling and transport sectors.

<u>Energy efficiency policies:</u>

Residential and services sector

Further increasing energy efficiency of buildings via increasing the rate of renovation and depth of renovation as well as behavioural change. In this model, better implementation of EPBD and EED, continuation of Art 7 of EED and dedicated national policies are depicted by the application of energy efficiency values (EEVs). EEVs are increased compared to EUCO27.
Financial instruments and other financing measures on the European level facilitating access to capital for investment in thermal renovation of buildings. This, together with further labelling policies for heating equipment, is depicted by a reduction of behavioural discount rates for households from 12% to 11.5%.
More stringent (compared to EUCO27) ec-design standards banning the least efficient technologies.
Policies facilitating uptake of heat pumps .
</td></tr>
</table>

	Industry • Application of Energy efficiency values in industry (fraction of those applied in residential and services sector) leading to deeper energy efficiency effort and heat recovery. • More stringent (compared to EUCO27) ecodesign standards for motors. **Transport** • CO_2 standard for cars: 80g/km in 2025; 70g/km in 2030 and 25 gCO_2/km in 2050. • CO_2 standards for vans: 130g/km in 2025; 110g/km in 2030; 60g/km in 2050. • 1.5% average annual energy efficiency improvements for new conventional and hybrid heavy goods vehicles (HGVs) between 2010-2030 and 0.7% between 2030-2050. • Measures on management of transport demand: - recently adopted measures for road freight, railways and inland navigation[70]; - gradual internalisation of transport local externalities[71] as of 2025 and full internalisation by 2050 on the inter-urban network; - modulation of infrastructure charges for HGVs according to CO2 emissions leading to faster fleet renewal; - eco-driving; - deployment of Collaborative Intelligent Transport Systems. **Non-CO2 policies** • No policy incentive until 2030 • After 2030, carbon values set at EU ETS carbon price level

4.4.3 EUCO+ scenarios with more ambitious 33, 35 and 40% energy efficiency targets

The table below summarises the assumptions on specific energy efficiency policies in EUCO+33, EUCO+35 and EUCO+40 scenarios that have been modelled. As these scenarios built on EUCO30 policy scenario they are progressively scaled up in terms of ambition of energy efficiency policies, only the differences that illustrate the increases level of ambition are listed.

Table 7: Assumptions in EUCO+33, EUCO+35, EUCO+40 scenarios

EUCO+33	**As EUCO30 except:** • **33% primary energy consumption reduction target is set** (i.e. achieving 1260 Mtoe in 2030) compared to PRIMES 2007 baseline (1887 Mtoe in 2030). This equals a reduction of primary energy consumption of 26% compared to 2005

70 Directive on Weights & Dimensions, Fourth railway package, NAIADES II package, Ports Package.
71 Costs of infrastructure wear & tear, congestion, air pollution and noise.

	primary energy consumption (1713 Mtoe in 2005). • As a result some 2030 GHG targets set by the European Council are slightly overshot: - 43% GHG reduction (wrt. 1990); - 44% GHG reduction in ETS sectors (wrt 2005) - 34% GHG emissions reduction in Effort Sharing Decision sectors (wrt 2005). • Also, as a result of energy efficiency policies reducing demand, 28% RES share in final energy consumption is achieved. **Main policies and incentives additional to Reference:** **<u>Energy efficiency policies:</u>** **Residential and services sector** • Further increasing of energy efficiency values compared to EUCO30. • Financial instrument and other financing measures are made more widely available on the European level further facilitating access to capital for investment in thermal renovation of buildings and further labelling policies for heating equipment are pursued – depicted by **reduction of the discount rates for households from 11.5% (in EUCO30) to 11%.** • More ambitious policies (than in EUCO30) facilitating uptake of heat pumps. **Industry** • Increasing energy efficiency values in industry (fraction of those applied in residential and services sector) leading to deeper energy efficiency effort and heat recovery (compared to EUCO30). • Application of Best Available Techniques. **Transport** • Promotion of public procurement that provides effective incentives for purchasing cleaner vehicles (i.e. Revision of Clean Vehicles Directive). • Additional measures on management of transport demand: - full internalisation of transport local externalities as of 2025 on the inter-urban network; - more ambitious deployment of Collaborative Intelligent Transport Systems and support for multimodal travel information; - promoting efficiency improvements and multimodality (e.g. review of Combined Transport Directive, review of Rail Freight Corridors Regulation, review of market access rules for road transport); - promotion of urban policies curbing pollutant emissions.

EUCO+35	**As EUCO+33 except:** • **35% primary energy consumption reduction target is set** (i.e. achieving 1220 Mtoe in 2030) compared to PRIMES 2007 baseline (1887 Mtoe in 2030). This equals a reduction of primary energy consumption of 29% compared to 2005 primary energy consumption (1713 Mtoe in 2005). • As a result all 2030 GHG targets set by the European Council are slightly overshot: - 44% GHG emissions reduction (wrt. 1990), - 44% GHG emissions reduction in ETS sectors (wrt 2005) - 36% GHG emissions reduction in Effort Sharing Decision sectors (wrt 2005) - Also, as a result of energy efficiency policies reducing demand, 28% RES share in final energy consumption is achieved. **Main policies and incentives additional to Reference:** **<u>Energy efficiency policies:</u>** **Residential and services sector** • Further increasing of energy efficiency values compared to EUCO+33. • More ambitious (than in EUCO+33) policies facilitating uptake of heat pumps. **Industry** • Increasing EEVs in industry (fraction of those applied in residential and services sector) leading to deeper energy efficiency effort and heat recovery (compared to EUCO+33). • Application of more advanced (compared to EUCO+33) Best Available Techniques **Transport** • CO_2 standard for cars: 77g/km in 2025; 67g/km in 2030 and 25 gCO_2/km in 2050. • CO_2 standards for vans: 118g/km in 2025; 106g/km in 2030; 60g/km in 2050. • Energy taxation aligning the minimum tax rates of petrol and gas oil used as motor fuel.
EUCO+40	**As EUCO+35 except:** • **40% primary energy consumption reduction target is set** (i.e. achieving 1129 Mtoe in 2030) compared to PRIMES 2007 baseline (1887 Mtoe in 2030). This equals a reduction of primary energy consumption of 34% compared to 2005 primary energy consumption (1713 Mtoe in 2005). • As a result all 2030 GHG targets set by the European Counci significantly overshot: - 47% GHG emissions reduction (wrt. 1990) is achieved.

	- 48% GHG emissions reduction in ETS sectors (wrt 2005) is achieved - 39% GHG emission reduction in Effort Sharing Decision sectors (wrt 2005) is achieved. • Also, as a result of energy efficiency policies reducing demand, 28% RES share in final energy consumption is achieved. **Main policies and incentives additional to Reference:** **Energy efficiency policies:** **Residential and services sector** • Further increasing of energy efficiency values compared to EUCO+35. • Financial instrument and other financing measures are made more widely available on the European level lowering access to capital for investment in thermal renovation of buildings and further labelling policies for heating equipment are pursued – depicted by **reduction of the discount rates for households from 11% (in EUCO35) to 10%.** • More ambitious policies facilitating uptake of heat pumps. **Industry** • Further increasing EEVs in industry (fraction of those applied in residential and services sector) leading to deeper energy efficiency effort and heat recovery (compared to EUCO+35). • Application of more advanced (compared to EUCO+35) Best Available Techniques **Transport** • CO_2 standard for cars: 74g/km in 2025; 64g/km in 2030 and 25 gCO_2/km in 2050[72]. • CO_2 standards for vans: 106g/km in 2025; 97g/km in 2030; 60g/km in 2050[73]. 1.6% average annual energy efficiency improvements for new conventional and hybrid heavy goods vehicles between 2010-2030 and 0.9% between 2030-2050.

4.4.4 Modelling input parameters

4.4.4.1 Energy Efficiency values

As described in above, the key modelling tool are energy efficiency values (EEV) – which are modelled as shadow values of virtual energy saving constraints optionally applying by energy

[72] The level of standards corresponds to the more ambitious edge of the range of standards for cars discussed for 2025 in recent trilogue discussions.

[73] The level of standards corresponds to the more ambitious edge of the range of standards for vans discussed for 2025 in recent trilogue discussions.

demand sector. Essentially, using the EEVs in the model is a way of representing non-identified policy measures which aim at achieving energy savings in order to achieve a pre-defined target level of primary energy consumption in 2030. Instead of modelling one-by-one the broad range of energy efficiency policy measures, a practical way is to assume a non-zero value of EEVs and increase it until the non-identified measures induce an assumed amount of energy savings. EEVs were applied in residential and tertiary sector and also in industry (at a lower level in order to reflect the fact that industrial sector is already partly exposed to ETS and that many MS have so far chosen to exempt industrial sector from energy efficiency measures).

The EEV, as described above in modelling terms, are used to simulate increasing energy savings related to improving thermal integrity of houses and buildings and changing energy consumption behaviour, implying reduced consumption of fuels and electricity. Currently, such obligations are chiefly driven by the Art 7 of the EED but in addition some MS have also put in place national policies aiming at renovation of the building stock (notably information campaigns, fiscal policies and financial incentives). As EEV increase step-wise by scenario and in time, they drive a faster pace of investments in renovations (as demonstrated by renovation rates) as well as increasing depth of renovations from an energy perspective (as demonstrated by the increased energy savings of the renovations). They also induce a behavioural change towards a more efficient use of energy. Other energy efficiency policies such as ecodesign, labelling etc. act in addition to the EEV by influencing the choice of equipment technologies and their turnover over time.

In the current exercise, the national component of EEV is equal to the level of national EEV in the REF2016 for the year 2020. The national EEV reflect the assessment of the implementation of the Art 7 of the EED as well as the impact of additional national energy efficiency policies that lead to thermal renovation of buildings and curbing their fuel and electricity use. This assessment was made when preparing the EU Reference scenario 2016, i.e. in 2015 to the best available knowledge at that time.

The national component of the EEV is combined with the European component, which is alike across all Member States reflecting an equal additional incentive on the European level, i.e. continuation of Art 7 of EED or measures with similar effect. It is the European component that is increased step-wise in scenarios. As a general rule, the higher the overall energy efficiency target, the higher the EEVs reflecting a higher energy saving level e.g. under the the energy efficiency obligation (or alternative measures) to be mandated by continuation of Art 7 of EED.

The table below shows, that significant EEVs are needed to achieve higher energy efficiency levels. To achieve 23.9% of energy reductions in 2030, only €5/toe are necessary. To achieve 27%, an EEV of €338/toe is already needed. This values needs to be increased to €713/toe to achieve an energy efficiency level of 30% in 2030. €2,525/toe would be needed to achieve a level of 40%. It has to be stressed that the absolute number of EEV has no direct meaning, because its influence depends on relative values not on absolute levels. As described in chapter 4.2.2.5 above, EEVs are not an energy tax or subsidy, they represent an incentive to invest in energy efficiency or to change behaviour towards a more efficient use of energy. All energy efficiency investments induced by EEVs are fully accounted for in the energy system costs and investment expenditures are reported in chapter 5.1.5 of the main text.

Table 8: Energy efficiency values

Energy efficiency values (2030)	Ref2016	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Average energy efficiency value in the residential and tertiary sector (€/ toe)	5	338	713	1302	1677	2525

Source: PRIMES

By varying the EEVs, the projected renovation rates escalate across scenarios. In PRIMES, the economic agent can decide – based on the EEVs incentive modelled – between different renovation packages. All renovation packages describe interventions only in the building shell of a household (replacement of windows, installation of insulation materials on walls and/or the roof and/or the basement), thus affecting the overall U-Value coefficient of the building (getting decreasing U-Values the deeper the renovation package is) and therefore the useful energy consumption of the building[74]. The deeper the renovation package, the higher the energy efficiency investments costs. These investments are reflected in the energy system costs of the PRIMES model.

Table 9: Renovation rates in the residential sector[75]

(%)	Average renovation rate EU28		Average energy saving % from renovation EU28	
	2015-2020	2021-2030	2015-2020	2021-2030
REF2016	1.5%	1.5%	43.4%	33.3%
EUCO27	1.5%	1.7%	46.8%	51.8%
EUCO30	1.5%	2.1%	47.3%	55.6%
EUCO+33	1.5%	2.7%	48.0%	59.3%
EUCO+35	1.5%	2.9%	48.4%	59.5%
EUCO+40	1.5%	3.1%	50.4%	63.0%

Source: NTUA Buildings model

4.4.4.2 RES values

Renewables policies necessary to achieve 27% target (in EUCO27, EUCO30, EUCO+33 and EUCO+35) and 30% in EUCO+40 are reflected by RES values applied in electricity, heating and cooling and transport sectors. RES values are used in order to ensure cost-efficient RES target achievement at European level.

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74 The “average useful energy for heating” is the energy needed for space heating, for the calculation of which the seasonal method of the standard EN 13790 'Energy performance of buildings - Calculation of energy use for space heating and cooling' is being used, the way it was described in the TABULA Methodology (http://episcope.eu/building-typology/webtool/). In the before mentioned methodology the "average useful energy for heating" derives from considering the thermal performance of the building shell (characteristics of building envelope), climatic data and standards on thermal comfort. The average useful energy demand for heating does not include the heating system choice.

75 The renovation rates shown in the table below are the result of an ex-post analysis performed with the dedicated buildings model additional to the classic PRIMES suite which was used for REF2016 and the policy scenarios.

Like the energy efficiency values, the RES value is a shadow price, a signal of potential costs per unit of renewable energy not achieved (relative to the target) which is internalized in the optimizing behaviours of actors and thus leads to higher RES uptake. RES values do not describe in detail the RES supporting policies, but are introduced if needed, in addition to the supporting policies, so as to complement them and reach the RES target. The RES value should not be confused with feed-in tariffs or green certificates, because it does not model any sort of power purchasing agreement with the RES developers and the RES projects compete on equal economic grounds with other forms of energy.

As shown in the table below, RES values needed to be slightly increased with more ambitious energy efficiency efforts in 2030 to achieve a share of renewables of at least 27% at the same time as a more ambitious energy efficiency level in 2030.

Table 10: RES values

RES values (2030)	Ref2016	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Average Renewables value (€/ MWh)	11	7	16	14	12	19

Source: PRIMES

4.4.4.3 Modelling of energy efficiency policies for the industrial sector

Anticipation of enforcement of Best Available Techniques (BAT) in Industry:

Energy efficiency progress in the industrial sector in the energy efficiency scenarios occurs through the deployment of BAT (best available techniques), both vertically and horizontally; vertically refers to technologies associated with the equipment used for specific industrial process; horizontally, refers to systems that affect all industrial processes, such as energy control systems and heat recovery systems.

In modelling, the BATs are reflected in the menu of available technologies, which is the same in all energy efficiency scenarios. What varies among scenarios is the uptake of technologies, depending on the intensity of energy efficiency policies assumed and regulatory enforcement of BATs. For the former the modelling mechanism is the following: the anticipation of more ambitious energy efficiency policies results in moderation of the perception of risk associated with advanced technologies, and in acceleration of their maturity and uptake. This effect is represented in the energy efficiency scenarios through modifying the parameters that reflect the perception of cost. In other words, industry anticipates that enforcement is likely to become more stringent in the future and so in order to avoid locking-in inferior technologies increases the uptake of more efficient technologies. Regulatory enforcement of BATs makes mandatory the application of specific BATs.

4.4.4.4 Reduced discount rates due to policy implementation

As described in the chapter describing the set-up of the scenarios, decision-making discount rates are lowered in the policy scenarios. This is in order to reflect financial instrument and other measures, which are assumed to be made more widely available on the European level lowering access to capital for investment in thermal renovation of buildings and to reflect the implementation of further labelling policies for heating equipment or the further development of ESCO markets. Discount rates applied for cost-accounting remain unchanged across all scenarios and throughout the projection period.

Please see in chapter 4.2 on the Reference scenario for explanation of the application of both decision-making and cost-accounting discount rates.

4.4.4.5 Modelling of ecodesign regulations

The ecodesign policy aims at reducing energy consumption of energy-related equipment and appliances by promoting product varieties which embed higher energy efficiency. Depending on implementing measures and voluntary agreements, the eco-design regulations certify specific energy consumption by product variety and eventually provides for mandatory requirements for certain products. The requirements impose a minimum bound on energy performance of products. The bounds are set for the next two to five years. This implies that the menu of technologies for consumer choices in the future is restricted to product varieties which have performances exceeding the minimum threshold value. The menu will still allow selecting technologies which perform above minimum threshold value; the choice will depend on relative costs, perception of technical risks and the policy context. The Ecodesign regulations, combined with the labelling directive, are playing an important role to remove uncertainties regarding technical risks and those stemming from lack of information.

PRIMES considers equipment in an aggregated manner, looking at the equipment performance in heating and cooling, water heating, cooking, lighting and (white and black) appliances.

The REF2016 scenario is assumed to include the currently adopted eco-design regulations. The effects additional of ecodesign regulations are then simulated to intensify towards the 2030 horizon relative to the REF2016 in EUCO27 and EUCO30 scenarios (as beyond EUCO30 the potential for improvement stemming from ecodesign is largely exhausted). Moving from 2030 to 2050, the effects are simulated to intensify further relative to the 2020-2030 period and approach technical potential in the ambitious case. The learning effects are modelled to be relatively lower until 2030 than after 2030.

The strongest progress in ecodesign happens in heating, cooling, cooking and appliances. In the table below, it can be noticed that there are some incremental improvements in energy efficiency EUCO+ scenarios as well. In particular, for space heating and cooking there is further improvement also beyond EUCO30. Nevertheless, this is not a result of extra ecodesign progress in the EUCO+ scenarios, rather of the electrification and the specific allocation of consumers in vintages of technologies in these scenarios, in other words, more households using efficient appliances.

Table 11: Residential sector - Improvements in efficiency compared to 2005

Residential sector: **Improvements in efficiency compared to 2005** **(% change)**	**2020**	**2030**	**2050**	**2020**	**2030**	**2050**
	Heating			**Cooling**		
REF2016	8.1	20.1	29.9	6.7	20.4	52.4
EUCO27	7.8	21.8	36.3	6.7	22.2	65.1
EUCO30	7.8	24.5	39.2	6.7	55.6	95.3
EUCO+33	7.8	29.1	44.8	6.7	56.0	95.0
EUCO+35	7.8	29.2	44.8	6.7	56.0	95.1
EUCO+40	8.0	33.2	50.1	6.7	57.7	94.9
	Water heating			**Cooking**		
REF2016	6.1	20.8	31.8	2.6	6.0	8.9
EUCO27	5.6	20.5	29.3	2.4	7.7	19.4
EUCO30	5.6	21.2	30.2	2.4	11.7	24.4
EUCO+33	5.7	21.5	30.8	2.4	18.5	32.1
EUCO+35	5.7	21.5	30.9	2.5	18.7	32.4
EUCO+40	5.9	22.5	31.9	2.7	21.5	36.0
	Lightning			**White appliances**		
REF2016	155.1	325.3	374.4	23.0	38.4	41.4
EUCO27	154.5	329.1	378.8	22.5	38.0	41.3
EUCO30	154.5	327.1	378.2	22.5	43.9	50.6
EUCO+33	154.3	327.5	377.8	22.6	44.0	50.6
EUCO+35	153.7	326.7	377.7	22.6	44.0	50.6
EUCO+40	152.5	328.4	377.2	22.5	44.0	50.7
	Black applainces			**Central boilers**		
REF2016	23.9	36.1	50.5	8.0	16.8	27.9
EUCO27	24.0	35.5	49.7	8.0	16.4	27.0
EUCO30	24.0	42.6	59.8	8.0	16.1	26.9
EUCO+33	24.0	42.6	59.8	8.0	16.9	28.6
EUCO+35	24.0	42.7	59.8	8.0	16.9	28.8
EUCO+40	24.0	42.6	60.1	8.0	19.4	31.9
	Gas heaters			**Heat pumps**		
REF2016	13.0	22.1	34.2	0.0	22.8	53.6
EUCO27	13.0	21.8	33.9	0.0	25.5	56.4
EUCO30	13.0	21.5	34.0	0.0	42.0	60.5
EUCO+33	13.0	22.0	35.4	0.0	44.3	61.3
EUCO+35	13.0	21.9	34.9	0.0	44.1	61.2
EUCO+40	13.0	25.1	38.8	0.0	46.8	64.4

Source: PRIMES

Table 12: Service sector - Improvements in efficiency compared to 2005

Service sector: Improvements in efficiency compared to 2005 (% change)	2020	2030	2050	2020	2030	2050
	Heating			Cooling		
REF2016	11.8	28.5	39.8	3.8	12.4	45.1
EUCO27	10.8	30.5	56.4	3.7	12.6	48.9
EUCO30	10.8	33.1	57.1	3.7	22.6	64.0
EUCO+33	10.8	33.1	57.1	3.7	22.6	64.0
EUCO+35	10.7	36.4	60.5	3.7	22.4	63.9
EUCO+40	10.6	37.4	61.7	3.6	22.9	64.1
	Other use			Lightning		
REF2016	3.6	14.0	20.0	194.8	350.4	395.6
EUCO27	3.3	15.1	20.8	184.3	348.1	395.1
EUCO30	3.3	15.2	20.8	184.6	366.0	396.3
EUCO+33	3.3	16.3	22.9	181.7	369.4	402.9
EUCO+35	3.3	16.3	22.9	176.9	368.6	402.8
EUCO+40	3.1	16.3	22.9	161.2	369.3	403.1
	Electric appliances					
REF2016	16.9	26.5	44.8			
EUCO27	16.9	26.6	44.9			
EUCO30	16.9	28.4	45.1			
EUCO+33	16.9	28.3	45.1			
EUCO+35	16.9	28.2	45.0			
EUCO+40	16.9	28.2	45.0			

Source: PRIMES

4.4.4.6 Modelling of transport policies

CO_2 standards for new cars and light commercial vehicles.

The tightening of CO_2 standards post-2020 is a key assumption, leading to improvements in energy efficiency and CO_2 emissions reduction in transport. The CO_2 standards assumed in the policy scenarios are provided in Table 13 for cars and in

Table 14 for light commercial vehicles.

Table 13: Assumptions on CO2 standards (gCO2/km) for new cars across scenarios[76]

Scenario	CO_2 standards (gCO_2/km) for new cars		
	2025	**2030**	**2050**
EUCO27	85	75	25
EUCO30	80	70	25
EUCO+33	80	70	25
EUCO+35	77	67	25
EUCO+40	74	64	25

Source: PRIMES

[76] On current test-cycle.

Table 14: Assumptions on CO2 standards (gCO2/km) for new light commercial vehicles across scenarios[77]

Scenario	CO_2 standards (gCO_2/km) for new light commercial vehicles		
	2025	**2030**	**2050**
EUCO27	135	120	60
EUCO30	130	110	60
EUCO+33	130	110	60
EUCO+35	118	106	60
EUCO+40	106	97	60

Source: PRIMES

Vehicle efficiency of new heavy goods vehicles

The following improvements in specific fuel consumption of new heavy goods vehicles were assumed:

- 1.5% per year on average in all scenarios. EUCO27, EUCO30, EUCO+33, EUCO+35 in 2010-30 and 0.7% per year in 2030-50;
- 1.6% per year on average in scenario EUCO+40 in 2010-30 and 0.9% per year in 2030-50.

Recently adopted measures

Measures adopted after the cut-off date of Reference scenario 2016 (i.e. Directive on Weights & Dimensions[78], Fourth railway package[79], NAIADES II package[80], and the Ports Package[81]) are assumed to apply in all scenarios. The input for modelling draw on the respective Impact Assessments.

Fair and efficient pricing for sustainable transport

1. Gradual internalisation of the costs of infrastructure wear & tear, congestion, air pollution and noise in the pricing of road transport on the inter-urban network is assumed from 2025 onwards. For rail, internalisation of the costs of air pollution, noise and congestion is assumed from 2030 onwards; for inland waterways internalisation of the costs of air pollution is assumed from 2030 onwards. In scenarios EUCO27 and EUCO30, the levels of the charges are gradually increased from 2025/2030 to 2050, when they become equal to the values of the 2014 Handbook on external costs of transport.[82]
2. Full internalisation of local externalities is assumed in scenarios EUCO+33, EUCO+35 and EUCO+40, meaning that the charges are set equal to the values of the 2014 Handbook on external costs of transport from 2025 onwards for road transport (on the inter-urban network) and from 2030 onwards for rail and inland waterways.

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[77] On current test-cycle.
[78] SWD(2013)109 final.
[79] SWD(2013) 10 final.
[80] SWD(2013) 324 final.
[81] SWD(2013) 181.
[82] Source: http://ec.europa.eu/transport/themes/sustainable/internalisation_en.htm.

3. Modulation of the infrastructure charges according to CO_2 emissions for heavy goods vehicles (HGVs) is assumed to apply in all scenarios except for EUCO27; it is assumed to apply on the inter-urban network from 2025 onwards. Starting from the average infrastructure charge in each Member State, a linear incremental variation is assumed for HGVs with higher emissions than average; a similar linear variation is assumed for HGVs with lower emissions than average (by HGVs category). The measure is assumed to apply similarly to the Euro class-differentiation of network-wide tolls and implies revenue neutrality.

Collaborative Intelligent Transport Systems (C-ITS)

Deployment of C-ITS in road transport has been assumed in all scenarios except for EUCO27.

2. In scenarios EUCO30, the input assumption for modelling draws on the central scenario of a Cost Benefit Analysis (CBA) study carried out by Ricardo AEA[83].
3. In scenarios EUCO+33, EUCO+35 and EUCO+40 more ambitious deployment of C-ITS is assumed, designed to represent the impact of using the cellular network to provide vehicle-to-infrastructure (V2I) services. The input for modelling draws on a sensitivity developed by Ricardo AEA within the same study.

Eco-driving

Promotion of eco-driving is assumed in all scenarios except for EUCO27; the input assumption used for modelling draw on "EU Transport GHG: Routes to 2050?" project[84]. It is assumed that virtually all drivers would be trained by 2050 (for road and rail). Savings from training decline to 2050 due to technology effects. No variation in the level of intensity of the measure is assumed between scenarios.

Promotion of public procurement through the revision of the Clean Vehicles Directive.

Using a conservative approach, it is assumed that starting from 2025 the level of vehicles purchased under the Directive (i.e. the upper estimate according to the evaluation study[85]) resemble the best-performing vehicles in the market in terms of internalised external costs. Measure included in scenarios EUCO+33, EUCO+35 and EUCO+40.

Review of market access rules for road transport (road haulage).

For modelling purposes, it is assumed that the measures would lead to a share of empty vehicle-km in total vehicle-km for cabotage equal to that of domestic hauliers carrying out national transport from 2025 onwards. Increasing the load factors in PRIMES-TREMOVE model allows capturing rebound effects and possible modal shift due to e.g. lower unit costs relative to rail. Measure included in scenarios EUCO+33, EUCO+35 and EUCO+40.

Support for multimodal travel information

The input for modelling is based on a 2014 study[86], showing that more effective network management and more efficient passenger transport through more efficient journeys and optimized travel choices reduce travel time. For modelling purpose, the measure is assumed to

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83 Source : http://ec.europa.eu/transport/themes/its/c-its_en.htm

84 "EU Transport GHG: Routes to 2050?" final report is available at: http://www.eutransportghg2050.eu/cms/assets/EU-Transport-GHG-2050-Final-Report-22-06-10.pdf

85 Source: http://ec.europa.eu/transport/facts-fundings/evaluations/doc/2015-09-21-ex-post-evaluation-directive-2009-33-ec.pdf

86 Source: http://ec.europa.eu/transport/themes/its/studies/doc/20140812-july9thversion-awtfinalreport.pdf

be implemented from 2025 onwards. Measure included in scenarios EUCO+33, EUCO+35 and EUCO+40.

Promoting intermodal transport

Drawing on a 2015 study[87], the main drivers are assumed to be the decrease in the operation costs for combined transport and time costs for rail, inland waterways and short sea shipping, leading to model shift away from road (mainly towards rail); implemented from 2025 onwards. Measure included in scenarios EUCO+33, EUCO+35 and EUCO+40.

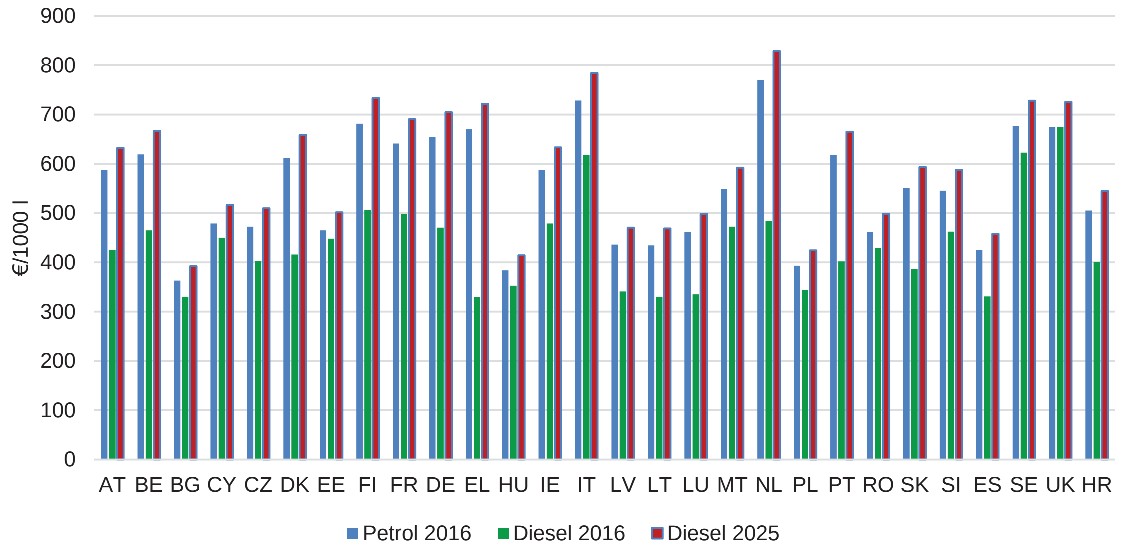
Promotion of urban policies

Urban policies aiming to curb pollutant emissions are reflected through air pollutants shadow values equal to the damage costs from the 2014 Handbook on external costs of transport; implemented from 2025 onwards[88]. Measure included in scenarios EUCO+33, EUCO+35 and EUCO+40.

Alignment of the national tax rates for petrol and gas oil used as motor fuels on the basis of energy content and CO_2 emissions

The changes in the excise duty rates affect diesel because at present this fuel is taxed at lower rates (considering the energy and CO2 content) in all Member States. The increases are assumed to be implemented from 2025 onwards and are presented in the figure below. Measure included in scenarios EUCO+35 and EUCO+40.

Figure 26: Changes in the excise duty rates for diesel (expressed in EUR per 1 000 l) by Member State from 2025 onwards



Source: PRIMES

4.4.4.7 Coordination policies

In this modelling exercise, all scenarios (except Reference) achieve decarbonisation in 2050 and hence assume an overall policy framework which enables this. Given that concrete policies will

[87] Source : http://ec.europa.eu/transport/themes/strategies/studies/doc/2015-01-freight-logistics-lot2-combined-transport.pdf

[88] Source: http://ec.europa.eu/transport/themes/sustainable/studies/sustainable_en.htm

most likely have to be proposed in order to fulfil the necessary conditions in infrastructure, technology, market coordination, the elements of this framework which go beyond the drivers and policies specified in the policy scenarios are called coordination policies. Coordination policies replace the "enabling conditions" which have been modelled in the 2030 framework impact assessment (in decarbonisation scenarios) and the 2014 impact assessment on energy efficiency target.

In the past modelling exercises, enabling conditions were present in all decarbonisation scenarios. Enabling conditions meant that because of good anticipation of future GHG emission reduction commitments, all conditions were met in infrastructure, technology learning, public acceptance and market coordination so as to enable the decarbonisation. In other words, enabling conditions enabled to maximize the effectiveness of policy instrument which aim at driving strong GHG emission cuts. These enabling conditions were fully costed in decarbonisation scenarios.

These assumptions have been revisited considering that concrete policies will most likely have to be proposed in order to fulfil the necessary conditions in infrastructure, technology, market coordination, etc. Consequently, enabling conditions are replaced by coordination policies as indicated in the list included in the table below. These coordination policies will be proposed by the Commission post 2020. Coordination policies are fully costed in the scenarios, as it was the case with enabling conditions. It is important to make a distinction between 2 types:

- coordination policies related to ongoing infrastructure developments that will enable a larger exploitation of cost-effective energy efficiency, RES, GHG abatement options after 2020.
- coordination policies related to R&D and public acceptance that are expected to be needed to meet long term decarbonisation objectives, and have effects post 2030

Table 15: Summary of coordination policies assumed

Enabling conditions in the 2030 Impact Assessment	New approach
Intelligent grids and metering (also for EVs)	Coordination policy post 2020 (Partly accomplished in the Reference scenario 2016 - implementation of the 3rd Internal Energy Market package).
Infrastructure to harvest decentralised as well as remote RES for power generation	Coordination policy post 2020
Carbon transportation and storage infrastructure and acceptance	coordination policy post-2030 (CCS is indispensable for decarbonisation towards 2050)
Gas and hydrogen: (technological progress enabling mix of hydrogen and bio-gas in gas supply and possibility to use hydrogen-based storage for balancing RES power)	coordination policy post-2030 (advanced storage is necessary and in that time perspective)
Battery technology development (for electric and plug-in hybrid vehicles) and	Reference scenario 2016 has assumptions on battery technology development and fuel cells which are rather conservative, consistent with

Enabling conditions in the 2030 Impact Assessment	New approach
fuel cells	the logic of a Reference scenario, i.e. without additional policies stimulating R&D, infrastructure or purchase. For the decarbonisation scenarios, increased R&D, expectations and learning effects lead to lower technology costs for electrification technology (for electric and plug-in hybrid vehicles) and fuel cells.
Recharging infrastructure	Coordination policy post 2020 (based on the Directive on the deployment of alternative fuels infrastructure)
Market acceptance (of electrification)	Coordination policies post 2020 (supported by the implementing measures following the Directive on the deployment of alternative fuels infrastructure)
Innovation in biofuels	Coordination policy with impacts post 2030 These are biomass related innovation and agriculture policies assumed to develop so as to allow the development of new generation bio-energy feedstock (basically lingo-cellulosic crops) at large scale. As a result, a new industry would emerge ranging from agriculture, industrial-scale collection and pre-treatment, bio-refineries with new conversion technologies, product standardization and commercialisation.
Overcoming some market barriers to Energy Efficiency in Buildings	Part of 2020-2030 policy mix as described in assumptions on policy options.
Heating equipment and appliances technology uptake in the domestic sector	As above
Energy efficiency innovation diffusion in Industry	As above

4.5 Additional PRIMES policy scenario results

Total energy system costs as described in chapter 5.1.6. from an end user perspective (as calculated in the modelling) comprise mainly three elements:

1) annuities for capital expenditure on energy using equipment,
2) fuel and electricity costs (energy purchasing costs[89]),
3) so-called direct energy efficiency investment costs[90] (not related to energy equipment itself), such as expenditure for insulation.

Average annual **capital costs** for the period 2021-2030 increase from €499 bn in the Reference scenario to €518 bn in EUCO27. Stepping up energy efficiency to 30% will lead to €7 bn additional average annual capital costs in EUCO30 and 1 billion less is necessary for a 33% target (small decline is mostly driven by transport demand management policies which lower the need for equipment purchase). Average annual capital costs would further increase for EUCO+35 and EUCO+40 scenarios.

Comparing costs between 27% and 30% target, capital costs are unchanged for industrial sectors. They increase only slightly in transport[91] and residential sectors.

