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

Report on behalf of DG ENER

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1 Summary of Main Results of the Report

1.1 Executive summary

The analysis of this study has two main objectives: (i) to report on the evaluation of the achievement of the 2020 energy efficiency target of 20%; (ii) to discuss energy efficiency potentials in two different time horizons (2020, 2030) mainly in view of a 2030 target frame for energy efficiency. For this purpose we carried out the following tasks:

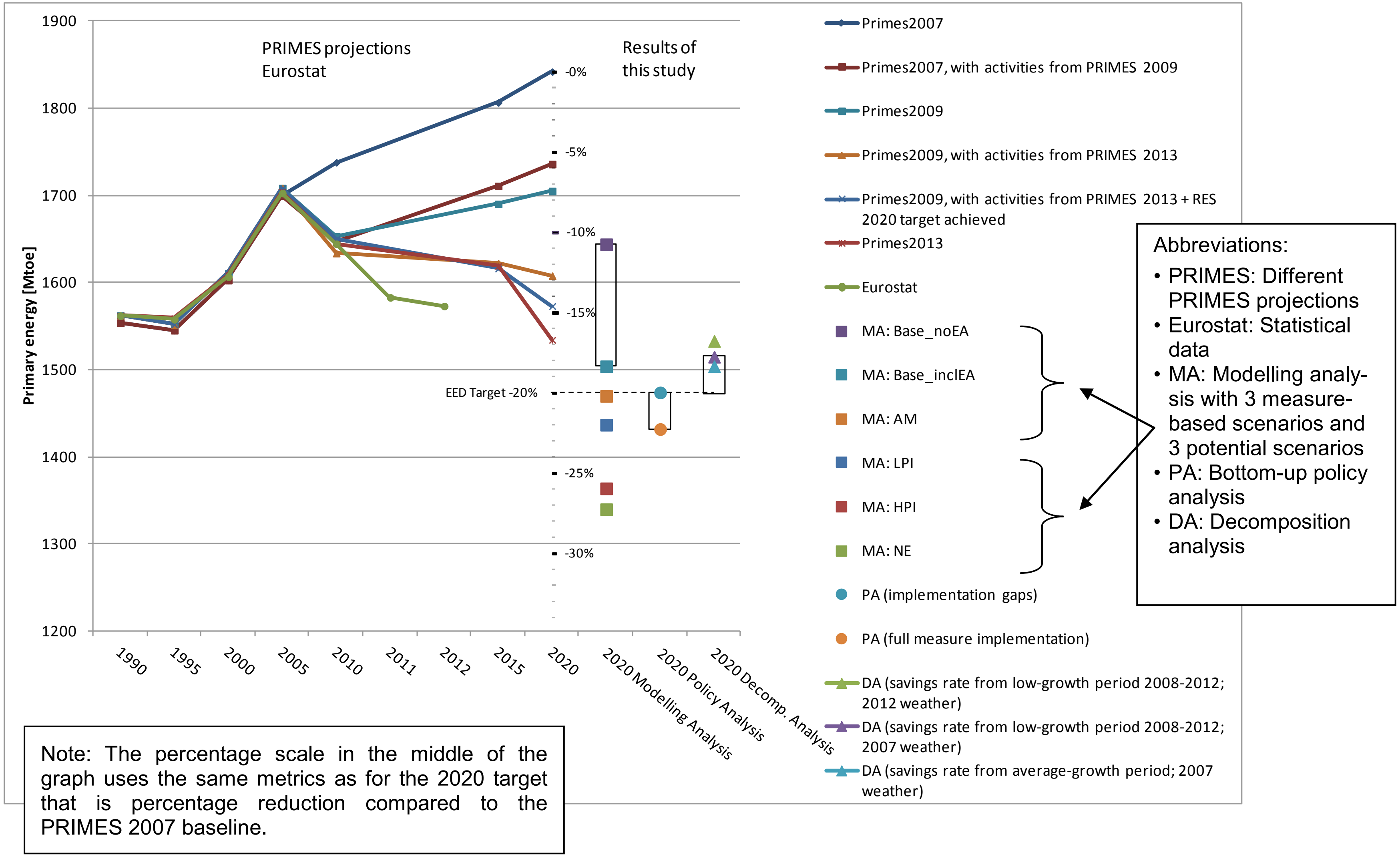
- Assessment of the effectiveness of a target selection of national measures and policies up to 2020 (**Bottom-up policy analysis** of Art. 3 of the EED).
- **Decomposition analysis** of past energy efficiency achievements (2000-2012 and 2008-12) based on Eurostat data and projection to 2020
- **Bottom-up modelling analysis of policies up to 2020** based on national and EU policies
- **Bottom-up modelling of energy efficiency potentials up to 2030**

The results of the analysis are summarized in Figure 1 to Figure 4. **Note that these figures use the same metrics as for the 2020 target that is a percentage reduction compared to a fixed baseline (the PRIMES 2007 baseline).**

For the energy efficiency gap for 2020 we find:

- The most recent PRIMES 2013 projections find a gap of 3% points for primary energy and of 4% points for final energy. The comparison of the different PRIMES projections by adjusting changing activity levels shows that most of the progress since 2007 is due to activity changes and roughly about 4-5% points from energy efficiency policies since then.
- Our findings with the three methods (bottom-up policy analysis, decomposition analysis and modeling analysis) find for both primary and final energy a gap 3% to 0% point, the latter for the bottom-up policy analysis. This implies, however, that a variety of planned measures are implemented by the EU Member States though we have taken already into account and confirmed through interviews that a number of measures proposed in the NEEAPs 2 and the Art. 7 notifications will have reduced impacts as compared to the planning. NEEAP3 reports were not yet available for the measure analysis.
- For 2030 we find, using the same metrics as for the 2020 target that economic potentials from a macro-economic perspective, using low discount rates and assumptions on non-economic instruments instead of economic instruments to overcome non-economic barriers, may be 37% in 2030 for final energy and 40% for primary energy. The baseline reaches around 24% reduction in 2030.

Figure 1: Summary of main results for the projected **primary** energy gap for the EU in **2020**

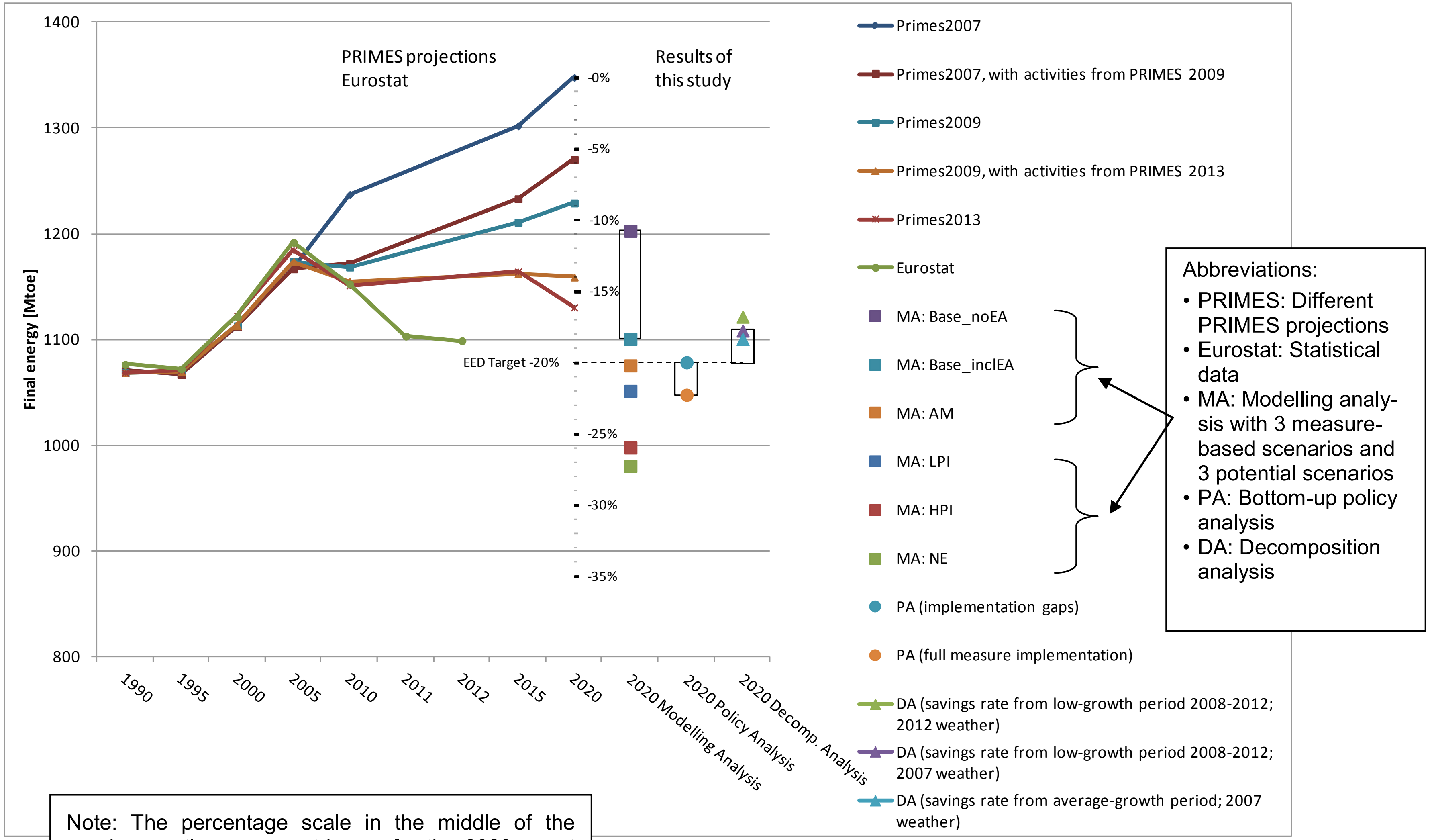


Abbreviations:

- PRIMES: Different PRIMES projections
- Eurostat: Statistical data
- MA: Modelling analysis with 3 measure-based scenarios and 3 potential scenarios
- PA: Bottom-up policy analysis
- DA: Decomposition analysis

Note: The percentage scale in the middle of the graph uses the same metrics as for the 2020 target that is percentage reduction compared to the PRIMES 2007 baseline.

Figure 2: Summary of main results for the projected **final** energy gap for the EU in **2020**

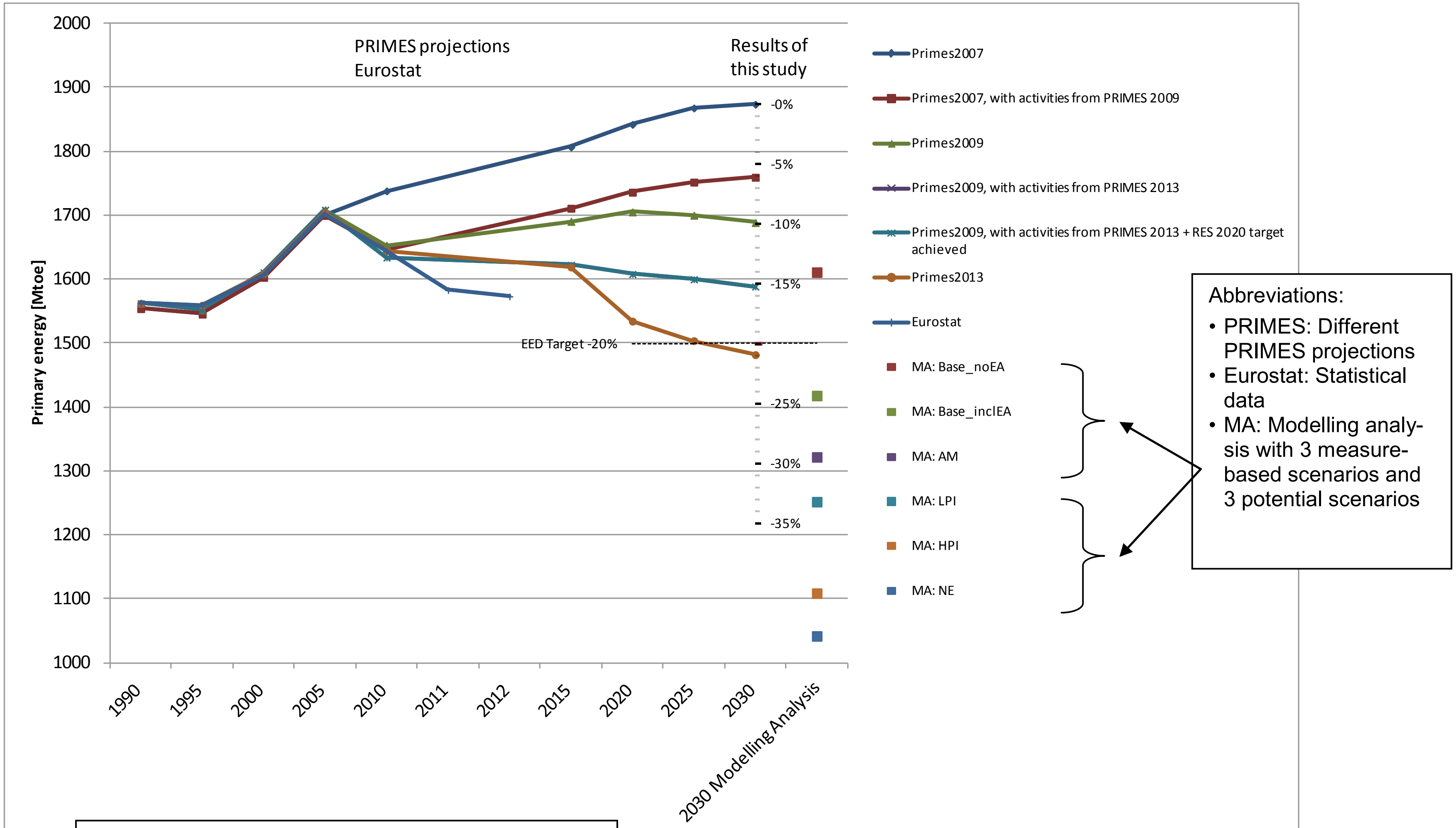


Abbreviations:

- PRIMES: Different PRIMES projections
- Eurostat: Statistical data
- MA: Modelling analysis with 3 measure-based scenarios and 3 potential scenarios
- PA: Bottom-up policy analysis
- DA: Decomposition analysis

Note: The percentage scale in the middle of the graph uses the same metrics as for the 2020 target that is percentage reduction compared to the PRIMES 2007 baseline.

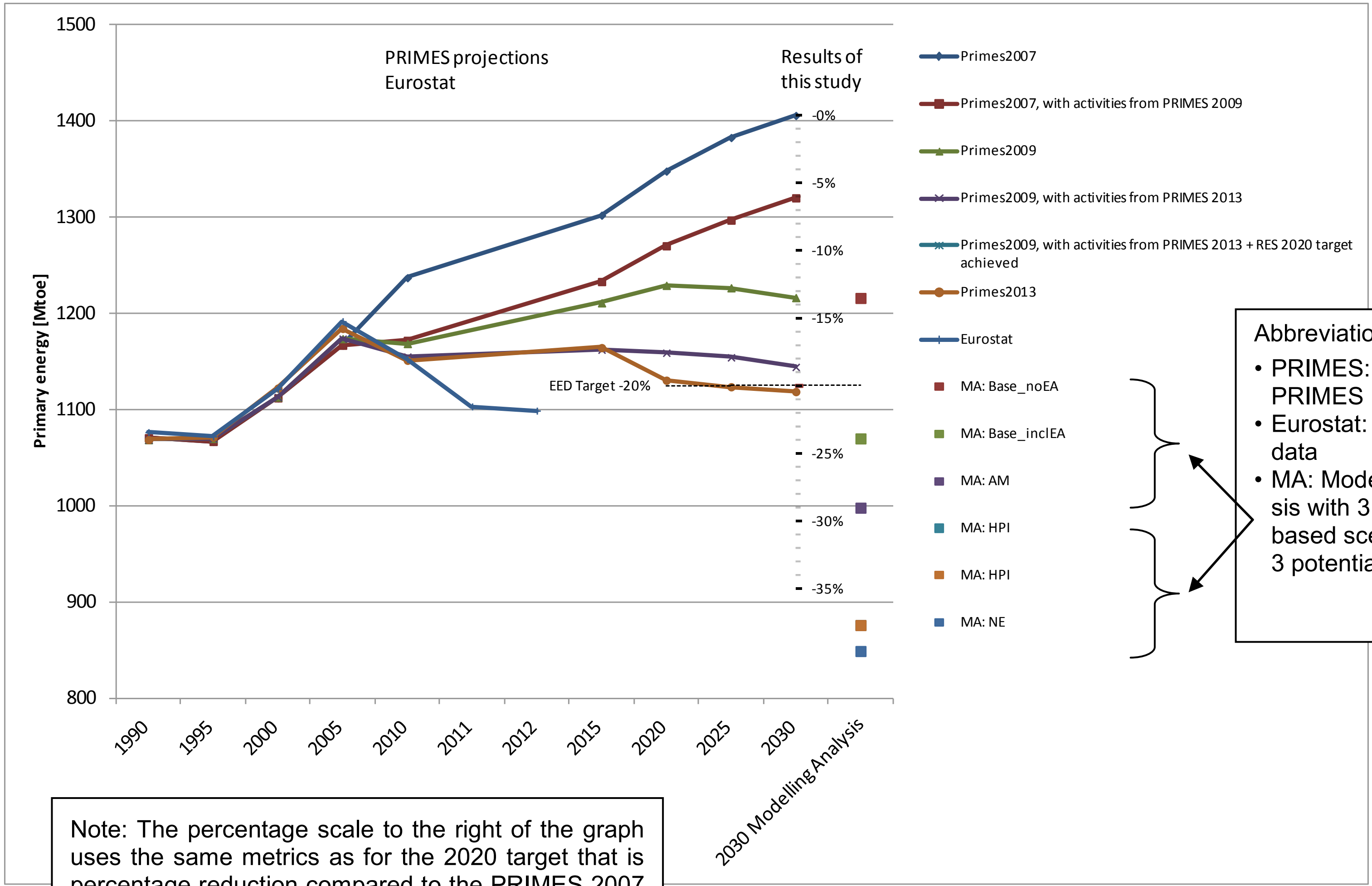
Figure 3: Summary of main results for the **primary** energy potentials for the EU in **2030**



Abbreviations:
- PRIMES: Different PRIMES projections
- Eurostat: Statistical data
- MA: Modelling analysis with 3 measure-based scenarios and 3 potential scenarios

Note: The percentage scale to the right of the graph uses the same metrics as for the 2020 target that is percentage reduction compared to the PRIMES 2007 baseline.

Figure 4: Summary of main results for the **final** energy potentials for the EU in **2030**



Abbreviations:

- PRIMES: Different PRIMES projections
- Eurostat: Statistical data
- MA: Modelling analysis with 3 measure-based scenarios and 3 potential scenarios

Note: The percentage scale to the right of the graph uses the same metrics as for the 2020 target that is percentage reduction compared to the PRIMES 2007 baseline.

1.2 Extended Summary

The analysis of this study has two main objectives: (i) to report on the evaluation of the achievement of the 2020 energy efficiency target of 20%; (ii) to discuss energy efficiency potentials in two different time horizons (2020, 2030) mainly in view of a 2030 target frame for energy efficiency. For this purpose we carried out the following tasks:

- Assessment of the effectiveness of a target selection of national measures and policies up to 2020 (**Bottom-up policy analysis** of Art. 3 of the EED).
- **Decomposition analysis** of past energy efficiency achievements (2000-2012 and 2008-12) based on Eurostat data and projection to 2020
- **Bottom-up modelling analysis of policies up to 2020** based on national and EU policies
- **Bottom-up modelling of energy efficiency potentials up to 2030**

The modeling analysis was carried out with the following models:

- The INVERT/EE-Lab model (run by TU Wien) for residential and non-residential buildings
- The FORECAST platform (run by Fraunhofer ISI), including an industrial model as well as the electricity uses in the residential and service sector
- The ASTRA model (run by Fraunhofer ISI) providing potentials for the transport sector
- The PowerACE model providing efficiency options, including renewable for the power sector.

The major difference of these bottom-up models as compared to a model like PRIMES is the **large degree of detail in the representation of technologies, actors and options which is necessary to reflect technology and actor-specific barriers**, or even measure-specific barriers. In the PRIMES descriptions it is frequently suggested that the model does integrate different types of barriers, however, it does so at an aggregate level which does not allow directly integrating policies aiming at alleviating such barriers. **Being able to represent this heterogeneity of technologies, actors and measure-specific barriers, which characterizes energy efficiency much more than for example renewable energy sources, is an important ingredient in a realistic investigation of barriers and policy measures to overcome the barriers.**

In addition, presenting technologies in such a detailed manner allows to better draw on the growing empirical basis for **technological learning** (hence lowering of the additional cost), which is possible with energy efficiency as it is with renewable energy sources. Considering technological learning in a realistic manner provides further information on how policy instruments may contribute the cost of early market penetration of efficient technologies.

The following scenarios were defined in this work:

Table 1: Overview of scenarios

Scenario name	**Short name**	**Explanation**
Baseline No Early Action	Base_noEA	Contains only measures before 2008. Can be roughly compared with the reference development of PRIMES 2009 (corrected for the drivers from PRIMES 2013), though the latter includes measures up to early 2009.
Baseline incl. Early Action	Base_inclEA	Contains measures up to 2013 including. Can be compared with PRIMES 2013. Is useful in conjunction with EED (Art. 7) which admits “Early Action”.
Baseline with measures	Base_WM	Contains also measures which are already accepted or close to being accepted in 2014 and the near future. Sometimes this maybe very close to Base_inclEA and can be the same.
Additional Measures	AM	Baseline with additional measures. Extends existing measures for each sector by around 3% in order to reach the EED target in case there is a gap. Some new measures (which represent a generalization of successful measures at the national level) are also proposed, especially for the transport sector and the space heating & hot water. The corresponding measures are listed in the report.
Potential 2030 (low policy intensity)	Potential_2030_LPI	Potentials to 2030 with high discount rates and barriers persisting. The discount rates are sector and partially country specific. Details are provided in the report.
Potential 2030 (high policy intensity)	Potential_2030_HPI	Potentials to 2030 with low discount rates and barriers (partially or totally) removed. The discount rates are sector specific.
Potential 2030 (near economic)	Potential_2030_NE	Potentials which are not economic (that is the Net Present Value is negative given the discount rates used in the HPI scenario) but the scenario induces costs not much higher than present level energy consumption entails. This differentiates the NE potential from a pure “technical” potential which may include also higher cost.

The report discusses in detail the **issue of discount rates** used to evaluate economic potentials. In that the PRIMES model and our scenario analysis take a rather different approach. While PRIMES integrates (perceived or existing) risks into the discount rates to a large degree with discount rates of up to 17.5% to evaluate both decision making energy system costs, our scenario approach essentially uses usual capital costs, considering that there are instruments to mitigate the risks and the risk perception. In that we argue that policies of the future can learn from present experiences. Also the perception of the energy user changes: with technologies developing they perceive less risk, awareness changes with respect to the threat of climate change, resource scarcity and high energy prices, a larger number consumers are willing to invest to mitigate those risks, policies are developed to accompany those awareness changes etc. In our view therefore, it is most appropriate to evaluate energy efficiency in the light of typical capital costs rather than by integrating risks and risk perception, as well as fragmented energy efficiency policies to a high degree already from the beginning into the calculation of both decision making and the total system costs.

This is supported by the recommendations of the latest 5th Assessment Report published by the International Panel for Climate Change IPCC who advocates the use of social discount rates (an approach which is not followed in this study) and decreasing discount rates over time for the long-term investments (especially for buildings) in order to respond to questions of intergenerational equity.

The following main messages can be extracted from the analysis for the EU27 for **final energy (**see Table 2 and Table 3**)**:

- In 2020 the Scenario “Baseline including Early Action” (Base_inclEA) misses the 2020 final energy target of 1078 Mtoe (EU27) by around 2.3%. This is somewhat less than the PRIMES projections and in line with the results from the decomposition analysis. The Base_WM scenario does not change considerable this figure.
- With an extension of present measures and the generalization of some successful measures from the national level it is possible to reach the 2020 target (AM Scenario). The corresponding extension of measures are discussed in the sectoral chapters 5.6 and in 5.7.1
- In view of a more ambitious realization of energy efficiency potentials up to 2030, it may be appropriate to discuss more ambitious measures already with a time horizon for 2020. This is shown by the fact that the HPI scenario (realization of economic potentials) exceeds the 2020 target by 4.9%.
- The measures initiated from 2008 onward have decreased final energy consumption so far (2012) by 38 Mtoe, and will have decreased final energy consumption in 2020 by 103 Mtoe.
- By 2030 the measures initiated up to 2013 will reduce final energy consumption to 1070 Mtoe. This is lower than the 1119 Mtoe projected by PRIMES 2013 for 2030. With the present measures introduced after 2013 included (measures already in an advanced stage of implementation or implemented in 2014) this value will only slightly drop further.

The results in the overview table provide a range for the gap from a maximum of 3.3% in primary energy terms (PRIMES 2013) to a minimum of -1.5% if all bottom-up measures identified are appropriately implemented. For final energy the range is + 3.9% (PRIMES 2013) to -2.1% for the bottom-up analysis % if all bottom-up measures identified are appropriately implemented.

The modeling analysis performed for this report confirms these results and shows that the (final) energy target is missed by a distance of around 2.3% which may be closed by providing a safety margin through the extension of existing measures and the generalisation of selected successful national measures. The primary energy target may be at a distance of 1.7% according to the assumptions in the modeling analysis. Hence assuming that the final energy target is reached assures the attainment of the primary energy target.

In total the different methods used to evaluate the 2020 (final and primary energy) targets suggest that a short safety margin may be necessary to reach them.

Table 2: Summary of Findings with respect to the 2020 gap (for EU27), including results from the PRIMES projections, the energy efficiency measure analysis, the Decomposition Analysis, and the modeling analysis performed for this report

	Distance to primary energy target		Distance to final energy target	
	Mtoe	%	Mtoe	%
PRIMES 2007 projections for 2020 on which the 20% target was derived	1842	20%	1348	20%
EED target (EU27)	1474	-	1078	-
Eurostat 2012	1573	5.4	1099	1.5
Result from PRIMES 2013 projections	1534	3.3	1130	3.9
Result from Bottom-up policy analysis (assuming that national policies are implemented as expected in the NEEAP2* and up to now)	1432	-2.3 (target overreached)	1057	-1.6 (target overreached)
Result from Bottom-up policy analysis (checking on implementation gaps)	1474	0.0 (target reached)	1086	0.6
Result from Decomposition analysis (savings rate from 2008 to 2012 with comparatively low growth)	1515	2.2	1116	2.6
Result from Decomposition analysis (average savings rate from 2000-2012 with average growth)	1504	1.6	1108	2.2
Result from Decomposition analysis (taking into account that 2007, the base year for the analysis was a warm year, even compared to the average of the past ten years)	1533	3.2	1129	3.8
Result from modelling analysis (Base_inclEA)	1504	1.7	1108	2.3

* NEEAP3 analysis from the MS was not available yet for this analysis. Our analysis is therefore, in addition to the NEEAP2 and the Notifications under Art. 7 of the EED based on the MURE database for energy efficiency which has been updated recently and interviews with energy experts in a larger number of countries (see bottom-up policy analysis).

The measures discussed in this report to close merely the gap for the 2020 target **save around 37 Mtoe additionally** to the Base_WM scenario and are:

- ***Residential/tertiary sector buildings:*** The EPBD (Recast) up to now is not fully implemented in the MSs and there are still a considerable number of open questions and some range of interpretation e.g. regarding the definition of nZEB. We assumed that MSs will implement the directive in an ambitious way to close the gap. These measures could contribute around 14.5 Mtoe to the required savings (of which two thirds in the residential sector). For details see section 5.6.1.

- ***Residential/tertiary sector appliances:*** This includes the revisions of implementing directives of the eco-design directive that are due in 2014/2015, the recast of the Labelling scheme due in 2014 and a moderate adoption of new implementing measures. Until 2020, the additional estimated saving potential of such new implementing measures is mainly driven by the current efforts to include a system approach for lighting and cooling within the policy framework of Ecodesign, EED and EPBD by 2016, leading to estimated savings of 10 TWh/year in 2020. Overall the extension of measure for residential appliances may contribute 1.4 Mtoe; additional measures for tertiary appliances contribute another 4.7 Mtoe to close the gap. For the tertiary appliances the AM scenario includes revisions of implementing directives measures (e.g. indoor lighting) of the Ecodesign Directive and extensions to new lots (e.g. ventilation and air-conditioning) in the coming years. For details see sections 5.6.2 and 5.6.3.

- ***Transport sector:*** The energy efficiency directive scenario includes four selected further transport policy measures (see section 5.6.4):

  - A road charge per vehicle-km driven on motorways for passenger cars implemented starting 2014.

  - The promotion of energy efficient public commercial vehicles in the EU from 2014 on.

  - A stimulus programme for cars older than 10 years.

  In difference to the other sectors these are not merely the extension of existing measures but rather the generalisation of successful measures existing partly at national level. In total such measures are expected to contribute around 11.3 Mtoe to close the gap to the 2020 target.

- ***Industry sector:*** Measures to close the gap in 2020 in the industrial sector include revisions of implementing directives for the Ecodesign Directive that are due in 2014/2015. They also include full implementation of the EPBD (recast) on MS level for which we assume an ambitious implementation for industrial premises particularly improving compliance with standards.

  For the Ecodesign Directive, we assume an extension to LEDs (2018), MEPS based on least-lifecycle costs for compressors (2016) and machine tools (2016), and MEPS based on Best Available Technology (BAT) for fans (2018), ventilation and air-conditioning > 12 kW (2018), circulators (2018), fans (2018) and water pumps (2018).

For policies modelled in an aggregated way (including support/obligations for energy audits, energy management, information, capacity building, procurement obligations and also voluntary agreements), a higher level of ambition is assumed across all countries. This could be promoted by so-called Learning Networks for Energy Efficiency (LEEN) among the less-energy intensive European Industries which have been experienced in Germany, Switzerland, Austria as well as outside Europe to overcome transaction costs in companies. In Germany there are at present 50 networks running grouping around 700 companies. These networks of 10-15 companies have shown that the energy efficiency path is doubled on average through such networks. In the potentials scenarios we further generalize in our modeling the use of such instruments.

Further included in the possible measures set is the structural reform proposed by the Commission to repair the ETS, resulting in an EUA price of about 35 Euros in 2030.

Measures in the industry sector are expected to contribute another 5 Mtoe to the closure of the gap to the 2020 target.

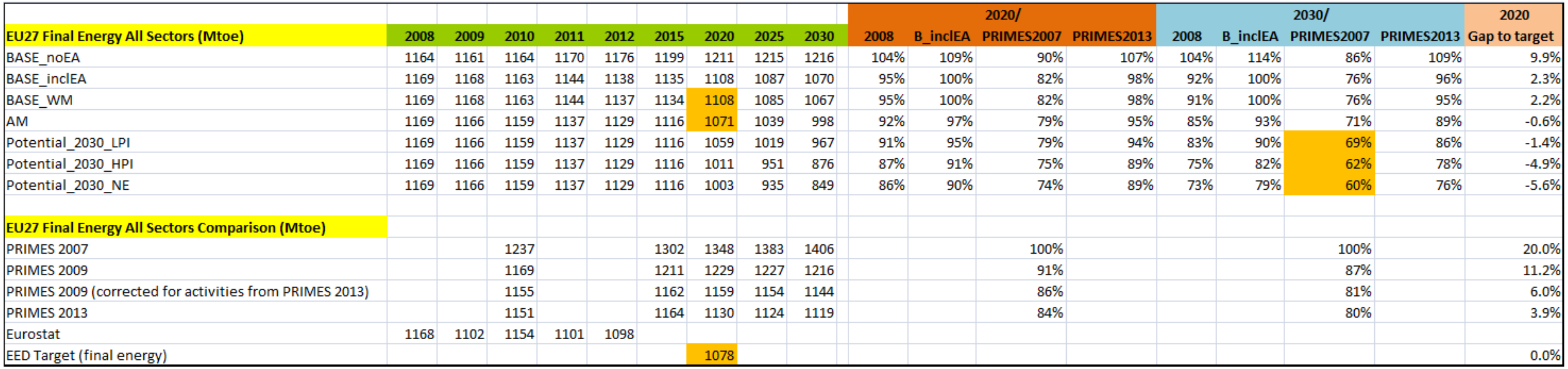
The following main messages can be extracted from the analysis for the EU27 for the time horizon 2030 for final and primary energy, as well as GHG emissions. For the analysis we assumed first that renewable would reach by 2030 a share of 27% in gross final energy consumption as proposed as a minimum value by the EU Commission. In a variant we investigated a 35% renewable share in gross final energy demand combined with higher shares of decentral CHP and 43% thermal power conversion efficiency, as well as a partial realization of economic energy efficiency potentials in view of realizing a 40% reduction in GHG emissions.

- In the High Policy Intensity Scenario, the final energy consumption could drop to 876 Mtoe, with the Near Economic scenario to 849 Mtoe, compared to a level of 1098 Mtoe reached in 2012. Compared to the present PRIMES 2013 reference development the HPI presents in 2030 additional economic savings of about 22%. Expressed in the same metric as for the 2020 target (that is compared to the PRIMES 2007 projection for 2030) the HPI achieves savings of 38%.
- The economic potentials (HPI) Scenario lead in 2030 to a level of primary energy consumption of 1160 Mtoe (using the conversion factors to primary energy from the PRIMES 2013 baseline) and to a level of 1109 Mtoe together with the projected penetration of renewables, the increased penetration of decentral CHP and a conversion efficiency for thermal power generation of 43%. This is -25% compared to the PRIMES 2013 reference development.
- In the HPI combined with a larger penetration of renewables (35% RES in final energy) and an enhanced efficiency in the conversion sector total GHG emissions can

be reduced by 49.5% compared to 1990 by realizing the economic potentials. Energy related CO_2 -emissions can be reduced by 55% compared to 1990.

- The overall economic benefits for realizing the High Policy Intensity Scenario as described in this report are in the range of 22-27 billion Euro annually on average up to 2030 for targets in the range of 30-34%, for the LPI in the range of 13-14 billion Euro. These benefits can largely compensate for the /rather modest additional costs as compared to renewable if RES targets in the range of 30-35% are envisaged as compared to the presently envisaged 27%.
- In order to realize a 40% GHG reduction target by 2030 less than 50% of economic potentials need to be mobilized.
- In case that near economic potentials are realized, final energy can be reduced by 24% compared to the PRIMES 2013 baseline.

Table 3: Overview of scenarios and potentials for final energy consumption in the EU27 up to 2020 (Mtoe)



										2020/				2030/				2020
EU27 Final Energy All Sectors (Mtoe)	**2008**	**2009**	**2010**	**2011**	**2012**	**2015**	**2020**	**2025**	**2030**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**Gap to target**
BASE_noEA	1164	1161	1164	1170	1176	1199	1211	1215	1216	104%	109%	90%	107%	104%	114%	86%	109%	9.9%
BASE_inclEA	1169	1168	1163	1144	1138	1135	1108	1087	1070	95%	100%	82%	98%	92%	100%	76%	96%	2.3%
BASE_WM	1169	1168	1163	1144	1137	1134	1108	1085	1067	95%	100%	82%	98%	91%	100%	76%	95%	2.2%
AM	1169	1166	1159	1137	1129	1116	1071	1039	998	92%	97%	79%	95%	85%	93%	71%	89%	-0.6%
Potential_2030_LPI	1169	1166	1159	1137	1129	1116	1059	1019	967	91%	95%	79%	94%	83%	90%	69%	86%	-1.4%
Potential_2030_HPI	1169	1166	1159	1137	1129	1116	1011	951	876	87%	91%	75%	89%	75%	82%	62%	78%	-4.9%
Potential_2030_NE	1169	1166	1159	1137	1129	1116	1003	935	849	86%	90%	74%	89%	73%	79%	60%	76%	-5.6%
EU27 Final Energy All Sectors Comparison (Mtoe)																		
PRIMES 2007			1237			1302	1348	1383	1406			100%				100%		20.0%
PRIMES 2009			1169			1211	1229	1227	1216			91%				87%		11.2%
PRIMES 2009 (corrected for activities from PRIMES 2013)			1155			1162	1159	1154	1144			86%				81%		6.0%
PRIMES 2013			1151			1164	1130	1124	1119			84%				80%		3.9%
Eurostat	1168	1102	1154	1101	1098													
EED Target (final energy)							1078											0.0%

Notes:

- The difference with Eurostat in the years 2008 to 2012 is largely due to the fact that Eurostat values not corrected for annual climatic variations, while the figures of the projections are normalized to 2005 (which was slightly colder than the average of the past ten years). For that reason warmer years such as 2009, 2011 and 2012 deviate stronger from the projections.

- The scenarios are also compared for 2020/2030 with 2008, with the Base_inclEA (which is considered here as the main baseline scenario and which is comparatively close to the recent PRIMES 2013 projections), with PRIMES 2013 and with the older PRIMES 2007 projections (which were used to establish the 20% energy efficiency target for 2020 and which were established before the financial and economic crisis which started 2008).

- The last column measures the gap to the 20% target. The percentage points for the gap refer here to the difference between the PRIMES 2007 projection of final energy of 1348 Mtoe in 2020 and the target of 1074 Mtoe in final energy. The total gap corresponds to 20%.

Table 4: Overview of scenarios and potentials for primary energy consumption in the EU27 (Mtoe)

											2020/				2030/				2020
EU27 Primary Energy All Sectors (Mtoe, excl. non-energy uses)	**2008**	**2009**	**2010**	**2011**	**2012**	**2015**	**2020**	**2025**	**2030**		**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**Gap to targe**
BASE_noEA	1682	1681	1669	1696	1697	1667	1644	1626	1611		98%	109%	89%	107%	96%	114%	86%	109%	9.2%
BASE_inclEA	1689	1691	1668	1658	1641	1578	1504	1454	1418		89%	100%	82%	98%	84%	100%	76%	96%	1.7%
BASE_WM	1689	1691	1667	1658	1641	1577	1503	1452	1413		89%	100%	82%	98%	84%	100%	75%	95%	1.6%
AM	1689	1688	1661	1649	1629	1552	1453	1390	1322		86%	97%	79%	95%	78%	93%	71%	89%	-1.1%
Potential_2030_LPI	1689	1688	1661	1649	1629	1552	1437	1363	1281		85%	95%	78%	94%	76%	90%	68%	86%	-2.0%
Potential_2030_LPI (+27%RES;44% RES-E;41% thermal electric eff.)	1689					1552	1437	1351	1252		85%	95%	78%	94%	74%	88%	67%	84%	-2.0%
Potential_2030_HPI	1689	1688	1661	1649	1629	1552	1373	1272	1160		81%	91%	75%	89%	69%	82%	62%	78%	-5.5%
Potential_2030_HPI (+35%RES;47% RES-E;43% thermal electric eff.)	1689					1552	1364	1243	1109		81%	91%	74%	89%	66%	78%	59%	75%	-6.0%
Potential_2030_NE	1689	1688	1661	1649	1629	1552	1361	1251	1125		81%	90%	74%	89%	67%	79%	60%	76%	-6.1%
Potential_2030_NE (+35%RES;55% RES-E;45% thermal electric eff.)	1689					1552	1340	1198	1042		79%	89%	73%	87%	62%	73%	56%	70%	-7.3%
EU27 Primary Energy (Mtoe, excl. non-energy uses)																			
PRIMES 2007			1738			1807	1842	1868	1873				100%				100%		20.0%
PRIMES 2009			1655			1677	1664	1654	1635				90%				87%		10.3%
PRIMES 2009 (corrected for activities from PRIMES 2013)			1636			1610	1569	1556	1538				85%				82%		5.2%
PRIMES 2013			1645			1619	1534	1504	1482				83%				79%		3.3%
Eurostat	1689	1595	1654	1597	1584														
EED Target (primary energy)							1474												0.0%

Notes:

- See the notes in Table 3
- The last column measures the gap to the 20% target. The percentage points for the gap refer here to the difference between the PRIMES 2007 projection of primary energy of 1842 Mtoe in 2020 and the target of 1478 Mtoe in primary energy. The total gap corresponds to 20%.
- The final energy scenarios LPI, HPI and NE are combined with supply scenarios which go beyond the PRIMES 2013 baseline:
  - LPI scenario: refurbishment of existing thermal power plants; renewables share at 27% (44% RES-E). Conversion efficiency of thermal power plants at 41% in 2030.
  - HPI scenario: electric conversion efficiency of thermal power generation at 43% through use of decentral CHP that support renewables by offering flexibility services, the installation of the most efficient coal and gas-fired power plants when it comes to reinvestment, and raising the share of RES to 35% (47% RES-E).
  - NE scenario: electric conversion efficiency of thermal power generation at 45% implying larger use of gas-fired CCGT plants and of decentral co-generation schemes together with a RES-E corridor of up to 55% by 2030 for the European power mix.

2 Objective of this Report

The *"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"* has two main objectives:

- On one hand, it shall report on the evaluation of the achievement of the 2020 energy efficiency target of 20% reduction in primary energy as compared to the reference development fixed by the PRIMES projections from 2007;
- On the other hand, it shall discuss energy efficiency potentials in two different time horizons (2020, 2030).

For this purpose we carried out the following tasks:

- Assessment of the effectiveness of a target selection of national measures and policies up to 2020 (**Bottom-up policy analysis** of Art. 3 of the EED, see Chapter 3).
- **Decomposition analysis** of past energy efficiency achievements (2000-2012 and 2008-12) based on Eurostat data and projection to 2020 (see Chapter 4)
- **Bottom-up modelling analysis of policies up to 2020** based on national and EU policies (see Chapter 5)
- **Bottom-up modelling of energy efficiency potentials up to 2030** (see Chapter 5)

The 2020 targets of Art. 3 of the Energy Efficiency Directive EED[1] was laid down as follows for the EU27 :

- the Union's 2020 energy consumption has to be no more than 1 474 Mtoe of primary energy or no more than 1 078 Mtoe of final energy

In the meantime Croatia entered the EU to form the EU28. With the accession of Croatia the target was revised to **"1 483 Mtoe primary energy or no more than 1 086 Mtoe of final energy"**[2].

This report evaluates therefore from a bottom-up perspective the amount of savings to be induced by the measures undertaken by the EU and the Member States and contributes thus to the reporting requirements of the EU Commission in the frame of the EED.

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[1] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on Energy Efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC

[2] Adaptation of the Energy Efficiency Directive 2012/27/EU: Directive 2013/12/EU
http://ec.europa.eu/energy/efficiency/eed/eed_de.htm

The report further evaluates the policy options up to 2030, in particular by the modeling based analysis of energy efficiency potentials up to 2030 but also by the analysis of the energy efficiency potentials in the frame of a possible 2030 target system comprising renewable and greenhouse gas emission targets.

The report is structured as follows:

- Chapter 3 presents the Bottom-up Policy Analysis of the Art. 3 EED Gap to Target.
- Chapter 4 presents the Decomposition Analysis of the progress to the Art. 3 EED Targets.
- Chapter 5 presents the model-based assessment of the 2020 gap and of options to close the gap, as well as of the potentials and policy options until 2030.

3 Bottom-up Policy Analysis of Art. 3 EED Gap to Target

This chapter presents the assessment of the effectiveness of a target selection of national measures and policies up to 2020 (Bottom-up policy analysis of Art. 3 of the EED).

3.1 Methodology

Data sources

The analysis underlying this report was based on three main sources of information:

- The **second National Energy Efficiency Action Plans NEEAP 2**[3], which is the latest systematic source of information available on energy efficiency policies. The third NEEAPs will only become available starting end of April 2014. The information contained in this report may then be updated with the third NEEAPs available until the end of the project.
- **Article 7 notifications**[4]**:** Member States had to notify by 5 December 2013 their plans, proposed measures and detailed methodologies for the implementation of Article 7 and Annex V of the Energy Efficiency Directive.
- The **MURE database**[5] on energy efficiency policies which has been developed by 30 energy efficiency agencies headed by ADEME (France) under the Intelligent Energy for Europe Programme. This database provides information on more than 2000 energy efficiency measures across all member states and has been updated recently. The MURE database and the Article 7 notifications were used in addition to the NEEAP 2 reports in order to complete the NEEAP2 with the most recent information on energy efficiency measures available.

By the time of the analysis the information comprised in the NEEAP3, which are just submitted at present, was not yet available.

We have developed a combined database of national energy efficiency measures from these main sources, containing as much **quantitative impacts** in energy terms on measures starting from 2008 (i.e. where impacts arise essentially from 2009 onwards) . The starting date 2008 was chosen, as this was the starting year of the Energy Service Directive ESD from 2006 and is equally the starting point of the EED (when considering

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[3] http://ec.europa.eu/energy/efficiency/eed/neep_en.htm

[4] http://ec.europa.eu/energy/efficiency/eed/article7_en.htm

[5] http://www.odyssee-mure.eu/

Early Action which is admitted under the EED from 2008 onwards). **This excludes in particular all measures that have been considered as “Early Action under the ESD that is measures initiated from 1995 onwards and before 2008, as those are part of the baseline. In some member states quite substantial amounts of the impacts reported in the NEEAP 2 was Early Action in that sense.**

The basic methodology of this bottom-up analysis of policies was that the impacts of each measure or package of measures is gathered in final energy terms for the time horizons 2016 and (as far as available) 2020. If 2020 was not available from this analysis, the savings were in some cases extrapolated to 2020 from the available information for 2010 and 2016, as well as on the starting year of the measure. Care had to be taken that some of the measure packages were not evaluated by the Member States in a bottom-up approach which yields more realistic impact evaluations but using top-down methods as developed under the ESD. The top-down approach based on energy efficiency indicators does not only include the measure impacts alone but also autonomous improvement of energy efficiency as well as the impacts of previous policies. Hence they overestimate the levels of impact, frequently by a factor of 2 or more. In principle it is possible to correct for this also in the top-down approach but under the ESD the decision was taken not to correct for autonomous changes. However, as these are part of the baseline, impact estimates by the Member States based on this approach had to be corrected in order to get a reliable picture of whether the 2020 energy efficiency targets will be met. The correction was based on information provided in the NEEAPs. Some countries specified for example both top-down and bottom-up results. Typically, the top-down approach doubles the savings achieved, as the autonomous energy efficiency progress is on average already 1% per year. In other case an estimate of the autonomous progress was used for the correction based on the Odyssee indicators for energy efficiency[6].

Initially not yet included was some correction of the estimated impacts if from the current perspective the measure may have less impact in 2020 than estimated in the NEEAPs. Later on, we circulated for the most important measures for a selected number of EU countries with the energy efficiency agencies involved in the Odyssee-MURE project) (see the website in the footnote) to get a good understanding of the real implementation of the measures.

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[6] www.odyssee-mure.eu

Approach for the verification of the state of implementation and enforcement of national key legislation

In the frame of this study we made contacts with national experts from the Odyssee-MURE network on energy efficiency to check with them the status of national implementation and enforcement of national key legislation. The exchange with the experts occurred with telephone interviews and/or email exchanges in the period of March to beginning of April 2014. The choice of countries occurred so to cover most of the final energy consumption and related measures in the European Union. In total **91.5% of final energy consumption of the European Union (EU27)** was covered through such an exchange. The verification tried to understand whether the expected impact of the measures was realistic or whether due to delayed implementation or changes in the design of the measure the impact may be lower. We focused on measures with the largest expected impacts. The list of the measures checked is provided in **Country Annex 1** (measures with an updated impact estimate).

The following 15 countries were covered by the verification:

- Austria
- Belgium
- Denmark
- Czech Republic
- Finland
- France
- Germany
- Italy
- Latvia
- Poland
- Netherlands
- Romania
- Spain
- Sweden
- UK

For the remaining countries covering 8.5% of EU final energy consumption we preceded based on impact assessment data available in the three sources mentioned previously and the methodology used by the countries to establish the impacts.

3.2 A bottom-up summary of national impact estimates for energy efficiency measures

The results of the interviews show that a variety of measures may have a lower impact as expected due to a lower than expected degree of implementation or delays. In this section we discuss briefly which type of measures may have less impact than expected and why. A more complete overview on the measures is provided in Country Annex 1.

General observation:

- Many countries have notified energy saving obligations under Art. 7. This is notably the case of: Bulgaria, Hungary, Lithuania, Luxembourg, Malta, Slovakia and Slovenia. Together with the existing 6 obligation schemes (see below), another 7 countries or more may introduce such schemes so that more than half of the EU MS may take advantage of such schemes. However, the introduction of the intended obligation system requires transition time which seems to be underestimated by many MS given the experience from the existing schemes with time it may take to introduce such a rather complex scheme. Start may in many cases only be in 2015, with major results only in 2016 possible. While in principle it could be feasible that the schemes may take up more speed after 2016 the time to 2020 seems short to recover the grounds lost during the transition period.
- Already introduced have such schemes been in the Belgium (Flanders), Denmark, France, Italy, Poland, UK. Also for those countries partly substantial discounts have to be made for the obligations. Example is Poland, which has introduced such schemes starting from 2013 onward. However, due to a slow start with the tender system it is rather unlikely that the expected impacts will be achieved by 2020. For the experts at national level substantial reductions in impacts appear as likely unless they can be recovered on a later phase of the scheme. Another example is Denmark where for the Energy-policy agreement of 22 March 2012: Update of the Energy Companies' saving effort high overlap with other measures is likely.
- In a variety of cases overlaps between measures do exist and do reduce the measure impacts though countries quite often consider overlaps explicitly in the NEEAPs.
- A last general issue is the impact of the financial and economic crisis on subsidy programmes in a variety of countries which has led to the cutting of subsidies.

Austria

- Austria has comparatively few measures evaluated individually in a quantitative manner. For the national recovery plan / renovation voucher, as an important measure, the Art. 7 Report assumes for the moment only a continuation of this measure but not an expansion as originally projected.

Belgium

- Flanders has the energy policy agreements with companies operating under the verifiable emission reduction (VER) system, as well as the Energy policy agreement with companies not operating under the verifiable emission reduction (VER) system. The settings for this measure include non-negligible amounts of autonomous progress.

Bulgaria:

- The introduction of the intended obligation system requires transition time. Start may only be in 2015, with major results only in 2016 possible.

Croatia

- As Croatia is new in the EU, we mainly took up in our estimates the figures given in the Art. 7 notification of the country as they are.

Cyprus

- There could be overlap between measures, e.g. between a measure aiming at smart meters (in reaction to which insulation is installed) and building regulation/subsidy programmes.

Czech Republic

- New updates became available for the country such as energy and CO_2 taxes. For the moment there are no indications on reduced measure impacts.

Denmark

- Danish saving obligations have a rather high overlap with other types of measures such as regulation and subsidy schemes.

Estonia

- New updates became available for the country such as the 2014-2020 New Green Savings Programme. For the moment there are no indications on reduced measure impacts.

Finland

- There are indications of some measures performing less well than expected, for example emission performance standards for new passenger cars could possibly perform lower due to car sales going down,
- Energy efficiency measures in server halls smaller savings are expected in NEEAP3.
- Energy Efficiency Agreement for Public Transport 2008-2016 overlaps with eco-driving

France:

- In France new estimates for NEEAP3 indicate that the expected savings could be lower as previously assumed, among others for the contribution clima-energie.
- Further, the measure estimates include partly double counting among measures: (i) Notably there are strong overlaps between the White Certificate Scheme and Tax deductions (ii) The thermal renovation plan for existing buildings has less impact than accounted for. Renovations are at present only at a quarter of the expected figure of 500000 renovations per year. (iii) Further, the French Ecotax for lorries was not implemented so far.

Germany

- Germany operated in the NEEAPs typically with rather important discount factors for measures with uncertainties. For the moment the expected impacts seem mostly on track.

Greece

- Greece had little quantitative impact assessments so far. The NEEAP 2 and the notification for Art. 7 provide only aggregated estimates which makes it hard to evaluate the impacts in detail.

Hungary

- The introduction of the intended obligation system requires transition time. Start may only be in 2015, with major results only in 2016 possible. Also there could be substantial overlaps between the planned obligation scheme and other measures.

Ireland

- For Ireland a variety of measures are not quantified. For the moment there are no indications on reduced measure impacts for the ones which have quantitative impact assessments.

Italy

- For the measure on fiscal incentives for energy savings in the household sector: Ecobonus 2014 and tax deduction for renovations and appliances, the impact estimate also includes early action.
- For the White Certificate Scheme there is overlap with the tax deduction scheme quite likely, similar to France.

Latvia

- Impacts of financial measures such as Investments in Municipal Public Buildings' Energy Efficiency to Reduce GHG emissions, Investments in Complex Solutions for GHG Emissions Reduction in Professional Education Institutions Buildings & Investments in Higher Education Institutions Buildings' Energy Efficiency to Reduce GHG emissions etc. is overestimated to a lower subsidy budget available.
- Improving minimum energy efficiency requirements for buildings: overestimate of impacts due to lower annual construction rates as expected.

Lithuania

- The introduction of the intended obligation system requires transition time. Start may only be in 2015, with major results only in 2016 possible. Also there could be substantial overlaps between the planned obligation scheme and other measures.

Luxemburg

- The introduction of the intended obligation system requires transition time. Start may only be in 2015, with major results only in 2016 possible. Also there could be substantial overlaps between the planned obligation scheme and other measures.

Malta

- The introduction of the intended obligation system requires transition time. Start may only be in 2015, with major results only in 2016 possible. Also there could be substantial overlaps between the planned obligation scheme and other measures.

Netherlands

- Measures related to voluntary agreements do usually include non-negligible amounts of autonomous progress as evaluations of the Dutch Long-term Agreements have shown

Poland

- Poland, which has introduced such schemes starting from 2013 onward. However, due to a slow start with the tender system it is rather unlikely that the expected impacts will be achieved by 2020. For the experts at national level substantial reductions in impacts appear as likely unless they can be recovered on a later phase of the scheme.

- New updates for NEEAP3 see lower impacts for measures such as
  - Priority Programme “Efficient use of energy. Part II” - Soft loans support for investments decreasing energy consumption,
  - 2007 to 2013 Infrastructure and Environment Operations Programme and Regional Operations Programme - Activity 9.1,
  - Traffic management system and transport of goods optimization
  - Information campaigns, training and education. This measure for example in simple information on measures on websites without particular campaigns. Measure impact seems largely overestimated which is also confirmed by new estimates for NEEAP 3.

Portugal

- The country uses top-down estimates for measure impacts without correction for autonomous progress. This leads to rather substantial overestimation of impacts.

Romania

- Romania has provided little information on quantitative impacts of individual measures. According to Art. 7 notifications it aims at alternative policy measures for the implementation of Art. 7 (EED) but provides little insight in the details and the implementation planning which does not take into account delays in the introduction of measures.

Slovakia

- The introduction of the intended obligation system requires transition time. Start may only be in 2015, with major results only in 2016 possible. Also there could be substantial overlaps between the planned obligation scheme and other measures.

Slovenia

- The introduction of the intended obligation system requires transition time. Start may only be in 2015, with major results only in 2016 possible. Also there could be substantial overlaps between the planned obligation scheme and other measures.

Spain

- Many of the activities underlying the impact estimates of NEEAP2 are considerably lower than the estimated impacts due to the economic crises. However, no corrections have been made so far. So the estimates of Spain, even after some correction for such type effects, still seems rather high compared to other countries.

Sweden

- The country provides only aggregate information on measure impacts. For the moment there are no indications on reduced measure impacts.

UK

- The Green Deal was seen as a measure with substantially lower impact as originally expected. The main reason could be the slow observed uptake as a consequence of the rather high discount rates used by the green dealers
- Similar the Suppliers obligations - Carbon Emissions Reduction Target (CERT) may have reduced impacts as some of the actions taken may have been less effective, for example 17% of the saving measures were saving lamps, which were partly not used (known from evaluations).
- The new Supplier Obligations - Energy Company Obligation (ECO) has also partly to be reduced in the impact estimates, given the fact that from three sub-targets in the obligation, one was recently reduced by 33%.

3.3 A bottom-up analysis of the contribution of energy efficiency measures to the primary energy target of Article 3 (EED)

This section analysis the contribution of energy efficiency measures to the final energy target of Article 3 (EED). The final energy target to be reached by the EU27 [8] in 2020 is 1474 Mtoe.

By 2020 energy savings may contribute 72.8 Mtoe in final energy terms and 101.1 Mtoe in primary energy terms. Based on the literature review of the three main sources of information the impacts found BEFORE verification were 101.9 Mtoe (final energy) and 141.3 Mtoe (primary energy) respectively. This means that roughly a good quarter of the estimated impacts may not materialize until specific efforts are made to overcome the obstacles to implementation. These figures have to be understood beyond a baseline which does only contain the measures up to 2008 including which is the case of the PRIMES (2009) projections[7]. Electricity savings were established separately and converted to primary energy with national electricity conversion factors from the PRIMES (2013) baseline or 2020. This contains a further penetration of renewables in the power mix. Further, the activity levels for energy consumption were updated in

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[7] In fact, the PRIMES 2009 Baseline includes measures up to April 2009 but the uncertainty of four months starting from early 2009 cannot be dissolved in the frame of this work. It is, however, expected that the impact on the results should be comparatively limited. The PRIMES 2009 Baseline has to be distinguished from the PRIMES 2009 Reference Scenario which contains measures until the end of 2009.

the PRIMES 2009 projections for the developments of the most recent PRIMES 2013 projections.

This section analysis the contribution of energy efficiency measures to the primary energy target of Article 3 (EED). In Art. 2 (EED) primary energy is defined as:

‘primary energy consumption’ means gross inland consumption, excluding non-energy uses;

We will use this definition throughout the report. The primary energy target to be reached by the EU27[8] in 2020 is 1474 Mtoe.

Figure 5 shows how these bottom-up energy efficiency impacts contribute to reach the 2020 primary energy target. The following curves are shown in this figure:

- First the original PRIMES (2007), which served to establish the 20% reduction target. This was a pre-economic crisis baseline and reached hence substantially higher values of primary energy consumption in 2020. Also the impacts of a variety of drivers was overestimated, independent from the economic crisis, so for example in transport. The impacts of renewables which have a lowering impact on primary energy due to the fact that a variety of renewable are accounted with 100% conversion efficiency, was under-estimated.
- From this original PRIMES (2007) projection the target of -20% was calculated which gives a value of 1474 Mtoe (for the EU27). This is indicated by the red line in the curve and by one of the lowest curves in the figure.
- Further in the graph are the PRIMES (2009) projections which already integrated to some degree the impacts of the economic crisis and correct also to some degree the other factors mentioned above. We used this as the baseline for our bottom-up evaluation of policies.
- However, given the fact that the drivers in PRIMES (2013) were further less strong than in PRIMES (2009) we converted the PRIMES (2009) figures with the new drivers from PRIMES (2013) at sectoral level (green curve in the graph). This brings us to a value of 1608 Mtoe primary energy in 2020.
- If then we take into account that renewable seem to be on-track to reach the 20% renewable target, which was not supposed in the PRIMES (2009) baseline but seems to be confirmed by recent in-depth evaluation of renewable energy policies, a value of 1573 Mtoe is reached.

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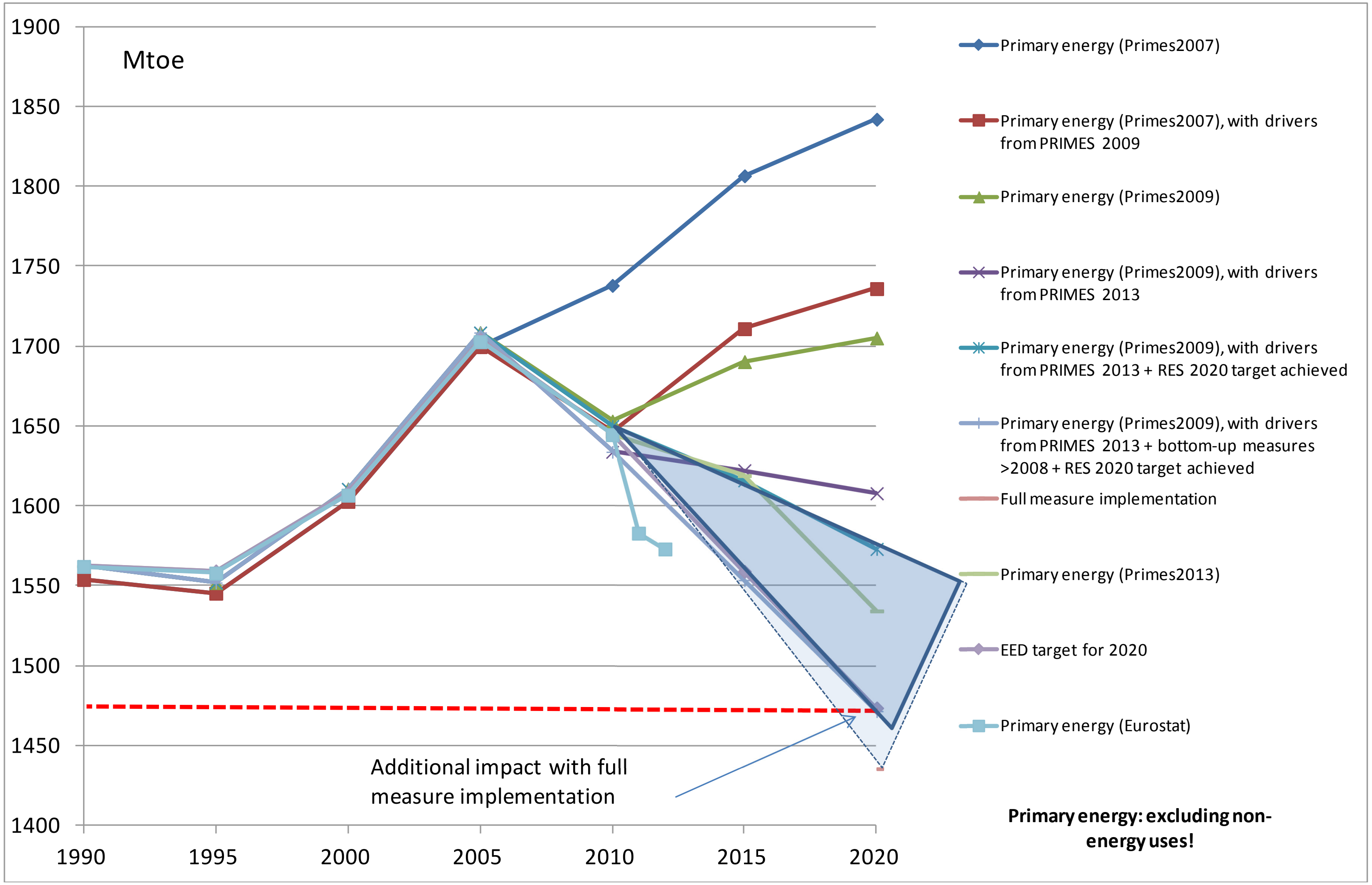
[8] In the meantime Croatia entered the EU to form the EU28. With the accession of Croatia the target was revised to "1 483 Mtoe primary energy or no more than 1 086 Mtoe of final energy".

- On that corrected baseline which comprises energy efficiency measures up to 2008 and integrates changes in drivers up to present but not energy efficiency measures beyond 2008 we applied our bottom-up estimate of energy efficiency policy impacts (corrected for delayed or incomplete implementation, early action or autonomous progress) of 101.1 Mtoe which brings us down to a value of 1472 Mtoe, hence close to the 2020 target of 1474 Mtoe.
- The Figure further shows that if the measures would be implemented as projected (138.3 Mtoe), a level of 1432 Mtoe could be reached, hence beyond the 2020 target for primary energy. However, some of the measures that are proposed for 2014 such as many energy saving obligations proposed in the Art. 7 notifications are still under development and it is rather unlikely that they can deliver the expected results in 2014 or even 2015. Introducing such new instruments takes time for learning as show the existing schemes. Hence, the new schemes must then be more ambitious in the second period to recover the grounds lost.
- The Figure further shows the PRIMES (2013) projections themselves which stay with 1534 Mtoe somewhat above the target value of 1474 Mtoe.
- The figure also shows the Eurostat figures for primary energy up to 2011 and an estimate for the 2012 values from the ENERDATA database which is based on national statistics (we used the growth rate from 20011 to 2012 instead of the absolute values. The development of the statistics seems to confirm that the path to 2020 is a bit lower than estimated by PRIMES (2013).

Figure 5: Contribution of energy efficiency measures to the **primary** energy target of Article 3 (EED)



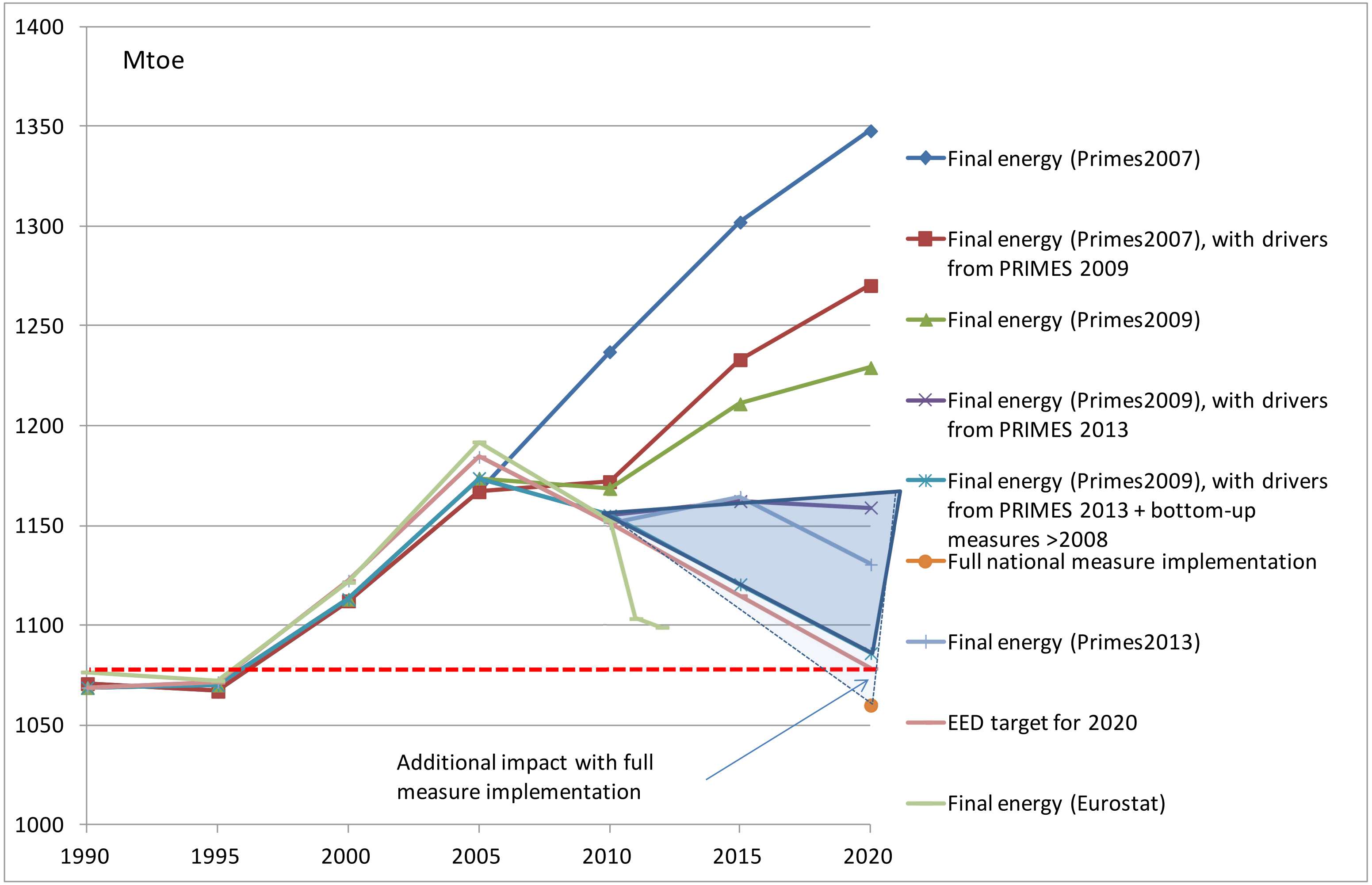
3.4 A bottom-up analysis of the contribution of energy efficiency measures to the final energy target of Article 3 (EED)

This section analysis the contribution of energy efficiency measures to the final energy target of Article 3 (EED). The final energy target to be reached by the EU27 [8] in 2020 is 1078 Mtoe.

Figure 5 shows how these bottom-up energy efficiency impacts contribute to reach the 2020 final energy target. The following curves are shown in this figure:

- First the original PRIMES (2007), which served to establish the 20% reduction target. Again this curve is higher for the same reasons as specified for primary energy.
- From this original PRIMES (2007) projection the final energy target of -20% was calculated which gives a value of 1078 Mtoe (for the EU27). This is indicated by the red line in the curve and by one of the lowest curves in the figure.
- Further in the graph are the PRIMES (2009) projections which already integrated to some degree the impacts of the economic crisis and correct also to some degree the other factors mentioned above. We used this as the baseline for our bottom-up evaluation of policies.
- However, given the fact that the drivers in PRIMES (2013) were further less strong than in PRIMES (2009) we converted the PRIMES (2009) figures with the new drivers from PRIMES (2013) at sectoral level (green curve in the graph). This brings us to a value of 1159 Mtoe final energy in 2020.
- On that baseline which comprises energy efficiency measures up to 2008 and integrates changes in activity levels up to present but not energy efficiency measures starting 2008 we applied our bottom-up estimate of energy efficiency policy impacts (corrected for delayed or incomplete implementation, early action or autonomous progress) of 73.2 Mtoe which brings us down to a value of 1086 Mtoe, **hence still at a small distance to the final energy 2020 target of 1078 Mtoe.**
- The Figure further shows that if the measures would be implemented as projected (101.9 Mtoe), a level of 1057 Mtoe could be reached, hence beyond the 2020 target for primary energy of 1078 Mtoe in the EU27.
- The Figure further shows the PRIMES (2013) projections themselves which stay with 1130 Mtoe somewhat above the target value of 1078 Mtoe.
- The figure also shows the Eurostat figures for primary energy up to 2011 and an estimate for the 2012 values from the ENERDATA database which is based on national statistics (we used the growth rate from 20011 to 2012 instead of the absolute values. The development of the statistics seems to confirm that the path to 2020 is a bit lower than estimated by PRIMES (2013).