Direct efficiency investment costs, representing mainly investment in the thermal integrity of buildings, increase in all scenarios already in EUCO27 scenario compared to REF2016 (€30 bn increase in average annual costs over 2021-2030). Compared to EUCO27, energy efficiency investments then increase by €25 bn for EUCO30. For more ambitious scenarios, an increase in average annual costs ranging from €73 bn to €184 bn.

Average **energy purchases** in 2021-2030 are reduced from €1,448 bn in Reference scenario to €1,415 bn in EUCO27. A further reduction of energy purchasing costs by €28 bn is possible in EUCO30 (compared to EUCO27). For more ambitious scenarios, a decrease in average annual energy purchases range from €52 to 86bn. Across all scenarios, the reductions are mainly achieved in residential and tertiary sectors.

A general shift in the structure of costs for energy consumers is observed, i.e. diminishing energy purchases (consumer paying less for fuels and electricity) and increasing investment expenditures (consumers paying for additional energy efficiency investments).

[89] Energy purchase costs include the capital costs corresponding to power & gas infrastructure (plants & grids), refineries and fossil fuel extraction, recovered in the model through end-user prices of energy products.

[90] Direct efficiency investment expenditures include the costs relating to (a) thermal integrity of buildings, i.e. for building insulation, triple glazing and other devices for energy savings including building management systems, and (b) for the industry sector they also include the investments that relate to the horizontal (not related to specific processes) energy saving investments, such as for energy control systems and heat recovery systems. There are no direct efficiency investment expenditures in transport sectors as they are only activated by energy efficiency values.

[91] The capital costs reported for transport relate to energy services.

Table 16: Components of energy system costs in 2030 and 2050.

Components of total energy system costs (2030/2050)	Ref2016	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Capital Costs in bn €'13 *(average annual 2021-30 and 2031-2050)*	499 / 639	518 / 704	525 / 721	524 / 721	527 / 722	539 / 739
Change to EUCO27 in billion €'13			7 / 17	6 / 17	9 / 18	21 / 35
Industry	31 / 46	33 / 54	33 / 56	35 / 60	37 / 62	44 / 80
Residential	262 / 317	258 / 309	262 / 319	263 / 319	263 / 319	262 / 317
Tertiary	60 / 81	58 / 70	57 / 72	55 / 68	54 / 67	52 / 64
Transport[92]	146 / 194	169 / 271	172 / 273	171 / 273	173 / 274	181 / 278
Direct Efficiency Investment costs in bn €'13 *(average annual 2021-30 and 2031-2050)*	6 / 2	36 / 162	61 / 155	109 / 223	142 / 258	220 / 339
Change to EUCO27 in billion €'13			25 / -7	73 / 61	106 / 96	184 / 177
Industry	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Residential	4 / 1	24 / 115	40 / 109	70 / 151	90 / 173	134 / 220
Tertiary	2 / 1	12 / 47	21 / 46	40 / 72	53 / 85	86 / 118
Transport	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Energy Purchases in bn €'13 *(average annual 2021-30 and 2031-2050)*	1,448 / 1,483	1,415 / 1,408	1,388 / 1,386	1,363 / 1,352	1,360 / 1,349	1,329 / 1,312
Change to EUCO27 in billion €'13			-28 / -22	-52 / -56	-55 / -59	-86 / -96
Industry	272 / 284	271 / 303	269 / 300	267 / 297	264 / 295	261 / 286
Residential	417 / 434	410 / 402	397 / 393	386 / 378	380 / 370	365 / 352
Tertiary	249 / 265	243 / 243	235 / 236	226 / 224	222 / 219	213 / 209
Transport	510 / 539	491 / 477	486 / 472	484 / 470	494 / 481	489 / 477

Source: PRIMES

92 The capital costs reported for transport relate to energy services.

4.6 Comparison with 2014 energy efficiency analysis

When comparing the Commission's 2014 analysis[93] of different levels of the energy efficiency target for 2030 (27%, 28%, 29%, 30%, 35% and 40% targets were analysed in 2014) and the analysis in this Impact Assessment, it has to be noted that several scenario assumptions have changed considerably.

The REF2016 has, notably:

- lower projections of international fossil fuel prices;
- slightly lower economic growth assumptions;
- updated technology cost curves (e.g. RES technologies such as PV are substantially less costly reflecting the changes observed in the last years) and
- more already adopted policies (notably in the field of energy efficiency but also for GHG emissions reduction such as the now adopted F-gas Regulation).

Consequently the REF2016 achieves 24% EE compared to 2007 baseline whereas it was only 21% in Reference scenario 2013). Furthermore, the period 2021-30, the REF2016 has slightly lower system costs but higher investment expenditure than the Reference scenario 2013.

The construction of policy scenarios has slightly changed as well. In 2014, the policy scenarios had exactly the same policy mix that was, as a general rule, intensified step-wise as scenarios became more ambitious (mostly through the increase of the energy efficiency values). While CO2 standards for LDV were intensified step-wise, other transport policies were, however, not. Some energy efficiency policies on the supply side were included and all scenarios included policies targeting non-CO2 emissions.

In the current analysis as well, as a general rule, the same policy mix is intensified step-wise as scenarios become more ambitious (mostly through the increase of the energy efficiency values). Transport policies are, however, also intensified progressively. Some additional transport and industrial policies are added only in more ambitious (EUCO+) energy efficiency scenarios. Standards for products are intensified mostly between EUCO27 and EUCO30 scenario, which demonstrate the cost-efficiency of energy efficiency standards based on internal market principles. A new policy featured in the policy mix is assumed for the promotion of electric heat pumps.

Looking at investments costs, the analysis shows that, in the period 2021-2030, the REF2016 has higher investment expenditure than the Reference scenario 2013 mostly because of investments in tertiary and residential sectors reflecting the most recently adopted national energy efficiency policies. On the other hand, generation and grid investments are somewhat lower reflecting notably lower costs of RES technologies and lower demand. Looking at policy scenarios, the additional investments mostly happen in tertiary and residential sector both in 2014 and current analysis. Very similar increases in investment expenditure can be observed comparing scenarios with 27% and 30% target and also comparing more ambitious scenarios to the one with 27% target. In 2014 analysis, the more ambitious scenarios had a somewhat more pronounced increase in investment as they incentivised more costly options in industry and tertiary sectors due to slightly different policy mix.

[93] SWD (2014)255.

Comparing system costs of scenarios with 30, 35 and 40% targets to scenario with 27% target, the overall picture is also similar to the 2014 analysis, although differences among scenarios are less pronounced than in 2014 analysis. As in 2014, increasingly higher targets mean increasingly higher investments, which are only partially recuperated through energy savings in 2030, and hence translate in higher system costs. Both analyses point to the same finding that as the targets become more ambitious, system costs in 2030 grow more than proportionally. However in this Impact Assessment, for the 30% target such higher system costs in 2021-2030 are more than balanced by lower system costs after 2030.

Next to other reasons mentioned above, the changed approach to bring cost accounting discount factors on the demand side more in line with supply side discount rates (WACC) result in a less pronounced increases in system costs.

4.7 Sensitivities

In this modelling exercise only one sensitivity has been performed combining the 30% energy efficiency target with 30% renewables looking at the impacts of combining two ambitious policy options. This sensitivity is described below.

Additional sensitivities could have been performed, notably on GDP growth, technological progress and fossil fuel prices developments. In the past modelling exercises, it has been observed that reasonable changes in assumptions (i.e. faster/slower economic growth, faster/slower technology learning, higher/lower fossil fuel prices), do not change key results of the analysis.

For example, reduction in energy imports will always be higher in EUCO 30 than in EUCO27 although with higher fossil fuel prices assumptions, the monetised impacts would be more pronounced. Likewise, investments in EUCO30 need to be higher than in EUCO27 although with faster technology progress, the investment expenditure difference might be less pronounced.

Looking at economic growth assumptions, it is clear that with faster economic growth, more effort would be needed to achieve desired targets but there will be always a step-wise increase going for more ambitious targets. Importantly, stronger economic growth has impact on energy demand but ETS acts as counterbalance on the amount of emissions. It should also be taken into account that increased economic growth will lead to a more rapid rate of replacement of products and a higher level of investment in new construction and building renovation, leading to more rapid "natural" diffusion of energy efficient products and buildings.

As already explained, EUCO scenarios assessed in this Impact Assessment achieve RES shares of 27% in 2030 by assumption and EUCO+ scenarios overshoot this target slightly (achieving 28%) . However, to test the implications of a combination of more ambitious energy efficiency and renewable energy policies, a sensitivity was modelled where both the energy efficiency and renewable energy targets reach 30%. This reflects the call from the European Parliament. The corresponding impacts of such a sensitivity on the energy system was assessed as described below:

EUCO3030

Compared to 2005 levels, GHG emission decrease by -43% overall; in the ETS sector by -48% and non-ETS by -31%. The reason for such a breakdown is due to the fact that this scenario achieves mostly additional GHG reductions in the power generation sector, where additional capacity would be installed. The increase in RES-E share is quite significant: 54% by 2030, a 5pp increase compared to EUCO30.

Mostly driven by the shift to RES in the power sector, additional reduction in primary energy consumption is achieved of 0.8 pp (-30.8% instead of -30% in EUCO30), while final energy consumption remains constant, due to similar energy efficiency policies as in EUCO30.

Due to the higher rate of RES deployment, import dependency is reduced compared with EUCO30, with the import dependency ratio 1.5 pp below than in EUCO30. The carbon intensity of power generation (t of CO_2/MWh) is also reduced by almost 15% compared with EUCO30, mostly due to the decrease of gas use.

Energy system costs only marginally increase compared to EUCO30 over the 2021-2030 period, with 0.23% increase, i.e. 5bn € increase in average annual costs. However, EUCO3030 becomes as cost-efficient as EUCO30 (0.12% difference) when looking at the 2021-2050 perspective. It is also to be noted that EUCO3030 remains less costly (both in short and long term perspective) than any scenario assuming more than 30% energy efficiency target.

As expected, investment increase in 2030 for power generation compared to EUCO30. Electricity prices increase by 2.5% in 2030 compared with EUCO30, but are the same as in EUCO27.

Table 17: Sensitivity on 30% RES and 30% in 2030

2030 results	REF	EUCO27	EUCO30	EUCO3030	EUCO33	EUCO35	EUCO40
Change in primary energy consumption in 2030 compared to PRIMES 2007 Baseline (1887 Mtoe in 2030) (% change)	-23,9	-27,4	-30,0	-30.8	-33.2	-35.3	-40.1
Final Energy Consumption in Mtoe	1.081	1.031	987	986	929	893	825
GHG reductions wrt 1990 (%)	-35,2	-40,7	-40,8	-43.2	-43.0	-43.9	-47.2
GHG emissions in ETS sectors wrt 2005 (%)	-37.7	-43.1	-43.1	-48.1	-44.3	-44.2	-48.3
GHG emissions in non-ETS sectors wrt 2005 (%)	-23.7	-30.2	-30.3	-30.7	-33.7	-35.5	-38.7
RES share in final energy consumption (%)	24.3	27.0	27.1	30.2	28.1	27.9	28.4
RES-H&C	25	27	26	29.9	28.6	28.5	28.3
RES-E	42	47	49	54.2	48.9	48.4	51.1
RES-T	14	18	19	20.7	19.2	20.0	22.4
Security of supply							
Import dependency (%)	57	54	53	52	53	52	52
Environmental impacts							
Carbon intensity of power generation (t of CO2/MWh)	0.2	0.18	0.18	0.16	0.18	0.19	0.18
Electricity and ETS impacts							
Net Installed Power Capacity - Thermal power in GWe	379	369	359	357	354	352	347
Average Price of Electricity (€/MWh)	158	161	157	161	158	157	159
ETS carbon price (€/t of CO2-eq)	34	42	27	27	27	20	14
Investments, energy purchasing costs and system cost impacts							
Total energy related investment expenditures in bn €'13 (average annual 2021-30)	938	1,036	1,115	1,128	1,232	1,324	1,565
Investment in power plants (average annual 2021-30) (bn € '13)	33	42	42	52	40	37	36
Investment in power plants (average annual 2031-50) (bn € '13)	38	58	57	59	60	60	279
Energy purchase (average annual 2021-30) (bn € '13)	1,448	1,415	1,388	1,391	1,363	1,360	1,329
Energy purchase (average annual 2031-50) (bn € '13)	1,483	1,408	1,386	1,409	1,352	1,349	1,312
Total System Costs (average annual 2021-30) (bn € '13)	1,928	1,943	1,952	1,956	1,977	2,014	2,077
Total System Costs (average annual 2031-50) (bn € '13)	2,130	2,264	2,255	2,257	2,290	2,324	2,384

Source: PRIMES

4.8 Description of modelling set-up for the policy scenarios for macroeconomic models

Macroeconomic and sectoral economic impacts are assessed using two macroeconomic models: E3ME of Cambridge Econometrics and GEM-E3 of E3M-Lab at the National Technical University of Athens. Similar to previous relevant Impact Assessments[94], the choice in this Impact Assessment has been to use two macroeconomic models that represent two main different schools of economic thought that have been frequently used in the macroeconomic assessment of energy and climate policies. This helps to effectively manage analytical uncertainties and reflect a more robust way of assessing the corresponding impacts. The application of two different macro-models enables not only to establish a range of possible impacts, but also to identify the conditions necessary for realising potential benefits.

Differences between the two models arise from their underlying assumptions and respective structures. E3ME is a macro-econometric model, based on a post-Keynesian demand-driven non-optimisation framework; GEM-E3 is a global computable general equilibrium model that draws strongly on supply-driven neoclassical economic theory and optimising behaviour of economic agents. However, the two macroeconomic models have many similarities, such as the inclusion of substantial sectoral detail, the assessment of complex interactions between the different sectors of an economy, markets and agents, as well as the simulation of inter-linkages between world economic and energy systems and the environment.

In this Impact Assessment, the approaches have been enhanced compared to previous analytical work. Notably, GEM-E3 has been enhanced with an explicit representation of the financial sector for each country and at the global level, allowing economic agents to borrow from banks in order to finance their required energy efficiency investment expenditures. E3ME, on the other hand, has further analysed the role of "crowding out" and capacity constraints in affecting investments in other productive sectors of the economy. This is all the more relevant in the case of more ambitious energy efficiency investment efforts, as investment expenditures represent an increasing share of overall GDP. Both models also allow for the modelling of unemployed labour resources. Thus, both models have been improved compared to the versions used in the energy efficiency Impact Assessment 2014, such that they permit an even more realistic representation of macroeconomic mechanisms that may be triggered by increasing the ambition of EU energy efficiency policies.

On the macro-side, E3ME and GEM-E3 have been aligned as best as possible in their assumptions, both taking as inputs the energy-specific policy scenario results from PRIMES. In addition, assumptions on the financing of energy efficiency investments in the two models have been better harmonised, such that:

a. Both models respect the fiscal neutrality assumption in their scenario setups. This means that energy efficiency policy interventions do not have any direct (first-order) impacts on public budgets. The method used to achieve this is that the scenarios are built such that costs to the public sector of initial energy efficiency investments are compensated by additional revenues from auctioned ETS allowances, as well as taxes if necessary.

[94] SWD(2014)255 final.

b. When changes in taxation are required (in order to achieve fiscal neutrality), both models target changes in general indirect taxation on products that affect both firms and households[95].

c. Both models make sure that energy efficiency investments in the private sector are privately financed, i.e. firms and households pay for improving energy efficiency. In the case of government sectors, investments are financed through EU ETS revenues and higher taxes on products if needed[96].

d. Both models can assume loan-based financing: businesses and households can borrow from the banking system and contract loans to cover their energy efficiency expenditures. GEM-E3 provides for an explicit representation of the banking system and can assume that private agents use a mix of own funds and loans to finance their expenditures. E3ME has only an implicit assumption on financing sources, and assumes that businesses borrow to make the investments[97], whereas households are assumed to self-finance (by reducing other expenditures).

Two versions of each macro-model have been run in order to provide a comprehensive picture of potential macro-benefits and constraints. In the case of E3ME, these refer to *"no crowding out"* and to *"partial crowding out"*, and in the case of GEM-E3, the two versions refer to *"loan-based"* finance and *"self-financing"*. The details of these model setups have been briefly described in the main text of this Impact Assessment.

The scenario inputs are taken from the PRIMES policy scenario results, such as energy savings and energy efficiency investments associated with each energy efficiency policy option. In other words, the macro-economic scenarios that have been modelled and built upon the PRIMES energy modelling scenarios of 27, 30, 33, 35 and 40% energy efficiency targets, presented in detail in chapter 4.4 of the Impact Assessment. The path and magnitude of investment in energy efficiency in each scenario is taken from projections made in PRIMES. In addition, other important drivers that are taken from projections made in PRIMES and used as inputs into E3ME and GEM-E3 include energy prices or overall energy balances. The E3ME and GEM-E3 models are then calibrated to represent these changes in the energy system so that their economy-wide impacts can be modelled.

Importantly, this Impact Assessment further improves the comparability of the macroeconomic results by better aligning the assumptions on fiscal neutrality and the financing of energy efficiency investments underpinning the two macro-modelling approaches.

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95 GEM-E3 targets a general tax on products and E3ME targets the value added tax.

96 Private financing for firms means that there is an increase in costs that may be passed onto prices (or taken out of profits) depending on cost pass through ratios specific to each model.

97 E3ME being post Keynesian draws on the endogenous money theory (money is created by commercial banks through the advancement of new loans that do not necessarily need to be backed by additional deposits because of leverage effects), and does not assume any competition for loans as is typically assumed in CGE models.

4.8.1 Modelling set-up for the E3ME model

4.8.1.1 Calibrating the E3ME model to the EU Reference scenario 2016

The term calibration is used differently for E3ME as for a CGE model. Calibration allows the model to match a given projected pathway. It does not determine the model parameters, which are econometrically estimated. The E3ME macroeconomic model was first calibrated to match the energy system projections associated with the EU Reference Scenario 2016 (REF2016) derived from PRIMES. E3ME takes the following indicators from the REF16 projections directly:

- GDP, consumer expenditure and sectoral economic output
- Energy and ETS prices
- Projections of energy demand by sector and by fuel
- Total CO_2 emissions

E3ME's energy sub-model (FTT-Power) which looks in detail at the power generation sectors has been fixed so that its outputs are fully consistent with the PRIMES results for the REF2016 scenario (given differences in model classifications, etc.). The main outputs from the FTT sub-model that have been calibrated to match PRIMES are:

- Fuel inputs into thermal power plants
- Electricity capacity
- Investment by the electricity supply sector
- Electricity prices

E3ME is frequently calibrated to match published PRIMES / Reference Scenario projections and the software routines to do the matching are now well established and have been documented as well in previous Impact Assessments[98]. In short, the calibration procedure has two main stages.

- In the first stage, the REF2016 projections are stored on one of the E3ME databanks as annual time series. The model is solved with all the econometric equation sets forced to match the figures that are stored. The differences ('scaling factors') between what the model would have predicted on its own and the figures on the databank are calculated and saved. These are then written on to another databank.
- In the second stage, the model is solved with the equation sets allowed to predict the outcomes. However, the scaling factors are applied to these results, with the result that they reproduce the energy-related reference or the policy scenarios produced by PRIMES. It is now possible to change the model inputs and use the equations to obtain different model outcomes, while maintaining consistency with the reference.

[98] SWD(2014) 255 final "Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy", Commission Staff Working Document Impact Assessment accompanying the document Communication from the Commission to the European Parliament and the Council, Part 2/3.

4.8.1.2 Implementing the energy efficiency policy scenarios in E3ME

This section focusing on the way PRIMES energy-related results for the energy efficiency policy options or scenarios were integrated as inputs to E3ME.

Power generation, electricity prices and CO_2 prices

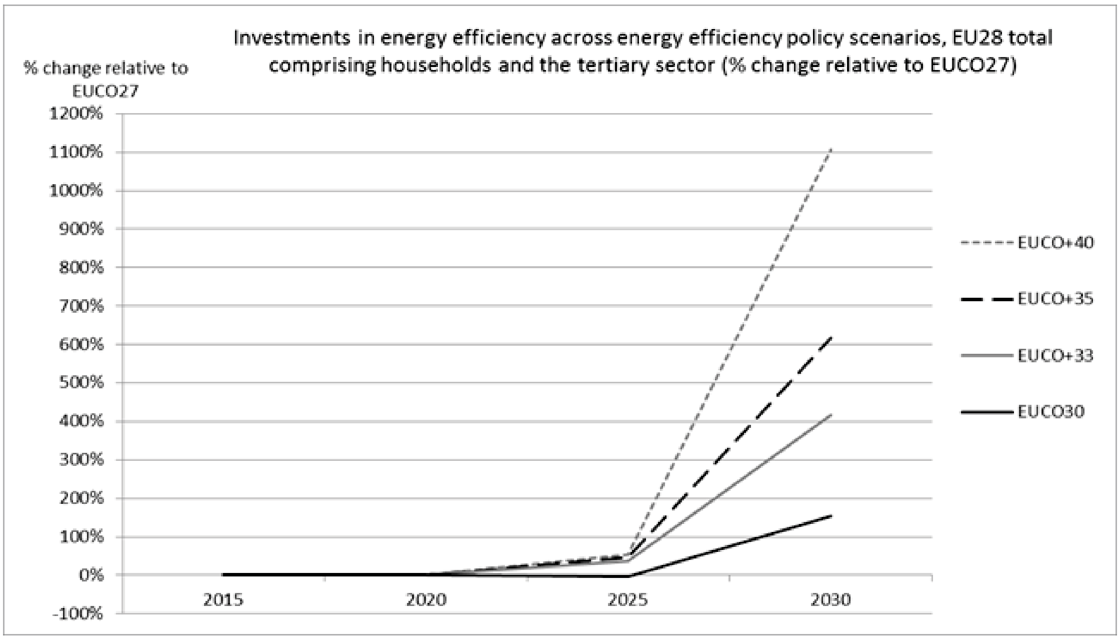
For the purpose of the macro-modelling assessment, the power generation sector is treated as exogenous in E3ME. In both the E3ME reference and energy efficiency policy scenarios the power generation results are set to match those from the PRIMES model, reflecting that model's more detailed representation of the sector.

An important input to the scenarios is the amount of investment required to bring about the changes in the power generation mix. Additional investment by the electricity supply sector used to bring about the change in power generation was added exogenously into E3ME. It is assumed to be financed by higher electricity prices, which are also taken from PRIMES. The EU ETS prices in each scenario that are used in E3ME are consistent with the prices used in the energy sector assessment with the PRIMES model.

Energy efficiency and investment

In E3ME, the energy-efficiency savings were entered exogenously in the model and were set to match the PRIMES results as closely as possible. Changes in energy efficiency investment (relative to the EU Reference scenario) resulting from PRIMES are added in E3ME's policy scenarios. The figure below charts the level of energy efficiency investments across the energy efficiency policy options compared to the EuCo27. The change in final energy demand from PRIMES was used as a guide for the level of energy efficiency savings. These savings were then distributed among sectors and energy carriers, using as a guide the level of investment made by each sector and the shares between energy carriers in proportion to energy consumption.

Figure 27: EU28 investments in energy efficiency across energy efficiency policy options relative to EuCo27 used as inputs into the E3ME macro-model, 2020-2030



Source: PRIMES results, E3M-Lab, National Technical University of Athens

Financing energy efficiency investments

The energy efficiency investments required to achieve the corresponding level of energy efficiency targets are assumed to be financed out-of-pocket, i.e. mostly from private financing. Households pay for the energy efficiency investment out-of-pocket. Consumer expenditure on energy efficiency goods increases, but spending on other consumer goods may be reduced by an equivalent amount (depending on other savings made from lower energy use). Firms pay for energy efficiency investment out-of-pocket. This is modelled as an increase in costs, some of which may be passed on to prices. Government sectors finance the energy efficiency investment from EU ETS revenues and increased VAT if needed.

Revenue recycling

The general approach is that the scenarios are directly revenue neutral with regard to costs to the public sector of energy efficiency investment and changes to the revenues from auctioned ETS allowances. VAT is adjusted as well when needed in order to ensure that the scenarios are directly revenue neutral. In other words, government sectors finance their energy efficiency investments from EU ETS revenues and increased VAT if needed. However, the scenarios are not fully budget-neutral (e.g. no corrections to changes in income tax receipts are made to ensure this) and the model allows for second-order effects of energy efficiency policy intervention on the overall public budget (e.g. via changes in the tax base resulting from changes in economic activity or reduced public expenditure on energy).

Crowding out

When discussing crowding out, it is important to make the distinction between supply constraints in different markets. The standard treatment in E3ME is labelled "no crowding out" and refers to not imposing a constraint on the maximum level of production due to potential capacity constraints in the products markets, as described below:

- Product markets: There is no maximum level of production but there are increases in prices as production levels increase (determined by estimated relationships) – hence there is partial crowding out. In other words, it is assumed for instance that the construction industry is able to increase its output as a result of EU policies targeting energy efficiency.
- Labour markets: The maximum employment level is determined by the size of the working age population. As employment increases and unemployment decreases, wages will increase causing employment reductions elsewhere. There is therefore partial crowding out, and full crowding out in situations of full employment.
- Financial markets: There is not a fixed amount of finance in the economy and so new loans can be issued without substituting from other sectors. There is therefore no financial crowding out in the model as standard.

Finally, further analysis was performed in E3ME by assuming that a certain share of partial crowding out occurs in the product markets. In this case ("partial crowding out"), a constraint on activity expansion has been inserted in the model by introducing a rule that would set a maximum amount that the sectors benefiting from energy efficiency policies would be allowed to increase without adversely affecting other economic activities. This rule is 5% over three years starting from 2021. For example, if in the year 2025, output is projected to increase in the construction sector by x% in EUCO27 relative to the Reference case, then in the next year (2026), the output of the respective sector is allowed to increase by a maximum of x% + (5/3)% without crowding out effects. In other words, the modelling of constrained expansion aims to implicitly mimic the effects of partial crowding out. The choice of 5% over three years starting in 2021 (translating in a 15% limit on additional / energy efficiency policy induced output growth by 2030) is arbitrary but suggests that first, firms keep enough spare capacity to cover 2-3 years of growth, and, second, that market players become aware of the increased investments in energy efficiency and try to adapt (the 3-year period allowing for the incorporation of changing expectations). Beyond that, physical and financial capital bottlenecks appear, constraining the potential for additional growth. Macro-results for GDP and total employment are presented in the main text of this Impact Assessment for both versions "no crowding out" and "partial crowding out" of E3ME.

4.8.1.3 Key model mechanisms driving the results

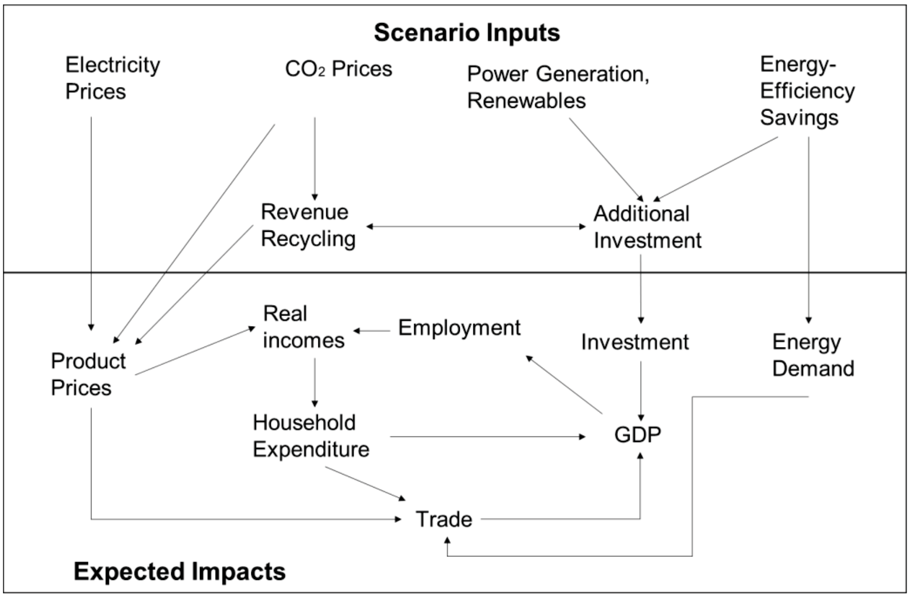
Figure 28 summarises how the policy scenario inputs from PRIMES (the top half of the diagram) affect key macroeconomic indicators in the model (the lower half). Although it is not possible to capture all the interactions in a single diagram, the most important ones are included.

GDP and other macro-impacts

The main ways in which GDP and other macro-aspects are affected are:

- Changes in electricity prices and CO_2 prices, which feed through to the prices of final products, depending on the rate of cost pass-through in the sectors involved (which is estimated empirically). Higher product prices would both reduce the purchasing power of domestic households (leading to lower real incomes and expenditure) and would adversely affect the competitiveness of European firms (leading to a worsening trade balance). In both cases the result will be a reduction in GDP.
- The revenue recycling, through changes to VAT rates, will also affect household income and expenditure. In the scenarios with high levels of public sector energy efficiency, VAT rates must increase to fund the measures. Reduced household income will lead to lower rates of spending and lower GDP.
- High rates of household energy efficiency will lead to a substitution effect of consumption towards energy efficiency equipment. This will not alter total consumption but the composition of consumption will be weighted more towards products that boost energy efficiency.
- Higher rates of investment will provide a boost to output in the construction and engineering sectors and their associated supply chains. Investment itself is a component of GDP and so the changes in investment have a direct impact.
- For most European countries, a reduction in energy demand will lead to reduced imports of fossil fuels, as long as Europe remains dependent on imported fuels. Resources that would have been spent on imported fuels may instead be spent on domestically-produced goods (households) or returned in the form of higher profits (businesses), in both cases providing a boost to GDP.

Figure 28: Main interactions between energy efficiency scenario inputs and expected macro-impacts in E3ME



Source: E3ME, Cambridge Econometrics

The net impact on GDP is the sum of these separate impacts. The impacts on employment are determined by a combination of the GDP impact and the sectoral pattern of output. As the scenarios modelled in this IA are based on a shift from energy to labour-intensive activities it is reasonable to expect employment to increase. As described below, this outcome is conditional on labour being available and wage rates not increasing to any significant extent.

Employment and multiplier effects

As noted above, E3ME does not assume an optimal starting point so it is possible for output to increase unless there are capacity constraints (see below). In addition, multiplier effects are a standard feature of the modelling results.

Type I multiplier effects occur through the supply chains that are represented in the model's input-output structure. In these scenarios, it is mainly the basic manufacturing sectors (e.g. metals, cement) that supply the sectors that produce and install energy efficiency investment goods. These supply chains may cross borders, with activity levels in one country allowed to influence those in its trading partners.

Type II multiplier effects relate to the loop from GDP to employment, real incomes and household expenditure. Essentially, higher employment levels and incomes are able to stimulate spending in other parts of the economy (e.g. in the retail sector), leading to further output and job creation. A positive feedback from this loop depends on there being available workers to meet an increase in the demand for labour; otherwise the result will instead be higher wages and inflation.

Capacity constraints

The issue of capacity constraints relates strongly to crowding out, as described above. Economists engage in efforts to estimate the 'output gap' and economic capacity at national level but there is no agreed definition and very few estimates at sectoral level. Over time, new investment can add to capacity. E3ME's equation structure allows prices to increase as output moves beyond a 'normal' or expected level, but does not attempt to estimate or impose an absolute level of capacity for industry production. This approach is in contrast to the CGE modelling approach, where the economy as a whole is typically assumed to be effectively operating at full capacity to begin with.

The exception to this in E3ME is the labour market, where there is a clear constraint imposed by the available labour force. As the economy moves towards full employment, further increases in labour demand translate into higher wage rates, leading to a crowding out of labour (increases in one sector drive up wage rates and reduce employment elsewhere). Nevertheless, this representation is still not complete; as with other modelling approaches, there is an implicit assumption that the workforce has the necessary skills to fill the available vacancies.

Overall, it is up to the model user to determine whether the scenarios that are being modelled breach constraints that are likely to exist in reality but are not recognised formally in the modelling framework. For marginal changes it is reasonable to assume that it would be possible to adjust production patterns to meet the additional demands placed on the economy. For the more ambitious energy efficiency scenarios, however, there is a much higher degree of uncertainty around the E3ME model results. For this reason, E3ME has also been run by assuming a gradual or partial crowding out of investments as the scenarios become more ambitious (as described above).

4.8.2 Modelling set-up of the GEM-E3 model

4.8.2.1 Dynamic calibration

GEM-E3 uses reduced-form consumption and production functions to find the mix of products in various sectors, whereas the PRIMES model uses complex formulations which represent engineering details together with economic behaviours. For this reason, it was decided that for the macroeconomic impact assessment, the energy projections of PRIMES will have to be replicated as much as possible by GEM-E3.

This is a complex task from a modelling perspective, called dynamic calibration. It was implemented mainly by modifying the values of parameters of production and consumption functions specifically for the Energy Efficiency policy scenarios or options and for the EU Reference scenario 2016 (REF2016). However, the replication cannot be exact, as the simultaneity of GEM-E3 involves complex relationships between the variables.

To facilitate dynamic calibration to PRIMES energy scenarios, the structure and nomenclature of GEM-E3 has been extended so as to be as close as possible to the classifications by sector followed by the energy model. For example, the GEM-E3 model version used in this assessment, includes modelling of power generation by technology in addition to the modelling of consumption of fuels in generation, split of transport activity in sub-sectors, inclusion of appropriate categories of durable goods in households' consumption function with distinct representation of equipment categories depending on efficiency and technology, representation of biofuel production in agriculture, and energy efficiency cost-potential curves by sector. The latter are nonlinear functions with positive slope relating cumulative expenditure for energy efficiency and the achieved rate of energy savings. Finally, GEM-E3 includes learning-by-doing (and RTD) functions specifically for key energy technologies, to capture policy-driven technology progress in an endogenous manner.

First, GEM-E3 is first calibrated to the energy system projections provided by PRIMES for the Reference scenario case. In other words, the GDP, employment and other macro-economic projections provided by GEM-E3 reference scenario are fully consistent with those that served as input for REF2016 (i.e. based on DG ECFIN's Ageing Report 2015). In addition, GEM-E3 produced for REF2016 a projection until 2050 of activity split in 28 sectors of 46 countries or regions (28 of which are the EU Member States) covering the entire global economy. The energy related projections for the EU countries are calibrated to replicate REF2016 projections performed using PRIMES. For the non-EU countries the energy related projections are calibrated to Prometheus global energy model scenario built in the context of REF2016 to project fossil fuel prices at global level.

The next steps involve dynamically calibrating the GEM-E3 model to the energy projections provided for each of the Energy Efficiency policy scenarios (also based on the PRIMES model). The energy and emissions projections for the non-EU countries use the same assumptions in the Energy Efficiency policy scenarios as in REF16.

4.8.2.2 Implementing the energy efficiency policy scenarios in GEM-E3

Five energy efficiency policy options or scenarios are used in this analysis, namely EUCO27, EUCO30, EUCO+ 33, EUCO+ 35 and EUCO+ 40. They differ particularly in the definition of the energy efficiency target for 2030. EuCo27 aims at achieving 27% energy consumption reduction in 2030, EUCO30 aims at 30%, and so forth, with the most ambitious being EUCO+40 that aims at 40%. All the corresponding energy efficiency targets are defined as percentage change of total primary energy requirements of the EU relative to a projection performed in 2007 using the PRIMES model.