Figure 6: Contribution of energy efficiency measures to the **final** energy target of Article 3 (EED)



3.5 Conclusion

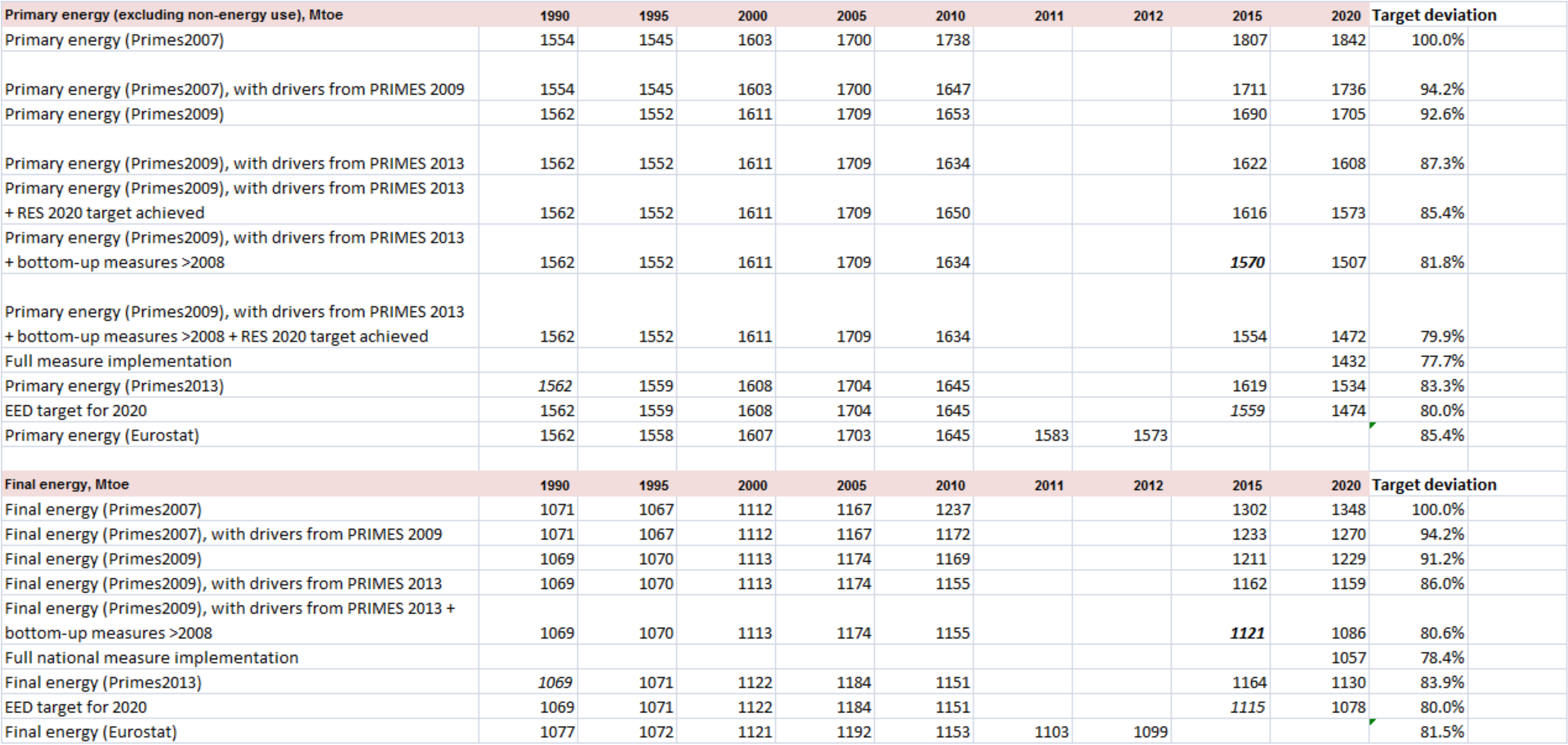
In conclusion the analysis (see Table 5) shows

- **that the 2020 primary energy target is just about to be reached after having adjusted for incomplete measure implementation, while the final energy targets under the EED may likely to be missed by 0.6 percentage points (referring to the original 20% gap) with the presently introduced policies.**
- **IF the measures would be implemented as originally expected by the EU Member States, both targets may be exceeded.**

It is important to underline that while in most cases we have taken a conservative approach, when evaluating the possible incomplete measure implementation, cases where left, where there is still some uncertainty left in the reality of the impacts to be achieved. However, these doubts could not be substantiated enough to decrease the impacts further.

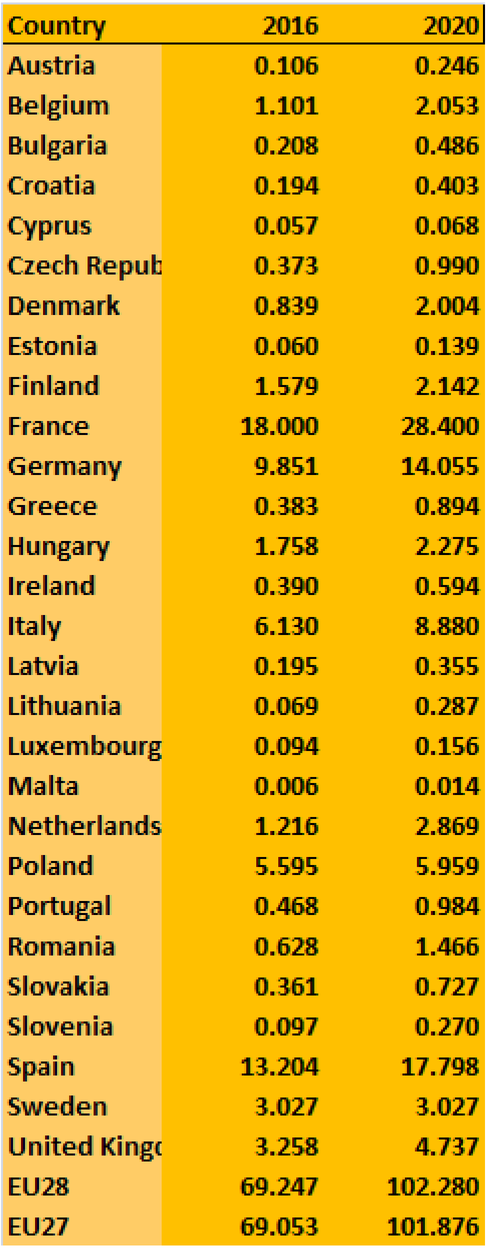
Table 6 shows in an overview table the updated impact evaluation for the different countries. Country Annex 1 shows the detailed measure set investigated based on the three data sources. For some countries measure sets had to be grouped in sectoral measure packages because the country only showed combined results. However, even in those cases the changes in impacts of the measure package were part of the validation process.

Table 5: Overview of primary and final energy developments according to different projections and integrating the impacts of a bottom-up evaluation of energy efficiency policies based on the NEEAP 2, the Art. 7 notifications and the MURE database on energy efficiency

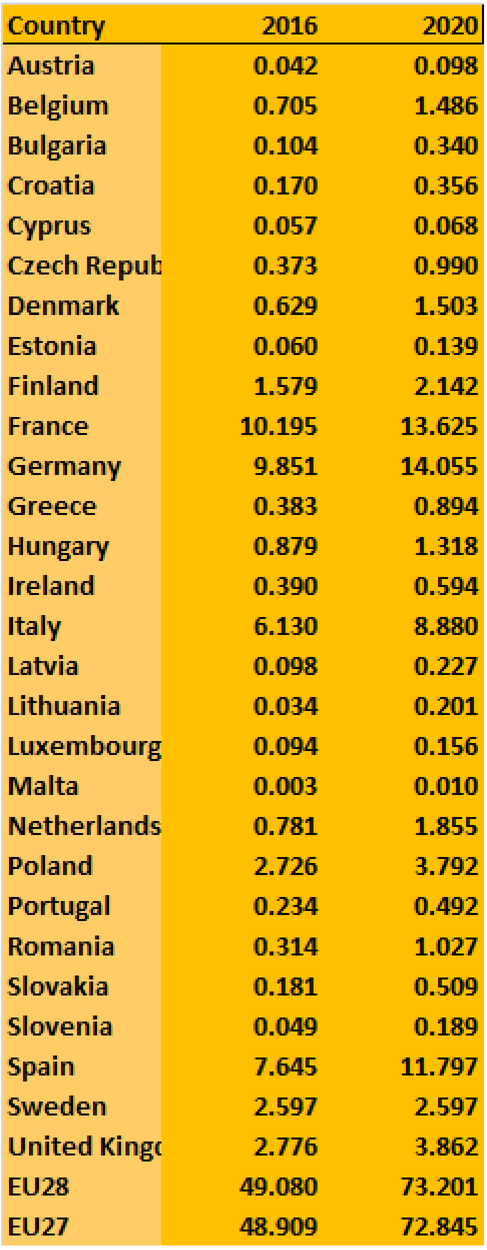


Primary energy (excluding non-energy use), Mtoe	**1990**	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2015**	**2020**	**Target deviation**
Primary energy (Primes2007)	1554	1545	1603	1700	1738			1807	1842	100.0%
Primary energy (Primes2007), with drivers from PRIMES 2009	1554	1545	1603	1700	1647			1711	1736	94.2%
Primary energy (Primes2009)	1562	1552	1611	1709	1653			1690	1705	92.6%
Primary energy (Primes2009), with drivers from PRIMES 2013	1562	1552	1611	1709	1634			1622	1608	87.3%
Primary energy (Primes2009), with drivers from PRIMES 2013 + RES 2020 target achieved	1562	1552	1611	1709	1650			1616	1573	85.4%
Primary energy (Primes2009), with drivers from PRIMES 2013 + bottom-up measures >2008	1562	1552	1611	1709	1634			***1570***	1507	81.8%
Primary energy (Primes2009), with drivers from PRIMES 2013 + bottom-up measures >2008 + RES 2020 target achieved	1562	1552	1611	1709	1634			1554	1472	79.9%
Full measure implementation									1432	77.7%
Primary energy (Primes2013)	*1562*	1559	1608	1704	1645			1619	1534	83.3%
EED target for 2020	1562	1559	1608	1704	1645			*1559*	1474	80.0%
Primary energy (Eurostat)	1562	1558	1607	1703	1645	1583	1573			85.4%
Final energy, Mtoe	**1990**	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2015**	**2020**	**Target deviation**
Final energy (Primes2007)	1071	1067	1112	1167	1237			1302	1348	100.0%
Final energy (Primes2007), with drivers from PRIMES 2009	1071	1067	1112	1167	1172			1233	1270	94.2%
Final energy (Primes2009)	1069	1070	1113	1174	1169			1211	1229	91.2%
Final energy (Primes2009), with drivers from PRIMES 2013	1069	1070	1113	1174	1155			1162	1159	86.0%
Final energy (Primes2009), with drivers from PRIMES 2013 + bottom-up measures >2008	1069	1070	1113	1174	1155			***1121***	1086	80.6%
Full national measure implementation									1057	78.4%
Final energy (Primes2013)	*1069*	1071	1122	1184	1151			1164	1130	83.9%
EED target for 2020	1069	1071	1122	1184	1151			*1115*	1078	80.0%
Final energy (Eurostat)	1077	1072	1121	1192	1153	1103	1099			81.5%

Table 6: Overview of original impact estimates (left) and updated impacts of efficiency policies (right) in the different EU Member States (in Mtoe)



Country	2016	2020
Austria	0.106	0.246
Belgium	1.101	2.053
Bulgaria	0.208	0.486
Croatia	0.194	0.403
Cyprus	0.057	0.068
Czech Repub	0.373	0.990
Denmark	0.839	2.004
Estonia	0.060	0.139
Finland	1.579	2.142
France	18.000	28.400
Germany	9.851	14.055
Greece	0.383	0.894
Hungary	1.758	2.275
Ireland	0.390	0.594
Italy	6.130	8.880
Latvia	0.195	0.355
Lithuania	0.069	0.287
Luxembourg	0.094	0.156
Malta	0.006	0.014
Netherlands	1.216	2.869
Poland	5.595	5.959
Portugal	0.468	0.984
Romania	0.628	1.466
Slovakia	0.361	0.727
Slovenia	0.097	0.270
Spain	13.204	17.798
Sweden	3.027	3.027
United King	3.258	4.737
EU28	69.247	102.280
EU27	69.053	101.876



Country	2016	2020
Austria	0.042	0.098
Belgium	0.705	1.486
Bulgaria	0.104	0.340
Croatia	0.170	0.356
Cyprus	0.057	0.068
Czech Repub	0.373	0.990
Denmark	0.629	1.503
Estonia	0.060	0.139
Finland	1.579	2.142
France	10.195	13.625
Germany	9.851	14.055
Greece	0.383	0.894
Hungary	0.879	1.318
Ireland	0.390	0.594
Italy	6.130	8.880
Latvia	0.098	0.227
Lithuania	0.034	0.201
Luxembourg	0.094	0.156
Malta	0.003	0.010
Netherlands	0.781	1.855
Poland	2.726	3.792
Portugal	0.234	0.492
Romania	0.314	1.027
Slovakia	0.181	0.509
Slovenia	0.049	0.189
Spain	7.645	11.797
Sweden	2.597	2.597
United King	2.776	3.862
EU28	49.080	73.201
EU27	48.909	72.845

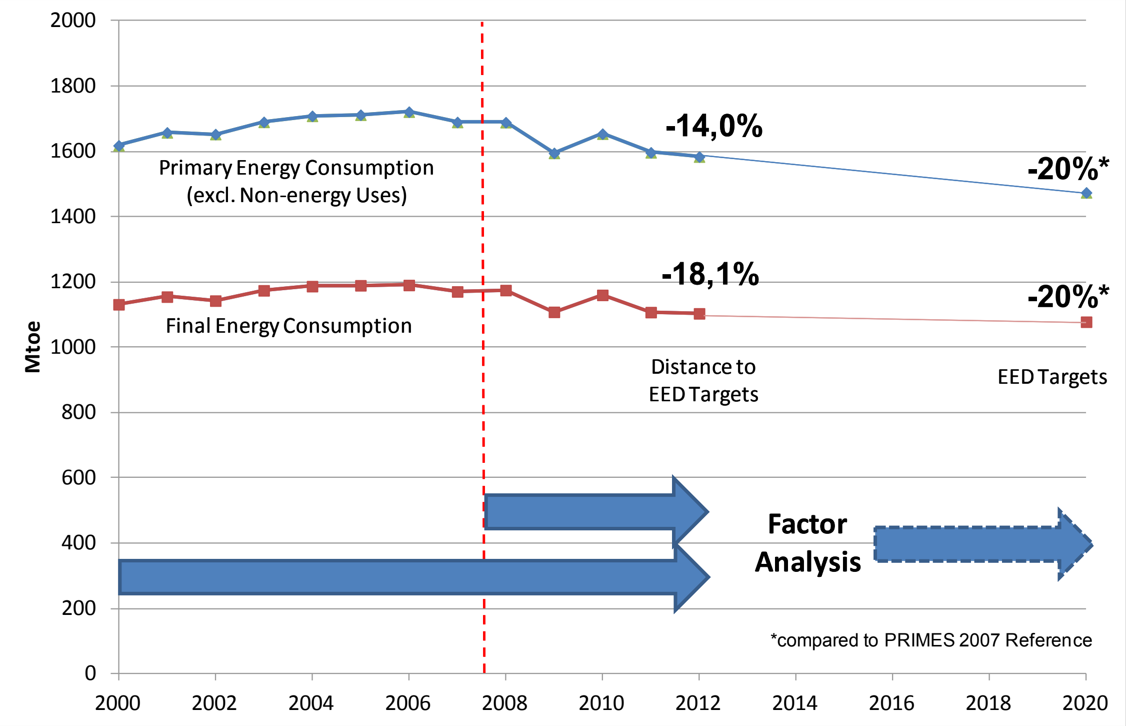
4 Decomposition Analysis of Progress to the Art. 3 EED Targets

This chapter presents the **Decomposition Analysis** of past energy efficiency achievements (2000-2012 and 2008-12) based on Eurostat data and projection to 2020.

4.1 Outline of the decomposition analysis

A decomposition analysis allows to understand the impact of different factors of influence on the development of a derived parameter, in our case the development of primary energy and of final energy (see Figure 7).

Figure 7: Development of primary energy and final energy (EU28)



Source: Eurostat (for the historic data up to 2012), EED (for the targets)

Since around 2005 both energy consumptions have reached a maximum and started to decrease thereafter. The decrease following 2007 was partly enhanced by the economic crisis. The figure also shows the primary (-20% compared to the reference development from 2007 or 1474 Mtoe for 2020) and final energy targets (-20% compared to the reference development from 2007 or 1078 Mtoe for 2020) as fixed by the EED for the EU27 and later on with slightly higher values for the EU28[9].

The decomposition analysis which we carry out is focused on the period 2008-2012 as this is the period relevant for the EED which is already covered by historic data. For comparison purposes we also provide the decomposition analysis for the period 2000-2012 which still comprises the period of rising primary and final energy consumption up to 2005.

The main purposes of the decomposition analysis is to separate energy savings from the impacts of other factors such as changes in activity levels, structural changes or comfort factors.

We further use then the decomposition analysis to project the savings to 2020 under the assumption that the savings build up in a linear manner.

4.2 Information sources

The analysis underlying this report was based on two main sources of information:

- The **Eurostat database** on energy consumption data was the main source of analysis. The data are fully consistent therefore with official data. This concerns both the decomposition analysis of primary energy and final energy.
- The **Odyssee database** on energy efficiency indicators[10] provided more detailed information in some demand side sectors as is provided by Eurostat (for example in the residential sector the split on different end-uses). This is based on national statistics. However, care was taken to insure that this information was compatible with the Eurostat data at more aggregate level. Therefore it can be estimated that also the more detailed results are in agreement with Eurostat data.
- Further the main drivers for energy consumption in the different energy demand sectors such as person-kilometers, tonne-kilometers, etc. were also provided by Eurostat data. Some of the 2012 data were completed with projections from previous years.

In total, based on these data, a database was built which allows carrying out the same analysis for each EU Member States. This database is fully compatible with

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[9] With the accession of Croatia the target was revised to "1 483 Mtoe primary energy or no more than 1 086 Mtoe of final energy". However, the additional contribution of Croatia in terms of energy consumption is less than 1%. Therefore the decomposition results are only slightly influenced by this fact as compared to EU27.

[10] http://www.odyssee-mure.eu/

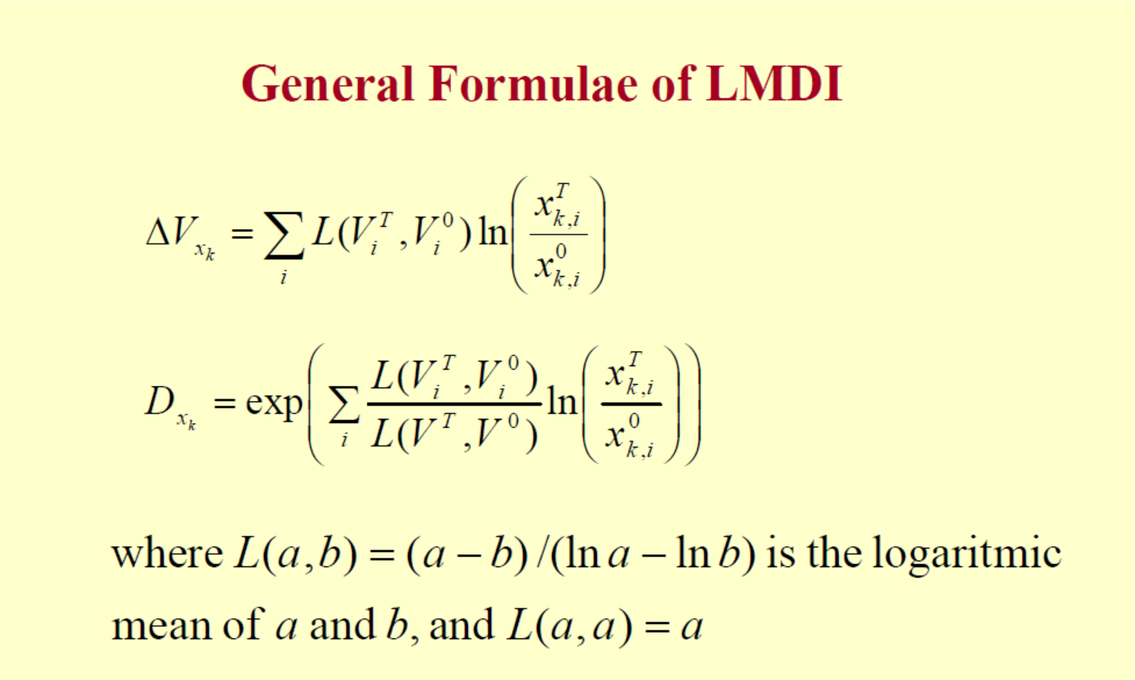
Eurostat data and can therefore easily be updated from year to year. In principle such a database could also be transferred to the Internet.

4.3 Decomposition method

We use in this report the LMDI (Logarithmic Mean Divisia Index) method[11]. This method has two main advantages[12]:

- In difference to other methods used, for example the simple Laspeyres factorisation method[11] used by the International Energy Agency IEA, the LMDI does not generate residuals which cannot be explained.
- The method is easily applied to a larger number of factors which is not the case for other decomposition methods which generate quite complex formula in such cases.

The following slides briefly illustrate the mathematics of the method and a simple three-factor composition into activity, structure and intensity effects. We use the multiplicative decomposition.



General Formulae of LMDI

$$\Delta V_{x_k} = \sum_i L(V_i^T, V_i^0) \ln\left(\frac{x_{k,i}^T}{x_{k,i}^0}\right)$$

$$D_{x_k} = \exp\left(\sum_i \frac{L(V_i^T, V_i^0)}{L(V^T, V^0)} \ln\left(\frac{x_{k,i}^T}{x_{k,i}^0}\right)\right)$$

where $L(a,b) = (a-b)/(\ln a - \ln b)$ is the logaritmic mean of a and b, and $L(a,a) = a$

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[11] See for example http://www.ise.nus.edu.sg/staff/angbw/pdf/A_Simple_Guide_to_LMDI.pdf. We use the LMDI-I method. A more complex LMDI-II method has also been developed.

[12] See for example B.W. Ang: The LMDI approach to decomposition analysis: a practical guide, Energy Policy Volume 33, Issue 7, May 2005, Pages 867–871

Decomposition of Energy Consumption Change

$$E = \sum_i E_i = \sum_i Q \frac{Q_i}{Q} \frac{E_i}{Q_i} = \sum_i Q S_i I_i$$

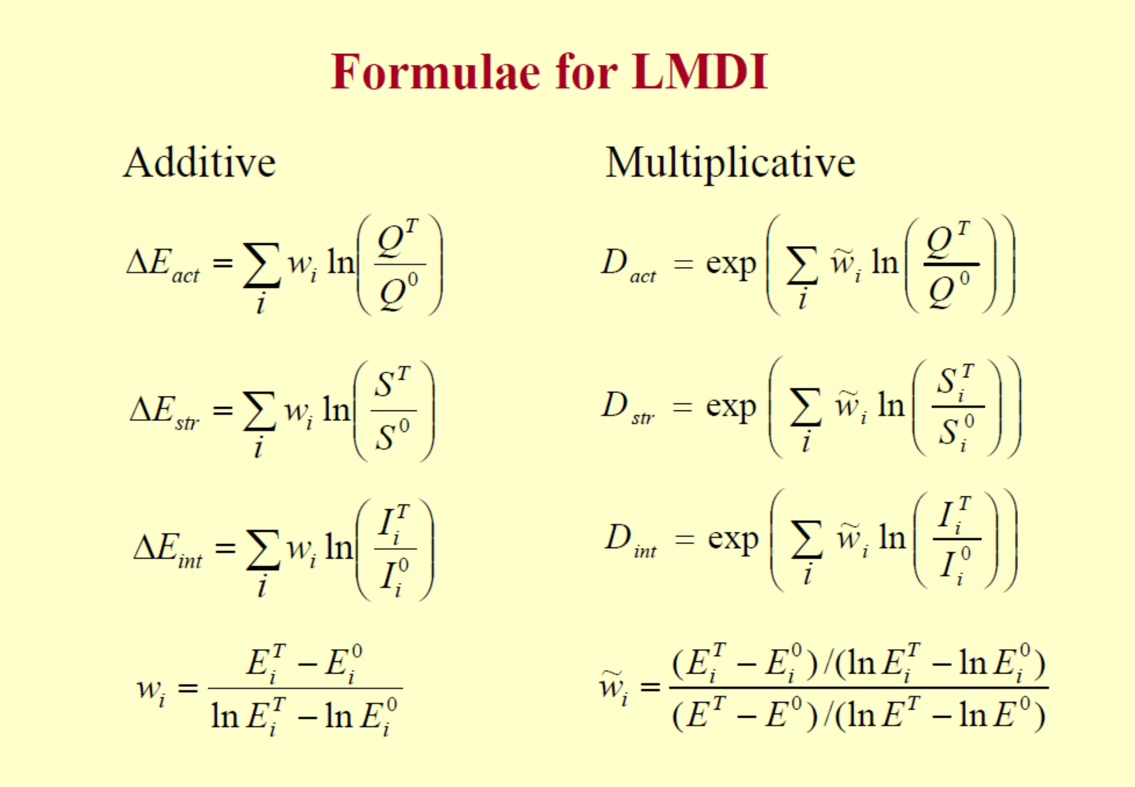
E	Total energy consumption (for all sectors)
Q	Overall activity level (for all sectors)
E_i	Energy consumption of sector *i*
Q_i	Activity level of sector *i*
S_i	Activity share of sector *i*
I_i	Energy intensity of sector *i*

Three Explanatory Effects

$$E^T - E^0 = \Delta E_{tot} = \Delta E_{act} + \Delta E_{str} + \Delta E_{int}$$

$$E^T / E^0 = D_{tot} = D_{act} D_{str} D_{int}$$

- **Activity effect**: The change in the aggregate associated with a change in the overall level of the activity.
- **Structure effect**: The change in the aggregate associated with a change in the mix of the activity by sub-category.
- **Intensity effect**: The change in the aggregate associated with changes in the sub-category energy intensities.



Formulae for LMDI

Additive

$$\Delta E_{act} = \sum_i w_i \ln\left(\frac{Q^T}{Q^0}\right)$$

$$\Delta E_{str} = \sum_i w_i \ln\left(\frac{S^T}{S^0}\right)$$

$$\Delta E_{int} = \sum_i w_i \ln\left(\frac{I_i^T}{I_i^0}\right)$$

$$w_i = \frac{E_i^T - E_i^0}{\ln E_i^T - \ln E_i^0}$$

Multiplicative

$$D_{act} = \exp\left(\sum_i \widetilde{w}_i \ln\left(\frac{Q^T}{Q^0}\right)\right)$$

$$D_{str} = \exp\left(\sum_i \widetilde{w}_i \ln\left(\frac{S_i^T}{S_i^0}\right)\right)$$

$$D_{int} = \exp\left(\sum_i \widetilde{w}_i \ln\left(\frac{I_i^T}{I_i^0}\right)\right)$$

$$\widetilde{w}_i = \frac{(E_i^T - E_i^0)/(\ln E_i^T - \ln E_i^0)}{(E^T - E^0)/(\ln E^T - \ln E^0)}$$

Source: http://www.ise.nus.edu.sg/staff/angbw/pdf/A_Simple_Guide_to_LMDI.pdf

4.4 Decomposition analysis of primary energy consumption

This section analyses the contribution of different factors to the change in primary energy consumption[13] of the European Union. The analysis is carried out at two levels:

- First the energy conversion sector is analysed as a whole by distinguishing three energy sector branches: electricity, heat and other sectors (which comprises solid fuels, petroleum products, gas, renewable and wastes not used for electricity or heat generation) (level 1, see Figure 8).
- Second the developments in the electricity and heat sector are analysed in greater detail (level 2, see Figure 9).

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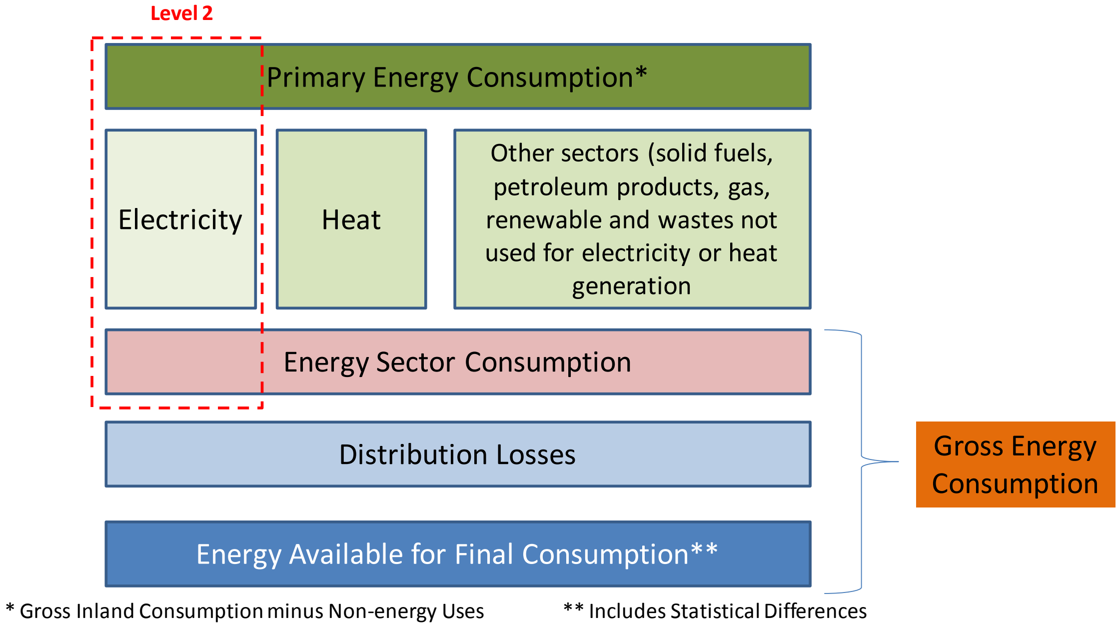
[13] Primary energy consumption is defined in this report as gross inland consumption minus non-energy uses according to the definition of the EED.

Figure 8: Structure for the level-1-analysis of changes in Primary Energy Consumption



Level-1-analysis (Figure 8) takes into account:

- Changes in energy available for final consumption[14], excluding non-energy uses
- Changes in the distribution losses across all energy sector branches
- Changes in the energy sector consumption
- Changes in the structure of the energy sector (mainly the influence from the increasing penetration of the electricity sector, which has a lower conversion efficiency as compared to the other branches of the energy sector).
- Changes in the efficiency of the electricity and heat sector (which is mainly driven by the structural change within the electricity sector, in particular by the penetration of renewable, see below).

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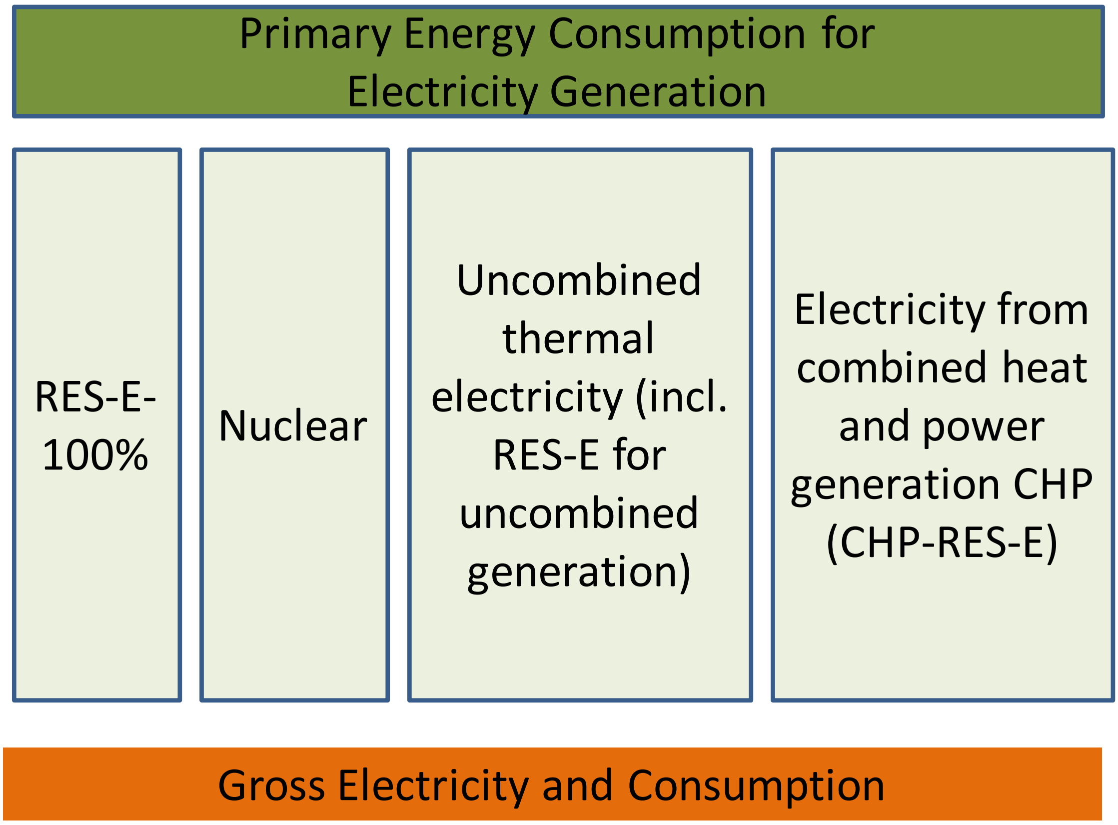
[14] This differs from final energy consumption in a minor manner through the inclusion of statistical differences. Note, however, that for some countries these statistical differences in the Eurostat database can be comparatively large any may lead for a different development for final energy and for energy available for final consumption (excluding non-energy uses).

Figure 9: Structure for the level-2-analysis of changes in primary energy consumption (impact of electricity sector)



Level 2 analysis with a focus on the electricity sector (Figure 9) takes into account:

- The change in Gross Electricity Consumption (which includes distribution losses and electricity consumption of the energy sector
- The penetration of “100% efficiency renewables” (RES-E-100%), that is wind energy, solar PV, hydro power, wave/ocean/tidal energy[15].
- The decrease in the share of nuclear (with a nominal conversion efficiency of 33%) due to the phase-our strategies in some Member States
- The penetration of electricity from Combined Heat and Power generation CHP

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[15] Note that solar thermal (both Concentrated Solar Power CSP and solar thermal for heat provision) are not accounted for in the same manner in Eurostat balances as are the other RES100%. These are directly accounted for in Gross Inland Consumption and are passed through to the electricity sector as Interproduct Returns. Solar Thermal (CSP) enters the transformation inputs as the solar heat is converted to steam.

- The efficiency improvement in uncombined thermal electricity generation (including renewable/wastes for uncombined generation.

For more explanations on the different factors, see also the introduction to the country analysis in the Country Annex.

Figure 10 shows the level-1-analysis of primary energy consumption:

- The total change in Primary Energy Consumption in the period 2008-2012[16] was 100 Mtoe.
- The main reason for the decrease was the decrease in final energy which amounted to -70 Mtoe from 2008 to 2012 but which in primary energy terms translates to -96 Mtoe.
- Distribution losses (+1.3 Mtoe, possibly due to a penetration of distributed renewables) and Energy Sector Consumption (-2.3 Mtoe) had smaller influence on the changes in primary energy consumption.
- A comparatively large increase in primary energy with +24 Mtoe came from the further penetration of the electricity sector in the structure of the energy sector branches.
- This was more than counterbalanced with -29 Mtoe by an improvement in the electricity sector efficiency, which in fact comprises different factors of influence, among others the penetration of RES-E-100%, see the analysis at Level-2.

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[16] Starting year of the factor analysis is 2007 as the last year before the period 2008-2012 under consideration

Figure 10: Decomposition analysis of changes in primary energy consumption 2008-2012 (Level 1)

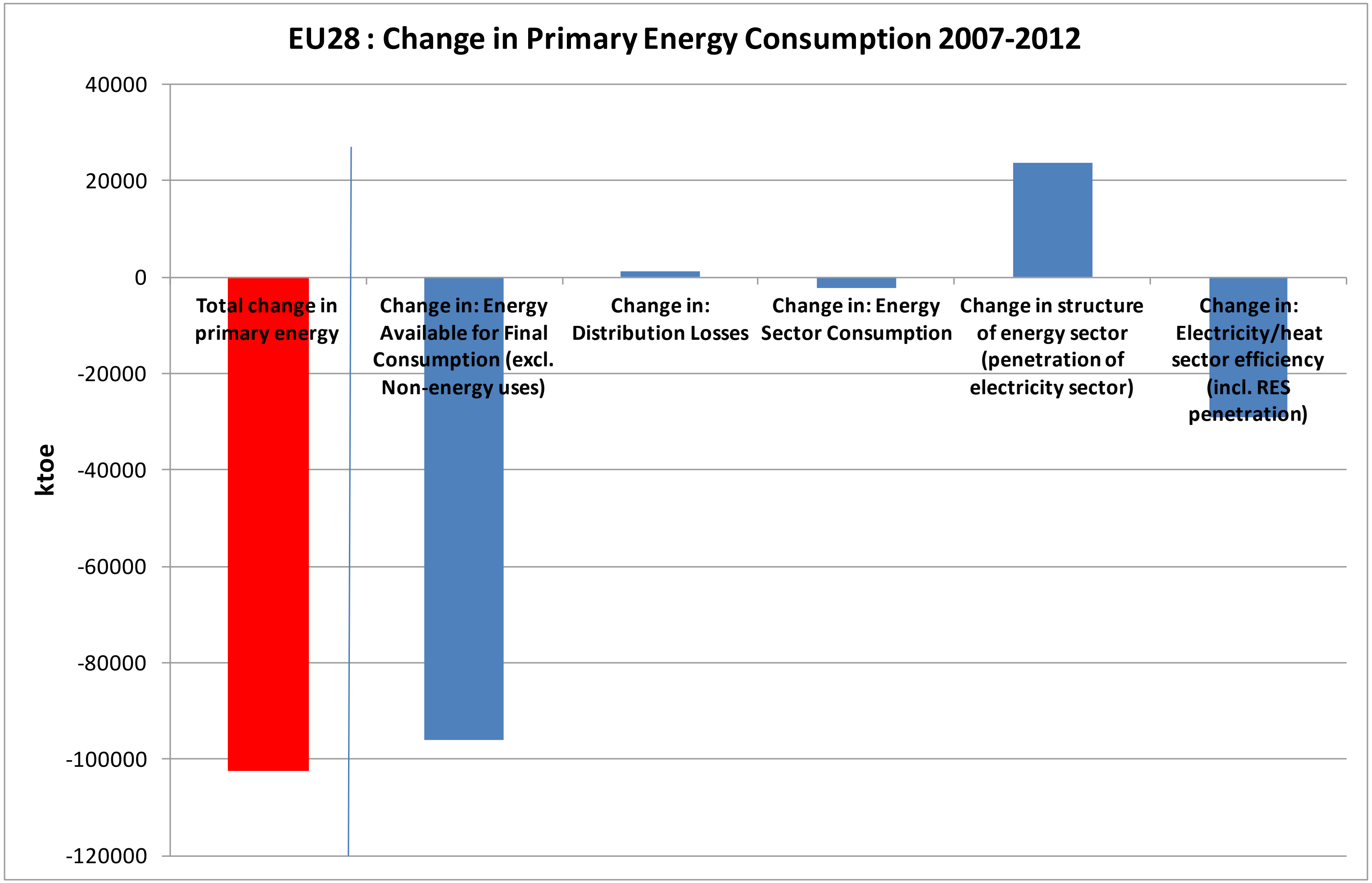


Figure 11: Decomposition analysis of changes in primary energy consumption 2000-2012 (Level 1)

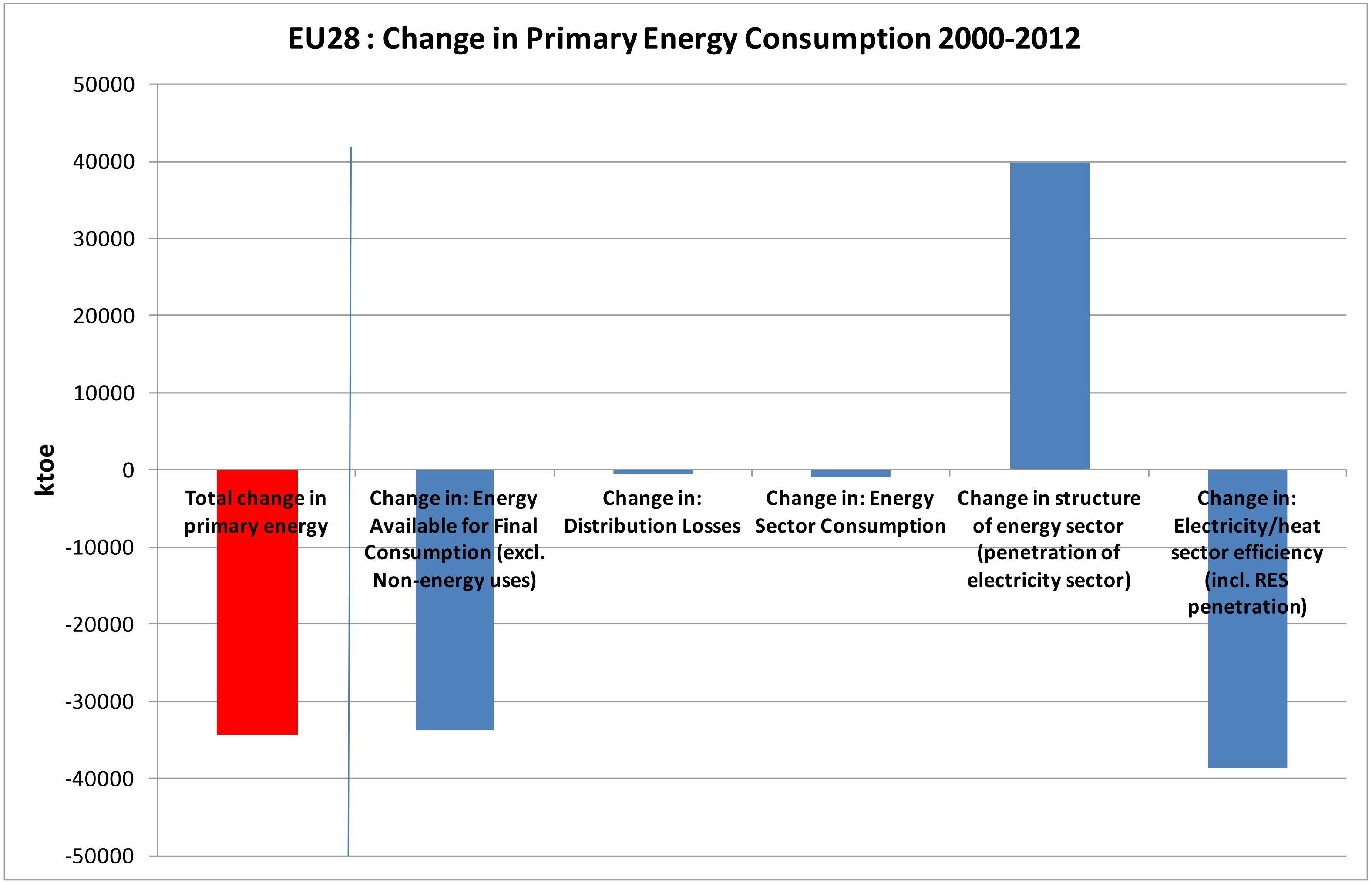


Figure 11 shows for comparison purposes the decomposition analysis for the longer time period 2000-2012. The main differences with the analysis for the period 2008 to 2012 is that primary energy is decreasing less (-34 Mtoe), that the penetration of the electricity sector was more pronounced (+40 Mtoe) but which was also nearly totally counterbalanced by the developments in electricity sector efficiency (-39 Mtoe).

Level-2 analysis shows the details of what happened in the electricity conversion from primary energy consumption to gross electricity consumption (Figure 12):

- The total change in primary energy consumption due to electricity generation was -34 Mtoe in the period 2008-2012. This was the combined effect of a decrease in gross electricity consumption (impact -15 Mtoe in primary energy terms), a change in the structure of electricity generation which induced a reduction of 29 Mtoe in primary energy, a worsening in thermal electricity generation which induced an increase in primary energy consumption of 10 Mtoe (possibly due to partly low capacity use of part of the thermal power plants).
- The structural effects were due to four individual components:
  - The increasing penetration of RES-E-100 and CHP electricity increased primary energy consumption by 18 Mtoe and 0.4 Mtoe respectively.
  - However, this was by far overcompensated by the decrease in nuclear (-5 Mtoe primary energy) and uncombined thermal power generation (-42 Mtoe) with their much lower efficiencies.

For comparison Figure 13 shows the same analysis for the longer period from 2000 to 2012. The main difference is that the electricity sector still increased primary energy consumption by 11 Mtoe, especially to the still strong increase in gross electricity demand (+46 Mtoe in primary energy terms), the counterbalancing effect of the structure changes in electricity generation (-49 Mtoe)

Figure 12: Decomposition analysis of changes in primary energy consumption due to electricity generation 2008-2012 (Level 2)

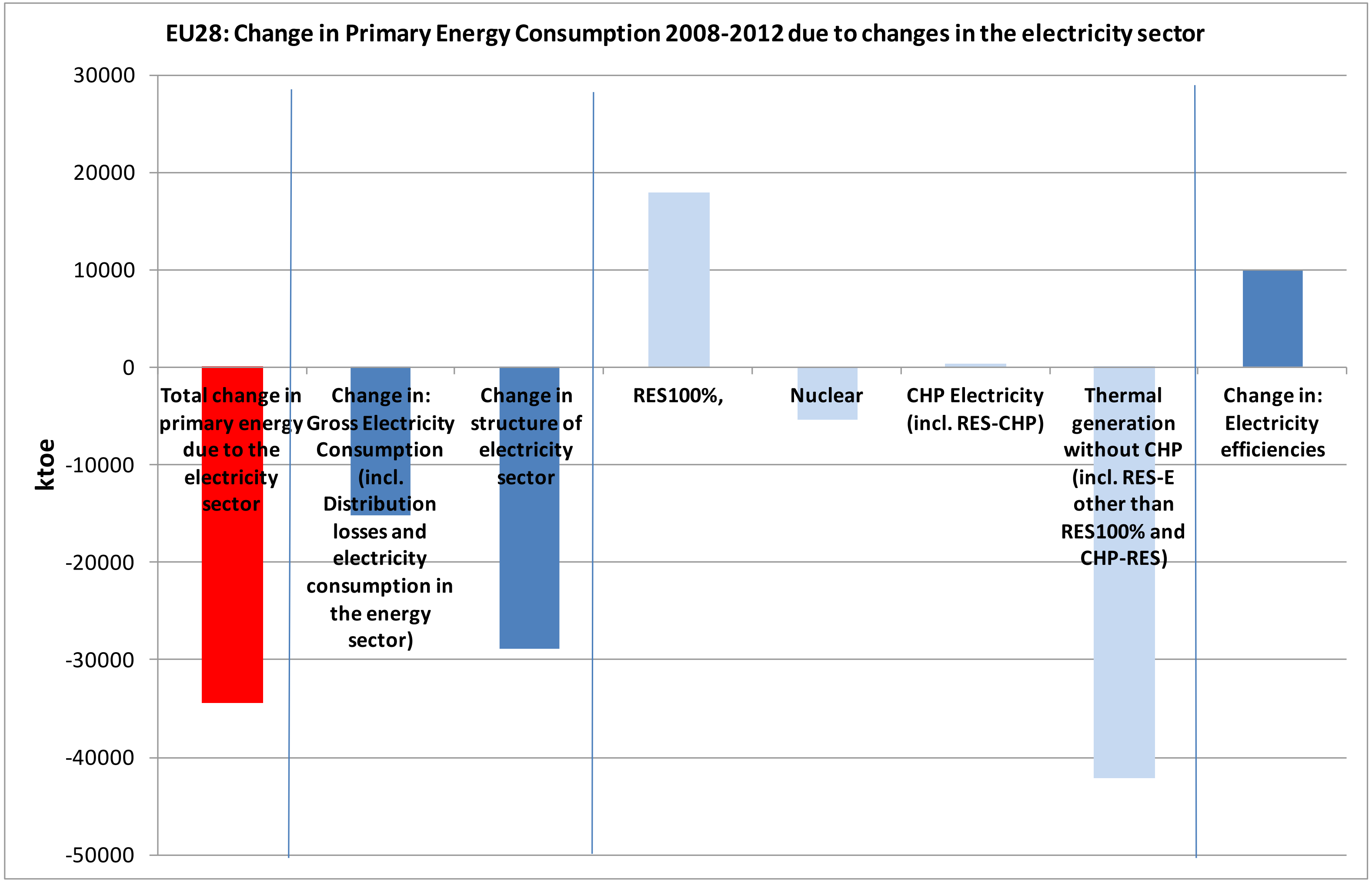
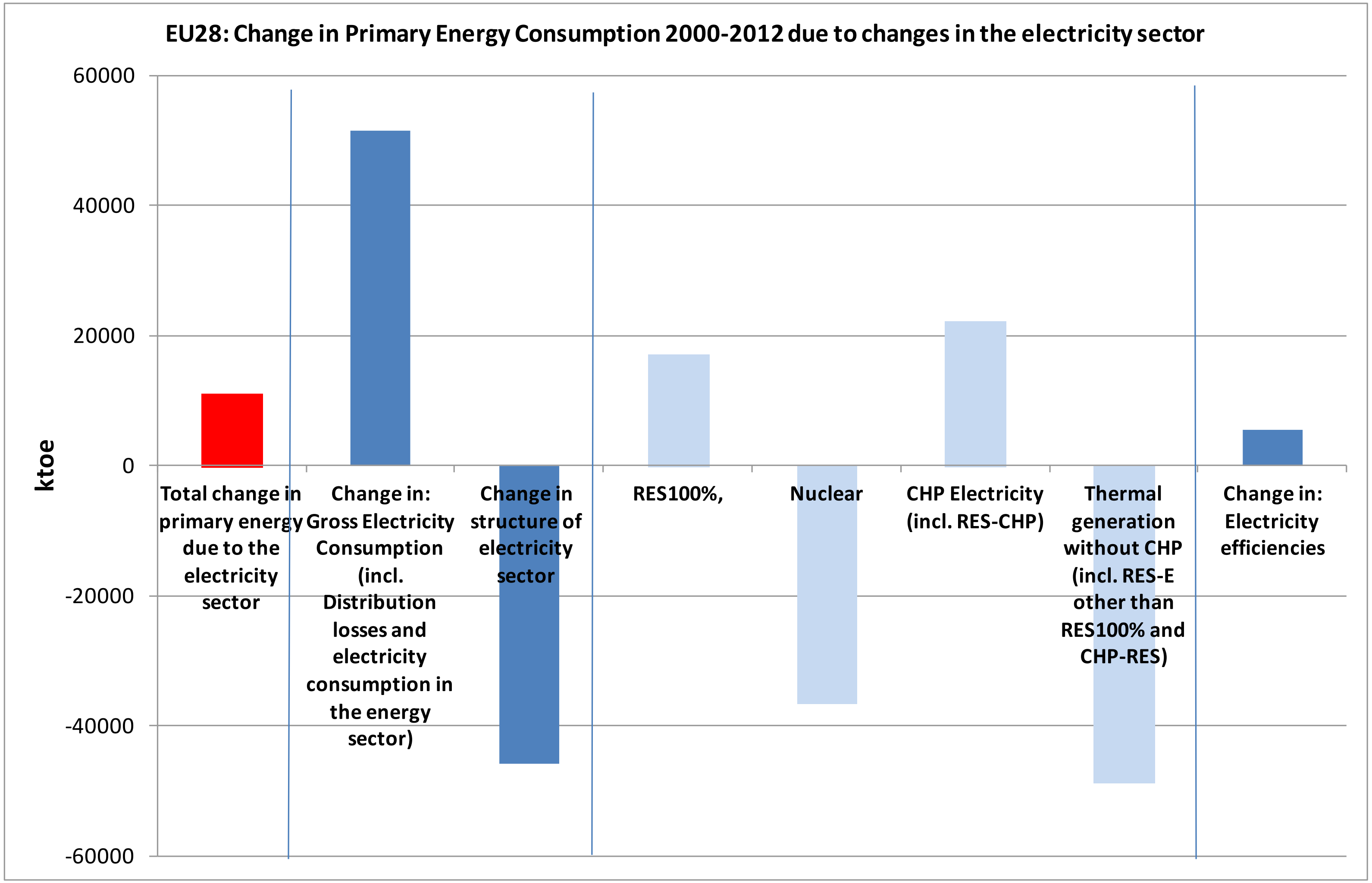


Figure 13: Decomposition analysis of changes in primary energy consumption due to electricity generation 2000-2012 (Level 2)



4.5 Decomposition analysis of final energy consumption

In the previous section we identified as the main driver for the decrease in primary energy consumption from 2008 to 2012 the decrease in final energy which amounted to -67.1 Mtoe but which in primary energy terms translated to -96 Mtoe. In this section we will analyse the details of the different final demand sector to the change of -67.1 Mtoe. An overview is provided by Figure 14. This change is due to changes in activity levels in the different sectors with nearly -33 Mtoe, further counter balancing impacts of structural changes in industry, modal shift in transport as well as comfort and social factors, climatic differences between the beginning and the end of the period, and finally an important contribution of energy efficiency with a reduction of nearly 53 Mtoe in the historic period 2008-2012 (**around 10.5 Mtoe or 1.0% annually compared to the overall final energy demand in 2012**). More sectoral details can be found in the overview Table 7 and the following section. This comprises both the impacts of autonomous energy savings and the impacts of energy efficiency measures.

Figure 14: Decomposition analysis of changes in final energy consumption 2008-2012

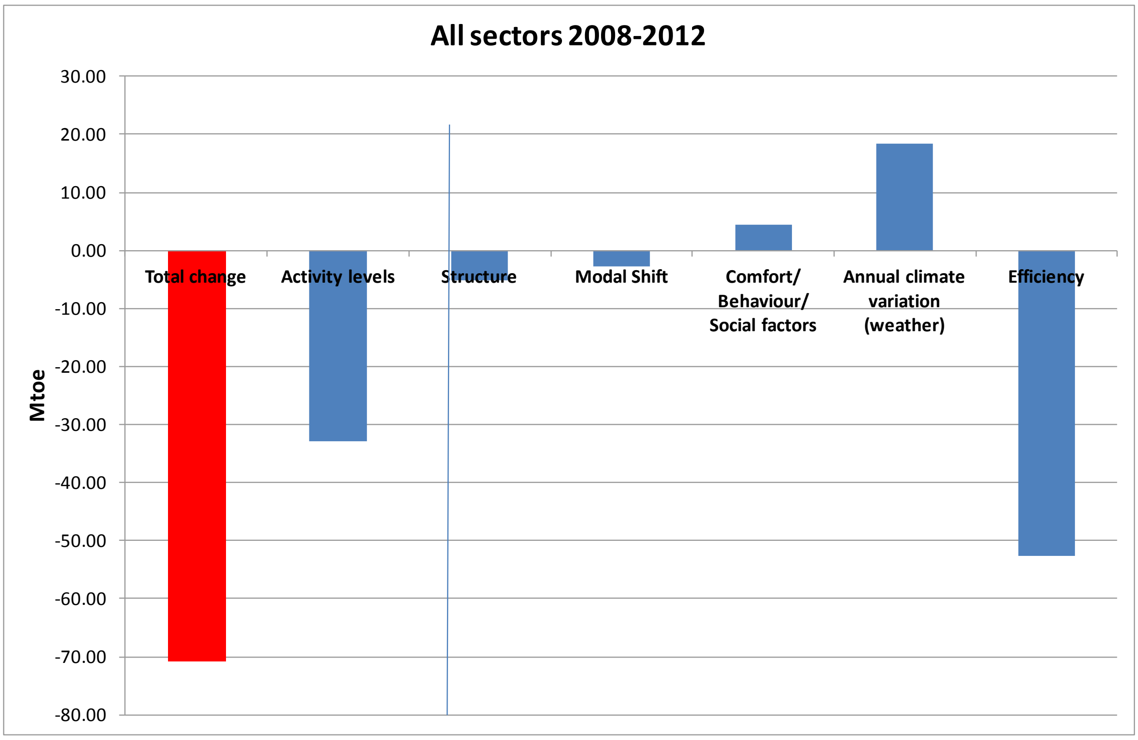


Figure 15: Decomposition analysis of changes in final energy consumption 2000-2012

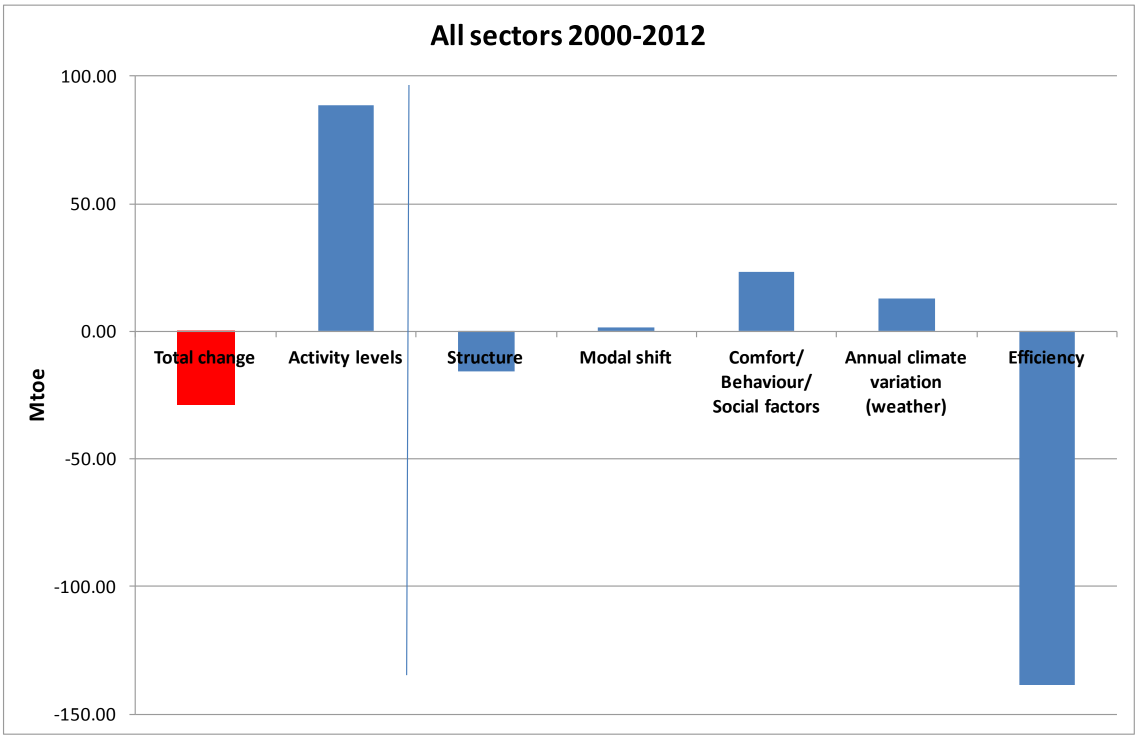
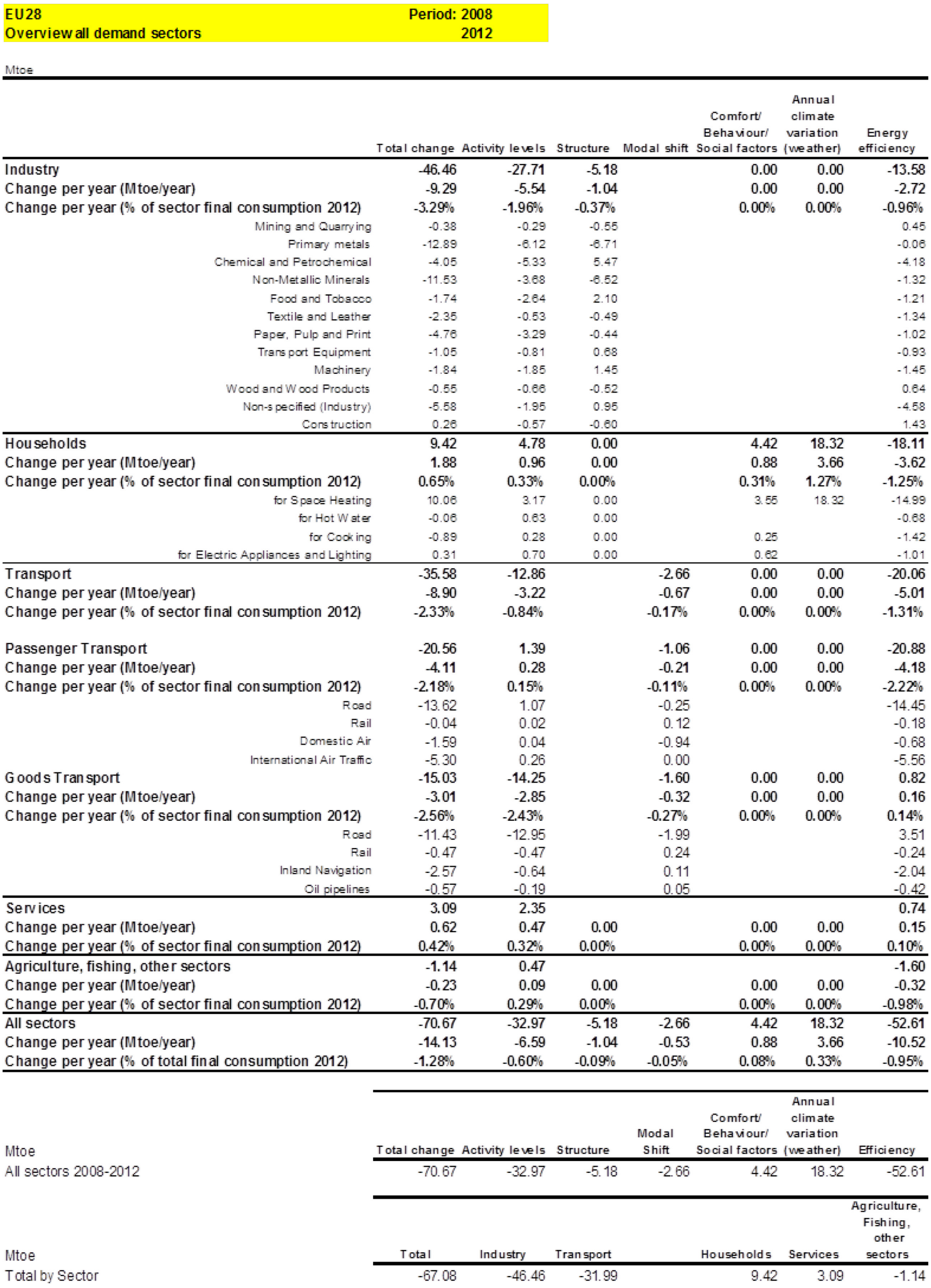


Table 8 and Figure 15 provide the same information for the longer period 2000 to 2012. The main difference with the period 2008 to 2012 is that activity changes were contributing to an increase in final energy consumption, as well as comfort factors, while energy efficiency improved more strongly with 11.5 Mtoe annual savings or 1.05% of final energy consumption of 2012. **This implies that in the first part of the period from 2000 to 2007 the energy efficiency improvement was higher than for the period 2008-2012.** However, given the high increasing impact of activity changes, as an overall result final energy decreased since 2000 only by around 28 Mtoe, as up to 2005 final energy demand was still increasing.

Table 7: Decomposition analysis final energy consumption 2008-2012 (EU28)



EU28 **Period: 2008**
Overview all demand sectors **2012**

Mtoe

	Total change	Activity levels	Structure	Modal shift	Comfort/ Behaviour/ Social factors	Annual climate variation (weather)	Energy efficiency
Industry	**-46.46**	**-27.71**	**-5.18**		**0.00**	**0.00**	**-13.58**
Change per year (Mtoe/year)	**-9.29**	**-5.54**	**-1.04**		**0.00**	**0.00**	**-2.72**
Change per year (% of sector final consumption 2012)	**-3.29%**	**-1.96%**	**-0.37%**		**0.00%**	**0.00%**	**-0.96%**
Mining and Quarrying	-0.38	-0.29	-0.55				0.45
Primary metals	-12.89	-6.12	-6.71				-0.06
Chemical and Petrochemical	-4.05	-5.33	5.47				-4.18
Non-Metallic Minerals	-11.53	-3.68	-6.52				-1.32
Food and Tobacco	-1.74	-2.64	2.10				-1.21
Textile and Leather	-2.35	-0.53	-0.49				-1.34
Paper, Pulp and Print	-4.76	-3.29	-0.44				-1.02
Transport Equipment	-1.05	-0.81	0.68				-0.93
Machinery	-1.84	-1.85	1.45				-1.45
Wood and Wood Products	-0.55	-0.66	-0.52				0.64
Non-specified (Industry)	-5.58	-1.95	0.95				-4.58
Construction	0.26	-0.57	-0.60				1.43
Households	**9.42**	**4.78**	**0.00**		**4.42**	**18.32**	**-18.11**
Change per year (Mtoe/year)	**1.88**	**0.96**	**0.00**		**0.88**	**3.66**	**-3.62**
Change per year (% of sector final consumption 2012)	**0.65%**	**0.33%**	**0.00%**		**0.31%**	**1.27%**	**-1.25%**
for Space Heating	10.06	3.17	0.00		3.55	18.32	-14.99
for Hot Water	-0.06	0.63	0.00				-0.68
for Cooking	-0.89	0.28	0.00		0.25		-1.42
for Electric Appliances and Lighting	0.31	0.70	0.00		0.62		-1.01
Transport	**-35.58**	**-12.86**		**-2.66**	**0.00**	**0.00**	**-20.06**
Change per year (Mtoe/year)	**-8.90**	**-3.22**		**-0.67**	**0.00**	**0.00**	**-5.01**
Change per year (% of sector final consumption 2012)	**-2.33%**	**-0.84%**		**-0.17%**	**0.00%**	**0.00%**	**-1.31%**
Passenger Transport	**-20.56**	**1.39**		**-1.06**	**0.00**	**0.00**	**-20.88**
Change per year (Mtoe/year)	**-4.11**	**0.28**		**-0.21**	**0.00**	**0.00**	**-4.18**
Change per year (% of sector final consumption 2012)	**-2.18%**	**0.15%**		**-0.11%**	**0.00%**	**0.00%**	**-2.22%**
Road	-13.62	1.07		-0.25			-14.45
Rail	-0.04	0.02		0.12			-0.18
Domestic Air	-1.59	0.04		-0.94			-0.68
International Air Traffic	-5.30	0.26		0.00			-5.56
Goods Transport	**-15.03**	**-14.25**		**-1.60**	**0.00**	**0.00**	**0.82**
Change per year (Mtoe/year)	**-3.01**	**-2.85**		**-0.32**	**0.00**	**0.00**	**0.16**
Change per year (% of sector final consumption 2012)	**-2.56%**	**-2.43%**		**-0.27%**	**0.00%**	**0.00%**	**0.14%**
Road	-11.43	-12.95		-1.99			3.51
Rail	-0.47	-0.47		0.24			-0.24
Inland Navigation	-2.57	-0.64		0.11			-2.04
Oil pipelines	-0.57	-0.19		0.05			-0.42
Services	**3.09**	**2.35**					**0.74**
Change per year (Mtoe/year)	**0.62**	**0.47**	**0.00**		**0.00**	**0.00**	**0.15**
Change per year (% of sector final consumption 2012)	**0.42%**	**0.32%**	**0.00%**		**0.00%**	**0.00%**	**0.10%**
Agriculture, fishing, other sectors	**-1.14**	**0.47**					**-1.60**
Change per year (Mtoe/year)	**-0.23**	**0.09**	**0.00**		**0.00**	**0.00**	**-0.32**
Change per year (% of sector final consumption 2012)	**-0.70%**	**0.29%**	**0.00%**		**0.00%**	**0.00%**	**-0.98%**
All sectors	**-70.67**	**-32.97**	**-5.18**	**-2.66**	**4.42**	**18.32**	**-52.61**
Change per year (Mtoe/year)	**-14.13**	**-6.59**	**-1.04**	**-0.53**	**0.88**	**3.66**	**-10.52**
Change per year (% of total final consumption 2012)	**-1.28%**	**-0.60%**	**-0.09%**	**-0.05%**	**0.08%**	**0.33%**	**-0.95%**

Mtoe	Total change	Activity levels	Structure	Modal Shift	Comfort/ Behaviour/ Social factors	Annual climate variation (weather)	Efficiency
All sectors 2008-2012	-70.67	-32.97	-5.18	-2.66	4.42	18.32	-52.61

Mtoe	Total	Industry	Transport		Households	Services	Agriculture, Fishing, other sectors
Total by Sector	-67.08	-46.46	-31.99		9.42	3.09	-1.14

Note: in the service sector no savings are identified because with the present degree of sectoral breakdown this is mixed with structural changes which still overwhelm the efficiency effects. In a more refined sector analysis this could be improved for some countries in the EU but not for all.