Achieving the targets within the energy efficiency policy scenarios mainly calls upon significantly higher investment in all sectors compared to energy related investment in the context of the Reference scenario. Households have to spent higher amounts as upfront costs to renovate houses, to purchase more efficient equipment and electric cars. Conversely, they will spend much less in fuel and electricity purchasing, due to higher energy efficiency, once the investment is implemented. From a macroeconomic perspective nonetheless the increase of upfront costs puts pressure on households’ budgets, depending on availability of external financing. Similarly, firms will have to spent higher amounts as upfront costs and lower amounts as running costs for getting the energy services. Financing the upfront costs may exert a crowding out effect, to the detriment of productive investment, at a degree which again depends on external financing and the availability of borrowing. Financing is also an issue in public finance and for utilities as they are also requested to spent higher amounts than in REF2016 for building infrastructure, such as grids, smart systems, battery recharging networks and others.

Energy efficiency improvement in industrial and services sectors, and in houses is modelled using the energy efficiency cost-potential curves, which are defined by sector. The dynamic calibration consists in varying cumulative expenditures in energy efficiency by sector until the energy saving performance is close to the figures projected using PRIMES for each energy efficiency policy scenario. The change of cumulative energy efficiency expenditures per year represents investment. To implement these investments, goods and services are needed. In GEM-E3, it is assumed that there are fixed proportions of the kinds of goods and services used to deliver energy efficiency improvement by sector. Such goods are construction, materials (ferrous and non-ferrous metals, chemical products, non-metallic minerals), and equipment, whereas the services required are mainly market services. For firms, expenditures in energy saving improve their energy intensity and do not add to their capital stock (as opposed to productive investments). Households' expenditures in energy efficiency improvements do not impact directly on their utility but indirectly through the income effect from the reduced energy costs. Households undertake the largest share of energy efficiency expenditures from all non – ETS sectors (near 70% of total expenditure).

Implementing the infrastructure, manufacturing the equipment and renovating the houses and buildings require increased domestic production of goods and services, as well as higher use of capital and labour, than in REF2016. Essentially, the low emission pathway is a continuous process of substitution of imported fossil fuels by domestically produced goods and services. The increased domestic activity acts positively on the economy through an activity multiplier effect, but also exerts pressures on markets for primary production factors, such as capital and labour. The prices of capital and labour will tend to increase due to higher demand. The magnitude of the increase depends on supply, namely financing supply concerning rates of return on capital and labour force supply concerning wage rates.

Overall, the transition to a low carbon economy is essentially a restructuring process which from a macroeconomic perspective depends on financing. For this purpose, the GEM-E3 model has been enhanced to include a detailed financial sector, learning-by-doing and research and technological development (RTD) mechanisms and a high resolution nomenclature to capture the energy-related details.

The GEM-E3 model is a global model. In this assessment, it is assumed that while the EU pursues the strong emission reduction policy, the rest of the world implement only the Cancun-Copenhagen pledges, as they also do in REF2016. The evaluation of macroeconomic consequences has a horizon until 2050.

The Emission Trading Sector is explicitly represented in GEM-E3. The auctions clear by adjusting ETS carbon prices which apply to sectors belonging to ETS. The model takes into account whether the allowances are distributed free or have to be purchased in auctions. The auction clearing prices are calculated in the model depending on the amount of allowances. The assumed shares of ETS revenues for auctioning in the period 2020 to 2050 are 100% in power generation, 70% in industry & energy branch and 30% in air transport. These are not assumed to change across scenarios analysed.

The auction revenues of the states are re-injected into the economy after accounting for the energy efficiency investment expenditures made from the public purse. In all Energy Efficiency policy scenarios, it is assumed that the revenues of the ETS carbon auctions are used to finance energy efficiency investments undertaken by the public sector, with the difference being recycled back to the economy through changes in general indirect taxes (decreases in indirect taxation if ETS revenues collected are greater that the energy efficiency investment expenditures spent by the public sector or vice-versa).

Furthermore, and most importantly, the GEM-E3 scenario setup and model features have been enhanced with new features that account for the explicit representation of financial flows. This is because the transition to a decarbonized and energy efficient system is a capital intensive process. Financing availability and their impact on interest rates are thus critical for the assessment of macroeconomic implications. The remainder of this section describes how financing assumptions have been dealt with in GEM-E3.

For the implementation of five energy efficiency policy scenarios or options, two alternative financing schemes have been considered for funding the required energy efficiency and equipment purchasing expenditures at amounts above Reference scenario (as described below). For investment in grids and energy supply including power generation no particular financing scheme has been assumed, as in these sectors tariffs increase in an endogenous manner to recover capital and other costs. However, the capital needs in these sectors, which are higher than in the Reference, add to the overall capital financing requirements of the economy. The same applies to all transport sectors providing transport services and to the industry as a whole. Of course, not all industrial sectors see increasing capital requirements for production purposes in the energy efficiency policy scenarios. Nonetheless, what is most relevant for this Impact Assessment is the additional investments in energy efficiency when comparing more ambitious energy efficiency policy efforts to EUCO27.

For energy efficiency investment expenditures, the following two finance variants have been considered.

- Self-financing variant: all expenditures are self-financed by the sectors undertaking investment; and
- Loan-based finance variant: agents use a mix of own funds and loans to finance the expenditures.

In the first self-financing variant, economic agents use their revenues to finance energy efficiency expenditures, such that:

- Households[99]: Household reduce consumption of other products to collect the funds required to finance their own energy efficiency expenditures.
- Firms (Non-ETS): Firms increase their selling price to finance their energy efficiency expenditures.
- Non-Market Services: The sector is subsidized for its energy efficiency expenditure by the government. The public retains its surplus/deficit neutrality by raising indirect taxes.

The self-financing variant corresponds to immediate financial closure and thus implies that the model will show the full crowding out effect.

In the second, loan-based finance variant, all agents receive a loan from the banking sector to finance their energy saving expenditures. To design the financial aspects of the scenarios, it is also important to define a financial sustainability rule for the loans which have to be repaid beyond the modelling horizon, i.e. 2050. For this purpose, it was assumed that the indebtedness of the sectors by 2050 as a share of their revenues should not exceed a certain threshold, which is calculated using the REF2016 projection. To calculate the threshold of the share of debt to GDP that remains after 2050 in the EUCO scenarios, the following variables are used: the reference GDP growth rate, the household income growth rate, the lending interest rate, and the accumulated debt level. To decide on the level of self-finance and the sustainability of debt is

[99] Self-financing of the energy efficiency expenditures by households may not always be feasible as low income households may not have sufficient resources (i.e. subsistence minima expenditures may exhaust all their income). In the GEM-E3 model no income classes are identified but a representative household per member state is considered.

based on two rules: 1) Debt sustainability: Any debt is treated as sustainable that is increasing at a lower rate than the growth rate of the sectors' income; and 2) The second rule regards the equalization of the monetary unit net present value of interest payments across scenarios (the net present value of all interest payments paid, during the loan period, for each monetary unit taken as loan should be equal across scenarios). This means that each euro borrowed requires the same interest payments across scenarios, bearing also in mind that an increasing level of loans increases also the total amount of interest to be paid. This rule helps the model to determine in an endogenous manner the upper limit of the loan schedule. Also this financing rule ensures that the energy efficiency policy scenarios and the REF2016 are comparable to each other. The rules apply across the energy efficiency policy scenarios, implying that thresholds are adjusted by scenario as interest rates change. In particular, in the EUCO+40 scenario where the majority of the payments takes place up to 2030, there is a smaller than EUCO debt left to be repaid after 2050 (around 4%).

As such, by assumption, the loan starts in 2020, it covers 90% (the upper limit) of total expenditure in 2020, and its share decreases after 2020, reaching 70% of total expenditure in 2035; afterwards the percentage remains constant. The loan lasts for 10 years and repayment starts one period after it is issued. The loan involves equal payments over time, covering principal and interests, the latter being calculated at market clearing interest rates of the year of payment. The simulations found that the additional requirement for financing has a small upwards effect on the EU interest rates for all energy efficiency policy scenarios. It is assumed that all European countries share the same currency (or have fixed currency exchange rates) and that there is a single financial market in the EU with sufficient liquidity. Country-specific differences have been ignored in this exercise. The justification is that the analysis has a long-term orientation and that the currently observed financial disequilibria are of short term nature and will not persist in the future.

Loans that are received up to 2035 are fully paid back (incl. interest) by 2050. Loans received in 2045 are partly paid back whereas those in 2050 are assumed to create debt beyond 2050. Overall households and firms pass on to the next period a debt that amounts to 6% of their total income (this debt can be considered sustainable as yearly savings of the private sector surpasses yearly instalments of the loan). In addition, as the full economic benefits (in the form of energy savings) of the 2050 expenditures are not "*capitalized*" within the year the results on macroeconomic adjustment (GDP) do not fully reflect the impact of the policies. In both finance variants, indirect taxes readjust to render energy efficiency policy interventions public revenue neutral as compared to REF2016. Key macro-results (GDP and total employment) have been presented in the main text of the IA for both "loan-based" and "self-financing" variants

4.8.2.3 Key model mechanisms driving the results

The macroeconomic impacts of the energy efficiency policy scenarios are the net result of the following positive and negative impacts:

- Positive effects on domestic activity due to reduced imports of fossil fuels,
- Positive effects on domestic activity due to increased demand for goods and services which implement higher efficiency and lower emissions,
- Cost benefits due to high learning rates for certain technologies,
- Negative impacts (reduction of non-energy consumption and losses in industrial competitiveness) due to higher average electricity prices and generally due to higher levelized cost of energy services and transport,

- Negative impacts due to crowding out effects arising from pressures in capital markets,
- Negative costs due to higher wage rates driven by pressures in labour markets, where applicable.

Industrial competitiveness is not only related to relative prices but also it depends on the ability to produce higher quality products, as compared to its competitors. The low carbon transformation is an opportunity for the EU industry to produce higher quality equipment goods of various types, which in addition will be environmentally cleaner. However, international demand for such improved goods will depend on whether the rest of the world countries will also pursue strong emission reduction policies. By assumption, this is not the case in the present assessment, and therefore the industrial opportunities raised in the context of the energy efficiency policy scenarios are exploited only in the EU internal market without any further benefit from exporting equipment goods. As a consequence, the impact on industrial competitiveness of the EU on the degree at which firms can compensate the energy saving expenditures and the higher energy costs (carbon prices in ETS sectors) are driven by the cost savings due to energy efficiency improvement and the cost mitigation due to acceleration of technology learning.

In the energy efficiency policy scenarios the economy replaces imported fossil fuels (including parts of gas) with domestically produced goods and service, hence the first order effect on employment is expected to be positive[100]. However, the total effect on employment depends also on:

- The magnitude of the negative impacts on domestic activity due to losses in industrial competitiveness driven by higher costs of energy
- The magnitude of the increase in wage rates due to pressures on labour market driven by higher domestic demand for certain goods and services
- The magnitude of the negative impacts of the crowding out effects (due to capital market pressures and to reduction of non-energy consumption because of higher energy costs) on domestic activity.

The comparative statics analysis of general economic equilibrium suggests that any upwards deviation from optimal investment plan requires that either consumption is reduced (so as to increase savings) or that other investment projects cancel out. Both are crowding out effects.

Depending on the liquidity of the financial sector, it is possible to mitigate the crowding out effects by means of deferring the immediate impacts to next periods. Theoretically, unlimited liquidity may even cancel out crowding out effects. In the model, the degree of mitigation is closely related to the impact that the additional financing requirements have on interest rates. The broader the geographic area of financial closure (e.g. EU as a whole), the lower is the impact on interest rates. Instability effects, for example, via adjusting currency exchange rates, can be another cause of rising interest rates, but in the modelling we have ignored such effects.

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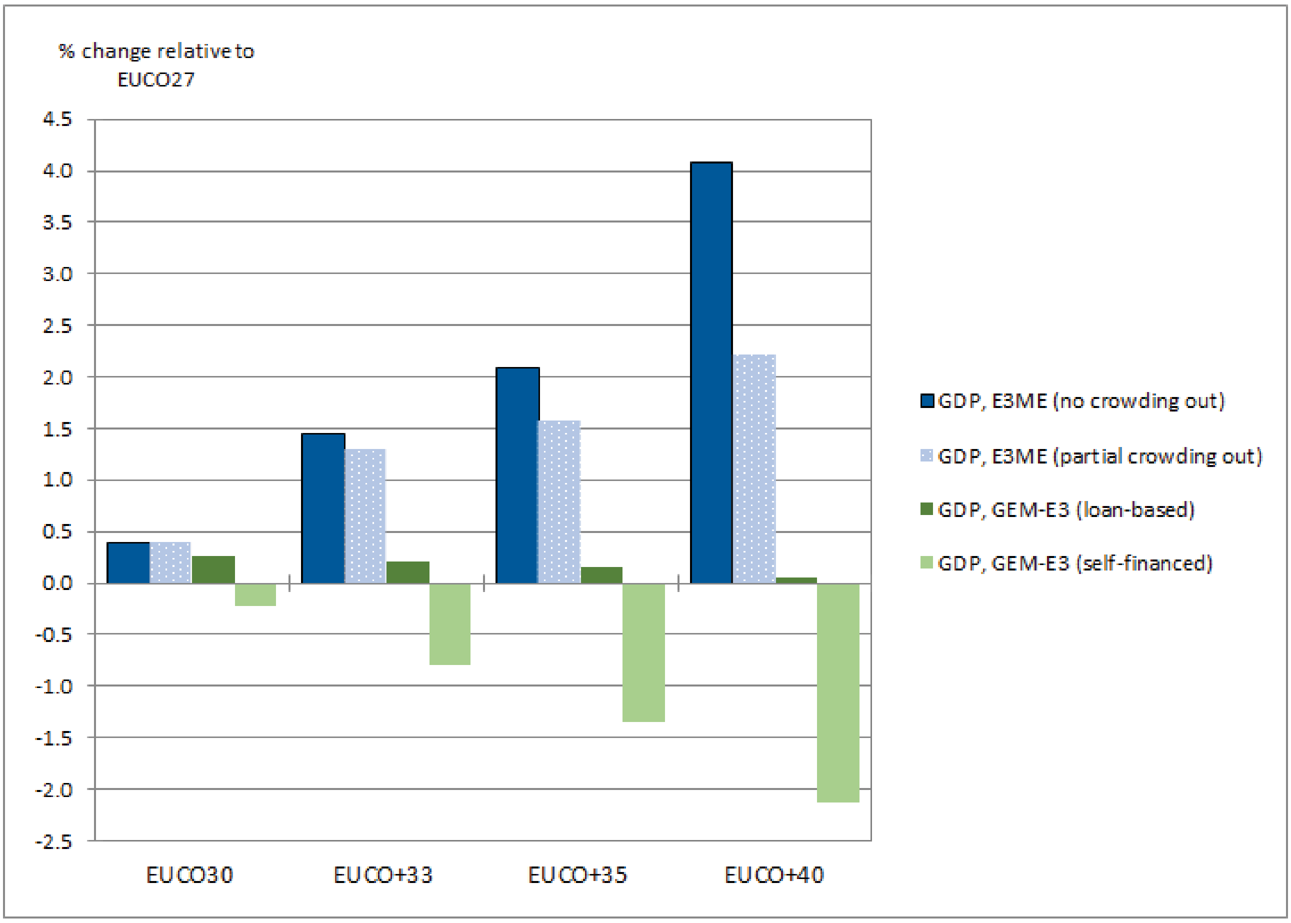
[100] As the model explicitly represents unemployment the demand for additional labour is covered by the pool of unemployed persons.

4.9 Additional macro-economic results

4.9.1 GDP impacts across time

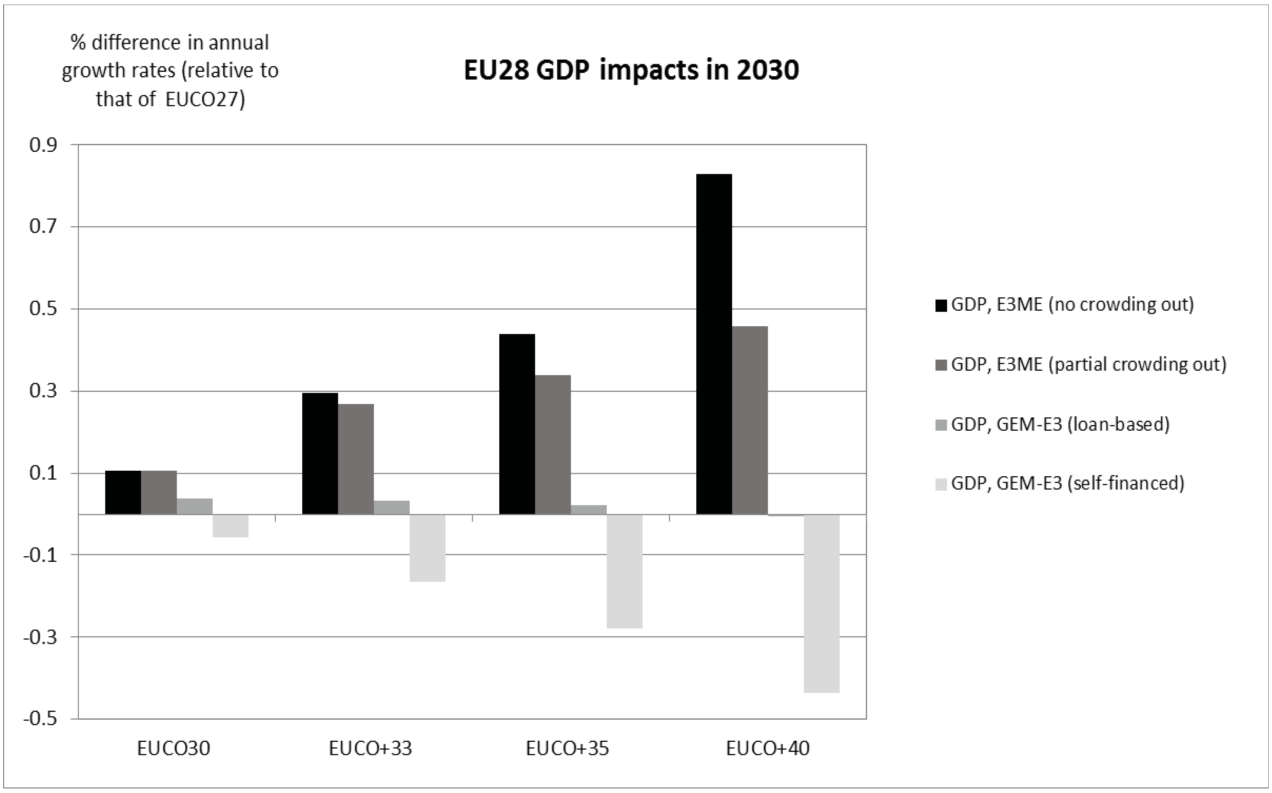
The two figures below show GDP impacts for the year 2030 across the two model versions for each of the two macro-models in terms of % change relative to EUCO27, and, respectively, in terms of % difference in annual growth rates relative to the projected GDP growth rate in the baseline policy EUCO27 scenario. They mirror the discussion on GDP impacts presented in the main body of this Impact Assessment and provide a clearer visualisation of the range of GDP impacts from increasing the ambition level of energy efficiency investments.

Figure 29: Range of GDP impacts in EU28 in 2030 depending on macro-model used and on financing and crowding out assumptions



Source: E3ME, Cambridge Econometrics and GEM-E3, National Technical University of Athens

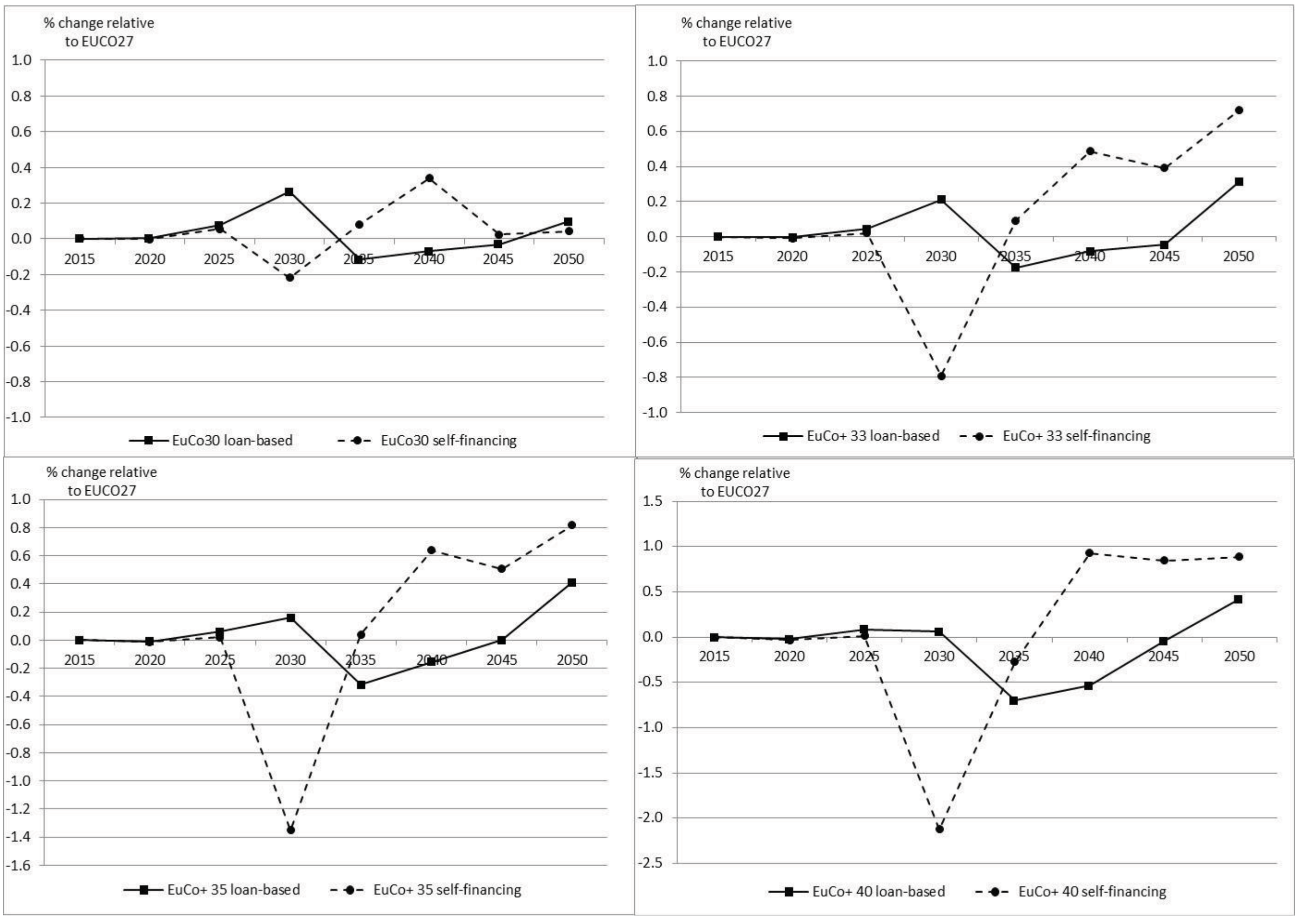
Figure 30: Range of GDP impacts in EU28 in 2030 when translating into differences in annual growth rates



Source: E3ME, Cambridge Econometrics and GEM-E3, National Technical University of Athens

The figure below shows the temporal GDP impacts for the two finance variants modelled in GEM-E3 ("loan based" and "self-financing") across the projected time period for the four energy efficiency policy options (all relative to the EUCO27 baseline). It can be seen that GDP impacts are more favourable in the 2030 horizon in the loan-based compared to the case self-financed variant (after 2030, impacts are mixed). The "self-financing" assumption implies that there is a strict closure between investments and savings, that re-orientating or increasing expenditures (for households) or investments (for firms) means that fewer funds are available for other productive purposes. These assumptions make the economy being very sensitive to crowding out effects, i.e. GDP is negatively affected in 2030 (when energy efficiency investment expenditures peak), and increasingly negative as the level of energy efficiency ambition increases. However, in the "loan-based" case, financing of energy efficiency expenditures is effectively leveraged via the banking system putting less pressure on capital markets in 2030 and allowing agents to smoothen their consumption and investment patterns. Nonetheless, beyond 2030, the economy is influenced by the repayment of the debt accumulated for energy efficiency investments before 2030. This means that over the period 2035-2045, GDP impacts are largely more favourable, this time, in the self-financed variant compared to the loan-based case. This is because energy efficiency benefits brought in by earlier investments pre-2030 that materialise post-2030 outweigh any adverse crowding out effects of new investments, the latter diminishing substantially post-2030. In the long term, the two financing assumptions tend to lead to converging GDP impacts in 2045-2050, depending on scenario.

Figure 31: GEM-E3 results showing the implications of borrowing versus no borrowing for EU GDP across time (2015-2050, %change in GDP relative to EUCO27)

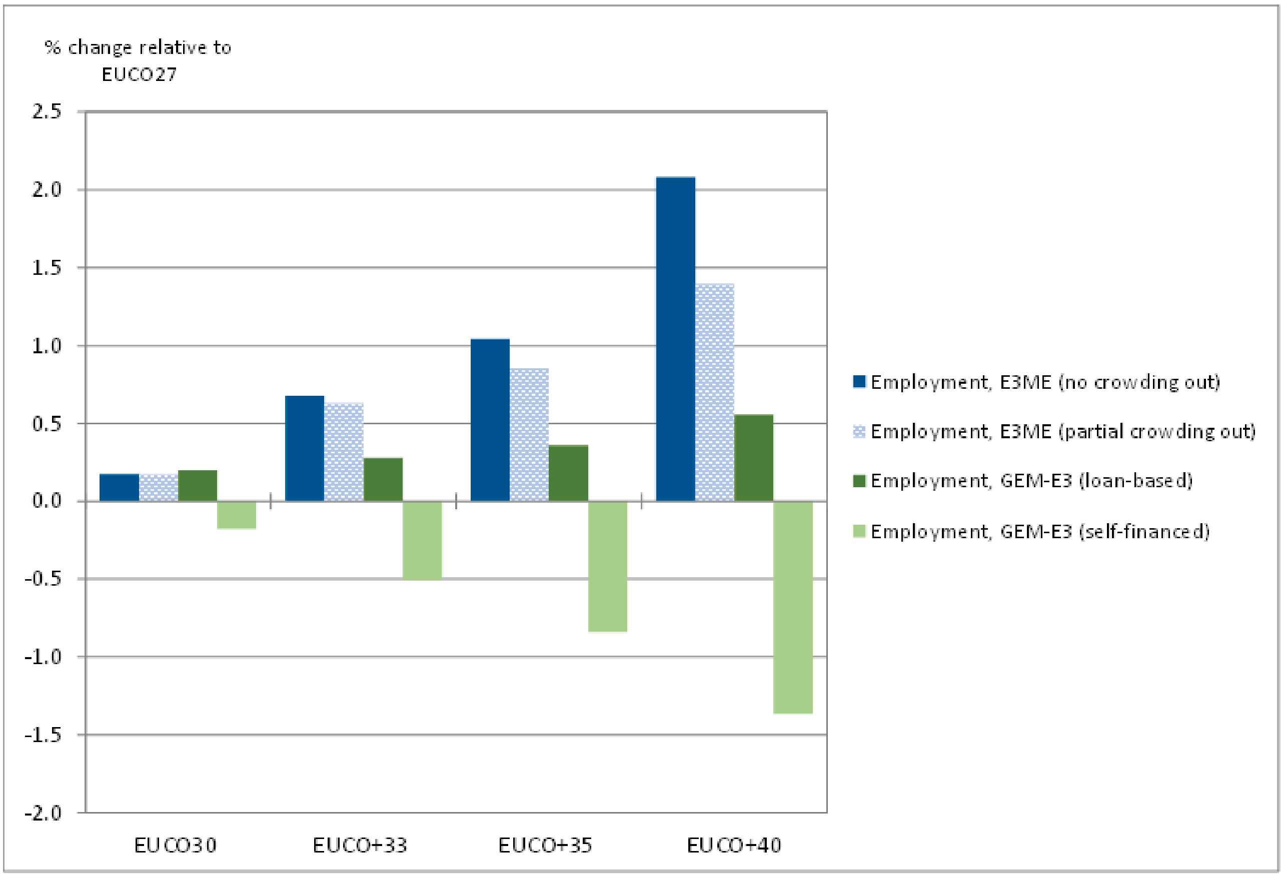


Source: GEM-E3, National Technical University of Athens

4.9.2 Sectoral output and employment impacts

The figures below display impacts by sector for the two models across the four energy efficiency policy scenario alternatives relative to the EUCO27 baseline. Results are reported for the "no crowding out" version of E3ME and the "loan-based" version of GEM-E3.

Figure 32: Range of employment impacts in EU28 in 2030 depending on macro-model used and on financing and crowding out assumptions



Source: E3ME, Cambridge Econometrics and GEM-E3, National Technical University of Athens

Increased energy efficiency expenditures lead, in both models, to increased demand in sectors providing goods and services to energy efficiency projects. Results show that higher energy efficiency ambition drives consumption expenditures towards sectors producing energy efficient equipment and energy savings projects (i.e. more efficient electrical appliances for households, retrofits, materials and insulation projects to improve thermal integrity of buildings, etc.).

Although the two models display a different sectoral classification, it can be noted that in both cases the sectors most likely to benefit activity-wise from energy efficiency policies are the construction sectors, engineering sectors as well as some basic manufacturing sectors (such as non-metallic industries and the iron and steel sector). When transiting from EUCO27 to EUCO30, the models show sectoral output increases in 2030 (relative to EUCO27), particularly for construction (1.4% in E3ME and 2.9% in GEM-E3), engineering (1.1% in E3ME and 2.1% in GEM-E3), and basic manufacturing (0.3% increase in E3ME), such as non-metallic products (3.3% in GEM-E3) and iron and steel (3.3% in GEM-E3). These sectors are projected to further increase their output (for the year 2030) with more ambitious energy efficiency investment efforts. The direct positive effect of increased energy efficiency expenditures on domestic activity is further strengthened by multiplier effects that reflect the increased intermediate demand for goods and services due to sectorial interconnections and long supply chains. Sectors with low exposure to foreign competition record relatively higher increases in their activity (e.g. construction), while for sectors characterised by higher trade exposure (e.g. engineering and transport equipment), part of the increased demand is satisfied by imports, depending on the degree of exposure to foreign competition. Thus, the positive effect of increased expenditures on their activity is weakened.

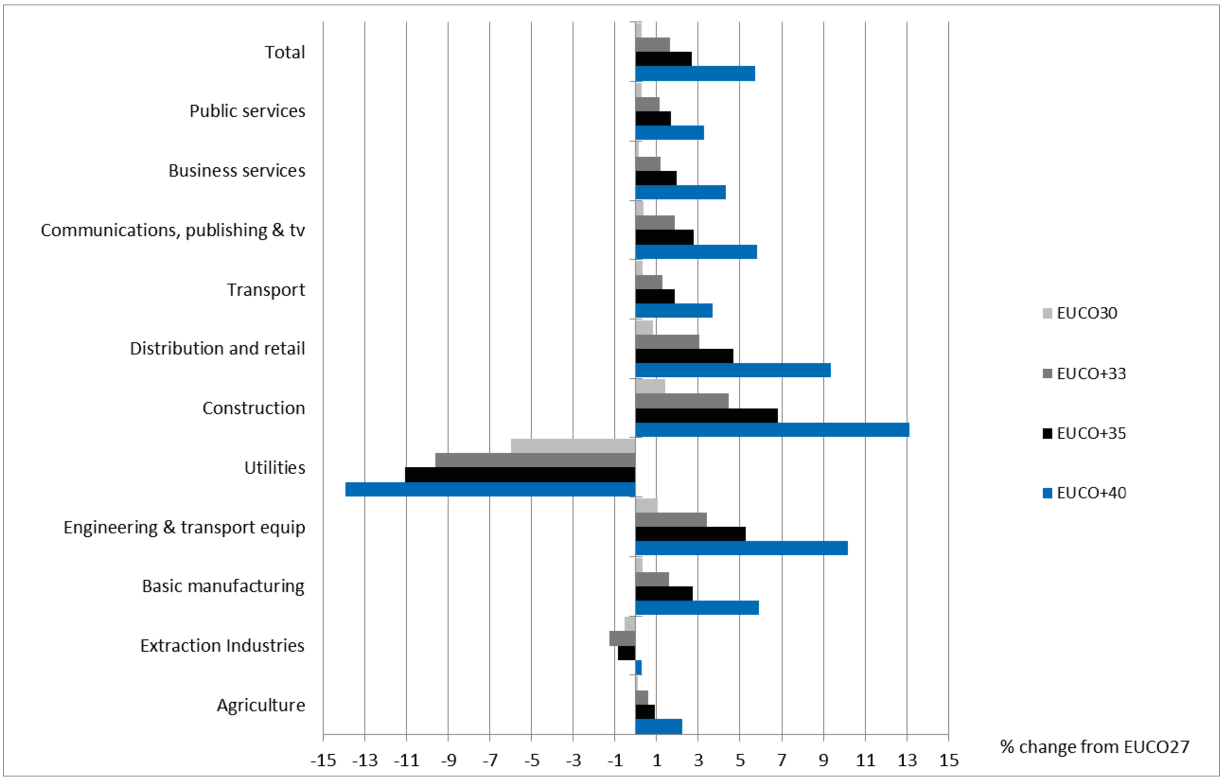
Demand for energy products or the use of electricity and gas declines in all scenarios in both models causing domestic energy production and imports to decrease. In other words, the shift in demand towards sectors which provide inputs to energy efficiency projects occurs at the expense of particularly energy-related sectors, such as the utilities and the extraction industries sectors. Again, when comparing to the 2014 European Council conclusions, in GEM-E3, changes in output for energy sectors and for power supply are projected to range from -2% in EUCO30 to -11.5% in EUCO+ 40 (relative to EUCO27). In E3ME, output is projected to contract the most in the utilities sector (ranging from -6% in EUCO30 to -14% in EUCO+ 40) and to some extent in the extraction industry (ranging from around -0.5% in EUCO30 to -1% for more stringent energy efficiency).

Overall, employment tends to increase in sectors that provide inputs to energy efficiency projects, and/or have significant forward and backward linkages with other sectors of the economy (e.g. construction sector, engineering, or non-metallic industries). The largest increase in employment, according to both models, is expected in the construction sector as a large share of the investment will require construction or installation activities. Also when taking into account both models, relatively more modest increases are also projected in the engineering and transport equipment sector, as well as in overall basic manufacturing. However, for the latter, more disaggregated GEM-E3 results show important employment gains for the non-metallic industries and iron and steel. Sectoral employment is projected to decrease in energy-related activities (such as the fossil fuel extraction and electricity supply industries) in line with the projected fall in output in these sectors.

Output and employment effects on other sectors are more nuanced, depending on the macro-modelling approach pursued and the level of sectoral aggregation. For instance, the E3ME model projects an increase in employment with the level of energy efficiency ambition for the "utilities" sector, despite its projected decrease in the sector's output, whereas the GEM-E3 model projects a decrease in employment for the "power supply" sector. This is because, E3ME bundles together under the "utilities" sector, electricity supply, gas steam & air con, water supply, and sewage & waste, while the GEM-E3 model singles out the power supply sector. In addition, the E3ME model portrays the renewable energy generation subsectors (favoured under the EUCO scenarios relative to REF2016) as being more labour intensive than their high-carbon counter-parts101. This, in combination with the projected increase in the output and employment of the "water supply" and "sewage & waste treatment" subsectors of the "utilities" sector more than counteracts the negative impacts on "electricity supply" and employment.

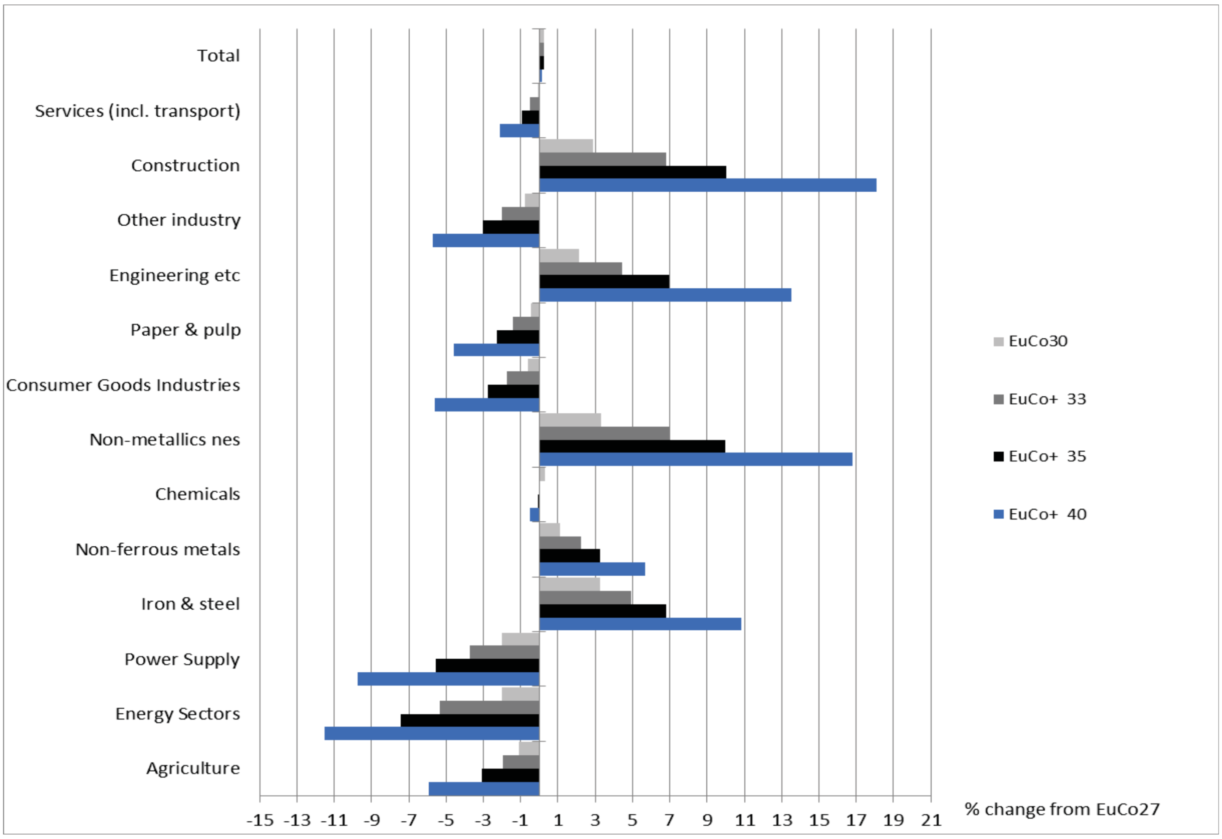
[101] See for instance the study by Institute for Sustainable Futures (2015) "Calculating Global Energy Sector Jobs: 2015 Methodology Update" (Jay Rutovitz, Elsa Dominish and jenni Dowes) that provides employment rations by type of low-carbon and high-carbon technologies, data upon which the E3ME model draws: http://opus.lib.uts.edu.au/bitstream/10453/43718/1/Rutovitzetal2015Calculatingglobalenergysectorjobsmethodology.pdf

Figure 33: E3ME sectoral output impacts in 2030 at the EU level (% change relative to EUCO27)



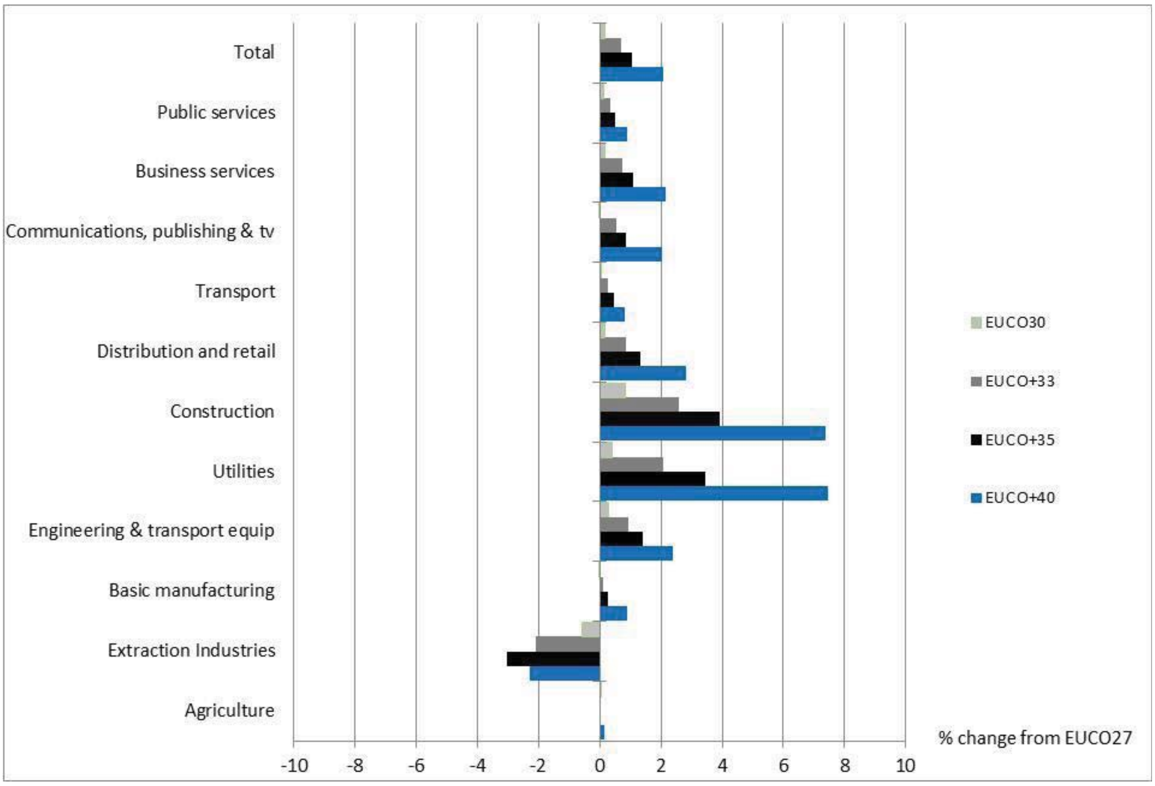
Source: E3ME (no crowding out), Cambridge Econometrics

Figure 34: GEM-E3 sectoral output impacts in 2030 at the EU level (% change relative to EUCO27)



Source: GEM-E3 (loan-based finance), National Technical University of Athens

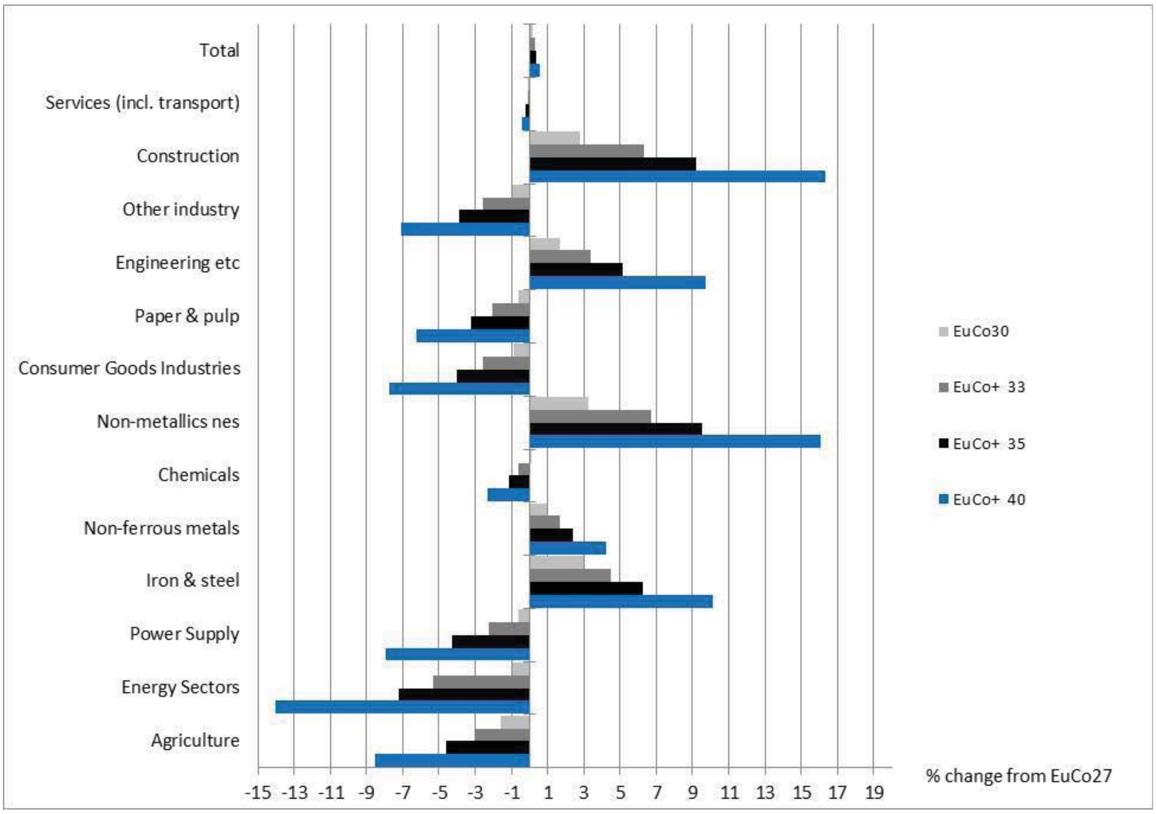
Figure 35: E3ME sectoral employment impacts in 2030 at the EU level (% change relative to EUCO27)[102]



Source: E3ME (no crowding out), Cambridge Econometrics

102 The positive results for the utilities sector are mainly due to an assumption that operation and maintenance of renewable technologies for elerctricity generation are more labour intensive than technologies that are supplanted.Cambridge Econometrics has based their modelling in part on the report "Calculating Global Energy Sector Jobs: 2012 Methodology". http://cfsites1.uts.edu.au/find/isf/publications/rutovitzharris2012globalenergyjobsmethycalc.pdf

Figure 36: GEM-E3 sectoral employment impacts in 2030 at the EU level (% change relative to EUCO27)



Source: GEM-E3 (loan-based finance), National Technical University of Athens

4.9.3 Trade, competitiveness and other core macroeconomic indicators

The table below shows the impacts of increasing energy efficiency investment efforts on trade and other relevant macroeconomic indicators in both models (again only for the "no crowding out" case in E3ME and the "loan-based finance" case in GEM-E3)[103]. In both models, trade increases with the level of energy efficiency efforts, although imports increase at a more rapid pace than exports. Energy savings lead to a decrease of fossil fuels imports in E3ME and GEM-E3, but imports increase in total. This is because there is an increasing demand for other goods due to higher GDP levels of overall demand for goods (particularly in E3ME), as well as for equipment products contributing to the realisation of energy efficiency projects. Exports increase with the stringency of the energy efficiency target because of overall GDP growth, and increased competitiveness in sectors (such as engineering) benefitting from lower energy costs and learning effects on energy efficient equipment.

The increase in EU exports may indirectly reflect an improvement in the region's overall competitiveness stance resulting from the economy-wide effects of energy efficiency investments. In other words, from an economy-wide level perspective, macroeconomic competitiveness via changes in extra-EU exports is projected to improve because of two push factors. First, increased macroeconomic activity spurred by energy efficiency investments increases the growth potential of high value-added firms and sectors. Second, sectors delivering energy efficiency investment goods (e.g. engineering) are incentivised to move closer to their production frontier via improved technologies and learning effects, which improves overall extra-EU export growth prospects.

However, a more direct link to competitiveness could be made by relating to changes in energy costs incurred by energy-intensive industries (i.e. sectoral competitiveness)[104]. For this purpose, changes in the ratio of total energy related costs (including capital costs, energy purchases and auction payments) to the value added for energy intensive industries projected by the PRIMES model are displayed in the tables below[105]. These are projected to decrease marginally with the stringency of energy efficiency policies relative to EUCO27, indicating that energy efficiency investment efforts may not adversely impact the competitiveness of energy-intensive industries. This is because any projected increase in the capital cost component is more than outweighed by the decrease in energy purchases (including auction payments).

[103] Import/export, income, investment and consumer expenditure differences in REF2016 projected levels between the two models expressed in billion €2013 are partly due to differences in definitions, differences in databases between the two models and partly due to each model endogenously modelling the respective macro-variables.

[104] Energy-intensive industries include iron and steel, non-ferrous metals, chemicals, paper and pulp, and non-metallic minerals.

[105] These ratios take into account only the initially assumed value added growth for these industries that serve as an input into the PRIMES energy system model and which do not vary across policy scenarios. However, there are additional feedback effects from interactions between the energy sector and the macro-economy, and the positive impacts on the output for some of these sectors (e.g. iron and steel, non-metallic minerals) described in the macroeconomic sectoral output results are not included in the calculation of these ratios. As such, the competitiveness of these sectors could be further improved via positive economy-wide impacts on the value added of the industries involved in providing energy efficiency investment goods.

Table 18: Other macroeconomic impacts in EU28 in 2030 (billion €2013)[106]

% change from EUCO27	Type of macro-model	REF2016	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Investment	E3ME	4,078.7	4,131.2	4,200.7	4,339.7	4,448.8	4,750.8
	GEM-E3	2,927.0	2,968.5	3,025.9	3,129.9	3,216.1	3,453.1
Consumer expenditure	E3ME	10,193.8	10,255.2	10,263.3	10,348.1	10,388.5	10,537.7
	GEM-E3	10,105.8	10,080.4	10,068.3	9,958.1	9,864.0	9,609.2
Real disposable income	E3ME	11,371.4	11,446.7	11,464.5	11,561.1	11,609.6	11,776.6
	GEM-E3	11,332.7	11,354.1	11,387.7	11,387.8	11,381.7	11,354.8
Extra-EU imports	E3ME	2,916.8	2,920.8	2,929.0	2,959.2	2,986.6	3,059.7
	GEM-E3	2,986.2	2,979.3	2,988.1	2,998.5	3,008.9	3,037.1
Extra-EU exports	E3ME	3,720.4	3,722.2	3,722.4	3,727.4	3,730.6	3,741.7
	GEM-E3	3,395.7	3,379.9	3,388.1	3,395.9	3,405.4	3,434.1

Source: E3ME, Cambridge Econometrics; GEM-E3, National Technical University of Athens

Table 19: Ratio of energy related costs to value added for energy intensive industries in EU in 2030

	REF2016	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Total energy related costs (% of value added)	40.3%	40.8%	40.1%	40.0%	39.8%	40.6%

Source: PRIMES, National Technical University of Athens

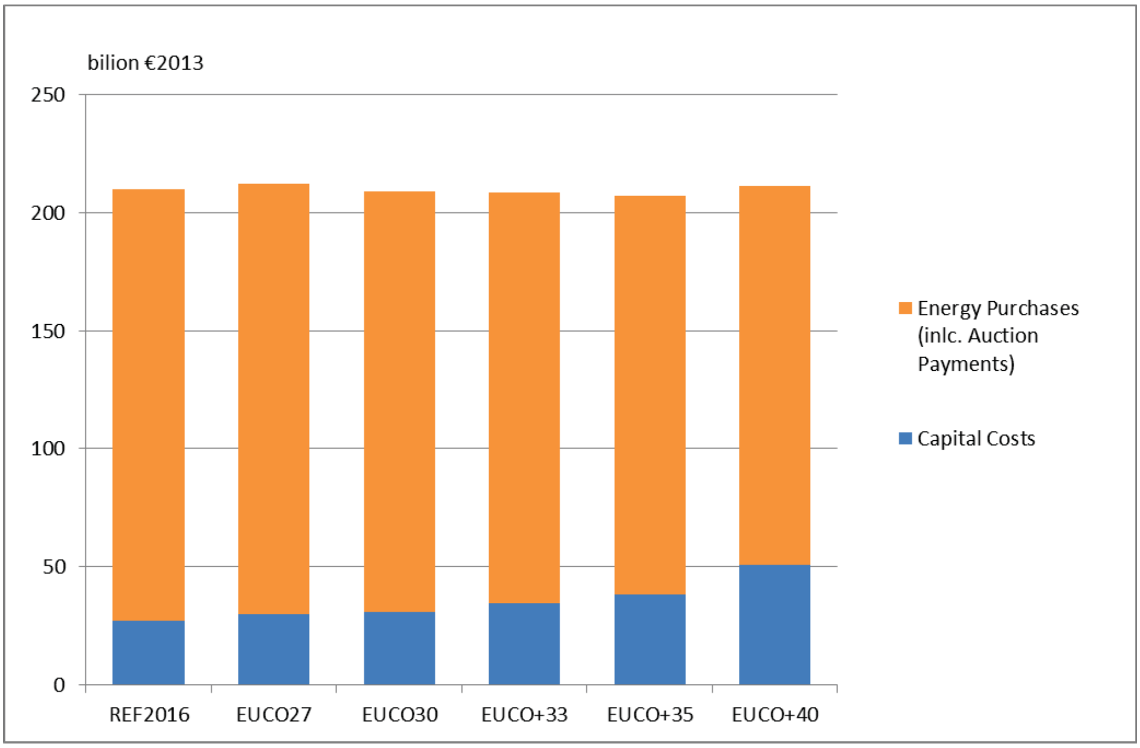
Table 20: Total energy-related costs for energy-intensive industry at EU level broken down by cost component in 2030 (billion €2013)

	REF2016	EUCO27	EUCO30	EUCO+33	EUCO+35	EUCO+40
Capital Costs	27.2	29.8	30.9	34.7	38.4	50.6
Energy Purchases	176.9	175.7	173.4	169.5	165.6	158.7
Auction Payments	5.7	6.8	4.5	4.2	3.1	2.1
Total energy-related costs	209.8	212.4	208.8	208.4	207.2	211.4

Source: PRIMES, National Technical University of Athens

106 Impacts above are reported for E3ME in the case of no-crowding out and GEM-E3 for the loan-based finance case.

Figure 37: Total energy-related costs for energy-intensive industry at EU level broken down by cost component across scenarios in 2030 (billion €2013)



Source: PRIMES, National Technical University of Athens

Both models show an increase in total investments in the EU as energy efficiency policies turn more ambitious. In the case of E3ME, total investments are stimulated by the initial energy efficiency investments that positively impact economic growth which in turn leads to further increases in investments. In other words, investments in E3ME are driven by the expectations of future production levels that are formed from current GDP growth rates. In GEM-E3, investments are largely explained by higher expenditures on energy efficiency projects and the increased return on capital.

Real disposable income increases in both models[107]. In E3ME this is partly due to higher employment levels and partly attributed to changes in prices (either higher wage demands because of a tighter labour market, or lower prices because of companies passing on efficiency savings). Adjustments in wage rates drive income results to a lesser extent in GEM-E3 due to the assumed wage stickiness[108]. Nonetheless, in both models, higher employment levels overall and a lower rate of unemployment lead to an increase in disposable income.

As energy efficiency efforts increase, consumption expenditure drops in GEM-E3, whereas it increases in E3ME. In GEM-E3, consumption expenditure decreases since households are obliged to allocate a larger part of their income towards the repayment of loans (interest rate increases) and towards more expensive energy efficient appliances. In E3ME, consumer

[107] Real disposable income is defined in both models as real household income after tax and equals to wages plus benefit payments + other sources of income (e.g. rents, interests) minus income tax minus employees' social security contributions. It refers to gross household income in the sense that it includes savings.

[108] That is, the assumption that wages rates are not much affected by changes in labour demand.

expenditure projections follow the patterns in real income developments. In addition, energy efficiency investments are not assumed to have an impact on interest rates, and household expenditures are projected to increase due to the savings they make from energy efficiency.

4.9.4 Public budgets

The table below shows the impacts of increasing energy efficiency investments on Member States public budgets for the "no crowding out" and "partial crowding out" cases in E3ME. The numbers shown are percentage changes in the public budget for the specific scenario in question, compared to the baseline scenario REF2016 (a positive number showing an improvement in the budget balance). In these cases, it is essential to recall that there are no first order (direct) effects on the public budget balance, as governments' expenditure to support more energy efficiency is unaffected by fiscal neutrality assumption. Therefore, only second order effects are captured by the model.

Such second order effects are manifest as there are changes in public budgets due to changes in GDP and the associated tax base. In the "no crowding out" case, public budgets improve at the aggregate EU level due to increases in GDP and the tax base for the more ambitious energy efficiency scenarios. Conversely, the impacts in the "partial crowding out" scenario are negative on the public budget balance. The small positive GDP impacts that the model projects are not sufficient to generate enough tax revenues to compensate for the loss in energy excise duties due to lower energy consumption.

Table 21: Public budget in EU28 in 2030

% change relative to EUCO27	Type of macro-model E3ME	REF2016	EUCO27	EUCO30
Public budgets	no crowding out	-	0,2	0,4
	partial crowding out	-	-0.3	- 0,7

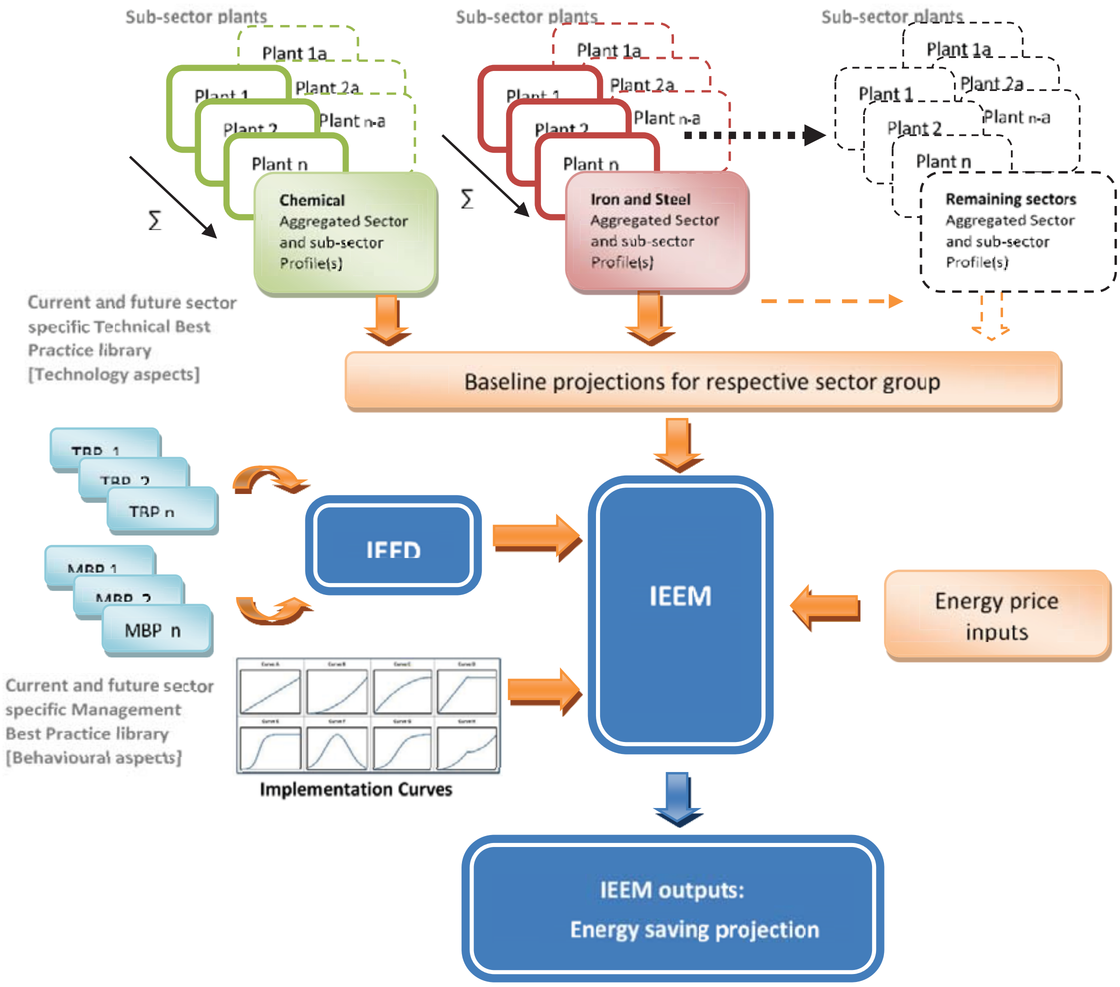
Source: E3ME, Cambridge Econometrics

4.10 Industrial Energy Efficiency Modelling (IEEM)

The Industrial Energy Efficiency Model (IEEM) operated by ICF is a bottom-up model for accounting for energy saving potentials based on a defined list of energy saving opportunities applicable to the respective industrial sector group.

The model applies data available in ICF's Industrial Energy Efficiency Database (IEED), which holds a comprehensive list of potential energy saving opportunities. The energy saving opportunities include savings potentials due to both Technical Best Practices and Management Best Practices. Each energy saving opportunity is applied in the IEEM to quantify energy saving potential as an output. The figure below provides an overview of IEEM modelling framework.

Figure 38: Overview of IEEM modelling framework



Source: ICF

A baseline projection is the starting point for the analysis and provides a detailed description of "where" and "how" energy is currently used in the selected sector group, including a breakdown of energy by end use. The baseline projection is the benchmark against which the energy savings are calculated.

For each Energy Saving Opportunity, one of eight “standard” uptake curves is applied by defining a starting point (current market penetration rate) and final point (estimated or target final market penetration rate). Application of the uptake curve takes into consideration the maturity of technology, capital, operating expenditures and complexity in implementation and operation.

IEEM can evaluate all the defined Energy Saving Opportunities individually for economic viability based on optional financial metrics. For this modelling work, a payback approach was applied, since it is still a widely utilized metric and not subjected to the complications associated with discount rates or Weighted Average Cost of Capital which differ widely among industries and Member States.

The economic benefits of the Energy Saving Opportunities account only for the direct energy saving benefits expressed in monetary value. It does not include any other direct or indirect benefits such as avoided carbon taxes, improved production or improved competitiveness, reduced maintenance costs, etc. The Energy Saving Opportunity cost includes the capital, Operating and Maintenance (O&M), and implementation costs. An energy price outlook is used as a main input to quantify the monetary value of energy savings, since the benefit of the ESO is dependent on the energy price.

For each Energy Saving Opportunity that meets the economic threshold (e.g. 2-year payback or 5-year payback), IEEM will account for it by subtracting its respective energy saving potential from the respective baseline projection. The accumulated energy savings for each ESO are added together to present the overall energy saving potential for the sector group, based on economical Energy Saving Opportunities being taken up at its respective pre-defined rate and trend.

IEEM computes energy savings based on the respective Energy Saving Opportunity applied. This accounting process is then repeated multiple times to account for multiple Energy Saving Opportunities applied. As a result, IEEM generates cumulated energy savings based on the Energy Saving Opportunity.

4.11 Modelling of international fuel price impacts

The impacts of different 2030 energy efficiency levels have been analysed with the POLES model from the Joint Research Centre of the European Commission.

POLES is a global energy model that covers the entire energy balance, from final energy demand, transformation and power production to primary supply and trade of energy commodities across countries and regions. It allows assessing the contribution to future energy needs of the various energy types (fossil fuels, nuclear, renewables) and energy vectors.

In addition, it calculates the evolution of GHG emissions: endogenously for the energy-industry sectors and through linkage with specialist models for GHG emissions from agriculture and land-use.

The model includes a detailed geographical representation, with a total of 66 regions modelled; that includes all G20 countries, detailed OECD and the main non-OECD economies. It operates on a yearly time step, allowing integrating recent developments.

The POLES model is well suited to evaluate the evolution of energy demand in the main World economies and international markets as well as to assess climate and energy policies. De facto it has been used for several Directorates General of the European Commission, as well as for national authorities. The POLES model has been applied in numerous research projects, and analyses based on POLES have been published widely[109].

The energy situation of non-EU countries and regions is derived from the GECO 2016 Reference scenario (Global Energy and Climate Outlook). This scenario includes climate and energy policies announced by countries before the Paris Climate Agreement[110].

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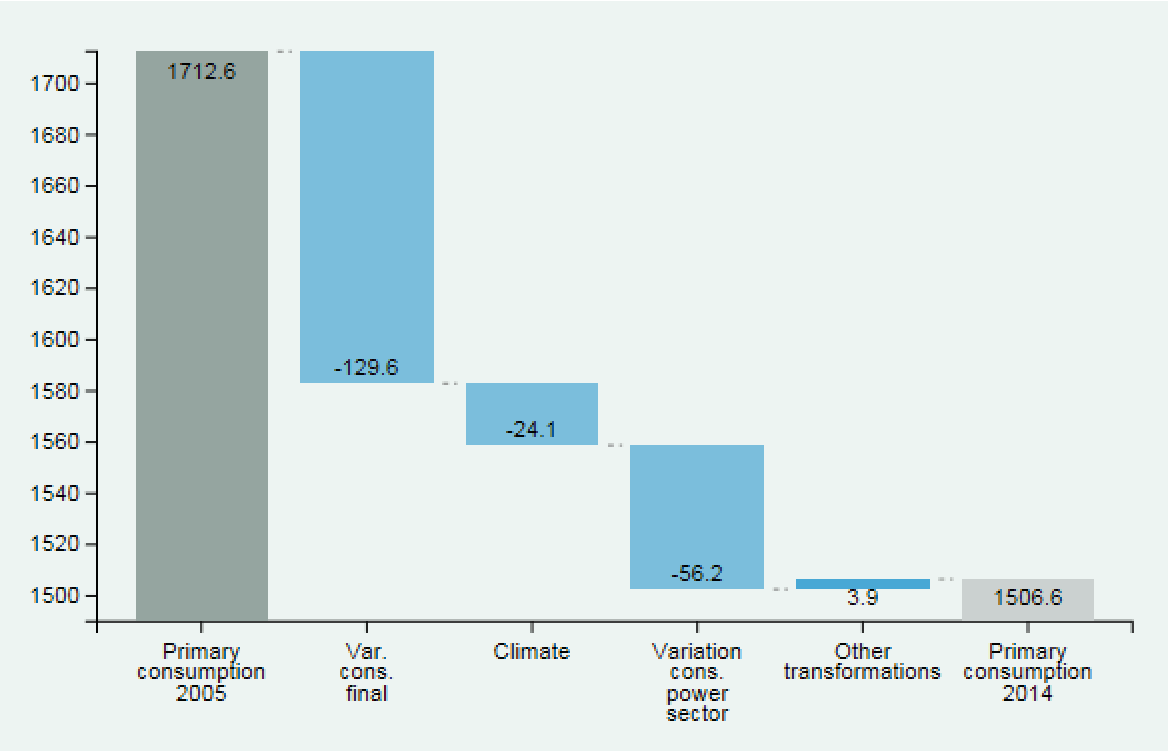
[109] More information can be found on: www.ec.europa.eu/jrc/poles.

[110] The GECO report is accessible on : www.ec.europa.eu/jrc/geco.

5 Annex - Additional information – decomposition analysis

A decomposition analysis of past trends was performed under the Odyssee-Mure project financed as one of the Horizon 2020 projects[111]. The results of the decomposition of the energy consumption 2005-2014 can be found below:

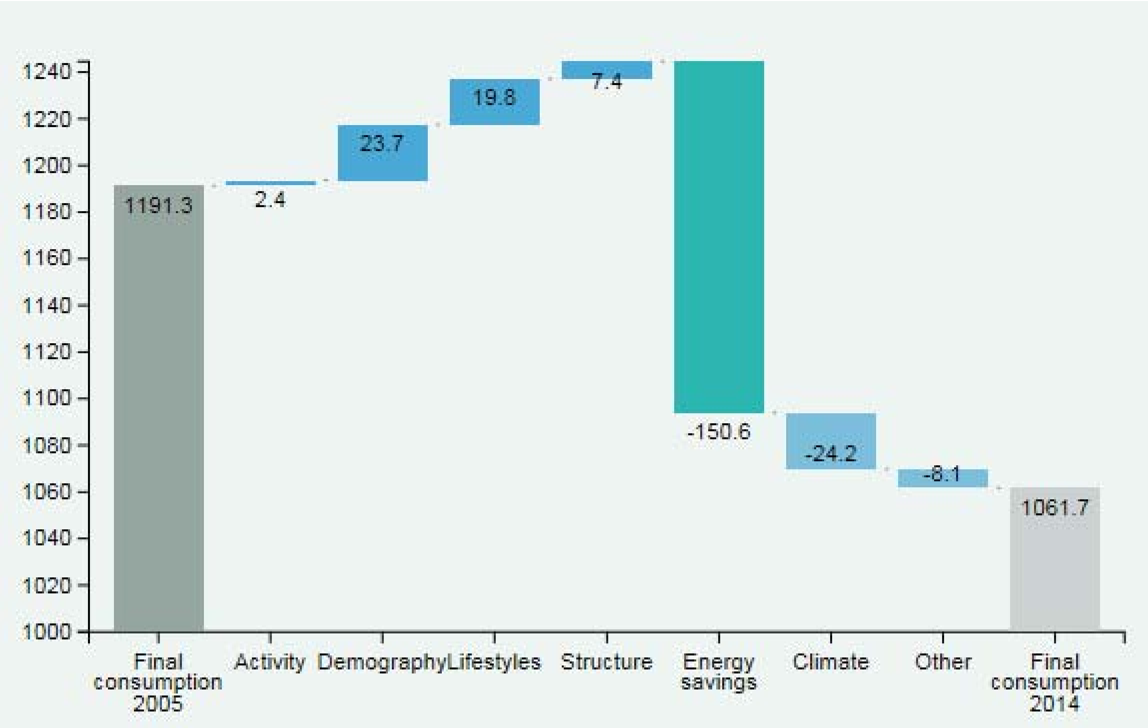
Figure 39: Variation primary energy consumption - European Union - Mtoe (2005-2014)



Source: Odyssee-Mure

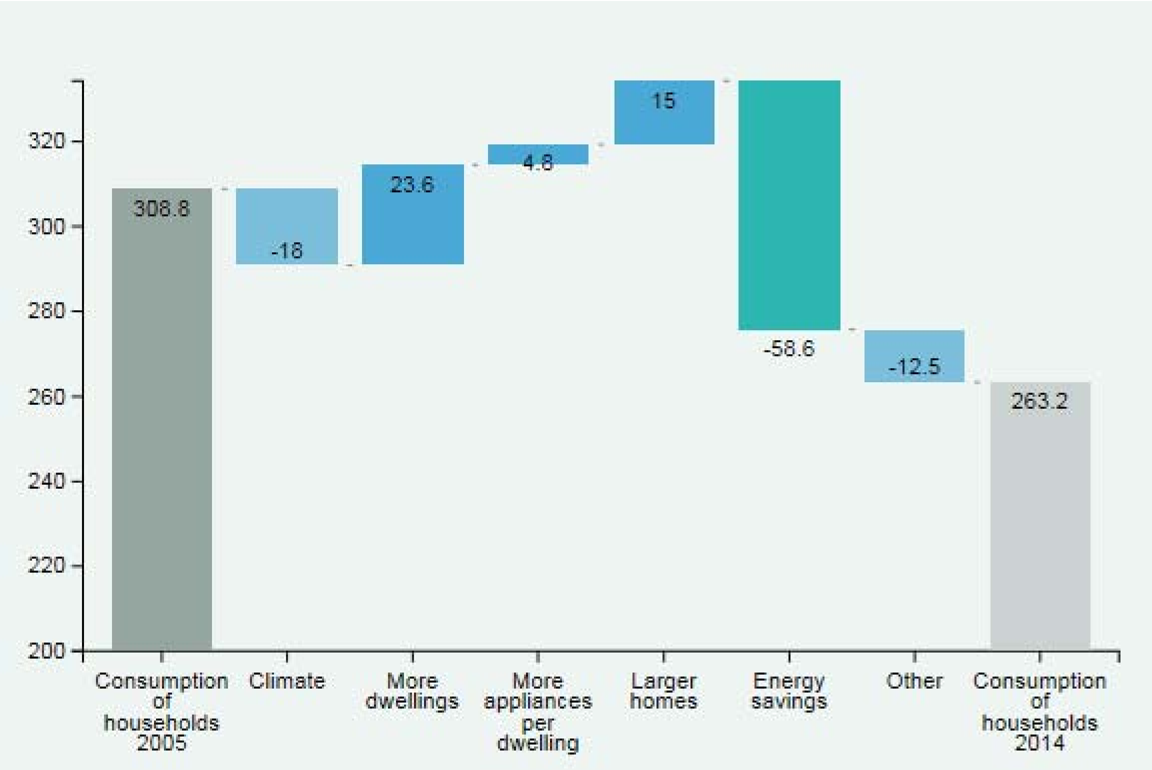
[111] Details on the methodology can be found here: http://www.indicators.odyssee-mure.eu/php/odyssee-decomposition/documents/interpretation-of-the-energy-consumption-variation-glossary.pdf.