Table 8: Decomposition analysis final energy consumption 2000-2012 (EU28)

EU28	Period: 2000
Overview all demand sectors	2012

Mtoe

	Total change	Activity levels	Structure	Modal shift	Comfort/ Behaviour/ Social factors	Annual climate variation (weather)	Energy efficiency
Industry	**-50.08**	**13.30**	**-15.89**		**0.00**	**0.00**	**-47.49**
Change per year (Mtoe/year)	**-4.17**	**1.11**	**-1.32**		**0.00**	**0.00**	**-3.96**
Change per year (% of sector final consumption 2012)	**-1.48%**	**0.39%**	**-0.47%**		**0.00%**	**0.00%**	**-1.40%**
Mining and Quarrying	-0.87	0.15	-1.79				0.78
Primary metals	-17.91	3.03	-16.09				-4.84
Chemical and Petrochemical	-1.68	2.50	9.27				-13.44
Non-Metallic Minerals	-9.52	1.72	-6.22				-5.03
Food and Tobacco	-2.77	1.28	0.32				-4.37
Textile and Leather	-6.15	0.32	-2.77				-3.70
Paper, Pulp and Print	-1.31	1.50	-3.60				0.79
Transport Equipment	-1.13	0.39	1.80				-3.31
Machinery	-0.21	0.85	3.31				-4.36
Wood and Wood Products	0.55	0.29	-0.66				0.91
Non-specified (Industry)	-9.22	1.00	1.16				-11.39
Construction	0.14	0.27	-0.61				0.48
Households	**-5.41**	**12.55**	**0.00**		**23.32**	**12.77**	**-54.04**
Change per year (Mtoe/year)	**-0.45**	**1.05**	**0.00**		**1.94**	**1.06**	**-4.50**
Change per year (% of sector final consumption 2012)	**-0.16%**	**0.36%**	**0.00%**		**0.67%**	**0.37%**	**-1.56%**
for Space Heating	-8.89	8.52	0.00		19.75	12.77	-49.92
for Hot Water	-1.77	1.64	0.00				-3.41
for Cooking	-0.81	0.72	0.00		1.08		-2.62
for Electric Appliances and Lighting	6.06	1.66	0.00		2.49		1.91
Transport	**5.23**	**41.64**		**1.45**	**0.00**	**0.00**	**-37.86**
Change per year (Mtoe/year)	**0.44**	**3.47**		**0.12**	**0.00**	**0.00**	**-3.16**
Change per year (% of sector final consumption 2012)	**0.14%**	**1.14%**		**0.04%**	**0.00%**	**0.00%**	**-1.03%**
Passenger Transport	**1.32**	**32.60**		**-0.41**	**0.00**	**0.00**	**-30.87**
Change per year (Mtoe/year)	**0.11**	**2.72**		**-0.03**	**0.00**	**0.00**	**-2.57**
Change per year (% of sector final consumption 2012)	**0.06%**	**1.44%**		**-0.02%**	**0.00%**	**0.00%**	**-1.37%**
Road	-2.26	15.94		-0.53			-17.68
Rail	-0.39	0.29		0.10			-0.79
Domestic Air	-0.86	0.52		0.01			-1.39
International Air Traffic	4.83	15.85		0.00			-11.02
Goods Transport	**3.91**	**9.03**		**1.86**	**0.00**	**0.00**	**-6.99**
Change per year (Mtoe/year)	**0.33**	**0.75**		**0.16**	**0.00**	**0.00**	**-0.58**
Change per year (% of sector final consumption 2012)	**0.28%**	**0.64%**		**0.13%**	**0.00%**	**0.00%**	**-0.50%**
Road	5.52	8.22		2.58			-5.28
Rail	-0.79	0.33		-0.11			-1.01
Inland Navigation	-1.72	0.41		-0.49			-1.64
Oil pipelines	0.90	0.07		-0.12			0.95
Services	**25.94**	**19.43**					**6.51**
Change per year (Mtoe/year)	**2.16**	**1.62**	**0.00**		**0.00**	**0.00**	**0.54**
Change per year (% of sector final consumption 2012)	**1.46%**	**1.09%**	**0.00%**		**0.00%**	**0.00%**	**0.37%**
Agriculture, fishing, other sectors	**-4.03**	**1.50**					**-5.53**
Change per year (Mtoe/year)	**-0.34**	**0.12**	**0.00**		**0.00**	**0.00**	**-0.46**
Change per year (% of sector final consumption 2012)	**-1.03%**	**0.38%**	**0.00%**		**0.00%**	**0.00%**	**-1.41%**
All sectors	**-28.35**	**88.41**	**-15.89**	**1.45**	**23.32**	**12.77**	**-138.40**
Change per year (Mtoe/year)	**-2.36**	**7.37**	**-1.32**	**0.12**	**1.94**	**1.06**	**-11.53**
Change per year (% of total final consumption 2012)	**-0.21%**	**0.67%**	**-0.12%**	**0.01%**	**0.18%**	**0.10%**	**-1.05%**

Mtoe	Total change	Activity levels	Structure	Modal shift	Comfort/ Behaviour/ Social factors	Annual climate variation (weather)	Efficiency
All sectors 2000-2012	-28.35	88.41	-15.89	1.45	23.32	12.77	-138.40

Mtoe	Total	Industry	Transport		Households	Services	Agriculture, Fishing, other sectors
Total by Sector	-27.77	-50.08	5.80		-5.41	25.94	-4.03

Note: see Table 7

Table 9: Decomposition analysis total primary energy consumption and primary energy consumption for electricity generation (2000-2012 and 2008-2012) (EU28)

EU28 **Period: 2000**
Change in overall primary energy consumption **2012**

[Mtoe]

	Total change	Energy Available for Final Consumption	Distribution Losses	Energy Sector Consumption	Structure of energy sector	Sector Efficiency
Changes in Primary Energy Consumption due to:	**-34.12**	**-33.78**	**-0.55**	**-0.99**	**39.74**	**-38.55**
Change per year (Mtoe/year)	**-2.84**	**-2.81**	**-0.05**	**-0.08**	**3.31**	**-3.21**
Change per year (% of primary consumption 2012)	**-0.18%**	**-0.18%**	**0.00%**	**-0.01%**	**0.21%**	**-0.20%**
for Electricity	11.02	-12.91	-0.21	-0.38	65.09	-40.57
for Heat	12.59	-1.72	-0.03	-0.05	12.16	2.23
for other energy sectors*	-57.73	-19.14	-0.31	-0.56	-37.50	-0.22

Period: 2008
2012

[Mtoe]

	Total change	Energy Available for Final Consumption	Distribution Losses	Energy Sector Consumption	Structure of energy sector	Sector Efficiency
Changes in Primary Energy Consumption due to:	**-102.11**	**-95.90**	**1.31**	**-2.26**	**23.79**	**-29.06**
Change per year (Mtoe/year)	**-25.53**	**-23.98**	**0.33**	**-0.56**	**5.95**	**-7.26**
Change per year (% of primary consumption 2012)	**-1.61%**	**-1.51%**	**0.02%**	**-0.04%**	**0.38%**	**-0.46%**
for Electricity	-34.31	-37.22	0.51	-0.88	22.33	-19.05
for Heat	0.96	-5.13	0.07	-0.12	5.24	0.90
for other energy sectors*	-68.76	-53.55	0.73	-1.26	-3.78	-10.91

* solid fuels, petroleum products, gas, renewables/wastes

EU28 **Period: 2000**
Change in primary energy due to electricity sector **2012**

[Mtoe]

				of which:				
	Total change	**Gross Electricity Consumption**	**Structure of electricity sector**	RES100	Nuclear	CHP (Elec)	Thermal power plants	**Electricity efficiencies**
Changes in Primary Energy Consumption due to:	**11.02**	**51.42**	**-45.84**	17.03	-36.52	22.18	-48.53	**5.44**
Change per year (Mtoe/year)	**0.85**	**3.96**	**-3.53**	1.31	-2.81	1.71	-3.73	**0.42**
Change per year (% of primary consumption for electricity/heat	**0.12%**	**0.56%**	**-0.50%**	0.19%	-0.40%	0.24%	-0.53%	**0.06%**
RES100	20.81	3.78	17.03					0.00
Nuclear	-16.87	19.64	-36.52					0.00
CHP (Elec), incl. biomass/biogas CHP	29.64	6.55	22.18					0.91
Thermal power plants (excl. CHP), incl. separate RES-E generation	-22.56	21.44	-48.53					4.53

Period: 2008
2012

[Mtoe]

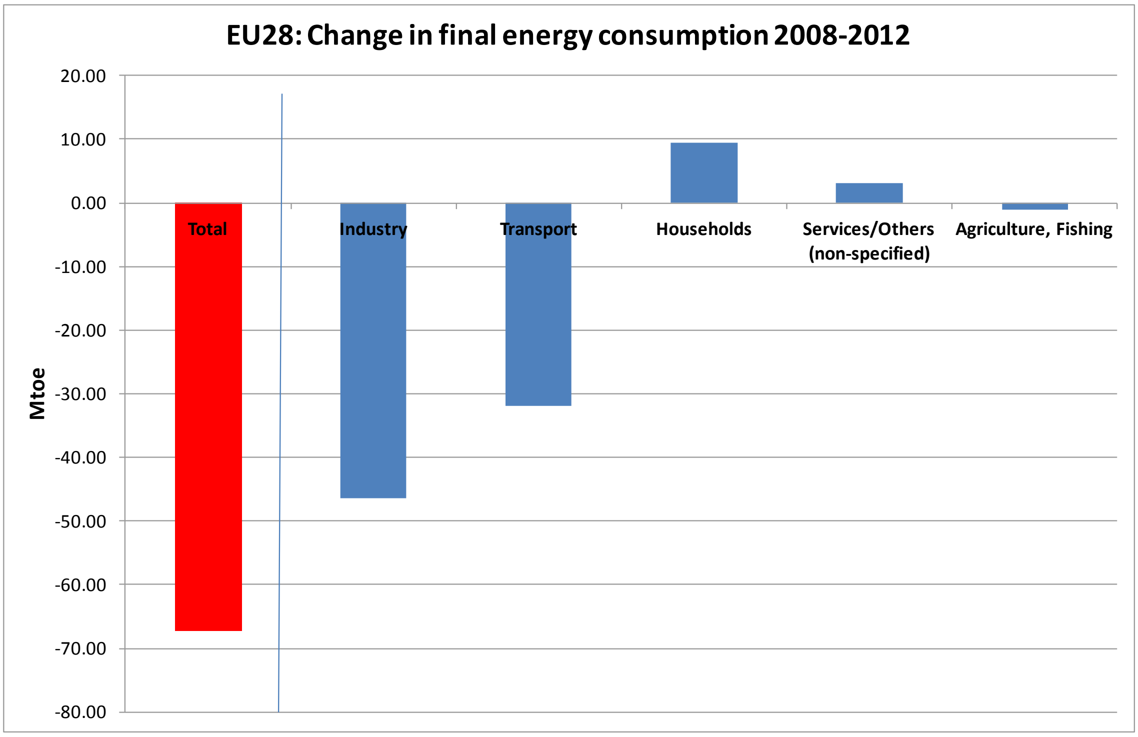
				of which:				
	Total change	**Gross Electricity Consumption**	**Structure of electricity sector**	RES100	Nuclear	CHP (Elec)	Thermal power plants	**Electricity efficiencies**
Changes in Primary Energy Consumption due to:	**-34.31**	**-15.24**	**-28.91**	17.95	-5.28	0.39	-41.97	**9.84**
Change per year (Mtoe/year)	**-6.86**	**-3.05**	**-5.78**	3.59	-1.06	0.08	-8.39	**1.97**
Change per year (% of primary consumption for electricity/heat	**-0.97%**	**-0.43%**	**-0.82%**	0.51%	-0.15%	0.01%	-1.19%	**0.28%**
RES100	16.81	-1.13	17.95					0.00
Nuclear	-10.82	-5.53	-5.28					0.00
CHP (Elec), incl. biomass/biogas CHP	-0.77	-2.26	0.39					1.10
Thermal power plants (excl. CHP), incl. separate RES-E generation	-39.54	-6.32	-41.97					8.74

4.6 Sectoral results of the decomposition analysis of final energy consumption

The following figures as well as Table 7 and Table 8 show sectoral details:

- Figure 16 shows that industry and transport reduced most final energy consumption in 2008-2012 while in 2000-2012 mainly industry contributed while services strongly increased final energy consumption in the longer period.
- However the reasons for this development were quite different from sector to sector:
  - The **residential sector** (Figure 17) had quite important contributions to energy efficiency in 2008 to 2012 with 1.3% of energy consumption saved annually. However this was compensated by the increase in activity (population), social factors (less persons in dwellings, hence more dwellings), comfort/behavior (e.g. more heated surfaces in homes) and by climatic influences (as 2012 was a cold year as compared to the reference year 2007 for this period).
  - For **industry** (Figure 18) activity effects (impact of the economic crisis), structural effects as well as efficiency effects all contributed to reduce energy consumption in the period 2008-2012, while in the longer period 2000-2012 the activity effect was positive. However, the savings rate has slowed down to below 0.96% annual savings in the period 2008 to 2012 as compared to 1.40% over the longer period 2000-2012 (Table 7 and Table 8).
  - For **passenger transport** (Figure 19) efficiency effects (CO_2 standards) strongly contributed to the reduction in energy consumption while activity effects were modest compared to the longer period 2000-2012. As passenger transport is less influenced by the impacts of economic down-turn, this is also a sign of saturation effects in transport. The annual savings rate is with 2.2% per year quite high (Table 7).
  - **Goods transport** (Figure 20) is like industry strongly impacted by the economic development, hence a negative activity effect from 2008 to 2012. The efficiency effect is reversed (annual increase 0.1% per year between 2008 and 2012 (Table 7).
  - In **Services** efficiency effects cannot be separated from structural effects at the level of the EU as a whole but only for some MS.
  - **Agriculture, fishing and other sectors** (Figure 21) is mainly dominated by efficiency changes which may also contain nevertheless some structural changes.

Figure 16: Sectoral decomposition of changes in final energy consumption 2008-2012 and 2000-2012



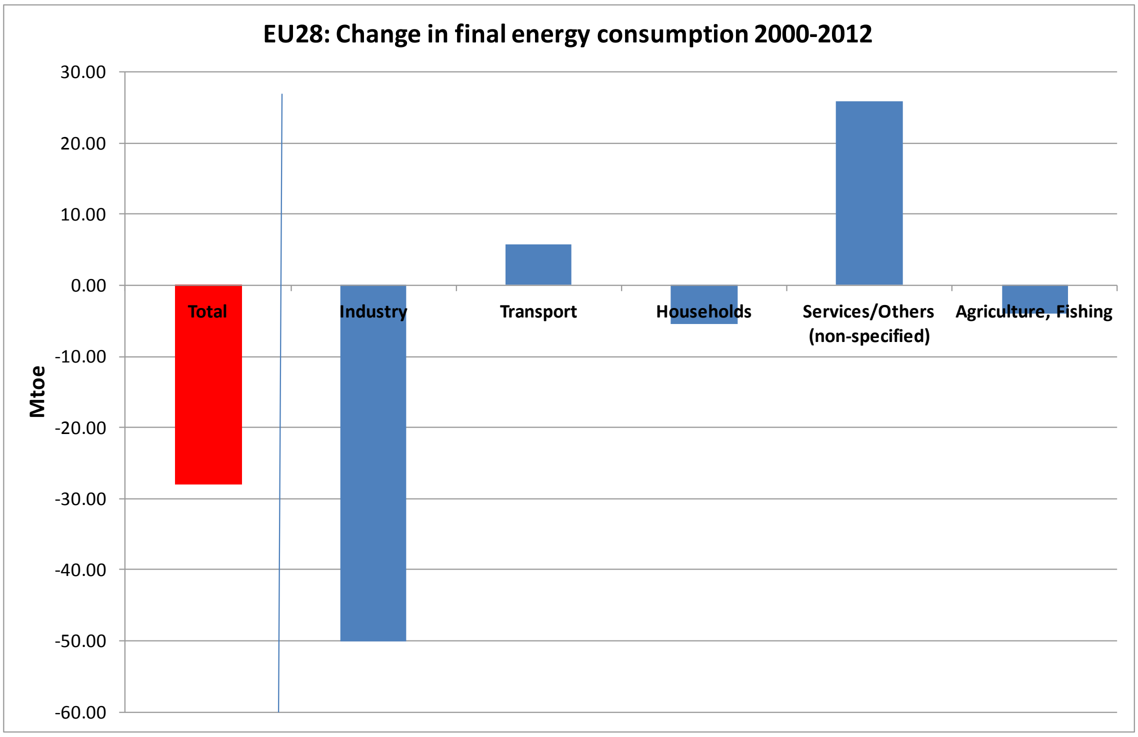
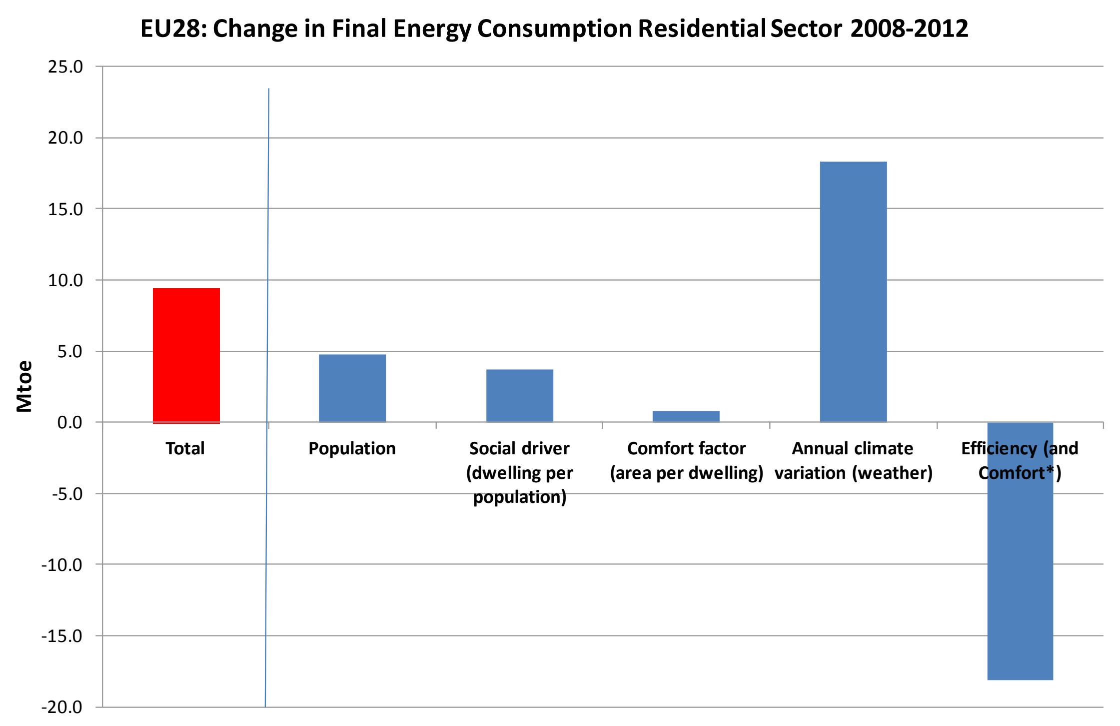
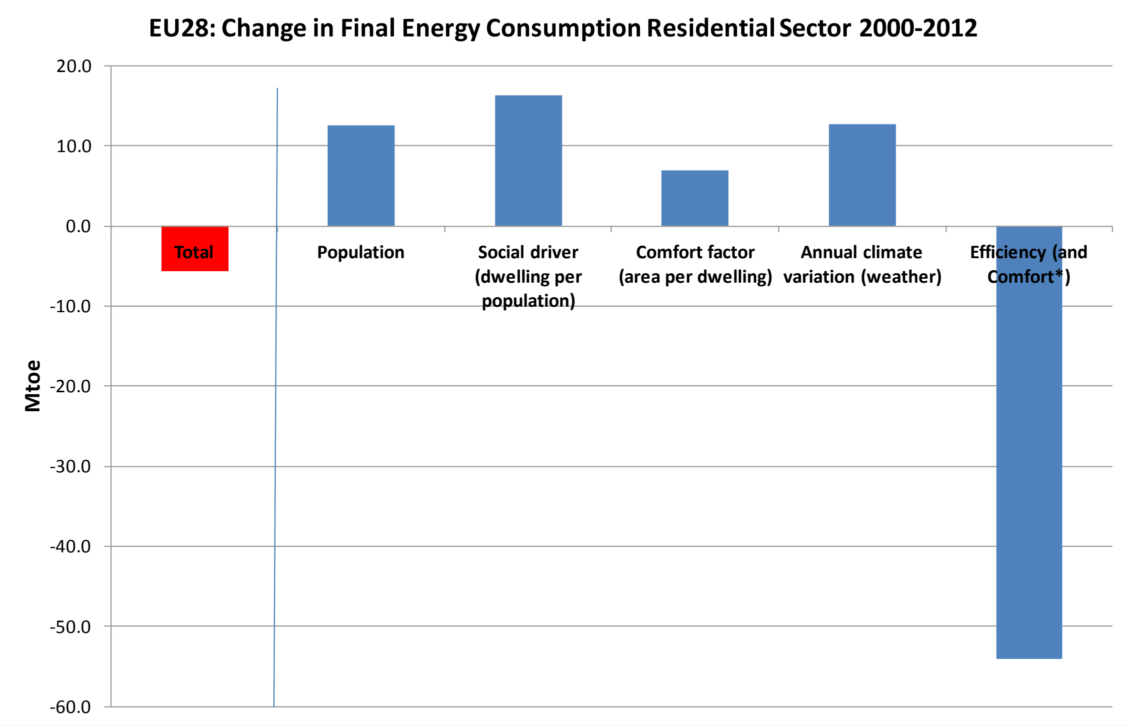


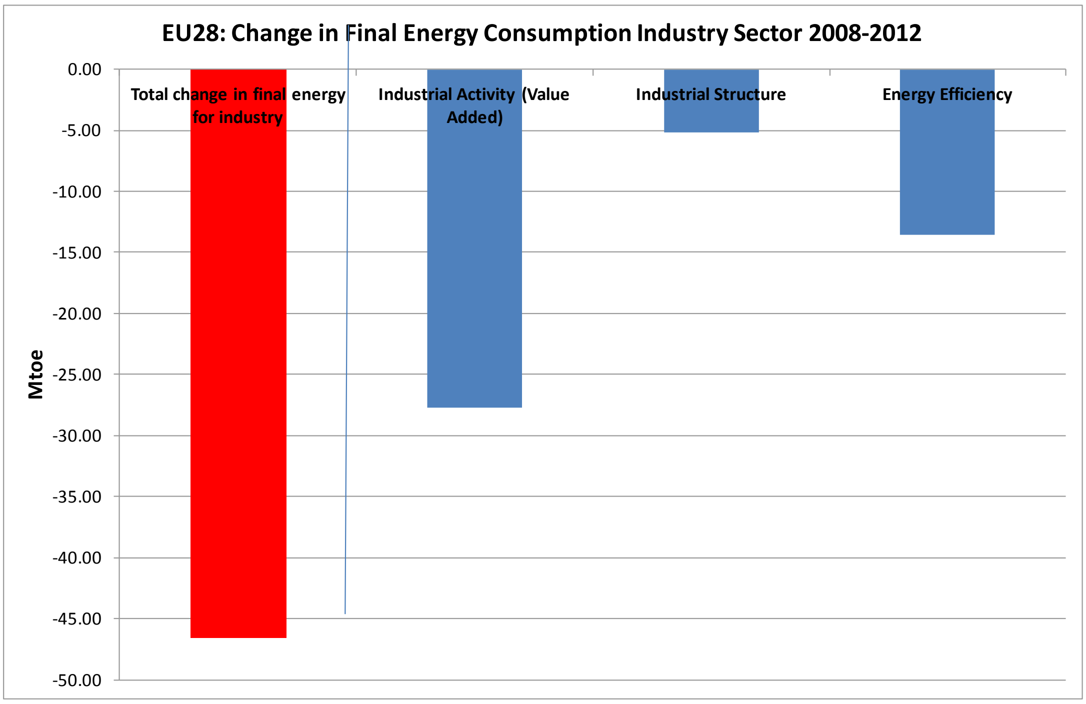
Figure 17: Sectoral decomposition analysis (**residential sector**) of changes in final energy consumption 2008-2012 and 2000-2012 (lower figure)

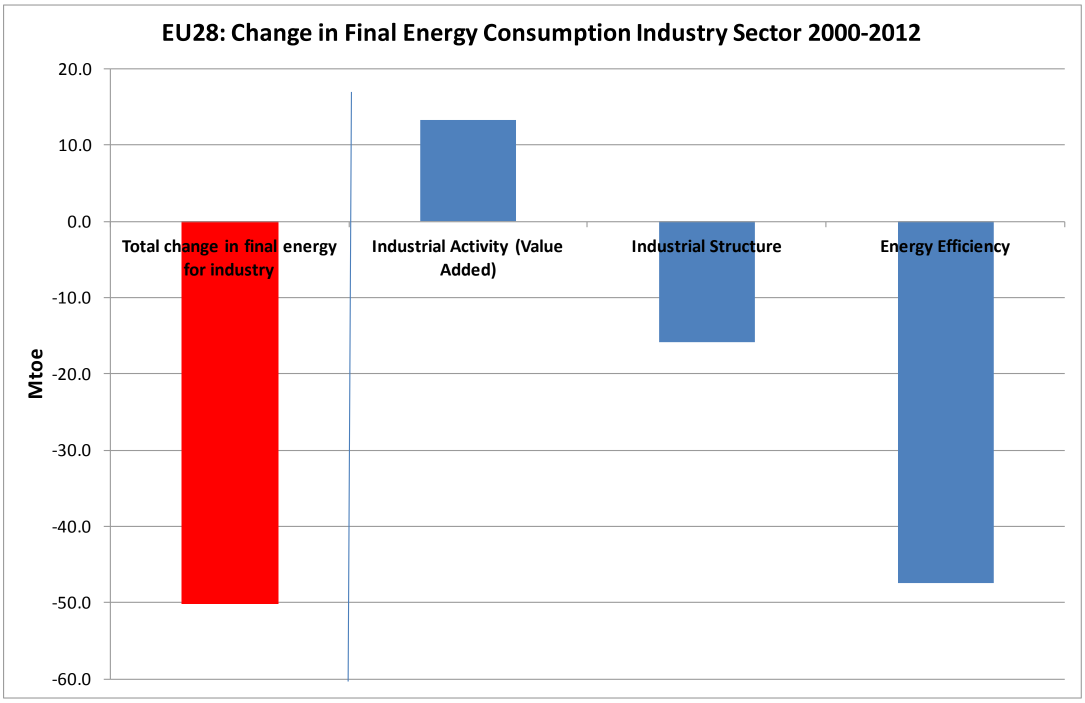




Note: The sector is broken down to the applications space heating, sanitary water heating, cooking and electric appliances/lighting. Some comfort factors in the trend towards more smaller electric appliances per dwelling could not be separated from efficiency effects for data reasons.

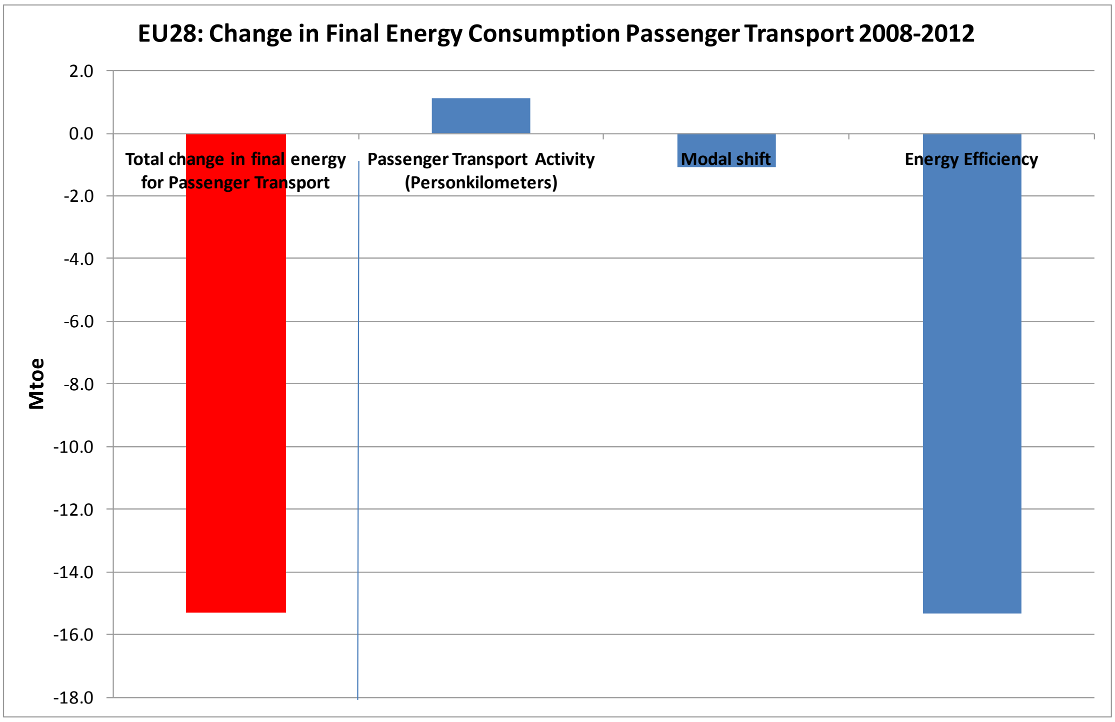
Figure 18: Sectoral decomposition analysis (**industry sector**) of changes in final energy consumption 2008-2012 and 2000-2012 (lower figure)

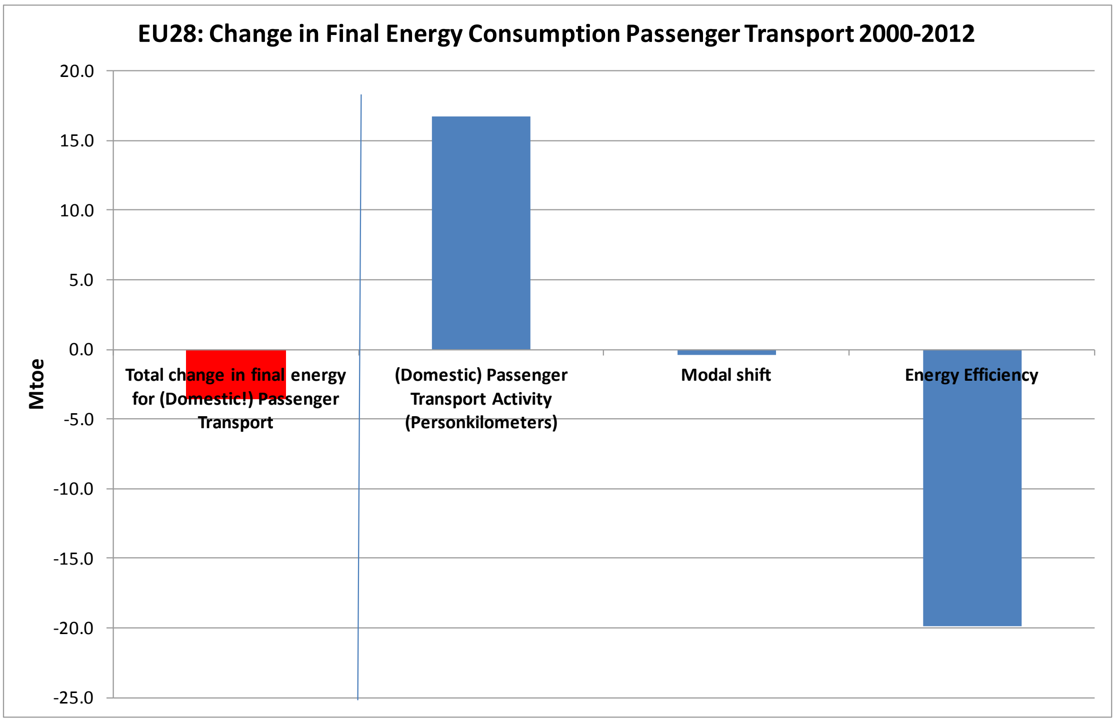




Note: the impacts of the industrial structure are based on the NACE-2 decomposition as used in the energy balance. Further structural changes at lower levels are small.

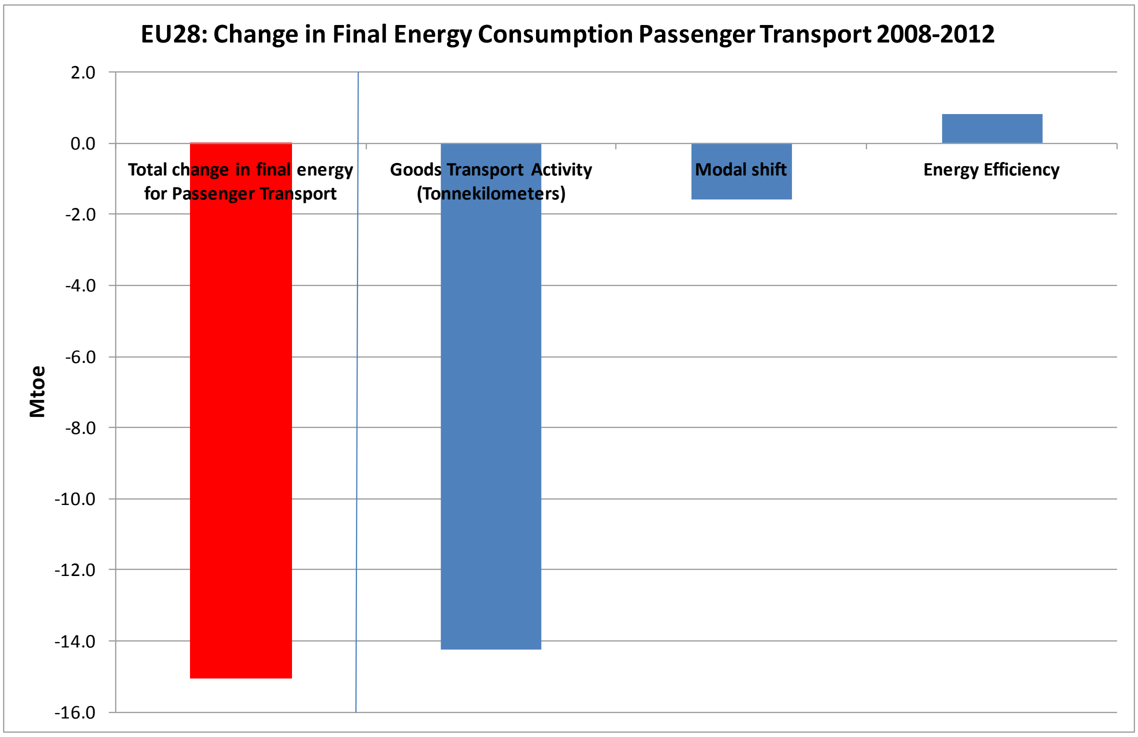
Figure 19: Sectoral decomposition analysis (**passenger transport sector**) of changes in final energy consumption 2008-2012 (upper figures) and 2000-2012 (lower figure)

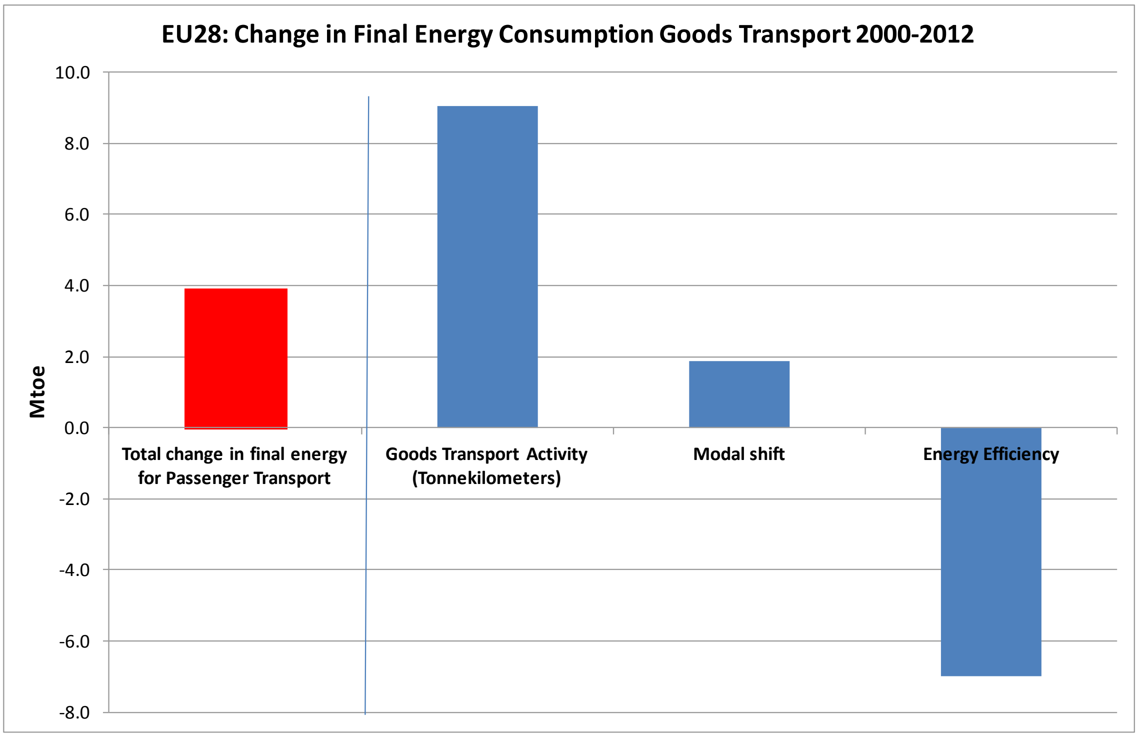




Note: Passenger transport is broken down to the modes road, rail, and domestic air transport. International air traffic is considered separately as it is not in competition with other modes for modal shift. Further details can be provided from the database.

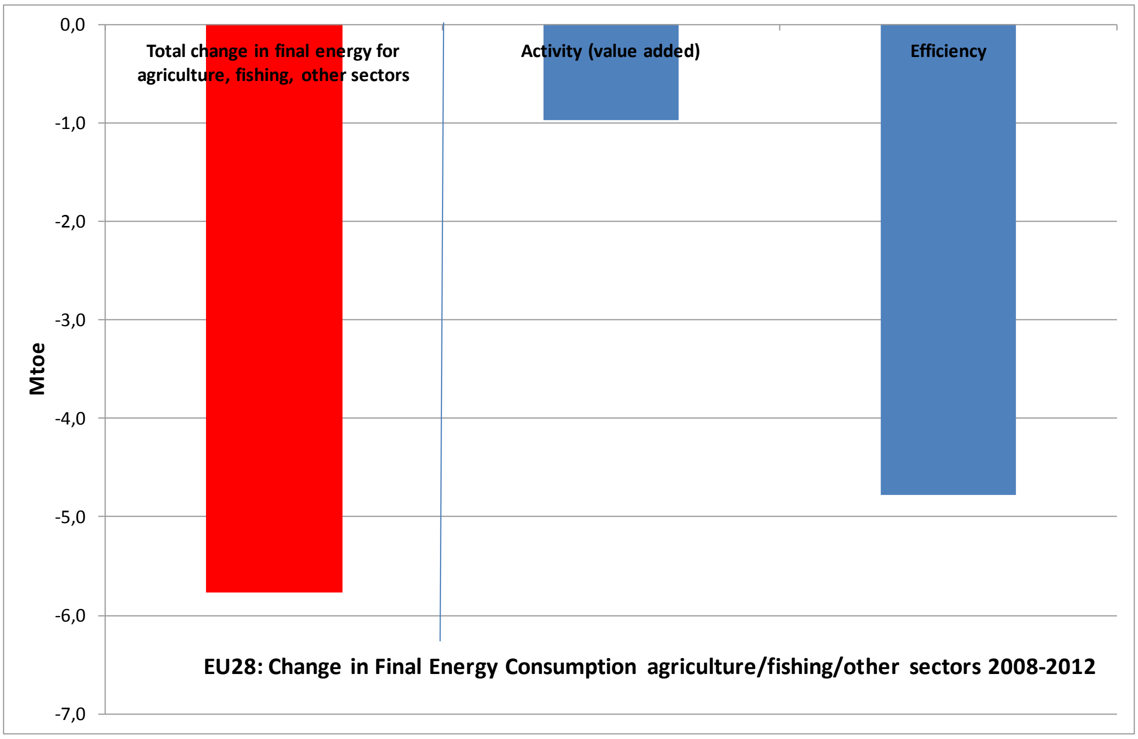
Figure 20: Sectoral decomposition analysis (**goods transport sector**) of changes in final energy consumption 2008-2012 (upper figures) and 2000-2012 (lower figure)

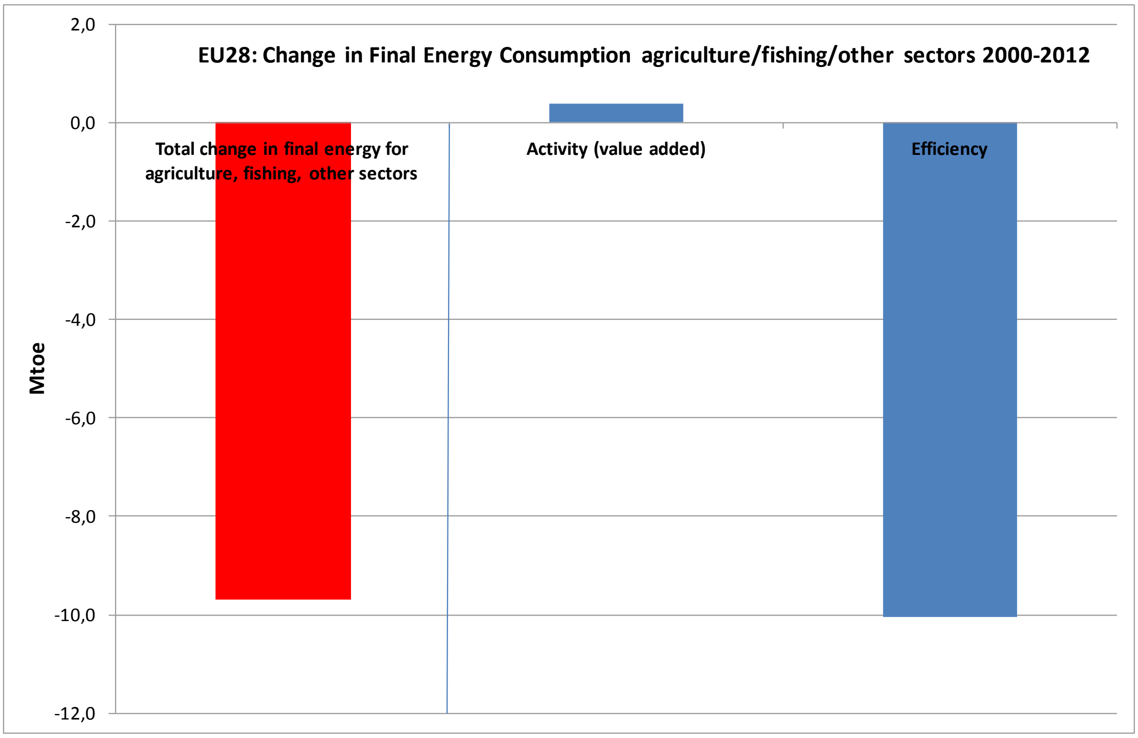




Note: Goods transport is broken down to the modes road, rail, inland water ways and pipelines. Further details can be provided from the database.

Figure 21: Sectoral decomposition analysis (**agriculture sector**) of changes in final energy consumption 2008-2012 (upper figures) and 2000-2012 (lower figure)





Note: Agriculture, fishing and other sectors is broken down into an activity effect and energy efficiency effect only as no further details are available.

4.7 Projection of the decomposition analysis 2008-2012 to 2020

In total final energy savings are nearly 53 Mtoe for the 5 years period (about 1.0% savings in final energy per year). This comprises both autonomous efficiency improvement and the impacts of energy efficiency policies. If projected to 2020 this could reduce final energy consumption by another 84 Mtoe up to 2020 from the level of 1104 Mtoe reached in 2012. However, the question is how the other factors of the decomposition may evolve. Activities have been decreasing in the period 2008 to 2012. This may reverse for the period 2013-2020, depending on the economic growth, and according to the recent PRIMES 2013 projections activities should increase final energy consumption compared to 2012 by 8.7% to a level of 1200 Mtoe. **The energy efficiency gains would bring this down once again to 1116 Mtoe**. Structural factors, modal shift and comfort factors are comparatively small and compensating in the period 2008 to 2012 and it can be expected that due to saturation effects no strong impact is expected for the period 2013-2020.

Annual climate effects (impacts of the year to year changes in weather) are different from year to year and there are two assumptions possible:

- Either we make here the assumption that 2020 will be comparable to 2007, the base year for the decomposition analysis, which was a rather warm year in the past 15 years. This assumption is not unrealistic, given the ongoing long-term trend of climate change which does increase the number of warmer years further. In total final energy demand would be at about **a level of 1116 Mtoe**, slightly above 2012 levels, and the distance to target would be with about 2.6 percentage points gap to the 2020 target a bit lower than the most recent Primes projections which reach a level of around 1130 Mtoe in 2020.
- On the other hand 2007, which is the starting year of the decomposition (the last year before the EED period), was very warm. Heating degree days were 7% below the average of 2001-2012 though this was already a warm period, well below the long-term average. As 2012 was a relatively cold year (though still below the long-term average), the heating degree days in 2012 are about 10% higher than in 2007. If the assumption is made that 2020 would be at the same level as 2012, the observed increase in final energy demand is around 19 Mtoe from the residential sector. There is also an effect in the service sector but this was not resolved for data reasons. By making the assumption that 2020 would be at the average of the period 2000-2012, this would add a “climate component” of the order of around 13 Mtoe by 2020, corresponding to the difference of the average of the last 10 years as compared to 2007. This would bring final energy demand in 2020 to **a level of 1129 Mtoe (gap of 3.8% to the 2020 target)**, **hence very close to the PRIMES projections** (which assume 2005 climate, which was quite close to the average of the period 2000-2012).

The climate effect is “erratic. This is the reason why we consider both possibilities here. However, in order to take a conservative stake, one would opt for 2020 being on average compared to the period 2000-2012.

The findings from the decomposition analysis contrast with the findings from the bottom-up policy analysis which shows that the National Energy Efficiency Action Plans NEEAPs (IF fully implemented as though by the Member States) contain enough savings to close the gap if they are properly implemented. There are two main reasons to explain this difference:

- First the decomposition analysis is influenced in the period 2008 to 2012 by the impacts of the economic crisis which has reduced investments in energy efficiency. **If the savings rate would return to the same level as for the period 2000 to 2012** (11.5 Mtoe annually) in total around 92 Mtoe savings up to 2020 may be realised. Including the correction for an average 2000/2012 climate in 2020, **the level of final energy consumption would be around 1121 Mtoe in 2020 (gap of 3.2%)**. If the climate correction would not be made to assume average 2000/2012 climate in 2020 **and the gap would be lowered to 2.2% (1108 Mtoe) hence closer to the “zero gap” identified from the bottom-up policy analysis**. Given the fact that the assumption of a more strongly growing economy as compared to the period of 2008 to 2012 is taken, it seems consistent to assume also a larger savings rate for that period.
- Second, the implementation of policies as identified in the bottom-up analysis may not be as successful as supposed in the NEEAPs, though a variety of countries have applied precautionary reduction factors in order not to overestimate the measure impacts. This is confirmed also by a more in-depth inquiry on the impacted impacts of the policies (see report on the policy analysis).

With respect to primary energy consumption the higher range of final energy consumption of 1129 Mtoe would correspond to a primary energy consumption of 1533 Mtoe (using primary energy conversion factors for 2020 which assume that the 20% renewable target is reached and which is relatively likely), **hence at a distance of 3.2% from the target of 1474 Mtoe**. **If the higher savings rate is retained and 2007 climate assumed, hence, the lower final energy demand of 1108 Mtoe, the gap remaining in primary energy is around 1.6% (1504 Mtoe).**

4.8 Country-specific analysis

In this section we show some selected country comparisons for the decomposition analysis. For comparison purpose the changes in the different factors are provided on an annual basis and normalized to the final or primary energy consumption of 2012 for the country (change in percent of final/primary energy per year). For more details for each country we refer to the country annex (see also some more explanations of the different factors there). Here we summarize the main observations:

Final energy (Figure 22 and Figure 23)

- While the annual total changes in final energy was still increasing in a number of countries in the period 2000-2012, especially in eastern Member States, it was decreasing in nearly all MS in the period 2008-2012.
- This was largely due to the impact of the financial and economic crisis as seen by the activity component, which was still largely contributing to the increase in final energy in the period 2000-2012, while it was reducing final consumption since 2008.
- The structural component (including for example modal shift in the transport sector as well as changes in industrial structure) was also contributing to the reduction in final energy on average in both periods but the changes were mixed across the countries.
- Comfort/behaviour and social factors were contributing in both periods to the increase in energy consumption though less in the period since 2008
- The impact of annual climate variations (weather impact) was to increase final consumption due to the fact that the end year 2012 was colder than both 2000 and 2007 (the base year for the 2008-2012 analysis) which in the period 2000-2012 appeared as rather warm years.
- The energy efficiency factor contributed to reduce final energy consumption by around 1% per year in both periods but it slowed down in the shorter period 2008-2012 due to impacts of the economic crisis which for example in industry or goods transport has a negative impact on energy consumption due to lower capacity uses.

Primary energy (Figure 24 and Figure 25)

- Primary energy reflects partly the changes in final energy consumption and the changes in the conversion sector. Hence, the total change in primary energy is differing across countries and is influenced by different factors. Overall, primary energy consumption decreased since 2008.
- Activities (demand for energy available for final demand) drove the primary energy demand up in the total period 2000-2012 but contributed to an increase since 2008. This is due to the combined impact of the different factors impacting on final energy and discussed in the previous section.
- Both distribution losses and own consumption in the energy sector overall contributed to reduce primary energy consumption but comparatively little in comparison with other factors.
- Structural change in the energy conversion sector was impacting negatively the consumption of primary energy with the penetration of the electricity sector which as

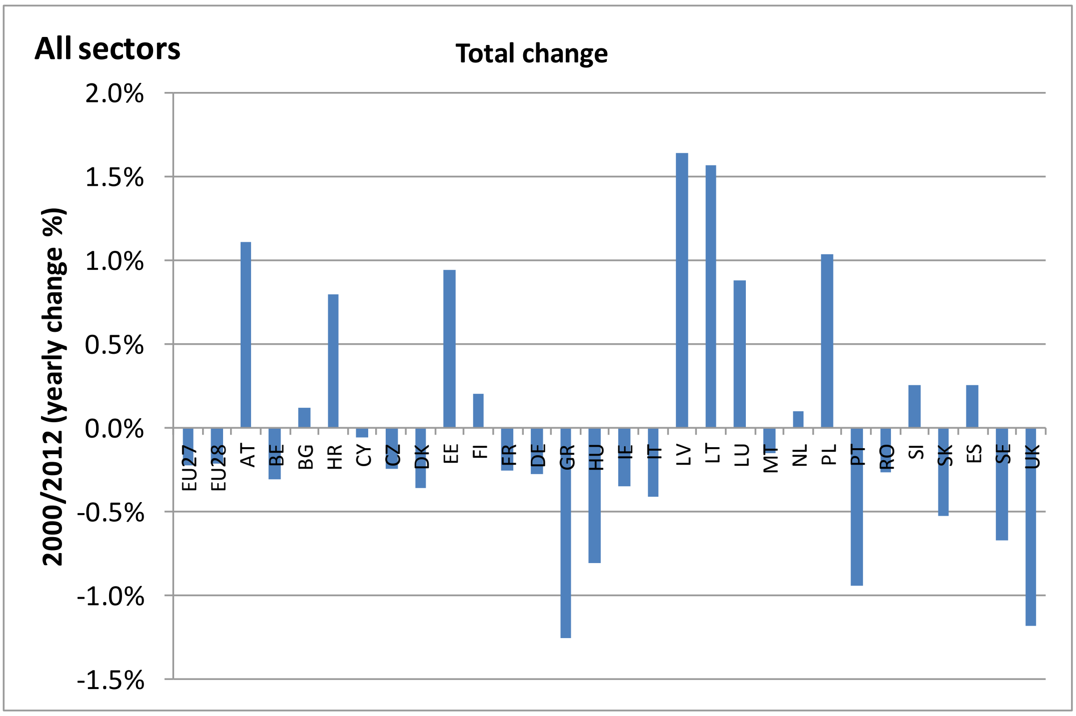
a lower efficiency than the other parts of the conversion sector. The impact was, however, less pronounced in the period since 2008.

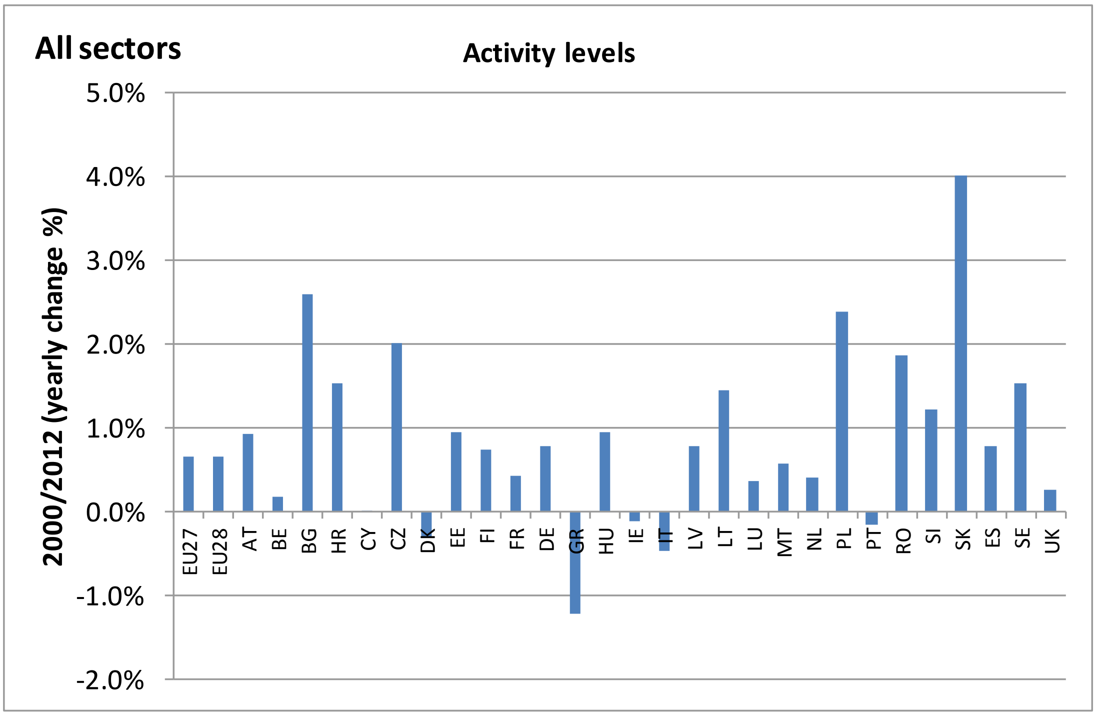
- Energy efficiency in the transformation sector contributed strongly to mitigate the impacts of the structural change. This was in particular due to the electricity sector itself (see the next section), which changing shares in renewable energy sources and CHP.

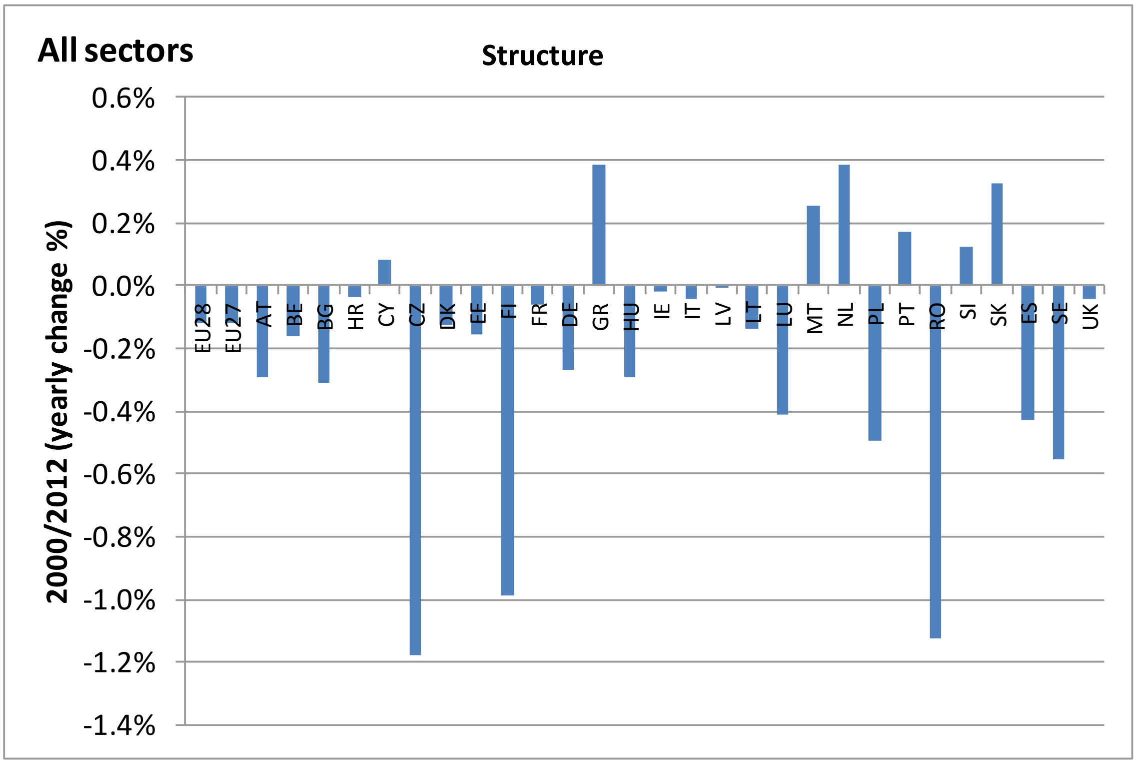
Changes in primary energy due to electricity generation (Figure 26 and Figure 27)

- The electricity sector was strongly contributing to the different changes in primary energy as discussed in the previous section. In the period 2000-2012 primary energy was increasing due the strong increase in gross final electricity demand in all countries (activity effect). This effect slowed down and even reversed in the period since 2008 that is less demand for gross electricity demand contributed to reduce primary energy demand for electricity generation
- A large impact came from structural change in the electricity generation, away from thermal power generation and nuclear towards more renewable (with 100% nominal efficiency) and CHP in some countries.
- The efficiency of (thermal) power plants contributed to an increase in primary energy consumption in the period since 2008, possibly due to lower capacities uses of thermal power plants (under the combined impacts of the penetration of renewable and the lowered demand for electricity since 2008).

Figure 22: Total change in final energy consumption and different factors 2000-2012 (annual change in percent)






All sectors
Structure
2000/2012 (yearly change %)
0.6%
0.4%
0.2%
0.0%
-0.2%
-0.4%
-0.6%
-0.8%
-1.0%
-1.2%
-1.4%
EU28
EU27
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
DE
GR
HU
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IT
LV
LT
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NL
PL
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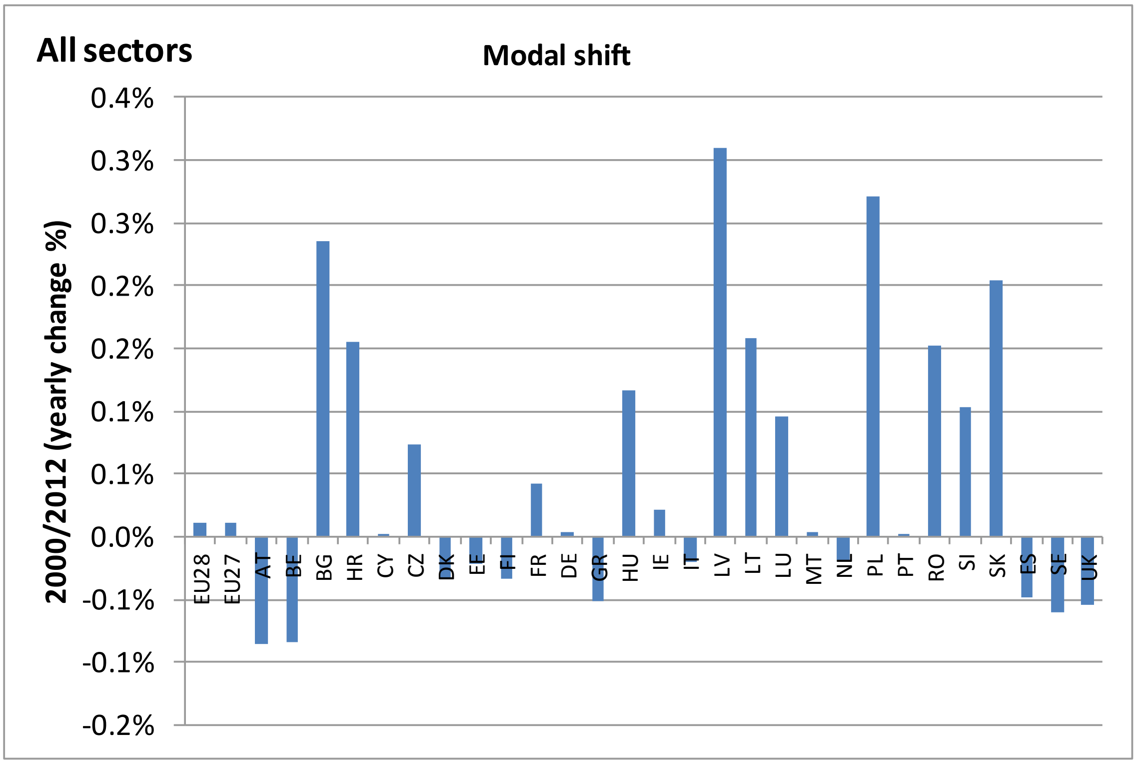
UK


All sectors
Modal shift
2000/2012 (yearly change %)
0.4%
0.3%
0.3%
0.2%
0.2%
0.1%
0.1%
0.0%
-0.1%
-0.1%
-0.2%
EU28
EU27
AT
BE
BG
HR
CY
CZ
DK
EE
FI
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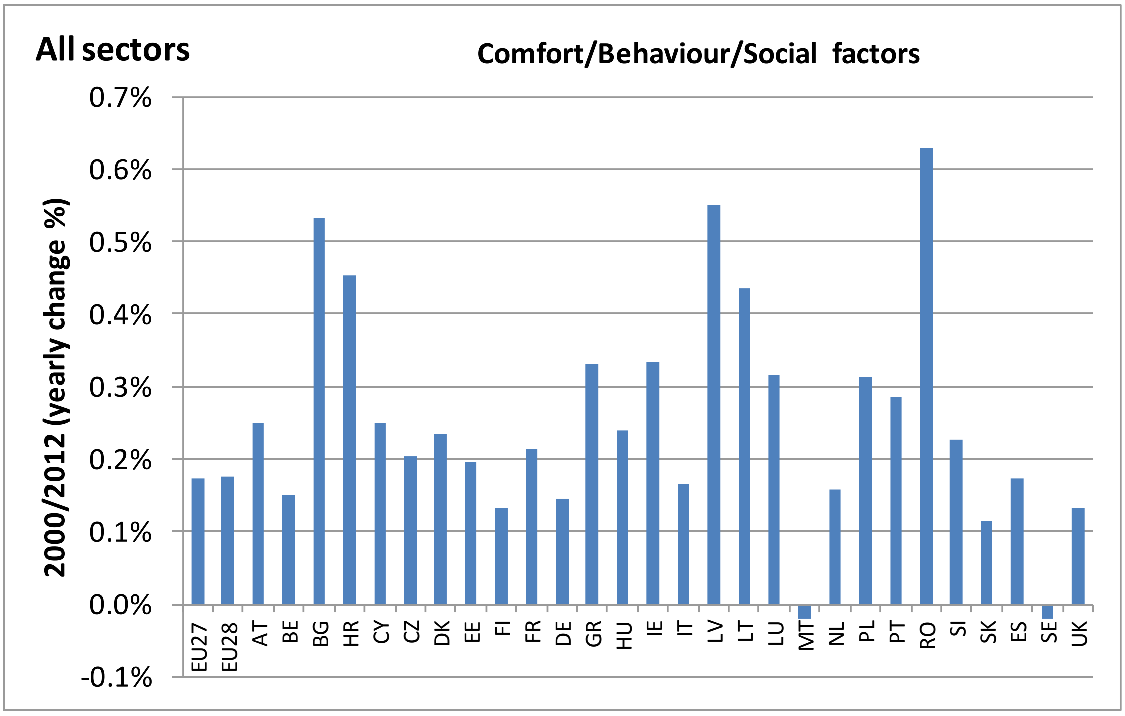
All sectors
Comfort/Behaviour/Social factors
2000/2012 (yearly change %)
0.7%
0.6%
0.5%
0.4%
0.3%
0.2%
0.1%
0.0%
-0.1%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
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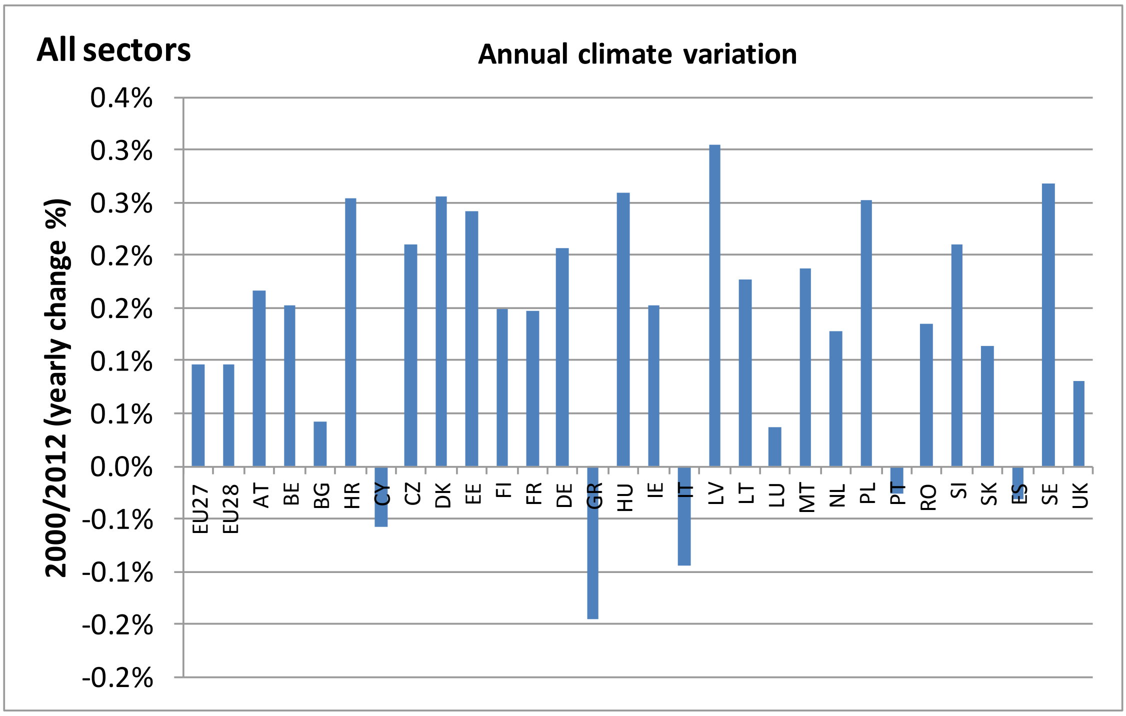
All sectors
Annual climate variation
2000/2012 (yearly change %)
0.4%
0.3%
0.3%
0.2%
0.2%
0.1%
0.1%
0.0%
-0.1%
-0.1%
-0.2%
-0.2%
EU27
EU28
AT
BE
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SE
UK

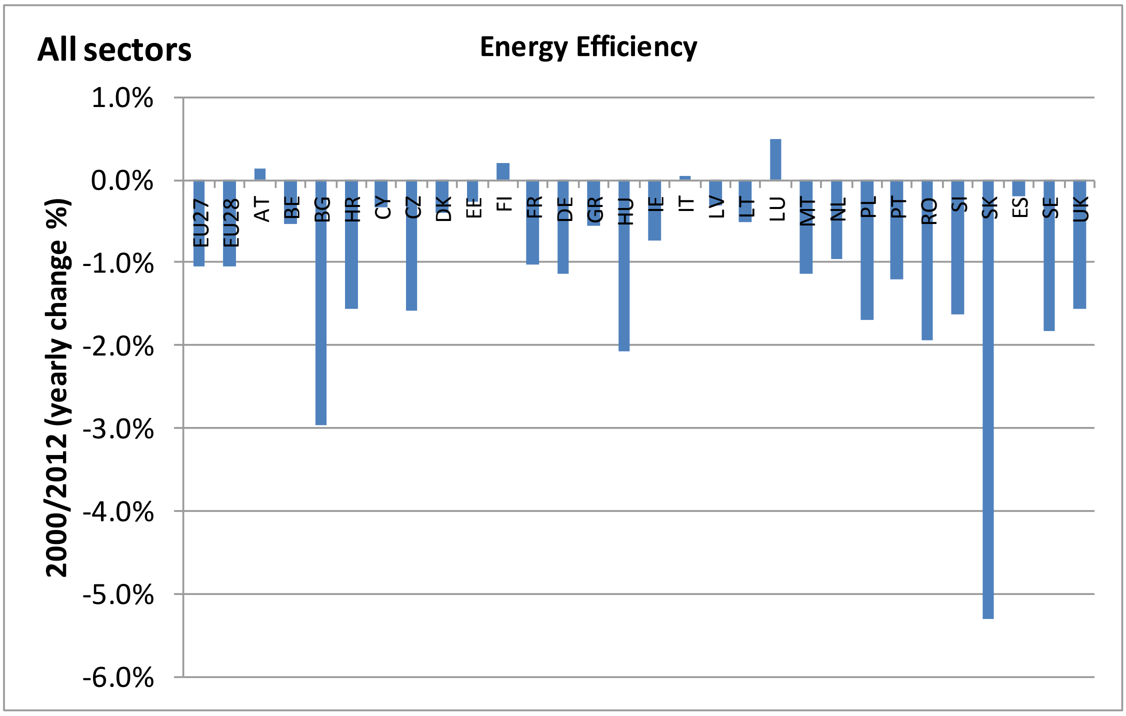
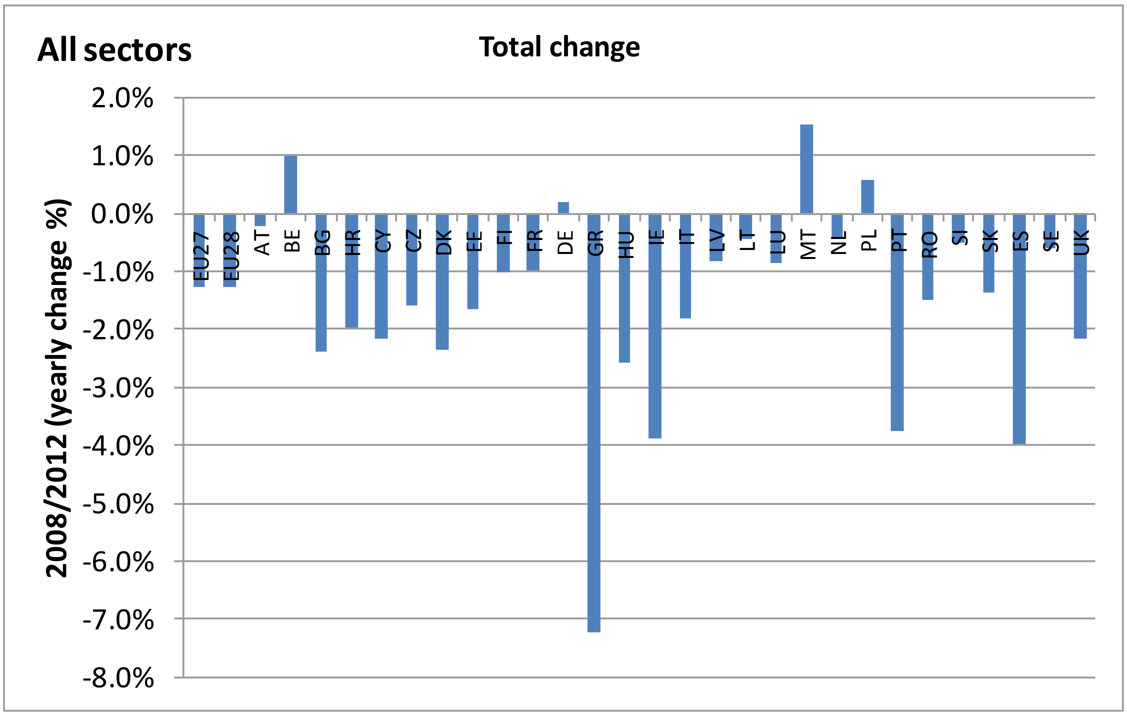
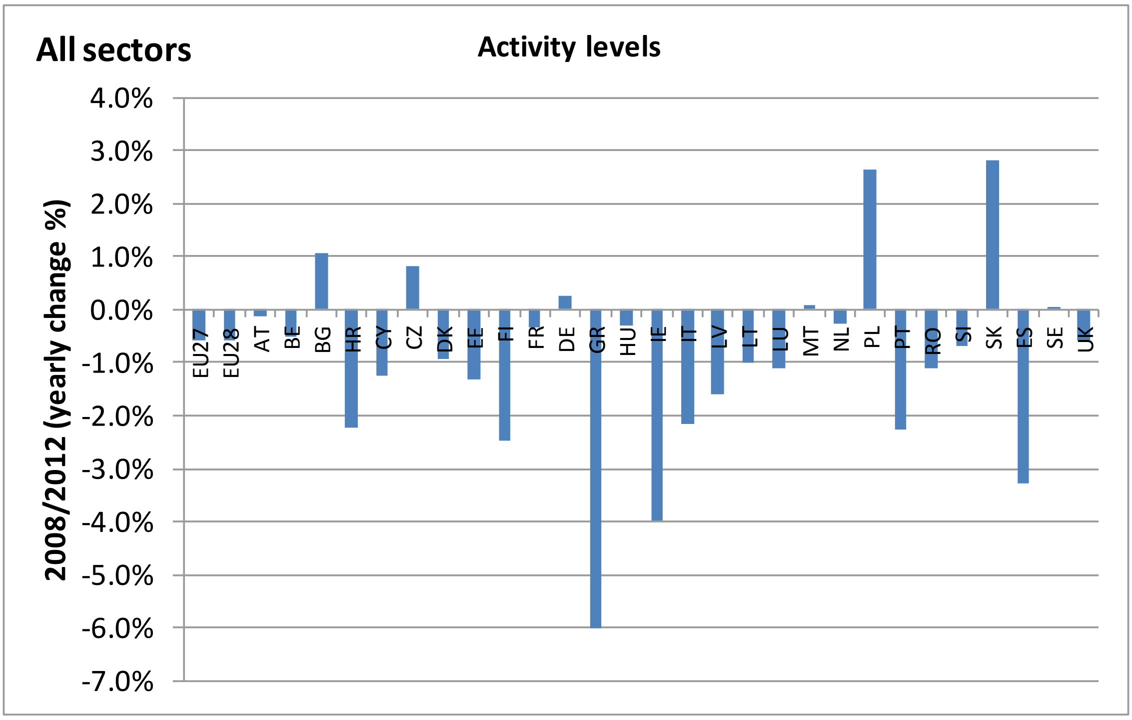