Figure 40: Variation final energy consumption - European Union - Mtoe (2005-2014)



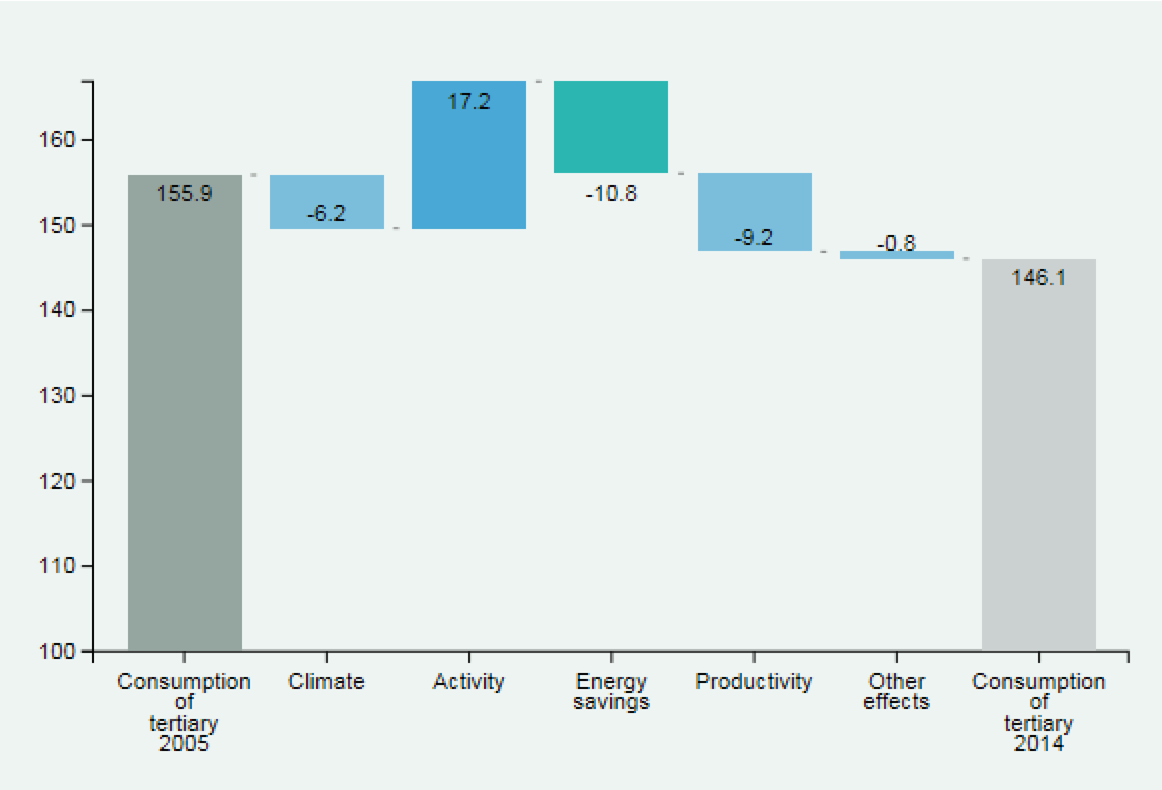
Source: Odyssee-Mure

Figure 41: Variation residential consumption - European Union - Mtoe (2005-2014)



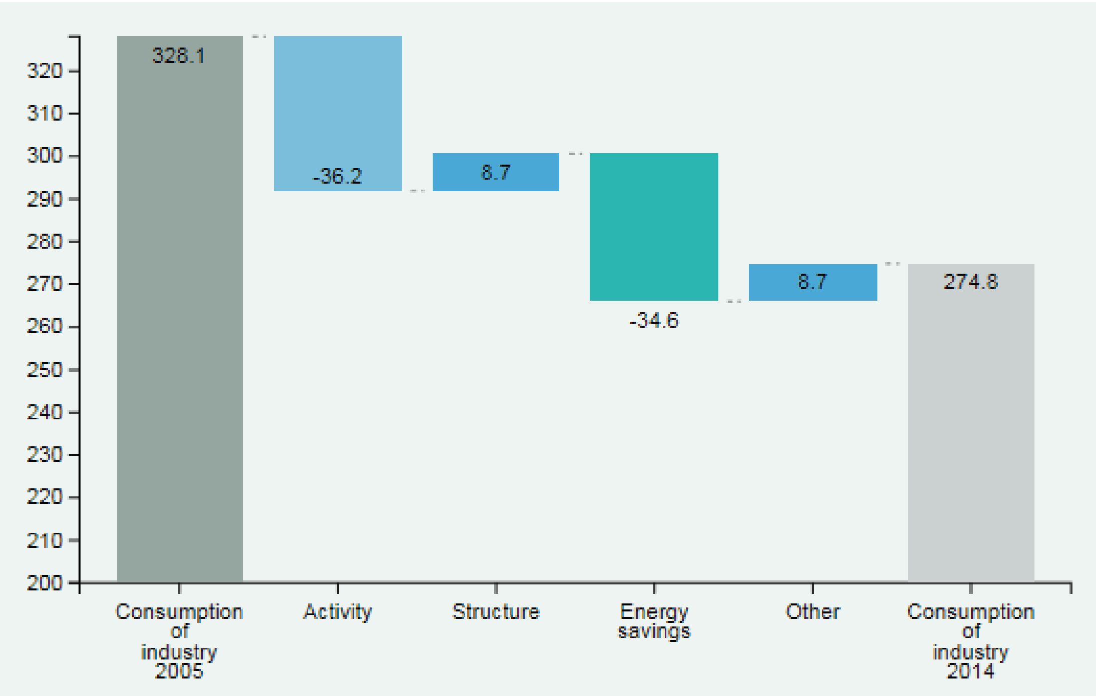
Source: Odyssee-Mure

Figure 42: Variation tertiary consumption - European Union - Mtoe (2005-2014)



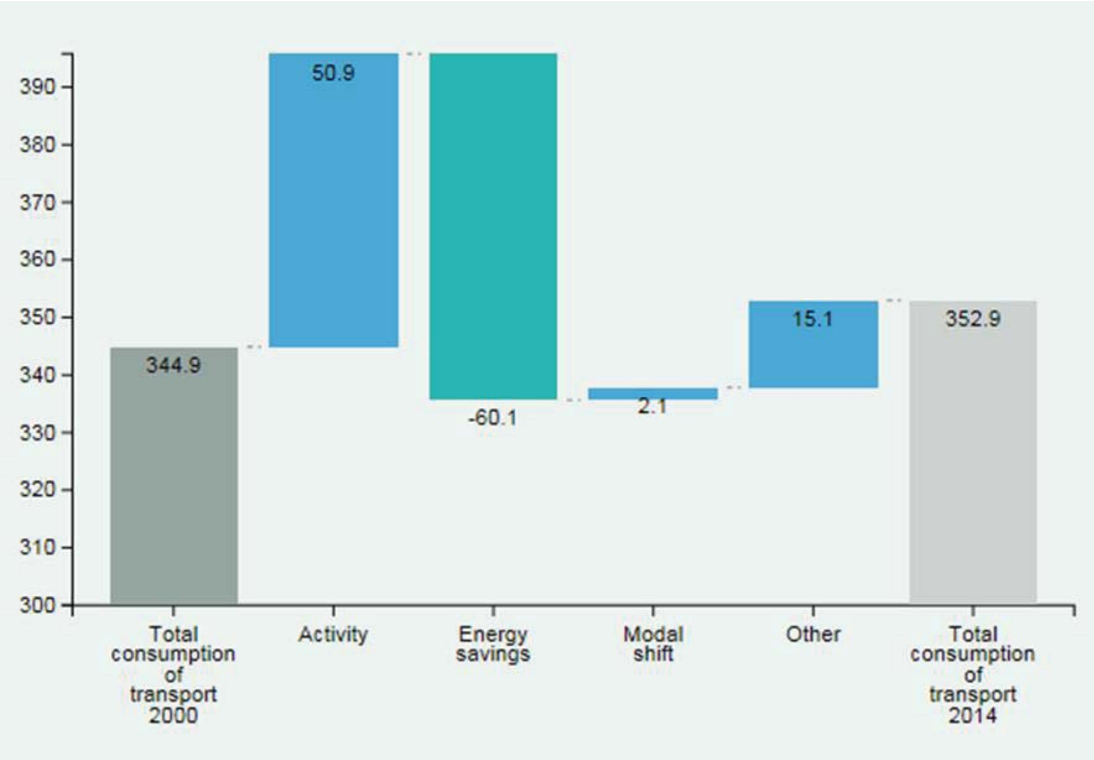
Source: Odyssee-Mure

Figure 43: Variation industry consumption - European Union - Mtoe (2005-2014)



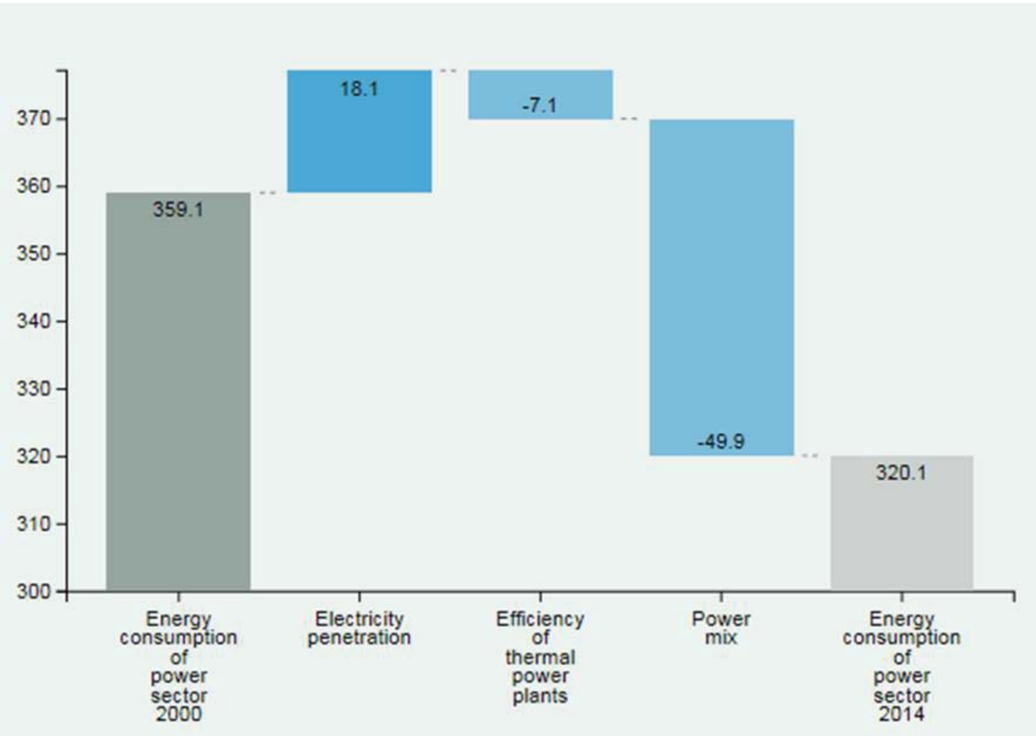
Source: Odyssee-Mure

Figure 44: Variation transport consumption - European Union - Mtoe (2005-2014)



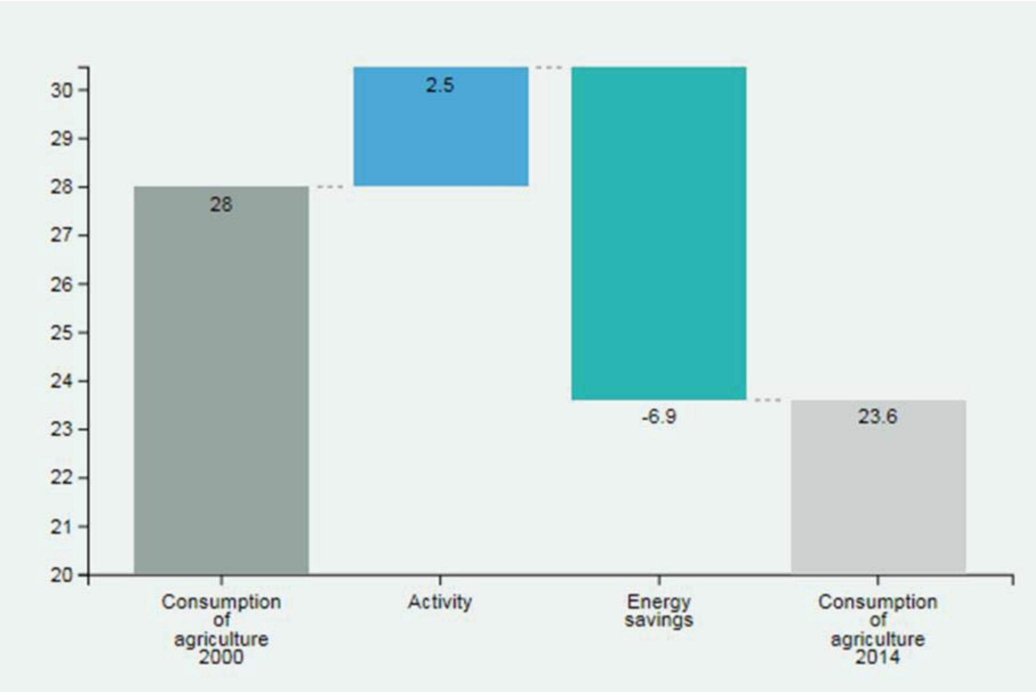
Source: Odyssee-Mure

Figure 45: Variation power sector consumption - European Union - Mtoe (2005-2014)



Source: Odyssee-Mure

Figure 46: Variation agriculture consumption - European Union - Mtoe (2005-2014)



Source: Odyssee-Mure

6 Annex –Analytical approach used for Articles 7 and 9-11

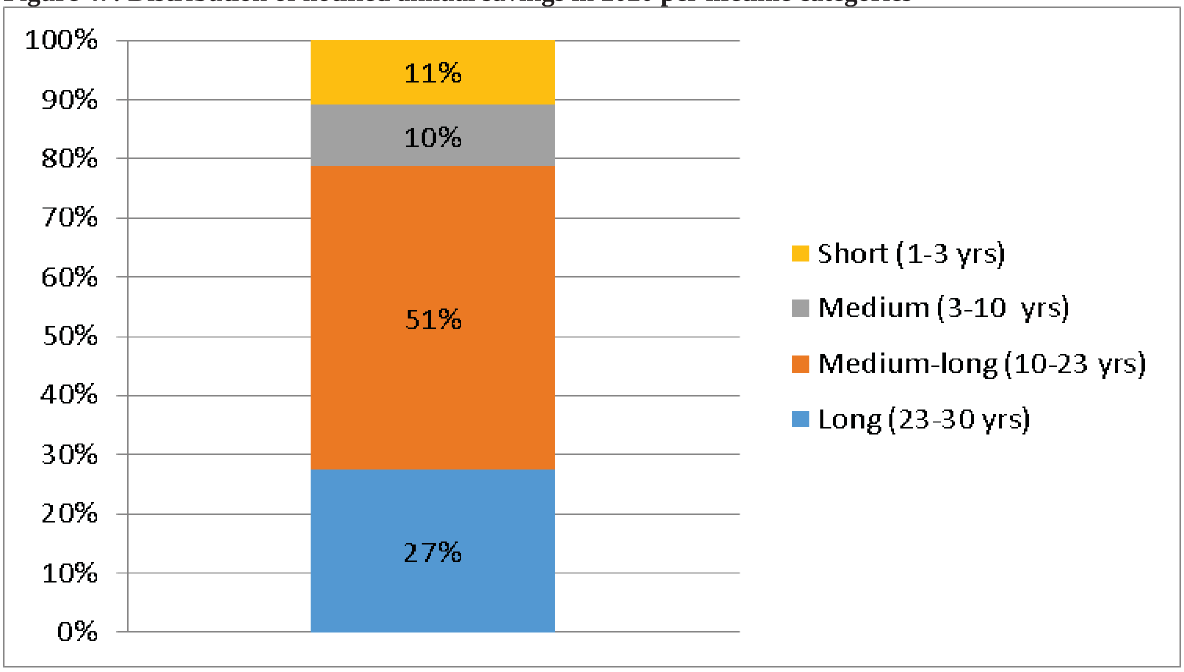
6.1 Analytical approach for Article 7

The quantitative estimates of the amount of energy savings expected from implementation of the measures (in the existing period 2014-2020) and estimates for the new period starting from 2021-2030 if Article 7 is extended were based on a bottom-up spreadsheet-based model developed by the contractor Ricardo AEA/ CE Delft under a specific contract[112]. A brief description of the methodology is outlined below.

Calculation of the baseline scenario - Article 7 expires post 2020

This analysis is based on the notified savings (cumulative amount of 250.3 Mtoe by 2020) from the policy measures that Member States have planned in order to fulfil their Article 7 energy savings requirement by 2020. The analysis is based on the notified annual savings per policy measure and the assigned lifetimes during which they will deliver energy savings based on CEN-values[113], as the savings notified by the Member States at the policy measure level contained actions with different lifetimes, which were not split per specific type of these energy saving actions. The data notified by the Member States enabled an attribution of only 57% of the savings to one of the four lifetime categories: with relative contributions of 27% long, 51% medium long, 10% medium and 11% short lifetimes (see Figure 47).

Figure 47: Distribution of notified annual savings in 2020 per lifetime categories

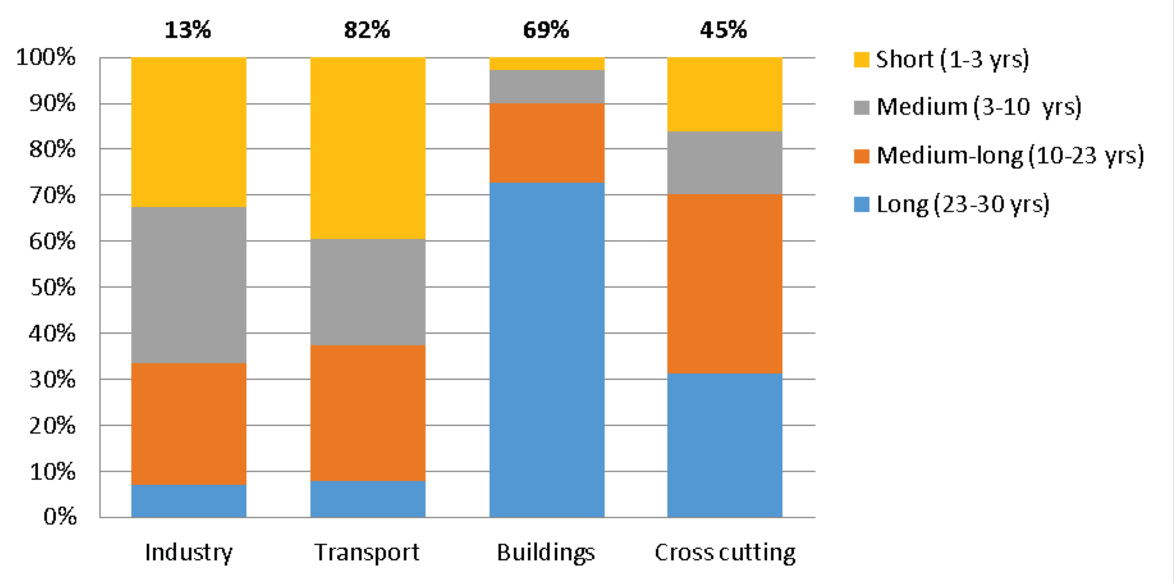


Source: Ricardo AEA/ CE Delft

[112] Detailed explanation of the methodology is provided in the Final Report on the Study evaluating implementation of Article 7 of the EED (chapter 3), Ricardo AEA/ CE Delft (2016).

[113] CEN, 2007: Saving lifetimes of energy efficiency improvement measures in bottom-up calculations, CWA 15693. [NB: CEN evaluates every three years whether the norm should be updated. This has happened twice since the publication in 2007. Both times, the outcome of the evaluation was that there was no need yet for an update of the lifetimes.]

Figure 48: Distribution of savings by lifetime categories per sector (% of savings with attributed lifetime categories to notified cumulative savings by 2020)



Source: Ricardo AEA/ CE Delft

The assumptions for the remaining 43% of the notified savings to the lifetime categories were made using the methodology described below.

In the absence of any more detailed information in the notifications, the relative contributions of the individual actions to the overall energy savings, and the associated lifetime of these energy savings, has been estimated based on the expert judgement by Ricardo AEA/ CE Delft. This took into account information that was available on sectors that were targeted by the measure (e.g. buildings, industry) and the types of actions that would be stimulated (e.g. technical measures, behavioural actions). However, in some cases there was limited evidence to make the judgement.

To help ensure a consistent approach when approximating the lifetime of the savings of each policy measure, a set of default factors was used to represent the different types of energy saving actions. This categorised different types of action, and then attributed typical lifetimes to each category. In estimating the energy savings it was therefore necessary to approximate the percentage of the energy savings that were expected to fall into each category. This approach is simplistic, but does ensure a degree of consistency in the assessment, and in the absence of precise data enables an approximation of the potential lifetimes associated with each of the individual policy measures.

The default lifetime categories were based on the detailed standardised lifetimes for energy efficiency actions provided by CEN. The CEN lifetimes were chosen since they provide the best available generally accepted overview of lifetimes of energy efficiency actions. They have been subject to an independent review by relevant experts and are impartial. Every three years, the CEN norms are evaluated on actuality. Some Member States have developed their own catalogue of savings and associated lifetimes which may be more applicable to their national circumstances, but may be less applicable to the circumstances in other Member States. In practice, lifetimes used by Member States are in most cases very similar to the CEN-lifetimes as they draw upon similar datasets (see).

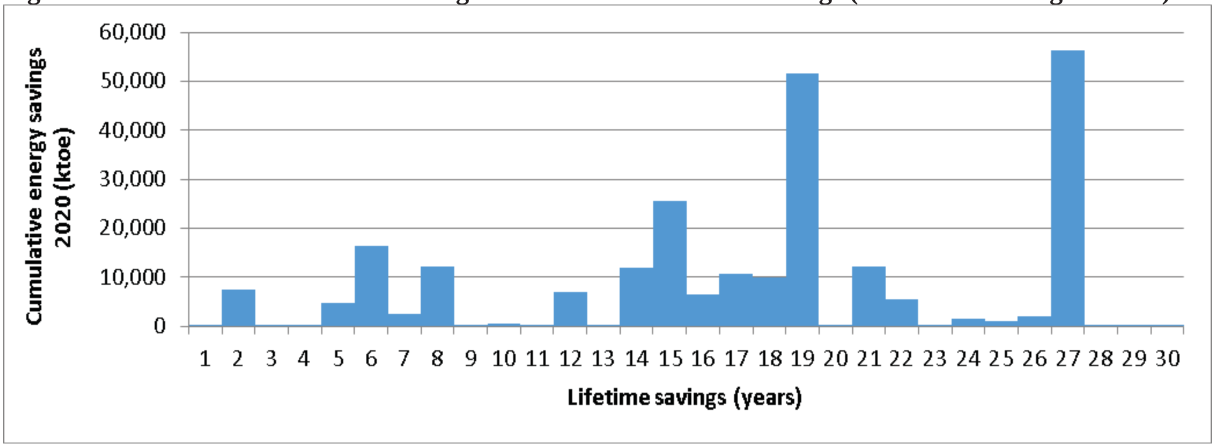
Table 22: Lifetime categories based on CEN-values

Lifetime category	Range (years)	Example	Lifetime used in the analyses (years)
Long lifetimes	23-30	e.g. Investments in building envelope	27
Medium long lifetimes	10-23	e.g. Investments in building installations	15
Medium lifetimes	3-10	e.g. Consumer electronics	5
Short lifetimes	1-3	e.g. Behavioural changes	2
Unclear	N/A	N/A	Average per policy measure category, based on attributed lifetime categories to the policy measures that were not 'unclear'

Source: Ricardo AEA/ CE Delft

CEN-values were used to ensure a uniform and harmonised approach in the assumptions made throughout the analysis. The assumptions for these remaining 43 % of the notified savings to the lifetime categories were made on the basis of CEN values.

Figure 49: Distribution of notified savings over the lifetimes of the savings (cumulative savings in 2020)

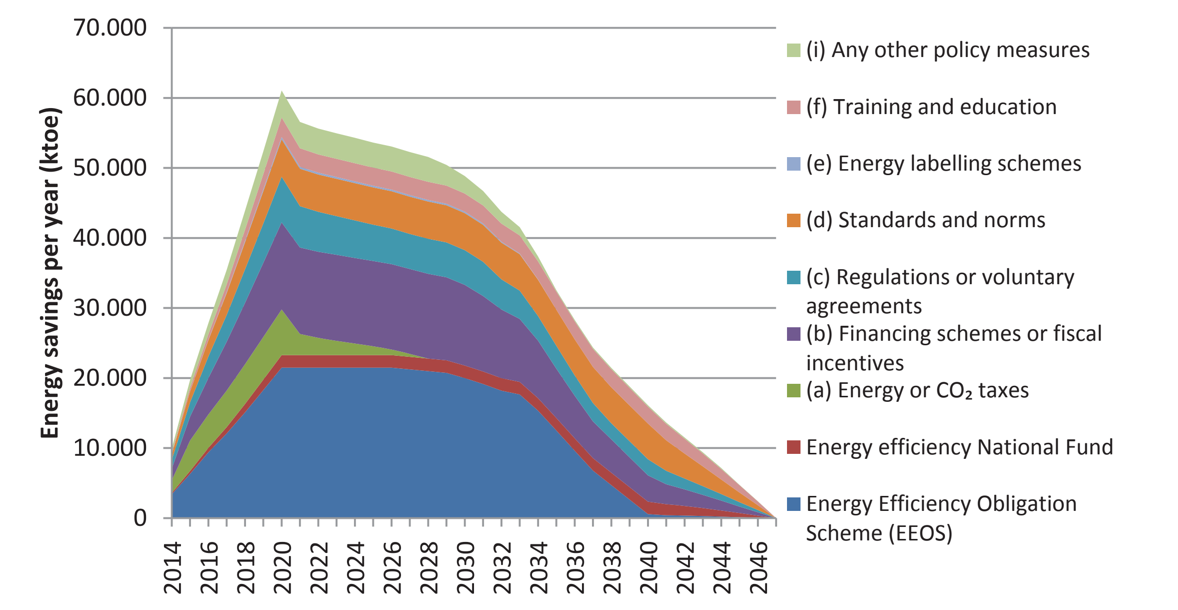


Source: Ricardo AEA/ CE Delft

The distribution of the savings over time was calculated therefore on the basis of the notified savings and their attributed lifetimes (see

Figure **50**).

Figure 50: Annual savings notified for the period 2014-2020 (per type of policy measure)[114]



Source: Ricardo AEA/ CE Delft

Results as presented in Figure **50** show that the policy measures notified for the period 2014-2020 will continue to deliver some savings even up to 2046. As shown in the same Figure **50**, the annual energy savings in year 2020 are estimated to reach 61 Mtoe. From 2020 onwards, the annual energy savings from Article 7 will decline, as without extension this policy will no longer provide stimulus for triggering 'new' savings per year (see Figure 51). According to the bottom-up engineering estimate some 49 Mtoe savings will continue to be delivered in 2030 as a result of the long term measures (e.g. renovation of buildings) introduced in the 2014-2020 period. As indicated in the section on impacts (5.4.1) of the main report, this engineering projection is optimistic, and is based purely on notified values and does not take into account a reality check.

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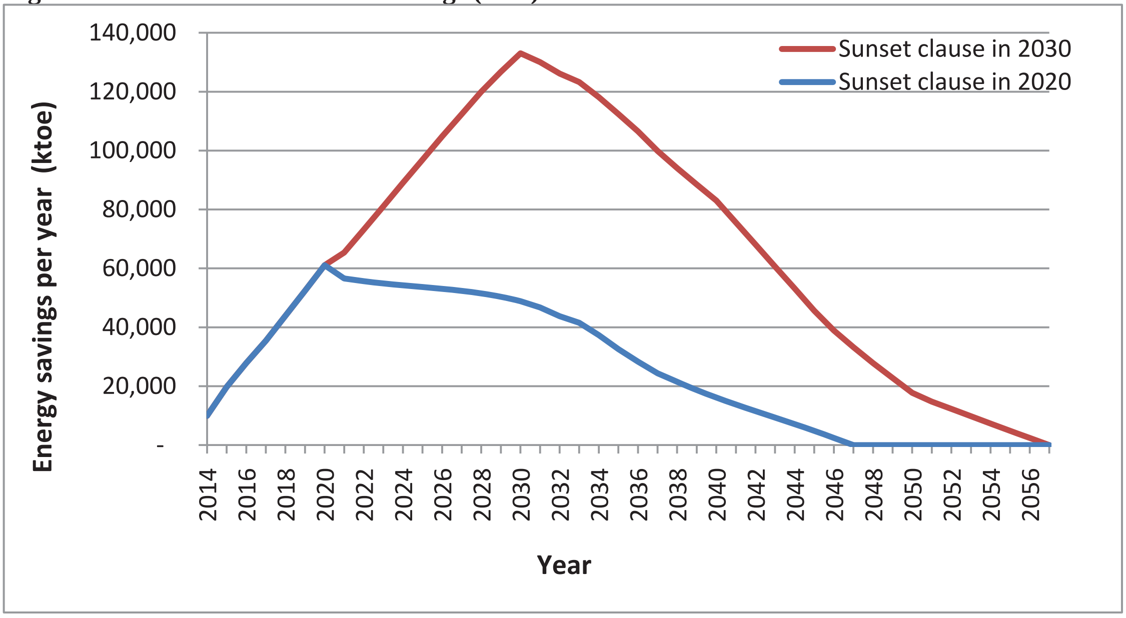
[114] Calculated on the basis of the baseline used for the 2014-2020 period (energy sales averaged over 2010-2012).

Figure 51: Estimated cumulative savings (ktoe) with and without extension of Article 7



Source: Ricardo AEA/ CE Delft

Calculation of the scenario with extended Article 7 to 2030

As described in the dedicated chapter on impacts for Article 7, the estimation of the amount of savings for the next period 2021-2030 was based on the same 1.5 % level of ambition, and considering also the maximum use of flexibilities (i.e. exclusion of energy sales in transport and exemptions up to 25 % limit under paragraph 2 and 3) currently allowed under Article 7.

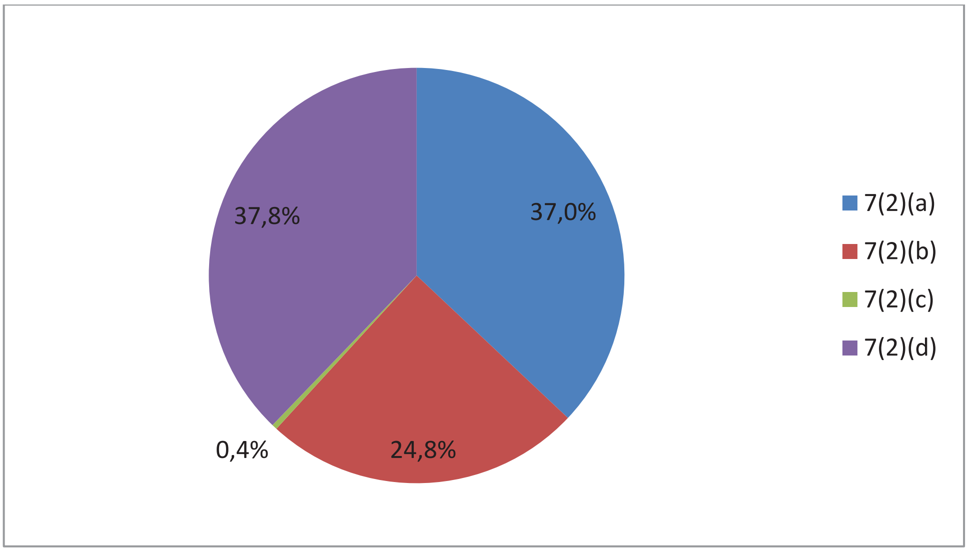
The effect depends on how the Member States will apply the flexibilities (i.e. excluding sales in transport) and exemptions under paragraph 2 which have a direct impact on the national savings contributions (see Annex 7) and were used by Member States in the current obligation period 2014-2020 as follows:

- **Self-generation** and **self-consumption** were excluded by 14 Member States (amounting to 46 Mtoe);
- Sales of energy in **transport** were excluded by 27 Member States (except for Sweden; the Netherlands and Bulgaria did not indicate the exact amount) which reduced the baseline by 332 Mtoe (from the total amount of energy sales of 1,101.5 Mtoe notified).
- **Exemptions under paragraph 2** of Article 7 such as (a) allowing lower rates in the beginning of the obligation period; (b) excluding sales to ETS industries; (c) allowing achieving certain savings from supply side option, and finally (d) allowing savings from early actions, resulted in almost full use of the maximum 25% reduction of the savings

requirement, since 24 Member States used the full 25% exemption provision (Denmark used 3%, and Sweden and Romania used 21%[115])..

As a result of the notified exemptions, the sum of the notified cumulative energy savings requirements decreased by 90 Mtoe (from 320 Mtoe[116] to 230 Mtoe). Exemption (a) ('slow start') was used the most, by 22 Member States amounting to 45 % of the total exemptions (33 Mtoe). As regards exemption (b) of energy sales to ETS industry, 15 Member States notified that they exclude energy use from industry under ETS from their target calculation for Article 7 amounting to about 22 Mtoe, or 24.8 % of the total exemptions (see Figure 52). Compared to the current 2020 cumulative target without exemptions, this amounts to 5 % reduction. For comparison, it is estimated that the share of energy consumption by industry covered by the ETS in the total final energy consumption in the EU-28 would amount to 16 % in 2020[117].