Figure 23: Total change in final energy consumption and different factors 2008 (incl.)-2012 (annual change in percent)




All sectors
Activity levels
2008/2012 (yearly change %)
4.0%
3.0%
2.0%
1.0%
0.0%
-1.0%
-2.0%
-3.0%
-4.0%
-5.0%
-6.0%
-7.0%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
EE
FI
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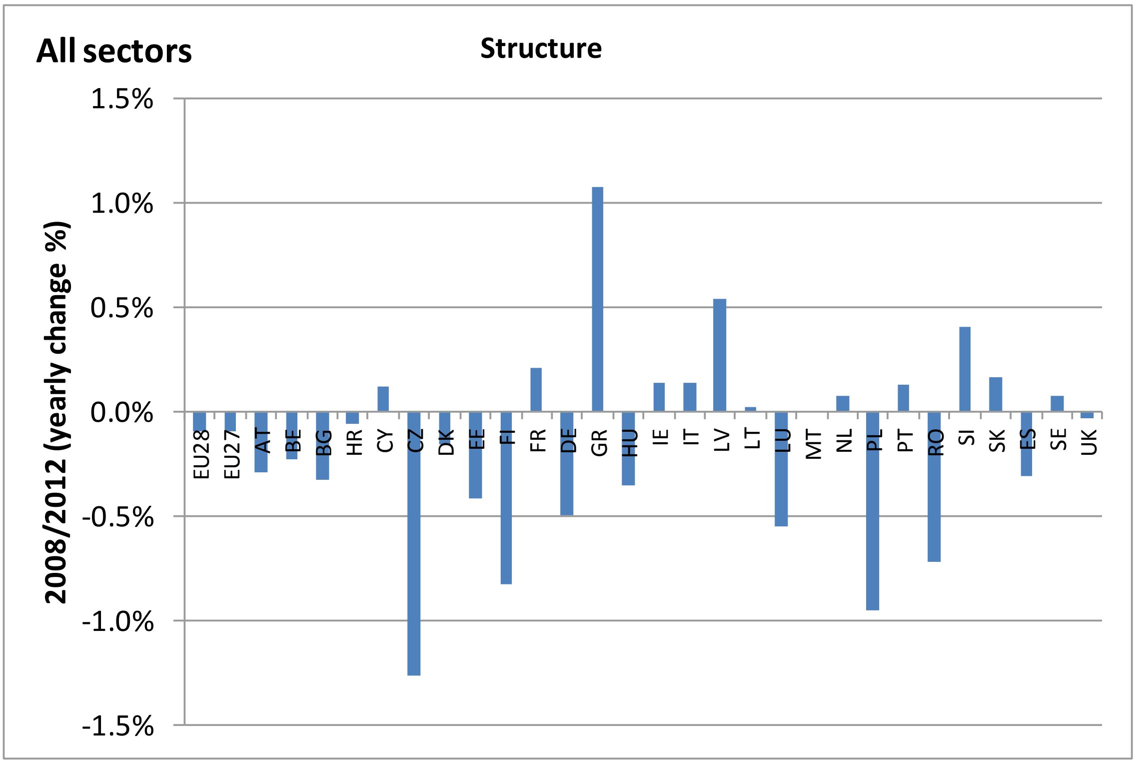
SE
UK


All sectors
Structure
2008/2012 (yearly change %)
1.5%
1.0%
0.5%
0.0%
-0.5%
-1.0%
-1.5%
EU28
EU27
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
DE
GR
HU
IE
IT
LV
LT
LU
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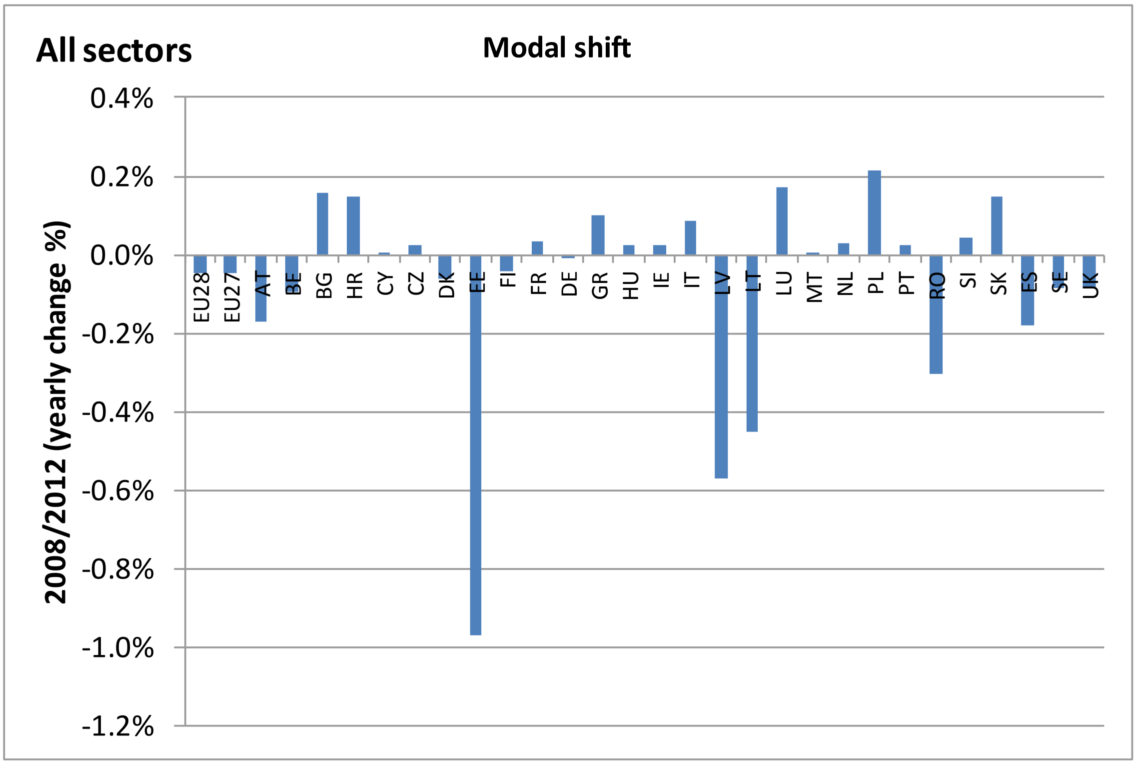
NL
PL
PT
RO
SI
SK
ES
SE
UK


All sectors
Modal shift
2008/2012 (yearly change %)
0.4%
0.2%
0.0%
-0.2%
-0.4%
-0.6%
-0.8%
-1.0%
-1.2%
EU28
EU27
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
DE
GR
HU
IE
IT
LV
LT
LU
MT
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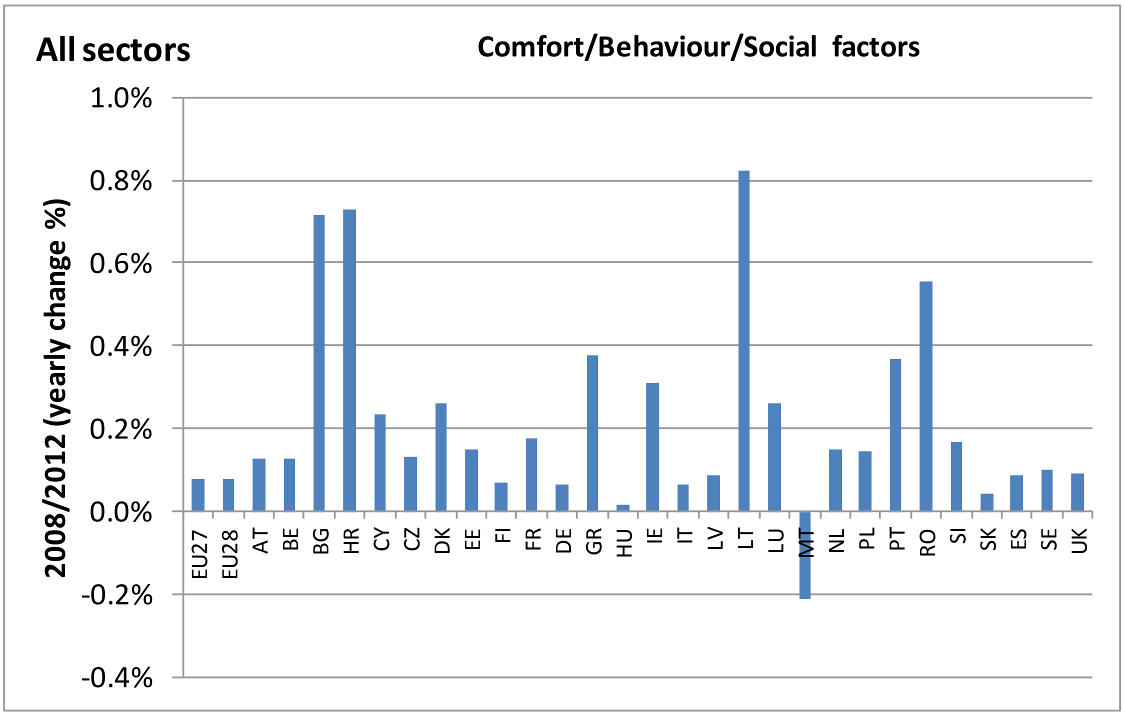
UK


All sectors
Comfort/Behaviour/Social factors
2008/2012 (yearly change %)
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
-0.2%
-0.4%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
DE
GR
HU
IE
IT
LV
LT
LU
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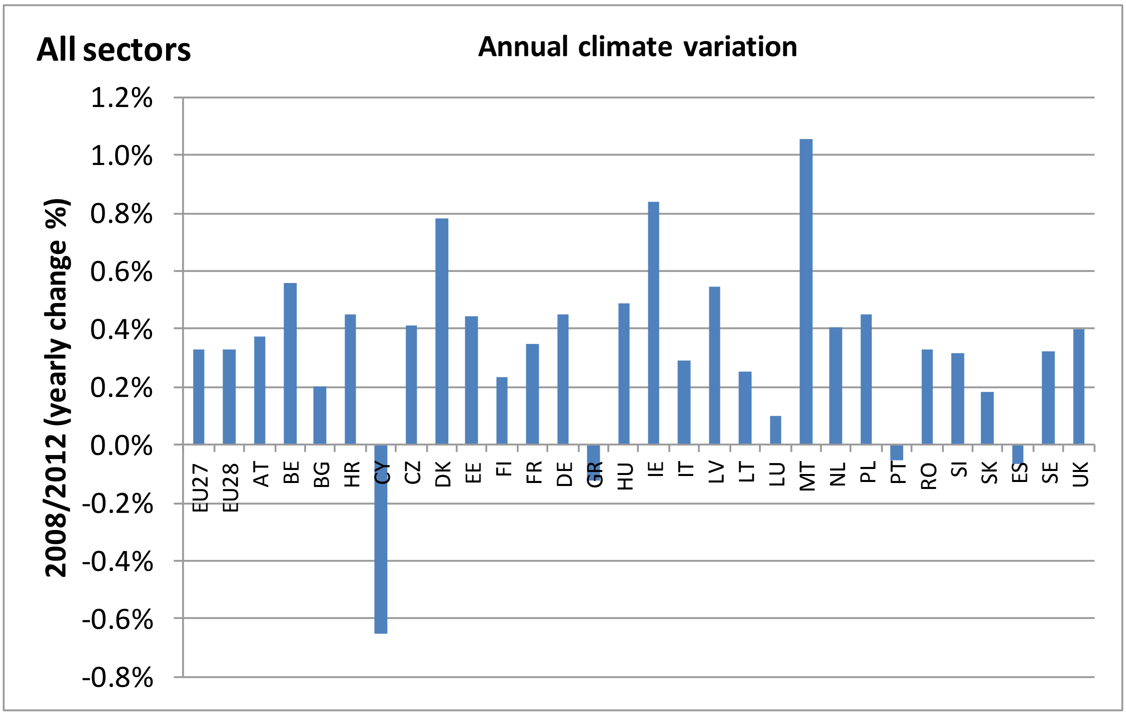
SE
UK


All sectors
Annual climate variation
2008/2012 (yearly change %)
1.2%
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
-0.2%
-0.4%
-0.6%
-0.8%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
DE
GR
HU
IE
IT
LV
LT
LU
MT
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RO
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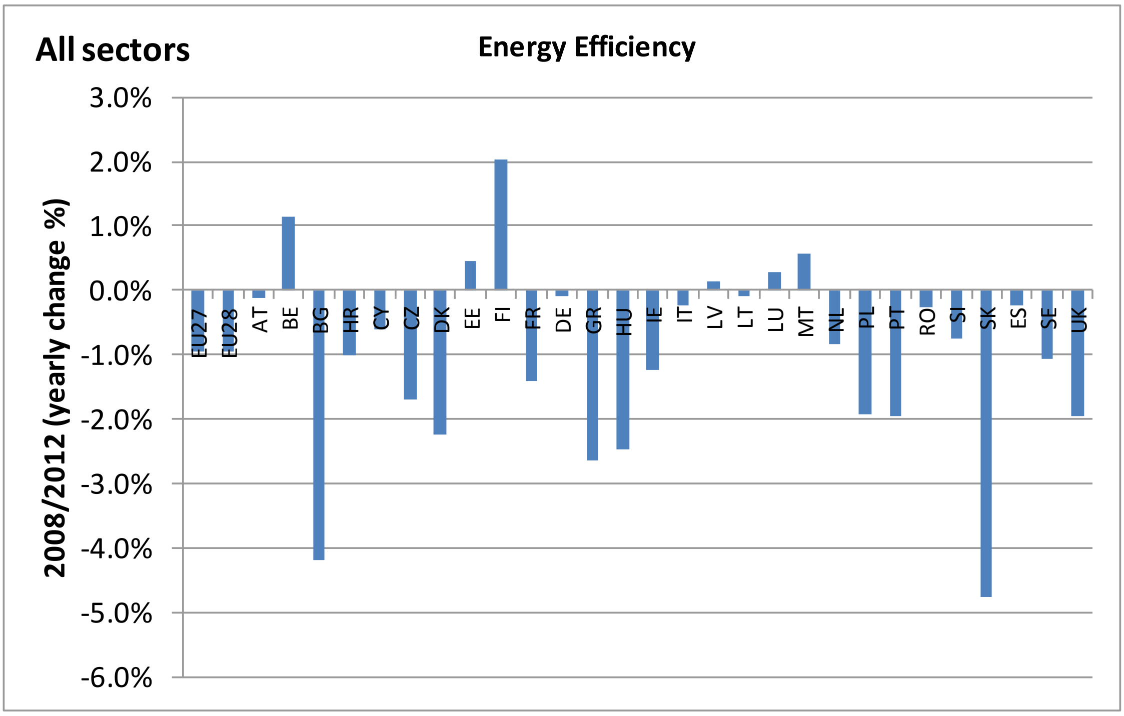
SK
ES
SE
UK


All sectors
Energy Efficiency
2008/2012 (yearly change %)
3.0%
2.0%
1.0%
0.0%
-1.0%
-2.0%
-3.0%
-4.0%
-5.0%
-6.0%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
DE
GR
HU
IE
IT
LV
LT
LU
MT
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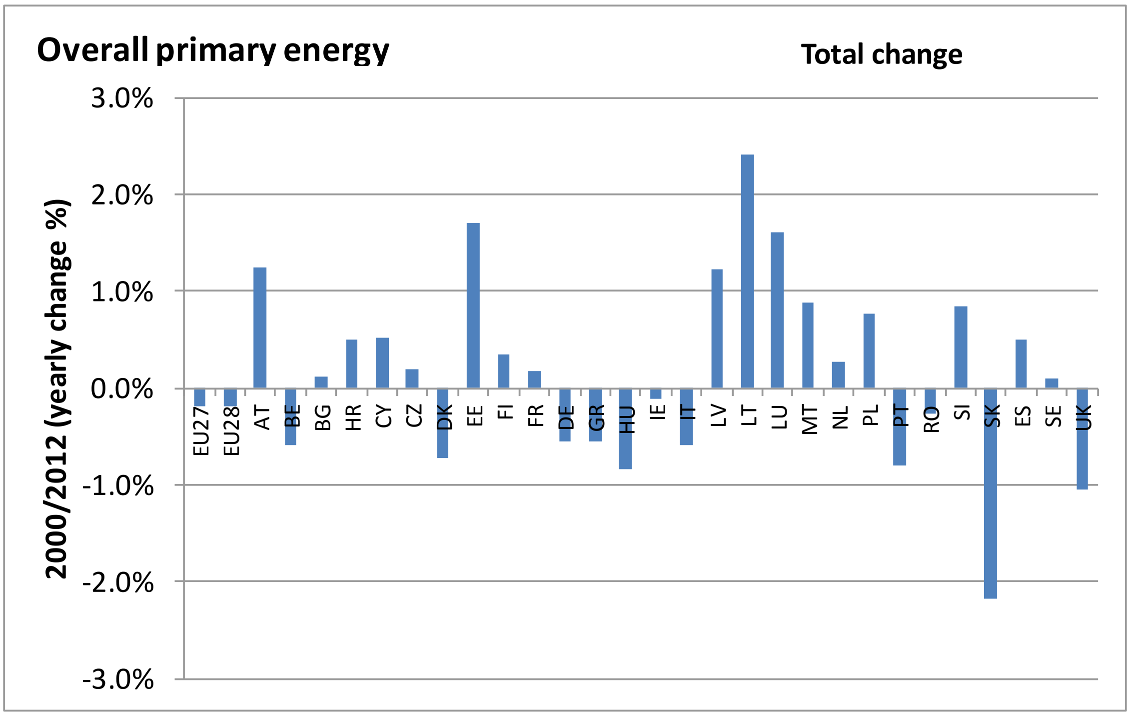
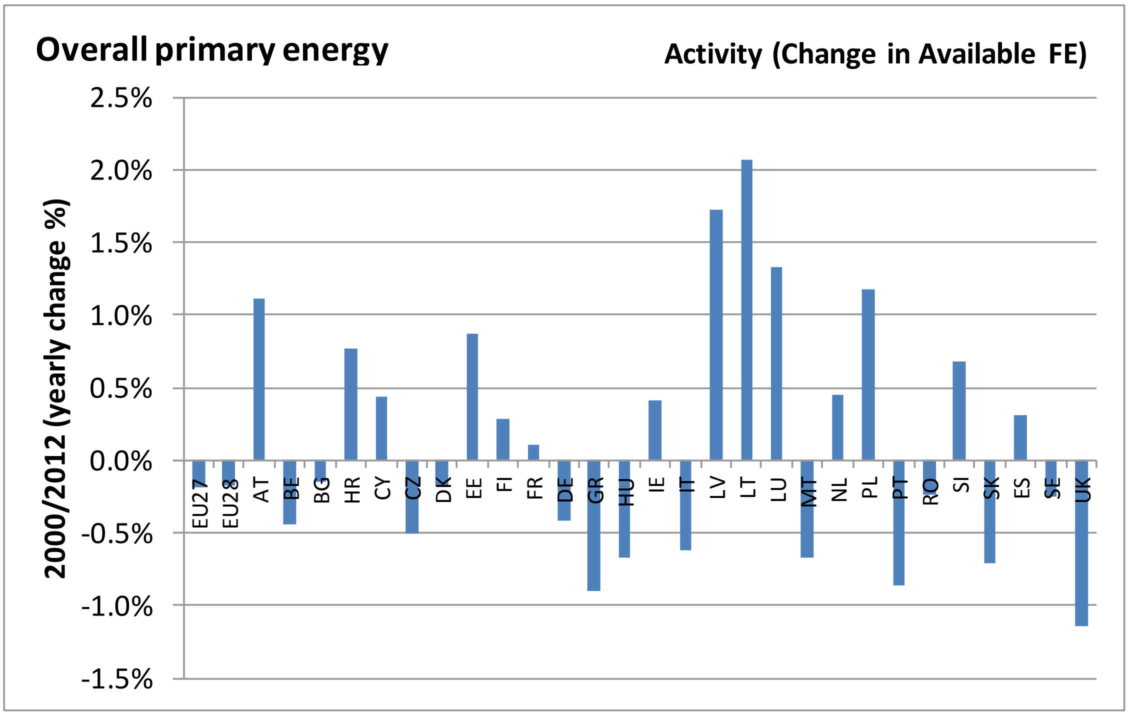
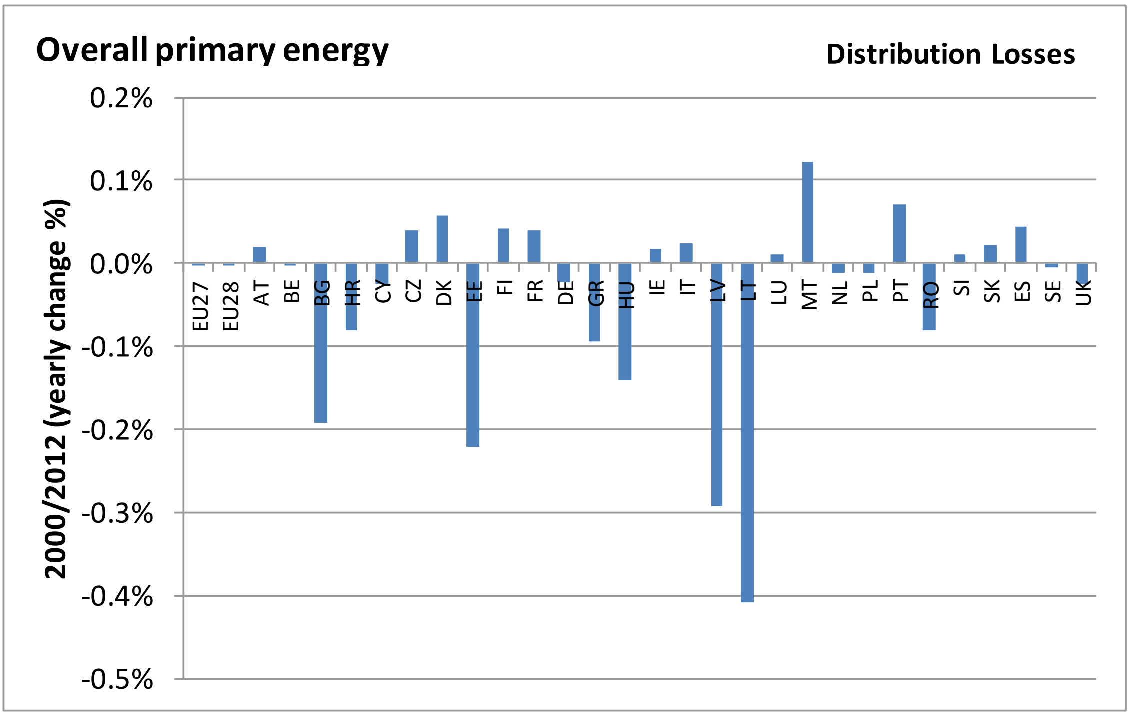
UK

Figure 24: Total change in primary energy consumption (excl. non-energy uses) and different factors 2000-2012 (annual change in percent)






Overall primary energy
Distribution Losses
2000/2012 (yearly change %)
0.2%
0.1%
0.0%
-0.1%
-0.2%
-0.3%
-0.4%
-0.5%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
DE
GR
HU
IE
IT
LV
LT
LU
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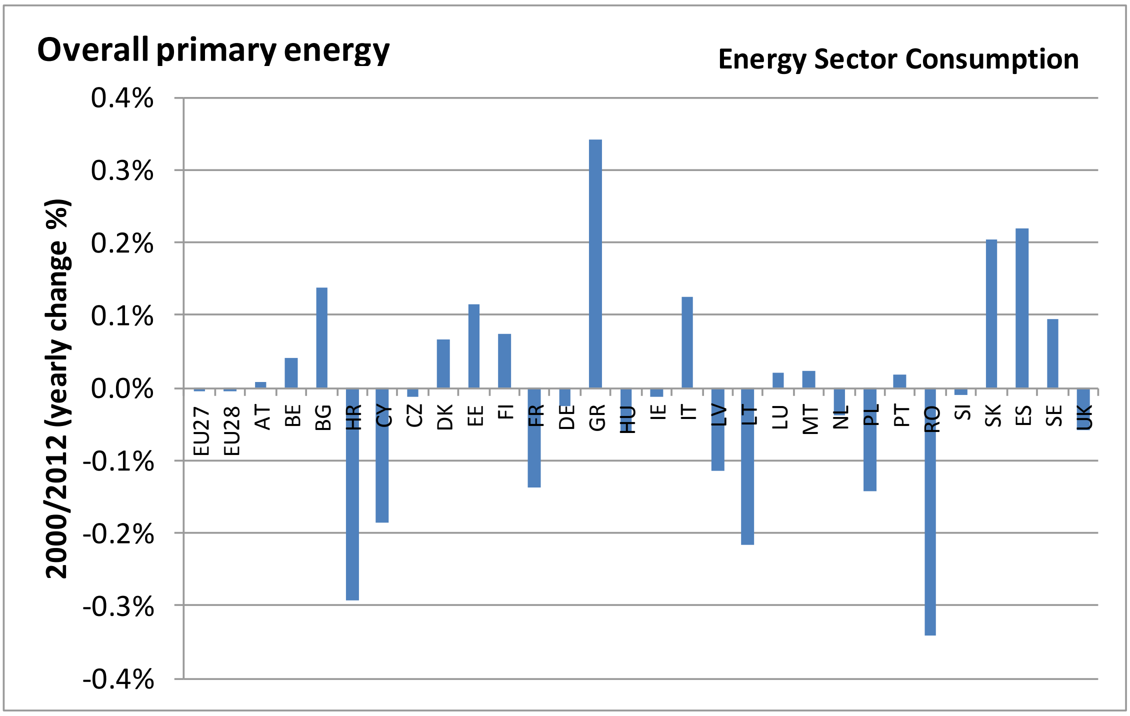
RO
SI
SK
ES
SE
UK


Overall primary energy
Energy Sector Consumption
2000/2012 (yearly change %)
0.4%
0.3%
0.2%
0.1%
0.0%
-0.1%
-0.2%
-0.3%
-0.4%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
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HU
IE
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LV
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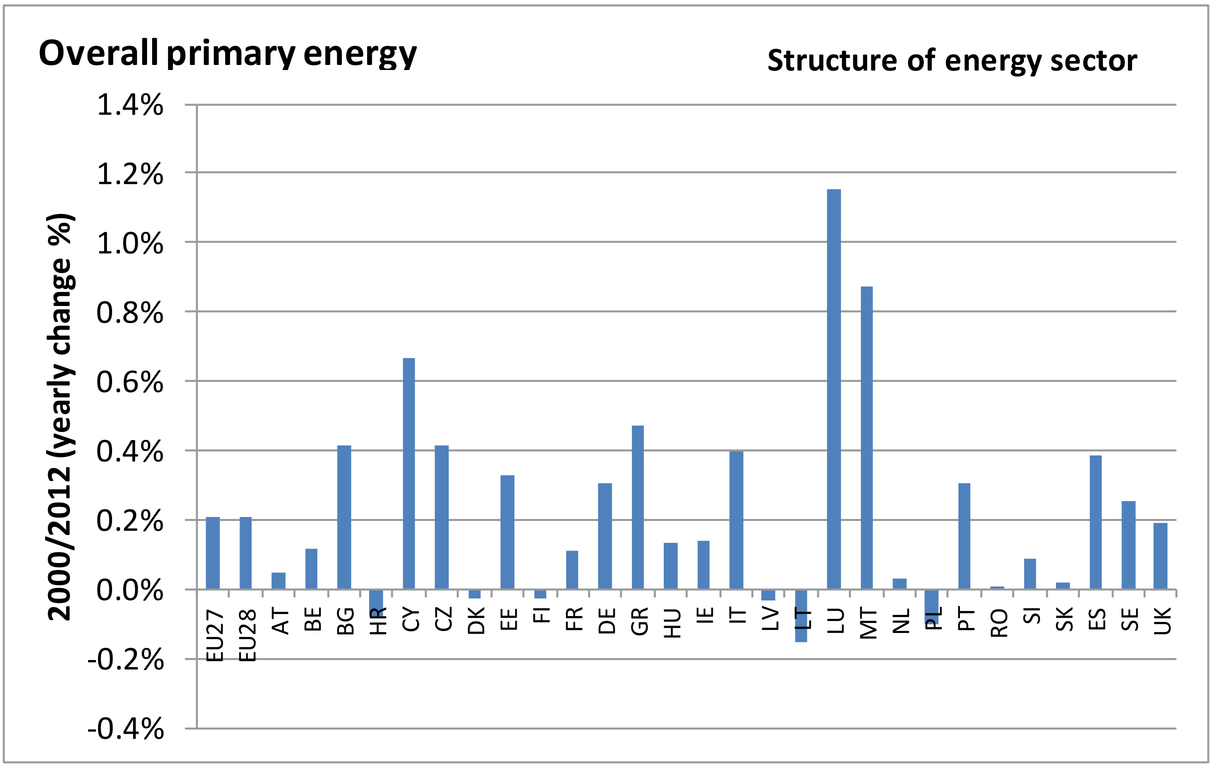
SK
ES
SE
UK


Overall primary energy
Structure of energy sector
2000/2012 (yearly change %)
1.4%
1.2%
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
-0.2%
-0.4%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
DE
GR
HU
IE
IT
LV
LT
LU
MT
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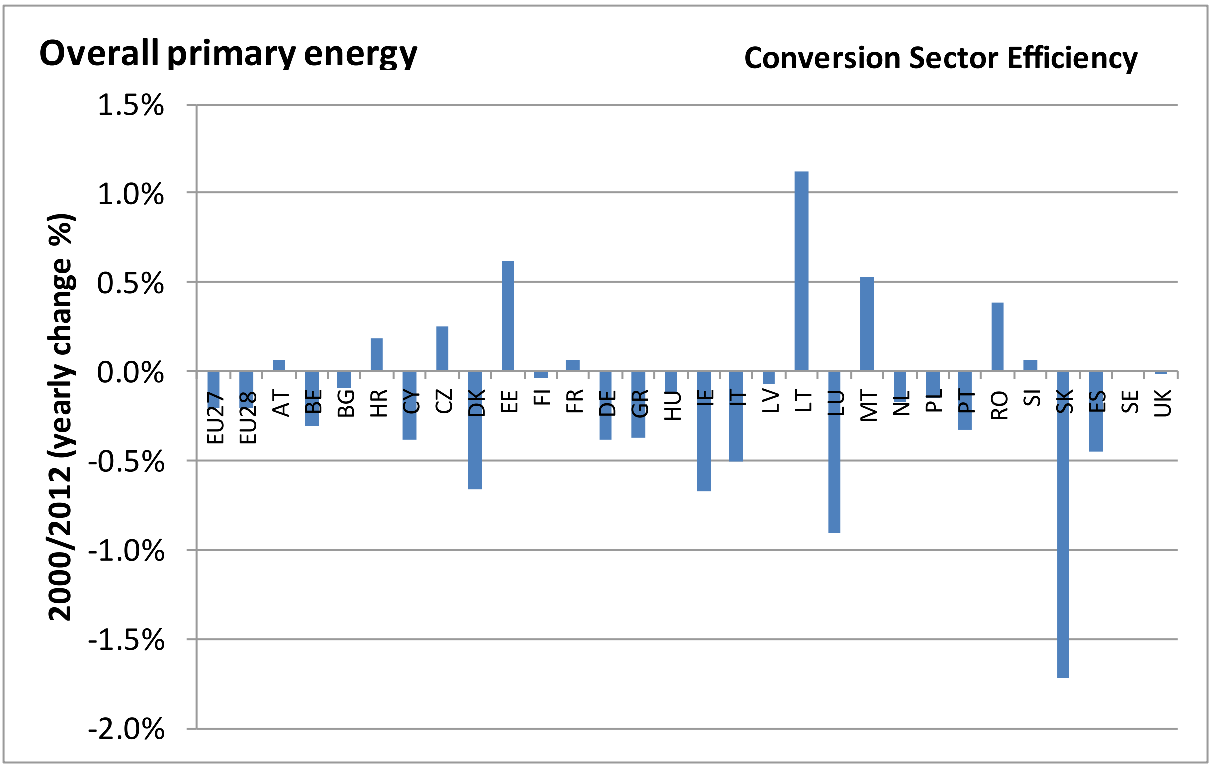
SI
SK
ES
SE
UK


Overall primary energy
Conversion Sector Efficiency
2000/2012 (yearly change %)
1.5%
1.0%
0.5%
0.0%
-0.5%
-1.0%
-1.5%
-2.0%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
DE
GR
HU
IE
IT
LV
LT
LU
MT
NL
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SK
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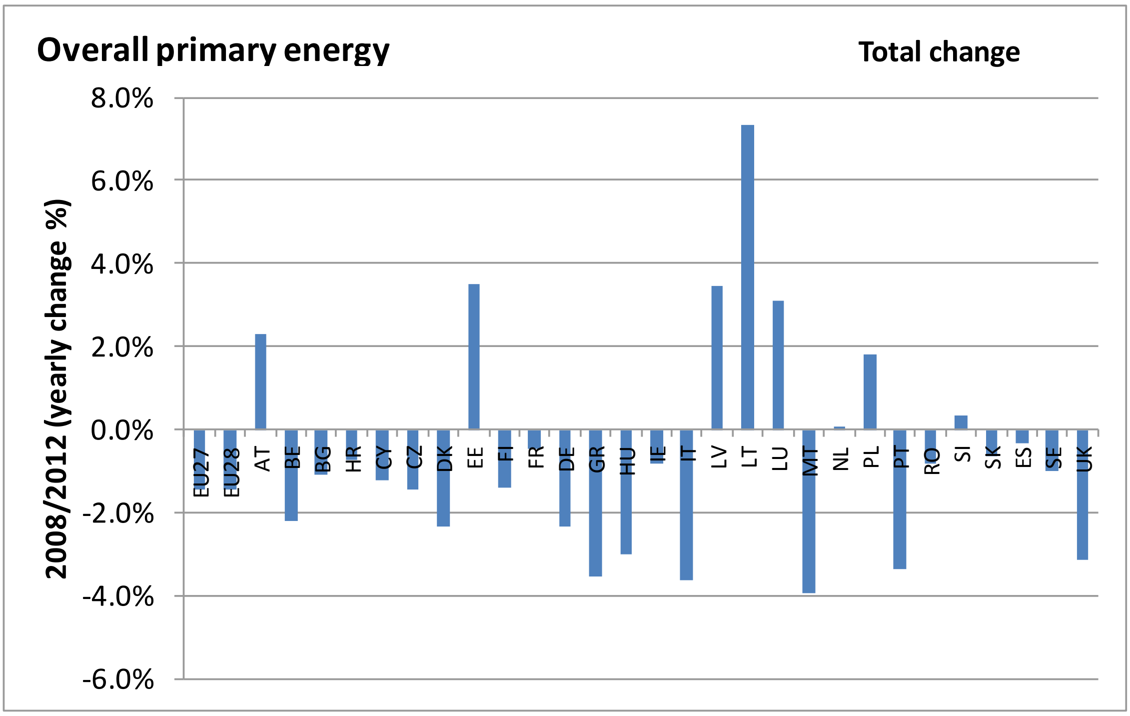
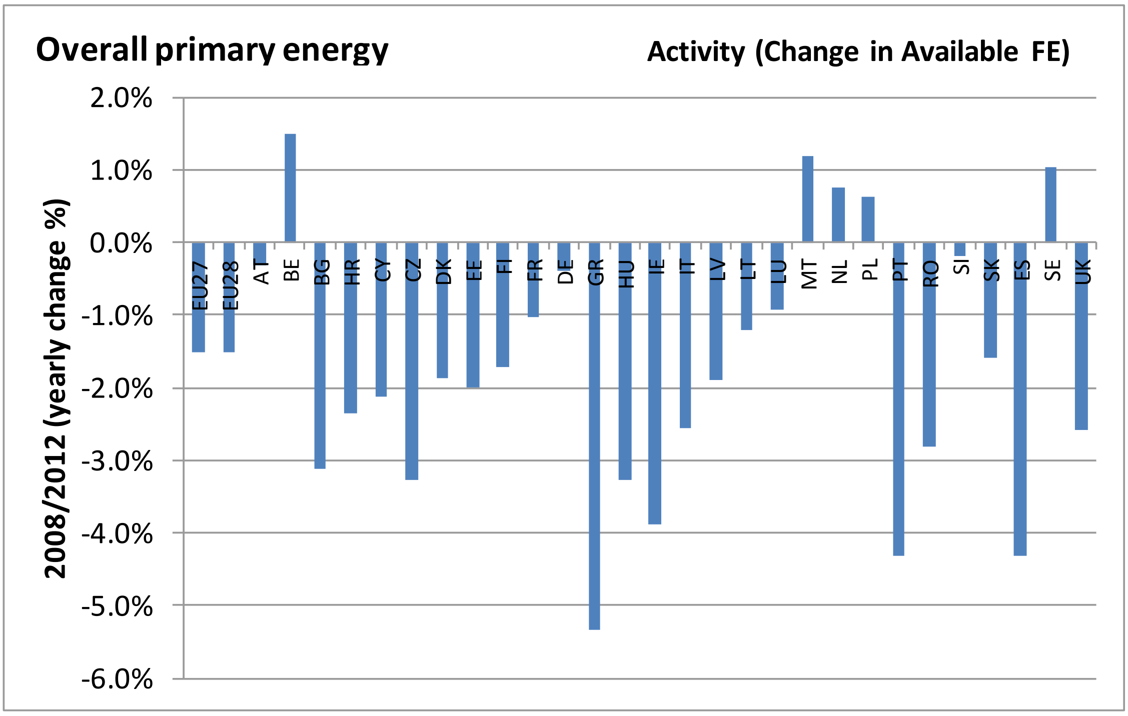
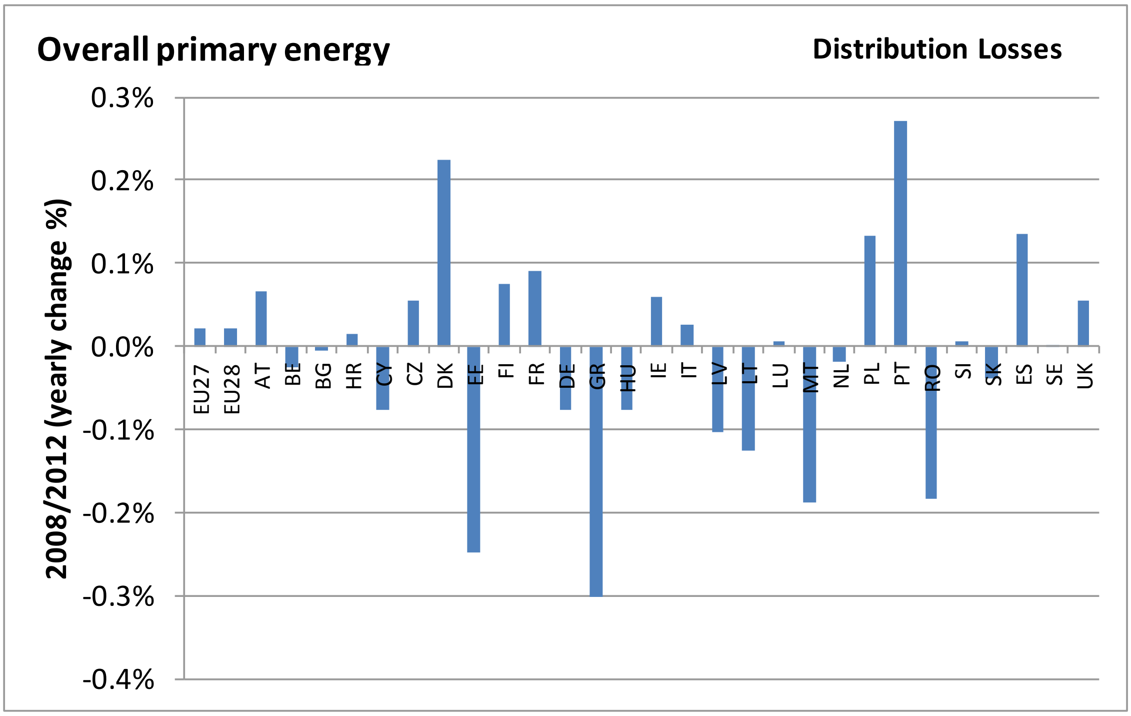
SE
UK

Figure 25: Total change in primary energy consumption (excl. non-energy uses) and different factors 2008 (incl.)-2012 (annual change in percent)






Overall primary energy
Distribution Losses
2008/2012 (yearly change %)
0.3%
0.2%
0.1%
0.0%
-0.1%
-0.2%
-0.3%
-0.4%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
DE
GR
HU
IE
IT
LV
LT
LU
MT
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SK
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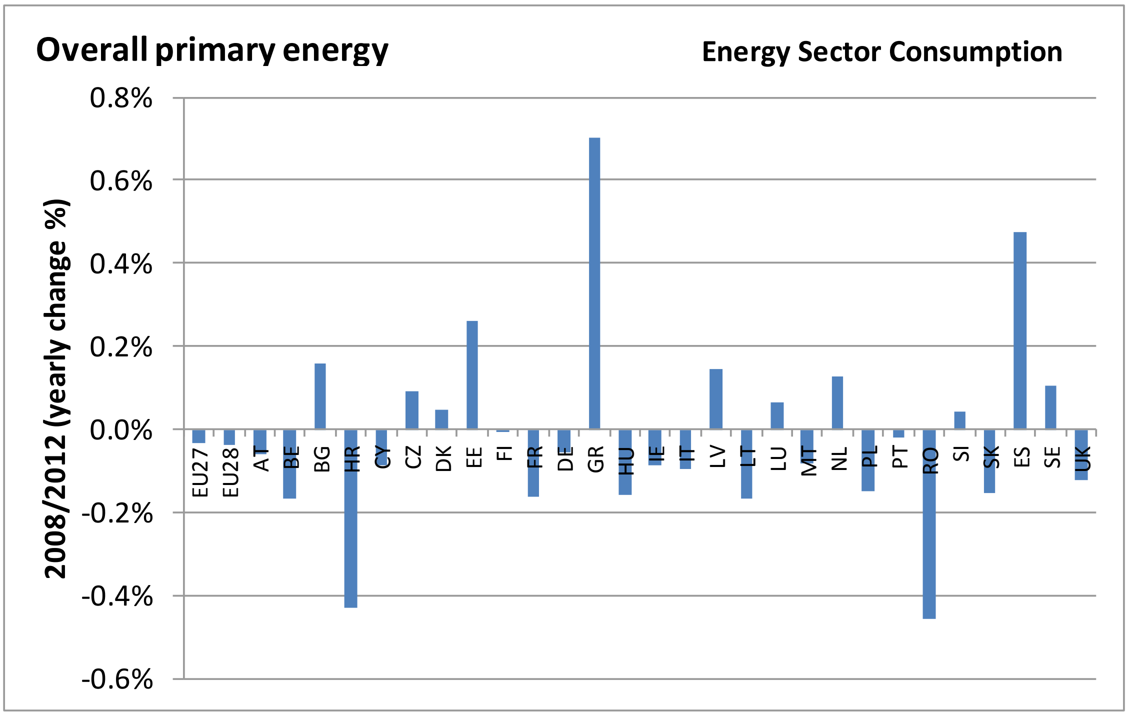
UK


Overall primary energy
Energy Sector Consumption
2008/2012 (yearly change %)
0.8%
0.6%
0.4%
0.2%
0.0%
-0.2%
-0.4%
-0.6%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
DE
GR
HU
IE
IT
LV
LT
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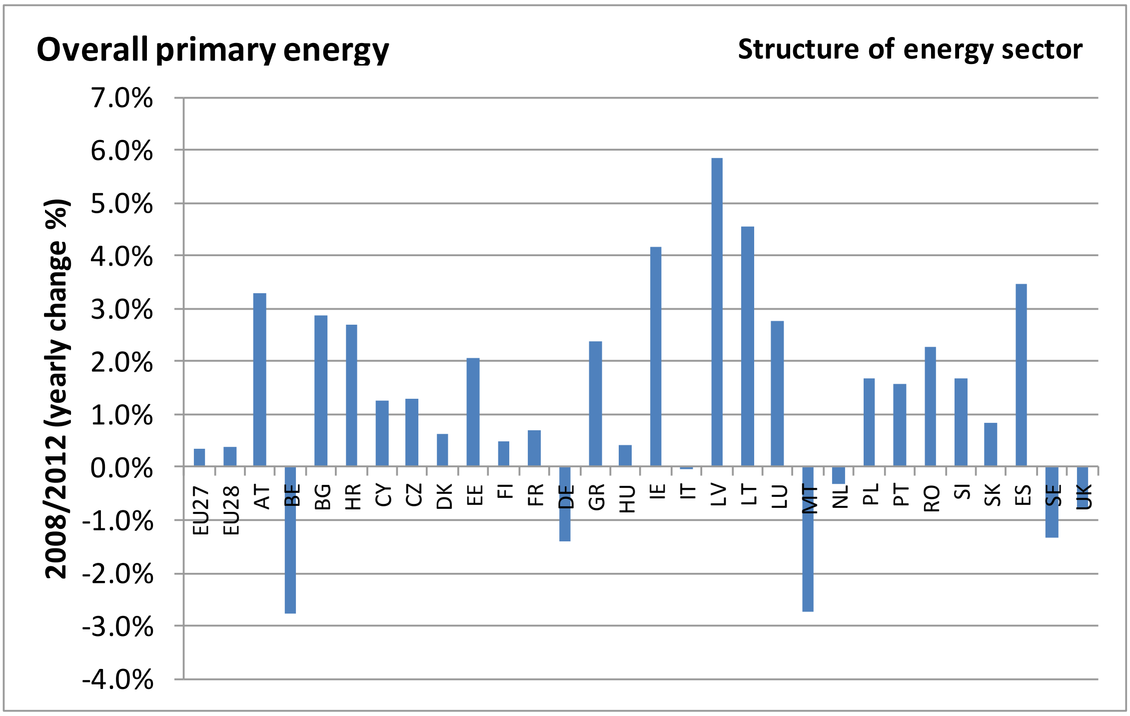
SK
ES
SE
UK


Overall primary energy
Structure of energy sector
2008/2012 (yearly change %)
7.0%
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
-1.0%
-2.0%
-3.0%
-4.0%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
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FI
FR
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HU
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IT
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LT
LU
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SE
UK

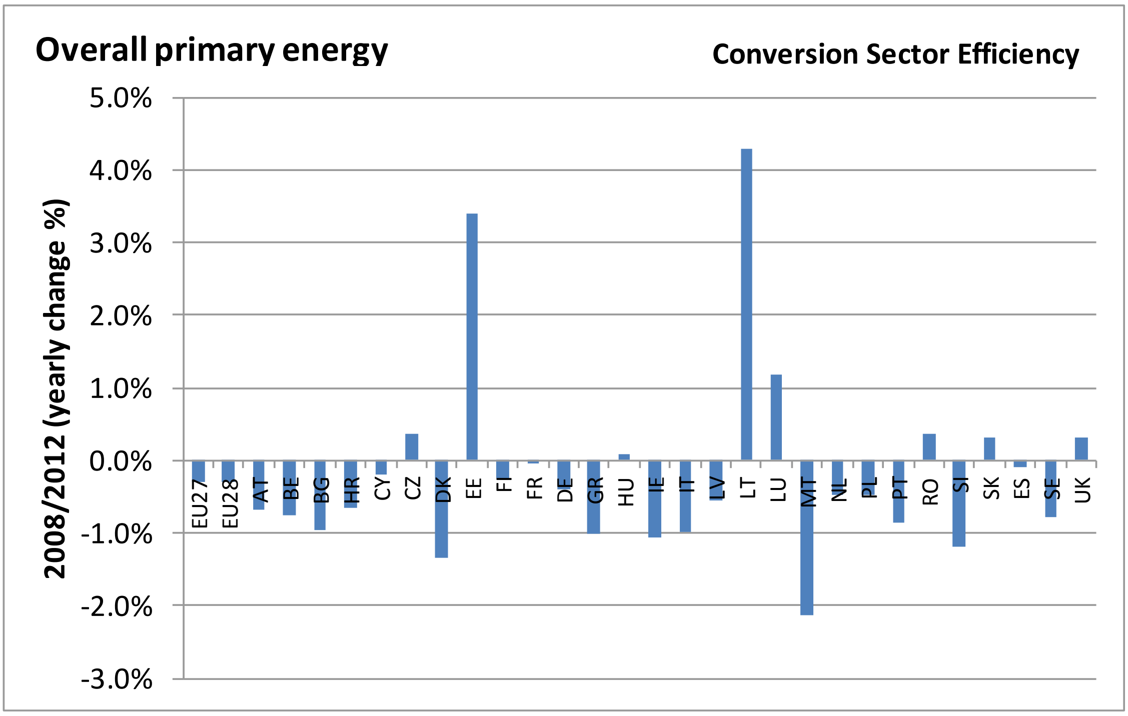
Overall primary energy
Conversion Sector Efficiency
2008/2012 (yearly change %)
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
-1.0%
-2.0%
-3.0%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
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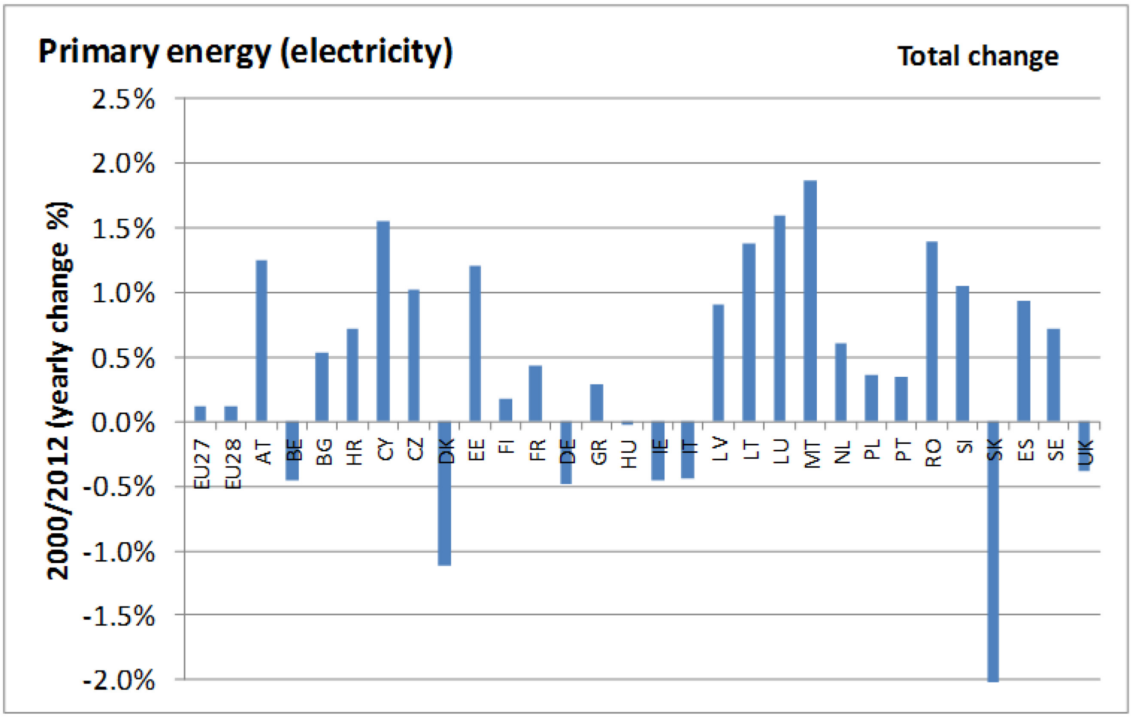
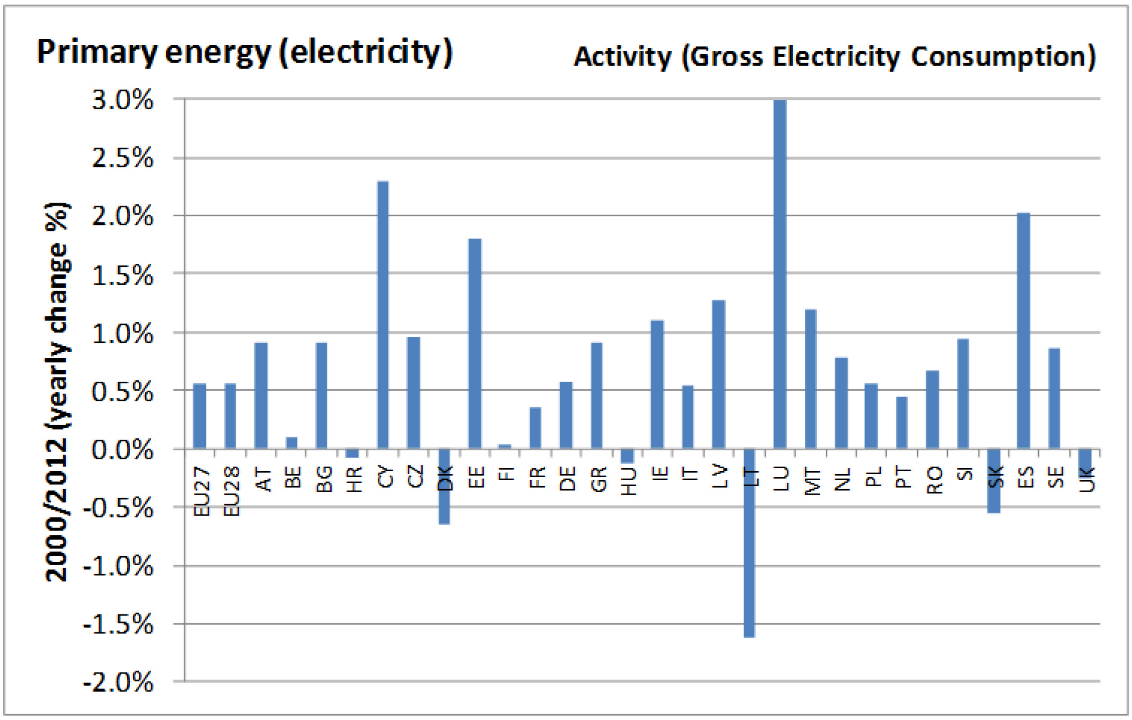
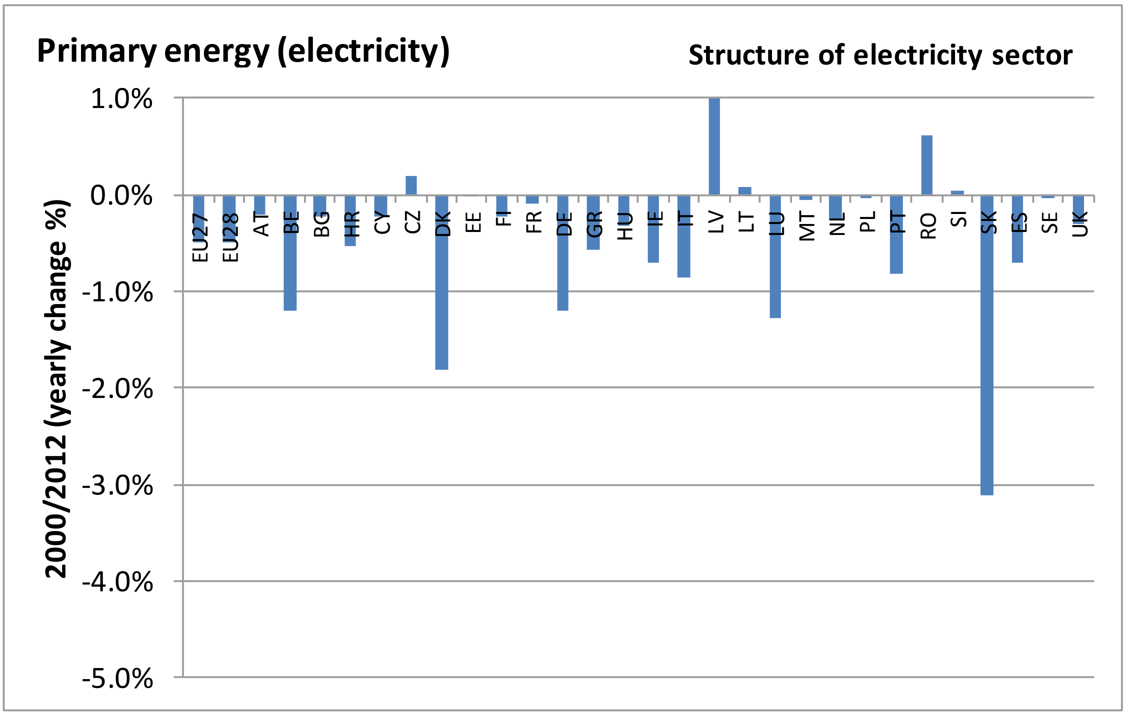
Figure 26: Total change in primary energy consumption for electricity generation and different factors 2000-2012 (annual change in percent)






Primary energy (electricity)
Structure of electricity sector
2000/2012 (yearly change %)
1.0%
0.0%
-1.0%
-2.0%
-3.0%
-4.0%
-5.0%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
DE
GR
HU
IE
IT
LV
LT
LU
MT
NL
PL
PT
RO
SI
SK
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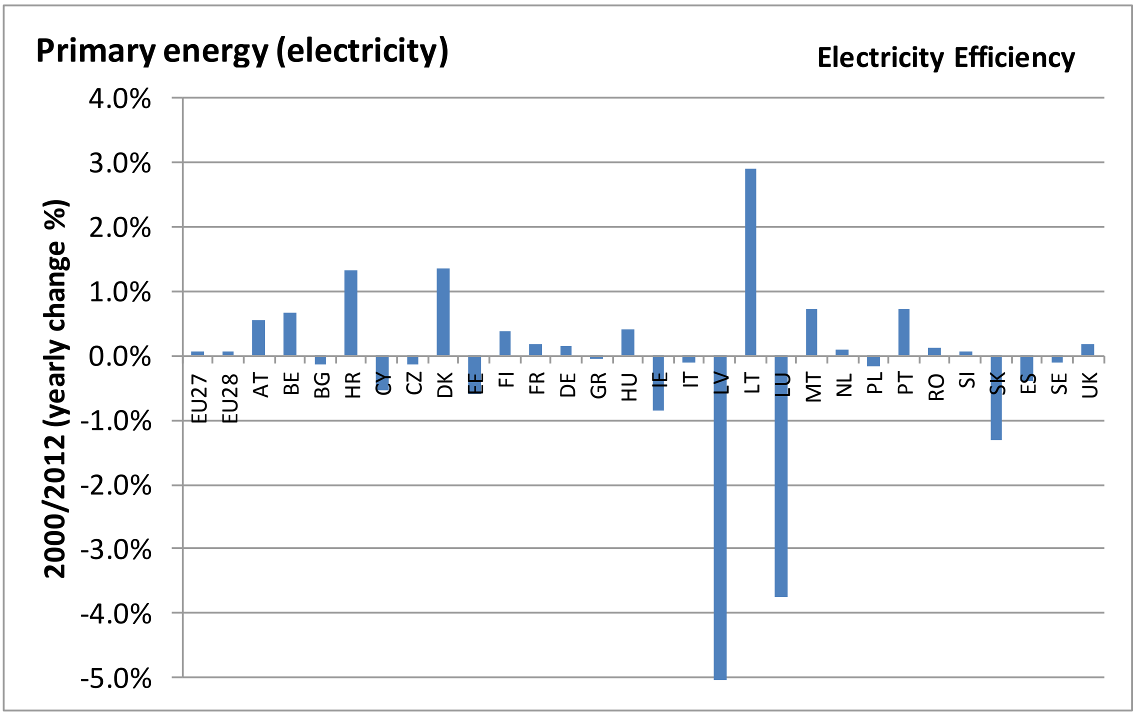
SE
UK


Primary energy (electricity)
Electricity Efficiency
2000/2012 (yearly change %)
4.0%
3.0%
2.0%
1.0%
0.0%
-1.0%
-2.0%
-3.0%
-4.0%
-5.0%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
EE
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GR
HU
IE
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LV
LT
LU
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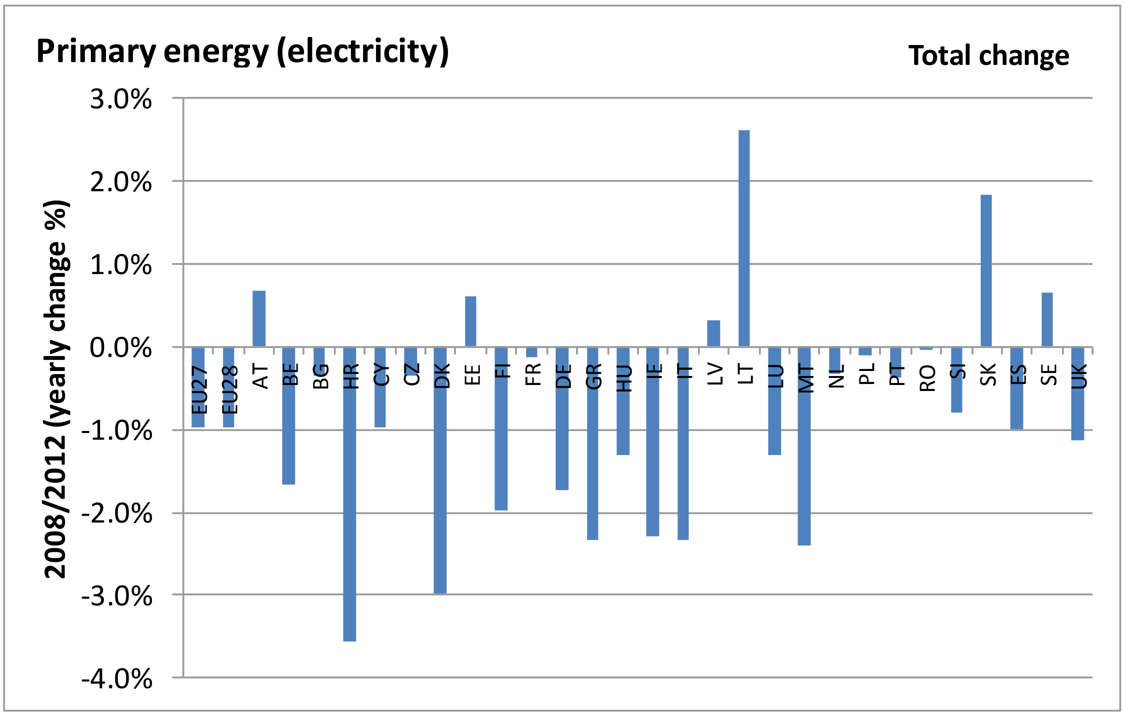
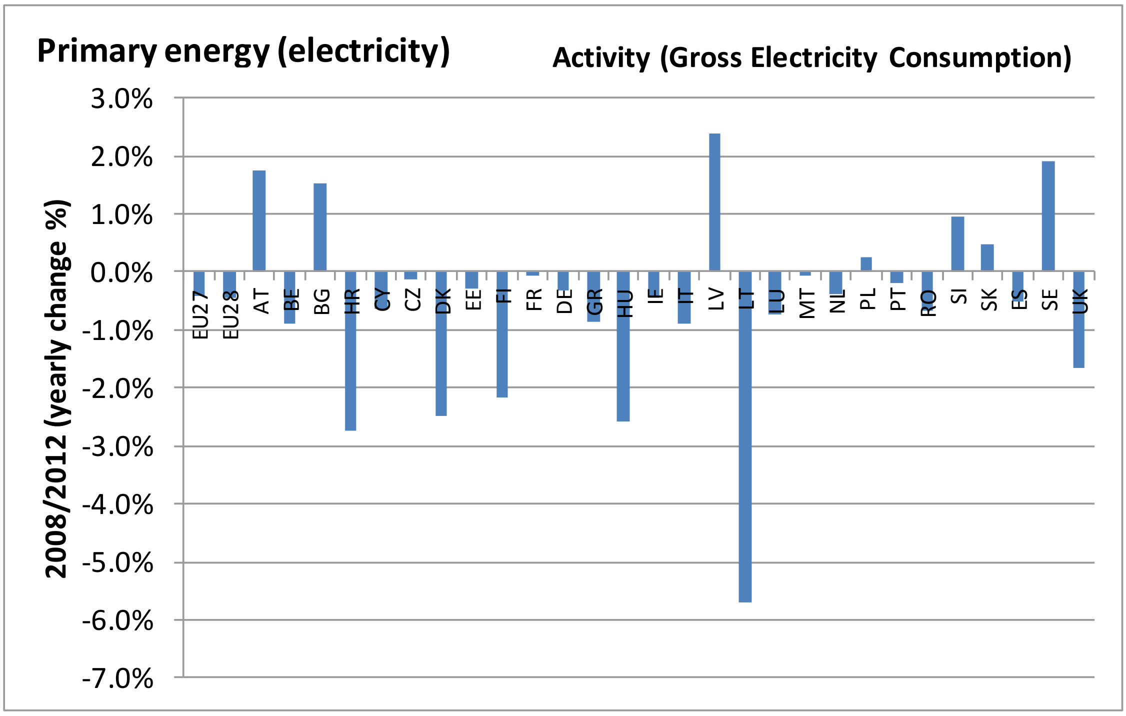
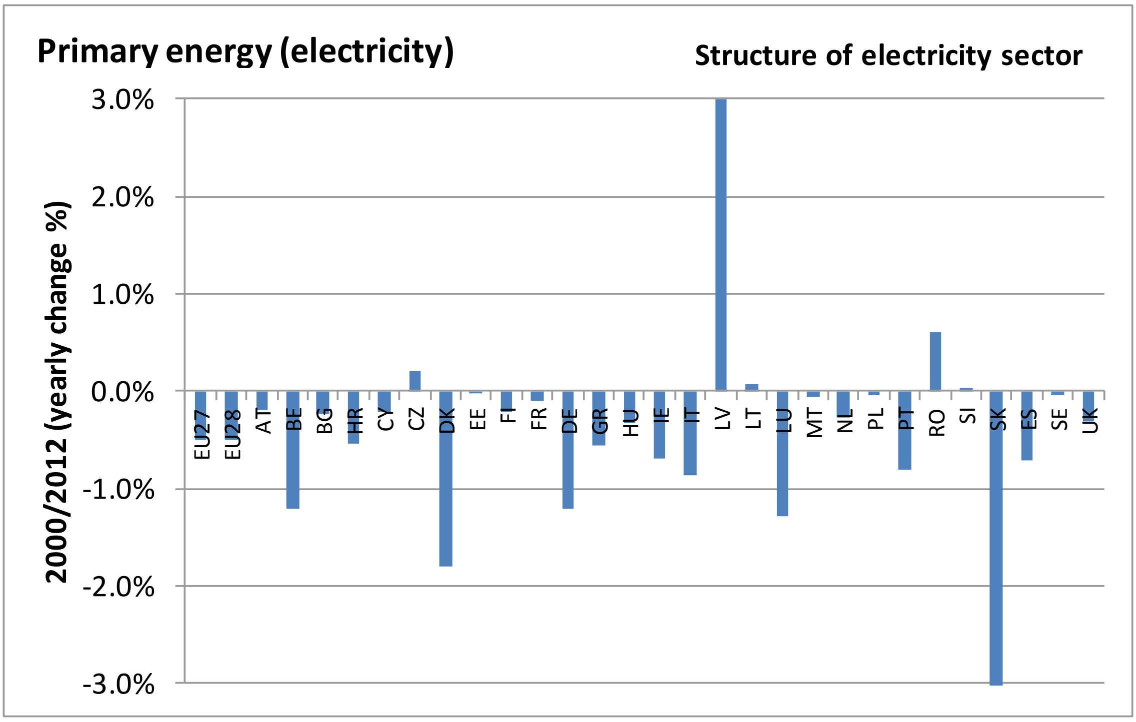
UK

Figure 27: Total change in primary energy consumption for electricity generation and different factors 2000-2012 (annual change in percent)






Primary energy (electricity)
Structure of electricity sector
2000/2012 (yearly change %)
3.0%
2.0%
1.0%
0.0%
-1.0%
-2.0%
-3.0%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
EE
FI
FR
DE
GR
HU
IE
IT
LV
LT
LU
MT
NL
PL
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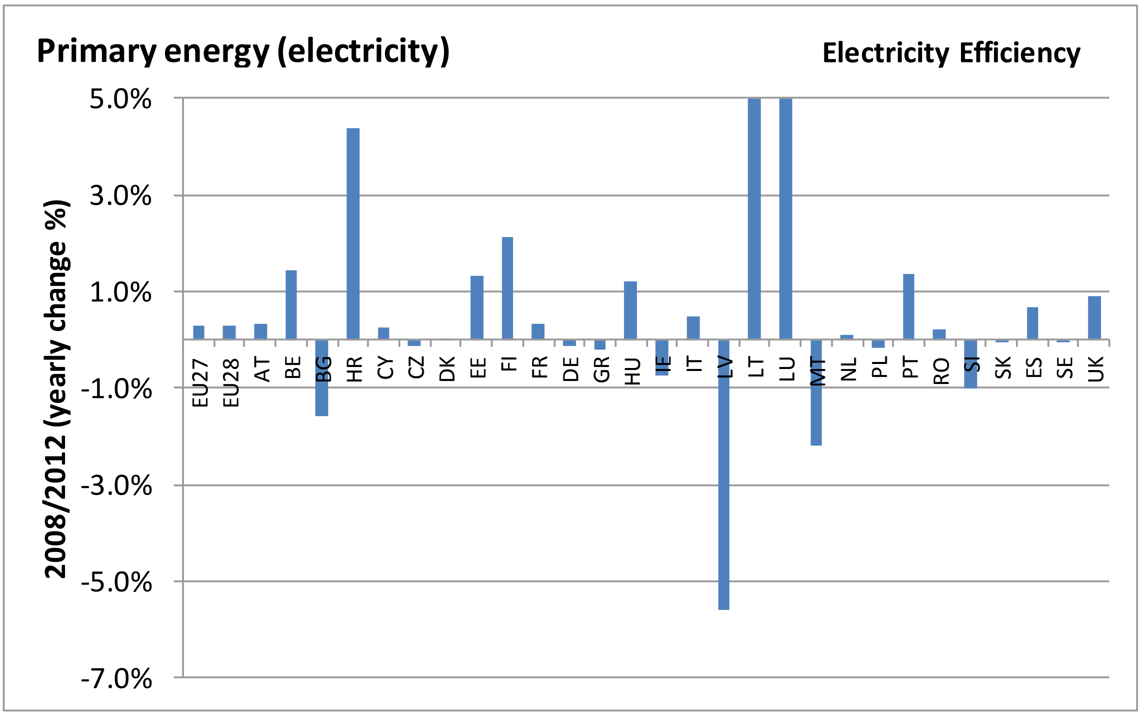
Primary energy (electricity)
Electricity Efficiency
2008/2012 (yearly change %)
5.0%
3.0%
1.0%
-1.0%
-3.0%
-5.0%
-7.0%
EU27
EU28
AT
BE
BG
HR
CY
CZ
DK
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UK

5 Model-based Assessment of Policy Options until 2020/2030

This chapter presents:

- the bottom-up modelling analysis of policies up to 2020 based on national and EU policies
- the bottom-up modelling of energy efficiency potentials up to 2030

5.1 Methodology

The analysis underlying the assessment of policy options until 2020/2030 report was based on two main methodologies:

- The use of **detailed modeling of the final energy demand in the different demand sectors**:
    - The INVERT/EE-Lab model (run by TU Wien) for residential and non-residential buildings
    - The FORECAST platform (run by Fraunhofer ISI), including an industrial model as well as the electricity uses in the residential and service sector
    - The ASTRA model (run by Fraunhofer ISI) providing potentials for the transport sector
    - The PowerACE model providing efficiency options, including renewable for the power sector.

  These models were used both to evaluate policy impacts up to 2020 as well as to evaluate in a detailed manner energy efficiency potentials up to 2030.
- An analysis of a 2030 target system based on the interaction of energy efficiency potentials with renewable to reduce primary energy consumption. In this analysis we also investigate the impact of energy efficiency and renewables on CO_2 and GHG emissions.

5.2 Overview of scenarios

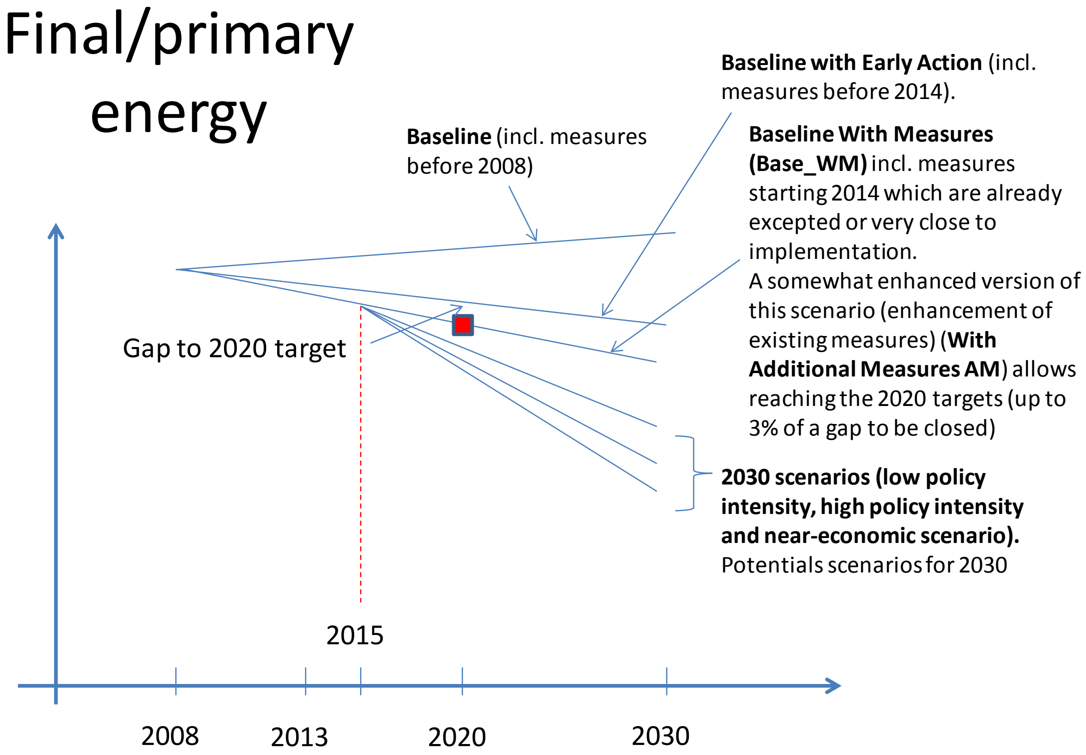
The following table shows the scenarios which are developed for the projections. The first four are relevant for the projections to 2020 and the comparison with the EED 2020 target. The last three are relevant for the 2030 potentials.

Table 10: Overview of scenarios

Scenario name	**Short name**	**Explanation**
Baseline No Early Action	Base_noEA	Contains only measures before 2008. Can be roughly compared with the reference development of PRIMES 2009 (corrected for the drivers from PRIMES 2013), though the latter includes measures up to early 2009.
Baseline incl. Early Action	Base_inclEA	Contains measures up to 2013 including. Can be compared with PRIMES 2013. Is useful in conjunction with EED (Art. 7) which admits "Early Action".
Baseline with measures	Base_WM	Contains also measures which are already accepted or close to being accepted in 2014 and the near future. Sometimes this maybe very close to Base_inclEA and can be the same.
Additional Measures	AM	Baseline with additional measures. Extends existing measures for each sector by around 3% in order to reach the EED target in case there is a gap. Some new measures (which represent a generalization of successful measures at the national level) are also proposed, especially for the transport sector and the space heating & hot water. The corresponding measures are listed in the report.
Potential 2030 (low policy intensity)	Potential_2030_LPI	Potentials to 2030 with high discount rates and barriers persisting. The discount rates are sector and partially country specific. Details are provided in the report.
Potential 2030 (high policy intensity)	Potential_2030_HPI	Potentials to 2030 with low discount rates and barriers (partially or totally) removed. The discount rates are sector specific.
Potential 2030 (near economic)	Potential_2030_NE	Potentials which are not economic (that is the Net Present Value is negative given the discount rates used in the HPI scenario) but the scenario induces costs not much higher than present level energy consumption entails. This differentiates the NE potential from a pure "technical" potential which may include also higher cost.

The graph below brings the different scenarios into the whole context.

Figure 28: Graphical presentation of the scenarios



The major difference of these bottom-up models as compared to a model like PRIMES is the **large degree of detail in the representation of technologies, actors and options which is necessary to reflect technology and actor-specific barriers**, or even measure-specific barriers. In the PRIMES descriptions it is frequently suggested that the model does integrate different types of barriers, however, it does so at an aggregate level which does not allow directly integrating policies aiming at alleviating such barriers. Some specification of the models used in this study illustrate this issue:

- The INVERT model distinguishes for each country a large number of different building types, building periods and specific decision makers with their actor-specific barrier structure. Individual technologies, e.g. for wall, roof or glazing, and their specific barriers are considered (see the examples of Figure 29 and Figure 30 for insulation packages in Bulgaria or Finland).

Figure 29: Relative energy reduction of different renovation packages in various building segments for the exemplary case of Bulgaria

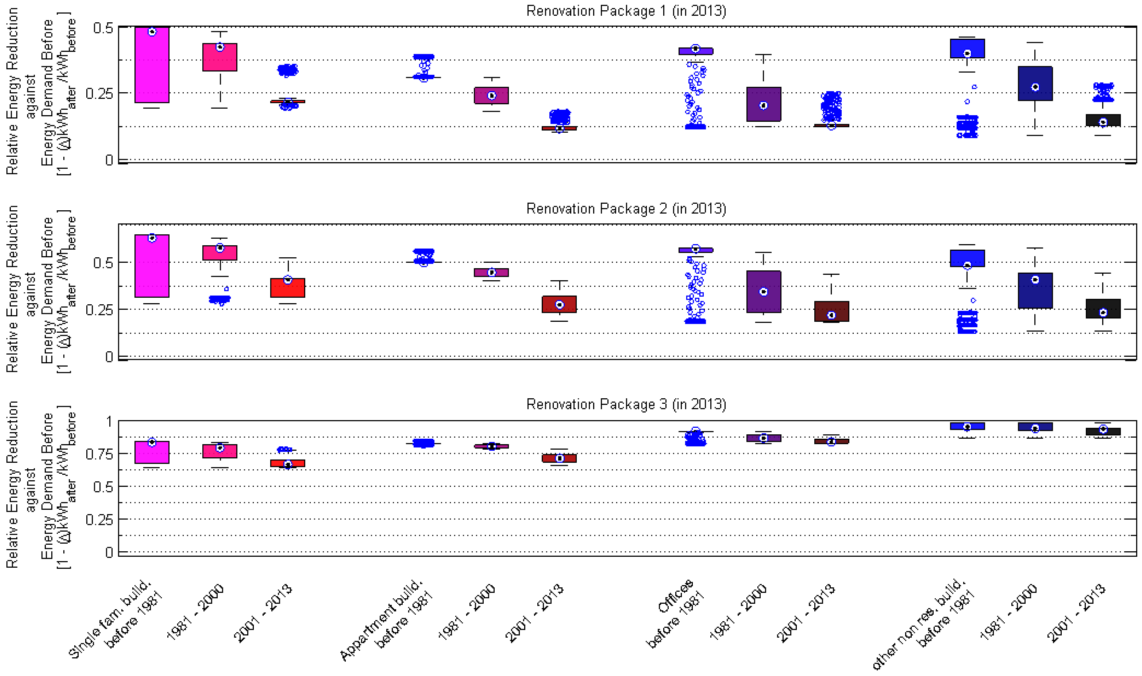
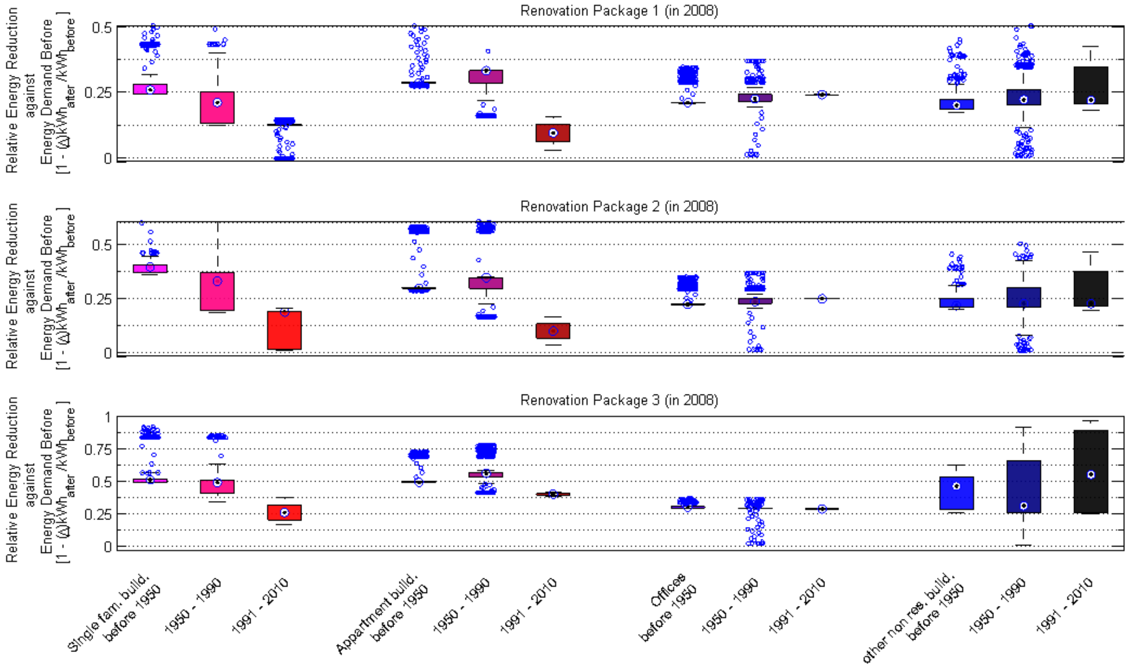


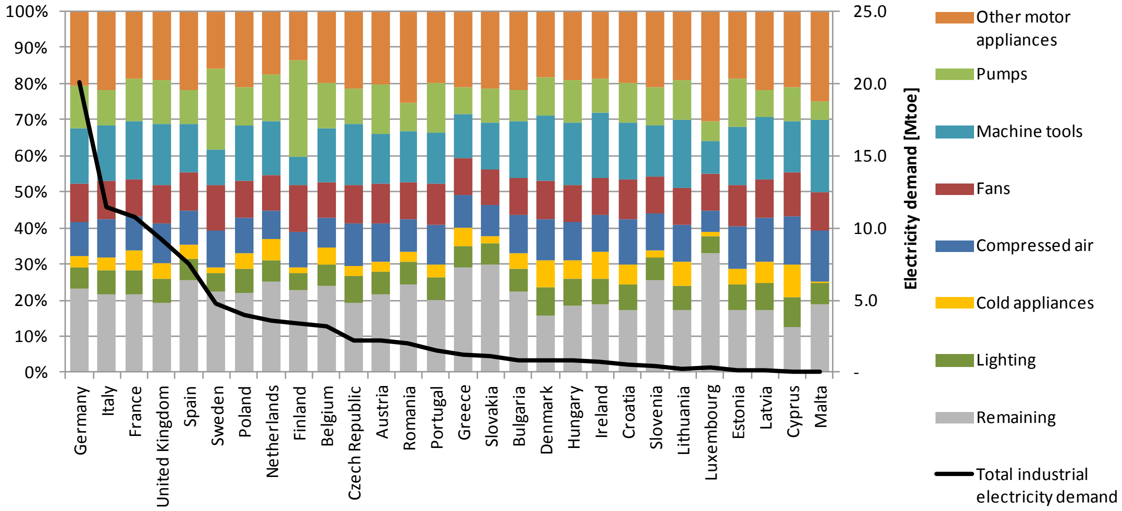
Figure 30: Relative energy reduction of different renovation packages in various building segments for the exemplary case of Finland



- FORECAST-Residential Appliances distinguishes a large number of individual appliances, with a separate model for IT-Appliances taking into account the specificity of each technology group, modeling therefore closely the impacts of eco-design standards, labelling and top-runner programmes. For the residential sector for example the model distinguishes:
    - Large appliances: The model distinguishes refrigerators, freezers, washing machines, dryers and dishwashers
    - Information/Communication Technologies ICT: we distinguish televisions, laptop computers, desktop computers, computer screens, modems, set top boxes grouped in this category.
    - Lighting
    - Air conditioning
    - (electric and non-electric) Cooking
    - Others: The energy using devices not covered in the previous bullet points are grouped here
- FORECAST-Tertiary Appliances is a coherent bottom-up model, which allows simulating the electricity demand of the tertiary sector of the European countries by country up to 2035. FORECAST-Tertiary is based on the concept of energy-efficiency measures (EEMs), which represent individual options that improve energy efficiency after being diffused through the equipment stock. Examples are fluorescent lamps, reduction of stand-by losses or changed user behaviour. Consequently, policies are modelled by adjusting the dynamics and the level of diffusion of such EEMs, depending on general and technology specific economic parameters. The model distinguishes 8 sub-sectors, and 14 energy services including lighting, ventilation and cooling, refrigeration, cooking, data centres with servers, elevators, street lighting and others.
- FORECAST-Industry belongs to the family of bottom-up models considering the dynamics of technologies and socio-economic drivers and their impact on energy demand. Energy efficiency improvements take place via the diffusion of energy-efficiency measures. Their diffusion, in turn, depends on the cost-effectiveness (mostly payback time) including assumptions about barriers and heterogeneous expectations among companies. The model considers around 50 individual energy-intensive processes and products. For each process, it can be defined if it whether it is within the scope of the EU ETS or not. We distinguish about 14 individual energy carriers (electricity, light fuel oil, heavy fuel oil, natural gas, lignite, hard coal, district heating, biomass, etc.), calibrated to the Eurostat energy balances. The model further distinguishes electric cross-cutting technologies (CCT-E), like lighting, ventilation or pump systems or thermal cross-cutting technologies (CCT-T) like steam and hot water raising in the industrial sector from process-specific technologies as barriers to energy efficiency for those technologies are quite different from barriers for process-specific technologies (see Figure 31). In the model a number of 10-20 en-

ergy-efficiency measures are related to each CCT. Building standards as well as heating systems in the industrial sector are included via a stock model approach. The model draws on similar policy information on building standards as the INVERT model. The model has also an approach with differentiates smaller from larger enterprises as they are subject to quite different barriers.

Figure 31: Electricity demand by cross-cutting technology (CCT) and country in 2010 as share of total industrial electricity demand



Source: FORECAST Industry model

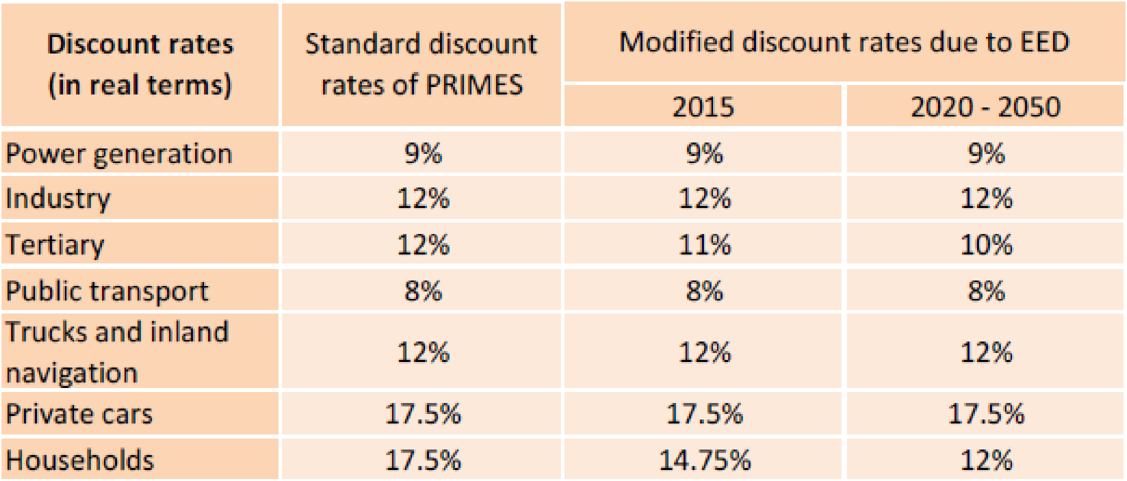
Being able to represent this heterogeneity of technologies, actors and measure-specific barriers, which characterizes energy efficiency much more than for example renewable energy sources, is an important ingredient in a realistic investigation of barriers and policy measures to overcome the barriers.

In addition, presenting technologies in such a detailed manner allows to better draw on the growing empirical basis for **technological learning** (hence lowering of the additional cost), which is possible with energy efficiency as it is with renewable energy sources. Considering technological learning in a realistic manner provides further information on how policy instruments may contribute the cost of early market penetration of efficient technologies.

5.3 Discount rates: an important parameter in the impact evaluation

The PRIMES model which is used by the EU Commission in the impact assessment of the 2030 targets as well as in the reference projections uses the following standard discount rates (Table 11). The table also shows somewhat modified discount rates due to the introduction of the Energy Efficiency Directive (see the discussion below).

Table 11: Discount rates used in PRIMES



Discount rates (in real terms)	Standard discount rates of PRIMES	Modified discount rates due to EED	
		2015	2020 - 2050
Power generation	9%	9%	9%
Industry	12%	12%	12%
Tertiary	12%	11%	10%
Public transport	8%	8%	8%
Trucks and inland navigation	12%	12%	12%
Private cars	17.5%	17.5%	17.5%
Households	17.5%	14.75%	12%

Source: European Commission (2014a)

These discount rates may be as high as 17.5% for the residential sector, lowered to 12% in the period after 2020[17].

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[17] The impact of such high discount rates on investment decisions is dramatic. This is illustrated with the following example: We consider the case that a standard individual house is replaced with a passive house building. Such a building may cost 300000 Euro and the additional costs for passive house standard are around 8% or 24000 Euro. The original house may use 30000 kWh/year and the passive house 3000 kWh/year. We assume 25 years lifetime for the investment. With a gas price of 5.5 centsEuro/kWh and a 17.5% discount rate the net present value of the energy saved is around 9800 Euro, hence far away from the additional 24000 Euro investment to be covered. With a discount rate of 12%, this would reach around 13000 Euro, with 9% around 16000 Euro, hence still not economic and leading to higher cost the more energy efficiency is introduced. On the other hand we may use typical capital costs of 2-4% as applied in our modeling. With 3% the net present value of the savings in the above example would be nearly 27000 Euro over the 25 years lifetime assumed. Hence the measure would be economic over the lifetime and the system costs would be lowered. This is argued in our High Policy Scenario by adequate financial arrangements and appropriate risk mitigation as well as by taking a macro-economic perspective rather than a micro perspective. It is further argued by the fact that many barriers are non-economic in nature and need non-economic instruments to overcome the barriers. As an example: if one would buy a refrigerator and would have no energy label, the implicit discount rate would be very high, as it would take a lot of time to find the appropriate information. If one has a label at hand, it takes only a fraction of seconds to choose the most efficient appliance. In that case applying a financial instrument (for example an energy tax) would not be appropriate and far too expensive as compared to the specific instrument which is the label, well adapted to the non-economic barrier. The high discount rate suggests that the barrier has to be overcome by financial instruments.

In contrast, the discount rates/payback periods used in the different scenarios underlying the investigation of energy efficiency potentials and costs in this study are presented by sector in Table 12. They are considerably lower than the discount rates used in the impact assessment and the reference projections. It should be noted that there is also a broad literature on the issue of the energy efficiency gap[18], discount rates and intergenerational equity that advocates for certain types of investments with longer time horizons to use discount rates approaching zero (see for example Tóth, 2000).

The IPCC 4th Assessment report notes on this: "*The debate on discount rates is a long-standing one. As the SAR (Second Assessment Report) notes (IPCC, 1996, Chapter 4), there are two approaches to discounting: a prescriptive approach[19] based on what rates of discount should be applied, and a descriptive approach based on what rates of discount people (savers as well as investors) actually apply in their day-to-day decisions. Investing in a project where the return is less than the standard interest rate makes the investor poorer. This descriptive approach based on a simple arbitrage argument justifies using the after-tax interest rate as the discount rate. The SAR notes that the former leads to relatively low rates of discount (around 2-3% in real terms) and the latter to relatively higher rates (at least 4% after tax and, in some cases, very much higher rates)….. For mitigation effects with a shorter time horizon, a country must base its decisions (at least partly) on discount rates that reflect the opportunity cost of capital. **In developed countries, rates of around 4–6% are probably justified**. Rates of this level are in fact used for the appraisal of public sector projects in the European Union (EU) (Watts, 1999). In developing countries, the rate could be as high as 10–12%.*"

Chapter 3 (Social, Economic and Ethical Concepts and Methods) of the 5th IPCC Assessment Report (Working Group III) argues further: *The use of a temporal discount rate has a crucial impact on the evaluation of mitigation policies and measures. The social discount rate is the minimum rate of expected social return that compensates for the increased intergenerational inequalities and the potential increased collective risk that an action generates. Even with disagreement on the level of the discount rate,* ***a consensus favours using declining risk-free discount rates over longer time horizons*** *(high confidence)* (5th AR, p.6).

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[18] The fact that energy efficiency investments seems to be linked to higher discount rates which is explained by some schools through market failures while others counterdict the existence of such market failures,

[19] The prescriptive approach has often been termed the 'ethical approach' in the literature

Table 12: Overview of discount rates used

Sector	Scenario	Discount rate
Household – space heating and hot water	All 1)	3.1% to 3.7% 2)
Tertiary – space heating and hot water	All 1)	4.7% to 5.4% 2)
Household - Appliances	AM Potential_2030_LPI	Typically 6% (discount rates vary between different countries, appliances)
	Potential_2030_HPI Potential_2030_NE	2% (assuming removal of barriers from 2020)
Tertiary - Appliances	Base_NoEA	40%
	Base_inclEA / Base_WM	30%
	AM	20%
	Potential_2030_LPI	15%
	Potential_2030_HPI	5%
	Potential_2030_NE	5%
Industry	Potential_2030_LPI	Paypack up to 2 years accepted by 50% of companies; heating systems 15%
	Potential_2030_HPI	Paypack up to 5 years accepted by 60% of companies; heating systems 15%
	Potential_2030_NE	Companies accept longer payback periods 3) heating systems 3%
Transport	N/A	N/A

Notes:

1) The difference among the different scenarios in the building sector is modelled through explicit policies that do remove existing barriers (in particular non-economic barriers) and the intensity of which varies across the scenarios. These policies are at first building codes (standards) with more or less compliance, varying degrees of economic incentives (e.g. for thermal building rehabilitation), different degrees of training and qualification (that act upon awareness and degree of information of the different actors and investors) as well as measures to enhance the rehabilitation rates or barriers, for example with respect to the user/investor dilemma. Hence, the discount rates in the building sector do not vary across the scenarios.

2) Discount rates are distinguished between countries and between different investor types. In particular, different ownership constellations, income situation and age of building owners are taken into account. The country specific differences of the interest rates are based on Eurostat. The differentiation between different investor types is based on the stakeholder analysis and investigation of barriers in the project ENTRANZE (www.entranze.eu). In countries like France,

Germany or Austria the interest rate is in the lower range from 3.1% to 3.7% for typical residential building owners, 4.7%-5.4% for non-residential buildings with higher values up to about 7.4% for low-income owners or elder people. In countries like Romania or Bulgaria the interest rates are in the higher range of 8-12% with higher values of up to 16% for low-income and aged building owners. We have refrained from assuming broad common European financing mechanisms to finance energy efficiency investments and to lower the risk perception in the countries for which we assumed higher discount rates. Though such a mechanism does not seem out of scope, it is unclear from the current perspective, if such a mechanism has a certain size, how it would interact with the standard financial markets. It is important to underline that the discount rates defined in such a way still are based on a financial market perspective and are to be distinguished from a "social discount" rate which may be derived from a societal perspective, taking into account societal benefits.

3) In the near economic scenario companies also invest in measures with longer payback times and accept interest rates close to zero (assuming that these efficiency measures will be made attractive to companies, e.g. by subsidies). However, most of the measures are still very close to being cost-effective.

The 5th IPCC Assessment Report digs further into social discount rates and argues in a detailed analysis **that *an appropriate social risk-free discount rate for consumption is between one and three times the anticipated growth rate in real per capita consumption*** *(medium confidence). This judgement is based on an application of the Ramsey rule using typical values in the literature of normative parameters in the rule. Ultimately, however, these are normative choices* (5th AR, p.6). For the European context this implies, as the growth rates in real per capita consumption is below 1% on the longer term, that 2-3% are considered appropriate by the IPCC for the social discount rates. We do not take up such a low discount rates here but remain in a range that reflects typical capital costs though it might have been argued by a broad European financing mechanism for energy efficiency (see the discussion in the footnote to Table 12).

Why these considerable differences in the discount rates used? Essentially this boils down to the question in how far discount rates used to evaluate FUTURE policies shall reflect PRESENT individual decision making processes with rather imperfect mechanisms to include risk assessment into the discount rates.

In that the PRIMES model and our scenario analysis take a rather different approach. While PRIMES integrates (perceived or existing) risks into the discount rates to a large degree[20], our scenario approach essentially uses usual capital **costs, considering that there are instruments to mitigate the risks and the risk perception**. In that we argue that policies of the future can learn from present experiences[21]. Also the perception of the energy user changes: with technologies developing they perceive less risk, awareness changes with respect to the threat of climate change, resource scarcity and high energy prices, a larger number consumers are willing to invest to mitigate those risks, policies are developed to accompany those awareness changes etc.

The PRIMES model, however, increasingly recognizes these changes which is the argument to lower the discount rates in some important cases, e.g. for households. However, the discount rates used are still well beyond typical capital costs. PRIMES argues that the broader introduction of energy services under the Energy Efficiency Directive will lead to lower discount rates as for example non-economic barriers are overcome, for example by bundling activities in the hand of an experienced energy service provider[22]. However, we believe that it is too narrow to merely take into account some beneficial impacts from energy services while essentially the policy framework is continued to be considered in a fragmented way. This is not to up to the challenge of reducing energy consumption by half in the middle of the century and

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[20] COM (2014a, p.25): "Discount rates pertaining to individual agents play an important role in their decision making. Agents' economic decisions are usually based on the concept of cost of capital, which is, depending on the sector, either weighted average cost of capital (for larger firms) or subjective discount rate (for individuals or smaller firms). In both cases, the rate used to discount future costs and revenues involves a risk premium which reflects business practices, various risk factors or even the perceived cost of lending. The discount rate for individuals also reflects an element of risk averseness."

[21] One could counter-argue that real policies will always be fragmented. However, it is not appropriate to integrate policy imperfections right from the beginning into the impact evaluation because this negates any scope for future improvement while the practice has shown that much can be learned from policy design.

[22] COM (2014a, p.25): "The decision-making environment of businesses and households on energy consumption is expected to change because of the implementation of the Energy Efficiency directive (EED). The EED will bring about higher market penetration of Energy Service Companies (ESCOs) or similar institutions as well as the reduction of associated risks as perceived by potential clients through quality controls and certifications. This will entail lower perceived discount rates."

GHG emissions by at least 80%. It seems that most recent Commission documents, see COM (2014b, p.186) increasingly involve in that sense and admits that “at a recent IEA workshop specifically on RES financing, it was concluded that technology risk is no longer seen as the main barrier to investment in renewable energy technologies; “**it is rather policy uncertainty which is perceived by developers and investors as the main risk that they are unable to manage, and that markets in which predictable long-term policies are in place, the business case is strong and there are many circumstances in which renewables can be competitive**”. This statement does not only hold for renewable energy but equally for energy efficiency policy. This is a major argument to evaluate future options not in a framework of fragmented policies still reflected in comparatively high discount rates as in the right hand of Table 11 but in a context of coherent and strong energy efficiency policies and changing awareness of risks and benefits. COM (2014b, p.74) rightly to conclude “With energy efficiency policies increasingly changing energy markets by addressing market failures and imperfections, **it appears appropriate to revisit this issue in future analyses**.”

It is important still to make the following distinction as PRIMES uses discount rates on two different levels:

1. for technology diffusion (decision on investments)

2. for calculation of total system cost

In our views and in the light of the above said:

1. is questionable because of low-cost instruments (e.g. labels) mitigating non-economic barriers

2. is strongly questionable because non-economic barriers to energy efficiency do not necessarily lead to higher systems costs[23].

In our view therefore, it is most appropriate to evaluate energy efficiency in the light of typical capital costs rather than by integrating risks and risk perception, as well as fragmented energy efficiency policies to a high degree already from the beginning into the calculation of the total system costs and the evaluation of the future policy frame.

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[23] This would be equivalent, once a decision has been taken to invest in a

5.4 Cross-cutting measures

As the Ecodesign Directive affects nearly all sectors, the approach to consider it in the analysis is described in the following. While the minimum energy performance standards (MEPS) mostly resulting from the Ecodesign Directive can very well be included in the bottom-up models, the challenge lies in the huge number of lots and documents available as well as the often low availability of market data. Adapted to this situation, we use a two step approach.

First, we identify relevant lots. Relevance is defined as covering at least a share of 5% of the fuels or electricity demand of a sector. In case, very high energy-savings are expected, we included also lots with a lower share. Table 13 illustrates the relevance of individual lots in the sectors residential, industry and tertiary.

Second, we assess the regulation (if already published), the impact assessment or the preparatory study and extract information necessary to include the standards in the model.

With regard to the individual scenarios, we use the following differentiation. The Base_noEA scenario considers no impact of the Ecodesign Directive. All Regulations (and other implementing measures) adopted until end of 2013 are included in the Base_inclEA scenario. In the AM scenario we assume a stricter implementation of MEPS by extending the scope to additional lots not yet covered by a Regulation or by setting more ambitious MEPS (e.g. based on BAT) for lots already covered with a regulation. For more details, see the sector chapters.

Overlaps with cross-cutting measures such as the Ecodesign Directive do occur for two reasons: first of all other measures such as building regulations may overlap with Ecodesign requirements for boilers. Such interactions have been taken into account by modeling the two requirements together, associating the Ecodesign standards with the minimum requirement on boilers. Second there may be an overlap between minimum standards, labeling requirements and possible “top-runner” programmes (that is programmes which promote the top-end of the most efficient appliances) for the different product group. This is taken into account by considering the combined impact of these instruments on the changes in labeling classes. Hence only the combined impact is determined. In order to separate these different instruments, empirical studies are necessary which allow finding out which instruments has influenced consumer choices to which degree.

Similar considerations for measure overlaps are also carried out for other types of measures in the modeling work.

Table 13: Overview of Ecodesign lots, their relevance measured as the share of electricity/fuels demand of a sector (all lots marked with „x“ are considered in the analysis; for additional lots, preparatory studies are being conducted).

Product Groups	Preparatory study	Impact Assessment	Regulation adopted	Classification		
				Industry	Tertiary	Household
Lot- Simple Set Top Boxes	Yes	yes	25/2/2010	🟨	🟨	🟧 X
Lot 1 Boilers and Combi-boilers	Yes	yes	2/8/2013	🟫 X	🟫 X	🟫 X
Lot 2 Water Heaters/Boilers	Yes	yes	2/8/2013	🟨	🟫 X	🟫 X
Lot 3 PC (Desktops and Laptops) and Computer Monitors	Yes	yes	26/6/2013	🟧	🟫	🟥 X
Lot 4 Imaging Devices	Yes	yes		🟨	□	🟨
Lot 5 Consumer Electronic: Television	Yes	yes	7/1/2010	🟨	□	🟥 X
Lot 6 Standby and (off-mode) Losses	Yes	yes	7/1/2010	🟨	🟥	🟥 X
Lot 7 External Power Supply Units	Yes	yes	27/4/2010	🟨	🟧	🟧
Lot 8 Office Lighting	Yes		13/4/2010	🟧 X	🟫 X	▨
Lot 9 Outdoor Lighting	Yes		13/4/2010	🟧 X	🟧 X	▨
Lot 10 Air Conditioner	Yes	yes	30/3/2012	▨	▨	🟨 X
Lot 10 Small Fans	Yes	yes	30/3/2012	▨	▨	🟨
Lot 10 Ventilation Systems	Yes			▨	▨	🟨
Lot 11 Electric Motors (0,75kW - 200kW)	Yes	yes	22/7/2009	🟫 X	🟫	▨
Lot 11 Circulators	Yes	yes	1/1/2013	🟥 X	🟧 X	🟥
Lot 11 Fans	Yes	yes	1/1/2013	🟫 X	□	▨
Lot 11 Water Pumps	Yes	yes	1/1/2013	🟫 X	▨	▨
Lot 12 Commercial Refrigerator- and Freezers	Yes			▨	🟥 X	▨
Lot 13 Household Refrigerators and Freezers	Yes	yes	1/7/2010	▨	▨	🟫 X
Lot 14 Household Dishwashers	Yes	yes	1/12/2011	▨	▨	🟥 X
Lot 14 Household Washing Machines	Yes	yes	1/12/2011	▨	▨	🟧 X
Lot 15 Small Plants combusting Solid Fuels	Yes			□	□	□
Lot 16 Tumble Dryers	Yes	yes	3/10/2012	▨	🟨	🟧 X
Lot 17 Vacuum Cleaners	Yes	yes	8/7/2013	▨	□	🟨
Lot 18 Complex Set top boxes	Yes	yes		🟨	🟨	🟨 X
Lot 19 Household Lighting: non-directional	Yes	yes	1/9/2009	🟨	🟥 X	🟥 X
Lot 19 Household Lamps. "Reflector Lamps"	Yes	yes	1/1/2013	🟨	🟥 X	🟧 X
Lot 20 Local Room Heating Products	Yes			🟧	🟥 X	🟫 X
Lot 21 Central Heating Products	Yes			🟧	🟥 X	🟫 X
Lot 22 Household and Commercial Ovens	Yes		20/02/2014	▨	□	🟥 X
Lot 23 Hobs and Grills	Yes		20/02/2014	▨	□	🟧
Lot 24 Washing Machines, Dryers Commercial	Yes			▨	🟨	▨
Lot 25 Coffee Machines for non-Commercial Purposes	Yes			▨	▨	🟧
Lot 26 Networked standby losses	Yes		22/8/2013	🟨	🟧	🟧
ENTR Imaging Systems in Medicine	no			▨	□	▨
ENTR Lot 1 Refrigerators and Freezers	Yes			🟧	🟨	▨
ENTR Lot 2 Transformers	Yes			□	▨	▨
ENTR Lot 3 Devices for Sound and Image Processing	Yes			🟨	🟨	🟧
ENTR Lot 4 Combustion Plants and Ovens	Yes			🟫	□	▨
ENTR Lot 5 Machine Tools	Yes			🟫 X	□	▨
ENTR Lot 6 Air-conditioners and Ventilation Systems > 12kW	Yes			🟥 X	🟧	▨

Legend

Relevance

High (>10%)	🟫
Medium (5-10%)	🟥
Low (1-5%)	🟧
Not relevant (<1%)	🟨
Per Definition not in question	▨
No Data	□

5.5 General framework conditions for the scenarios

In order to ensure comparability with the PRIMES projections, drivers such as the international fuel prices, the energy wholesale prices, the number of dwellings and the carbon prices were adapted from PRIMES 2013.

The international fuel prices are displayed in Table 14.

Table 14: International Fuel prices (in €'10 per boe)

	2010	2015	2020	2025	2030
Oil	60,0	86,0	88,5	89,2	93,1
Gas	37,9	53,8	61,5	58,9	64,5
Coal	16,0	22,0	22,6	23,7	24,0

Source: PRIMES 2013

Based on the international fuel prices and the country-specific electricity wholesale prices from the PRIMES 2013 projections, the end-use energy prices were projected based on the historical country- and sector-specific tax rates. For the Baseline-No-Early-Action Scenario, taxes were fixed at the 2008 levels, whereas the remaining scenarios include all additional taxes up to 2013.

Sector-specific framework conditions are mentioned in the individual sector chapters.

5.6 Sectoral overview

5.6.1 Space heating and hot water preparation in residential and tertiary buildings

This chapter covers the end-uses space heating and hot water preparation in residential and tertiary buildings. The modelling approach and general aspects are the same or very similar. Differences in the drivers and results between den residential and the tertiary sector will be highlighted.

Modelling approach and sector-specific framework conditions

For the development of energy demand scenarios for space heating and hot water preparation we apply the model Invert/EE-Lab (see Annex 2). Invert/EE-Lab is a dynamic bottom-up simulation tool that evaluates the effects of different side conditions, policies and promotion schemes (in particular different settings of economic and regulatory incentives) on the energy carrier mix, CO_2 reductions and costs. Furthermore, Invert/EE-Lab is designed to simulate different scenarios (price scenarios, policy scenarios, different consumer behaviours, etc.) and their respective impact on future trends of renewable as well as conventional energy sources on a national and regional level in the building sector.

The basic idea of the model is to describe the building stock, heating, cooling and hot water systems on highly disaggregated level, calculate related energy needs and delivered energy, determine reinvestment cycles and new investment of building components and technologies and simulate the decisions of various agents (i.e. owner types) in case that an investment decision is due for a specific building segment.

Standard outputs from the Invert/EE-Lab on an annual basis are:

- Total final and useful energy demand as well as delivered energy by energy carriers and building categories (GWh)
- Installation of heating and hot water systems by energy carrier and technology (number of buildings, number of dwellings supplied)
- Refurbishment measures by level of refurbishment (number of buildings, number of dwellings)
- Policy programme costs, e.g. support volume for investment subsidies (M€)
- Total investment (M€)

More details on the model are given in the annex and on www.invert.at.

For a better understanding of how Invert/EE-Lab investigates the impact of policies, we shortly explain the basic approach how decision making is modelled. Invert/EE-Lab models the decision making of agents (i.e. building owner types) regarding building renovation and heating, hot water and cooling systems. Policy instruments may affect these decisions (in reality and in Invert/EE-Lab) in the following ways:

- Economic incentives change the economic effectiveness of different options and thus lead to other investment decisions. This change leads to higher market share of the supported technology in the Invert/EE-Lab (via the nested logit approach).
- Regulatory instruments (e.g. building codes or renewable heat obligations) restrict the technological options that decision makers have; limited compliance with these measures can be taken into account by limiting the information level of different agents regarding this measure (see next bullet point).
- Information, advice, etc: Agents have different levels of information. Lack of information may lead to neglecting of innovative technologies in the decision making process or to a lack of awareness regarding subsidies or other support policies. Information campaigns and advice can increase this level of information. Thus, the consideration of innovative technologies, knowledge about support programmes and compliance with regulatory standards increases.

- R&D can push technological progress. The progress in terms of efficiency increase or cost reduction of technologies can be implemented in Invert/EE-Lab.

The policies trigger the uptake of certain building refurbishment measures and technologies. As technologies for thermal building renovation, we take into account the following building components: roof, floor, façade and windows/doors. Heat recovery is also counted as “envelope” technologies since it addresses the reduction of the energy need (useful energy) not the reduction of delivered energy (final energy). The following table shows the range of considered renovation measures. Due to different traditions, building codes, climatic conditions, nZEB[24] market maturity and barriers, the list of considered renovation measures slightly differs between countries. The key approach to determine the renovation measures for each country followed the idea to link the selection of renovation measures to cost-optimality calculations carried out in selected countries in the frame of the EPBD[25] recast. The standard renovation package reflects currently typically applied renovation measures. “Good” renovation is linked to good quality in the area of cost-optimality. “Ambitious” renovation is defined as in the area of minimum primary energy, what could be called “nZEB-renovation”, i.e. on the left hand side of the cost-optimality curve. However, we want to emphasize that the cost-optimality calculations of course also include heating and cooling systems as well as – to some extent – appliances. For the purpose in this chapter here, we selected only the measures with direct impact on the energy need, i.e. measures improving the thermal quality of the building envelope and heat recovery.

The resulting reduction in energy need for space heating varies in a quite considerable range. This is mainly due to the historical building codes and thermal quality of the building stock and climatic conditions. The figures below show the exemplary case of Finland and Bulgaria. Compared to Bulgaria, Finland implemented effective and comparably strict building codes already before the 1970’s. Thus, the relative energy saving potential of renovation measures is lower than in Bulgaria with a lower energetic performance of the building stock.

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[24] Nearly Zero Energy Buildings

[25] Energy Performance Directive for Buildings

Table 15: Renovation measures modelled in Invert/EE-Lab. Differences in different countries and different building categories occur due to different climate, traditions, building codes, barriers and technological opportunities

	Standard	Good	Ambitious
Roof	10-15 cm of thermal insulation	20 cm of thermal insulation	30 cm of thermal insulation
Wall	5-10 cm of thermal insulation	15 cm of thermal insulation	20 cm of thermal insulation
Base	5 cm of thermal insulation	10 cm of thermal insulation	15 cm of thermal insulation
Windows	Double glass Ug= 1.7-2.7 W/m²K	Double glass Ug= 1-1.7 W/m²K	Triple glass Ug= 0.65 – 1.7 W/m²K
Heat recovery	no	no / yes	no / yes
Reduction space heating energy need (construction period<1950)	21% - 47%	26% - 58%	44% - > 85%
Reduction space heating energy need (construction period 1950-1990)	23% - 42%	25%-52%	27% - > 85%
Reduction space heating energy need (construction period > 1990)	12% - 20%	10%-39%	25% - > 80%

Figure 32: Relative energy reduction of different renovation packages in various building segments for the exemplary case of Bulgaria

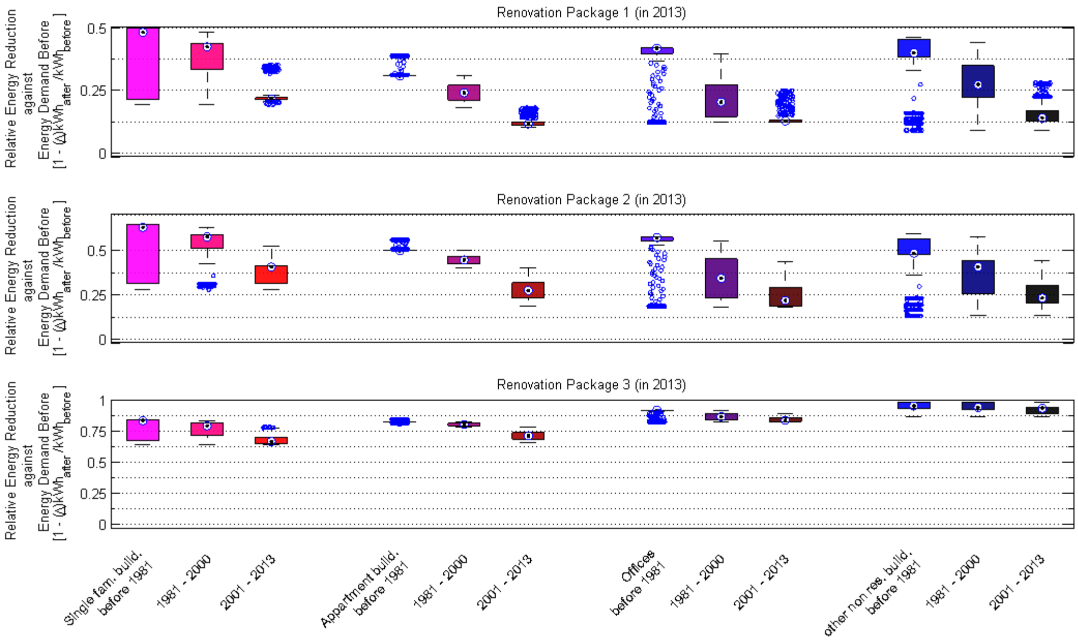
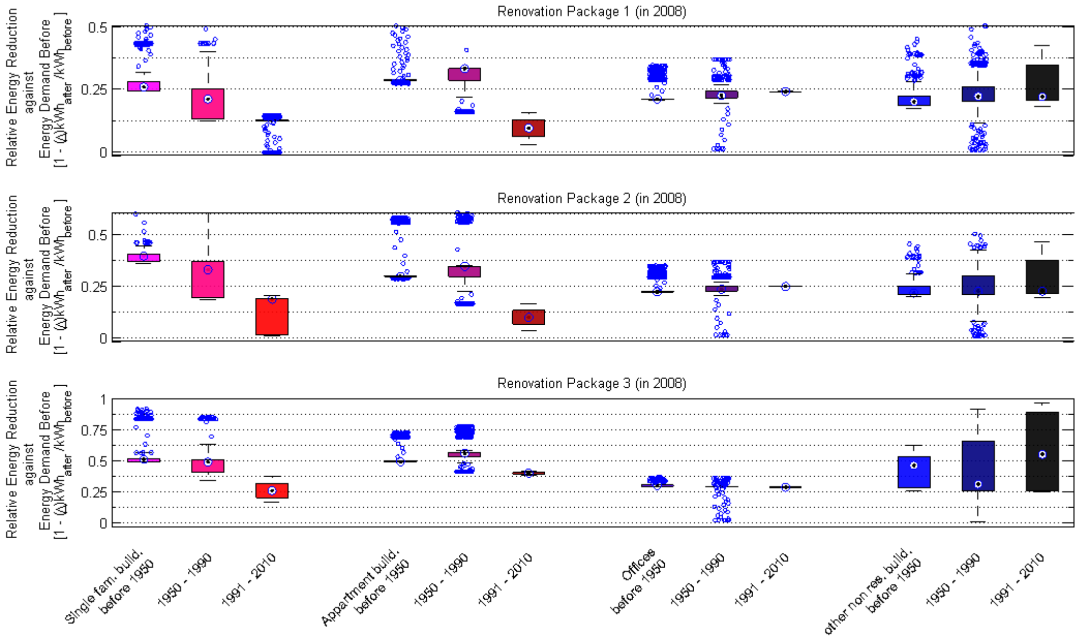


Figure 33: Relative energy reduction of different renovation packages in various building segments for the exemplary case of Finland



The model Invert/EE-Lab selects for each building segment which is undergoing some renovation activities the economic effectiveness and endogenously determines the market share of renovation qualities. This market share is shown for the different scenarios below.

Discount rates are distinguished between countries and between different investor types. In particular, different ownership constellations, income situation and age of building owners are taken into account. The country specific differences of the interest rates are based on Eurostat. The differentiation between different investor types is based on the stakeholder analysis and investigation of barriers in the project ENTRANZE (www.entranze.eu). In countries like France, Germany or Austria the interest rate is in the lower range from 3.1% to 3.7% for typical residential building owners, 4.7%-5.4% for non-residential buildings with higher values up to about 7.4% for low-income owners or elder people. In countries like Romania or Bulgaria the interest rates are in the higher range of 8-12% with higher values of up to 16% for low-income and aged building owners.

The Energy Performance of Buildings Directive EPBD (recast), the Energy Efficiency Directive EED and the Renewable Energy Directive RED include the different economic, regulatory and informative aspects mentioned above and which Member States have to adopt (and partly already have adopted). This includes e.g. building codes for new buildings and renovation, RES-H (renewable for heat) use obligation, economic incentives (e.g. tax incentives, investment subsidies, energy taxes) for building renovation and RES-H/C or awareness raising which are modelled as described above.

All values indicated in the scenarios below are Heating Degree Days HDD adjusted to the level of 2005. So, we assume a constant climate throughout the period until 2030 at the level of the year 2005. This is similar to the approach taken in the PRIMES projections. Therefore, there is also some gap between the values indicated for 2008 and real consumption in 2008 according to Odyssee and Eurostat.

Specific energy-uses covered

This chapter covers the following energy end-uses:

- Space heating in residential buildings (distinguished by new and existing buildings and by heating systems and envelope for the latter ones)
- Space heating in tertiary buildings (also distinguished by new and existing buildings and by heating systems and envelope for the latter ones)
- Hot water preparation in residential buildings
- Hot water preparation in tertiary buildings

Other building related end-uses like cooling or lighting within this project are covered in the chapters about residential and tertiary sector appliances.

Scenario-independent drivers

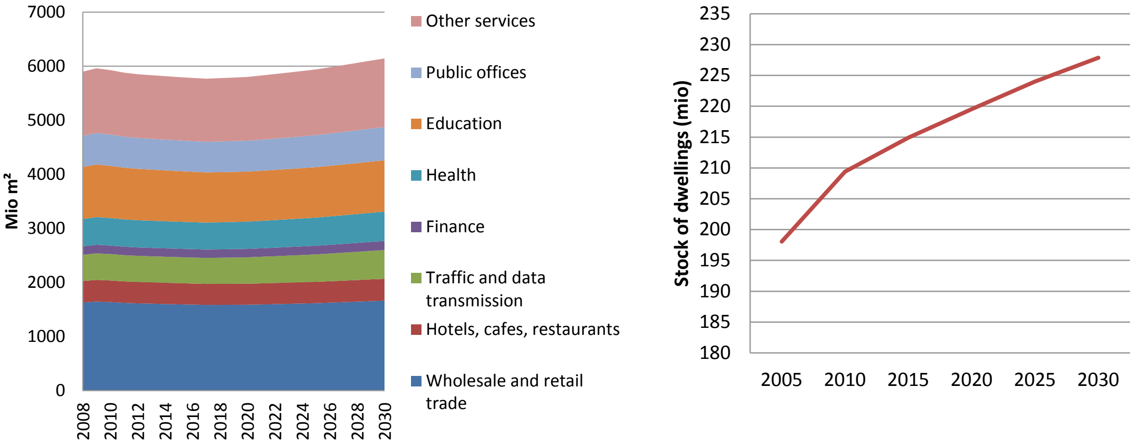
The energy demand of space heating and hot water depends on a number of exogenous drivers such as the number of households, population, lifetime and technology data, behavior etc. The uptake of renovation measures and of different heating and hot water systems is modelled endogenously in the model.

Table 16: Main scenario-independent drivers residential/tertiary buildings

Driver	**Source**
Number of households	PRIMES 2013
Technology data (cost development, technology specification etc)	ENTRANZE
Electricity, oil, coal, biomass and gas wholesale prices	PRIMES 2013

Table 16 provides an overview over the main drivers and the data sources used in this project and which are applied for all scenarios.

Figure 34: Development of building stock (left: floor area of tertiary buildings, right: number of residential dwellings)



Data regarding the status quo of the building stock, related energy use, etc. are based on the following sources: BPIE data hub (www.buildingsdata.eu), Odyssee–MURE, Eurostat, ENTRANZE (www.entranze.eu), national building statistics, national statistics on various economic sectors for non-residential building data, Tabula and similar projects regarding building typologies.

Scenario definition and implementation

The implementations of the scenarios include the following policy measures.

1. Baseline Scenario (no early action): The Base_noEA includes policy measures that were adopted before 2008. It therefore includes no implementation of the EPBD (recast) or the Energy Efficiency Directive EED and the Renewable Energy Directive RED. However, national building codes which in some MSs were tightened already before 2008 are implemented. In a similar way, promotion schemes for thermal building refurbishment or efficient heating and hot water systems or energy taxation schemes already in place before 2008 are implemented.

2. Baseline Scenario (including early action): The Base_inclEA scenario includes policy measures that were adopted between 2008 and 2013. However, on MS level, a highly extensive research would have been necessary to investigate in detail, which measures in the recently submitted national plans are already legally adopted or which are just in preparation. The same is true for the nZEB standards to be implemented until 2018 and 2020. Only in a few countries, these standards according to the nZEB plans are already binding, although much more countries have announced certain values. Therefore, some assumptions had to be made in order to separate those measures included in this scenario from those which are included in the AM – Scenario (see below). For those countries, where we had sufficient information (e.g. Germany, France, Austria, Romania) we modelled the concrete, real implementation of policies between 2008 and 2013. In the remaining countries, we assumed that half of the measures which should be implemented according to the EPBD (recast) and the EED have already been established before 2013. This does not mean that they definitely have an impact already in 2013 but that the corresponding legislation or promotion scheme has been adopted until 2013, e.g. a building code enhancement which has been adopted in 2013 to come into force in the year 2016.

3. Baseline Scenario (With Measures): The Base_WM scenario includes measures taken starting 2014 or close of being taken. Given the uncertainties discussed for the previous scenario it was decided to not distinguish this scenario from the Base_inclEA.

4. Additional Measures Scenario (AM): The AM scenario includes the policy measures of the previous scenario as well as revisions of the implementation of the directives (EED and EPBD) that are due in 2014/2015. In particular we assume full implementation of the EPBD (recast) on MS level. As pointed out above, the EPBD (recast) up to now is not fully implemented in the MSs and there are still a considerable number of open questions and some range of interpretation e.g. regarding the definition of Nearly Zero Energy Buildings (nZEB). We assumed that MSs will implement the directive in an ambitious way. This means that the member states will be in time with the implementation. Moreover, it means that the definition of nZEB will be established in a way which goes beyond cost-optimal levels. Previous literature (in particular Hermelink 2013 and Atanasiu 2011) indicates that the intention of the EPBD (recast) is that the nZEB standard should be more ambitious than the cost-optimal level. However, recent examples from national nZEB plans show that some member state refer to the cost-optimal level in the definition of the national nZEB standard and others go beyond. In this scenario we assume that a majority of member states fulfill the intention behind the EPBD (recast) and go beyond the cost-optimal level in the definition of national nZEB standards. Moreover, we assumed that Member States start to implement also such policy instruments which are partly discussed but still only rarely realized, such as renovation obligations for buildings with a certain age, renovation obligations in case of building sales or change of tenants, strict control and compliance to building codes in case of renovation (i.e. that pure maintenance measures on buildings for esthetic or security reasons are phased out).

5. Potential 2030 – Low Policy impact (LPI): Since the concrete implementation of the EPBD is still vague, in particular regarding the nZEB definition, in this scenario we assumed that a large majority of MSs does not adopt ambitious nZEB targets and that the uptake of renovation activities is slower due to barriers and lack of information and related policy support. This is the reason why in the particular case of buildings the LPI Scenario is less ambitious than the AM Scenario.

6. Potential 2030 – High Policy impact (HPI): Includes all measures implemented in the AM scenario, however, the implementation on MSs level is even more ambitious in terms of building codes for new buildings and major building renovation. Moreover, effective measures for increasing the renovation rate are taken and RES-H use obligations are introduced in an increasing number of countries. Concrete policy measures to achieve this target in this field are directly modelled in Invert/EE-Lab. They include: (1) obligations to increase energy efficiency standards in case that there is a change in ownerships or tenancy of a building, (2) financial support of thermal building renovation, (3) measures to increase the compliance with building codes or standards for efficient heating systems, both for new buildings and building renovation, (4) training of builders and installers to improve the practical implementation of measures and increase the impact of efficiency measures in real life.

7. Potential 2030 – Near Economic (NE): The intention of the Near-Economic scenario is to assume measures which are not economic but induce costs not much higher than present level energy consumption entails. In contrast to other sectors, this is already the case in the HPI-scenario (and to some extent even in the AM-scenario). Cost-optimality calculations carried out in the frame of the EPBD (recast) have shown that in most cases there is some financial gap between the cost-optimal solution and nZEB standard. Thus, the consequent implementation of nZEB-standard in general means to go beyond pure economic measures, even considering low discount rates. Moreover, the increase of building renovation and heating system replacement would mean to advance investments which are related to higher costs compared to the case that a building renovation is required due to the end of lifetime of one or several building components[26]. For these reasons, the NE scenario follows the same level as the HPI-scenario.

However, we want to emphasize that this scenario does not reflect technical efficiency potentials which could be achieved. Higher energy savings would be achievable in particular by the following measures: (1) Higher share of deep renovation activities, (2) higher renovation rates, which in practice would mean to advance building renovation also in cases where technical lifetime of building components are not yet reached;

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[26] We include in our calculation some enhancement of building renovation rates without considering the full cost of renovation. This is due to the fact the in many countries thermal building renovation leads to maintain or increase the value of the building, which would otherwise degrade (see the next section).

strong measures like mandatory renovation plans on building level, minimum efficiency standards for every building after a certain period of time, progressive property taxes depending on efficiency standards etc; (3) higher rate of heating system exchange; this includes the boiler exchange but also the change of heat distribution systems in buildings in order to allow lower inflow temperature and thus higher efficiency, e.g. of heat pumps or condensing boilers; (4) improvement of quality of energy efficiency measures by training and qualification of professionals.

All these measures are well known and some parts of them are also implemented in reality (and in the AM and the HPI scenario). However, a broad and rigorous establishment of these measures is beyond the intention of the “near economic” scenario.

Renovation rates

In the model Invert/EE-Lab, renovation rates are an endogenous result and not an input into the model. They result from the age and structure of the building stock, of the building components and from typical life time of these components. Due to uneven and discontinuous building construction and renovation activities in the past, in most of the countries the model results in an increase of the “natural” building renovation rate from now until 2030. However, the share of thermal renovation in these measures and the potential increase of the “natural” building renovation rate leads to different results of the thermal building renovation in the different countries and in various building categories.

The term “renovation rate” is often used, but in very different contexts and with different definitions. We understand the term “renovation rate” as equivalent “full thermal renovation rate”. E.g. in case that only replacement of windows is carried out in a building, this is not counted as full renovation. In Invert/EE-Lab, the different single thermal renovation measures are combined to packages and for these packages of “equivalent” full renovation, the renovation rate is derived.

This “equivalent full thermal renovation rate” in the baseline scenarios remains low in the range of 0.7%-1%. It remains at the same level in the LPI scenario. The additional measures scenario (AM) results in renovation rates in the range from 0.9%-1.2% (so a comparatively small increase in the renovation rate), whereas the High Policy Intensity scenario (HPI) leads to renovation rates in the range from 1.4% - 2.5% (all values average from 2008-2030, differing between building categories).

In this context, we want to emphasize that the impact on final energy demand is strongly driven by the quality of thermal building renovation and the efficiency standards applied in the measures. Hence, scenarios with the same renovation rate can lead to different final energy demand. The following table summarizes the results of the different scenarios regarding the share of three clusters of renovation depths (see above, Table 15, Figure 32 and Figure 33). Considering the high quality of ambitious renovation, it becomes clear that in particular for the scenarios AM, HPI and NE strong policy measures will be required, including economic incentives, regulatory instruments and qualification and training activities.

Table 17: Share of renovation depth on total renovation activities until 2020 and 2030

		Base_inclEA		Base_WM		AM		LPI		HPI		NE	
		2020	2030	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
Share of standard renovation	Residential	74%	65%	74%	65%	43%	37%	45%	39%	25%	25%	25%	25%
Share of good renovation	Residential	18%	21%	18%	21%	36%	38%	35%	37%	37%	32%	37%	32%
Share of ambitious renovation	Residential	9%	15%	9%	15%	22%	25%	21%	24%	39%	43%	39%	43%
Share of standard renovation	Tertiary	73%	72%	73%	72%	54%	48%	56%	50%	35%	33%	35%	33%
Share of good renovation	Tertiary	12%	16%	12%	16%	25%	30%	24%	29%	29%	24%	29%	24%
Share of ambitious renovation	Tertiary	9%	13%	9%	13%	22%	23%	20%	22%	36%	43%	36%	43%

Cost degression

Cost degression is highly uncertain in the field of building renovation. Material cost could even increase due to higher resource prices. On the other hand, training, increasing experience of more and more qualified staff or prefabricated insulation elements could also help to bring renovation costs down. Due to these uncertainties, we assumed no cost degression for standard efficiency measures (e.g. conventional polystyrene façade insulation). For more innovative, ambitious measures, e.g. installing heat recovery in renovated buildings, slight cost degression of 10% up to 2030 have been assumed. Due to these conservative assumptions, we can assume that we might overestimate additional investments, in particular if R&TD as well as training and qualification measures are successful.

Sector results

The following tables present the main scenario-results for both residential and tertiary buildings. They show the total energy demand for space heating and hot water preparation, the split into hot water and space heating and for space heating into existing and new buildings. The results reveal that new buildings, in particular after 2020 only slightly increase the energy consumption due to increasing thermal performance of buildings compared to the existing building stock.

Moreover, for the HPI and NE scenarios, the impact of envelope improvement and more efficient heating systems is shown compared to the AM scenario. These latter results are also shown in absolute terms in Mtoe, as all other results as well.

The impact of building envelope is much stronger than the efficiency improvement of heating systems. Large parts of the efficiency improvement of heating systems according to the Ecodesign Directive are already implemented in the AM scenario. However, we assumed some minor lack of compliance with these standards in the AM scenario which are removed in the HPI scenario.