Figure 52: share of exemptions used by Member States under paragraph 2



Source: Ricardo AEA/ CE Delft

The share of exemption (c) allowing achieving savings in the supply side was 0.4 Mtoe (or 0.4 %) used only by 3 Member States. Early actions under exemption (d) amounted to 34 Mtoe (or 37.8 %) of all exemptions applied by 13 Member States using this possibility under paragraph 2.

As mentioned above, the effect of extending Article 7 to 2030 was calculated on the basis of 1.5 % annual savings rate, assuming that the total amount of cumulative savings that Member States will be required to achieve by 2030 will have the same distribution of energy savings actions (and therefore lifetimes) as in 2020. As a result, the expected new savings would amount to 81 Mtoe in year 2030 (with the maximum reductions applied) and in cumulative terms it would amount to 443 Mtoe for the whole period 2021-2030 (see Table 23). This is a

115 Updated figures on the basis of the information received through the structured dialogue with the Member States and in the Annual Reports 2016.
116 Amount of savings (before exemptions applied) - all figures are rounded up.
117 PRIMES (2016) reference scenario.

conservative estimate based on 2016 PRIMES reference scenario on how final energy consumption would evolve over the next years by 2020. In reality Member States might have higher reduction levels in final energy consumption which would thus result in lower amount of energy savings required by 2030.

Table 23: Calculation of the 1,5% savings requirement for the period 2021-2030 (ktoe)[118]

	2015	2020	Average 2015-2020	2030
Total final energy consumption	1,133,457	1,133,797	1,133,627	
Transport	360,838	353,833	357,336	
Self-generation for own use[119]	54,100	65,100	59,600	
Adjusted baseline (energy sales in transport and self-generation for own energy use excluded)	718,519	714,864	716,691	
Total amount of cumulative savings for the whole period				591,270
Exemptions with max 25% applied				147,818
Total cumulative savings for the whole period, max 25% cap applied				**443,453**
Annual savings in year 2030				**80,628**

Source: Ricardo AEA/CE Delft (2016)

In terms of annual distribution of the new energy savings for the period 2021-2030, these are depicted in Figure 53 on the assumption that each year 1.5% of new savings are achieved. In reality Member States are flexible how they phase the savings as long as the overall amount of the end use savings for the whole obligation period is achieved.

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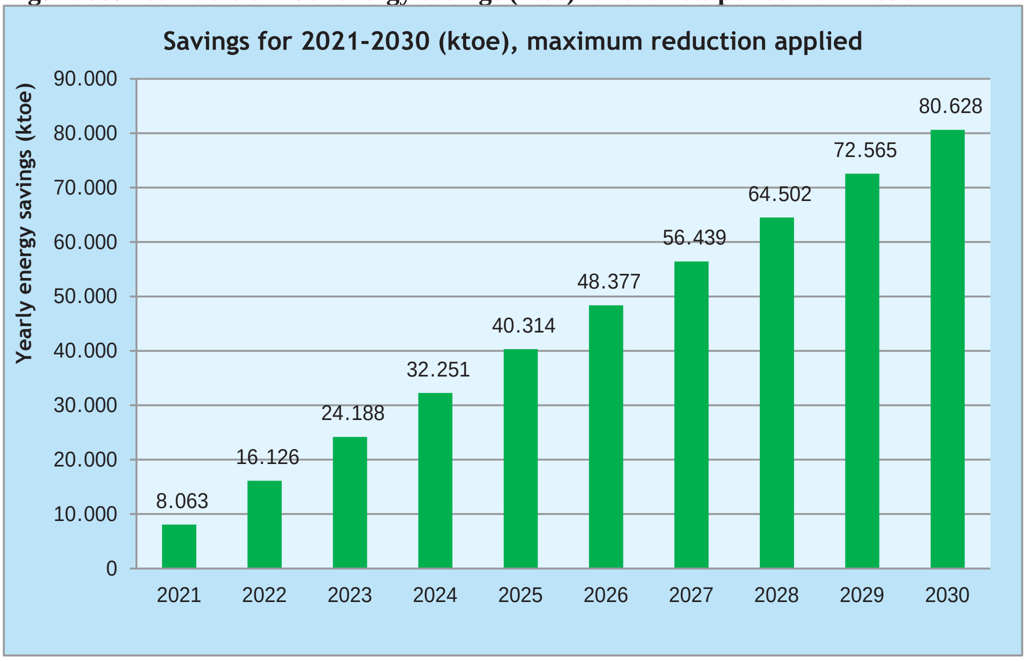
118 Calculation based on the final energy consumption averaged over 2015-2020 (2016 PRIMES reference scenario).

119 Estimation based on interim Results of the Study for Realisation of the 2016 Report on Renewable Energy, Öko-Institut (2016). This figure is indicative and the estimated baseline should be taken as a theoretical reference, as it might differ when the actual data on final consumption become available in view of the calculation the national savings requirements for 2021-2030 period.

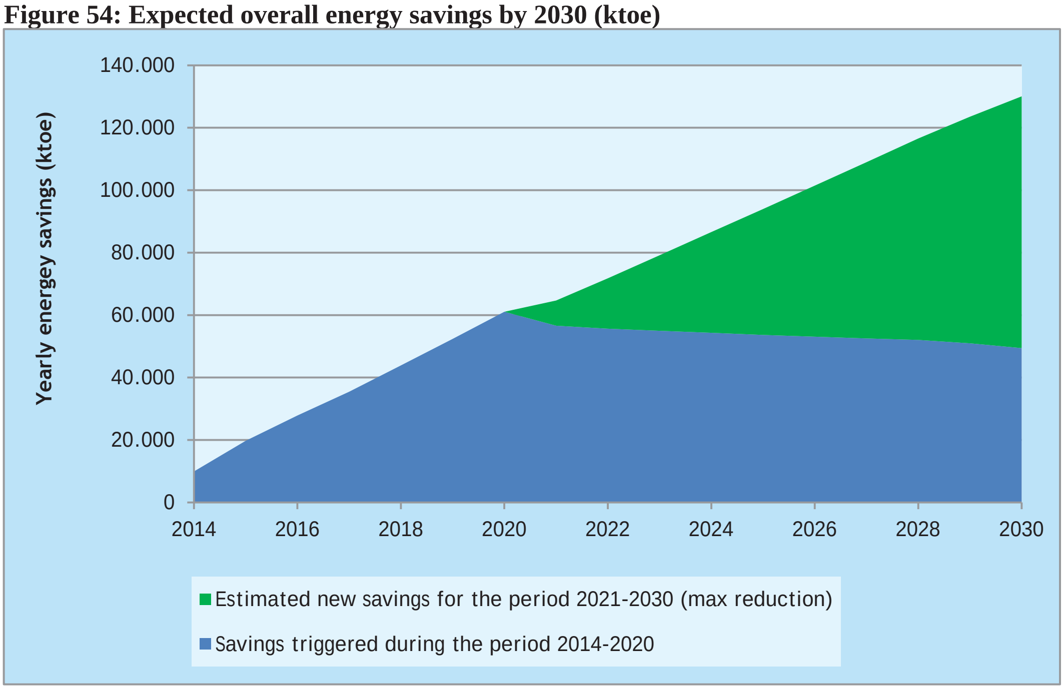
Figure 53: Estimated annual energy savings (ktoe) for the new period 2021-2030



Source: Ricardo AEA/CE Delft (2016)

It is important to recognise the long-term impact from certain measures with long lifetimes such as savings stemming from the renovation of buildings which will continue to have an effect also after 2020 in addition to the savings triggered by new policy measures or individual actions put in place to achieve the required savings requirement for the period 2021-2030. The overall impact of the energy savings generated under Article 7 is depicted in Figure 54.

Figure 54: Expected overall energy savings by 2030 (ktoe)



Source: Ricardo AEA/CE Delft (2016)

The Guidance note on Article 7[120] provides a step-by-step explanation how to calculate the overall amount of energy savings to be achieved by 2020 commitment period, which if retained at the same level of intensity, will apply in equivalent way up to 2030.

Member States first had to establish the baseline which equals the average of the annual **energy sales** by volume, to final consumers of all energy distributors or all retail energy sales companies over the three years before 1 January 2013 (i.e. 2010-2012). Energy sales in transport sector can be fully or partially excluded from the baseline. Energy volumes transformed on site and used for own-use and those that are used for the production of other energy forms for non-energy use are excluded.

The next step is to multiply by 1.5% the average final energy consumption (over 2010-2012) in order to obtain the "new" annual amount to be saved. In addition, under the concept of lifetimes in Annex V, part 2, point (e), each individual energy-saving action is considered to deliver savings not only in the year of implementation, but in also in future years up to 2020.

For this reason, the required amount of savings has to be 'cumulated' year-on-year (if not, one year's actions could be considered enough to fulfil the entire requirement). The overall amount to be reached over the whole new period is therefore a sum of the following cumulative percentages: 2021 – 1.5%; 2022 – 3%; 2023 – 4.5%; 2024 – 6%; 2025 – 7.5%; 2026– 9%; 2027 – 10.5%; 2028 – 12%; 2029 – 13.5% and 2030 – 15%. For example, if the total amount of energy sales (averaged over 3 year period) is 100 Mtoe, then this implies that the total cumulative amount of energy savings required over the whole ten-year period would be 82,5 Mtoe (see table below).

Table 24: Total cumulative amount of energy savings required 2021-2030

Year	Energy savings [Mtoe]										Total
2021	1.5										1.5
2022	1.5	1.5									3.0
2023	1.5	1.5	1.5								4.5
2024	1.5	1.5	1.5	1.5							6.0
2025	1.5	1.5	1.5	1.5	1.5						7.5
2026	1.5	1.5	1.5	1.5	1.5	1.5					9.0
2027	1.5	1.5	1.5	1.5	1.5	1.5	1.5				10.5
2028	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5			12.0
2029	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5		13.5
2030	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	15.0
Total:											**82.5**

Section B4 of the Guidance on Article 7 provides a detailed description on how each of allowed four exemptions under paragraph 2 subject to paragraph 3 can be applied once the total amount of savings to be achieved has been established.

[120] SWD(2013) 451 final (section B2, page 5).

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COMMISSION

Brussels, 30.11.2016
SWD(2016) 405 final

PART 3/3

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the document

Proposal for a Directive of the European Parliament and of the Council amending Directive 2012/27/EU on Energy Efficiency

{COM(2016) 761 final}
{SWD(2016) 406 final}

EN EN

6.2 Analytical approach for Articles 9-11

For Articles 9-11, no formal analytical models were used in the assessment of impacts.

The quantitative **estimates of the potential** for energy savings from implementation of the existing EED provisions on sub-metering of heating in multi-flat buildings were produced using an ad-hoc bottom-up/engineering spreadsheet-based model created by consultants Empirica under a specific contract. The methodology is outlined below.

As regards the **estimate of each option's contribution to realising this potential**, and the additional potential represented by enhanced consumption feedback, these were also based on a simple bottom-up approach set out in the main report.

There is strong evidence that introducing heat meters and heat cost allocators, to provide A) consumption-based cost allocation (i.e. "pay in relation to your actual/own consumption") and B) consumption information services (e.g. more frequent, informative billing information), leads to more careful use of energy by building occupants, and that this behaviour change results in significant energy savings. Multiple studies provide evidence of the percentage energy savings triggered, however, it is now known that the percentage resulting from the same change in user behaviour is not constant but varies with building quality. A model recently developed for Germany[121] applies key building characteristics to convert between percentages and behaviour effects. Extension of this energy saving conversion model for application to the EU-28 requires the following data set:

1) Building characteristics:
   a) Building performance (i.e. building envelope) and user control (over settings, windows)
   b) Climate at the location of the building (e.g. heating degree days)
2) Behavioral effects:
   a) Average reduction in internal temperature through care in temperature settings
   b) Average reduction in air changes per hour (ACH) through more careful ventilation (e.g. with regard to how windows are used)

Evidence of behavioural effects

Evidence of the behavioural effects is derived from savings shown in multiple studies followed by application of the energy saving conversion model. Existing evidence[122] collected in several studies (some of which are shown in the figure below, is that, in older buildings, the energy savings achieved by the introduction of consumption-based cost allocation amounts to around **20%** of actual final consumption.

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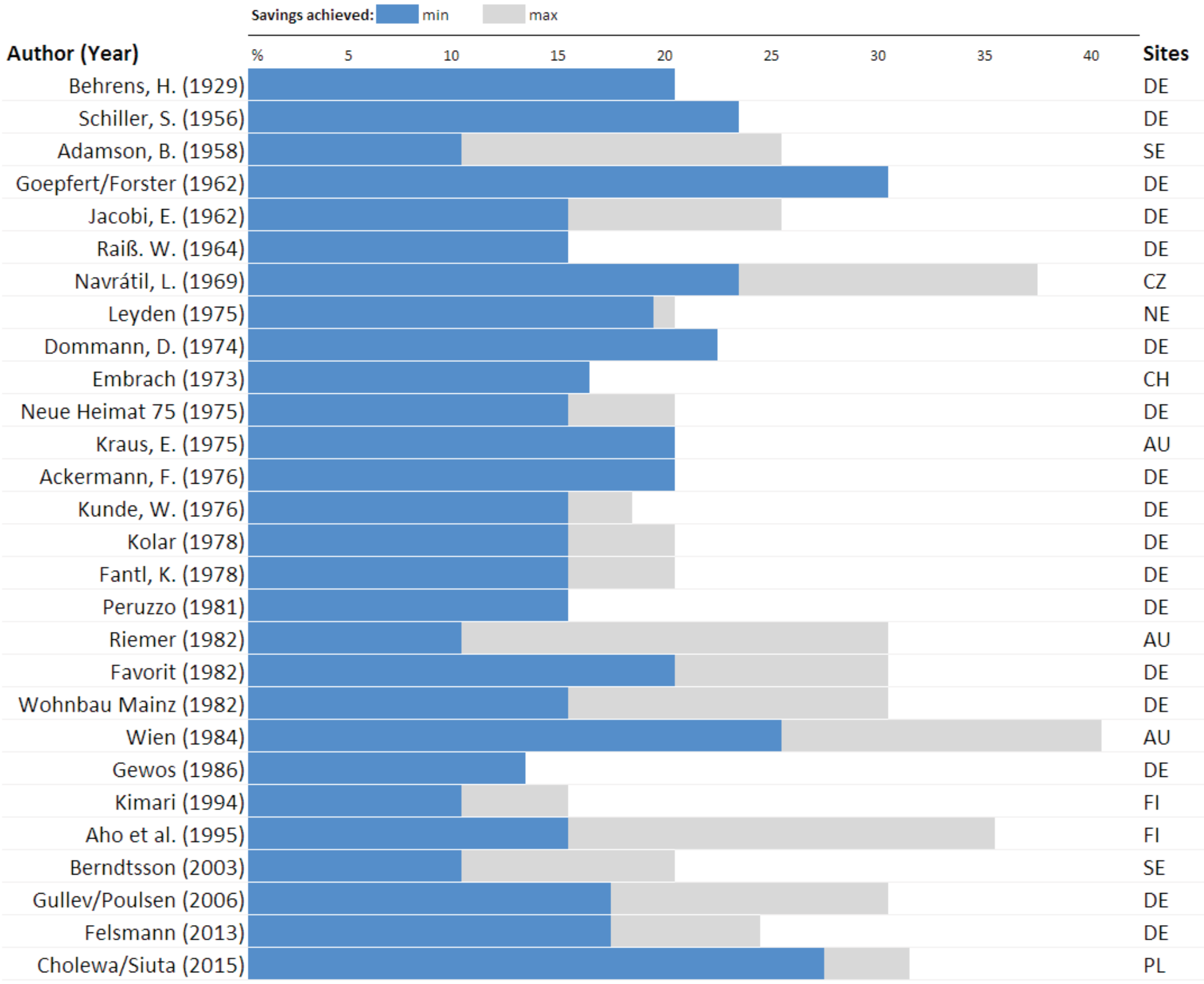
121 Bert Oschatz: Heating Cost Allocation Cost Efficiency Assessed for Buildings in Germany, Berlin 2015.

122 Cf. empirica (2016) Guidelines on good practice in cost-effective cost allocation and billing of individual consumption of heating, cooling and domestic hot water in multi-apartment and multi-purpose buildings, Available at https://ec.europa.eu/energy/sites/ener/files/documents/MBIC_Guidelines20160530D.pdf.

Figure 1: Literature review: energy savings through heat sub-metering (in %)



Source: Empirica literature review

Based on a set of studies in buildings of known performance characteristics and in known climate locations, also showing 20% savings, and assuming neither behavioural effect is dominant (50-50 split), the following behavioural effects can be shown for the introduction of consumption-based cost allocation:

- Temperature reduction by 1.1 Kelvin
- Ventilation reduction by 0.25 per h (ACH)

Additional savings are achieved through changes in user behaviour by introducing consumption information service. Over many studies the median estimate for the additional savings triggered by a variety of such services amount to some **3%.** Reusing the results of the energy saving conversion model for consumption-based cost allocation, the following additional behavioural effects can be shown for the introduction of consumption information services**::**

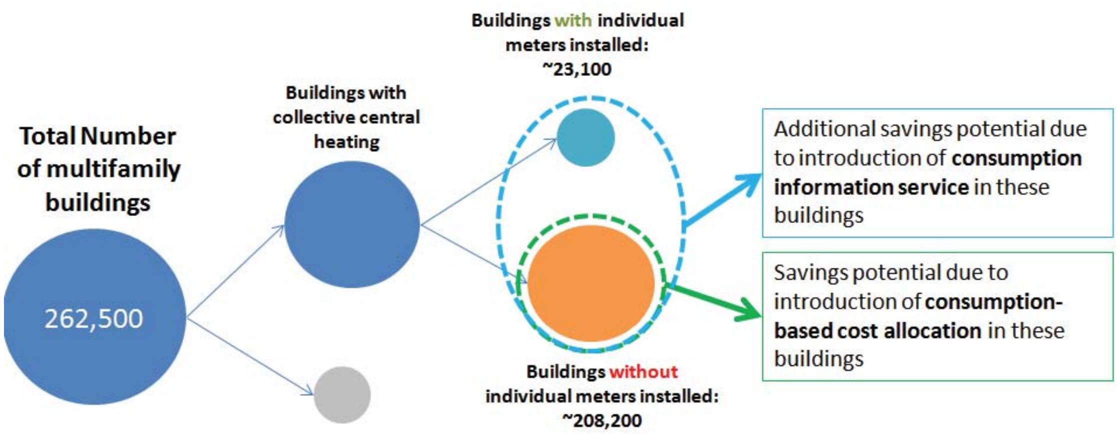
- Temperature: 1.1 * 3%/20% = 0.165 Kelvin
- Ventilation: 0.25 * 3%/20% = 0.0375 per h

Based on figures for hot water consumption researched in the UK (DEFRA/energy saving trust[123]), and on an analysis of 13 studies by Sønderlund et al.[124], the 20% saving for consumption-based cost allocation is applied to a baseline consumption of hot tap water of 46 and 26 litres per day, per dwelling and per person respectively (total dwelling consumption = 46 + 26*N litres / day)[125]. An additional 3% savings are achieved by introducing consumption information services. Household size is based on the most recent data available on eurostat[126]. Delivery temperature is assumed to be 60°C following health recommendations[127].

Building stock - multi-unit buildings

The energy saving potential from EED metering and billing provisions in EU-28 depends on the building stock to benefit from the measures, that is, on the characteristics of existing buildings and their location. The building stock relevant here is the stock of multi-unit buildings not already being provided with consumption-based cost allocation (or consumption information services, respectively). The calculation of the relevant numbers in a Member State is illustrated in the figure below (with data for the UK):

Figure 2: Illustration of methodology for calculating potential energy saving (in this case for the UK)



Source: empirica calculations based on data from BPIE and estimates from JRC and EVVE

Using statistics available for all the EU-28 (see figures below), the existing residential building stock in a country is reduced to that proportion which falls under the provisions of the EED Article 9(3) and is not already provided with consumption-based cost allocation. These are the buildings able to benefit from the introduction of consumption based cost allocation.

This assessment is conservative in that commercial multi-purpose buildings are not included due to lack of data.

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123 DEFRA(2008) Measurement of Domestic Hot Water Consumption in Dwellings

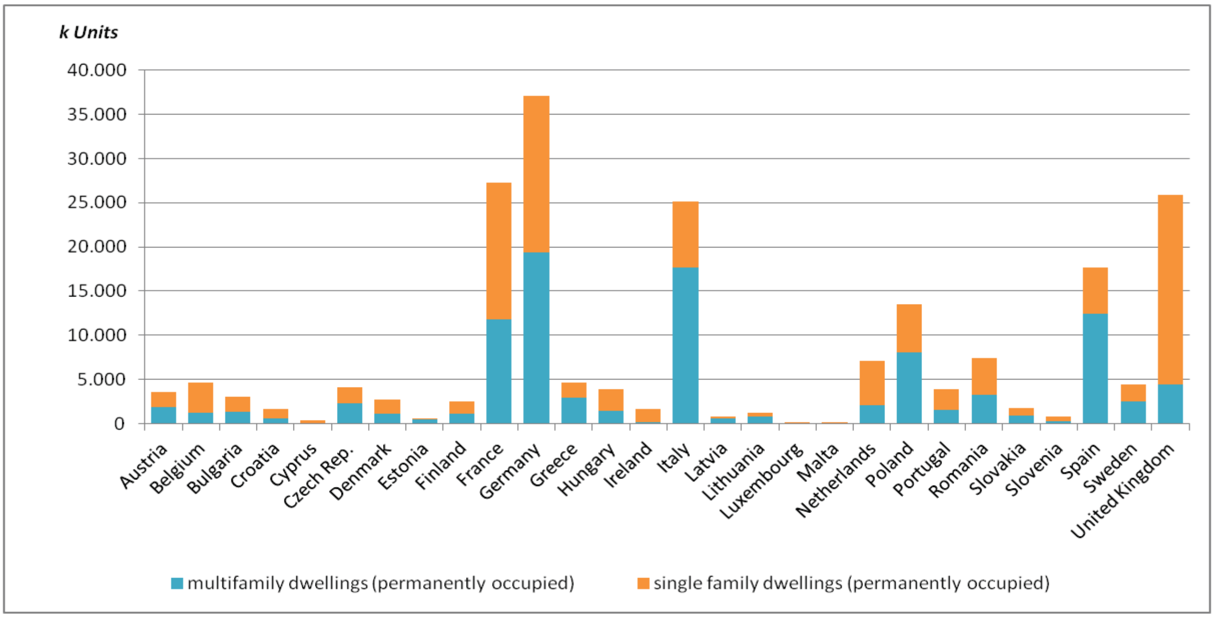
124 Sønderlund, A.L., Smith, J.R., Hutton, C., Kapelan, Z. (2014) Using Smart Meters for Household Water Consumption Feedback: Knowns and Unknowns, Procedia Engineering 89, 990-997.

125 Member state specific values on individual daily consumption were used for Denmark (18.1l), Finland (23.8l) and Sweden (49.3l)

126 Eurostat (2015) Average household size - EU-SILC survey [ilc_lvph01]

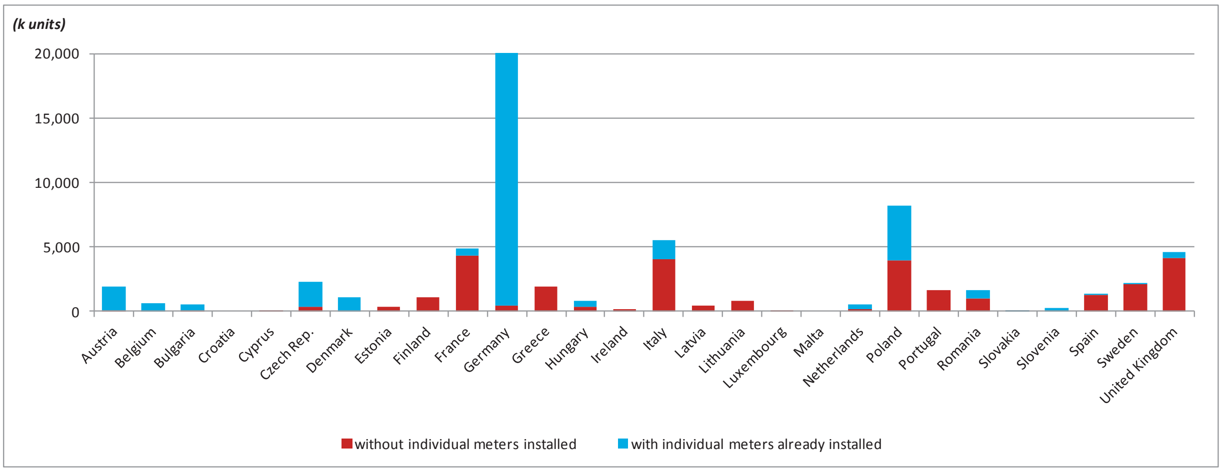
127 WHO (2007) LEGIONELLA and the prevention of legionellosis

Figure 3: Composition of residential building stock per country



*Source: Odyssee (*BG; CY; CZ; IT; LV; LT; LU; PL – estimates based on entranze dataset)*

Figure 4: Stock of dwellings in multi-apartment buildings with collective central heating systems



Source: Empirica calculations based on JRC and EVVE estimates and ODYSSEE data

Building performance and climate

The impact of EED related sub-metering measures on different buildings in Europe vary with climate and insulation quality. These are taken into account in the energy saving conversion model. Climate is accounted for using existing statistics of degree days and production days. Differences in the quality of insulation of the elements of the building envelope - outside walls, windows and roof - are reflected in the heat transfer coefficient (U, in W/m²•K) of each element.

Recent statistics on average U values for the main building elements, coupled with transparent assumptions of the relative area of the different elements in an average building, yield the average value of the heat transfer coefficient of building stock in each Member State (see table below).

Table 1: U-values (weighted average based on stock)

Regions	Countries	WALL (30%)	WINDOW (20%)	FLOOR (25%)	ROOF (25%)	u-value
Southern Dry	Portugal	1.31	4.07	1.97	2.48	**2.32**
	Spain	1.76	4.61	1.74	1.15	**2.17**
Mediterranean	Cyprus	1.20	2.97	0.00	1.47	**1.32**
	Greece	1.34	3.77	2.29	1.96	**2.22**
	Italy	1.47	4.98	1.68	1.76	**2.30**
	Malta	1.61	5.80	2.44	1.87	**2.72**
Southern Continental	Bulgaria	1.42	2.49	0.95	1.14	**1.45**
	France	1.77	3.67	1.43	1.78	**2.07**
	Slovenia	1.20	2.09	0.95	0.94	**1.25**
Oceanic	Belgium	1.73	4.17	0.95	1.99	**2.09**
	Ireland	1.38	3.99	1.12	0.73	**1.67**
	United Kingc	1.40	4.40	1.41	1.42	**2.01**
Continental	Austria	1.00	2.62	1.21	0.61	**1.28**
	Czech Rep.	0.90	2.87	1.00	0.74	**1.28**
	Germany	0.96	2.92	1.04	0.98	**1.37**
	Hungary	1.34	2.45	0.93	0.96	**1.36**
	Luxembourg	1.27	3.03	1.00	0.00	**1.24**
	Netherlands	1.30	3.26	1.40	1.29	**1.72**
Northern Continental	Denmark	0.75	2.50	0.57	0.34	**0.95**
	Lithuania	0.79	2.03	0.83	0.67	**1.02**
	Poland	1.11	3.05	1.23	0.62	**1.41**
	Romania	1.57	2.44	1.29	1.23	**1.59**
	Slovakia	1.04	3.28	1.61	1.09	**1.64**
Nordic	Estonia	0.38	1.50	0.40	0.38	**0.61**
	Finland	0.43	1.92	0.40	0.26	**0.68**
	Latvia	0.95	2.54	0.78	1.05	**1.25**
	Sweden	0.35	2.79	0.20	0.32	**0.79**

Source: empirica calculations based on data from iNSPiRe (2014)[128]

Results – EU wide potential

The estimated impact/potential in each of the EU-28 Member States (MS) is given by applying the energy saving conversion model to the two behavioural effects (ventilation and temperature) for the relevant building stock in each MS. For each MS the thermal transfer coefficient is taken from Table 1 and weighted averages across the country's climate are used for degree days and production days.

Total outstanding annual savings in EU-28 due to full implementation of EED provisions on **consumption based cost allocation** is estimated at around **13.46 Mtoe** in final energy consumption terms.

Table 2: Estimated savings potential from full/"perfect" implementation of current EED provisions on cost allocation and information for space heating and hot water in multi-family buildings

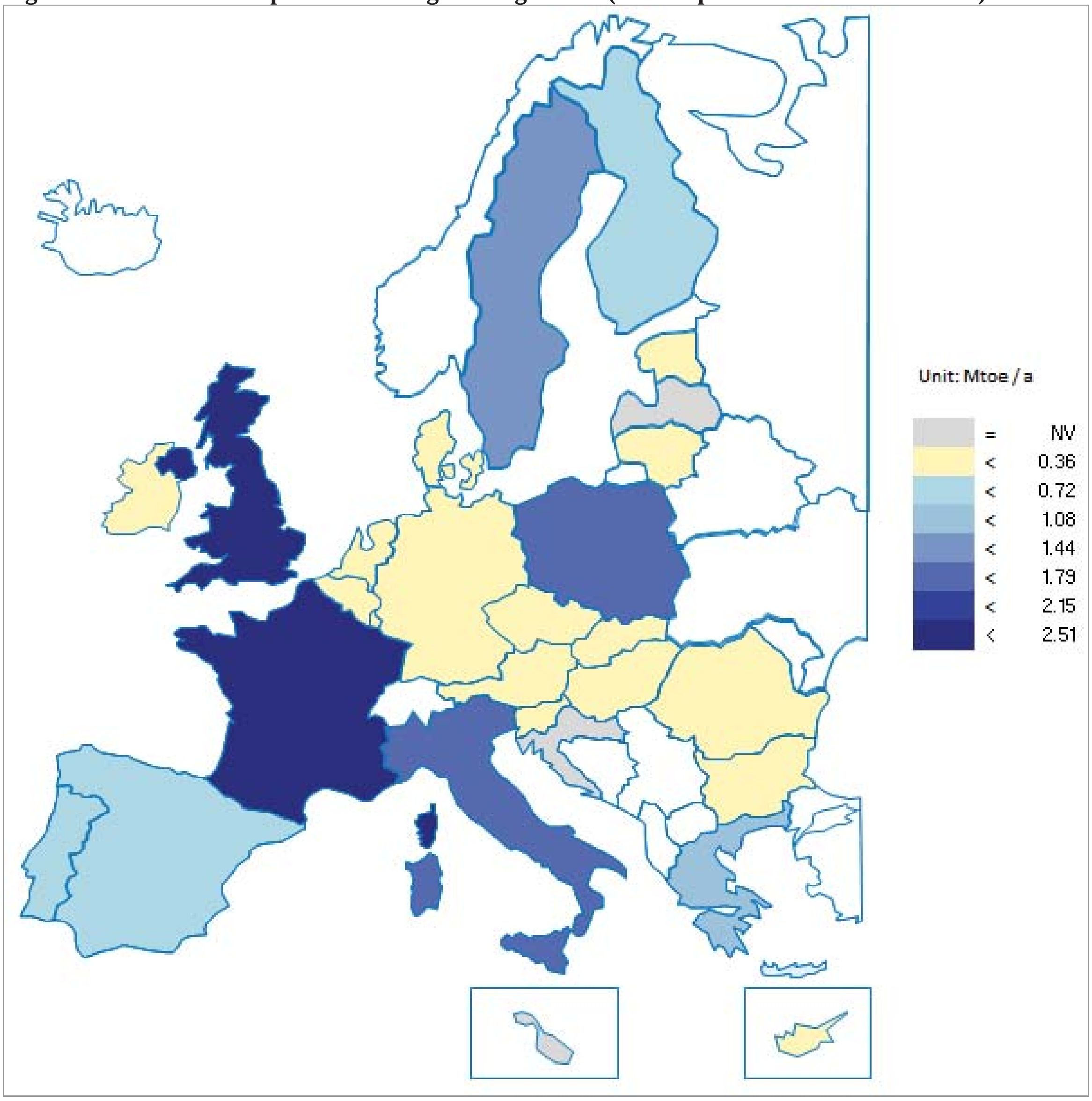
Measure	Mtoe
Space heating: Consumption based cost allocation	12.06
Space heating: Consumption information services	4.00
Hot water: Consumption based cost allocation	1.38
Hot water: Consumption information services	0.44
Total	**17.88**

Source: empirica estimations based on Guidelines for good practice[129]

128 iNSPiRe (2014) Survey on the energy needs and architectural features of the EU building stock

The total outstanding annual savings potential in EU-28 due to implementation of EED provisions on **consumption information services** is estimated at around **4.4 Mtoe** with the existing building stock.