Table 18: Results for space heating and hot water, residential buildings EU27 (Mtoe)

Residential Buildings

EU27 , Mtoe, Final Energy Demand

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Residential Buildings	247,89	241,87	223,06	232,31	209,84	232,31	209,84	222,34	192,64	226,18	197,12	197,49	156,78	197,49	156,78
New buildings (space heating)	0,00	9,62	15,73	9,22	14,77	9,22	14,77	8,82	13,53	8,98	13,87	7,80	10,94	7,80	10,94
Existing buildings (space heating), of	205,85	191,07	168,58	183,22	158,27	183,22	158,27	175,31	144,97	178,51	148,61	154,98	117,25	154,98	117,25
*envelope **										4,72	9,85	31,12	45,47	31,12	45,47
*heating systems **										0,35	1,05	1,13	3,38	1,13	3,38
Hot Water	42,22	41,37	38,92	40,05	36,99	40,05	36,99	38,43	34,37	38,86	34,81	34,93	28,82	34,93	28,82

** (absolute difference to AM scenario)*

EU27, %, change compared to 2008

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Residential Buildings	100%	98%	90%	94%	85%	94%	85%	90%	78%	91%	80%	80%	63%	80%	63%
New buildings (space heating)															
Existing buildings (space heating), of	100%	93%	82%	89%	77%	89%	77%	85%	70%	87%	72%	75%	57%	75%	57%
*envelope **															
*heating systems **															
Hot Water	100%	98%	92%	95%	88%	95%	88%	91%	81%	92%	82%	83%	68%	83%	68%

** (absolute difference to AM scenario)*

EU27, %, change compared to Base_inclEA

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Residential Buildings				100%	100%	100%	100%	96%	92%	97%	94%	85%	75%	85%	75%
New buildings (space heating)				100%	100%	100%	100%	96%	92%	97%	94%	85%	74%	85%	74%
Existing buildings (space heating), of which				100%	100%	100%	100%	96%	92%	97%	94%	85%	74%	85%	74%
*envelope **															
*heating systems **															
Hot Water				100%	100%	100%	100%	96%	93%	97%	94%	87%	78%	87%	78%

* (absolute difference to AM scenario)

Table 19: Main results by country for the residential sector (residential buildings)

Residential Buildings

Member States
Mtoe, Final Energy Demand

Member States
%, change compared to Base_inclEA

										Potential_2030										
Country	2008	Base_noEA		Base_inclEA		Base_WM		AM		LPI		HPI		NE		Country	HPI		NE	
		2020	2030	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030		2020	2030	2020	2030
Austria	5,85	5,26	4,83	5,14	4,61	5,14	4,61	5,03	4,46	4,99	4,42	4,74	3,85	4,74	3,85	Austria	92%	84%	92%	84%
Belgium	7,81	8,18	7,67	7,64	6,99	7,64	6,99	7,41	6,33	7,48	6,40	6,06	4,75	6,06	4,75	Belgium	79%	68%	79%	68%
Bulgaria	1,91	1,65	1,42	1,65	1,42	1,65	1,42	1,52	1,29	1,62	1,39	1,45	1,17	1,45	1,17	Bulgaria	88%	83%	88%	83%
Croatia	2,28	2,51	2,32	2,42	2,21	2,42	2,21	2,14	1,82	2,32	2,07	2,05	1,71	2,05	1,71	Croatia	85%	77%	85%	77%
Cyprus	0,18	0,22	0,26	0,22	0,25	0,22	0,25	0,20	0,23	0,21	0,23	0,19	0,19	0,19	0,19	Cyprus	86%	75%	86%	75%
Czech Republic	6,20	6,12	5,49	5,89	5,24	5,89	5,24	5,58	4,76	5,66	4,89	5,36	4,46	5,36	4,46	Czech Republic	91%	85%	91%	85%
Denmark	2,17	1,96	1,85	1,86	1,57	1,86	1,57	1,80	1,51	1,88	1,62	1,77	1,45	1,77	1,45	Denmark	95%	92%	95%	92%
Estonia	1,00	0,84	0,68	0,81	0,65	0,81	0,65	0,86	0,72	0,78	0,61	0,83	0,67	0,83	0,67	Estonia	102%	103%	102%	103%
Finland	4,74	4,26	3,83	4,17	3,66	4,17	3,66	4,05	3,51	4,21	3,76	3,97	3,37	3,97	3,37	Finland	95%	92%	95%	92%
France	36,16	36,81	33,96	34,49	31,07	34,49	31,07	33,47	28,14	33,81	28,43	27,02	20,70	27,02	20,70	France	78%	67%	78%	67%
Germany	58,31	49,10	41,72	48,00	39,80	48,00	39,80	46,95	38,53	46,56	38,21	43,42	31,87	43,42	31,87	Germany	90%	80%	90%	80%
Greece	4,25	4,35	4,30	4,22	4,09	4,22	4,09	3,98	3,75	4,06	3,83	3,63	3,06	3,63	3,06	Greece	86%	75%	86%	75%
Hungary	5,48	5,53	5,08	5,32	4,85	5,32	4,85	4,73	4,02	5,11	4,52	4,54	3,77	4,54	3,77	Hungary	85%	78%	85%	78%
Ireland	2,81	3,19	3,16	2,98	2,88	2,98	2,88	2,89	2,61	2,92	2,63	2,37	1,96	2,37	1,96	Ireland	80%	68%	80%	68%
Italy	20,05	20,88	20,40	20,17	19,26	20,17	19,26	19,02	17,66	19,40	18,02	17,37	14,43	17,37	14,43	Italy	86%	75%	86%	75%
Latvia	1,56	1,31	1,08	1,26	1,03	1,26	1,03	1,26	1,03	1,21	0,96	1,21	0,97	1,21	0,97	Latvia	96%	94%	96%	94%
Lithuania	1,48	1,24	1,00	1,19	0,96	1,19	0,96	1,27	1,07	1,14	0,89	1,22	1,01	1,22	1,01	Lithuania	103%	105%	103%	105%
Luxembourg	0,45	0,52	0,51	0,48	0,47	0,48	0,47	0,47	0,42	0,47	0,43	0,38	0,32	0,38	0,32	Luxembourg	79%	68%	79%	68%
Malta	0,03	0,03	0,02	0,03	0,02	0,03	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	Malta	86%	74%	86%	74%
Netherlands	8,68	8,51	8,07	8,31	7,68	8,31	7,68	8,13	7,44	8,07	7,38	7,21	5,57	7,21	5,57	Netherlands	87%	72%	87%	72%
Poland	10,73	12,28	11,35	11,81	10,84	11,81	10,84	9,74	8,15	11,35	10,12	9,35	7,65	9,35	7,65	Poland	79%	71%	79%	71%
Portugal	1,47	1,48	1,47	1,44	1,40	1,44	1,40	1,36	1,28	1,39	1,31	1,24	1,05	1,24	1,05	Portugal	86%	75%	86%	75%
Romania	6,26	6,02	5,26	6,02	5,26	6,02	5,26	5,57	4,77	5,92	5,14	5,28	4,25	5,28	4,25	Romania	88%	81%	88%	81%
Slovakia	2,21	2,24	2,04	2,15	1,95	2,15	1,95	2,06	1,82	2,07	1,82	1,98	1,71	1,98	1,71	Slovakia	92%	88%	92%	88%
Slovenia	1,06	1,16	1,07	1,12	1,03	1,12	1,03	0,99	0,84	1,07	0,96	0,95	0,79	0,95	0,79	Slovenia	85%	77%	85%	77%
Spain	12,07	11,64	10,63	11,68	10,70	11,68	10,70	11,03	9,84	11,25	10,03	10,02	8,00	10,02	8,00	Spain	86%	75%	86%	75%
Sweden	5,61	5,09	4,53	5,04	4,48	5,04	4,48	4,89	4,31	5,09	4,61	4,80	4,13	4,80	4,13	Sweden	95%	92%	95%	92%
United Kingdom	39,33	42,00	41,35	39,21	37,69	39,21	37,69	38,04	34,13	38,43	34,49	31,13	25,61	31,13	25,61	United Kingdom	79%	68%	79%	68%
EU-27	247,89	241,87	223,06	232,31	209,84	232,31	209,84	222,34	192,64	226,18	197,12	197,49	156,78	197,49	156,78	EU-27	85%	75%	85%	75%
EU-28	250,17	244,38	225,37	234,72	212,06	234,72	212,06	224,47	194,46	228,50	199,19	199,54	158,49	199,54	158,49	EU-28	85%	75%	85%	75%

Table 20: Results for space heating and hot water, tertiary buildings EU27 (Mtoe)

Tertiary Buildings

EU27 , Mtoe, Final Energy Demand

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Tertiary Buildings	91,22	88,16	79,10	83,49	73,24	83,49	73,24	79,06	65,79	81,11	68,92	71,19	54,18	71,19	54,18
New buildings (space heating)		3,24	5,60	3,07	5,18	3,07	5,18	2,91	4,66	2,98	4,88	2,61	3,82	2,61	3,82
Existing buildings (space heating), of	82,89	76,52	65,31	72,41	60,42	72,41	60,42	68,56	54,28	70,34	56,84	61,60	44,52	61,60	44,52
*envelope **										0,88	1,50	10,57	15,71	10,57	15,71
*heating systems **										0,06	0,15	0,39	1,10	0,39	1,10
Hot Water	8,32	8,41	8,18	8,00	7,62	8,00	7,62	7,60	6,84	7,79	7,20	6,97	5,81	6,97	5,81

** (absolute difference to AM scenario)*

EU27, %, change compared to 2008

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Tertiary Buildings	100%	97%	87%	92%	80%	92%	80%	87%	72%	89%	76%	78%	59%	78%	59%
New buildings (space heating)															
Existing buildings (space heating), of	100%	92%	79%	87%	73%	87%	73%	83%	65%	85%	69%	74%	54%	74%	54%
*envelope **															
*heating systems **															
Hot Water	100%	101%	98%	96%	91%	96%	91%	91%	82%	94%	86%	84%	70%	84%	70%

** (absolute difference to AM scenario)*

EU27, %, change compared to Base_inclEA

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Tertiary Buildings				100%	100%	100%	100%	95%	90%	97%	94%	85%	74%	85%	74%
New buildings (space heating)				100%	100%	100%	100%	95%	90%	97%	94%	85%	74%	85%	74%
Existing buildings (space heating), of which				100%	100%	100%	100%	95%	90%	97%	94%	85%	74%	85%	74%
*envelope **															
*heating systems **															
Hot Water				100%	100%	100%	100%	95%	90%	97%	94%	87%	76%	87%	76%

* (absolute difference to AM scenario)

Table 21: Main results by country for the tertiary sector (tertiary buildings)

Tertiary Buildings

Member States
Mtoe, Final Energy Demand

Member States
%, change compared to Base_inclEA

										Potential_2030										
Country	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**		**Country**	**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**		**2020**	**2030**	**2020**	**2030**
Austria	2,23	1,93	1,60	1,93	1,58	1,93	1,58	1,89	1,53	1,87	1,52	1,92	1,53	1,92	1,53	Austria	100%	97%	100%	97%
Belgium	3,16	3,03	2,55	2,71	2,24	2,71	2,24	2,63	2,03	2,66	2,05	2,14	1,51	2,14	1,51	Belgium	79%	68%	79%	68%
Bulgaria	0,41	0,36	0,33	0,36	0,33	0,36	0,33	0,33	0,29	0,35	0,31	0,30	0,22	0,30	0,22	Bulgaria	82%	65%	82%	65%
Croatia	0,63	0,69	0,65	0,66	0,63	0,66	0,63	0,56	0,45	0,64	0,58	0,53	0,42	0,53	0,42	Croatia	81%	68%	81%	68%
Cyprus	0,08	0,10	0,12	0,09	0,11	0,09	0,11	0,09	0,10	0,09	0,10	0,08	0,08	0,08	0,08	Cyprus	85%	74%	85%	74%
Czech Republic	2,33	2,35	2,23	2,27	2,14	2,27	2,14	1,96	1,58	2,18	1,99	1,88	1,48	1,88	1,48	Czech Republic	83%	69%	83%	69%
Denmark	1,00	0,96	0,97	0,92	0,85	0,92	0,85	0,89	0,82	0,93	0,88	0,88	0,78	0,88	0,78	Denmark	95%	92%	95%	92%
Estonia	0,25	0,23	0,21	0,22	0,20	0,22	0,20	0,19	0,15	0,21	0,19	0,19	0,14	0,19	0,14	Estonia	84%	67%	84%	67%
Finland	1,31	1,27	1,24	1,24	1,15	1,24	1,15	1,20	1,10	1,25	1,18	1,18	1,06	1,18	1,06	Finland	95%	92%	95%	92%
France	12,92	11,81	9,85	10,81	8,87	10,81	8,87	10,49	8,04	10,60	8,12	8,43	5,88	8,43	5,88	France	78%	66%	78%	66%
Germany	19,94	16,71	13,17	16,63	12,99	16,63	12,99	16,26	12,58	16,13	12,47	15,53	10,97	15,53	10,97	Germany	93%	84%	93%	84%
Greece	0,60	0,65	0,66	0,60	0,59	0,60	0,59	0,57	0,54	0,58	0,55	0,52	0,43	0,52	0,43	Greece	85%	74%	85%	74%
Hungary	2,19	2,17	2,06	2,09	1,97	2,09	1,97	1,76	1,43	2,01	1,84	1,69	1,34	1,69	1,34	Hungary	81%	68%	81%	68%
Ireland	1,04	1,08	0,96	0,97	0,84	0,97	0,84	0,94	0,76	0,95	0,77	0,77	0,57	0,77	0,57	Ireland	80%	68%	80%	68%
Italy	13,58	15,03	15,13	13,86	13,35	13,86	13,35	13,07	12,25	13,33	12,49	11,81	9,83	11,81	9,83	Italy	85%	74%	85%	74%
Latvia	0,52	0,46	0,42	0,44	0,41	0,44	0,41	0,38	0,28	0,43	0,38	0,36	0,27	0,36	0,27	Latvia	82%	66%	82%	66%
Lithuania	0,34	0,32	0,30	0,31	0,29	0,31	0,29	0,27	0,20	0,30	0,27	0,25	0,19	0,25	0,19	Lithuania	82%	65%	82%	65%
Luxembourg	0,24	0,26	0,23	0,23	0,21	0,23	0,21	0,22	0,19	0,23	0,19	0,18	0,14	0,18	0,14	Luxembourg	78%	66%	78%	66%
Malta	0,02	0,02	0,02	0,02	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	Malta	87%	75%	87%	75%
Netherlands	5,91	5,86	5,19	5,82	5,11	5,82	5,11	5,69	4,95	5,65	4,91	5,13	3,79	5,13	3,79	Netherlands	88%	74%	88%	74%
Poland	4,12	4,40	4,18	4,25	4,00	4,25	4,00	3,49	2,77	4,08	3,73	3,35	2,60	3,35	2,60	Poland	79%	65%	79%	65%
Portugal	0,77	0,82	0,83	0,76	0,74	0,76	0,74	0,71	0,67	0,73	0,69	0,65	0,54	0,65	0,54	Portugal	85%	74%	85%	74%
Romania	1,72	1,73	1,63	1,73	1,63	1,73	1,63	1,57	1,41	1,67	1,52	1,42	1,06	1,42	1,06	Romania	82%	65%	82%	65%
Slovakia	1,52	1,61	1,57	1,55	1,51	1,55	1,51	1,29	1,07	1,49	1,41	1,24	1,00	1,24	1,00	Slovakia	80%	66%	80%	66%
Slovenia	0,29	0,32	0,30	0,31	0,29	0,31	0,29	0,26	0,21	0,29	0,27	0,25	0,20	0,25	0,20	Slovenia	81%	68%	81%	68%
Spain	3,29	3,46	3,23	3,13	2,81	3,13	2,81	2,96	2,59	3,02	2,64	2,69	2,09	2,69	2,09	Spain	86%	74%	86%	74%
Sweden	1,82	1,78	1,71	1,77	1,64	1,77	1,64	1,71	1,58	1,78	1,69	1,68	1,52	1,68	1,52	Sweden	95%	92%	95%	92%
United Kingdom	9,62	9,43	8,37	8,46	7,38	8,46	7,38	8,21	6,68	8,30	6,75	6,66	4,95	6,66	4,95	United Kingdom	79%	67%	79%	67%
EU-27	91,22	88,16	79,10	83,49	73,24	83,49	73,24	79,06	65,79	81,11	68,92	71,19	54,18	71,19	54,18	EU-27	85%	74%	85%	74%
EU-28	91,85	88,85	79,75	84,15	73,86	84,15	73,86	79,62	66,24	81,74	69,51	71,72	54,60	71,72	54,60	EU-28	85%	74%	85%	74%

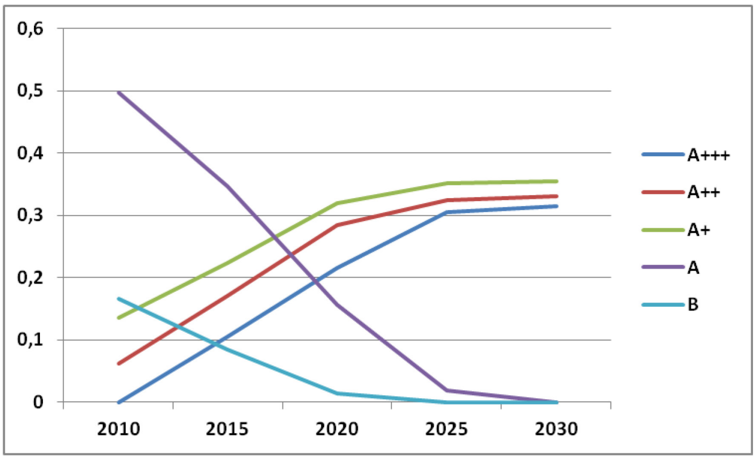
5.6.2 Residential sector appliances

Modelling approach and sector-specific framework conditions

The energy demand for household appliances, lighting, air conditioning and electronic devices is projected with the FORECAST model using a bottom-up approach that distinguishes individual technologies (see Annex 2).

The energy saving potentials for household appliances depend on the market uptake of energy efficient technologies. For each appliance, the FORECAST model distinguishes between a variety of technologies, where the energy efficiency is typically indicated by the energy efficiency index (EEI) or the energy use per year in order to model the requirements specified in the European product policy documents. For appliances covered under the Labelling legislation, the energy efficiency classes are distinguished as defined in the legislative documents. For illustration, Figure 35 shows the increase of the market share of high-efficient washing machines in the Base_inclEA Scenario including the adoption of the Ecodesign implementing measure and the addition of the new Labelling classes.

Figure 35: Transformation of the market share of washing machines by energy class in the Base_inclEA Scenario



The diffusion of technologies is modeled as a result of individual investment decisions taken over time. The investment decisions are modeled as a discrete choice process, where households choose among alternative technologies. The implementation of the investment decisions follows a logit-approach considering the total cost of ownership of an investment as well as non-monetary barriers to the investment in energy efficient appliances. This approach ensures that even if one technology choice is more cost-effective than the others, it will not gain a 100% market share, reflecting the heterogeneity in the market, niche markets and non-rational behavior. The replacement of appliances is based on a vintage stock approach allowing to realistically model the replacement of the capital stock considering its age distribution.

For household appliances, the main energy-efficiency policies are implemented in the FORECAST model as follows.

- *Minimum energy performance standards (MEPS)* are modelled by restricting the market share of new appliances starting in the year the standards come into force.
- The effect of *Energy Labelling* policies is modelled in two ways: On the one hand, Labelling policies have an effect on appliance manufacturers, who direct innovation efforts towards the development of products in the highest efficiency class. This effect is modeled through the introduction of new Labelling classes in the market. On the other hand, Labelling has an influence on the investment decisions of consumers, directing the preferences towards more energy-efficient devices. This information-based effect is modeled by adjusting the logit parameters and thus assuming a less heterogeneous market, in which a higher share of consumers will select the appliance with the lowest total cost of ownership.
- *Energy taxes* for end-consumers can be modeled explicitly for individual countries. Energy taxes have an effect on the cost-of ownership of appliances and therefore influence the investment decisions. The model further takes into account positive in-

teractions between energy taxes and information-based policies that direct consumers towards appliances with the lowest total cost of ownership.

- *Non-monetary barriers, discount rates and logit parameter:*
  - *Barriers related to the lack of information:* Without Energy Labelling (or when most products have reached the highest Labelling class), consumers lack information about the life-cycle costs of appliances. A number of recent studies show that Energy Labelling has a significant effect on the awareness of consumers on the life-cycle costs and contributes to lowering the discount rates for residential appliances. However, especially for low-income households the lack of capital for investing in appliances with higher efficiency leads to purchases with higher than optimal life-cycle costs. In our projections, the discount rates (Table 22) vary between different countries, appliances and scenarios and range between 2 and 8%. The high policy scenario assumes discount rates of 2% from 2020, implying that barriers related to the lack of capital have been removed The market introduction of new Labelling classes is modelled by introducing a diffusion process in the utility function reflecting the gradual market take-up of (economically favourable) new appliances.
  - *Lack of interest/preferences in product features:* For products where the purchase decision depends strongly on product features and is influenced only marginally by life-cycle-cost considerations (e.g. ICT appliances), a low logit parameter is chosen to reflect the limited sensitivity on life-cycle-costs.

Table 22: Discount used for residential appliances in the scenarios

Scenario name	**Short name**	**Discount rates used**
Additional Measures	AM	Typically 6% (discount rates vary between different countries, appliances)
Potential 2030 (Low Policy Intensity)	Potential_2030_LPI	
Potential 2030 (High Policy Intensity)	Potential_2030_HPI	2% (assuming removal of barriers from 2020)
Potential 2030 (Near Economic)	Potential_2030_NE	

Specific energy-uses covered

The model covers the most relevant energy using devices identified in Table 13, in particular:

- ***Large appliances:*** The model distinguishes refrigerators, freezers, washing machines, dryers and dishwashers

- ***Information/Communication Technologies ICT:*** we distinguish televisions, laptop computers, desktop computers, computer screens, modems, set top boxes grouped in this category.
- ***Lighting***
- ***Air conditioning***
- ***(electric and non-electric) Cooking***
- ***Others:*** The energy using devices not covered in the previous bullet points are grouped under

Scenario-independent drivers

The energy demand of household appliances depends on a number of exogenous drivers such as the number of households, the appliance ownership rates, electricity prices and the lifetime of appliances. These drivers are the same for all scenarios. Table 23 provides an overview over the main drivers and the data sources used in this project.

Table 23: Main scenario-independent drivers

Driver	**Source**
Number of households	PRIMES 2013
Rate of ownership	Odyssee and own projections
Appliance Stock in base year	GFK
Appliance lifetime	Ecodesign implementing measures
Electricity and gas wholesale prices	PRIMES 2013
Appliance investment price in base year	GFK, Eurostat
Yearly operation hours	Eco-design documents

Scenario definition and implementation

A number of Ecodesign implementing measures as well as new energy labelling regulations concerning domestic energy use were adopted between 2008 and 2013. The implementation of the Energy Efficiency Directive provides further momentum to the revision and acceleration of current implementing measures as well as a widening of the scope of the directives.

The implementation of the scenarios includes the following policy measures (for details see Table 24).

1. Baseline No Early Action (Base_noEA): The baseline scenario includes policy measures that were adopted before 2008. It therefore includes no Ecodesign implementing measures, however, it includes the Labelling regulations for white goods from the early 1990s. Energy taxes are fixed at the 2007 values.

2. Baseline incl. Early Action (Base_inclEA): This scenario includes policy measures that were adopted between 2008 and 2013. Ecodesign and Labelling measures are explicitly modeled for refrigerators, washing machines, freezers, dryers, dishwashers, stoves and lighting (see Table 24) and are modeled as an average over technologies for televisions, set-top boxes, laptops, desktop computers, computer screens, modems and air conditioning.

3. Baseline with measures (Base_WM): Includes the policy measures of the previous scenario as well as the adaption of additional Ecodesign measures in 2014 covering a final energy demand of 33 TWh in the EU 27.

4. Additional Measures – Scenario (AM): The Additional Measures scenario includes the policy measures of the previous scenario as well as revisions of implementing directives that are due in 2014/2015 (see Table 24), the recast of the Labelling scheme due in 2014 (see Table 24) and a moderate adoption of new implementing measures. Until 2020, the additional estimated saving potential of such new implementing measures is mainly driven by the current efforts to include a system approach for lighting and cooling within the policy framework of Eco-design, EED and EPBD[27] by 2016, leading to estimated savings of 10 TWh/year in 2020. The 2030 saving potential further assumes the adoption of implementing measures from 2020 for products which are currently not covered by Ecodesign, leading to estimated savings of 57 TWh/year in 2030.

5. Potential 2030 (low policy intensity) (Potential_2030_LPI): Includes all measures implemented in the AM scenario as well as an accelerated adoption of new measures.

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[27] Eco-design, EED are EPBD are partly overlapping among each other and with national regulation, e.g. through the standards for heating boilers in residential/tertiary buildings or the lighting in tertiary sector buildings. Overlap with EPBD is considered in the modeling of the residential/tertiary buildings which takes the Eco-design standards into account. Overlap with EED occurs through the additional counting of European measures in the National Energy Efficiency Actions Plans (NEEAPs) which is excluded here to a separate modeling of national measures, excluding European measures. Further overlaps may occur through national measures such as promotion schemes for efficient appliances. These overlaps are considered by the modeling approach which is based on labeling classes as far as available and stockmodelling which allows to define baselines set by Eco-design standards.

6. Potential 2030 (high policy intensity) (Potential_2030_HPI): Includes all measures implemented in the Low Policy Intensity Scenario and assumes that consumers' choices are strongly based on life-cycle-costs, reflecting the assumption that non-monetary barriers to the adoption of energy efficiency technologies have been reduced. The discount rates are fixed at 2% for all appliances.

7. Potential 2030 (near economic) (Potential_2030_NE): Scenario in which Ecodesign levels are set at the best technology (BAT) that is currently on the market by 2015.

Table 24: Overview over Ecodesign and Labelling measures implemented in the Scenarios

Appliance	Scenario	Ecodesign[28]	Energy Label
Refrigerators	Baseline without early actions	-	Former A to D Labelling
	Baseline with early actions 2008-2013	EEI ≤ 55 from 2010 EEI ≤ 44 from 2012 EEI ≤ 42 from 2014	A+++ at EEI ≤ 22 A++ at EEI ≤ 33 A+ at EEI ≤ 44
	Baseline With Measures	EEI ≤ 55 from 2010 EEI ≤ 44 from 2012 EEI ≤ 42 from 2014	A+++ at EEI ≤ 22 A++ at EEI ≤ 33 A+ at EEI ≤ 44
	Additional Measures	EEI ≤ 38 from 2016 EEI ≤ 35 from 2019	Rescaling with highest class set at EEI ≤ 16 in 2016
	Potential 2030 – low policy	EEI ≤ 38 from 2016 EEI ≤ 35 from 2019 EEI ≤ 32 from 2022 EEI ≤ 28 from 2025	Rescaling with highest class set at EEI ≤ 16 in 2016
	Potential 2030– high policy	EEI ≤ 34 from 2016 EEI ≤ 38 from 2019 EEI ≤ 25 from 2022 EEI ≤ 22 from 2025	Rescaling with highest class set at EEI ≤ 16 in 2016
	Potential 2030 – Near Economic	EEI ≤ 22 (current A+++) in 2016	Rescaling with highest class set at EEI ≤ 16 in 2016
Washing machines	Baseline without early actions	-	Directive 95/12/EC
	Baseline with early actions 2008-2013	EEI ≤ 68 in 2011 EEI ≤ 59 in 2013	A+++ at EEI ≤ 46 A++ at EEI ≤ 52 A+ at EEI ≤ 59
	Baseline With Measures	EEI ≤ 68 in 2011 EEI ≤ 59 in 2013	A+++ at EEI ≤ 46 A++ at EEI ≤ 52 A+ at EEI ≤ 59
	Additional Measures	EEI ≤ 54 in 2016 EEI ≤ 50 in 2019	
	Potential 2030 – low policy	EEI ≤ 54 from 2016 EEI ≤ 50 from 2019 EEI ≤ 46 from 2022 EEI ≤ 44 from 2025	Rescaling with highest class set at EEI ≤ 41 in 2016
	Potential 2030– high policy	EEI ≤ 52 from 2016 EEI ≤ 46 from 2019 EEI ≤ 44 from 2022 EEI ≤ 41 from 2025	Rescaling with highest class set at EEI ≤ 41 in 2016
	Potential 2030 – Near Economic	EEI ≤ 46 (current A+++) in 2016	Rescaling with highest class set at EEI ≤ 41 in 2016

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[28] Indicative values that depend on the exact specifications on the size and technological properties of each product

Table 24 (continued)

Appliance	**Scenario**	**Ecodesign**[29]	**Energy Label**
Dishwashers	Baseline without early actions	-	
	Baseline with early actions 2008-2013	EEI ≤ 80 from 2011 EEI ≤ 71 from 2013 EEI ≤ 63 from 2016	A+++ at EEI ≤ 50 A++ at EEI ≤ 56 A+ at EEI ≤ 63
	Baseline With Measures	EEI ≤ 80 from 2011 EEI ≤ 71 from 2013 EEI ≤ 63 from 2016	A+++ at EEI ≤ 50 A++ at EEI ≤ 56 A+ at EEI ≤ 63
	Additional Measures	EEI ≤ 63 from 2016 EEI ≤ 56 from 2019	Rescaling with highest class set at EEI ≤ 45 in 2016
	Potential 2030 – low policy	EEI ≤ 63 from 2016 EEI ≤ 56 from 2019	Rescaling with highest class set at EEI ≤ 45 in 2016
	Potential 2030– high policy	Non-monetary barriers removed	Rescaling with highest class set at EEI ≤ 45 in 2016
	Potential 2030 – Near Economic	EEI ≤ 50 (current A+++) from 2016	Rescaling with highest class set at EEI ≤ 45 in 2016
Stoves	Baseline without early actions	-	-
	Baseline with early actions 2008-2013	-	A+++ at EEI ≤ 45 A++ at EEI ≤ 62 A+ at EEI ≤ 82 A at EEI ≤ 107 B at EEI ≤ 132 C at EEI ≤ 159 D at EEI > 159
	Baseline With Measures	- EEI ≤ 146 from 2015 EEI ≤ 121 from 2016 EEI ≤ 96 from 2019	To be added Rescaling with highest class remaining at EEI ≤ 45
	Additional Measures	EEI ≤ 146 from 2015 EEI ≤ 121 from 2016 EEI ≤ 96 from 2019	Rescaling with highest class remaining at EEI ≤ 45
	Potential 2030 – low policy	EEI ≤ 146 from 2015 EEI ≤ 121 from 2016 EEI ≤ 96 from 2019	Rescaling with highest class remaining at EEI ≤ 45
	Potential 2030– high policy	Non-monetary barriers removed	Rescaling with highest class remaining at EEI ≤ 45
	Potential 2030 – Near Economic	EEI ≤ 62 (current A++) from 2016	

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[29] Indicative values that depend on the exact specifications on the size and technological properties of each product

Table 24 (continued)

Appliance	**Scenario**	**Ecodesign**[30]	**Energy Label**
Dryers	Baseline without early actions	-	
	Baseline with early actions 2008-2013	EEI ≤ 85 from 2013 EEI ≤ 76 from 2015	A++ at EEI ≤ 24 A+ at EEI ≤ 32 A at EEI ≤ 42
	Baseline With Measures	EEI ≤ 85 from 2013 EEI ≤ 76 from 2015	A++ at EEI ≤ 24 A+ at EEI ≤ 32 A at EEI ≤ 42
	Additional Measures	EEI ≤ 85 in 2013 EEI ≤ 76 in 2015	
	Potential 2030 – low policy	EEI ≤ 85 in 2013 EEI ≤ 76 in 2015	
	Potential 2030– high policy	Non-monetary barriers removed	
	Potential 2030 – Near Economic	EEI ≤ 24 (current A++) from 2016	
Lighting	Baseline without early actions	-	-
	Baseline with early actions 2008-2013	EEI ≤ 80 from 2010-2013 depending on technology EEI ≤ 60 from 2016	A++ at EEI ≤ 11 A+ at EEI ≤ 17 A at EEI ≤ 24 B at EEI ≤ 60 C at EEI ≤ 80 D at EEI ≤ 95 E at EEI > 95
	Baseline With Measures	EEI ≤ 80 from 2010-2013 depending on technology EEI ≤ 60 from 2016	A++ at EEI ≤ 11 A+ at EEI ≤ 17 A at EEI ≤ 24 B at EEI ≤ 60 C at EEI ≤ 80 D at EEI ≤ 95 E at EEI > 95
	Additional Measures	EEI ≤ 60 from 2016 EEI ≤ 24 from 2019	Rescaling with highest class remaining at EEI ≤ 11
	Potential 2030 – low policy	EEI ≤ 60 from 2016 EEI ≤ 24 from 2019	Rescaling with highest class remaining at EEI ≤ 11
	Potential 2030– high policy	EEI ≤ 85 in 2013 EEI ≤ 76 in 2015	Rescaling with highest class remaining at EEI ≤ 11
	Potential 2030 – Near Economic	EEI ≤ 17 (current A+) from 2016	

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[30] Indicative values that depend on the exact specifications on the size and technological properties of each product

Table 24 (continued)

Appliance	**Scenario**	**Ecodesign**[31]	**Energy Label**
Laptops	Baseline without early actions	-	-
	Baseline with early actions 2008-2013	-kWh/year ≤ 36; 48; 80,5 depending on technology (modeled as average) from 2014 -kWh/year ≤ 27; 36; 60,5 depending on technology (modeled as average) from 2016	-
	Baseline With Measures	-kWh/year ≤ 36; 48; 80,5 depending on technology (modeled as average) from 2014 -kWh/year ≤ 27; 36; 60,5 depending on technology (modeled as average) from 2016	-
	Additional Measures	-kWh/year ≤ 36; 48; 80,5 depending on technology (modeled as average) from 2014 -kWh/year ≤ 27; 36; 60,5 depending on technology (modeled as average) from 2016	
	Potential 2030 – low policy		
	Potential 2030– high policy	EEI ≤ 85 in 2013 EEI ≤ 76 in 2015	
	Potential 2030 – Near Economic		

Sector results

The results for the Baseline incl. Early Action show significant reductions as compared to the No Early Action Scenario. The savings are mainly achieved through the implementation of the Ecodesign and Labelling directives that were adopted between 2008 and 2013. In the AM Scenario, further savings are achieved through the upcoming rescaling of the Energy Label as well as the adoption of further Ecodesign implement-

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[31] Indicative values that depend on the exact specifications on the size and technological properties of each product

ing measures. In the Potential 2030 Scenarios, significant savings are achieved in the period between 2020 and 2030, mainly through the adoption of additional implementing measures and by increasing the ambition of the levels set by Ecodesign and Labelling.

Table 25: Main results by end-uses and scenario for the residential sector (appliances) in the EU27 (in Mtoe)

Residential Appliances

EU27 , Mtoe, Final Energy Demand

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Residential Appliances	61,30	79,25	90,09	68,04	70,96	67,24	67,78	65,81	60,34	65,81	60,34	63,58	51,42	61,40	45,08
Electric appliances (excl. IT)	14,31	18,50	19,71	13,55	12,08	13,55	12,08	13,13	8,37	13,13	8,37	13,13	8,32	11,98	5,19
IT-Appliances	7,32	12,83	14,17	11,68	12,31	11,42	12,03	11,28	11,75	11,28	11,75	11,09	9,87	11,07	9,63
Lighting	7,33	8,22	8,91	6,34	5,95	6,34	5,95	6,28	5,82	6,28	5,82	5,77	5,06	5,71	4,84
Cooking, of which	16,33	20,16	21,41	17,29	15,39	17,21	14,48	17,14	14,37	17,14	14,37	17,04	13,63	16,88	13,08
electric	6,12	6,51	6,70	6,06	4,71	6,06	4,71	5,99	4,60	5,99	4,60	5,89	3,86	5,87	3,77
non-electric	10,21	13,65	14,71	11,23	10,68	11,15	9,77	11,15	9,77	11,15	9,77	11,15	9,77	11,00	9,31
Air conditioning	0,92	2,18	2,91	1,82	2,26	1,82	2,26	1,79	2,05	1,79	2,05	1,79	2,04	1,74	1,84
Others	15,09	17,36	22,97	17,36	22,97	16,89	20,97	16,19	17,97	16,19	17,97	14,76	12,51	14,03	10,51

EU27, %, change compared to 2008

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Residential Appliances	100%	129%	147%	111%	116%	110%	111%	107%	98%	107%	98%	104%	84%	100%	74%
Electric appliances (excl. IT)	100%	129%	138%	95%	84%	95%	84%	92%	59%	92%	59%	92%	58%	84%	36%
IT-Appliances	100%	175%	194%	160%	168%	156%	164%	154%	161%	154%	161%	152%	135%	151%	132%
Lighting	100%	112%	122%	87%	81%	87%	81%	86%	79%	86%	79%	79%	69%	78%	66%
Cooking, of which	100%	123%	131%	106%	94%	105%	89%	105%	88%	105%	88%	104%	83%	103%	80%
electric	100%	106%	109%	99%	77%	99%	77%	98%	75%	98%	75%	96%	63%	96%	62%
non-electric	100%	134%	144%	110%	105%	109%	96%	109%	96%	109%	96%	109%	96%	108%	91%
Air conditioning	100%	236%	316%	198%	246%	198%	246%	195%	222%	195%	222%	195%	221%	189%	200%
Others	100%	115%	152%	115%	152%	112%	139%	107%	119%	107%	119%	98%	83%	93%	70%

EU27, %, change compared to Base_inclEA

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Residential Appliances				100%	100%	99%	96%	97%	85%	97%	85%	93%	72%	90%	64%
Electric appliances (excl. IT)				100%	100%	100%	100%	97%	69%	97%	69%	97%	69%	88%	43%
IT-Appliances				100%	100%	98%	98%	97%	95%	97%	95%	95%	80%	95%	78%
Lighting				100%	100%	100%	100%	99%	98%	99%	98%	91%	85%	90%	81%
Cooking, of which				100%	100%	100%	94%	99%	93%	99%	93%	99%	89%	98%	85%
electric				100%	100%	100%	100%	99%	98%	99%	98%	97%	82%	97%	80%
non-electric				100%	100%	99%	92%	99%	92%	99%	92%	99%	92%	98%	87%
Air conditioning				100%	100%	100%	100%	98%	90%	98%	90%	98%	90%	95%	81%
Others				100%	100%	97%	91%	93%	78%	93%	78%	85%	54%	81%	46%

Table 26: Main results by country for the residential sector (appliances)

Residential Appliances

Member States
Mtoe, Final Energy Demand

Member States
%, change compared to Base_inclEA

										Potential_2030								
Country	2008	Base_noEA		Base_inclEA		Base_WM		AM		LPI		HPI		NE		Country	HPI		NE	
		2020	2030	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030		2020	2030	2020	2030
Austria	1,12	1,38	1,59	1,23	1,32	1,21	1,27	1,18	1,11	1,18	1,11	1,13	0,92	1,10	0,86	Austria	92%	69%	89%	65%
Belgium	1,39	1,81	2,10	1,58	1,70	1,56	1,62	1,52	1,43	1,52	1,43	1,47	1,21	1,42	1,05	Belgium	93%	71%	90%	62%
Bulgaria	0,67	0,93	1,08	0,80	0,90	0,79	0,85	0,77	0,74	0,77	0,74	0,73	0,57	0,70	0,50	Bulgaria	91%	63%	87%	56%
Croatia	0,54	0,76	0,91	0,63	0,70	0,62	0,68	0,61	0,62	0,60	0,58	0,59	0,53	0,57	0,47	Croatia	94%	75%	91%	67%
Cyprus	0,16	0,21	0,25	0,18	0,19	0,18	0,18	0,17	0,17	0,17	0,17	0,16	0,14	0,16	0,13	Cyprus	92%	73%	89%	66%
Czech Republic	1,07	1,45	1,63	1,16	1,12	1,16	1,09	1,13	0,96	1,13	0,96	1,11	0,87	1,07	0,76	Czech Republic	95%	77%	92%	67%
Denmark	0,77	0,90	0,99	0,78	0,79	0,77	0,77	0,75	0,68	0,75	0,68	0,72	0,56	0,69	0,48	Denmark	92%	71%	89%	61%
Estonia	0,23	0,29	0,31	0,25	0,24	0,25	0,23	0,25	0,21	0,25	0,21	0,24	0,19	0,24	0,18	Estonia	95%	80%	93%	73%
Finland	0,92	1,16	1,30	1,01	1,03	1,00	1,00	0,97	0,89	0,97	0,89	0,93	0,75	0,89	0,65	Finland	92%	73%	88%	63%
France	8,87	11,79	13,68	10,24	10,98	10,09	10,40	9,84	9,14	9,84	9,14	9,53	7,75	9,17	6,69	France	93%	71%	90%	61%
Germany	10,26	12,46	13,22	10,79	10,41	10,68	10,09	10,44	8,94	10,44	8,94	10,01	7,38	9,63	6,33	Germany	93%	71%	89%	61%
Greece	1,31	1,60	1,76	1,32	1,26	1,31	1,23	1,29	1,12	1,29	1,12	1,25	0,99	1,22	0,90	Greece	95%	79%	93%	71%
Hungary	0,98	1,34	1,46	1,09	1,06	1,09	1,02	1,07	0,95	1,07	0,95	1,05	0,88	1,03	0,80	Hungary	96%	83%	94%	75%
Ireland	0,51	0,66	0,78	0,56	0,58	0,55	0,56	0,54	0,50	0,54	0,50	0,52	0,43	0,51	0,39	Ireland	94%	75%	91%	67%
Italy	6,33	8,71	10,15	7,57	8,21	7,47	7,80	7,29	6,89	7,29	6,89	7,11	5,92	6,86	5,14	Italy	94%	72%	91%	63%
Latvia	0,21	0,26	0,28	0,21	0,20	0,21	0,19	0,21	0,18	0,21	0,18	0,20	0,17	0,20	0,15	Latvia	96%	83%	94%	76%
Lithuania	0,36	0,46	0,50	0,37	0,36	0,37	0,35	0,36	0,32	0,36	0,32	0,36	0,29	0,35	0,27	Lithuania	95%	81%	93%	74%
Luxembourg	0,07	0,10	0,13	0,09	0,12	0,09	0,11	0,09	0,09	0,09	0,09	0,08	0,07	0,08	0,06	Luxembourg	90%	62%	86%	51%
Malta	0,05	0,06	0,06	0,05	0,05	0,05	0,04	0,05	0,04	0,05	0,04	0,05	0,04	0,05	0,03	Malta	96%	82%	94%	75%
Netherlands	1,97	2,58	3,03	2,27	2,52	2,25	2,41	2,19	2,10	2,19	2,10	2,10	1,71	2,02	1,47	Netherlands	93%	68%	89%	58%
Poland	3,43	4,89	5,52	4,05	4,09	4,01	3,90	3,94	3,54	3,94	3,54	3,86	3,17	3,75	2,86	Poland	95%	77%	93%	70%
Portugal	1,79	2,39	2,68	2,01	2,00	2,00	1,90	1,97	1,78	1,97	1,78	1,92	1,60	1,88	1,47	Portugal	96%	80%	94%	73%
Romania	3,13	4,40	4,74	3,63	3,47	3,60	3,26	3,58	3,11	3,58	3,11	3,54	2,96	3,46	2,75	Romania	97%	85%	95%	79%
Slovakia	0,43	0,59	0,69	0,49	0,53	0,48	0,50	0,47	0,45	0,47	0,45	0,46	0,39	0,44	0,34	Slovakia	94%	73%	91%	65%
Slovenia	0,24	0,29	0,33	0,24	0,26	0,24	0,25	0,23	0,22	0,23	0,22	0,23	0,18	0,22	0,16	Slovenia	93%	71%	89%	61%
Spain	4,39	5,72	6,65	4,82	5,19	4,77	4,95	4,68	4,44	4,68	4,44	4,51	3,87	4,36	3,39	Spain	94%	75%	90%	65%
Sweden	2,40	3,02	3,59	2,79	3,18	2,75	3,02	2,69	2,70	2,69	2,70	2,50	2,08	2,40	1,78	Sweden	90%	65%	86%	56%
United Kingdom	8,22	9,80	11,58	8,44	9,20	8,32	8,78	8,11	7,64	8,11	7,64	7,80	6,33	7,50	5,52	United Kingdom	92%	69%	89%	60%
EU-27	61,30	79,25	90,09	68,04	70,96	67,24	67,78	65,81	60,34	65,81	60,34	63,58	51,42	61,40	45,08	EU-27	93%	72%	90%	64%
EU-28	61,84	80,00	90,99	68,67	71,66	67,86	68,46	66,42	60,96	66,41	60,92	64,17	51,95	61,97	45,55	EU-28	93%	72%	90%	64%

5.6.3 Tertiary sector appliances

Modelling approach and sector-specific framework conditions

For the analysis of the tertiary sector we use the bottom-up model FORECAST-Tertiary (see **Annex 2**), which was commonly developed with TEP Energy GmbH. The model has been developed and extended in a number of studies in recent years. It is a coherent bottom-up model, which allows simulating the electricity demand of the tertiary sector of the European countries by country up to 2035. FORECAST-Tertiary is based on the concept of energy-efficiency measures (EEMs), which represent individual options that improve energy efficiency after being diffused through the equipment stock. Examples are fluorescent lamps, reduction of stand-by losses or changed user behaviour. Consequently, policies are modelled by adjusting the dynamics and the level of diffusion of such EEMs, depending on general and technology specific economic parameters.

The model basically adopts a bottom-up methodology which consists of a “sum product” of global drivers such as the number of employees or floor area, specific energy service drivers (specific equipment or diffusion rates, e.g. share of cooled floor area, number of computers per employee) and specific energy consumption indicators. The latter consist of technical data on the end-uses such as installed power per unit of driver. Energy services and their techno-economic description represent a key element of the modelling approach. For a more detailed description see Fleiter et al. (2011) and Jakob et al. (2012).

Policies in the tertiary sector are mainly MEPS from the EU Ecodesign Directive, but also more information-based policies as well as energy taxes.

Specific energy-uses covered

The model distinguishes 8 sub-sectors, and 14 energy services including lighting, ventilation and cooling, refrigeration, cooking, data centres with servers, elevators, street lighting and others. The shares of each sub-sector and energy service of the total electricity demand of the tertiary sector are shown below. The energy services are modelled on the level of individual sub-sectors. Thus, the model provides an energy balance that is much more detailed than official energy balances. End-uses/energy services related to space heating are considered in the respective chapter on tertiary sector buildings.

Figure 36: Sub-sectors considered in FORECAST-Tertiary and their share of EU28 electricity demand in 2008

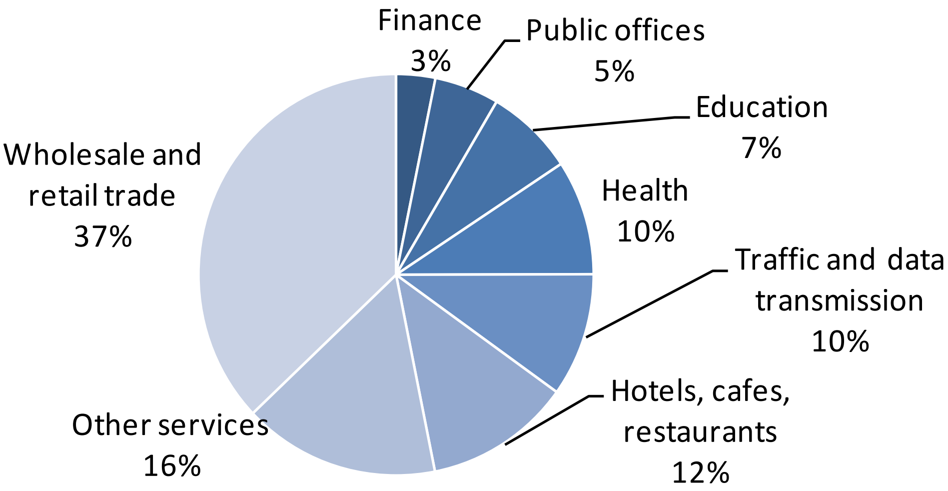
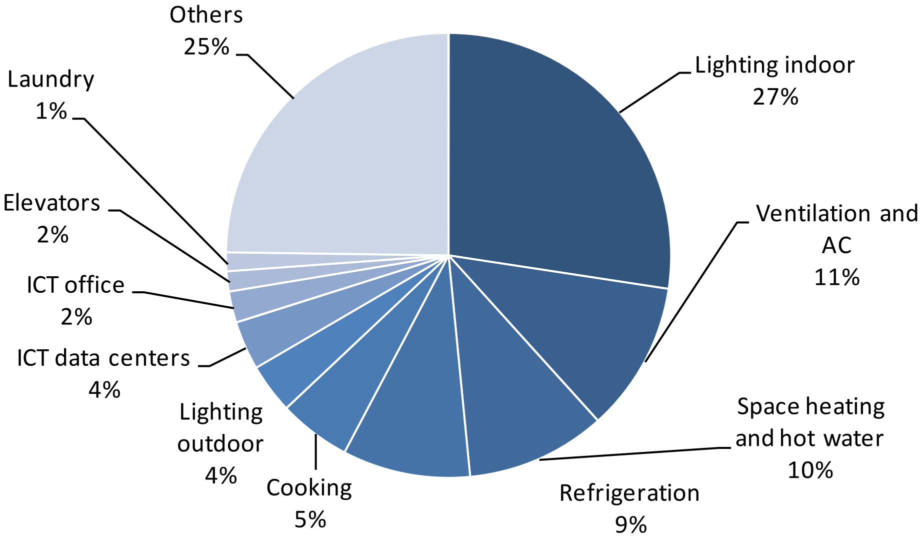


Figure 37: Energy-services considered in FORECAST-Tertiary and their share of EU28 electricity demand in 2008 (space heating and hot water see separate chapter)



Scenario-independent drivers

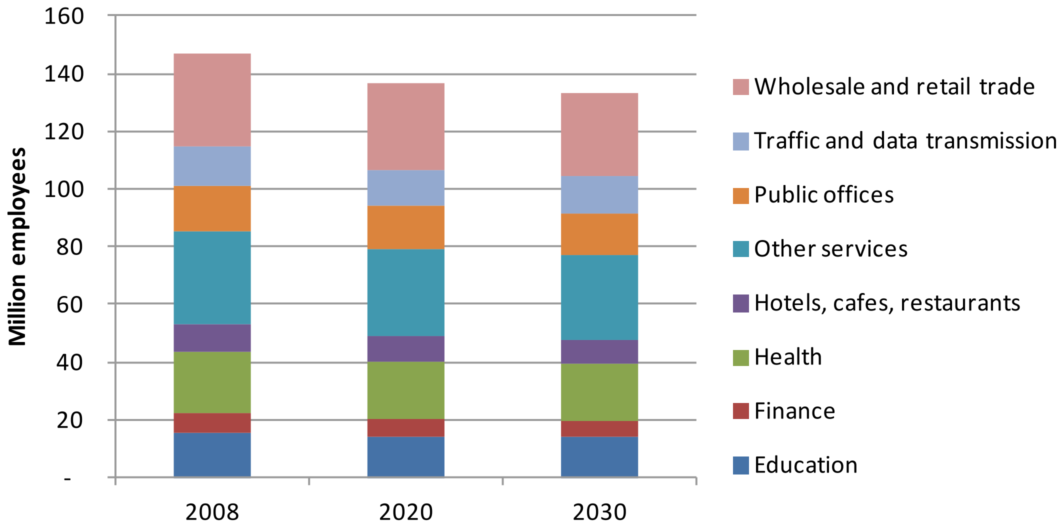
In the tertiary sector energy demand is mainly driven by the number of employees as well as the floor area of buildings. We have adjusted the projection of both variables based on the development of value added in the tertiary sector as reported by PRIMES (2013). Both drivers are disaggregated on the level of individual sub-sectors and countries. Each energy service is either driven by the number of employees (e.g. computers) or the floor area (e.g. office lighting).

Table 27: Main scenario-independent drivers for the tertiary sector

Driver	**Source**
Number of employees by sub-sector	Eurostat, projections in correspondence to PRIMES (2013) scenario
Floor area by sub-sector	Based on the development of number of employees

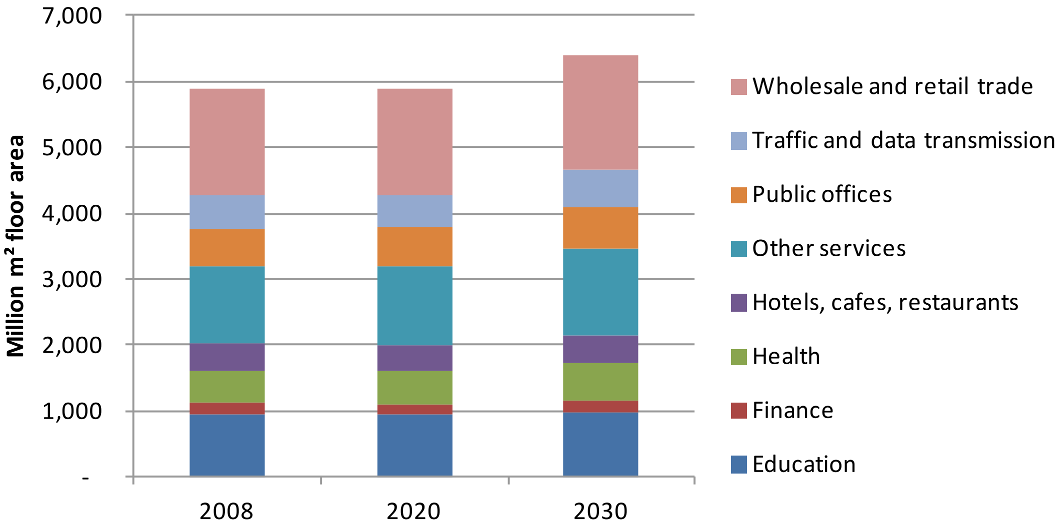
The resulting projection of employment is correlated to the value added from PRIMES (2013) and assuming a decrease of about 9% from 2008 to 2030 (see Figure 38).

Figure 38: development of EU28 employment in the tertiary sector [million persons]



The specific floor area per employee is continuously increasing over time resulting in an increase of total floor area until 2030 By about 8% compared to 2008 (see Figure 39), whereas it remains relatively stable until 2020.

Figure 39: development of EU28 floor area in the tertiary sector [million m²]



Scenario definition and implementation

The implementation of the scenarios includes the following policy measures (for details see Table 28).

1. Baseline Scenario (no early action): The Base_noEA scenario considers the policies implemented until 2008 and the past trends. It does not cover the Ecodesign Directive. It considers the energy taxes frozen to the level of 2008.

2. Baseline Scenario (including early action): The Base_inclEA scenario considers all policies adopted until 2013. This comprises the Ecodesign Directive, changes in taxes and a number of information-based policies. In the frame of the Ecodesign Directive a number of regulations were adopted until 2013 that will substantially affect electricity demand in the tertiary sector. Among them are the regulations addressing office and street lighting, commercial refrigerators and freezers as well as non-directional and reflector lamps. Space heating related lots are considered in the corresponding chapter for tertiary sector buildings. Energy taxes are frozen on the level of 2013.

3. Baseline Scenario (With Measures): The Base_WM scenario includes measures taken starting 2014 or close of being taken. Here we do not distinguish this scenario from the Base_inclEA.

4. Additional Measures Scenario: The AM scenario includes the policy measures of the Base_inclEA scenario as well as extensions of the Ecodesign Directive to new lots (i.e. ventilation and air-conditioning) in the coming years.

5. Potential 2030 – Low Policy impact: Compared to the AM scenario, the LPI scenario further extends the Ecodesign standards to new lots and to more ambitious levels (e.g. indoor lighting revision).

6. Potential 2030 – High Policy impact: In the HPI scenario a low discount rate of 5% is assumed for all available energy-efficiency measures. All energy-efficiency measures with a positive Net Present Value NPV at given energy prices and financial parameters such as the discount rate specified are implemented.

7. Potential 2030 – Near Economic: Here, we consider a diffusion path of energy-efficiency measures that still takes the investment cycle of appliances into account but that is not limited to cost-effectiveness. Although, very costly measures are not included, the NE-scenario also considers measures with negative NPV values.

Table 28 summarizes the policy assumptions by scenario. This involves the modelling of Ecodesign standards, the consideration of non-monetary barriers, the discount rate (reflecting payback expectations) as well as the electricity tax. The latter is either set to the level of 2008 or 2013.

Table 28: Main policy assumptions by scenario for tertiary sector appliances

Scenario	Electricity tax	Discount rate	Non-monetary barriers	Ecodesign standards
Base_noEA	2008	40%	Very high	-
Base_inclEA/ Base_WM	2013	30%	High	Outdoor lighting, indoor lighting, office lighting, commercial refrigeration
AM	2013	20%	Medium	Base_inclEA plus ventilation & AC
LPI	2013	15%	-	AM plus indoor lighting (tier 1), ICT office, elevators, data centers, commercial refrigeration (tier 2), outdoor lighting (tier 2)
HPI	2013	5%	-	as LPI
NE	-	Technical potential	-	-

Sector results

The results for the Base_inclEA scenario show a limited reduction as compared to the No Early Action scenario (~4.3 Mtoe by 2030 and ~2.5 Mtoe by 2020 for the EU27). The savings are mainly achieved through the implementing measures of the Ecodesign

Directives that were adopted between 2008 and 2013. In the AM scenario, further savings are achieved through the adoption of further Ecodesign implementing measures (i.e.. ventilation and air-conditioning) adding additional savings of about 12.8 Mtoe until 2030 and about 4.7 Mtoe until 2020. In the LPI scenario, significant savings are achieved in the period between 2020 (3.2 Mtoe compared to AM scenario) and 2030 (6.1 Mtoe), mainly through the adoption of additional implementing measures and by increasing the ambition of the levels set by Ecodesign Directive. The HPI scenario adds additional 4.3 Mtoe of energy savings by 2030 (~1.4 Mtoe by 2020) by reducing the discount rate to applied to 5%. As in the HPI, all measures are cost-effective or implemented via standards, the NE scenario does not add additional savings.

As shown in Figure 40 the dynamic increase in electricity demand in the tertiary sector observed since 1990 will flatten in the future, even in the baseline scenarios. Only the NE, HPI and LPI scenarios arrive at a demand in 2030, which is below the 2010 demand. The AM scenario only manages to compensate the increasing demand, which is driven by an expansion of energy services like data centers, lighting, ventilation and air-conditioning, refrigeration and others (including new energy services).

Figure 40: Electricity demand for tertiary sector appliances in EU27 by scenario (the gap between historic electricity demand and projections is explained by space heating and hot water demand – see section 5.6.1)

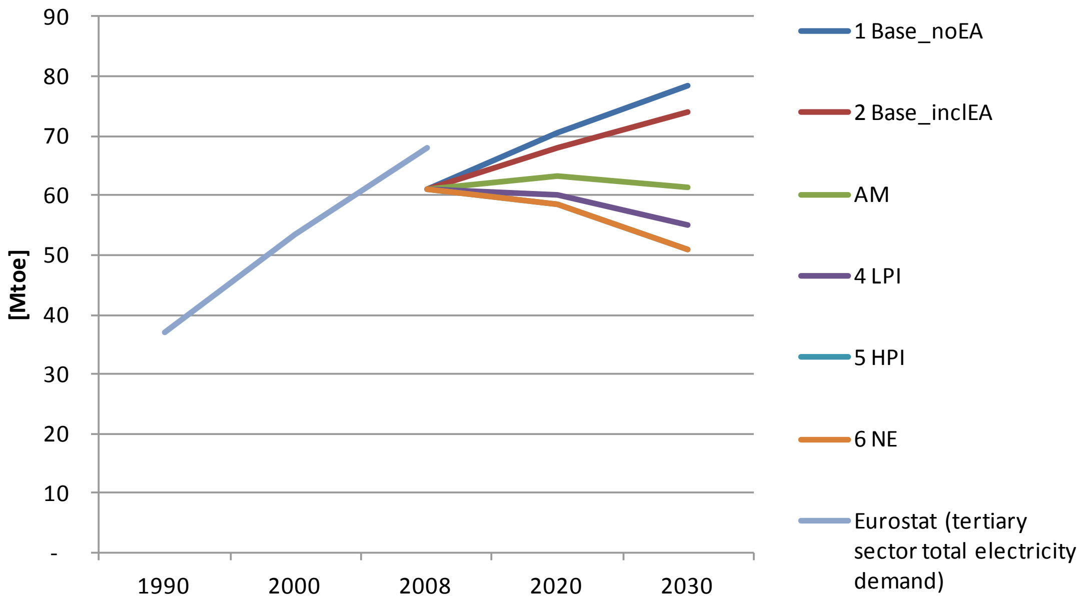


Table 29: Main results by end-uses and scenario for the tertiary sector (appliances) in the EU27 (in Mtoe)

Tertiary Appliances

EU27 , Mtoe, Final Energy Demand

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Tertiary Appliances	**61,08**	**70,42**	**78,28**	**67,87**	**73,96**	**67,87**	**73,96**	**63,18**	**61,18**	**59,96**	**55,09**	**58,59**	**50,79**	**58,59**	**50,79**
Cooking	3,57	2,77	2,62	2,77	2,62	2,77	2,62	2,77	2,62	2,77	2,62	2,31	2,18	2,31	2,18
Elevators	1,01	0,80	0,81	0,80	0,82	0,80	0,82	0,80	0,82	0,81	0,84	0,79	0,80	0,79	0,80
ICT data centers	2,41	3,98	5,05	3,81	4,77	3,81	4,77	3,77	4,68	3,77	4,67	3,77	4,67	3,77	4,67
ICT office	1,54	1,22	1,34	1,18	1,30	1,18	1,30	1,16	1,28	0,85	0,95	0,85	0,95	0,85	0,95
Lighting	18,63	19,33	18,29	17,85	15,80	17,85	15,80	17,85	15,80	16,01	12,17	15,46	9,75	15,46	9,75
Lighting street	2,45	2,58	2,74	2,58	2,73	2,58	2,73	2,54	2,61	2,12	1,85	2,12	1,85	2,12	1,85
Refrigeration	6,30	6,70	6,81	6,29	6,15	6,29	6,15	6,26	6,11	6,10	5,79	6,10	5,79	6,10	5,79
Ventilation and air-conditioning	7,41	12,46	17,37	12,44	17,31	12,44	17,31	8,92	9,10	8,92	9,10	8,92	9,10	8,92	9,10
Others	17,76	20,58	23,27	20,17	22,46	20,17	22,46	19,11	18,17	18,61	17,10	18,28	15,71	18,28	15,71
Sub-Sectors	**61,08**	**70,42**	**78,28**	**67,87**	**73,96**	**67,87**	**73,96**	**63,18**	**61,18**	**59,96**	**55,09**	**58,59**	**50,79**	**58,59**	**50,79**
Education	4,88	5,29	5,72	5,07	5,37	5,07	5,37	4,93	4,87	4,63	4,30	4,49	3,69	4,49	3,69
Finance	2,11	2,33	2,69	2,27	2,58	2,27	2,58	1,98	2,00	1,90	1,85	1,86	1,68	1,86	1,68
Health	4,47	4,59	4,88	4,36	4,43	4,36	4,43	4,30	4,20	4,14	3,91	3,59	3,22	3,59	3,22
Hotels, cafes, restaurants	7,00	7,77	9,07	7,41	8,48	7,41	8,48	6,67	6,53	6,54	6,29	6,43	5,99	6,43	5,99
Other services	8,08	10,07	12,40	9,67	11,74	9,67	11,74	9,19	10,44	8,69	9,46	8,43	8,17	8,43	8,17
Public offices	3,19	3,51	4,03	3,33	3,74	3,33	3,74	3,25	3,42	3,00	2,94	2,89	2,48	2,89	2,48
Traffic and data transmission	5,48	6,09	6,80	5,88	6,43	5,88	6,43	5,74	5,92	5,07	4,68	4,98	4,26	4,98	4,26
Wholesale and retail trade	25,88	30,77	32,69	29,89	31,18	29,89	31,18	27,14	23,80	25,98	21,65	25,92	21,31	25,92	21,31

EU27, %, change compared to 2008

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Tertiary Appliances	100%	115%	128%	111%	121%	111%	121%	103%	100%	98%	90%	96%	83%	96%	83%
Cooking	100%	78%	73%	78%	73%	78%	73%	78%	73%	78%	73%	65%	61%	65%	61%
Elevators	100%	80%	81%	80%	81%	80%	81%	80%	81%	80%	84%	78%	80%	78%	80%
ICT data centers	100%	165%	209%	158%	198%	158%	198%	156%	194%	156%	194%	156%	194%	156%	194%
ICT office	100%	79%	87%	77%	85%	77%	85%	75%	83%	55%	62%	55%	62%	55%	62%
Lighting	100%	104%	98%	96%	85%	96%	85%	96%	85%	86%	65%	83%	52%	83%	52%
Lighting street	100%	105%	112%	105%	111%	105%	111%	104%	106%	87%	75%	87%	75%	87%	75%
Refrigeration	100%	106%	108%	100%	98%	100%	98%	99%	97%	97%	92%	97%	92%	97%	92%
Ventilation and air-conditioning	100%	168%	234%	168%	234%	168%	234%	120%	123%	120%	123%	120%	123%	120%	123%
Others	100%	116%	131%	114%	126%	114%	126%	108%	102%	105%	96%	103%	88%	103%	88%
Sub-Sectors															
Education	100%	108%	117%	104%	110%	104%	110%	101%	100%	95%	88%	92%	76%	92%	76%
Finance	100%	111%	128%	108%	123%	108%	123%	94%	95%	90%	88%	88%	80%	88%	80%
Health	100%	103%	109%	98%	99%	98%	99%	96%	94%	92%	87%	80%	72%	80%	72%
Hotels, cafes, restaurants	100%	111%	130%	106%	121%	106%	121%	95%	93%	93%	90%	92%	86%	92%	86%
Other services	100%	125%	153%	120%	145%	120%	145%	114%	129%	108%	117%	104%	101%	104%	101%
Public offices	100%	110%	127%	105%	117%	105%	117%	102%	107%	94%	92%	91%	78%	91%	78%
Traffic and data transmission	100%	111%	124%	107%	117%	107%	117%	105%	108%	93%	85%	91%	78%	91%	78%
Wholesale and retail trade	100%	119%	126%	115%	121%	115%	121%	105%	92%	100%	84%	100%	82%	100%	82%

EU27, %, change compared to Base_inclEA

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Tertiary Appliances				100%	100%	100%	100%	93%	83%	88%	74%	86%	69%	86%	69%
Cooking				100%	100%	100%	100%	100%	100%	100%	100%	83%	83%	83%	83%
Elevators				100%	100%	100%	100%	100%	100%	101%	103%	98%	98%	98%	98%
ICT data centers				100%	100%	100%	100%	99%	98%	99%	98%	99%	98%	99%	98%
ICT office				100%	100%	100%	100%	98%	99%	72%	73%	72%	73%	72%	73%
Lighting				100%	100%	100%	100%	100%	100%	90%	77%	87%	62%	87%	62%
Lighting street				100%	100%	100%	100%	99%	96%	82%	68%	82%	68%	82%	68%
Refrigeration				100%	100%	100%	100%	100%	99%	97%	94%	97%	94%	97%	94%
Ventilation and air-conditioning				100%	100%	100%	100%	72%	53%	72%	53%	72%	53%	72%	53%
Others				100%	100%	100%	100%	95%	81%	92%	76%	91%	70%	91%	70%
Sub-Sectors															
Education				100%	100%	100%	100%	97%	91%	91%	80%	89%	69%	89%	69%
Finance				100%	100%	100%	100%	87%	78%	84%	72%	82%	65%	82%	65%
Health				100%	100%	100%	100%	99%	95%	95%	88%	82%	73%	82%	73%
Hotels, cafes, restaurants				100%	100%	100%	100%	90%	77%	88%	74%	87%	71%	87%	71%
Other services				100%	100%	100%	100%	95%	89%	90%	81%	87%	70%	87%	70%
Public offices				100%	100%	100%	100%	97%	91%	90%	79%	87%	66%	87%	66%
Traffic and data transmission				100%	100%	100%	100%	98%	92%	86%	73%	85%	66%	85%	66%
Wholesale and retail trade				100%	100%	100%	100%	91%	76%	87%	69%	87%	68%	87%	68%

Table 30: Main results by country for the tertiary sector (appliances)

Tertiary Appliances

Member States
Mtoe, Final Energy Demand

Member States
%, change compared to Base_inclEA

										Potential_2030										
Country	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**		**Country**	**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**		**2020**	**2030**	**2020**	**2030**
Austria	1,03	1,16	1,22	1,10	1,13	1,10	1,13	1,06	1,00	1,00	0,89	0,97	0,81	0,97	0,81	Austria	88%	71%	88%	71%
Belgium	1,58	1,67	1,74	1,61	1,63	1,61	1,63	1,56	1,47	1,46	1,28	1,42	1,17	1,42	1,17	Belgium	88%	72%	88%	72%
Bulgaria	0,58	0,77	0,93	0,75	0,88	0,75	0,88	0,68	0,69	0,64	0,61	0,63	0,56	0,63	0,56	Bulgaria	84%	63%	84%	63%
Croatia	0,39	0,48	0,56	0,46	0,53	0,46	0,53	0,42	0,42	0,39	0,37	0,39	0,34	0,39	0,34	Croatia	84%	64%	84%	64%
Cyprus	0,17	0,19	0,22	0,19	0,21	0,19	0,21	0,16	0,15	0,16	0,14	0,16	0,13	0,16	0,13	Cyprus	82%	63%	82%	63%
Czech Republic	0,93	1,19	1,33	1,15	1,25	1,15	1,25	1,09	1,07	1,03	0,95	1,00	0,87	1,00	0,87	Czech Republic	87%	69%	87%	69%
Denmark	0,94	1,11	1,19	1,05	1,09	1,05	1,09	1,03	1,01	0,97	0,89	0,93	0,80	0,93	0,80	Denmark	89%	73%	89%	73%
Estonia	0,20	0,27	0,31	0,26	0,29	0,26	0,29	0,25	0,25	0,23	0,22	0,23	0,19	0,23	0,19	Estonia	87%	68%	87%	68%
Finland	1,25	1,40	1,47	1,33	1,35	1,33	1,35	1,30	1,25	1,22	1,11	1,19	0,99	1,19	0,99	Finland	89%	73%	89%	73%
France	9,63	10,89	11,79	10,48	11,12	10,48	11,12	9,71	9,03	9,22	8,15	9,02	7,54	9,02	7,54	France	86%	68%	86%	68%
Germany	9,16	10,19	11,67	9,76	10,94	9,76	10,94	9,41	9,68	8,83	8,53	8,56	7,64	8,56	7,64	Germany	88%	70%	88%	70%
Greece	1,64	1,89	2,13	1,84	2,05	1,84	2,05	1,60	1,50	1,54	1,39	1,52	1,31	1,52	1,31	Greece	82%	64%	82%	64%
Hungary	0,77	0,89	1,02	0,85	0,95	0,85	0,95	0,81	0,81	0,76	0,72	0,74	0,65	0,74	0,65	Hungary	87%	68%	87%	68%
Ireland	0,72	0,82	0,77	0,79	0,72	0,79	0,72	0,76	0,64	0,72	0,57	0,71	0,53	0,71	0,53	Ireland	89%	73%	89%	73%
Italy	6,52	7,60	8,85	7,42	8,51	7,42	8,51	6,70	6,66	6,41	6,10	6,32	5,80	6,32	5,80	Italy	85%	68%	85%	68%
Latvia	0,21	0,28	0,34	0,27	0,32	0,27	0,32	0,26	0,27	0,24	0,24	0,24	0,22	0,24	0,22	Latvia	88%	68%	88%	68%
Lithuania	0,28	0,41	0,51	0,39	0,48	0,39	0,48	0,38	0,41	0,36	0,36	0,35	0,33	0,35	0,33	Lithuania	88%	69%	88%	69%
Luxembourg	0,18	0,18	0,18	0,17	0,17	0,17	0,17	0,17	0,15	0,16	0,14	0,16	0,13	0,16	0,13	Luxembourg	90%	76%	90%	76%
Malta	0,05	0,05	0,06	0,05	0,06	0,05	0,06	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	Malta	83%	64%	83%	64%
Netherlands	2,58	2,88	3,16	2,77	2,97	2,77	2,97	2,67	2,66	2,53	2,39	2,46	2,18	2,46	2,18	Netherlands	89%	74%	89%	74%
Poland	3,54	3,92	4,51	3,78	4,26	3,78	4,26	3,56	3,56	3,34	3,19	3,27	2,92	3,27	2,92	Poland	87%	68%	87%	68%
Portugal	1,28	1,99	2,48	1,95	2,41	1,95	2,41	1,66	1,64	1,60	1,53	1,58	1,47	1,58	1,47	Portugal	81%	61%	81%	61%
Romania	0,53	0,69	0,82	0,65	0,75	0,65	0,75	0,63	0,69	0,58	0,57	0,56	0,52	0,56	0,52	Romania	86%	69%	86%	69%
Slovakia	0,53	0,61	0,69	0,59	0,65	0,59	0,65	0,54	0,53	0,52	0,48	0,50	0,43	0,50	0,43	Slovakia	86%	67%	86%	67%
Slovenia	0,25	0,27	0,31	0,26	0,29	0,26	0,29	0,24	0,24	0,23	0,22	0,22	0,20	0,22	0,20	Slovenia	86%	68%	86%	68%
Spain	6,52	8,37	9,54	8,17	9,18	8,17	9,18	6,98	6,48	6,75	6,06	6,66	5,81	6,66	5,81	Spain	82%	63%	82%	63%
Sweden	2,10	2,28	2,38	2,16	2,18	2,16	2,18	2,12	2,04	2,00	1,81	1,94	1,62	1,94	1,62	Sweden	90%	74%	90%	74%
United Kingdom	7,92	8,43	8,65	8,09	8,10	8,09	8,10	7,82	7,26	7,41	6,51	7,22	5,95	7,22	5,95	United Kingdom	89%	73%	89%	73%
EU-27	61,08	70,42	78,28	67,87	73,96	67,87	73,96	63,18	61,18	59,96	55,09	58,59	50,79	58,59	50,79	EU-27	86%	69%	86%	69%
EU-28	61,47	70,90	78,84	68,33	74,49	68,33	74,49	63,60	61,59	60,35	55,46	58,98	51,13	58,98	51,13	EU-28	86%	69%	86%	69%

5.6.4 Transport sector

Modelling approach and sector-specific framework conditions

The evaluation of final energy consumption of the transport sector is based on modeling results from the ASTRA-EC model (see Annex 2). ASTRA-EC is the most recent version of the ASTRA model family developed in the context of the ASSIST project on behalf of the European Commission DG MOVE in the 7th framework programme and can be used to assess social, economic, transport and environmental impacts of sustainable transport policies and strategies suggested in the most recent Transport White Paper from 2011. ASTRA-EC is an integrated transport, economic, technology and environmental model. It is based on System Dynamics methodology and simulates the development of all modeled indicators for the whole time series from 1995 to 2050 in quarter year steps. It covers all EU27 member states plus Norway and Switzerland. All key indicators in ASTRA-EC are calibrated to match statistical time series data mainly from EUROSTAT. As opposed to other transport models, ASTRA-EC does not provide static forecasts for a future data but the whole pathway towards the future date. The dynamics leading to a growth or decline of an indicator are steered by feedback loops such that ASTRA-EC does only require few exogenous inputs like volume-to-value ratios for freight transport or load factors. Another difference to static models is that the calibration of behavioral functions in ASTRA-EC is done with time series of data. Therefore, deviations to a small degree can occur and are unavoidable focusing on only one or two certain years in calibration period from 1995 to 2012.

The final energy consumption of the transport sector depends on the development of transport activity in terms of vehicle-km for both passenger and freight transport and on the specific energy respectively fuel consumption for each transport mode. ASTRA-EC simulates the transport performance indicators in a state-of-the art four stage transport modeling approach. For passenger transport, the average number of trips for different purposes and for groups with similar travel behavior (differentiated by age, income and country) is derived from different European travel surveys (Krail 2009). After generating the total number of trips for each NUTS2 zone in Europe, ASTRA-EC distributes all trips to destinations based on changing travel costs, times and value of times using an elasticity approach. Finally, all trips are shifted to available transport modes (car, bus, train, air and slow modes) via elasticities. The final stage, the assignment to a real transport network is simulated in a simplified way using speed flow curves and total network capacities. ASTRA-EC calculates mode-specific passenger-km from the transport demand matrices using mode-specific distances.

Even if income plays a significant role and is influenced by the economy, the most important driver of passenger transport is demography. Hence, ageing societies and a stagnation of population in the EU until 2030 significantly influences passenger transport trends.

For freight transport, ASTRA-EC follows a similar approach differing only in the generation of freight volumes. While domestic freight volumes are derived via volume-to-value ratios from the national production values per sector, international freight transport is directly influenced by trade flows between EU countries and rest-of-the-world regions. ASTRA-EC distinguishes five freight modes: heavy duty vehicles, light duty vehicles, rail freight, maritime shipping and inland waterways.

For both, passenger and freight transport, ASTRA-EC makes use of statistical occupancy rates and load factors (derived from ETIS plus matrices – see Fermi et al. 2013) to convert passenger-km respectively ton-km into vehicle-km. This conversion is required to enable the calculation of fuel consumption, CO_2 and air pollutant emissions as well as of final energy consumption per mode and fuel type.

Besides the projection of transport activity, the technical composition of the vehicle fleets and the resulting fuel consumption factors play an important role in estimating the final fuel respectively energy consumption. ASTRA-EC calculates vehicle fleet stocks for road modes endogenously. The diffusion of fuel technologies are as well endogenously modeled depending on the evolution of fuel prices, of vehicle prices, taxes, of ranges and filling station infrastructure. These are factors directly affected by a number of policy measures. As opposed to PRIMES-TREMOVE, ASTRA-EC cannot consider second hand car markets such that all registrations are allocated to first registrations. This can lead to differences in fuel consumption due to the technical evolution of fuel consumption of passenger cars over time.

In order to harmonize ASTRA-EC with most recent PRIMES-TREMOVE Reference Scenario from 2013, the GDP growth was made in line with the PRIMES projections. Demographic trends are as well in line with the PRIMES trends. Furthermore, the basic motorization trends are synchronized with PRIMES-TREMOVE but there is a difference in the composition of passenger car fleets. PRIMES-TREMOVE assumes a further strong increase of the share of diesel cars in the stock while ASTRA-EC considers a stagnation of diesel shares on new registrations. This difference is based on the most recent technical improvements of injection technologies for gasoline cars and the resulting higher technological efficiency potential. Even if there are in many MS excise duty regimes favoring diesel cars, the technological gap in average fuel consumption between both technologies is supposed to decrease according to automotive experts

(Schade et al. 2011). ASTRA-EC assesses the diffusion of fuel technologies based on adapted TCO (total cost of ownership) approach. The choice function is determined by a cost and by a non-cost component. The non-cost component reflects the acceptance of a fuel technology. Both parts are calibrated for the time series from 1995 to 2008. Hence, the change of fuel costs due to decreasing fuel consumption of gasoline cars is the driver of the stagnation of diesel car sales until 2030.

The growth of freight and passenger transport performance in terms of ton-km respectively passenger-km per MS was made in line with the 2013 PRIMES-TREMOVE projections until 2050 (Krail et al. 2014). Nevertheless, the projections for passenger and freight transport activity in EU27 differ slightly in some cases. The demographic development as major driver of passenger transport leads to a lower increase of passenger-km in the decade from 2020 to 2030 than in the decade before even if total income per capita will especially in the EU12 increase stronger in this decade. PRIMES-TREMOVE estimates a higher growth of passenger-km in the second decade from 2020 to 2030 than in the first decade from 2010 to 2020 due to the increase of income per capita in EU12.. ASTRA-EC differs as it considers not only total income per capita but its distribution into income groups.. Average growth rates for passenger-km per mode are similar except for aviation which also reflects the impact of income distribution as air passenger-km strongly depend on the development of medium to high income groups. PRIMES-TREMOVE assesses an average annual growth of 2.5% while ASTRA-EC estimates a growth of 1.6%. For freight transport ASTRA-EC is as well a bit less optimistic than PRIMES-TREMOVE. Ton-km for trucks grow by 1.2% p.a. while PRIMES TREMOVE estimates 1.4% average annual growth from 2010 to 2030.

Another difference influencing the evolution of final energy consumption is based on differing assumptions on the development of load factors for road freight transport. TREMOVE assumes a higher growth of truck fleets in EU27 then ASTRA-EC (69% between 2010 and 2050 compared to 32% in ASTRA-EC). The difference is mainly caused by a stronger growth of Light Duty Vehicles (LDV) in PRIMES-TREMOVE then in ASTRA-EC. Even of the growth of total ton-km in ASTRA-EC is very close to PRIMES-TREMOVE, there is a difference in the distribution into distance bands. A further slight difference consists in the assumption of average load factors. Both models assume a growth of load factors, ASTRA-EC is slightly more optimistic due to the growing pressure from fossil fuel price increase on the logistics sector.

Specific energy-uses covered

ASTRA-EC covers almost all consumers of energy in the transport sector despite freight transport via pipelines and passenger transport on ships and ferries. The transport model differentiates between passenger transport for different distance bands for car, bus, train, air and non-motorized modes. Via distance bands, trains can be further distinguished by trams respectively metro and intercity trains. It includes intercontinental air transport activities originating from Europe.

As regards freight transport, ASTRA-EC covers freight transport on roads via heavy and light duty vehicles, on railways, via inland waterways (IWW) and maritime ships. Like for passenger transport, international bunkers are included in ASTRA-EC.

Scenario-independent drivers

ASTRA-EC is calibrated towards EUROSTAT data for 1995 to 2012 for major indicators which holds for all scenarios besides the Baseline NoEA. The development of energy and fuel prices is the same for all scenarios. The demographic development influencing mainly passenger transport but via consumption patterns as well freight transport is another scenario-independent driver of final energy consumption. Travel patterns are as well scenario-independent.

GDP marginally differs between the scenarios as GDP is an endogenously calculated indicator in ASTRA-EC. GDP is not supposed to be kept constant over all scenarios as the policies and measures itself induce economic changes as well as further rebound effects that appear in real life and should be considered.

Scenario definition and implementation

The understanding of the underlying assumptions is crucial for evaluating a model-based scenario evaluation. The main purpose of this section is to frame the policies considered and not considered in the different scenarios. Therefore, this section describes the main measures and policies considered for the calculation of final energy consumption in the transport sector.

1. Baseline NoEA (Base_noEA):

The baseline scenario includes EU and MS policy measures that were adopted before 2008. As opposed to the Base_inclEA scenario, the Base_noEA scenario is calculated with a previous ASTRA version which has been validated towards PRIMES projections. The basic difference between PRIMES 2007 and the Base_noEA sceanario consists in the consideration of the impacts of the Economic and the Euro Crisis. PRIMES 2007 does not take them into account such that there is a continuous growth of economic development reflected as well in freight and passenger transport performance. The gap between the projections of final energy consumption in 2020 and 2030 is therefore caused by these assumptions. The EU policies considered in the Base_noEA are as follows:

Table 31: List of EU measures implemented in the Baseline NoEA scenario

N°	Measures	Legislative reference
1	Biofuels directive	Directive 2003/30/EC
2	Regulation EURO 5 and 6	Regulation No 715/2007
3	Third railway package	Directive 2007/58/EC
4	TEN-T guidelines	Decision 884/2004/EC and expected continuation – 2012 Council agreement on revised TEN-T guidelines

2. Baseline including Early Action (Base_inclEA) and Baseline With Measures (WM):

Final energy consumption in the Base_inclEA and all following scenarios is calculated with the most recent ASTRA version (ASTRA-EC) which can be applied by DG MOVE for integrated assessment of transport policies and strategies. ASTRA-EC is calibrated to EUROSTAT data until 2012 (where available) and made in line in major economic, demographic, transport, environmental and energy variables with the 2013 EC Reference Scenario from PRIMES-TREMOVE. ASTRA-EC simulates already a slight decrease of final energy consumption in 2011 and 2012 which is in line with EUROSTAT data. The projections of PRIMES-TREMOVE differ slightly as the final energy consumption is expected to increase until 2015.

The Base_inclEA scenario considers all major policy measures that were decided upon between 2008 and 2013. A general rule for the selection of the set of policies for the Base_inclEA scenario was the legislative status and the quantitative approval of the policy. E.g. the revision of the Energy Taxation Directive has not been considered as part of this scenario because an agreement on this proposal has not yet been reached by the co-legislators. Finally approved policies like the regulation on emission standards Euro 5 and Euro 6 or the CO_2 regulations for passenger cars and light duty vehicles are taken into account. Furthermore, the Base_inclEA considers the New EU rules for safer and more environmental lorries leading to a reduction of fuel consumption up to 10% due to improved aerodynamics.

The following EU measures and policies are implemented in the Base_inclEA scenario (see Table 32). Further measures implemented in the Base_inclEA scenario are those evaluated in the MURE-ODYSSEE database with a high impact on energy savings. Those comprise country-specific measures from the NEEAPs like eco-driving, speed limits, renewal of vehicle fleets, promotion activities for walking and cycling, infrastructure programs, etc.

Table 32: List of EU measures implemented in the Base_inclEA scenario

N°	Measures	Legislative reference
1	RES directive	Directive 2009/28/EC
2	GHG Effort Sharing Decision	Decision 406/2009/EC
3	EU ETS directive	Directive 2003/87/EC as amended by Directive 2004/101/EC, Directive 2008/101/EC and Directive 2009/29/EC
4	Biofuels directive	Directive 2003/30/EC
5	Fuel Quality Directive	Directive 2009/30/EC
6	Regulation on CO_2 from cars	Regulation No 443/2009
7a	Labelling regulation for tyres	Regulation No 1222/2009
7b	Tyre labelling implementation regulations	Regulations 228/2011 and 1235/2011
8	Regulation EURO 5 and 6	Regulation No 715/2007
9	Regulation on CO_2 from vans	Regulation (EU) No 510/2011
10	Regulation Euro VI for heavy duty vehicles	Regulation No 595/2009
11	Eurovignette Directive on road infrastructure charging	Directive 2011/76/EU
12	Regulation on common rules for access to the international road haulage market	Regulation No 1072/2009
13	Third railway package	Directive 2007/58/EC
14	Emission standards for diesel trains (UIC Stage IIIA)	
15	Directive on inland transport of dangerous goods	Directive 2008/68/EC

N°	Measures	Legislative reference
16	ICAO Chapters 3 (emissions)	
17	Regulation on ground handling services at Union airports	Council agreement on general approach, EP vote on 16 April 2013(part of "Better airports package")
18	Regulation on noise-related operating restrictions at Union airports	Council agreement on general approach, EP vote on 11 December 2012 (part of "Better airports package")
19	IMO Energy Efficiency Design Index (EEDI)	IMO Resolution MEPC.203(62)
20	Port state control Directive	Directive 2009/16/EC
21	Directive amending directive 1999/32/EC as regards the sulphur content of marine fuels	Directive 2012/33/EU
22	Implementation of MARPOL Convention ANNEX VI	2008 amendments - revised Annex VI
23	TEN-T guidelines	Decision 884/2004/EC and expected continuation – 2012 Council agreement on revised TEN-T guidelines
24	Energy Taxation Directive	Directive (2003/96/EC) but not the revision
25	Fourth Railway Package	Directive (2012/34/EU), Regulation (EC) 1370/2007, Regulation (EC) 881/2004 and Directive (2008/57/EC)
26	New EU rules for safer and more environmental lorries	European Commission - IP/13/328
27	Clean Power for Transport package	COM(2013) 17, COM(2013) 18
28	Accelerating the implementation of the Single European Sky (SES 2+)	COM(2013) 408

No distinction was made with the Base_WM scenario as all relevant measures are already included in the Base_inclEA scenario.

3. Additional Measures Scenario (AM):

The Additional Measures (AM) scenario includes the policy measures of the previous scenario (Base_inclEA) as well as selected further transport policy measures. The selection of four measures is based on the ASSIST project (Kritzinger et al. 2013) which assessed the social and economic impacts of transport policy measures selected by DG MOVE as regards their probability of implementation indicated by the Transport White Paper from 2011. As the transport sector assessment results for the Base_inclEA scenario indicate, the measures considered are expected to push the final energy consumption already below the EED target for transport (if the overall 20% target would be broken down in a flat rate all sectors equally). Hence, the measures considered in this scenario are not strictly related to the measures proposed by the MS for the implementation of Article 7 of the Energy Efficiency Directive. These have been considered in the Base_inclEA scenario. However, few MS have are proposing transport measures. The following measures were selected:

- A road charge of 6 EuroCent per vehicle-km driven on motorways for passenger cars is implemented starting in 2014. The charge is assumed to substitute existing charges in case that the existing charge is lower than the new one.
- The promotion of energy efficient public commercial vehicles in the EU will be implemented from 2014 on. It is assumed to lead to a step-wise reduction of fuel consumption of buses and light duty vehicles via influencing purchase decisions of public vehicles (Kritzinger et al. 2013).
- A stimulus programme is assumed providing owners of cars older than 10 years a rebate of 2000 Euro for buying a more efficient new car. The programme starts in 2014 and initiates a higher scrapping ratio of cars older than 10 years.
- A feebate system is implemented for all Member States in 2014 assuming a rebate or a fee for buying a new car depending on the CO_2 emission per vehicle-km of the car. For each Gramme of CO_2 less than a declining border until 2020, a rebate is given of 25 Euro. The border declines in parallel with the values in the passenger car CO_2 regulation down to 95 Gramme in 2021. The measure is expected to influence the purchasing behaviour for passenger cars (Schade et al. 2011).

Table 33: List of EU measures implemented in the Additional Measure scenario

N°	Measures	Assumptions
1	Road charges for passenger cars and light duty vehicles on motorways	Setting a charge of 6 EuroCent per vehicle-km substituting the previous charges in case that they have been lower; Implementation in 2014
2	Promotion of energy efficiency commercial vehicles (delivery vans, taxis, buses, etc.)	Start of promotion activities in 2014; step-wise reduction of fuel consumption factors for commercial vehicles
3	Increased replacement rate of inefficient and polluting vehicles	Initiating in 2014 and offering a rebate of 2000 Euro for purchasing a more efficient new car while scrapping the old and inefficient car
4	Feebates for purchasing passenger cars based on CO_2 emissions	System that provides rebates/requests fees for purchasing new cars based on CO_2 emissions; implemented in 2014 replacing previous feebate systems (e.g. in Finland) or bonus-malus schemes (e.g. in France); threshold CO_2 emissions continuously decreases from 130 g in 2015 down to 95 g CO2 per vehicle-km in 2021. Level of rebates/fees: 25 Euro per gramme of CO_2 less/higher than the annual threshold

4. Potential 2030 – low policy intensity (Potential_2030_LPI):

Policies and energy efficiency measures with low policy intensity are considered in the Potential 2030 – low policy intensity scenario. The scenario comprises all measures implemented in the AM scenario plus two additional measures which are under micro-economic perspective cost-effective. The first is a technical measure and the second a behavioral measure. Infrastructure measures are not considered in this scenario due to the largely high policy intensity of those. The additional measures are:

- The intensive promotion and teaching of eco-driving in all MS. Eco-driving measures will be implemented in all countries which have not yet considered it in their NEEAPs. The measure induces fuel consumption reduction of 5-7% until 2030. The impact on fuel consumption will steadily increase from 2015 where the measure is supposed to be initiated. In general, CO_2 emissions for new registered vehicles vary among the member states due to the different diffusion pathways for alternative fuel vehicles. CO_2 emission targets for passenger cars and for light duty vehicles were considered reaching a level of 80 gramme CO_2 per vehicle-km (according to NEDC) for an average new registered passenger car in EU28 in 2030.
- New registered LDVs are supposed to emit on average 110 gramme CO_2 per vehicle-km in 2030. As for heavy duty vehicles, the scenario considers a reduction of average fuel consumption of 23% from 2014 until 2030. This is still above the technical and economical feasibility assessed by Schade and Krail (2011).

5. Potential 2030 – high policy intensity (Potential_2030_HPI):

The Potential 2030 – high policy intensity scenario is per definition a scenario considering measures that are plausible under very ambitious legislative and regulatory framework conditions. It should therefore reflect the theoretical potential of final energy consumption savings possible under these circumstances. Therefore, it includes measures which require a high policy intensity.

The scenario includes all measures implemented in the AM scenario and on top three selected measures affecting technical improvement of vehicles, behavioral change of drivers as well as infrastructure investments to improve railway infrastructure. The measures comprise:

- The intensive promotion and teaching of eco-driving in all MS. Eco-driving measures will be implemented in all countries which have not yet considered it in their NEEAPs. The measure induces fuel consumption reduction of 5-7% until 2030. The impact on fuel consumption will steadily increase from 2015 where the measure is supposed to be initiated.
- Based on Regulation No 443/2009 and Regulation (EU) No 510/2011 determining the CO2 emission targets for passenger cars and light duty vehicles until 2021, a further improvement of average new fleet emissions for passenger cars and light duty vehicles is considered. According to the GHG-TransPoRD study (Schade and Krail 2011), a reduction of average CO_2 emissions per vehicle-km for new passenger cars of 70 g CO_2 per vehicle-km (according to NEDC) until 2030 is technically and economically feasible. Hence, this target will be considered in this scenario. A similar reduction is considered for light duty vehicles which reach a level of 90 gramme CO_2 per vehicle-km for new registered LDVs in 2030. On top of these technical improvements, the scenario considers a reduction of average fuel consumption per vehicle-km of heavy duty vehicles of 27% from 2014 until 2030 which as well corresponds to the technical and economical feasibility assessed by Schade and Krail (2011).
- As regards the targets of the Transport White Paper from 2011, additional investments in improving railway infrastructure is included in this scenario starting in 2015. This comprises investments in improving passenger high-speed railway connections and bottlenecks in the TEN as well as freight railway connections. On top of the 250 billion Euro invested in TEN additional 384 billion investments are assumed leading to a link-specific improvement of travel times.

6. Potential 2030 – near economic (Potential_2030_NE):

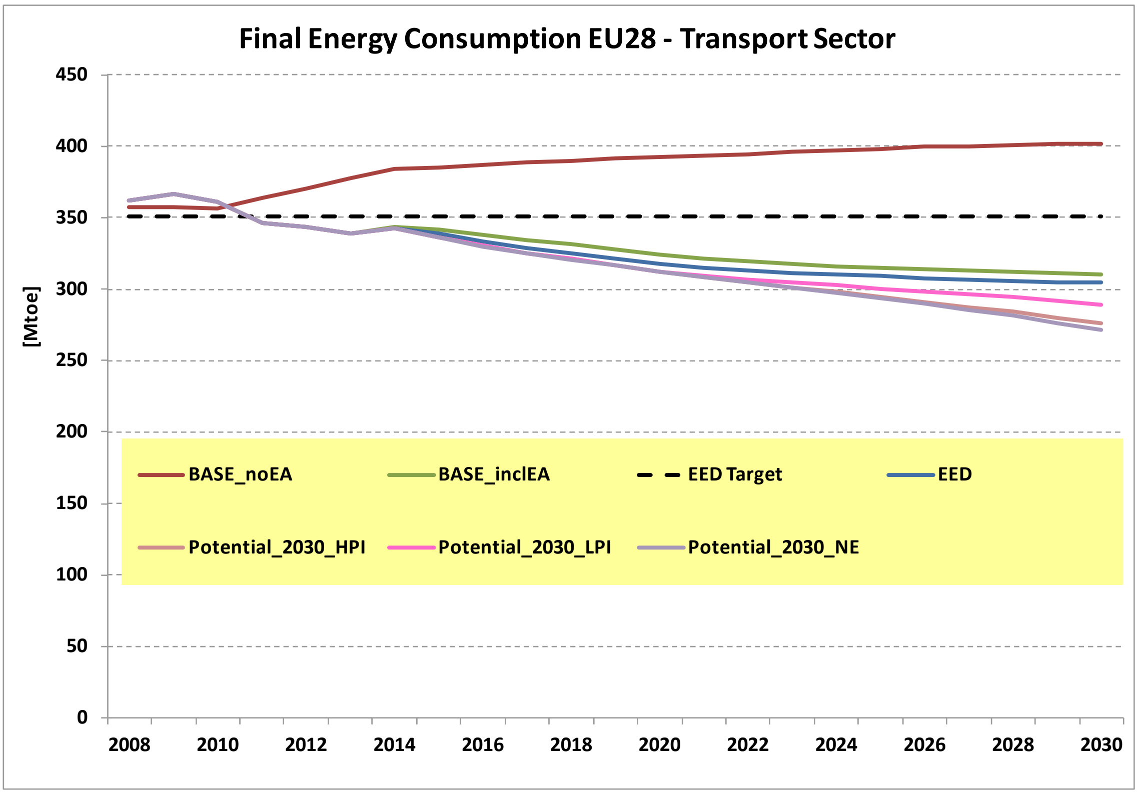
According to its definition, the Potential 2030 – near economic scenario focuses on technical measures that can be implemented without any additional costs for the whole life-cycle of a vehicle. According to Schade and Krail (2011) the majority of GHG mitigation technologies for passenger cars, light duty vehicles, buses and trucks have negative marginal abatement costs. This means that they are beneficial for the purchasers as the additional investment costs amortize over the whole life-cycle taking average interest rates into account. Hence, the measures considered in this scenario can be considered as close to the maximum technical feasibility. The scenario considers all measures from the AM scenario plus the following measures:

- Like for the Potential 2030 – high policy intensity scenario, eco-driving is taken into account.
- CO_2 emission targets for passenger cars and for light duty vehicles were considered reaching a level of 67 gramme CO_2 per vehicle-km (according to NEDC) for an average new registered passenger car in EU28 in 2030. New registered LDVs are supposed to emit on average 90 gramme CO_2 per vehicle-km in 2030. As for heavy duty vehicles, the scenario considers a reduction of average fuel consumption of 42% from 2014 until 2030. This corresponds with the technical and economical feasibility assessed by Schade and Krail (2011).The same infrastructure investments as in the HPI scenario are selected in order to allow a direct comparison between the HPI and the NE scenario.

Sector results

Applying the energy efficiency target for all sectors of -20% as compared with the PRIMES 2007 projections to the transport sector, the transport sector should achieve at maximum a final energy consumption of around 351 Mtoe in EU28 in 2020. Figure 41 provides an overview of the final energy consumption pathways (in Mtoe) for each scenario until 2030 on EU28 level for total transport. Table 34 presents the ASTRA-EC results in terms of final energy consumption on EU27 level differentiated by mode and for the years 2020 and 2030 (in Mtoe) for each scenario. Table 35 indicates the final energy consumption for each EU28 member state for 2020 and 2030 (in Mtoe) per scenario.

Figure 41:Overview on final energy consumption of the transport sector in each scenario for EU28



Source: Fraunhofer-ISI, ASTRA-EC

ASTRA-EC assesses a reduction of final energy consumption in the Baseline inclEA scenario of about -26.1% compared to PRIMES 2007. As described in the section on model approach and framework conditions, there are some differences between the PRIMES 2013 projections and the ASTRA-EC projections in this scenario which result in a stronger improvement of energy efficiency. According to the ASTRA-EC results, the transport sector should be able to contribute significantly to the achievement of the energy efficiency target until 2020. It is obvious that the major contribution to this reduction stems from the CO_2 regulations for passenger cars and light duty vehicles (Regulation (EU) No 443/2009 and Regulation (EU) No 510/2011). Nevertheless, the reduction of average CO_2 emissions per vehicle-km from 143 g of CO_2 in 2010 down to 95 g of CO_2 in 2021 for passenger cars induces also rebound effects such as increasing average distances and a higher modal share of passenger cars. These effects arise due to decreasing total cost of ownership as the costs for operating a car decreases stronger than the increase of average prices due to additional GHG mitigation technologies implemented in passenger cars (Schade et al. 2011). Regarding the technical potential of all non-road modes, the average lifetime of vehicles play a significant role. While passenger cars have by 12 to 14 years a comparably small lifetime, ships, aircrafts and trains sometimes reach lifetimes of 30 to 50 years. Hence, a renewal of the fleet by energy efficient vehicles is a longer process for all non-road modes. On top of this barrier, the technical potentials to improve energy efficiency in these modes are significantly lower than for the road mode (Schade and Krail 2011). In absolute terms, ASTRA-EC estimates the final energy consumption for the transport sector of 322 Mtoe in 2020 and 309 Mtoe in 2030 in the Baseline inclEA scenario for the EU27.

Table 34: Main results by end-uses and scenario for the transport sector in the EU27 (in Mtoe)

Transport

EU27

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Transport	**360,02**	**390,01**	**399,73**	**322,23**	**308,86**	**322,23**	**308,86**	**310,96**	**295,15**	**305,22**	**280,45**	**305,13**	**267,46**	**305,11**	**262,88**
Technical	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	102,36	93,13	102,36	86,01	102,33	83,56
Modal shift/Infrastructure	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	102,37	95,08	102,30	92,08	102,33	91,02
Behaviour	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	100,49	92,24	100,47	89,37	100,45	88,30
Passenger Transport	**254,92**	**280,06**	**286,39**	**220,94**	**207,32**	**220,94**	**207,32**	**213,44**	**198,77**	**209,60**	**189,55**	**209,55**	**179,79**	**209,53**	**178,84**
Road (cars/motorcycles)	201,39	216,37	221,88	166,74	153,07	166,74	153,07	160,26	146,05	156,73	137,41	156,67	127,70	156,65	126,77
Road (buses)	12,61	12,40	12,37	11,29	10,43	11,29	10,43	10,21	9,36	9,96	8,99	9,96	8,98	9,96	8,98
Rail	3,17	3,71	3,96	3,21	3,21	3,21	3,21	3,17	3,19	3,15	3,18	3,18	3,18	3,18	3,17
Air	37,76	47,57	48,17	39,70	40,61	39,70	40,61	39,80	40,17	39,75	39,98	39,73	39,93	39,73	39,92
Goods Transport	**105,10**	**109,95**	**113,34**	**101,30**	**101,53**	**101,30**	**101,53**	**97,52**	**96,38**	**95,62**	**90,90**	**95,58**	**87,67**	**95,58**	**84,04**
Road (Light and Heavy Duty Vehicles)	98,94	102,15	105,32	94,52	94,35	94,52	94,35	90,86	89,39	88,98	83,97	88,94	80,72	88,94	77,13
Rail	1,34	1,48	1,44	1,40	1,44	1,40	1,44	1,38	1,39	1,38	1,35	1,38	1,38	1,38	1,35
Ship (maritime)	3,27	1,76	1,74	3,74	3,93	3,74	3,93	3,67	3,83	3,65	3,81	3,65	3,81	3,65	3,79
Ship (inland navigation)	1,53	4,55	4,84	1,64	1,81	1,64	1,81	1,61	1,77	1,61	1,77	1,61	1,77	1,61	1,77

EU27, %, change compared to 2008

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Transport	100%	108%	111%	90%	86%	90%	86%	86%	82%	85%	78%	85%	74%	85%	73%
Technical															
Modal shift/Infrastructure															
Behaviour															
Passenger Transport															
Road (cars/motorcycles)	100%	107%	110%	83%	76%	83%	76%	80%	73%	78%	68%	78%	63%	78%	63%
Road (buses)	100%	98%	98%	90%	83%	90%	83%	81%	74%	79%	71%	79%	71%	79%	71%
Rail	100%	117%	125%	101%	101%	101%	101%	100%	101%	100%	100%	100%	100%	100%	100%
Air	100%	126%	128%	105%	108%	105%	108%	105%	106%	105%	106%	105%	106%	105%	106%
Goods Transport															
Road (Light and Heavy Duty Vehicles)	100%	103%	106%	96%	95%	96%	95%	92%	90%	90%	85%	90%	82%	90%	78%
Rail	100%	110%	107%	104%	107%	104%	107%	102%	104%	102%	101%	102%	102%	102%	101%
Ship (maritime)	100%	54%	53%	114%	120%	114%	120%	112%	117%	112%	116%	112%	116%	112%	116%
Ship (inland navigation)	100%	297%	315%	107%	118%	107%	118%	105%	115%	105%	115%	105%	115%	105%	115%

EU27, %, change compared to Base_inclEA

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Transport				100%	100%	100%	100%	97%	96%	95%	91%	95%	87%	95%	85%
Technical															
Modal shift/Infrastructure															
Behaviour															
Passenger Transport															
Road (cars/motorcycles)				100%	100%	100%	100%	96%	95%	94%	90%	94%	83%	94%	83%
Road (buses)				100%	100%	100%	100%	90%	90%	88%	86%	88%	86%	88%	86%
Rail				100%	100%	100%	100%	99%	99%	98%	99%	99%	99%	99%	99%
Air				100%	100%	100%	100%	100%	99%	100%	98%	100%	98%	100%	98%
Goods Transport															
Road (Light and Heavy Duty Vehicles)				100%	100%	100%	100%	96%	95%	94%	89%	94%	86%	94%	82%
Rail				100%	100%	100%	100%	98%	97%	98%	94%	98%	95%	98%	94%
Ship (maritime)				100%	100%	100%	100%	98%	97%	98%	97%	98%	97%	98%	96%
Ship (inland navigation)				100%	100%	100%	100%	98%	97%	98%	98%	98%	97%	98%	97%

Source: Fraunhofer-ISI, ASTRA-EC

Additional measures considered in the AM scenario further reduce final energy consumption but not significantly. A reduction of final energy consumption by -27.5% in 2020 can be achieved by adding the set of measures defined for the AM scenario. In absolute terms, the AM scenario is expected to have a final energy consumption in 2020 of 311 Mtoe (in 2030: 295 Mtoe) in EU27. The major energy consumption reduction potential in the Potential 2030 (high policy intensity) scenario appears between the decade from 2020 to 2030. ASTRA-EC assesses a slight further reduction of final energy consumption in 2020 of about 6 Mtoe as compared with the AM scenario. Looking to 2030, ASTRA-EC simulates a final energy consumption of 268 Mtoe to be achieved by behavioral changes due to intensified teaching and implementation of eco-driving and due to a further and stronger regulation of CO_2 emissions from passenger cars and light duty vehicles but also a new regulation on truck CO_2 emissions.

The Potential 2030 scenarios mainly impact the final energy consumption after 2020 as the main driver of change in this scenario is the technical development for road vehicles (passenger cars, buses, trucks and light duty vehicles). An intensified promotion and teaching of eco-driving is considered in all Potential 2030 scenarios (LPI, HPI and NE). While the high policy intensity scenario supposes additional investments in closing bottlenecks of the TEN network on rail both influencing passenger and freight transport, the other scenarios focus on technical measures. As an example, average new registered passenger cars in 2030 in EU28 are expected to emit 80 gramme CO_2 per vehicle-km (according to NEDC) in the Potential 2030 – low policy intensity scenario, the new fleet in 2030 reaches 70 gramme in the Potential 2030 – high policy scenario and even 67 gramme in the near economic scenario.

ASTRA-EC estimates the final energy consumption for transport by 305 Mtoe for EU27 in 2020 for all three Potential 2030 scenarios. In 2030, the near economic scenario reaches by 263 Mtoe the lowest final energy consumption. The high policy intensity scenario is assessed to lead to 268 Mtoe in 2030 as opposed to 281 Mtoe in the low policy intensity scenario (EU27).

Table 35: Scenario overview of final energy consumption per Member State in the transport sector in Mtoe

Transport

Member States
Mtoe, Final Energy Demand

Member States
%, change compared to Base_inclEA

										Potential_2030										
Country	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**		**Country**	**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**		**2020**	**2030**	**2020**	**2030**
Austria	8,44	8,71	8,61	8,07	8,20	8,07	8,20	7,73	7,75	7,54	7,26	7,53	6,92	7,53	6,73	Austria	93%	84%	93%	82%
Belgium	9,45	10,14	10,52	8,23	8,11	8,23	8,11	7,87	7,67	7,68	7,13	7,67	6,73	7,67	6,61	Belgium	93%	83%	93%	82%
Bulgaria	2,25	2,92	3,37	2,50	2,49	2,50	2,49	2,42	2,38	2,42	2,34	2,42	2,25	2,42	2,19	Bulgaria	96%	91%	96%	88%
Croatia	1,99	2,89	3,19	2,33	2,41	2,33	2,41	2,13	2,09	2,08	2,04	2,08	1,89	2,08	1,99	Croatia	89%	79%	89%	82%
Cyprus	0,89	0,83	0,92	0,94	0,91	0,94	0,91	0,91	0,86	0,89	0,82	0,89	0,78	0,89	0,78	Cyprus	95%	86%	95%	85%
Czech Republic	5,96	6,69	6,91	5,91	5,88	5,91	5,88	5,69	5,58	5,55	5,28	5,55	5,11	5,55	5,02	Czech Repub	94%	87%	94%	85%
Denmark	5,25	5,10	5,04	4,17	4,06	4,17	4,06	4,02	3,83	3,93	3,64	3,93	3,53	3,93	3,39	Denmark	94%	87%	94%	84%
Estonia	0,80	0,97	1,07	0,74	0,76	0,74	0,76	0,71	0,72	0,70	0,69	0,70	0,66	0,70	0,65	Estonia	94%	86%	94%	85%
Finland	4,87	4,88	4,95	4,17	4,11	4,17	4,11	4,05	3,94	4,05	3,85	4,05	3,74	4,04	3,57	Finland	97%	91%	97%	87%
France	51,63	56,11	56,28	48,89	46,06	48,89	46,06	46,99	43,75	45,87	41,12	45,86	39,16	45,86	38,57	France	94%	85%	94%	84%
Germany	60,87	61,48	56,97	52,84	47,72	52,84	47,72	51,20	45,76	50,06	43,21	50,04	41,14	50,04	40,56	Germany	95%	86%	95%	85%
Greece	7,66	7,74	8,37	6,20	5,94	6,20	5,94	5,93	5,69	5,93	5,60	5,93	5,34	5,93	5,18	Greece	96%	90%	96%	87%
Hungary	4,32	4,69	4,79	4,10	3,94	4,10	3,94	3,97	3,79	3,87	3,60	3,87	3,46	3,87	3,39	Hungary	94%	88%	94%	86%
Ireland	5,12	4,44	5,03	4,02	4,63	4,02	4,63	3,92	4,44	3,82	4,18	3,83	4,00	3,82	3,85	Ireland	95%	86%	95%	83%
Italy	42,26	46,75	47,37	35,89	33,60	35,89	33,60	34,91	32,42	34,05	30,31	34,03	28,69	34,03	28,34	Italy	95%	85%	95%	84%
Latvia	1,15	1,53	1,66	1,05	1,22	1,05	1,22	1,02	1,17	0,99	1,12	0,99	1,08	0,99	1,06	Latvia	94%	88%	94%	87%
Lithuania	1,24	1,50	1,51	1,17	1,16	1,17	1,16	1,13	1,11	1,10	1,03	1,10	0,97	1,10	0,97	Lithuania	94%	83%	94%	83%
Luxembourg	2,28	2,51	2,64	1,89	1,92	1,89	1,92	1,79	1,79	1,74	1,67	1,74	1,58	1,74	1,56	Luxembourg	92%	82%	92%	81%
Malta	0,32	0,37	0,42	0,22	0,21	0,22	0,21	0,21	0,20	0,21	0,20	0,21	0,20	0,21	0,19	Malta	96%	93%	96%	90%
Netherlands	14,27	14,88	14,41	12,48	12,16	12,48	12,16	12,00	11,56	11,78	11,04	11,77	10,63	11,77	10,41	Netherlands	94%	87%	94%	86%
Poland	14,25	21,16	22,71	17,83	17,25	17,83	17,25	17,13	16,39	17,13	16,11	17,13	15,44	17,13	15,02	Poland	96%	90%	96%	87%
Portugal	7,12	7,36	7,80	6,66	6,24	6,66	6,24	6,49	6,11	6,34	5,73	6,33	5,51	6,33	5,33	Portugal	95%	88%	95%	85%
Romania	4,90	5,96	7,15	4,98	5,19	4,98	5,19	4,77	4,90	4,66	4,64	4,66	4,47	4,66	4,36	Romania	94%	86%	94%	84%
Slovakia	2,24	2,71	2,99	1,99	2,03	1,99	2,03	1,90	1,90	1,85	1,78	1,85	1,70	1,84	1,65	Slovakia	93%	84%	93%	81%
Slovenia	1,73	2,12	2,11	1,72	1,56	1,72	1,56	1,61	1,44	1,56	1,38	1,56	1,31	1,56	1,30	Slovenia	91%	84%	91%	83%
Spain	38,23	41,38	44,51	31,59	32,47	31,59	32,47	30,69	31,34	30,68	30,75	30,69	29,53	30,68	29,12	Spain	97%	91%	97%	90%
Sweden	8,60	9,08	9,60	7,24	6,97	7,24	6,97	6,84	6,51	6,68	6,16	6,68	5,85	6,68	5,68	Sweden	92%	84%	92%	82%
United Kingdom	53,95	57,98	62,03	46,75	44,06	46,75	44,06	45,08	42,14	44,14	39,83	44,12	37,69	44,12	37,40	United Kingd	94%	86%	94%	85%
EU-27	360,02	390,01	399,73	322,23	308,86	322,23	308,86	310,96	295,15	305,22	280,45	305,13	267,46	305,11	262,88	EU-27	95%	87%	95%	85%
EU-28	362,01	392,90	402,92	324,57	311,26	324,57	311,26	313,09	297,24	307,29	282,50	307,21	269,35	307,19	264,86	EU-28	95%	87%	95%	85%

Source: Fraunhofer-ISI, ASTRA-EC

5.6.5 Industry sector

Modelling approach and sector-specific framework conditions

For the analysis of the industrial sector we apply the model FORECAST-Industry (see Annex 2). The model aims to develop long-term scenarios for future energy demand of individual countries for the industrial sector until 2050. It belongs to the family of bottom-up models considering the dynamics of technologies and socio-economic drivers and their impact on energy demand. Energy efficiency improvements take place via the diffusion of energy-efficiency measures. Their diffusion, in turn, depends on the cost-effectiveness (mostly payback time) including assumptions about barriers and heterogeneous expectations among companies.

As a simulation model, FORECAST-Industry aims to capture real-life patterns of technology diffusion. Consequently, it is well suited to capture the impact of policy instruments. We distinguish the following types of policies in our analysis:

- **The EU emissions trading scheme (ETS)**: can be explicitly modelled via the price of EU Allowances (EUAs). The model considers around 50 individual energy-intensive processes and products. For each process, it can be defined if it whether it is within the scope of the EU ETS or not (examples of products are: clinker, flat glass, container glass, primary and secondary aluminium, oxygen steel, electric steel, coke, sinter, paper, ceramics, ammonia, adipic acid, chlorine), distinguishing between phase 3 (from 2013 onwards) and before. The price of EUAs is then affecting the cost-effectiveness of energy-efficiency measures and, consequently, affecting the investment decision of companies.
- **Energy taxes**: For the industrial sector we distinguish about 14 individual energy carriers (electricity, light fuel oil, heavy fuel oil, natural gas, lignite, hard coal, district heating, biomass, etc.), calibrated to the Eurostat energy balances. For each of these energy carriers country specific prices are considered. Prices include taxes that increase the cost-effectiveness of energy-efficiency measures and thus speed up their diffusion.
- **Minimum energy performance standards (MEPS)**: Such MEPS are implemented in the frame of the EU Ecodesign Directive. The Ecodesign Directive per definition addresses products in the area of electric cross-cutting technologies (CCT-E), like lighting, ventilation or pump systems or thermal cross-cutting technologies (CCT-T) like steam and hot water raising in the industrial sector. In the model a number of 10-20 energy-efficiency measures are related to each CCT. Measures for which an Ecodesign Regulation sets MEPS will experience a faster diffusion.
- **Building standards:** Building standards as well as heating systems in the industrial sector are included via a stock model approach. The model draws on similar policy information on building standards as the INVERT model. INVERT is used to model

residential and tertiary sector buildings. Thus, the introduction of standards is modelled straight forward by restricting the market shares of inefficient building insulation or boilers.

- **Information-based and national policies***:* This term describes a broad bundle of various policy instruments that aim to overcome non-financial barriers to the adoption of energy-efficiency measures. Examples are energy audits, labelling or energy management. They are typically more complicated to model due to their rather "qualitative character" and the scarce empirical information available. We model this bundle of measures by adapting the payback time expectations of companies: in a country with very comprehensive sets of information-based policies, companies are expected to accept longer payback times. In this way, the heterogenous bundles of national policy measures are included in the analysis.

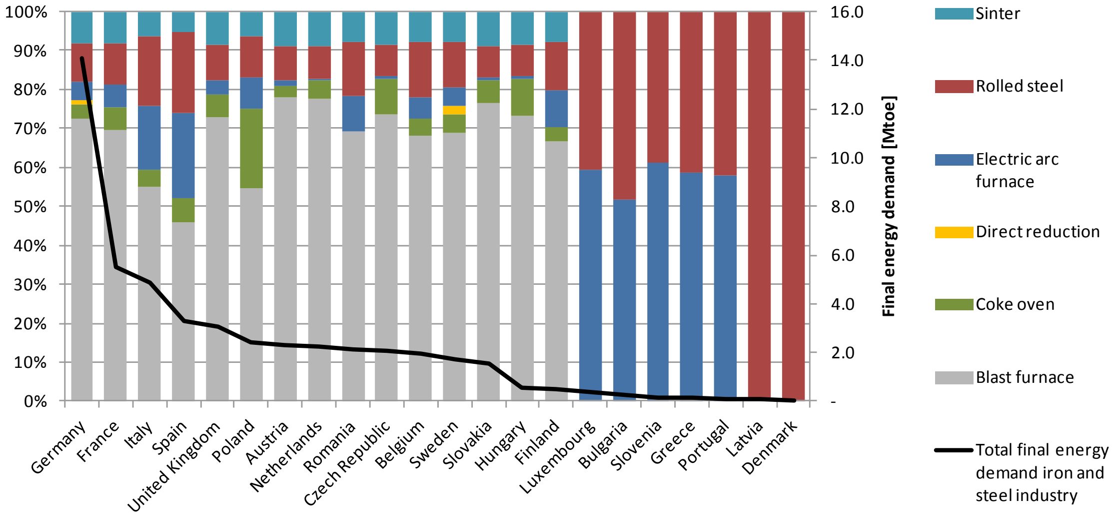
Specific energy-uses covered

Compared to the other sectors, the industrial sector shows the highest level of heterogeneity with regard to technologies and energy users (i.e. companies). This poses a huge challenge to a bottom-up model, which always needs to focus on large energy user groups that are as homogenous as possible to allow the use of average values. At the same time, the number of energy uses should not be too high, as gathering input data is very time and resource intensive.

Regarding the technological basis of the model, we differentiate between process-specific technologies and cross-cutting technologies (CCTs). Blast furnaces in steel-making are one example of the former; these are sector- and even process-specific. In contrast, cross-cutting technologies are widespread across very different industrial sectors. Examples include electric motors or lighting equipment, which are applied throughout all industrial sectors, but also space heating and steam systems.

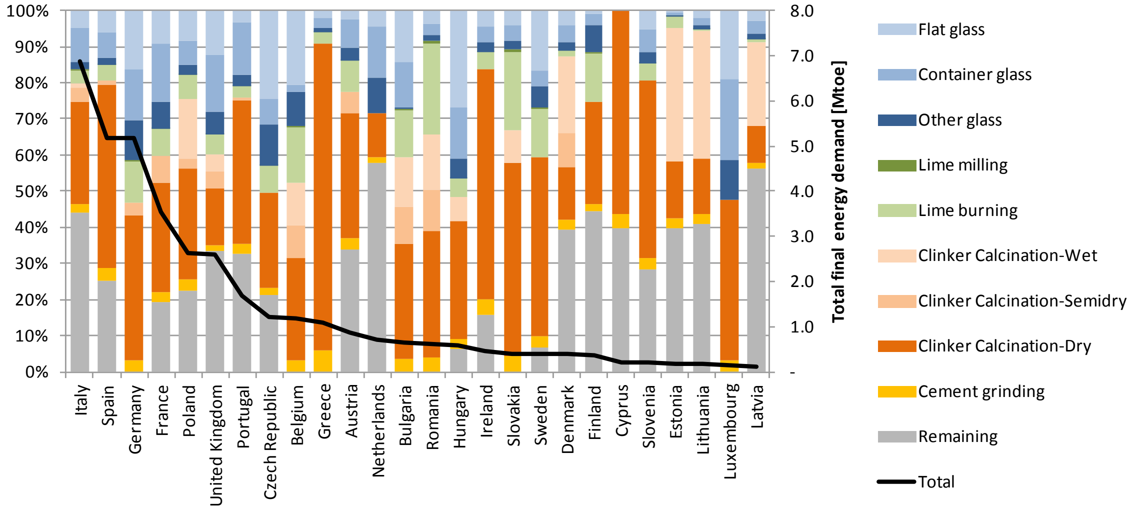
For **process-specific technologies**, the main driver is the projection of physical production (e.g. tons of crude steel from blast furnaces). This is linked to the general economic assumptions for the industrial sector but takes into account the specific conditions in a country when it comes to the physical production of goods. For example the level of primary aluminium production in a specific consumption does only depend little on the exact economic context but on the long-term expectation for the economic environment. About 40 of the most energy- and greenhouse-gas-intensive processes were considered separately in the model. For each of these processes, the specific energy consumption/GHG emissions and the physical production output per country are modelling parameters. In order to illustrate the level of detail of the modelling approach, the figures below show the energy demand of individual processes in the iron and steel as well as in the non-metallic minerals industries by country. For the steel industry the processes sintering, coke oven, blast furnace, steel rolling, electric arc furnace and direct reduction are considered in the model. As can be observed from Figure 42, in countries producing oxygen steel, the blast furnace is the most important energy consumer. The share of sintering and rolling is around 10% in most countries. Only the use of electric arc furnace varies heavily, depending on the production structure of the countries.

Figure 42: Final energy demand in the iron and steel industry by process and country in 2010



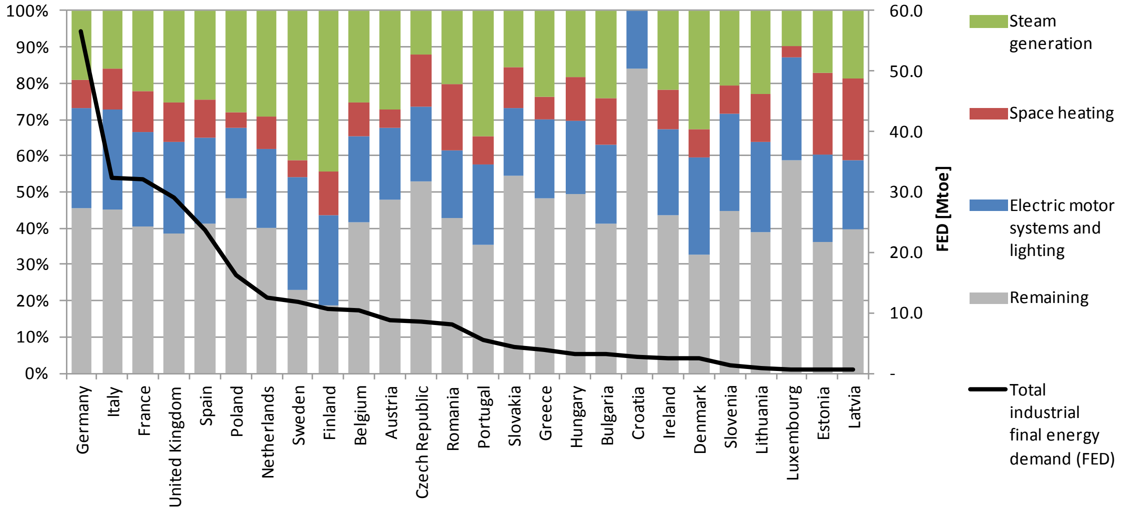
In the non-metallic minerals industry, various production processes for making glass, clinker and lime are distinguished. The calcination of clinker is by far the most relevant energy consumer in this industry, as shown in Figure 43. Most countries (and especially the large producers of cement) already apply the dry-calcination process, which is more energy-efficient than wet and semi-dry calcination.

Figure 43: Final energy demand in the non-metallic mineral industry by process and country in 2010



Although individual CCTs are usually smaller in size than the process-specific technologies, the numbers involved are huge, due to their widespread application. Thus they are responsible for an important share of industrial energy consumption (see Figure 44).

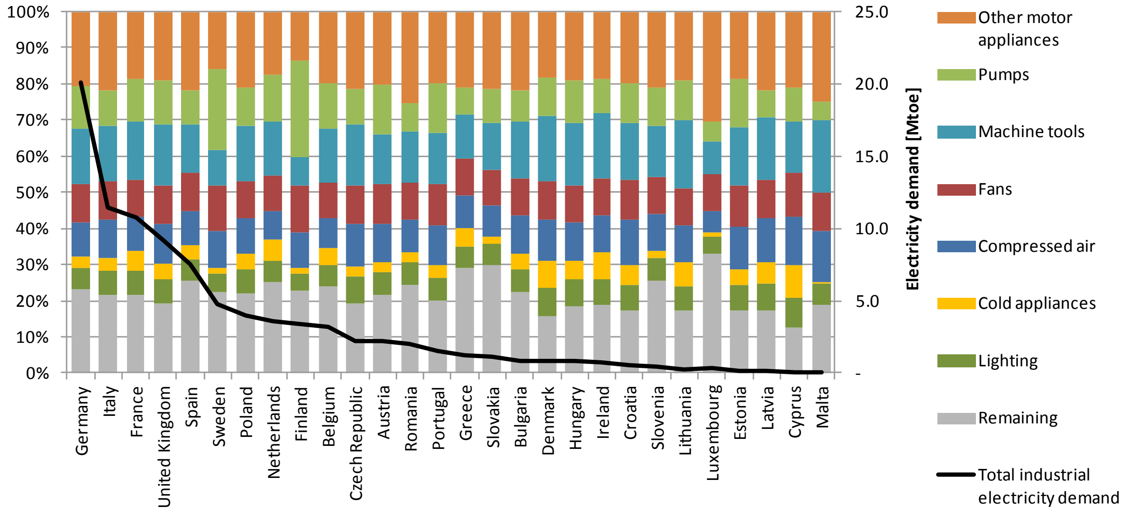
Figure 44: Final energy demand by technology and country in 2010 as share of total industrial final energy demand



Source: FORECAST model

Electric **motor systems and lighting** account for more than 70% of the industrial electricity consumption. They are implemented in the model as a share of the total sub-sector's electricity consumption. Their main driver is the projected development of value added per industrial sector. A number of studies have underlined the high saving potential in electric motor systems, like pumping, ventilation or compressed air systems. Often savings are in the order of 30% with short payback times. Typical efficiency measures comprise the replacement of individual components like electric motors or compressors but also the optimization of entire motor systems. Many of the components of such systems have recently been addressed by the EU Ecodesign Directive setting minimum energy performance standards or making e.g. the use of variable speed drives mandatory. System improvement is more difficult to address with policies and includes measures like the reducing leakages in compressed air systems, reducing the system pressure or adjusting the installed power of the motor to the real need of the system.

Figure 45: Electricity demand by cross-cutting technology (CCT) and country in 2010 as share of total industrial electricity demand



Source: FORECAST model

Furthermore **space heating** accounts for roughly 10% of the industrial energy demand in Europe, which is equivalent to the entire energy demand of the European pulp and paper industry. Furthermore, industrial buildings have not been as well optimized in the past as many of the energy-intensive processes have been. Consequently, improving both the insulation of industrial buildings and the efficiency of heating systems has a considerable energy-efficiency potential in Europe. At the same time, information on the current energy demand of space heating in Europe is very scarce. In FORECAST, space heating demand is derived from the heated floor area per country and sub-sector distinguishing office and production buildings. The future energy demand is derived in two steps: first by simulating the replacement and refurbishment of buildings and in a second step by simulating the replacement of heating systems using a stock-model approach.

Steam systems account for about 20-25% of EU industrial final energy demand. Steam is used in a wide range of industrial processes. About one third of the final energy demand in the EU industry is used to generate steam. Some examples for the end use of steam are drying, fractionation, component separation or heating. The main users of steam are the pulp and paper industry, the chemical industry as well as the food processing and refining industries. Based on a number of international case studies, the IEA (2007) concludes that the energy-efficiency potential of steam systems amounts to about 10 to 15% on average. While steam boilers have an average efficiency of 80 to 85% (IEA, 2007) additional losses between 15% (USDOE, 2004) and 20% (Ecofys, 2012) occur during the distribution of steam.

Possible techniques to increase the efficiency of the steam system can be found throughout the whole system. One of the most important technologies is the economizer, which uses waste heat to preheat boiler feedwater. With the installation of an economizer savings of up to 7 % can be achieved (EC 2009). The distribution system can be optimized with the insulation of not insulated parts or by repairing damaged insulation. This can lead to fuel saving of up to 13 % (Einstein et al. 2001). Another important aspect is to ensure that unused lines are isolated from the distribution system and that all steam traps are functioning. The latter should be checked regularly to avoid high steam losses (EC 2009).

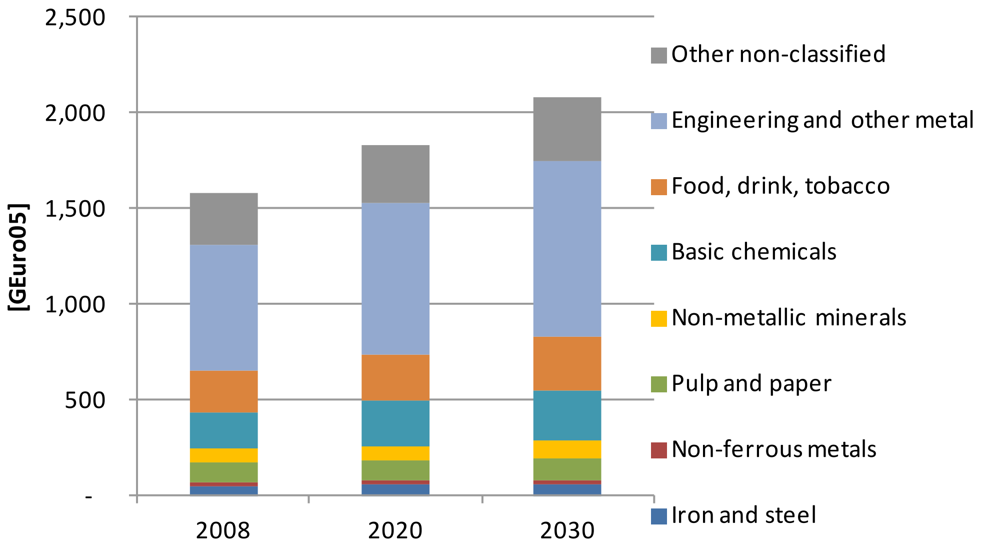
Scenario-independent drivers

The main driver of industrial energy demand is the gross value added differentiated by sub-sector and country (see Figure 46). For energy-intensive processes we distinguish the physical production like the tonnes of oxygen steel produced in a given year. For the building-module we use the number of employees (differentiated into blue and white collar workers) to calculate the floor area in production and office buildings. The floor area then directly affects the demand for space heating.

Table 36: Main scenario-independent drivers for the industry sector

Driver	Source
Gross value added per sub-sector	PRIMES 2013
Employment per sub-sector	Eurostat and own projection based on value added
Physical production per process	Various sources (PRODCOM when possible, UN commodity production database, US geological survey, UNFCCC, industry organizations (World steel organization, CEPI, Cembureau, Eurochlor, etc.), projection is related to gross value added

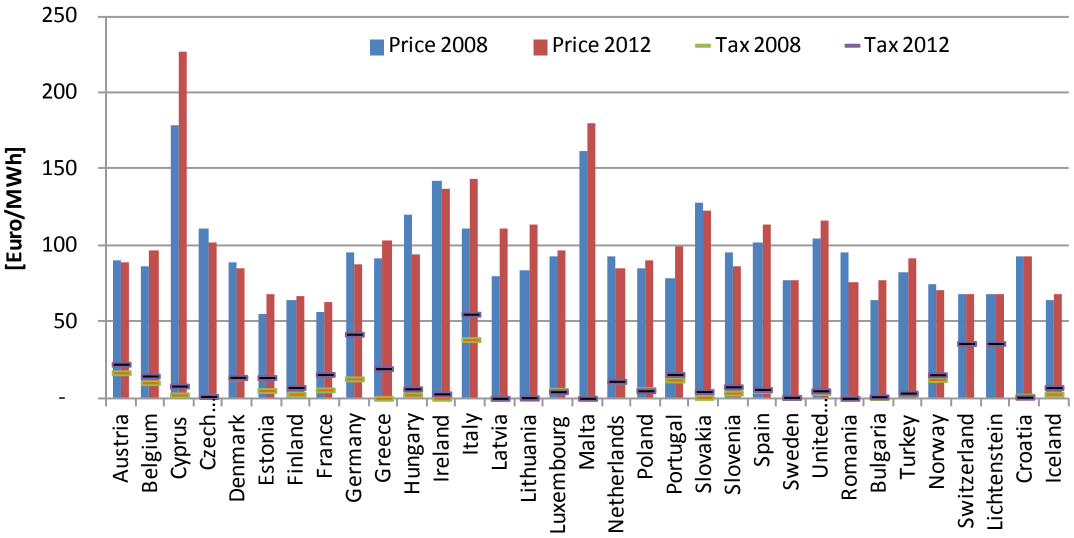
Figure 46: Development of gross value added by industrial sub-sector for the EU27



Scenario definition and implementation

1. Baseline Scenario (no early action): The Base_noEA scenario considers all policies implemented until 2008. It does not cover any impact of the EPBD nor the Ecodesign Directive. It considers the energy taxes frozen to the level of 2008 and the emissions trading scheme with EUA prices as used in the PRIMES (2013) scenarios (e.g. increasing to 10 Euros per EUA in 2020 and to 35 Euros in 2030). Figure 47 shows the underlying taxes for electricity as well as the prices for 2008 and 2012. While in 2012 the taxes tend to be a little higher in many countries, the total differences are relatively moderate compared to the electricity prices. Similarly, data for natural gas is available from Eurostat. The certificate prices of the EU ETS will remain on a low level of a maximum of 10 Euros per EUA until 2030. No structural reforms of the EU-ETS are assumed.

Figure 47: Electricity prices and taxes in 2008 and 2012 by country



Source: Eurostat

2. Baseline Scenario (including early action): The Base_inclEA scenario considers all policies adopted until 2013. This comprises the EPBD, the Ecodesign Directive, changes in taxes and a number of information-based policies. While the implementation of the EPBD still faces a certain degree of uncertainty on the member state level, we have assumed that it will be comprehensively implemented. Still, there will be a high degree of non compliance with the standards for new buildings.

Energy taxes are assumed to be frozen on the level of 2012 and will remain on this level in the following scenarios.

In the frame of the Ecodesign Directive a number of regulations were adopted until 2013 that will substantially affect electricity demand in industry. Among them are the regulations addressing electric motors (MEPs in force from 2013 and 2015), circulation pumps (2013 and 2015), fans (2013 and 2015), water pumps (2013 and 2015) and boilers. Based on a first qualitative assessment of the potential impact of all product groups (see Table 13) the most relevant are identified and individually assessed in the scenarios. Table 37 shows the lots separately analysed as well as the year of implementation and the standard.

Table 37: Overview of scenario assumptions regarding the implementation of MEPS in the frame of the EU Ecodesign Directive *

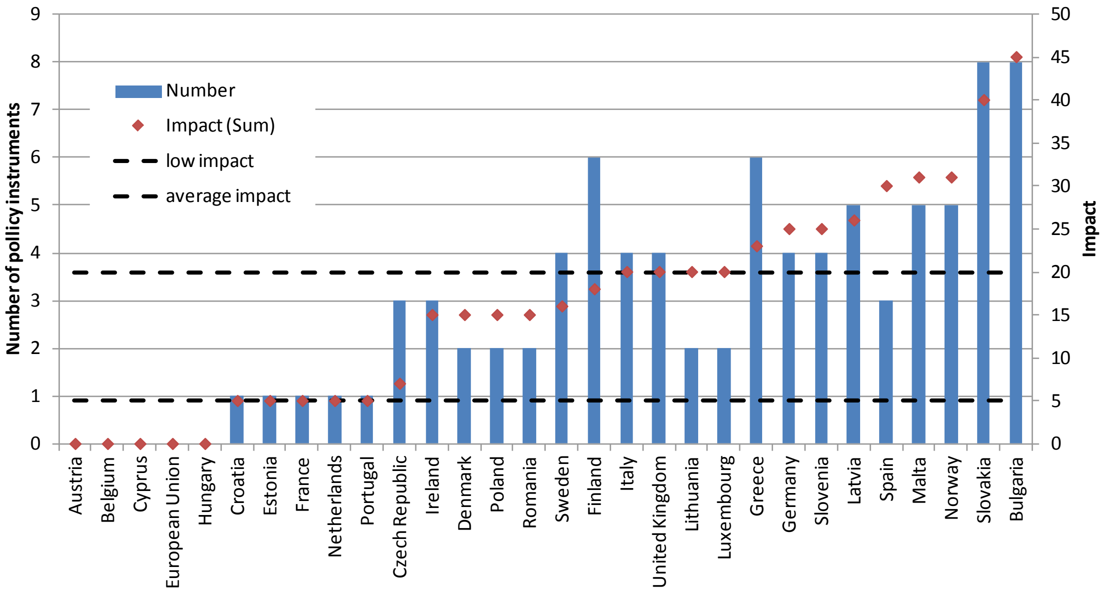
Product group	Base _noEA	Base_inclEA	AM	LPI, HPI, NE
Lot 1: boilers and combi-boilers	-	Tier 1: 2015	= Base_inclEA	LPI: Tier 2: 2020 HPI: Tier 3: 2023 NE: Tier 2: 2017, Tier 3: 2020, Tier 4: 2023
Lot 8: office lighting & lot 9: street lighting	-	fluorescent lamps : 2010/2012 HID lamps: 2012	LEDs: 2018	= AM
Lot 11: electric motors	-	IE2 motors: 2011 IE3 motors: 2015/2017 VSDs: 2015/2017	= Base_inclEA	= AM
Lot 11: water pumps	-	Tier 1: 2013 Tier 2: 2015	BAT: 2018	= AM
Lot 11: circulators	-	Tier 1: 2013 Tier 2: 2015	BAT: 2018	= AM
Lot 11: fans	-	Tier 1: 2013 Tier 2: 2015	BAT: 2018	= AM
Lot 5 (ENTR): machine tools	-	-	LLCC: 2016	= AM
Lot 6 (ENTR): large air-conditioning	-	-	LLCC: 2018	= AM
Lot 6 (ENTR): large ventilation	-	-	LLCC: 2018	= AM
Lot 31: compressors	-	-	Tier 1: 2016	= AM

* Each regulation typically comprises several levels (tiers) with individual effective dates. The higher tiers tighten up the efficiency levels a few years after tier 1 becomes effective, reflecting the expectation that products will become more energy efficient over time. BAT sets standards on the level of best available technology and LLCC stands for standards following least lifecycle costs.

Further, all scenarios contain assumptions about rather information-based policies, which often differ among member states and are more difficult to include in a quantitative model. Particularly as empirical information about the impact of the policies is mostly not available and the number as well as diversity of policies is very high. Such measures comprise support/obligations for energy audits, energy management, information, capacity building, procurement obligations and also voluntary agreements. These policies are modelled in an aggregated way by adjusting the companies' expectations about the payback time of energy-efficiency measures.

Figure 48 shows the number of such (national) policies by country as well as their cumulated impact. For the Base_inclEA scenario only policies implemented until 2013 were considered. The impact is calculated by distinguishing three levels of impacts: low (1 point), medium (5 points) and high (10 points). According to the cumulated impact per country, the average company payback time expectations are also adjusted by distinguishing three groups: low, medium and high (dotted lines in Figure 48). Consequently, the diffusion of energy-efficiency measures varies across those three country groups and is slowest for the group of countries with a cumulated impact equal to or below 5.

Figure 48: Overview of (mostly) national policies modelled in an aggregated way (including support/obligations for energy audits, energy management, information, capacity building, procurement obligations and also voluntary agreements)



The Base_inclEA does include “Back-loading” of auctions in phase 3 of the ETS. The Back-loading measure is to counteract the surplus allowances present in the ETS at the short term. At the start of phase 3 in 2013 the surplus was at almost two billion allowances (more than an annual inventory in the ETS). This surplus was due to several factors: the economic context, strong use of the Clean Development Mechanism, auctioning of phase 2 allowances and remaining allowances in the new entrant reserve, early auctioning of phase 3 allowances, and sales of phase 3 allowances to generate funds for the NER300 programme. As a short-term measure, the Commission is postponing the auctioning of 900 million allowances until 2019-2020 to allow demand to pick up. This ‘back-loading’ of auctions is being implemented through an amendment to the EU ETS Auctioning Regulation. Back-loading does not reduce the overall number of allowances to be auctioned during phase 3, only the distribution of auctions over the period. In 2014 the auction volume will be reduced by 400 million allowances, in 2015 by 300 million and in 2016 by 200 million. However without further action the structural surplus will persist for most of phase 3 and will come back towards the end of the period. The amendment was finally adopted in December 2013, clarifying that the timing of auctions may be changed to ensure the orderly functioning of the carbon market. We include the impact of this policy change through the assumption that prices will slightly increase in the short term to about 10 Euros per EUA. In the medium term (2020 and onwards) no changes in prices are expected from the back-loading.

Table 38: Scenario assumptions on EUA prices in the EU emissions trading scheme (ETS) in [Euro/EUA]

Scenario	2008	2015	2020	2025	2030	Explanation
Baseline_noEA	22	5	10	10	10	no backloading
Baseline_inclEA	22	10	10	10	10	including backloading
AM	22	10	10	14	35	Including structural reform
LPI	22	10	10	14	35	as AM
HPI	22	15	25	35	50	fundamental structural reform
NE	22	15	25	35	50	as HPI

3. Baseline Scenario (With Measures): The Base_WM scenario includes measures taken starting in 2014 or close of being taken. We do not distinguish this scenario from the Base_inclEA.

In principle the proposal for a structural reform of the ETS (establishment of a market stability reserve) could have been integrated in this scenario. The Commission proposes to establish a market stability reserve at the beginning of the next trading period in 2021. The reserve would address the surplus of emission allowances that has built up as well as improve the system's resilience to major shocks by automatically adjusting the supply of allowances to be auctioned. It would operate entirely according to predefined rules which would leave no discretion to the Commission or Member States in its implementation. Efforts to address the market imbalance would be supported by an increase in the annual linear reduction factor which determines the EU ETS cap. To achieve the target of a 40% reduction in EU greenhouse gas emissions below 1990 levels by 2030, set out in its 2030 framework for climate and energy policy, the Commission proposes an increase in the linear reduction factor to 2.2% per year from 2021, compared with 1.74% currently. The legislative proposal, put forward in January 2014 (at the same time as the framework for climate and energy policies up to 2030) requires approval by the Council and the European Parliament to become law. However, we still consider the outcome of the debate has quite uncertain at the moment. For that reason the possible impacts of the structural reform of the ETS are included in the AM scenario.

4. Additional Measures Scenario: The AM scenario includes the policy measures of the previous scenario as well as revisions of implementing directives for the Ecodesign

Directive that are due in 2014/2015. It also includes full implementation of the EPBD (recast) on MS level for which we assume an ambitious implementation for industrial premises particularly improving compliance with standards.

For the Ecodesign Directive, we assume an extension to LEDs (2018), MEPS based on least-lifecycle costs for compressors (2016) and machine tools (2016), and MEPS based on Best Available Technology (BAT) for fans (2018), ventilation and air-conditioning > 12 kW (2018), circulators (2018), fans (2018) and water pumps (2018). For policies modelled in an aggregated way (see Figure 48), a higher level of ambition is assumed across all countries.

This scenario also includes the structural reform proposed by the Commission to repair the ETS presented under the previous scenario. We do include the impacts by keeping the carbon price at the levels proposed by PRIMES (2013) up to 2030, resulting in an EUA price of about 35 Euros in 2030.

5. Potential 2030 – Low Policy Impact: In contrast to the foregoing scenarios the LPI scenario rather shows a saving potential than a specific policy impact. It is defined by adjusting the expectations, companies have, concerning the payback time of energy-efficiency measures. The information-based policies summarized in Figure 48 are set to a similar level of ambition across all countries. In the LPI scenario we assume that close to 50% of all companies invest in energy-efficiency measures with a payback time of up to 2 years (this also includes lacking information about the availability of measures). In the following two potential scenarios, this level of ambition is continuously increased.

While in the scenarios looking at 2030 saving potentials (LPI, HPI, NE) no additional MEPS are assumed, these standards also become less important, because most barriers addressing the adoption of cost-effective energy-efficiency measures are overcome. Thus, even in the absence of standards, companies tend to adopt technologies based on a Total Cost of Ownership TCO assessment.

For new heating systems, we assume a discount rate of 15%. Energy efficiency potentials in steam systems in this scenario stand for 60% of the technically available potentials and represent a rather large jump compared to the AM scenario.

The ETS prices are not changed compared to the AM scenario.

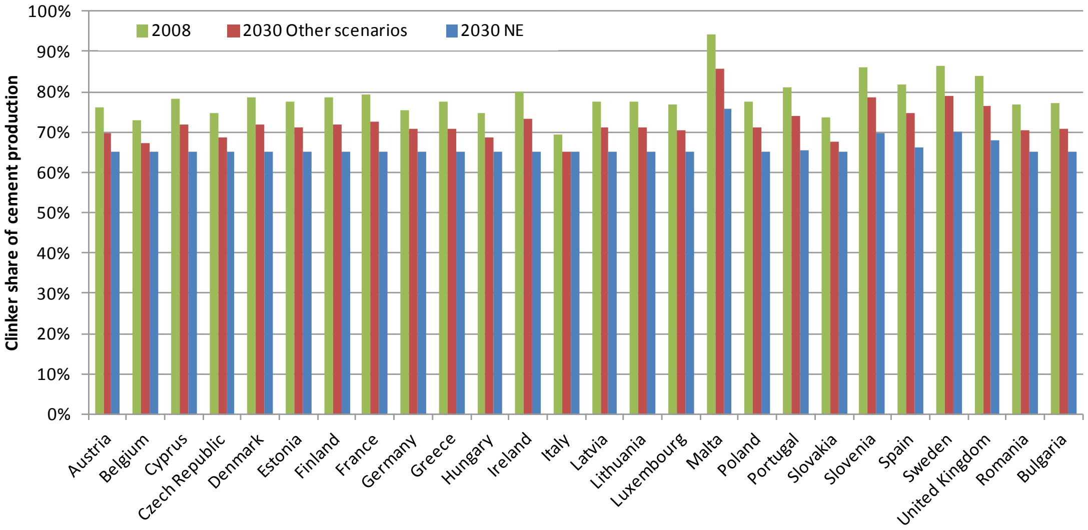
6. Potential 2030 – High Policy Impact: In the HPI, we assume that about 60% of all companies still invest when energy-efficiency measures have a payback time of up to 5 years. This reflects an even higher level of ambition for information-based policies. Investments in heating systems are subject to a discount rate of 15%.