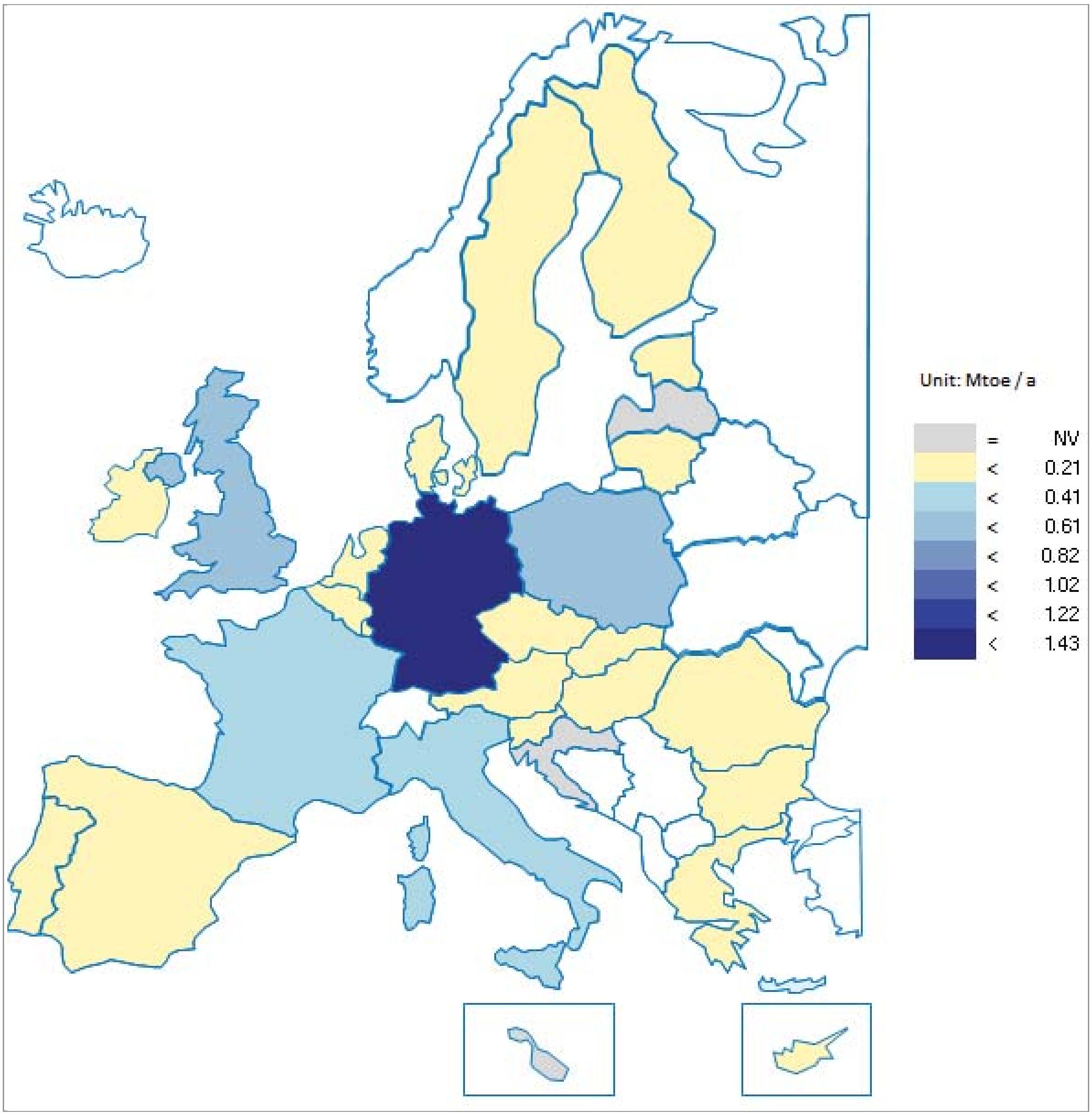
Figure 5: Distribution of potential savings among EU-28 (consumption based cost allocation)



Source:empirica estimates (2016)

129 empirica (2016) Guidelines on good practice in cost-effective cost allocation and billing of individual consumption of heating, cooling and domestic hot water in multi-apartment and multi-purpose buildings, Available at https://ec.europa.eu/energy/sites/ener/files/documents/MBIC_Guidelines20160530D.pdf

Figure 6: Distribution of potential savings among EU-28 (consumption information services)



Source: empirica estimates (2016)

7 Annex – Tables and figures on Article 7[130]

Table 3: Notified baselines for the calculation of the national savings requirements for period 2014-2020

Member State	Final energy consumption (ktoe)	Adjusted baseline (ktoe)*	Transport excluded (ktoe)	Energy production for own use and non-energy use, if excluded (ktoe)
Austria	26,570	16,508	8,565	1,497
Belgium	30,171	21,940	8,231	Yes (not specified for all regions)
Bulgaria	9,116	6,167	2,956	-
Croatia	6,151	4,113	2,037	-
Cyprus	1,863	767	1,023	73
Czech Republic	26,228	14,491	5,864	3,219
Denmark	15,086	9,833	4,973	277
Estonia	2,872	1,938	787	146
Finland	25,534	13,373	4,939	7,222
France	153,850	99,567	49,380	4,903
Germany	215,845	133,324	61,192	21,329
Greece	18,335	10,580	7,328	427
Hungary	15,859	11,681	4,172	5
Ireland	11,295	6,873	4,422	-
Italy	121,961	80,960	41,001	-
Latvia	3,970	2,702	1,109	159
Lithuania	4,768***	3,188	1,556	-
Luxembourg	4,267	1,636	2,631	-
Malta	451	179	272	-
Netherlands	37,045	36,591	Yes (not specified)	454
Poland	64,610	47,040	17,570	-
Portugal	17,571	8,039	6,903	2,629
Romania	22,722	17,415	5,307	-
Slovakia	9,466	7,252	2,214	-
Slovenia	4,974	2,999	1,911	64
Spain	85,965	50,727	35,239	-
Sweden	Not provided	27,438	-	Yes (not specified)
UK	142,132	88,392	53,740	-
Total	**1,078,676****	**725,715**	**335,322****	**42,404****

Source: Ricardo AEA/ CE Delft

* *Adjusted means the value after subtracting 'energy use by transport' and 'generation for own use', where relevant*
** *Not specified by all Member States.*
*** *New final energy consumption for years 2010-2012 as 4768 ktoe notified without changes to the savings requirement.*

[130] This Annex contain the updated information per Member State (for the existing period 2014-2020) obtained trhough the structured dialogue with Member States and updates reported by Member States through the annual reports 2016.

Table 4: Notified sum of expected cumulative energy savings (and share by EEOS) by 2020, perMember State[131]

Member State	Notified target (ktoe)	Notified sum of expected savings (ktoe)	Percentage to be delivered by EEOS (%)
Austria	5,200	9,145	42%
Belgium	6,911	7,268	
Bulgaria	1,942	1,943	100%
Croatia	1,296	1,295	41%
Cyprus	242	243	
Czech Republic	4,841	5,186	
Denmark	3,841*	7,355*	100%
Estonia	610	611	5%
Finland	4,213	7,531	
France	31,384	31,131	87%
Germany	41,989	45,302	
Greece	3,333	3,333	Not provided
Hungary	3,680	3,689	
Ireland	2,164	2,243	48%
Italy	25,502	25,800	62%
Latvia	851	851	65%
Lithuania	1,004	699	
Luxembourg	515	515	100%
Malta	56	67	14%
Netherlands	11,512	11,270	
Poland	14,818	14,818 ***	100%
Portugal	2,532	2,532	
Romania	5,817	5,863	
Slovakia	2,284	2,288	
Slovenia	945	945	33%
Spain	15,979	14,361**	44%
Sweden	9,114	11,505	
UK	27,859	34,041	24%
Total	**230,434**	**251,830**	**35%**

Source: Ricardo AEA/ CE Delft

** Denmark's notified the energy savings target is 4,130 ktoe, this however includes savings in energy transformation, distribution and transmission sectors. Savings in these sectors accounted for 6% of the total reported savings in 2012, in 2013 for 5% and in 2014 for 7%. A reduction of 7% has been applied for the purposes of this report and the energy savings target and expected savings have been reduced accordingly.*
*** Excludes 1,619 ktoe of savings notified by Spain in related taxation measures, as these arise in 2013, so cannot count towards the 2014 - 2020 saving period.*
**** The expected amount of savings is the same as the target, as only annual savings for 2016 and 2020 were notified by Poland.*

131 The total amount of expected energy savings contain also the savings achieved under exemptions (c) and (d) of Article 7(2) for the relevant Member using these exemptions.

Table 5: Overview of policy measures per Member State (period 2014-2020)[132]

	Energy efficicncy obligation scheme	Energy Efficiency National Fund	(a) Energy or CO_2 taxes	(b) Financing schemes or fiscal incentives (including grants)	(c) Regulations or voluntary agreements	(d) Standards and norms mandatory and applicable in MS under EU law	(e) Energy labelling schemes	(f) Training and education in reducing end-use energy consumption	i) Any other policy measures, and/or category not clear	Total number of policy measures
Austria	1		1	4	1	1			1	9
Belgium		1		12	4	3			1	21
Bulgaria	1									1
Croatia	1			10						11
Cyprus				3					2	5
Czech Republic				23						23
Denmark	1									1
Estonia	1		1	1						3
Finland			1	1	2	1			3	8
France	1			1				1		3
Germany[133]		1	1	20	3		1	13	67	106
Greece	1			15	1	1		1		19
Hungary				29	1			4		19
Ireland	1			2		4		3		10
Italy	1			2						3
Latvia	1			4	1				1	7
Lithuania			1	4	1				2	8
Luxembourg	1									1
Malta	1*			14	19					34
Netherlands									31	31
Poland	1									1
Portugal		1		1	1				2	5
Romania				20	1			2	6	28
Slovakia[134]								7	59	66
Slovenia	1	1								2
Spain	1		1	10				2	1	15
Sweden			1							1
UK	3**		1	4	6	3			3	20
Total [number of measures]	**18**	**4**	**8**	**180**	**41**	**13**	**1**	**33**	**179**	**477**
Total [number of MS]	**16**	**4**	**8**	**20**	**12**	**6**	**1**	**8**	**13**	**28**

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132 These measures were notified by Member States and are subject to possible changes. Notified EEOSs do not necessary mean that they are all operational , -four Member States are still to put in place the scheme.

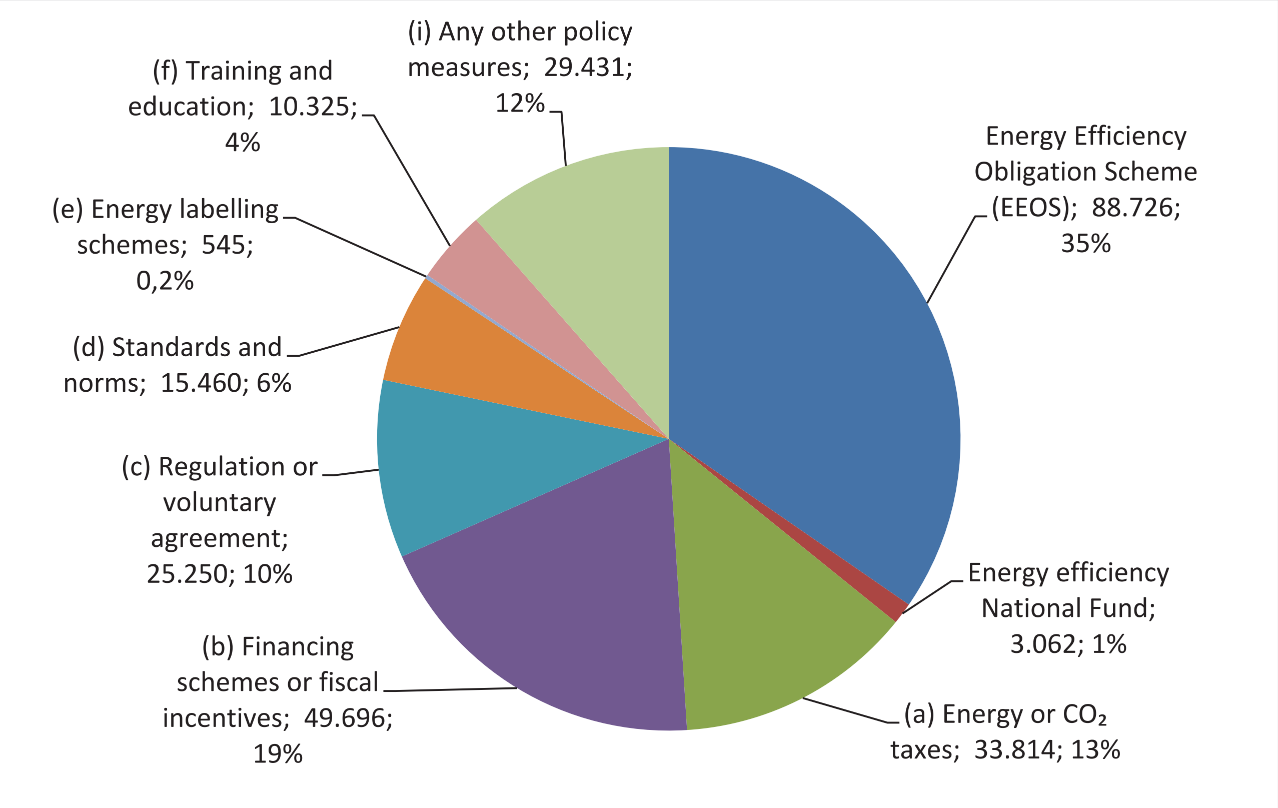
133 Germany notified 65 policy measures that are implemented by the German States (Länder).

134 Slovakia provided savings per group of policy measures, targeted to a specific sector; not savings per individual policy measure.

Source: Ricardo AEA/ CE Delft

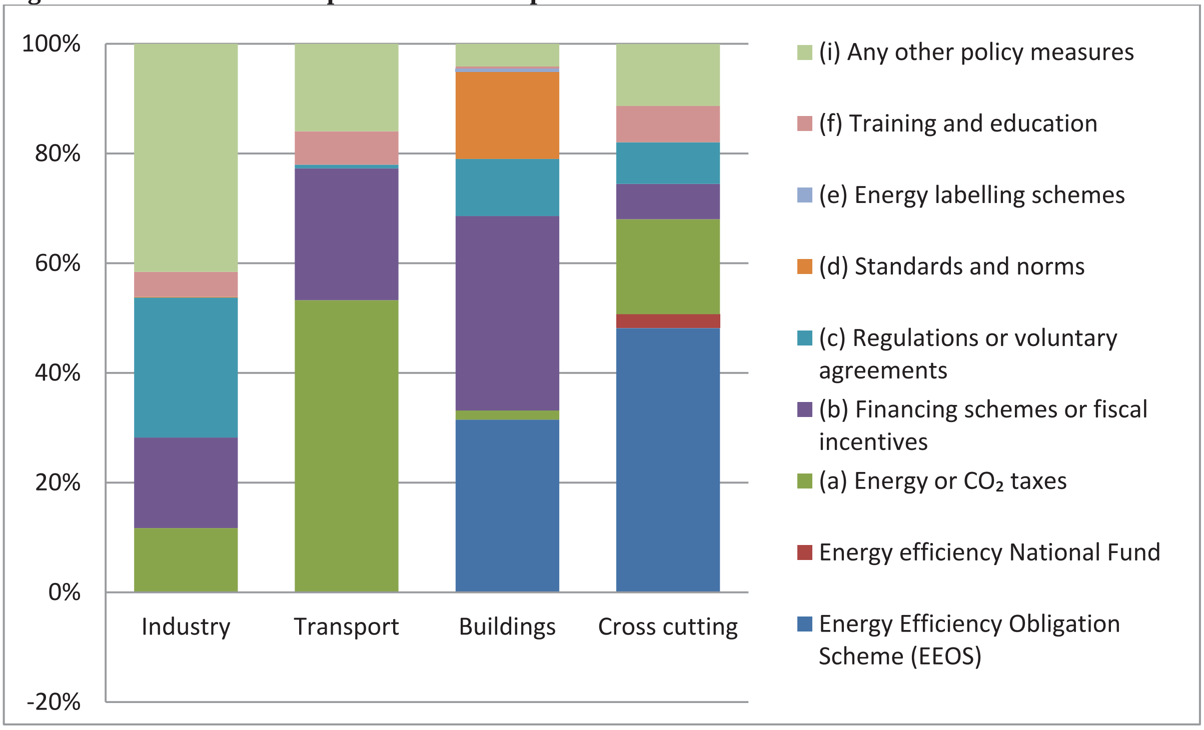
** Malta notified 4 measures labelled as EEOS (which are individually included in the total of 35 measures for Malta). In practice these are four separate measures that form part of a single EEO scheme, and thus represents just one policy measure. This is recorded as a single EEOS, but as 4 measures in the total column.*
*** The UK notified three EEOS. Two of the schemes ran from 2010-2012 and are now expired, so only one scheme is planned to be operational for the 2014 to 2020 commitment period.*

Figure 7: Breakdown of expected energy savings by type of policy measure (ktoe)



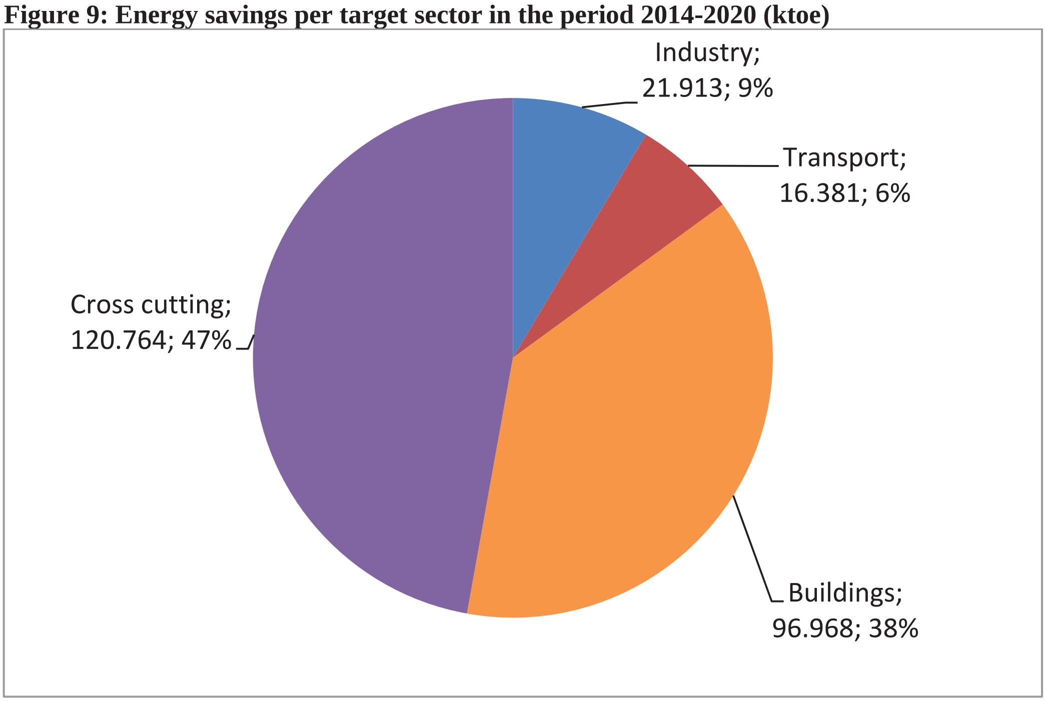
Source: Ricardo AEA/ CE Delft

Figure 8: Notified measures per sector for the period 2014-2020



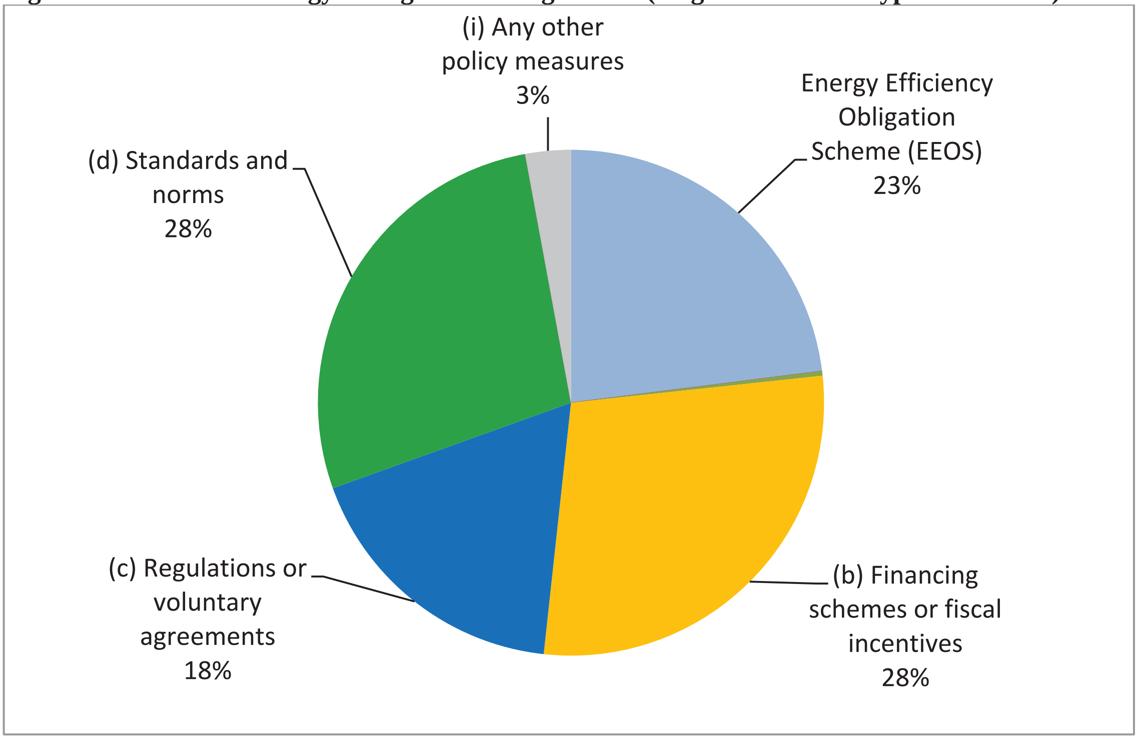
Source: Ricardo AEA/ CE Delft

Figure 9: Energy savings per target sector in the period 2014-2020 (ktoe)



Source: Ricardo AEA/ CE Delft

Figure 10: Division of energy savings in buildings sector (long lifetimes over type of measure)



Source: Ricardo AEA/ CE Delft

Table 6: Application of exemptions under paragraph, per Member State for period 2014-2020

Member State	% exemptions used	Sum of exemptions used (ktoe)	Calculated effect per exemption (ktoe)			
			slow start 7(2)(a)	**ETS Industry** 7(2)(b)	**supply side** 7(2)(c)	**early actions** 7(2)(d)
Austria	25%	1,733	-	-	-	1,733
Belgium	25%	Yes (not specified)	Yes (not specified)	Yes (not specified)	-	Yes (not specified)
Bulgaria	25%	648	540	-	-	108
Croatia	25%	431	359	72	-	-
Cyprus	25%	81	41	40	-	-
Czech Republic	25%	1,604	1,268	-	-	336
Denmark	7%*	289	-	-	289	-
Estonia	25%	204	170	25	-	9
Finland	25%	1,404	-	-	-	1,404
France	25%	27,750	-	14,500	-	13,250
Germany	25%	13,996	-	-	-	13,996
Greece	25%	1,111	554	557	-	-
Hungary	25%	1,226	1,022	204	-	-
Ireland	25%	721	601	120	-	-
Italy	25%	8,501	7,083	-	-	1,418
Latvia	25%	283	236	47	-	-
Lithuania	25%	335	279	-	28	28
Luxembourg	25%	172	143	29	-	-
Malta	25%	19	16	-	-	3
Netherlands	25%	3,794	3,187	607	-	-
Poland	25%	4,939	-	3,439	-	1,500
Portugal	25%	844	703	141	-	-
Romania	21%	1,531	1,531	-	-	-
Slovakia	25%	761	635	-	-	126
Slovenia	25%	314	262	-	52	-
Spain	25%	5,326	4,438	888	-	-
Sweden	21%	2,408	2,408	-	-	-
UK	25%	9,286	7,739	1,548	-	-
Total		**89,711**	**33,215**	**22,217**	**369**	**33,911**

Source: Ricardo AEA/ CE Delft

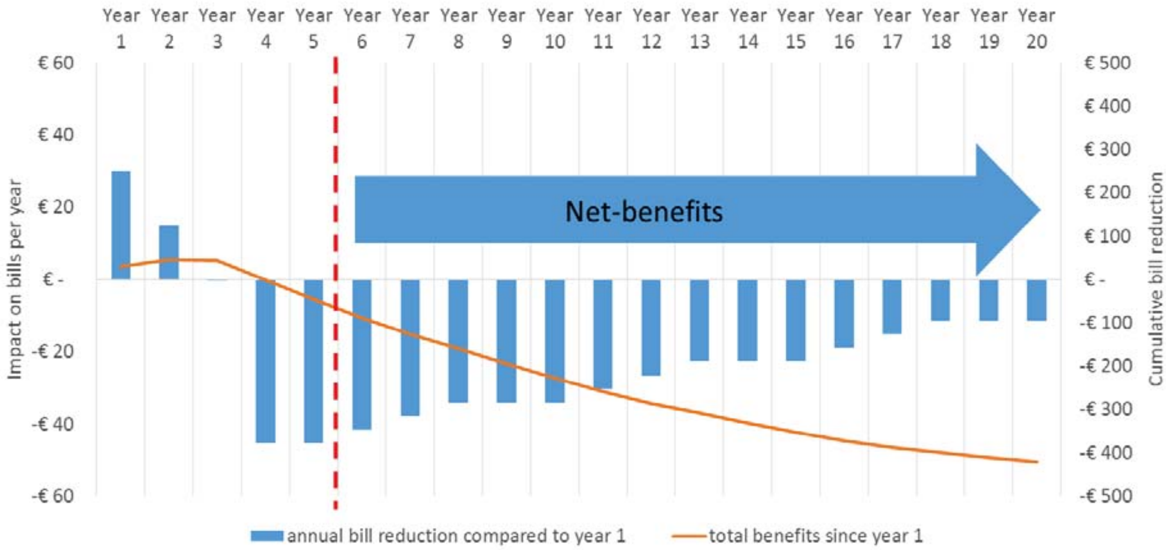
* *The energy savings under exemption paragraph 2(c) are calculated in Denmark on the basis of the achieved savings. Savings in these sectors accounted for 6% of the total reported savings in 2012, in 2013 for 5% and in 2014 for 7%. A 7% reduction has been assumed for purposes of this report.*

Table 7: Impact on energy consumption due to the measures implemented under the EEOS[135]

	Time period	Final energy savings per year (ktoe)	Reduction of final energy consumption per year	Sector
UK	2008-2012	237	0.5%	household sector
Denmark	2015	291	4.2%	all sectors
France	2011-2013	377	0.4%	all sectors
Italy	2015	500	0.4%	all sectors
Austria	2015	136	0.9%	household and industry sectors
Vermont, U.S.	2012-2014	10	1.7%	all sectors except transport
California, U.S.	2010-2012	384	1%	all sectors except transport

Source: Regulatory Assistance Project

Figure 11: Illustrative long-term impact of EEOSs on energy bills[136]

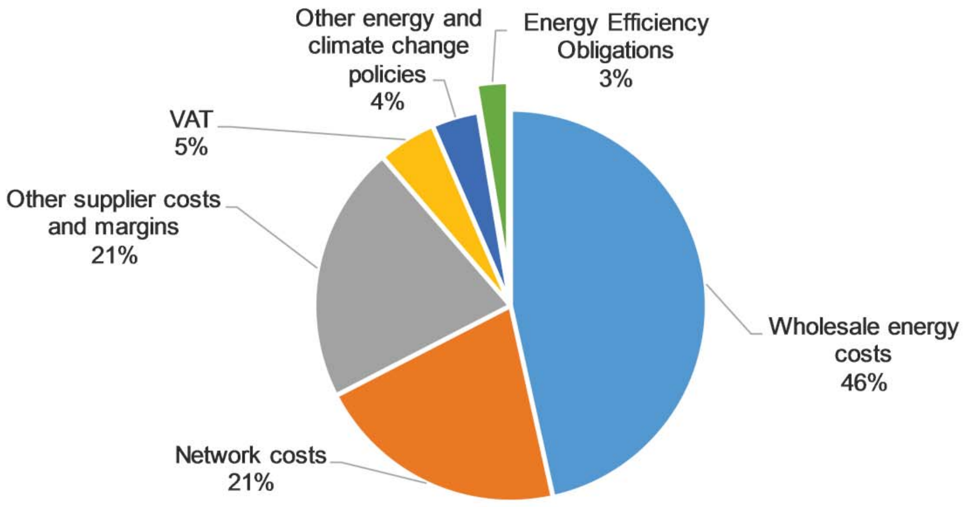


Source: Regulatory Assistance Project

Figure 12: Breakdown of the average household energy bill in the UK (2014)

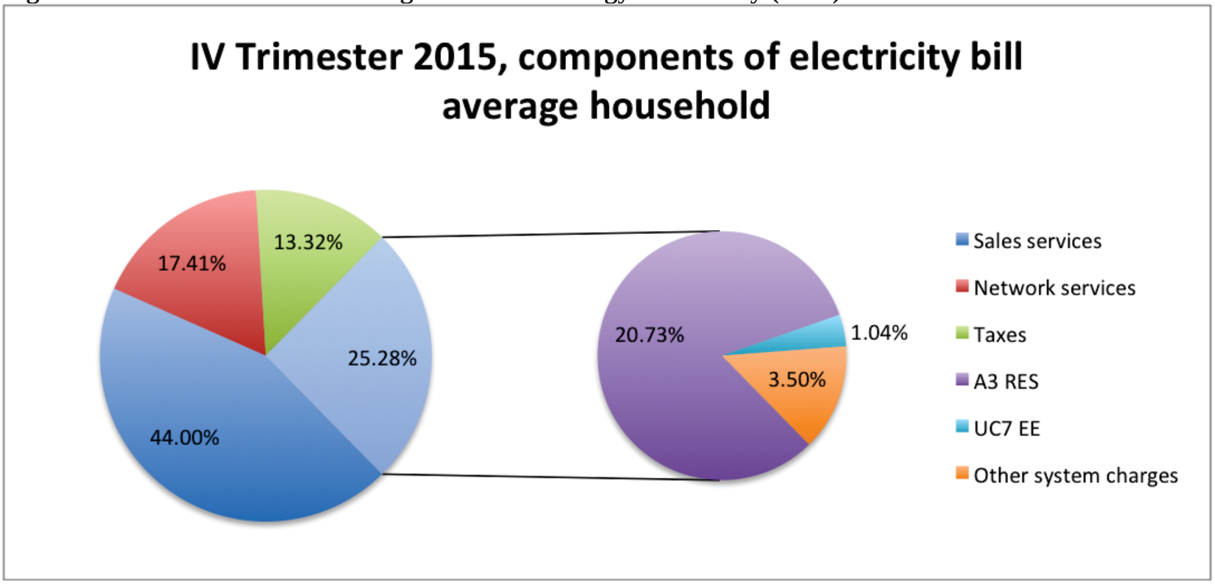
135 The reduction of final energy consumption per year is expressed in both absolute values and as a percentage of anticipated consumption under a BAU scenario).

136 The data presented are based on: 3 year operational period and termination thereafter; assuming no EEOS in place before; only applies to household sector; average yearly savings of 1%; average cost as share of total energy bill of 3%; split of lifetimes of measures: 25% 5 years, 25% 10 years, 25% 15 years and 25% 20 years; and average annual household energy bill of 1,500 Euro.



Source: DECC (2014a)

Figure 13: Breakdown of the average household energy bill in Italy (2014)



Source: Regulatory Assistance Project

Table 8: Reported energy savings achieved in 2014 under Article 7, ktoe[137]

Member State	Savings achieved in 2014	Expected savings in 2014 (if notified[138])	Cumulative savings requirement by 2020	Compared to expected savings in 2014 (if notitified)	Estimated savings on the basis of annual rate 2014[139]	Compared to estimated savings on the basis of annual rate[140]	Compared to total cumulative savings requirement by 2020
Austria	714	400	5,200		186	384%	14%
Belgium	180[141]	247	6,911		247	73%	4%
Bulgaria	15	69	1,942	22%	69	22%	0%
Croatia	2.5	29	1,296	9%	46	7%	0%
Cyprus	2.2	7	242	34%	9	22%	1%
Czech Republic	65	173	4,841		173	38%	1%
Denmark	204	238[142]	3,841	86%	137	149%	5%
Estonia	41	48	610	87%	22	186%	7%
Finland	561		4,213		150	374%	13%
France	1,585	738	31,384	215%	1121	141%	5%
Germany	2,548	2,844	41,989	90%	1500	170%	6%
Greece	74	100	3,333	74%	119	62%	2%
Hungary	75	75	3,680	100%	131	57%	2%
Ireland	71	73	2,164	97%	77	92%	3%
Italy	1,232	850	25,502	145%	911	135%	5%
Latvia	5	6	851	78%	30	17%	1%
Lithuania	38		1,004		36	106%	4%
Luxembourg	8.6	25	515	35%	18	50%	2%
Malta	1.5	1	56	238%	2	50%	3%
Netherlands	666	373	11,512	179%	411	162%	6%
Poland	403		14,818		529	76%	3%

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137 All savings reported by Member States have been converted into ktoe to ensure consistency of data presented.

138 Expected savings in 2014 were not notified for all policy measures therefore is it not reflected in column 4.

139 This column provides an indication of savings estimated for 2014 on the basis of the annual rate of the notified total cumulative savings requirement (target) by 2020 per each Member State on the assumption that Member States would achieve new savings each year (in reality Member States have freedom how they phase the achievement of their savings over the whole obligation period, which most of the Member States have notified to the Commission). It serves purely as a theoretical reference to allow monitoring progress of the savings per country and across EU-28.

140 This column provides an indication of savings estimated for 2014 on the basis of the annual rate of the notified total cumulative savings requirement (target) by 2020 per each Member State on the assumption that Member States would achieve new savings each year (in reality Member States have freedom how they phase the achievement of their savings over the whole obligation period, which most of the Member States have notified to the Commission). It serves purely as a theoretical reference to allow monitoring progress of the savings per country and across EU-28.

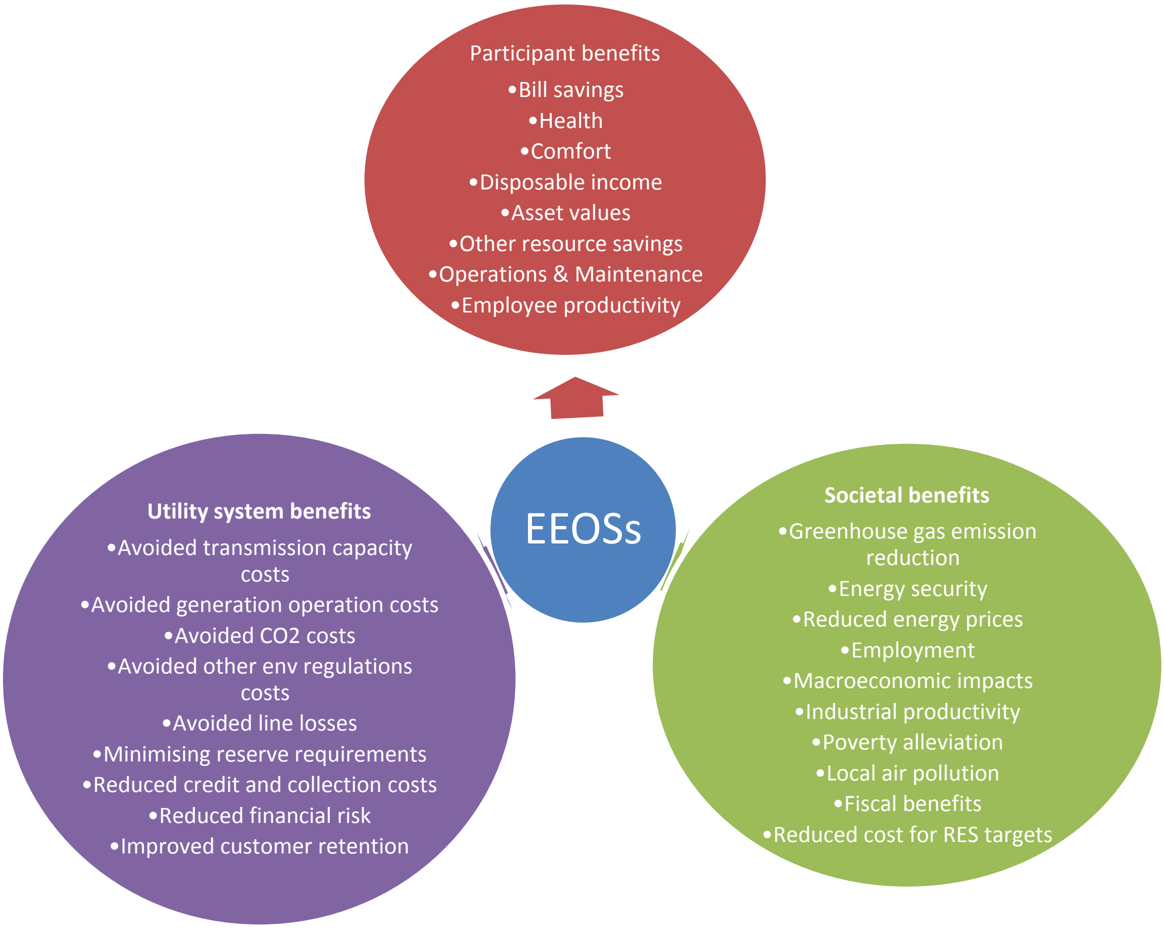
141 Belgium has notified 301.85 ktoe in energy savings in total (summed up for each region). Since these savings contain also 122.03 ktoe stemming from early actions, this of have been deducted.

142 Denmark has notified the energy savings target and expected savings inclusive of savings in energy transformation, distribution and transmission sectors (exemption (c) under paragraph 2). Savings in these sectors accounted for 6% of the total reported savings in 2012, in 2013 for 5% and in 2014 for 7%. The expected savings have therefore been reduced by 7%.

Portugal	46	53	2,532	88%	90	51%	2%
Romania	364	346	5,817	105%	208	175%	6%
Slovakia	72	71	2,284	101%	82	88%	3%
Slovenia	18	23	945	76%	34	53%	2%
Spain	565	493	15,979		571	99%	4%
Sweden	252	997	9,114	25%	326	77%	3%
UK	2,382[143]	2,347	27,859	101%	995	239%	9%
Total	**12,191**	**10,626**	**230,434**	**95%**	**8,230**	**113%**	**4%**

Source: Ricardo AEA/ CE Delft

Figure 14: Multiple benefits of Energy Efficiency Obligation Schemes[144]



143 UK notified total for all policy measures 27.7 TWh (28 TWh as rounded).

144 Rosenow and Bayer (2016) based on IEA (2014) report on multiple benefits of energy efficiency

8 Annex – Energy efficiency investments

The exact size of the energy efficiency market is difficult to estimate. Investments in energy efficiency are challenging to track because they are carried out by a multitude of agents, private households and companies, often without external financing. They also frequently constitute only a portion of broader investments and are not accounted for separately. There are broadly two possible methodologies to estimate energy efficiency investment flows[145]:

- *Bottom-up* approaches involve counting the individual exchanges of goods and services that increase energy efficiency. This method can provide a robust estimate of the size of the market, as long as the appropriate data are available and aggregation systems are in place. A bottom-up approach tracks the many individual activities that take place within homes and businesses. Bottom-up calculation requires relatively detailed data over time to compute stock adoption, the energy performance of each different stock type and behaviour changes down to the individual or business level. Typically, these data are not currently available, at least at an economy-wide or other broad level.

- In the absence of available granular data, a *top-down* method can evaluate trends in energy consumption and economic growth to estimate the scale of investment required to improve efficiency. In light of data challenges, this can be a more practical approach. Top-down methods sacrifice accuracy but still provide insight on the size of the market and changes over time.

The market size also varies significantly depending on the definition of energy efficiency investment. For example, it is possible to make the distinction between autonomous investments and motivated investments. Autonomous investments happen by themselves (e.g. replacement of equipment, normal refurbishment of buildings, etc.). In that case, energy efficiency is not the primary motivation for investing, and market actors might undertake such investment without knowing that it will deliver energy savings. On the contrary, motivated investments are typically induced by policies, where investments are explicitly designed to achieve energy efficiency objectives.

Most of the studies presented below have tried to estimate the additional investment costs for improving energy efficiency. This means the capital expenditure necessary to go beyond business-as-usual investment for autonomous investments, and the whole up-front costs for the motivated investments. For instance, in the case of energy efficient equipment, the additional investment cost represents the difference of purchasing costs between an energy efficient appliance and a "regular" one. The main challenge is therefore to define what is meant by "regular" (i.e. to define a baseline), which is by definition moving over time because of continued technological improvements[146].

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145 https://www.iea.org/publications/freepublications/publication/EEMR2014.pdf.

146 A caveat of this methodology is that it does not show larger market dynamics that also contribute to energy efficiency improvements. For instance, for some appliances, one can buy a more energy efficient equipment without any additional costs. In that case, no monetary contribution is taking into account in the estimated energy efficiency investment flows.

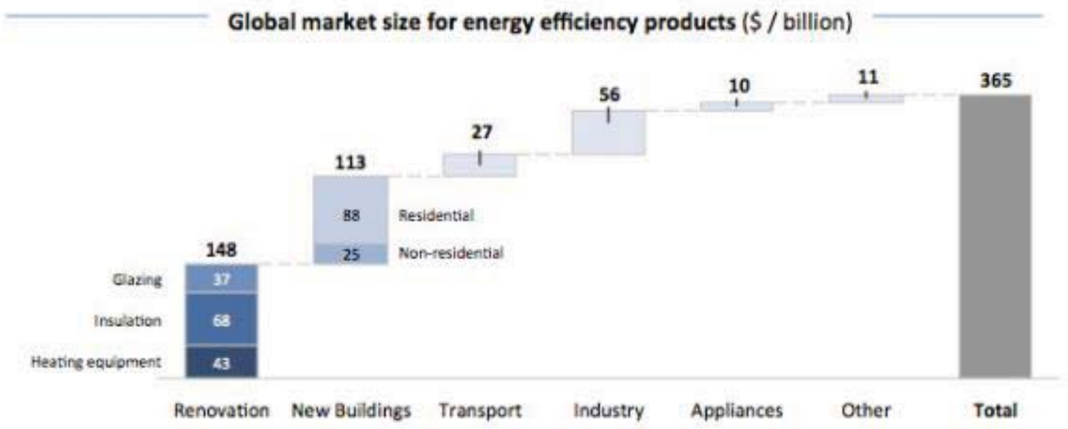
At the global level, several top-down and bottom-up studies estimate energy efficiency investments in the range of EUR 100 – 300 billion per annum[147]. This is summarised in the table below.

Table 9: Studies estimate energy efficiency investments

Source	Estimate	Comments
World Energy Investment Outlook (IEA, 2014)[148]	$130 billion per year	The estimate refers to energy efficiency investments by end-users in 2013 to increase the efficiency of devices above the 2012 stock efficiency level (**bottom-up** estimate).
Energy Efficiency Market Report (IEA, 2014)[149]	$310 – 360 billion per year	In their 2014 Energy Efficiency Market Report, IEA presents six different **top-down** methods to estimate the size of the energy efficiency market.
Sizing energy efficiency investment (HSBC, 2014)[150]	$365 billion per year	The estimate refers to 2012 and includes investment in the purchase of energy efficient equipment in the transport, buildings and industry sectors.

The HSBC study (referred above) also provides a detailed break-down by sector. The following graph illustrates the segments leading to their estimated total market size of $365 billion.

Figure 15: Global market size for energy efficiency products (HSBC study)



Source: HSBC

At the EU level, a number of bottom-up and top-down studies broadly outline current or expected energy efficiency investments in different market sectors, as shown in the table below.

147 The average EUR/USD exchange rate in 2000-2015 (1.21) is used to convert the estimates provided in USD to EUR

148 https://www.iea.org/publications/freepublications/publication/WEIO2014.pdf

149 https://www.iea.org/publications/freepublications/publication/EEMR2014.pdf

150 https://www.research.hsbc.com/R/20/K2kb6gL5ynU7

Table 10: Sectorial bottom-up and top-down studies estimating energy efficiency investments

Source	Sector	Estimate	Comments
BEAM² model	All buildings (new and refurbished)	€120 billion per year (in 2016)	This figure refers to the estimated current costs of building envelope related measures (such as insulation and windows) and the costs of energy efficient technical building systems. It includes both new and refurbished buildings. This capital expenditure should be compared with the overall EU market for building renovation which represents annually around EUR 500 billion and the market for new construction of around EUR 400 billion.
Supporting study for the fitness check on the construction industry[151]	Residential buildings (new and refurbished)	€80 billion per year (in 2010-2014)	In this study, the EE-related market for buildings renovations is defined as the value of the works and related goods and services utilized to upgrade the energy efficiency of dwellings. Around €73 billion is for renovations, and €7 billion would be the additional energy efficiency cost for new buildings.
Ecodesign Impact Accounting report[152]	Ecodesign Products	€62 billion per year (in 2020)	This is an estimate of the extra acquisition costs for more energy efficient products in 2020. These acquisition costs represent around 12% of the yearly capital expenditures and they are expected to trigger €173 billion of gross savings on running costs (91% energy).

These studies show that the European market for energy efficiency is already sizeable and that it represents investments well above €100 billion per year.

One important question related to investment is to identify, for different policy scenarios, the sectors where additional energy efficiency investments will be the most needed in the future. One way to answer that question is to use the PRIMES model by looking at the investment gap between the EUCO27 policy scenario and the more ambitious ones for the period 2021-2030. By taking this approach, it is possible to disregard the investment related to the 2030 GHG and RES targets that are included in PRIMES investment figures, and solely focus on energy efficiency investments. The table below shows the results of this approach.

[151] Supporting Study for the Fitness Check on the Construction Industry – Draft Final Report.
[152] https://ec.europa.eu/energy/sites/ener/files/documents/Ecodesign%20Impacts%20Accounting%20%20-%20final%2020151217.pdf.

Table 11: Energy efficiency investment gap

Investment Expenditures	EUCO27 Average annual values 2021-2030 (billion €'13)	EUCO30	EUCO+33	EUCO+35	EUCO+40
Total energy related investment Expenditures	1,036	8%	19%	28%	51%
Industry	17	6%	36%	69%	192%
Residential	168	28%	71%	101%	171%
Tertiary	40	72%	200%	295%	547%
Transport [153]	731	1%	0%	0%	1%
Grid	39	-8%	-12%	-21%	-33%
Generation and boilers	42	0%	-4%	-11%	-14%

Source: PRIMES

According to the PRIMES projections, the energy efficiency investment expenditure increases in all scenarios compared to EUCO27 - more significantly in more ambitious scenarios and mostly in the residential and tertiary sectors. For instance, in the EUCO30 scenario, the model estimates the need to increase by 28% the energy related investment expenditures in the residential sector, and by 72% in the tertiary sector, compared to the investments foreseen in the EUCO27 scenario.

When estimating future energy efficiency investments, the level of cost intensity[154] of future energy efficiency measures is as important as the level of achievable energy savings. However, predicting the cost intensity of future energy saving measures is difficult as it depends on many factors. For instance, it depends on the nature of the remaining energy saving potential, on future technological progress or on future price reductions of energy efficiency solutions due to e.g. increased sales volumes, more efficient installation procedures, or improved productivity. The table below illustrates the disparity in cost intensity factor based on past experiences and modelling assumptions.

153 Investment in transport equipment for mobility purposes (e.g. rolling stock but not infrastructure) and energy efficiency; excluding investments in recharging infrastructure.

154 The capital expenditure required to achieve 1 Mtoe of energy saving per year (e.g. billion EUR/Mtoe).

Table 12: Cost for energy efficiency improvement measures[155]

Source	Methodology	Sector	Energy efficiency cost intensity [bn EUR/Mtoe]
CONCERTO database	Cost intensity based on the monitoring of 58 pilot cities in 23 Member States	Buildings: energy renovation	11,6
Projects supported under ELENA	Cost intensity based on the monitoring of 21 energy efficiency projects	Buildings: energy renovation and street lighting	15,7
Study Fraunhofer-ECOFYS ISI 2011	bottom- up and top down approach estimating the required upfront-investments for the period 2011-2020	Buildings: additional upfront investments	5,3
BEAM²	building cost modelling	Buildings: renovation and new buildings (2016-2030)	20,1
Study on renovating Germany's building stock - BPIE	This report investigates a number of scenarios for improving the energy performance of Germany's building stock. The focus is on the economic viability of different levels of renovation from the perspective of the investor or building owner. The reported figure is the one from the Business as usual scenario.	Buildings: renovation (2015-2030)	23,6

155 Sources: Concerto (http://smartcities-infosystem.eu/concerto/concerto-archive); Study on renovating Germany's building stock, BPIE (http://bpie.eu/wp-content/uploads/2016/02/BPIE_Renovating-Germany-s-Building-Stock-_EN_09.pdf), Study Fraunhofer-ECOFYS (http://www.isi.fraunhofer.de/isi-wAssets/docs/x/de/publikationen/Building-policies_Brochure_Final_November-2012.pdf); BEAM² (EPBD Impact Assessment SWD).

9 Annex – Review of the default coefficient – Primary Energy Factor for electricity generation referred to in Annex IV of Directive 2012/27/EU

CONTEXT

In the context of energy efficiency implementation, a so-called Primary Energy Factor (PEF) has been used to determine the primary energy consumption to generate one kWh of electricity. Directive 2012/27/EU on energy efficiency (EED) establishes in Annex IV a default coefficient of 2.5 for savings in kWh electricity[156], to transform electricity savings into primary energy savings. This coefficient is a single value for the EU. Member States may apply a different coefficient provided they can justify it.

Article 22 of the EED empowers the European Commission to review the default coefficient.

For the PEF review a study was tendered from August 2015 to April 2016[157] and three meetings[158] took place at the European Commission premises:

1. On 11 December 2014 and on 17 June 2016, two consultative joint meetings of Member States' representatives for the EED with the consultation forum under art. 18 of the Ecodesign of energy-related products Directive 2009/125/EC, including stakeholders (minutes are available online[159]). The reason for the joint meetings is that the PEF value from the EED is used by several implementing regulations under the Ecodesign and Energy Labelling Directives, for comparing the efficiency of products using electricity and products using other fuels such as gas or liquid fuels. The PEF review in the EED would have implications in existing or forthcoming Ecodesign and Energy Labelling Regulations[160, 161].
2. On 21 January 2016, a technical meeting with Member States' representatives for the EED and stakeholders: this meeting was a relevant input to the tendered study[162].

Most Member States and stakeholders argued that the current 2.5 value is outdated and should be revised.

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156 Which means an average, European-wide conversion efficiency of 40% (excluding grid losses).

157 Contract No. Reference: ENER/C3/2013-484/02/FV2014-558/SI2.710133 "Review of the default primary energy factor (PEF) reflecting the estimated average EU generation efficiency referred to in Annex IV of Directive 2012/27/EU and possible extension of the approach to other energy carrier" – Contractor: Trinomics. Technical leadership: Fraunhofer ISI.

158 Together with EU Member States, EEA countries and over 50 European associations were involved.

159 11 December 2014 meeting minutes: http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=18412&no=2 17 June 2016 meeting minutes: http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=24733&no=2

160 However, even if the value is revised in the EED, no instantaneous change of its value within the Ecodesign or the Energy Labelling Regulations should take place. Any review would take place in the context of the relevant regulation.

161 The discussion about the PEF value is also relevant in the context of the establishment of a common EU voluntary certification scheme for non-residential building under the Directive 2010/31/EU on the energy performance of buildings where a PEF for electricity has to be determined to calculate, in a default setting, the energy performance of buildings.

162 The scope of this meeting was to provide an analysis of the whole range of calculation options from a scientific perspective. Main points of discussion were on marginal or average approach, which method to adopt for renewables – and non-combustible renewables – and the weighting of the options.

The tendered study was requested to look in particular at how to measure the efficiency of electricity generation, including the following aspects: average vs. marginal electricity generation; current, future or desired efficiency of the electricity generation; time of use of energy. The study also looked at if the use of PEF should be extended to other energy carriers.

APPROACH

The basic concept to calculate the PEF for electricity is to relate the raw primary energy demand of electricity generation with the electricity produced.

The calculation process of the PEF for electricity is made of two consequential steps that can be structured according to the following formula:

$$PEF\ Electricity = \frac{PEF\ of\ Fuel}{Conversion\ efficiency}$$

The first step is to determine the "PEF of Fuel", i.e. how much energy was needed to get one unit of *ready-to-use* fuel (before being converted into electricity). This is done for each fuel. In this document, all energy sources are named as “fuel”[163]. In this step, issues like system boundaries counts, e.g. transmission and distribution losses or the energy used to extract, clean and transport coal.

The second step is to determine the conversion efficiency of the electricity generation process, for each *ready-to-use* fuel.[164] Hence, a PEF for electricity for each fuel is calculated (e.g. a PEF for electricity from coal; a PEF for electricity from wind; etc). The total PEF for electricity is the weighted sum of the single PEFs according to the relative amount of every fuel in the total primary energy.

The tendered study selected four calculation methods for examination that looked into different options for the two steps:

- Calculation method 1 is designed to be in line with the Eurostat calculation for primary energy and electricity production.
- Calculation method 2 is designed to reflect the total consumption of non-renewable sources only.
- Calculation method 3 is a variation of method 1 in order to analyse the impact of changing the allocation method for CHP from the “IEA method” to the “Finish method”[165].
- Calculation method 4 modifies calculation method 3 by adding the life cycle perspective to the conventional fuels.

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[163] This also includes wind, solar or hydro which are normally not called “fuel” in the classical sense E.g. Eurostat refers to them as energy products. Elsewhere (e.g. some UN standards) they are also called energy sources or carriers.

[164] Regarding non-conventional fuels, such as wind, solar PV, hydro, geothermal or nuclear, there is a range of methodological choices to be made to define the primary energy content.

[165] The IEA method attributes the primary energy to the outputs power and heat in relation to their relative output shares. The Finish method takes into account the average efficiency in single heat and power plants as a reference. The Finish method attributes a higher share of primary energy consumption to electricity. The Finish method is the method in Annex II of the EED for determining the efficiency of the cogeneration process..

All calculated PEF values after the year 2015 are below 2.5.

Calculations are based on the PRIMES 2016 Reference Scenario – the most recent available version. PRIMES contains projections of the development of the European electricity mix by taking into account the impact that will generate from current policies (e.g. from EU energy policies to 2030 a higher share of renewable sources of energy). The historical years in PRIMES are calibrated based on official statistics from Eurostat, i.e. reaching consistency with real data as for the previous years. The focus is on the time framework 2005-2020.

The analysis looked into 51 options in total (Table 1) and the results were weighted according to policy objectives (Table 2). Each calculation method was the result of a decision tree (Table 3).

Table 13: Options for PEF calculation

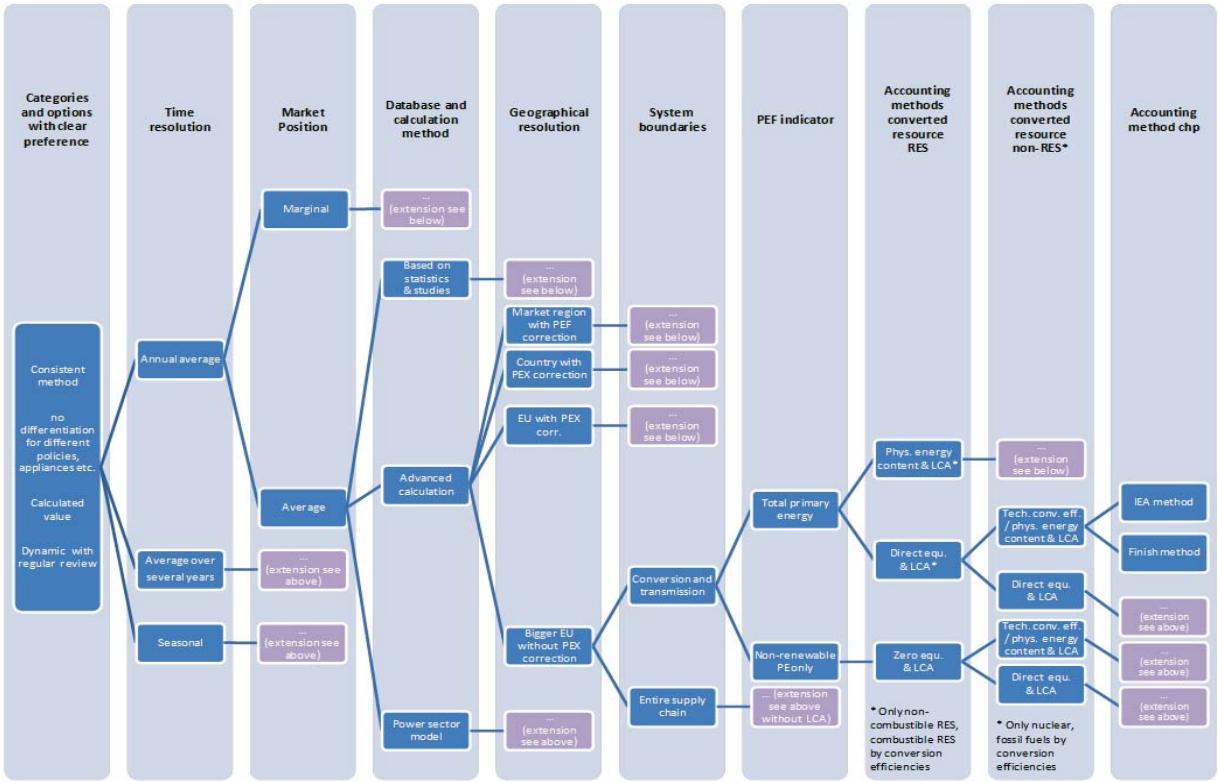
Category	Option	
Strategic and political considerations		
PEF purpose	Desired	
	Calculated	
Applicability	Abolish the use of a PEF	
	No differentiation	
	Different for different policies	
	Different for different electric appliances	
	Different for different policies <u>and</u> electric appliances	
	Different for delivered and produced electricity	
Adjustment and review process	Constant over time	
	Regular review/adjustment	
Database and calculation method	Based on statistics and studies	
	Advanced calculations based on statistics and studies	
	Power sector model calculations	
Representation of the electricity sector		
Geographical resolution	Bigger EU (EU+Norway)	With Power Exchange (PEX) correction
		No PEX Correction
	EU	With PEX correction
		No PEX Correction
	Member States	With PEX correction
		No PEX Correction
	Market regions	With PEX correction
		No PEX Correction
	Subnational regions	With PEX correction
		No PEX Correction
Development over time	Constant	
	Dynamic	
Time resolution	Average over several years	
	Annual average	
	Seasonal	
	Hourly time of use	
Market position	Average electricity production	
	Marginal electricity production	
General PEF methodology		
PEF indicator	Total primary energy	
	Non-renewable energy only	

System boundaries	Entire supply chain
	Energy conversion and transmission/distribution
Accounting method for nuclear electricity (and heat) generation	Technical conversion efficiencies
	Direct equivalent method
	Physical energy content method
Accounting method for power (and heat) generation using non-combustible RES	Zero equivalent method
	Substitution method
	Direct equivalent method
	Physical energy content method
	Technical conversion efficiencies
Accounting method electricity (and heat) generation using biomass	Zero equivalent method
	Technical conversion efficiencies
Accounting method for cogeneration (CHP)	IEA method
	Efficiency method
	Finish method
Methodological consistency	Same method in all Member States
	Different methods in different Member States
	Different methods in different Member States with correction mechanism

Table 14: Policy evaluation criteria with weightings

Methodological Suitability						Acceptance					
70 %						30 %					
Precision	Data Availability					Target: internal market (including Energy Union)	Target: 2020 climate	Target: 2020 security of supply	Target: Long-term decarbonisation (including Electrification)	Complexity	Transparency
	20 %										
	Effort required	Credibility	Data quality	Uncertainty	Flexibility						
50 %	2 %	4 %	6 %	6 %	2 %	8 %	4 %	4 %	6 %	4 %	4 %

Figure 69: Decision tree



RESULTS

The following conclusions apply to all the four calculation methods:

- It appears appropriate for the approach of **single PEF value for electricity in the EU to be kept** (for use in the contexts where it is currently used) and the same PEF value for electricity to be used **in all EU legislation** where it is appropriate. This is to avoid distortions, take account of the interconnected European electricity system and be consistent with the EU Internal market vision. Where the same requirements or labels are applied to products using different fuels, a PEF is needed in order to obtain comparable information. In addition, since the Regulations published under the Ecodesign and the Energy Labelling Directives are directly applicable in all EEA countries (Norway, Liechtenstein and Iceland) and the free movements of goods needs to be maintained, a single European PEF value needs to be used.
- The analysis covers **EU28 and Norway**, because of the relevance of Directive 2012/27/EU for the EEA countries, of which Norway is the most relevant trading partner. This choice is a trade-off between precision and data availability and complexity. Since the PRIMES dataset does not contain Norway, the contractor developed an extra dataset for Norway based on ENTSO-E[166] data, which the Norwegian representatives verified at the Technical meeting.

166 ENTSO-E is the European network of transmission system operators for electricity. It provides freely accessible data on the electricity system in Europe. https://www.entsoe.eu/disclaimer/Pages/default.aspx

- It seems appropriate for the PEF value to be a **calculated value and to be revised regularly**, in order to reflect reality (and forthcoming reality) at best. The projected development of the electricity sector changes regularly and especially technologies such as nuclear, renewables and CHP are subject to political influence, which may change their future development over time.
- The time of use of energy is based for all methods on **annual average values**. Seasonal values – the most relevant alternative option – are excluded because they would require complex calculations: most statistical and projected data exists on a yearly basis and hence seasonal values would need to be deduced from a power sector model, with detriment to transparency and impartiality of the results.
- Regarding the accounting methods for primary energy, as for **nuclear** electricity (and heat) generation, the **Physical energy content method** is used. As for electricity (and heat) generation using **biomass**, the **Technical conversion efficiency** method is used. This is in line with the Eurostat approach.
- An **average market position** is favoured for all calculation methods over a marginal position. The dimension "Market position" concerns the question, which power generator is taken as the basis for the calculation. While the average generation mix is easy to estimate, determining the marginal generation unit requires more complex assumptions. The rationale behind using the marginal generation unit is that relatively small changes in consumption lead to changes only in the generation of electricity in the last units used to cover demand. If an efficiency measure reduces power consumption in hours of high demand, renewable energies and base load power plants will continue to produce and only the peak load plants (mostly gas and oil turbines) will adjust their power generation accordingly. The primary energy consumption of the marginal generator often differs substantially from the average generation: the party in favour of a marginal position claims this would better show the primary energy consumption of new appliances. Yet, normally the effect of one single new appliance in the system is marginally low. Complex and time-consuming power system model calculations would have to be carried out to determine the marginal supplier for a specific point in time.
- For fossil fuels and directly combustible renewable fuels, the **conversion efficiency** is given by the heat value generated during combustion of the fuels (output) divided by the raw primary energy demand (input). For non-combustible renewables a conversion efficiency of 100% is assumed. For geothermal power stations a conversion efficiency of 10% is assumed, while for nuclear power stations a conversion efficiency of 33% applies. These values are commonly applied and in line with Eurostat.

The four calculation methods differ for three aspects:

1) the **system boundaries,**

2) the **treatment of renewable energy sources (RES),** and

3) the **allocation method used for CHP**.

These three aspects are represented in the last five columns of the decision tree in Table 3.

The category **"System boundaries"** defines if only the primary energy that is used within the conversion and distribution process is considered or if also additional energy consumption, related to the (entire or partial) life cycle of the conversion, transmission and distribution infrastructure. Calculation methods 2 and 4 take into account the life cycle perspective.

As for **RES**, the issue is if to consider the primary energy at the origin of RES as *total* primary energy or *non-renewable* primary energy. In the latter case, the guiding question being "How much *non-renewable* primary energy was used to get 1 unit of fuel to be converted into electricity?" and the answer being "Zero", the *Zero equivalent method* is applied. The PEF of fuel for all RES would therefore be 0. It would instead be of value 1 with the *Total primary energy method* ("How much *total* primary energy was used to get 1 unit of fuel to be converted into electricity?"). The Zero equivalent method is applied in Calculation method 2, while methods 1, 3 and 4 apply the Total primary energy method.

As regards **CHP**, there is the need to identify how much of the fuel input that goes into a CHP plant is used to produce heat and electricity, i.e. what is the quota of primary energy that is used to produce respectively heat and electricity. Various methods exist. The study shed light on two methods: the *IEA method* and the *Finish method* (also known as Alternative production method). The IEA method attributes the primary energy to the power and heat outputs in relation to their relative output shares. The Finish method takes into account the average efficiency of single heat plants and single power plants as a reference. As a result, the IEA attributes a higher share of primary energy to heat than the Finish method, i.e. the efficiency of electricity production in CHP with the IEA method results higher than with the Finish method. Thus, heat production in CHP appears less efficient with the IEA method than in reality is: the Finish method allows for results that are more realistic. The IEA method is used by Eurostat as a default method when Member States do not provide own calculations.

For the calculation in the Finish method, it is necessary to get data on average conversion efficiencies. The most recent data available from Eurostat are used: 40% for reference power plants, 90% for reference heat plants and 70% overall efficiency for CHP plants.

Calculation method 1 applies the IEA method, while methods 2, 3 and 4 apply the Finish method.

The calculations below show the difference between the IEA method and the Finish method:

STARTING DATA (FROM PRIMES 2016)	**Operator**	**Indicator**	**2015**	**Unit**
CHP OUTPUT		CHP El. Generation	397	TWh
	+	CHP Heat Generation	941	TWh
	=	Total CHP Output	1337	TWh

CHP INPUT		Primary energy	1911	TWh

RESULTS			
With IEA method		**With Finish method**	
Primary Energy share of electricity	**567 TWh**	**Primary Energy share of electricity**	**931 TWh**
PEF for electricity from CHP	**1.43**	**PEF for electricity from CHP**	**2.34**
PEF for heat from CHP	**1.43**	**PEF for heat from CHP**	**1.03**

The results show that according to the IEA method 1.43 TWh of primary energy are needed to produce 1TWh of electricity from a CHP plant (and the same amount is needed to produce 1TWh of heat), while with the Finish method the result is 2.34 TWh to get 1 TWh of electricity and 1.03 to get 1TWh of heat. The Finish method is closer to reality, because heat production is much more efficient than electricity production (in single plants, as well as in CHP), as confirmed by latest studies and documents by the European Commission[167].

CHP stakeholders and Member States investing in CHP are in favour of getting heat production valorised as much as possible: the Finish method allows for this more than the IEA method.

CONCLUSIONS AND PROPOSAL

The PEF of 2.5 is not adequate and should be revised: all calculation methods show a decrease of the PEF due to the projected growth of electricity generation from RES.

Table 15: Results PEF for electricity from the tendered study[168]

Calculation method	2005	2010	2015	2020
Method 1	2,35	2,25	1,98	1,88
Method 2	2,33	2,12	1,73	1,54
Method 3	2,48	2,38	2,09	1,99
Method 4	2,60	2,48	2,17	2,06

The analysis shows that no calculation method can claim absoluteness. On balance, it appears appropriate to proceed with **Calculation method n.3 and an appropriate value for the default coefficient in the EED for electricity production is 2.0.** The reasons for choosing method n.3 are the following:

- With the exception of CHP, it is in line with the primary energy calculation made by Eurostat, the official EU statistics body fed with national statistics;
- Calculation method n.3 applies the Finish method for **CHP**, which gives a more realistic result of the primary energy share used for electricity production in CHP plants than the IEA method, applied by Eurostat. This choice is also justified by the fact that Eurostat is working with DG Energy on CHP reporting forms to be integrated in the annual Eurostat questionnaire to Member States probably in the next 2-3 years, in the context of the requirements under Art. 24(6) of the EED. The new reporting forms will allow moving from aggregation on plant level to the aggregation on the unit level and will enable to make calculations in line with the Finish method[169];
- The Finish method is the methodology in the EED – Annex II to determine the efficiency of the CHP process;
- As for **RES**, calculation method n.3 applies the Total primary energy method for the primary energy at the origin of RES. The reasons to prefer this method are the following:

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167 See Eurostat energy balances. See Review of the Reference Values for High-Efficiency Cogeneration – RICARDO-AEA. Report for EC DG Energy ENER/C3/2013-424/SI2.682977 ED59519. See Best Available Techniques (BAT) Reference Document for Large Combustion Plants Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) JOINT RESEARCH CENTRE Institute for Prospective Technological Studies Sustainable Production and Consumption Unit European IPPC Bureau Final Draft (June 2016), http://eippcb.jrc.ec.europa.eu/reference/BREF/LCP_FinalDraft_06_2016.pdf. Other calculation methods exist, some of which aim to valorise the heat production in CHP (e.g. the 200% heat efficiency in Denmark).

168 Compared to the tendered study, these calculations are updated with the last available PRIMES Reference Scenario from 2016.

169 Eurostat will continue using the IEA method only in case no better data exist for the preparation of energy balance (annual questionnaires) at national level.

- The PEF value from the EED is used by several implementing regulations under the Ecodesign and Energy Labelling Directives, to compare the performance of products such as electric heaters and gas heaters. The share of renewable energy in electricity generation is heading for 35%. By using a PEF of 0 for RES, that would mean that 35% of the electricity used would be ignored when comparing the performance of electricity and gas appliances. The choice for PEF of 0 for RES could undermine the credibility of a consumer-serving label;
- A PEF as 1 for RES recognises that it makes sense to place value on, and save where possible, all types of energy including renewable energy;
- The role of RES for sustainable and climate policies is already recognised by the assumption of full conversion efficiency into electricity (100%) – i.e. by the use of a factor of 1 rather than the higher values used for other technologies.

- As for **system boundaries**, calculation method n.3 applies no life cycle approach. The reasons are the following:
  - Neither the tendered study nor literature and Member States' experiences show clear and consistent data on the consumption of primary energy in the upstream chain of fuels from being raw to becoming fuels ready to be converted into electricity. There are also doubts on how far to go in the upstream chain;
  - The application of the PEF for electricity in the Ecodesign and Energy Labelling Directives to compare the performance of products leads to the question, whether or not a similar method has to be applied to other energy carriers as well, such as coal or gas. Currently, their final energy consumption is calculated to be equivalent to its primary energy consumption. By choosing method n.3 there is consistency with the approach adopted so far in the Ecodesign and Energy Labelling Directives.

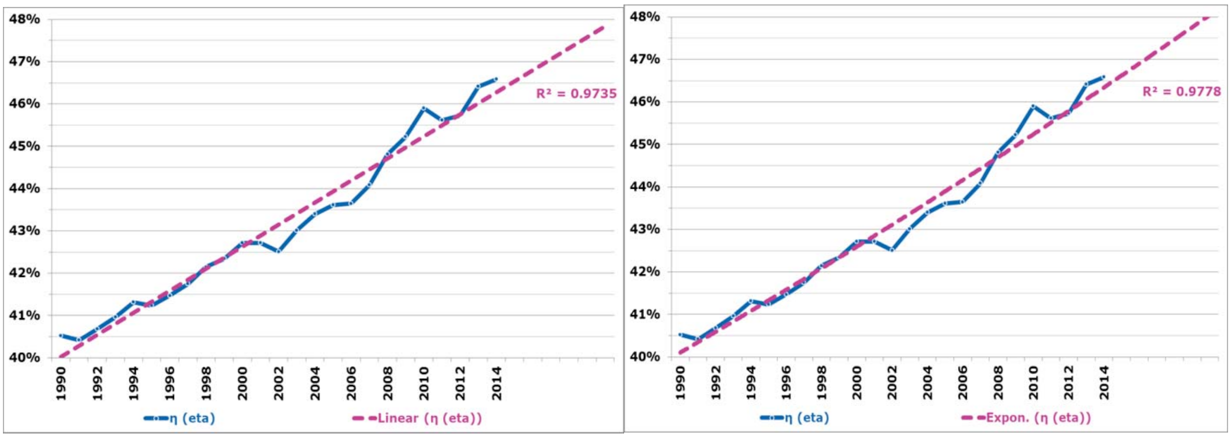
The value of 2.0 is the projected result for the year 2020. The choice of the year 2020 seems reasonable to take into account the effect of on-going energy policies in the forthcoming years and at the same time to keep limited the uncertainty from modelling. This approach is in line with the intention to have a regular review of the PEF value, notably every five years.

An alternative option would be to make an extrapolation (linear or exponential) of the η factor developed by Eurostat[170]. The η factor is the efficiency of electricity generation: PEF would be = 1/ η. As of 2020, the extrapolated PEF would result in 2.1 (see Tables 5 and 6).

Before comparing the result from method n.3 and the Eurostat extrapolation, two passages are needed. First, the extrapolated value has the IEA method for CHP and it is necessary to adapt the value with the Finish method. According to calculations from the study, a factor of 0.1 needs to be added (2.1+0.1=2.2). Second, the extrapolation of historical data from Eurostat does not show the evolution of on-going energy policies (notably growing quota of RES, which mean a lower PEF) – while PRIMES do. 1/η will be higher than the result of any method from the study.

[170] http://ec.europa.eu/eurostat/documents/38154/43500/ETA_time_series.xlsx/8d4ae449-8795-44d8-b903-ddd6ff36ba42

Figure 70: Extrapolation of η factor by Eurostat (as of 2020: η =48%, PEF=2,08)



In conclusion, the result from method n.3 is counter proven and based on robust assumptions.