In addition, we also assume an increase in the EU ETS certificate prices, reflecting a fundamental reform of the EU ETS. The prices are assumed to reach 50 Euros per EUA in 2030.

7. Potential 2030 – Near Economic: In the near economic scenario companies also invest in measures with longer payback times and accept interest rates close to zero (assuming that these efficiency measures will be made attractive to companies, e.g. by subsidies). However, most of the measures are still very close to being cost-effective. For the investment in heating systems the discount rate is only 3%. The renovation rate for buildings is 20% higher than in the AM scenario. Boiler standards are very ambitious and only allow the most efficient class in the market with a very dynamic upgrading of standards. Steam system improvement follows a very ambitious path assuming that after 20 years all steam systems will be retrofitted or replaced to cope with BAT efficiency. Still, for all those technical changes, the scenario does not assume a premature replacement of equipment, i.e. the stock turnover is not affected.

Additionally, improved material efficiency strategies are assumed for the NE scenario. This includes the reduction of the clinker share in cement production and the replacement by alternative “fillers”, the shift from primary production to secondary (e.g. steel, aluminium and paper) as well as a reduced product demand. Replacing energy-intensive clinker by alternative material can substantially reduce energy consumption for cement production. Figure 49 shows the share of clinker in 2008 as well as 2030 in the NE and the other scenarios. In the NE scenario, the clinker share decreases to about 65% in most countries.

Figure 49: Clinker share in 2008 and by scenario in comparison



Sector results

The main sector results for the main end-uses in the industrial sector and for the different EU Member States are shown in the following figures and tables.

Industrial electricity demand has shown a continuous increase in the EU27 since 2010 (see Figure 50). This increase is expected to continue in the Base_noEA scenario. The Base_inclEA and the AM scenario achieve a saturation of electricity demand, while in the LPI, HPI and even more the NE scenario, demand falls until 2030. In the NE scenario it even decreases back to the level of 1990.

Figure 50: Electricity demand in the EU27 industry by scenario

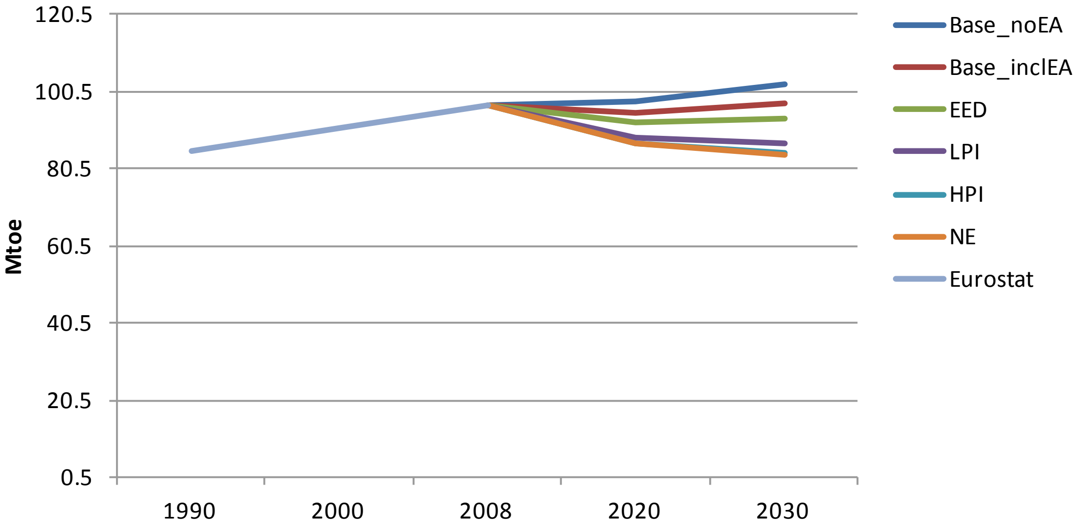
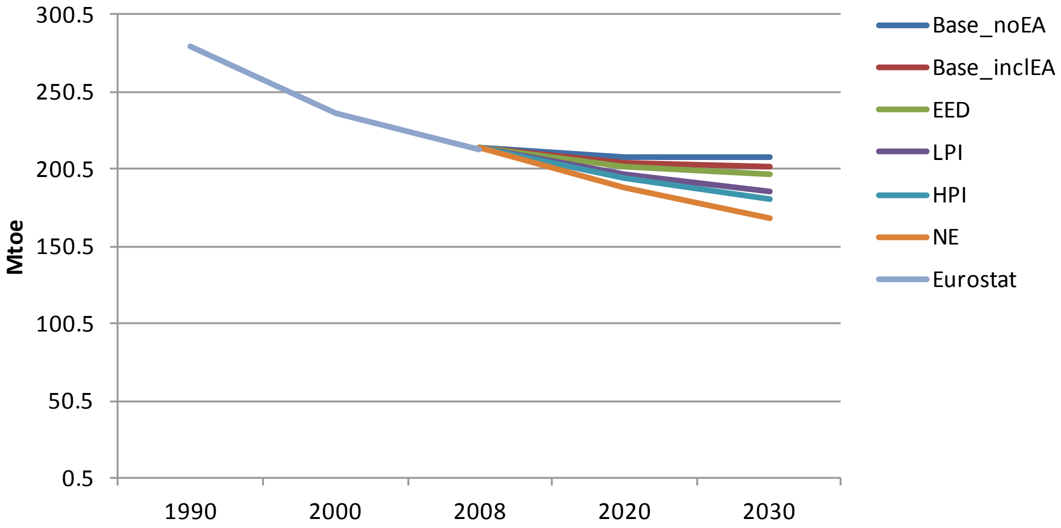


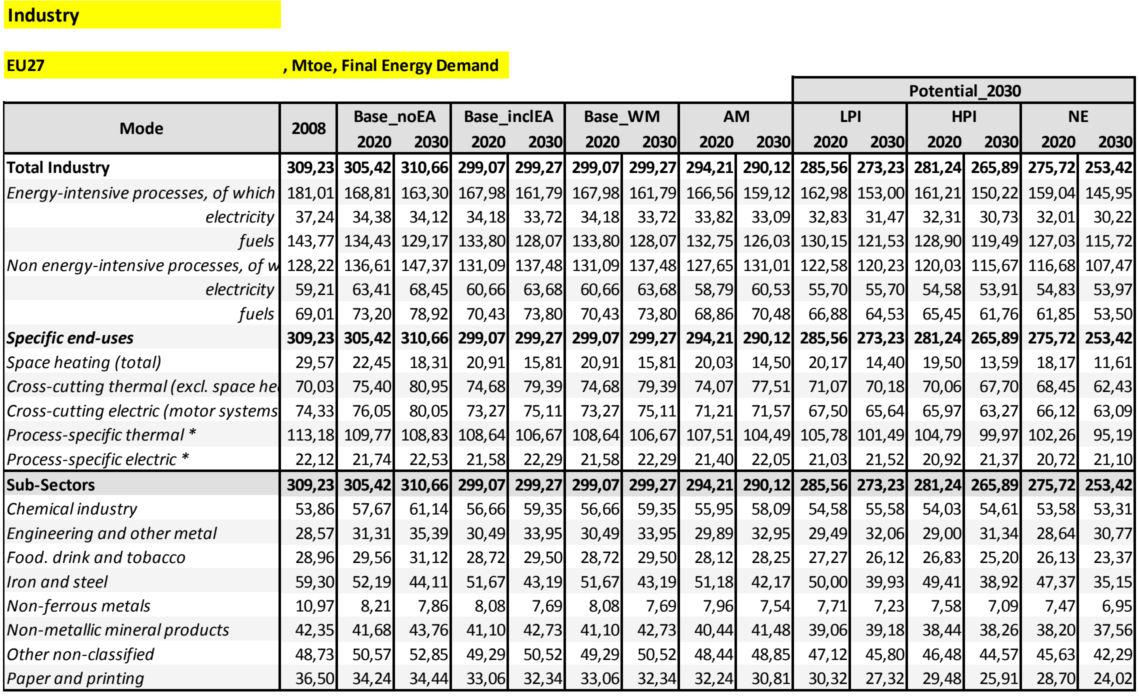
Figure 51: Fuel demand in the EU27 industry by scenario



In contrast to electricity demand, the fuel demand fell sharply in the EU27 since 1990. Much of the decrease in the early 1990s was due to the shutdown of numerous inefficient plants in the eastern European countries (incl. eastern Germany). In both baseline scenarios, the falling demand in the past is not continued. Instead, fuel demand remains relatively flat on the level of 2008. Only the NE scenario achieves a continuation of the past trend by implementing very ambitious energy-efficiency and material-efficiency measures. Consequently, the past trend is not only a result of energy-efficiency improvement, but also of structural changes within the industry. The latter are expected to slow down in the scenarios' macro-economic assumptions.

Looking at the individual end-uses, we can observe a moderate saving potential for energy-intensive processes. Efficiency improvements for these processes have been driven by high energy costs in the past. The NE scenario achieves additional 14% of savings until 2030 as compared to the Base_inclEA. On the other hand, space heating (27%), electric motor systems and lighting (16%) and steam systems (21%) show relatively high saving potentials.

Table 39: Main results by end-uses and scenario for the industry sector in the EU27 (in Mtoe)



Industry

EU27 , Mtoe, Final Energy Demand

										Potential_2030					
Mode	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Total Industry	**309,23**	**305,42**	**310,66**	**299,07**	**299,27**	**299,07**	**299,27**	**294,21**	**290,12**	**285,56**	**273,23**	**281,24**	**265,89**	**275,72**	**253,42**
Energy-intensive processes, of which	181,01	168,81	163,30	167,98	161,79	167,98	161,79	166,56	159,12	162,98	153,00	161,21	150,22	159,04	145,95
electricity	37,24	34,38	34,12	34,18	33,72	34,18	33,72	33,82	33,09	32,83	31,47	32,31	30,73	32,01	30,22
fuels	143,77	134,43	129,17	133,80	128,07	133,80	128,07	132,75	126,03	130,15	121,53	128,90	119,49	127,03	115,72
Non energy-intensive processes, of w	128,22	136,61	147,37	131,09	137,48	131,09	137,48	127,65	131,01	122,58	120,23	120,03	115,67	116,68	107,47
electricity	59,21	63,41	68,45	60,66	63,68	60,66	63,68	58,79	60,53	55,70	55,70	54,58	53,91	54,83	53,97
fuels	69,01	73,20	78,92	70,43	73,80	70,43	73,80	68,86	70,48	66,88	64,53	65,45	61,76	61,85	53,50
Specific end-uses	**309,23**	**305,42**	**310,66**	**299,07**	**299,27**	**299,07**	**299,27**	**294,21**	**290,12**	**285,56**	**273,23**	**281,24**	**265,89**	**275,72**	**253,42**
Space heating (total)	29,57	22,45	18,31	20,91	15,81	20,91	15,81	20,03	14,50	20,17	14,40	19,50	13,59	18,17	11,61
Cross-cutting thermal (excl. space he	70,03	75,40	80,95	74,68	79,39	74,68	79,39	74,07	77,51	71,07	70,18	70,06	67,70	68,45	62,43
Cross-cutting electric (motor systems	74,33	76,05	80,05	73,27	75,11	73,27	75,11	71,21	71,57	67,50	65,64	65,97	63,27	66,12	63,09
*Process-specific thermal **	113,18	109,77	108,83	108,64	106,67	108,64	106,67	107,51	104,49	105,78	101,49	104,79	99,97	102,26	95,19
*Process-specific electric **	22,12	21,74	22,53	21,58	22,29	21,58	22,29	21,40	22,05	21,03	21,52	20,92	21,37	20,72	21,10
Sub-Sectors	**309,23**	**305,42**	**310,66**	**299,07**	**299,27**	**299,07**	**299,27**	**294,21**	**290,12**	**285,56**	**273,23**	**281,24**	**265,89**	**275,72**	**253,42**
Chemical industry	53,86	57,67	61,14	56,66	59,35	56,66	59,35	55,95	58,09	54,58	55,58	54,03	54,61	53,58	53,31
Engineering and other metal	28,57	31,31	35,39	30,49	33,95	30,49	33,95	29,89	32,95	29,49	32,06	29,00	31,34	28,64	30,77
Food. drink and tobacco	28,96	29,56	31,12	28,72	29,50	28,72	29,50	28,12	28,25	27,27	26,12	26,83	25,20	26,13	23,37
Iron and steel	59,30	52,19	44,11	51,67	43,19	51,67	43,19	51,18	42,17	50,00	39,93	49,41	38,92	47,37	35,15
Non-ferrous metals	10,97	8,21	7,86	8,08	7,69	8,08	7,69	7,96	7,54	7,71	7,23	7,58	7,09	7,47	6,95
Non-metallic mineral products	42,35	41,68	43,76	41,10	42,73	41,10	42,73	40,44	41,48	39,06	39,18	38,44	38,26	38,20	37,56
Other non-classified	48,73	50,57	52,85	49,29	50,52	49,29	50,52	48,44	48,85	47,12	45,80	46,48	44,57	45,63	42,29
Paper and printing	36,50	34,24	34,44	33,06	32,34	33,06	32,34	32,24	30,81	30,32	27,32	29,48	25,91	28,70	24,02

EU27, %, change compared to 2008

										Potential_2030					
Mode	2008	Base_noEA		Base_inclEA		Base_WM		AM		LPI		HPI		NE	
		2020	2030	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
Total Industry	100%	99%	100%	97%	97%	97%	97%	95%	94%	92%	88%	91%	86%	89%	82%
Energy-intensive processes, of which	100%	93%	90%	93%	89%	93%	89%	92%	88%	90%	85%	89%	83%	88%	81%
electricity	100%	92%	92%	92%	91%	92%	91%	91%	89%	88%	84%	87%	83%	86%	81%
fuels	100%	94%	90%	93%	89%	93%	89%	92%	88%	91%	85%	90%	83%	88%	80%
Non energy-intensive processes, of w	100%	107%	115%	102%	107%	102%	107%	100%	102%	96%	94%	94%	90%	91%	84%
electricity	100%	107%	116%	102%	108%	102%	108%	99%	102%	94%	94%	92%	91%	93%	91%
fuels	100%	106%	114%	102%	107%	102%	107%	100%	102%	97%	94%	95%	90%	90%	78%
Specific end-uses	100%	99%	100%	97%	97%	97%	97%	95%	94%	92%	88%	91%	86%	89%	82%
Space heating (total)	100%	76%	62%	71%	53%	71%	53%	68%	49%	68%	49%	66%	46%	61%	39%
Cross-cutting thermal (excl. space he	100%	108%	116%	107%	113%	107%	113%	106%	111%	101%	100%	100%	97%	98%	89%
Cross-cutting electric (motor systems	100%	102%	108%	99%	101%	99%	101%	96%	96%	91%	88%	89%	85%	89%	85%
*Process-specific thermal **	100%	97%	96%	96%	94%	96%	94%	95%	92%	93%	90%	93%	88%	90%	84%
*Process-specific electric **	100%	98%	102%	98%	101%	98%	101%	97%	100%	95%	97%	95%	97%	94%	95%
Sub-Sectors	100%	99%	100%	97%	97%	97%	97%	95%	94%	92%	88%	91%	86%	89%	82%
Chemical industry	100%	107%	114%	105%	110%	105%	110%	104%	108%	101%	103%	100%	101%	99%	99%
Engineering and other metal	100%	110%	124%	107%	119%	107%	119%	105%	115%	103%	112%	102%	110%	100%	108%
Food. drink and tobacco	100%	102%	107%	99%	102%	99%	102%	97%	98%	94%	90%	93%	87%	90%	81%
Iron and steel	100%	88%	74%	87%	73%	87%	73%	86%	71%	84%	67%	83%	66%	80%	59%
Non-ferrous metals	100%	75%	72%	74%	70%	74%	70%	73%	69%	70%	66%	69%	65%	68%	63%
Non-metallic mineral products	100%	98%	103%	97%	101%	97%	101%	95%	98%	92%	93%	91%	90%	90%	89%
Other non-classified	100%	104%	108%	101%	104%	101%	104%	99%	100%	97%	94%	95%	91%	94%	87%
Paper and printing	100%	94%	94%	91%	89%	91%	89%	88%	84%	83%	75%	81%	71%	79%	66%

EU27, %, change compared to Base_inclEA

										Potential_2030					
Mode	2008	Base_noEA		Base_inclEA		Base_WM		AM		LPI		HPI		NE	
		2020	2030	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
Total Industry				100%	100%	100%	100%	98%	97%	95%	91%	94%	89%	92%	85%
Energy-intensive processes, of which				100%	100%	100%	100%	99%	98%	97%	95%	96%	93%	95%	90%
electricity				100%	100%	100%	100%	99%	98%	96%	93%	95%	91%	94%	90%
fuels				100%	100%	100%	100%	99%	98%	97%	95%	96%	93%	95%	90%
Non energy-intensive processes, of which				100%	100%	100%	100%	97%	95%	94%	87%	92%	84%	89%	78%
electricity				100%	100%	100%	100%	97%	95%	92%	87%	90%	85%	90%	85%
fuels				100%	100%	100%	100%	98%	95%	95%	87%	93%	84%	88%	72%
Specific end-uses				100%	100%	100%	100%	98%	97%	95%	91%	94%	89%	92%	85%
Space heating (total)				100%	100%	100%	100%	96%	92%	96%	91%	93%	86%	87%	73%
Cross-cutting thermal (excl. space heating)				100%	100%	100%	100%	99%	98%	95%	88%	94%	85%	92%	79%
Cross-cutting electric (motor systems and lighting)				100%	100%	100%	100%	97%	95%	92%	87%	90%	84%	90%	84%
*Process-specific thermal **				100%	100%	100%	100%	99%	98%	97%	95%	96%	94%	94%	89%
*Process-specific electric **				100%	100%	100%	100%	99%	99%	97%	97%	97%	96%	96%	95%
Sub-Sectors				100%	100%	100%	100%	98%	97%	95%	91%	94%	89%	92%	85%
Chemical industry				100%	100%	100%	100%	99%	98%	96%	94%	95%	92%	95%	90%
Engineering and other metal				100%	100%	100%	100%	98%	97%	97%	94%	95%	92%	94%	91%
Food. drink and tobacco				100%	100%	100%	100%	98%	96%	95%	89%	93%	85%	91%	79%
Iron and steel				100%	100%	100%	100%	99%	98%	97%	92%	96%	90%	92%	81%
Non-ferrous metals				100%	100%	100%	100%	99%	98%	95%	94%	94%	92%	92%	90%
Non-metallic mineral products				100%	100%	100%	100%	98%	97%	95%	92%	94%	90%	93%	88%
Other non-classified				100%	100%	100%	100%	98%	97%	96%	91%	94%	88%	93%	84%
Paper and printing				100%	100%	100%	100%	98%	95%	92%	84%	89%	80%	87%	74%

Table 40: Scenario overview of final energy consumption per Member State in the industry sector in Mtoe

Industry

Member States
Mtoe, Final Energy Demand

Member States
%, change compared to Base_inclEA

										Potential_2030										
Country	**2008**	**Base_noEA**		**Base_inclEA**		**Base_WM**		**AM**		**LPI**		**HPI**		**NE**		**Country**	**HPI**		**NE**	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**		**2020**	**2030**	**2020**	**2030**
Austria	8,96	9,52	9,46	9,34	9,14	9,34	9,14	9,19	8,86	8,87	8,24	8,74	8,02	8,53	7,63	Austria	94%	88%	91%	83%
Belgium	11,93	11,74	11,46	11,50	11,03	11,50	11,03	11,31	10,66	10,93	9,93	10,78	9,66	10,66	9,32	Belgium	94%	88%	93%	85%
Bulgaria	3,41	3,52	3,79	3,43	3,64	3,43	3,64	3,38	3,53	3,29	3,35	3,25	3,29	3,20	3,16	Bulgaria	95%	90%	93%	87%
Croatia	1,65	3,12	3,49	3,10	3,46	3,10	3,46	3,09	3,44	3,06	3,39	3,05	3,38	3,06	3,38	Croatia	98%	98%	99%	98%
Cyprus	0,31	0,31	0,34	0,31	0,33	0,31	0,33	0,30	0,32	0,29	0,31	0,29	0,30	0,29	0,29	Cyprus	94%	90%	94%	89%
Czech Republic	8,73	8,94	9,46	8,69	9,03	8,69	9,03	8,52	8,72	8,29	8,26	8,19	8,09	7,64	7,49	Czech Republic	94%	90%	88%	83%
Denmark	2,65	2,64	2,80	2,59	2,71	2,59	2,71	2,55	2,63	2,49	2,48	2,46	2,43	2,43	2,34	Denmark	95%	90%	94%	86%
Estonia	0,76	0,77	0,85	0,75	0,81	0,75	0,81	0,73	0,79	0,71	0,74	0,70	0,72	0,68	0,69	Estonia	94%	88%	92%	84%
Finland	12,24	11,51	11,80	11,17	11,20	11,17	11,20	10,92	10,73	10,42	9,83	10,18	9,44	9,94	8,88	Finland	91%	84%	89%	79%
France	34,06	32,08	32,23	31,39	30,99	31,39	30,99	30,83	29,95	29,83	27,98	29,31	27,12	29,06	26,27	France	93%	88%	93%	85%
Germany	58,97	56,32	52,57	55,17	50,68	55,17	50,68	54,38	49,29	52,88	46,65	52,09	45,38	51,50	43,53	Germany	94%	90%	93%	86%
Greece	4,21	4,15	4,22	4,09	4,10	4,09	4,10	4,03	3,98	3,92	3,77	3,85	3,67	3,80	3,55	Greece	94%	90%	93%	87%
Hungary	3,32	3,25	3,37	3,20	3,26	3,20	3,26	3,15	3,16	3,05	2,97	3,01	2,89	2,94	2,77	Hungary	94%	89%	92%	85%
Ireland	2,44	2,80	3,34	2,75	3,23	2,75	3,23	2,70	3,14	2,64	2,99	2,61	2,93	2,57	2,82	Ireland	95%	91%	94%	87%
Italy	35,96	32,09	32,94	31,50	31,84	31,50	31,84	30,97	30,85	30,16	29,21	29,66	28,40	28,43	26,90	Italy	94%	89%	90%	84%
Latvia	0,65	0,70	0,73	0,68	0,70	0,68	0,70	0,67	0,68	0,66	0,66	0,65	0,64	0,64	0,62	Latvia	96%	91%	94%	87%
Lithuania	0,96	0,96	1,03	0,93	0,98	0,93	0,98	0,91	0,95	0,88	0,89	0,87	0,87	0,85	0,84	Lithuania	93%	89%	91%	85%
Luxembourg	0,74	0,55	0,54	0,54	0,52	0,54	0,52	0,54	0,51	0,52	0,47	0,51	0,46	0,51	0,45	Luxembourg	93%	88%	93%	87%
Malta	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	Malta	95%	91%	95%	91%
Netherlands	12,60	13,13	12,85	12,88	12,39	12,88	12,39	12,68	12,01	12,33	11,28	12,15	10,98	11,88	10,32	Netherlands	94%	89%	92%	83%
Poland	16,34	19,83	21,90	19,44	21,20	19,44	21,20	19,15	20,61	18,59	19,50	18,38	19,09	17,78	17,69	Poland	95%	90%	91%	83%
Portugal	5,52	5,67	5,81	5,57	5,62	5,57	5,62	5,48	5,44	5,27	5,06	5,18	4,92	5,09	4,70	Portugal	93%	88%	91%	84%
Romania	8,86	12,52	12,97	12,27	12,56	12,27	12,56	12,08	12,22	11,81	11,66	11,65	11,40	11,49	10,59	Romania	95%	91%	94%	84%
Slovakia	4,07	4,41	4,70	4,30	4,49	4,30	4,49	4,22	4,33	4,10	4,09	4,04	3,99	4,02	3,94	Slovakia	94%	89%	94%	88%
Slovenia	1,46	1,60	1,72	1,57	1,67	1,57	1,67	1,55	1,63	1,52	1,56	1,50	1,53	1,48	1,48	Slovenia	95%	91%	94%	89%
Spain	25,78	24,92	27,13	24,44	26,19	24,44	26,19	24,10	25,47	23,50	24,15	23,16	23,54	22,67	22,61	Spain	95%	90%	93%	86%
Sweden	12,20	11,99	12,42	11,67	11,83	11,67	11,83	11,41	11,37	10,86	10,38	10,62	9,95	10,42	9,45	Sweden	91%	84%	89%	80%
United Kingdom	32,06	29,44	30,16	28,85	29,08	28,85	29,08	28,41	28,24	27,71	26,77	27,37	26,15	27,17	25,06	United Kingdom	95%	90%	94%	86%
EU-27	309,23	305,42	310,66	299,07	299,27	299,07	299,27	294,21	290,12	285,56	273,23	281,24	265,89	275,72	253,42	EU-27	94%	89%	92%	85%
EU-28	310,88	308,54	314,16	302,17	302,74	302,17	302,74	297,30	293,56	288,62	276,62	284,30	269,27	278,77	256,80	EU-28	94%	89%	92%	85%

5.6.6 Conversion sector

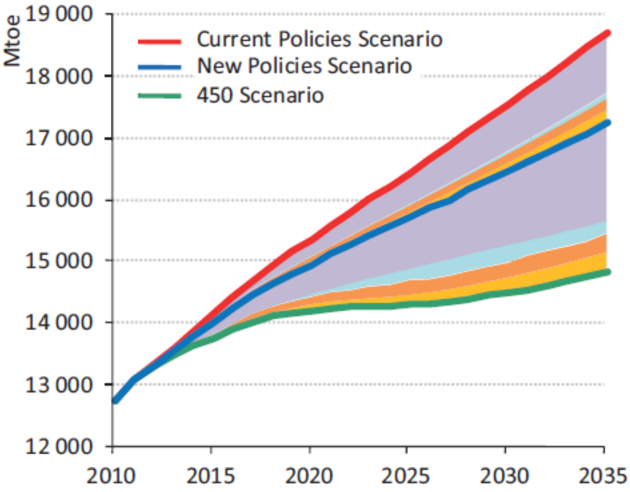
The potentials on the conversion side are more limited. The arguments are as follows:

- The main “potential” on the conversion side lies in the penetration of renewable energy sources. Renewables, due to the fact that large amounts like wind, solar and hydro have a nominal 100% conversion efficiency, lead to a reduction in primary energy). Therefore, if an increasing share of (100%) renewable can be combined with energy efficiency on the demand side, the impact on primary energy is enhanced. These potentials depend to a large degree on the potentials for renewable energy sources and on the policies to realize these potentials. However, it is not the purpose of this report to analyse the impacts of large shares of renewables. We therefore limit ourselves here to the minimum level of 27% as proposed by the EU Commission. For comparison purpose we also evaluate the energy efficiency potentials with a renewable share of 35% which may be achievable by 2030 given current development paths. Renewables, at present, nevertheless come at net positive costs, until cost degression has reached levels where Levelized Cost of Electricity reaches the band of the fossil reference technologies which is about to happen for some of the renewable.
- A further potential is in the improvement of the conversion efficiency of EXISTING power plants. This is possible to some degree but the potentials which are found while discussing with producers of power plants are in the range of one percentage point in efficiency, hence 2% improvement in primary energy potentials.
- Then there is the potential of new fossil plants. However, most of that is in the baseline as it is always economic to gain on the efficiency in power plants. So the additional potentials are limited. Second, this is strongly correlated with the penetration of renewables. If there is a strong penetration of renewable in the power sector then the remaining potential for new fossil power plants beyond the reference is small. This is clearly a function of the scenarios developed. If we assume a weak policy on renewable, the potentials could be higher but still limited as much is in the baseline scenario. Nevertheless, due to the relatively small share of renewable in 2030 we have introduced in the scenario calculations an increase in average EU power plant efficiency of 50% by 2030. This implies that power plants being built at present are only gas-fired plants and that some of the older fossil fuel plants are put out of service. It also implies that the lifetime of nuclear is not extended (in contradiction to some discussions in EU countries with higher share of renewable), see below.
- Further there is the “efficiency gain” if nuclear is phased out (33% nominal efficiency while the average electricity efficiency in Europe is already 40%). However, this is a political setting and cannot be considered in the potentials. It also raises the question of the reference development and in how far the extension of the lifetime of nuclear power plants may be part of the baseline.

- In addition, there is the issue of Combined Heat and Power Generation CHP. The potentials of large CHP are limited. This depends strongly on the building policy strategy being implemented. If there are strong building policies (which we assume here in our potential scenarios HPI and NE), then the heat demand of buildings will be much lower and so is the heat density. Hence district networks and the CHP plants get less economic. There are certainly still potentials for distributed CHP. These potentials could benefit from more investigation; however the data side is weak, at present. One has to take into account the local conditions for CHP, the heat levels available and in use, the distance between source and use of the heat etc. This is a rather complex analysis. On the other hand, economics of distributed CHP could also depend much on the contribution they can make in terms of flexibility to the electricity markets with increasing shares of fluctuating renewables. CHP may be as much financed by providing flexibility as by saving (primary) energy. This is, however, strongly dependant on the organization of electricity markets.
- Finally there are the distribution and transmission grids. We found in the past potentials of up to 50% on the distribution side in particular (see Bossmann et al. 2012). However, there is also the counteracting effect of the penetration of renewable at the demand side which leads to a degradation of the efficiency at the distribution side once again, compensating for the efficiency gains. With the introduction of intelligent grids (smart grids) the balance could be in favour of positive gains but here again this requires some more detailed technical study than could be done in the frame of this study.

Overall, the conversion potentials are much more limited (if the penetration of renewable is not considered) as compared to the demand side potentials. This is confirmed by the analysis of the IEA in their World Energy Outlook 2012 which shows that at the global level efficiency at the energy supply side represents a comparatively small fraction of the overall energy efficiency potentials (about 5-8%, which nevertheless at the world level still represents a rather important fraction of savings). In Europe, with the strong penetration of renewable energy sources and the decreasing demand, the possible role of energy efficiency at the supply level can only be considerably smaller in percentage terms than at the world level though quite some of the fossil-fired plants in Europe are at age. However, the “potential” of replacing them with the newest plants is only there if by 2050 there is still a substantial fraction of fossil fuels in the power sector. These may be indeed plants with carbon capture and storage to reduce strongly the CO_2 emissions from power generation as requested by EU Climate Roadmap 2050. However, in that case the energy consumption, as opposed to the CO_2 emissions will rise, given the higher consumption from CCS plants, compensating for the efficiency gains associated with new generation facilities.

Figure 52: Energy efficiency contributions from the supply and the demand side at the world level



Energy savings in 2035	CPS to NPS	NPS to 450
■ Efficiency in end-uses	67%	66%
■ Efficiency in energy supply	5%	8%
■ Fuel and technology switching	12%	12%
■ Activity	16%	14%
Total (Mtoe)	1 479	2 404

Note: CPS = Current Policies Scenario;
NPS = New Policies Scenario;
450 = 450 Scenario.

Source: IEA World Energy Outlook 2012

A look to the recent PRIMES 2013 projections shows that while the renewable share in electricity in 2030 may reach 42.6% in gross electricity generation. While this is already quite an important share at the time horizon 2030, under a 35% overall RES target, which many projections believe, could be reached by 2030, then 47% renewable in gross electricity may be possible. As much of these are “100% conversion efficiency” RES (solar, wind, hydro) this has some impact on primary energy but limited. Only reaching corridors of 50-55%[32] could substantially enhance the additional impact of renewables on primary energy by 2030.

Another way of enhancing the conversion efficiency would be to enhance the share of high efficiency plants by 2030. PRIMES 2013 foresees an increase in thermal power efficiency from at present 36% at EU level to 40% in 2030. This could be further enhanced by building mainly high efficiency combined cycle gas fired power plants when it comes to new investments. These have net power generation efficiency of 58%. Given, however, the long lifetimes of power plants, the average thermal power generation may reach 50% by 2030 but only if all plants would be gas-fired by then, which may be in discussion in countries that rely still strongly on coal. It may also pose problems with respect to supply security. Nevertheless, if older plants would be encouraged to be substituted, an average thermal power efficiency of 45% seems possible.

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[32] Germany in the Coalition Agreement from end 2013 foresees RES corridors of 40 to 45% by 2025 and 55 to 60% by 2035. Originally this corridor was under discussion for 2030 already. Taking the higher end this implies a corridor of 50-55% in 2030.

We combine in the following different conversion scenarios with the different final energy scenarios:

- First we use the conversion factors from final to primary energy derived from PRIMES 2013 to convert all final energy scenarios to primary energy.
- Second we use specific conversion factors for the 2030 potential scenarios LPI, HPI and NE:
  - We combine the LPI scenario additionally to the conversion factors derived from PRIMES 2013 with a scenario which realizes the potentials for the refurbishment of existing power plants and brings the renewables share to 27% (44% RES-E). This brings the conversion efficiency of thermal power plants to 41% in 2030.
  - Further, we combine the HPI with a scenario which brings the electric conversion efficiency of thermal power generation to 43% through the use of decentral CHP that support renewables by offering flexibility services, the installation of the most efficient coal and gas-fired power plants when it comes to reinvestment, and raising the share of RES to 35% (47% RES-E). The economics of these options strongly depends on the further cost degression of renewables and of the development of CHP schemes which allow to bundle activities (development of local heat grids, organization of electricity markets to reward flexibility provided etc.)
  - Finally we combine the NE scenario with a thermal conversion efficiency of 45%, implying larger use of gas-fired CCGT plants and of decentral cogeneration schemes together with a RES-E corridor of up to 55% by 2030 for the European power mix. The economics of this may also depend strongly on the factors mentioned but it can be expected, given the present cost path of the different renewable options that some of these are not yet fully cost economic. Hence the choice to combine this with the NE scenario.

The results of these conversion scenarios are discussed in section 5.7.2 after the discussion of the final energy scenarios. For the calculation of additional supply options we make use of the PowerAce model (see Annex 2).

5.7 Detailed overall results

5.7.1 The 2020 target in final energy terms

This section discusses the question whether the final energy target in 2020 of 1078 Mtoe will be reached and in which scenario. Table 41 shows that **the gap to the 2020 final energy target in the Base_inclEA (that is including measures up to 2013) is about 30 Mtoe (2.3% out of the 20% reduction to be reached[33]), while the Base_WM scenario which includes measures which are about to being introduced 2014/2015 reduces the gap hardly further by 2020.**

The gap can be closed by the measures discussed in this report in the different sectoral chapters and which are briefly presented here as they may constitute a policy lever. We are concentrating here on the enhancement of existing policy measures which seems more rational given that the gap to the 2020 target is comparatively small. **However, in view of a more ambitious realization of energy efficiency potentials up to 2030, it may be appropriate to discuss more ambitious measures already with a time horizon for 2020.** This is shown by the fact that **the HPI scenario (realisation of economic potentials) exceeds the 2020 target by 4.9% (67 Mtoe)**.

The measures discussed in this report to close merely the gap for the 2020 target **save around 37 Mtoe additionally** to the Base_WM scenario and are:

- ***Residential/tertiary sector buildings:*** The EPBD (Recast) up to now is not fully implemented in the MSs and there are still a considerable number of open questions and some range of interpretation e.g. regarding the definition of nZEB. We assumed that MSs will implement the directive in an ambitious way to close the gap. These measures could contribute around 14.5 Mtoe to the required savings (of which two thirds in the residential sector). For details see section 5.6.1.
- ***Residential/tertiary sector appliances:*** This includes the revisions of implementing directives of the eco-design directive that are due in 2014/2015 (see Table 24), the recast of the Labeling scheme due in 2014 (see Table 24) and a moderate adoption of new implementing measures. Until 2020, the additional estimated saving potential of such new implementing measures is mainly driven by the current efforts to include a system approach for lighting and cooling within the policy framework of Ecodesign, EED and EPBD by 2016, leading to estimated savings of 10 TWh/year in 2020. Overall the extension of measure for residential appliances may contribute

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[33] The percentage points for the gap refer here to the difference between the PRIMES 2007 projection of final energy of 1348 Mtoe in 2020 and the target of 1074 Mtoe in final energy. The total gap corresponds to 20%. In the whole text we will report the gaps in such a way.

1.4 Mtoe; additional measures for tertiary appliances contribute another 4.7 Mtoe to close the gap. For the tertiary appliances the AM scenario includes revisions of implementing directives measures (e.g. indoor lighting) of the Ecodesign Directive and extensions to new lots (e.g. ventilation and air-conditioning) in the coming years. For details see sections 5.6.2 and 5.6.3.

- ***Transport sector:*** The energy efficiency directive scenario includes four selected further transport policy measures (see section 5.6.4):
  - A road charge per vehicle-km driven on motorways for passenger cars implemented starting 2014.
  - The promotion of energy efficient public commercial vehicles in the EU from 2014 on.
  - A stimulus programme for cars older than 10 years.

  In difference to the other sectors these are not merely the extension of existing measures but rather the generalisation of successful measures existing partly at national level. In total such measures are expected to contribute around 11.3 Mtoe to close the gap to the 2020 target.

- ***Industry sector:*** Measures to close the gap in 2020 in the industrial sector include revisions of implementing directives for the Ecodesign Directive that are due in 2014/2015. They also include full implementation of the EPBD (recast) on MS level for which we assume an ambitious implementation for industrial premises particularly improving compliance with standards.

  For the Ecodesign Directive, we assume an extension to LEDs (2018), MEPS based on least-lifecycle costs for compressors (2016) and machine tools (2016), and MEPS based on Best Available Technology (BAT) for fans (2018), ventilation and air-conditioning > 12 kW (2018), circulators (2018), fans (2018) and water pumps (2018).

  For policies modelled in an aggregated way (including support/obligations for energy audits, energy management, information, capacity building, procurement obligations and also voluntary agreements), a higher level of ambition is assumed across all countries. This could be promoted by so-called Learning Networks for Energy Efficiency (LEEN) among the less-energy intensive European Industries which have been experienced in Germany, Switzerland, Austria as well as outside Europe to overcome transaction costs in companies. In Germany there are at present 50 networks running grouping around 700 companies. These networks of 10-15 companies have shown that the energy efficiency path is doubled on average through such networks. In the potentials scenarios we further generalize in our modeling the use of such instruments.

  Further included in the possible measures set is the structural reform proposed by the Commission to repair the ETS, resulting in an EUA price of about 35 Euros in 2030.

  Measures in the industry sector expected to contribute another 5 Mtoe to the closure of the gap to the 2020 target.

A summary of the sectoral results is provided in the sectoral overviews (Table 42 to Table 45) as well as in the detailed presentation of results by end-use in the sectoral chapters in 5.6.

The results for the final energy saving potentials for 2030, also presented in Table 41 will be discussed in section 5.7.3.

Table 41: Overview of scenarios and potentials for final energy consumption in the EU27 (Mtoe)

										2020/				2030/				2020
EU27 Final Energy All Sectors (Mtoe)	**2008**	**2009**	**2010**	**2011**	**2012**	**2015**	**2020**	**2025**	**2030**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**Gap to target**
BASE_noEA	1164	1161	1164	1170	1176	1199	1211	1215	1216	104%	109%	90%	107%	104%	114%	86%	109%	9.9%
BASE_inclEA	1169	1168	1163	1144	1138	1135	1108	1087	1070	95%	100%	82%	98%	92%	100%	76%	96%	2.3%
BASE_WM	1169	1168	1163	1144	1137	1134	1108	1085	1067	95%	100%	82%	98%	91%	100%	76%	95%	2.2%
AM	1169	1166	1159	1137	1129	1116	1071	1039	998	92%	97%	79%	95%	85%	93%	71%	89%	-0.6%
Potential_2030_LPI	1169	1166	1159	1137	1129	1116	1059	1019	967	91%	95%	79%	94%	83%	90%	69%	86%	-1.4%
Potential_2030_HPI	1169	1166	1159	1137	1129	1116	1011	951	876	87%	91%	75%	89%	75%	82%	62%	78%	-4.9%
Potential_2030_NE	1169	1166	1159	1137	1129	1116	1003	935	849	86%	90%	74%	89%	73%	79%	60%	76%	-5.6%
EU27 Final Energy All Sectors Comparison (Mtoe)																		
PRIMES 2007			1237			1302	1348	1383	1406			100%				100%		20.0%
PRIMES 2009			1169			1211	1229	1227	1216			91%				87%		11.2%
PRIMES 2009 (corrected for activities from PRIMES 2013)			1155			1162	1159	1154	1144			86%				81%		6.0%
PRIMES 2013			1151			1164	1130	1124	1119			84%				80%		3.9%
Eurostat	1168	1102	1154	1101	1098													
EED Target (final energy)							1078											0.0%

Notes:

- The difference with Eurostat in the years 2008 to 2012 is largely due to the fact that Eurostat values not corrected for annual climatic variations, while the figures of the projections are normalized to 2005 (which was slightly colder than the average of the past ten years). For that reason warmer years such as 2009, 2011 and 2012 deviate stronger from the projections.

- The scenarios are also compared for 2020/2030 with 2008, with the Base_inclEA (which is considered here as the main baseline scenario and which is comparatively close to the recent PRIMES 2013 projections), with PRIMES 2013 and with the older PRIMES 2007 projections (which were used to establish the 20% energy efficiency target for 2020 and which were established before the financial and economic crisis which started 2008).

- The last column measures the gap to the 20% target. The percentage points for the gap refer here to the difference between the PRIMES 2007 projection of final energy of 1348 Mtoe in 2020 and the target of 1074 Mtoe in final energy. The total gap corresponds to 20%.

Table 42: Overview of scenarios and potentials for final energy consumption in the residential sector in the EU27 (Mtoe)

										2020/				2030/			
EU27, Residential buildings (Mtoe)	**2008**	**2009**	**2010**	**2011**	**2012**	**2015**	**2020**	**2025**	**2030**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**
BASE_noEA	247.9	247.4	246.9	246.4	245.9	244.4	241.9	232.5	223.1	98%	104%			90%	106%		
BASE_inclEA	247.9	246.6	245.3	244.0	242.7	238.8	232.3	221.1	209.8	94%	100%			85%	100%		
BASE_WM	247.9	246.6	245.3	244.0	242.7	238.8	232.3	221.1	209.8	94%	100%			85%	100%		
AM	247.9	245.8	243.6	241.5	239.4	233.0	222.3	207.5	192.6	90%	96%			78%	92%		
Potential_2030_LPI	247.9	245.8	243.6	241.5	239.4	233.0	226.2	211.6	197.1	91%	97%			80%	94%		
Potential_2030_HPI	247.9	245.8	243.6	241.5	239.4	233.0	197.5	177.1	156.8	80%	85%			63%	75%		
Potential_2030_NE	247.9	245.8	243.6	241.5	239.4	233.0	197.5	177.1	156.8	80%	85%			63%	75%		
Residential Appliances (Mtoe)																	
BASE_noEA	61.3	62.8	64.3	65.8	67.3	71.8	79.2	84.7	90.1	129%	116%			147%	127%		
BASE_inclEA	61.3	61.9	62.4	63.0	63.6	65.2	68.0	69.5	71.0	111%	100%			116%	100%		
BASE_WM	61.3	61.8	62.3	62.8	63.3	64.8	67.2	67.5	67.8	110%	99%			111%	96%		
AM	61.3	61.7	62.1	62.4	62.8	63.9	65.8	63.1	60.3	107%	98%			98%	89%		
Potential_2030_LPI	61.3	61.7	62.1	62.4	62.8	63.9	65.8	63.1	60.3	107%	97%			98%	85%		
Potential_2030_HPI	61.3	61.7	62.1	62.4	62.8	63.9	63.6	57.5	51.4	104%	93%			84%	72%		
Potential_2030_NE	61.3	61.7	62.1	62.4	62.8	63.9	61.4	53.2	45.1	100%	90%			74%	64%		
										2020/				2030/			
Residential Sector (Mtoe)	**2008**	**2009**	**2010**	**2011**	**2012**	**2015**	**2020**	**2025**	**2030**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**
BASE_noEA	309.2	310.2	311.2	312.2	313.2	316.1	321.1	317.1	313.1	104%	107%	96%	108%	101%	112%	91%	106%
BASE_inclEA	309.2	308.5	307.7	307.0	306.2	304.0	300.4	290.6	280.8	97%	100%	89%	101%	91%	100%	82%	95%
BASE_WM	309.2	308.4	307.6	306.8	306.0	303.6	299.6	288.6	277.6	97%	100%	89%	101%	90%	99%	81%	94%
AM	309.2	307.4	305.7	303.9	302.2	296.9	288.1	270.6	253.0	93%	96%	86%	97%	82%	90%	74%	86%
Potential_2030_LPI	309.2	307.4	305.7	303.9	302.2	296.9	292.0	274.7	257.5	94%	97%	87%	98%	83%	92%	75%	87%
Potential_2030_HPI	309.2	307.4	305.7	303.9	302.2	296.9	261.1	234.6	208.2	84%	87%	78%	88%	67%	74%	61%	70%
Potential_2030_NE	309.2	307.4	305.7	303.9	302.2	296.9	258.9	230.4	201.9	84%	86%	77%	87%	65%	72%	59%	68%
Residential Sector Comparison (Mtoe)																	
PRIMES 2007			320.5			329.7	336.0	340.2	343.3			100%				100%	
PRIMES 2009			309.2			317.2	316.4	312.2	308.3			94%				90%	
PRIMES 2009 (corrected for activities from PRIMES 2013)			310.5			315.0	312.2	308.2	303.4			93%				88%	
PRIMES 2013			309.7			310.0	297.4	298.1	295.4			89%				86%	
Eurostat	289.9	287.5	309.6	274.7	287.2												

Table 43: Overview of scenarios and potentials for final energy consumption in the transport sector in the EU27 (Mtoe)

										2020/				2030/			
Transport Sector (Mtoe)	**2008**	**2009**	**2010**	**2011**	**2012**	**2015**	**2020**	**2025**	**2030**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**
BASE_noEA	355.2	355.0	354.8	361.6	368.3	383.3	390.0	396.2	399.7	110%	121%	89%	109%	113%	129%	86%	114%
BASE_inclEA	360.0	364.6	359.4	344.4	341.1	340.0	322.2	313.0	308.9	90%	100%	73%	90%	86%	100%	67%	88%
BASE_WM	360.0	364.6	359.4	344.4	341.1	340.0	322.2	313.0	308.9	90%	100%	73%	90%	86%	100%	67%	88%
AM	360.0	364.6	359.4	344.4	341.1	336.6	311.0	307.5	295.1	86%	97%	71%	87%	82%	96%	64%	84%
Potential_2030_LPI	360.0	364.6	359.4	344.4	341.1	336.6	305.2	298.5	280.5	85%	95%	70%	86%	78%	91%	61%	80%
Potential_2030_HPI	360.0	364.6	359.4	344.4	341.1	336.6	305.1	292.7	267.5	85%	95%	70%	86%	74%	87%	58%	76%
Potential_2030_NE	360.0	364.6	359.4	344.4	341.1	336.6	305.1	291.7	262.9	85%	95%	70%	86%	73%	85%	57%	75%
Transport Sector Comparison (Mtoe)																	
PRIMES 2007			390.9			418.3	438.6	454.1	463.1			100%				100%	
PRIMES 2009			370.3			388.2	394.9	390.0	379.1			90%				82%	
PRIMES 2009 (corrected for activities from PRIMES 2013)			358.1			360.3	363.8	364.6	361.4			83%				78%	
PRIMES 2013			365.1			370.1	356.8	351.0	351.8			81%				76%	
Eurostat	376.4	363.3	361.8	360.0	349.1												

Table 44: Overview of scenarios and potentials for final energy consumption in the industry sector in the EU27 (Mtoe)

										2020/				2030/			
Industry Sector (Mtoe)	**2008**	**2009**	**2010**	**2011**	**2012**	**2015**	**2020**	**2025**	**2030**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**
BASE_noEA	309.2	308.9	308.6	308.3	308.0	307.0	305.4	308.0	310.7	99%	102%	83%	100%	100%	104%	80%	102%
BASE_inclEA	309.2	308.4	307.5	306.7	305.8	303.3	299.1	299.2	299.3	97%	100%	81%	98%	97%	100%	77%	98%
BASE_WM	309.2	308.4	307.5	306.7	305.8	303.3	299.1	299.2	299.3	97%	100%	81%	98%	97%	100%	77%	98%
AM	309.2	308.0	306.7	305.5	304.2	300.5	294.2	292.2	290.1	95%	98%	80%	97%	94%	97%	75%	95%
Potential_2030_LPI	309.2	308.0	306.7	305.5	304.2	300.5	285.6	279.4	273.2	92%	95%	78%	94%	88%	91%	71%	89%
Potential_2030_HPI	309.2	308.0	306.7	305.5	304.2	300.5	281.2	273.6	265.9	91%	94%	76%	92%	86%	89%	69%	87%
Potential_2030_NE	309.2	308.0	306.7	305.5	304.2	300.5	275.7	264.6	253.4	89%	92%	75%	91%	82%	85%	66%	83%
Industry Sector Comparison (Mtoe)																	
PRIMES 2007			338.5			355.3	367.7	378.4	386.4			100%				100%	
PRIMES 2009			312.8			322.8	332.9	338.8	344.3			91%				89%	
PRIMES 2009 (corrected for activities from PRIMES 2013)			304.3			307.3	306.5	305.8	305.4			83%				79%	
PRIMES 2013			289.6			303.3	304.6	304.1	305.3			83%				79%	
Eurostat	315.7	268.4	289.4	288.0	281.2												

Table 45: Overview of scenarios and potentials for final energy consumption in the tertiary sector in the EU27 (Mtoe)

										2020/				2030/			
Tertiary buildings (incl. electric heating/hot water) (Mtoe)	**2008**	**2009**	**2010**	**2011**	**2012**	**2015**	**2020**	**2025**	**2030**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**
BASE_noEA	91.2	91.0	90.7	90.5	90.2	89.4	88.2	83.6	79.1	97%	106%			87%	108%		
BASE_inclEA	91.2	90.6	89.9	89.3	88.6	86.7	83.5	78.4	73.2	92%	100%			80%	100%		
BASE_WM	91.2	90.6	89.9	89.3	88.6	86.7	83.5	78.4	73.2	92%	100%			80%	100%		
AM	91.2	90.2	89.2	88.2	87.2	84.1	79.1	72.4	65.8	87%	95%			72%	90%		
Potential_2030_LPI	91.2	90.2	89.2	88.2	87.2	84.1	81.1	75.0	68.9	89%	97%			76%	94%		
Potential_2030_HPI	91.2	90.2	89.2	88.2	87.2	84.1	71.2	62.7	54.2	78%	85%			59%	74%		
Potential_2030_NE	91.2	90.2	89.2	88.2	87.2	84.1	71.2	62.7	54.2	78%	85%			59%	74%		
Tertiary appliances (Mtoe)																	
BASE_noEA	61.1	61.9	62.6	63.4	64.2	66.5	70.4	74.4	78.3	115%	104%			128%	106%		
BASE_inclEA	61.1	61.6	62.2	62.8	63.3	65.0	67.9	70.9	74.0	111%	100%			121%	100%		
BASE_WM	61.1	61.6	62.2	62.8	63.3	65.0	67.9	70.9	74.0	111%	100%			121%	100%		
AM	61.1	61.3	61.4	61.6	61.8	62.3	63.2	62.2	61.2	103%	93%			100%	83%		
Potential_2030_LPI	61.1	61.3	61.4	61.6	61.8	62.3	60.0	57.5	55.1	98%	88%			90%	74%		
Potential_2030_HPI	61.1	61.3	61.4	61.6	61.8	62.3	58.6	54.7	50.8	96%	86%			83%	69%		
Potential_2030_NE	61.1	61.3	61.4	61.6	61.8	62.3	58.6	54.7	50.8	96%	86%			83%	69%		
Agriculture/Fishing (Mtoe)																	
BASE_noEA	25.6	24.7	25.0	24.2	24.5	24.5	24.2	23.7	23.0	94%	100%			90%	100%		
BASE_inclEA	25.6	24.7	25.0	24.2	24.5	24.5	24.2	23.7	23.0	94%	100%			90%	100%		
BASE_WM	25.6	24.7	25.0	24.2	24.5	24.5	24.2	23.7	23.0	94%	100%			90%	100%		
AM	25.6	24.7	25.0	24.2	24.5	24.5	24.2	23.7	23.0	94%	100%			90%	100%		
Potential_2030_LPI	25.6	24.7	25.0	24.2	24.5	24.5	23.9	23.1	21.8	93%	99%			85%	95%		
Potential_2030_HPI	25.6	24.7	25.0	24.2	24.5	24.5	23.5	22.4	20.5	92%	97%			80%	89%		
Potential_2030_NE	25.6	24.7	25.0	24.2	24.5	24.5	22.9	21.1	17.9	89%	95%			70%	78%		
										2020/				2030/			
Tertiary Sector (Mtoe)	**2008**	**2009**	**2010**	**2011**	**2012**	**2015**	**2020**	**2025**	**2030**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**
BASE_noEA	190.1	187.3	189.9	187.5	186.8	192.1	194.5	193.5	192.4	102%	104%	95%	113%	101%	106%	90%	116%
BASE_inclEA	190.1	186.7	188.7	185.7	184.4	187.6	186.8	184.0	181.1	98%	100%	91%	109%	95%	100%	85%	109%
BASE_WM	190.1	186.7	188.7	185.7	184.4	187.6	186.8	184.0	181.1	98%	100%	91%	109%	95%	100%	85%	109%
AM	190.1	186.0	187.2	183.4	181.3	182.1	177.2	168.7	160.0	93%	95%	86%	103%	84%	88%	75%	96%
Potential_2030_LPI	190.1	186.0	187.2	183.4	181.3	182.1	175.8	166.1	156.0	92%	94%	86%	102%	82%	86%	73%	94%
Potential_2030_HPI	190.1	186.0	187.2	183.4	181.3	182.1	163.8	149.6	134.3	86%	88%	80%	95%	71%	74%	63%	81%
Potential_2030_NE	190.1	186.0	187.2	183.4	181.3	182.1	163.0	148.0	131.0	86%	87%	79%	95%	69%	72%	62%	79%
Tertiary Sector Comparison (Mtoe)																	
PRIMES 2007			187.1			198.7	205.5	210.0	212.9			100%				100%	
PRIMES 2009			176.2			182.8	185.0	185.6	184.7			90%				87%	
PRIMES 2009 (corrected for activities from PRIMES 2013)			182.1			179.7	176.5	175.7	174.1			86%				82%	
PRIMES 2013			186.8			180.9	171.6	170.6	166.2			84%				78%	
Eurostat (incl. Agriculture/fishing and non-specifed others	186.3	182.6	193.1	178.6	180.2												

5.7.2 The 2020 target in primary energy terms

This section discusses the question whether the primary energy target in 2020 of 1474 Mtoe will be reached and in which scenario.

Table 46 discusses the level of primary energy which is reached in the different scenarios. For this purpose we use (1) the conversion factors to primary energy (excluding non-energy use) provided by PRIMES 2013; (2) conversion factors derived from calculations with the PowerAce model (see Annex 2) under the assumptions described in section 5.6.6.

Table 46 shows the level of primary energy which is reached in the Base_inclEA scenario. The primary energy target in 2020 is missed by 1.7%[34]. The same holds for the WM scenario. The conversion to primary energy assumes the same power generation mix as PRIMES 2013, hence a similar share for renewable energy sources as in the PRIMES 2013 baseline. The AM closes the gap to the EED target and reaches a level of 1453 Mtoe. **Hence, assuring that the final energy gap is closed, also assures that the primary energy gap will be closed.**

With the potential scenarios that aim for 2030, the primary energy target is exceeded, especially when the final energy scenarios are combined with supply scenarios using higher shares of renewable, more decentral CHP schemes and higher efficiency power plants based on gas.

In GHG terms a reduction of over 27% would be reached by 2020 in the AM scenario (see Table 47).

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[34] The percentage points for the gap refer here to the difference between the PRIMES 2007 projection of primary energy (excl. non-energy uses) of 1842 Mtoe in 2020 and the target of 1478 Mtoe in final energy. The total gap corresponds to 20%. In the whole text we will report the gaps in such a way.

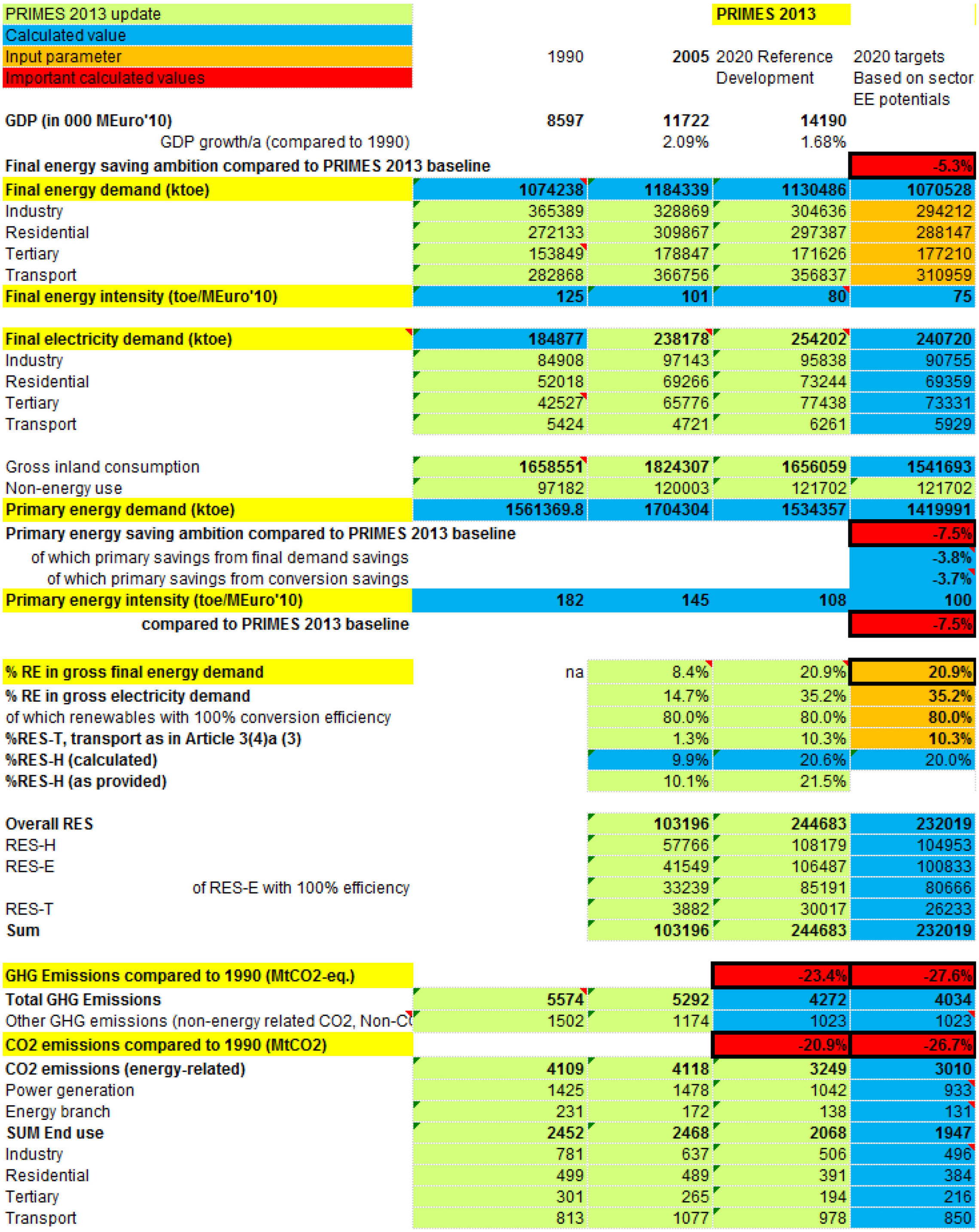
Table 46: Overview of scenarios and potentials for primary energy consumption in the EU27 (Mtoe)

										2020/				2030/				2020
EU27 Primary Energy All Sectors (Mtoe, excl. non-energy uses)	**2008**	**2009**	**2010**	**2011**	**2012**	**2015**	**2020**	**2025**	**2030**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**2008**	**B_inclEA**	**PRIMES2007**	**PRIMES2013**	**Gap to targe**
BASE_noEA	1682	1681	1669	1696	1697	1667	1644	1626	1611	98%	109%	89%	107%	96%	114%	86%	109%	9.2%
BASE_inclEA	1689	1691	1668	1658	1641	1578	1504	1454	1418	89%	100%	82%	98%	84%	100%	76%	96%	1.7%
BASE_WM	1689	1691	1667	1658	1641	1577	1503	1452	1413	89%	100%	82%	98%	84%	100%	75%	95%	1.6%
AM	1689	1688	1661	1649	1629	1552	1453	1390	1322	86%	97%	79%	95%	78%	93%	71%	89%	-1.1%
Potential_2030_LPI	1689	1688	1661	1649	1629	1552	1437	1363	1281	85%	95%	78%	94%	76%	90%	68%	86%	-2.0%
Potential_2030_LPI (+27%RES;44% RES-E;41% thermal electric eff.)	1689					1552	1437	1351	1252	85%	95%	78%	94%	74%	88%	67%	84%	-2.0%
Potential_2030_HPI	1689	1688	1661	1649	1629	1552	1373	1272	1160	81%	91%	75%	89%	69%	82%	62%	78%	-5.5%
Potential_2030_HPI (+35%RES;47% RES-E;43% thermal electric eff.)	1689					1552	1364	1243	1109	81%	91%	74%	89%	66%	78%	59%	75%	-6.0%
Potential_2030_NE	1689	1688	1661	1649	1629	1552	1361	1251	1125	81%	90%	74%	89%	67%	79%	60%	76%	-6.1%
Potential_2030_NE (+35%RES;55% RES-E;45% thermal electric eff.)	1689					1552	1340	1198	1042	79%	89%	73%	87%	62%	73%	56%	70%	-7.3%
EU27 Primary Energy (Mtoe, excl. non-energy uses)																		
PRIMES 2007			1738			1807	1842	1868	1873			100%				100%		20.0%
PRIMES 2009			1655			1677	1664	1654	1635			90%				87%		10.3%
PRIMES 2009 (corrected for activities from PRIMES 2013)			1636			1610	1569	1556	1538			85%				82%		5.2%
PRIMES 2013			1645			1619	1534	1504	1482			83%				79%		3.3%
Eurostat	1689	1595	1654	1597	1584													
EED Target (primary energy)							1474											0.0%

Notes:

- See the notes in Table 41
- The last column measures the gap to the 20% target. The percentage points for the gap refer here to the difference between the PRIMES 2007 projection of primary energy of 1842 Mtoe in 2020 and the target of 1478 Mtoe in primary energy. The total gap corresponds to 20%.
- The final energy scenarios LPI, HPI and NE are combined supply scenarios which go beyond the PRIMES 2013 baseline:
    - LPI scenario: refurbishment of existing thermal power plants; renewables share at 27% (44% RES-E). Conversion efficiency of thermal power plants at 41% in 2030.
    - HPI scenario: electric conversion efficiency of thermal power generation at 43% through use of decentral CHP that support renewables by offering flexibility services, the installation of the most efficient coal and gas-fired power plants when it comes to reinvestment, and raising the share of RES to 35% (47% RES-E).
    - NE scenario: electric conversion efficiency of thermal power generation at 45% implying larger use of gas-fired CCGT plants and of decentral cogeneration schemes together with a RES-E corridor of up to 55% by 2030 for the European power mix.

Table 47: Primary energy savings and GHG savings in the AM scenario in the EU27 in 2020



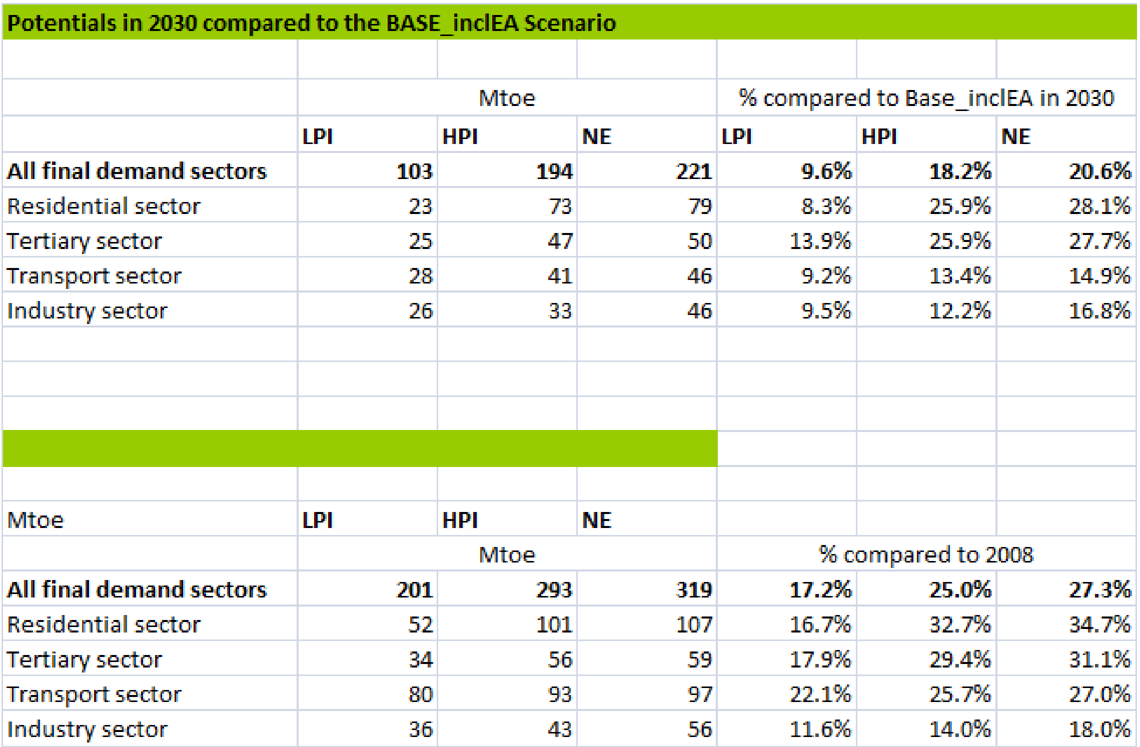
🟩 PRIMES 2013 update
🟦 Calculated value
🟧 Input parameter
🟥 Important calculated values

	1990	2005	PRIMES 2013 2020 Reference Development	2020 targets Based on sector EE potentials
GDP (in 000 MEuro'10)	**8597**	**11722**	**14190**	
GDP growth/a (compared to 1990)		2.09%	1.68%	
Final energy saving ambition compared to PRIMES 2013 baseline				-5.3%
Final energy demand (ktoe)	**1074238**	**1184339**	**1130486**	**1070528**
Industry	365389	328869	304636	294212
Residential	272133	309867	297387	288147
Tertiary	153849	178847	171626	177210
Transport	282868	366756	356837	310959
Final energy intensity (toe/MEuro'10)	**125**	**101**	**80**	**75**
Final electricity demand (ktoe)	**184877**	**238178**	**254202**	**240720**
Industry	84908	97143	95838	90755
Residential	52018	69266	73244	69359
Tertiary	42527	65776	77438	73331
Transport	5424	4721	6261	5929
Gross inland consumption	**1658551**	**1824307**	**1656059**	**1541693**
Non-energy use	97182	120003	121702	121702
Primary energy demand (ktoe)	**1561369.8**	**1704304**	**1534357**	**1419991**
Primary energy saving ambition compared to PRIMES 2013 baseline				-7.5%
of which primary savings from final demand savings				-3.8%
of which primary savings from conversion savings				-3.7%
Primary energy intensity (toe/MEuro'10)	**182**	**145**	**108**	**100**
compared to PRIMES 2013 baseline				-7.5%
% RE in gross final energy demand	na	8.4%	20.9%	**20.9%**
% RE in gross electricity demand		14.7%	35.2%	**35.2%**
of which renewables with 100% conversion efficiency		80.0%	80.0%	**80.0%**
%RES-T, transport as in Article 3(4)a (3)		1.3%	10.3%	**10.3%**
%RES-H (calculated)		9.9%	20.6%	20.0%
%RES-H (as provided)		10.1%	21.5%	
Overall RES		**103196**	**244683**	**232019**
RES-H		57766	108179	104953
RES-E		41549	106487	100833
of RES-E with 100% efficiency		33239	85191	80666
RES-T		3882	30017	26233
Sum		**103196**	**244683**	**232019**
GHG Emissions compared to 1990 (MtCO2-eq.)			-23.4%	-27.6%
Total GHG Emissions	**5574**	**5292**	**4272**	**4034**
Other GHG emissions (non-energy related CO2, Non-C	1502	1174	1023	1023
CO2 emissions compared to 1990 (MtCO2)			-20.9%	-26.7%
CO2 emissions (energy-related)	**4109**	**4118**	**3249**	**3010**
Power generation	1425	1478	1042	933
Energy branch	231	172	138	131
SUM End use	**2452**	**2468**	**2068**	**1947**
Industry	781	637	506	496
Residential	499	489	391	384
Tertiary	301	265	194	216
Transport	813	1077	978	850

5.7.3 The 2030 potentials in final energy terms

Table 41 to Table 45 also represent the final energy potentials in the different scenarios for 2030. Table 48 summarises these potentials compared to the Base_inclEA and compared to 2008 for the LPI/HPI/NE scenarios (EU27). The summary shows that all sectors contribute substantially to the 2030 potentials, the transport and industry sector more strongly in the LPI scenario compared to the residential/tertiary sectors, and the latter more in the HPI and NE scenarios. The transport section contributes less in percentage terms because quite a lot is already included in the Base_inclEA. For the differences with the PRIMES 2013 projection see the discussion in section 5.6.4.

Table 48: Summary of final energy savings in the LPI/HPI/NE scenarios (EU27) for 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%
Mtoe	**LPI**	**HPI**	**NE**			
	Mtoe			% compared to 2008		
All final demand sectors	**201**	**293**	**319**	**17.2%**	**25.0%**	**27.3%**
Residential sector	52	101	107	16.7%	32.7%	34.7%
Tertiary sector	34	56	59	17.9%	29.4%	31.1%
Transport sector	80	93	97	22.1%	25.7%	27.0%
Industry sector	36	43	56	11.6%	14.0%	18.0%

Compared to the present PRIMES 2013 reference development the HPI presents in 2030 additional economic savings of about 22%. In absolute terms a level of final energy of 876 Mtoe may be reached for the EU27 in the HPI, compared to a level of 1098 Mtoe[35] reached in 2012 (Eurostat).

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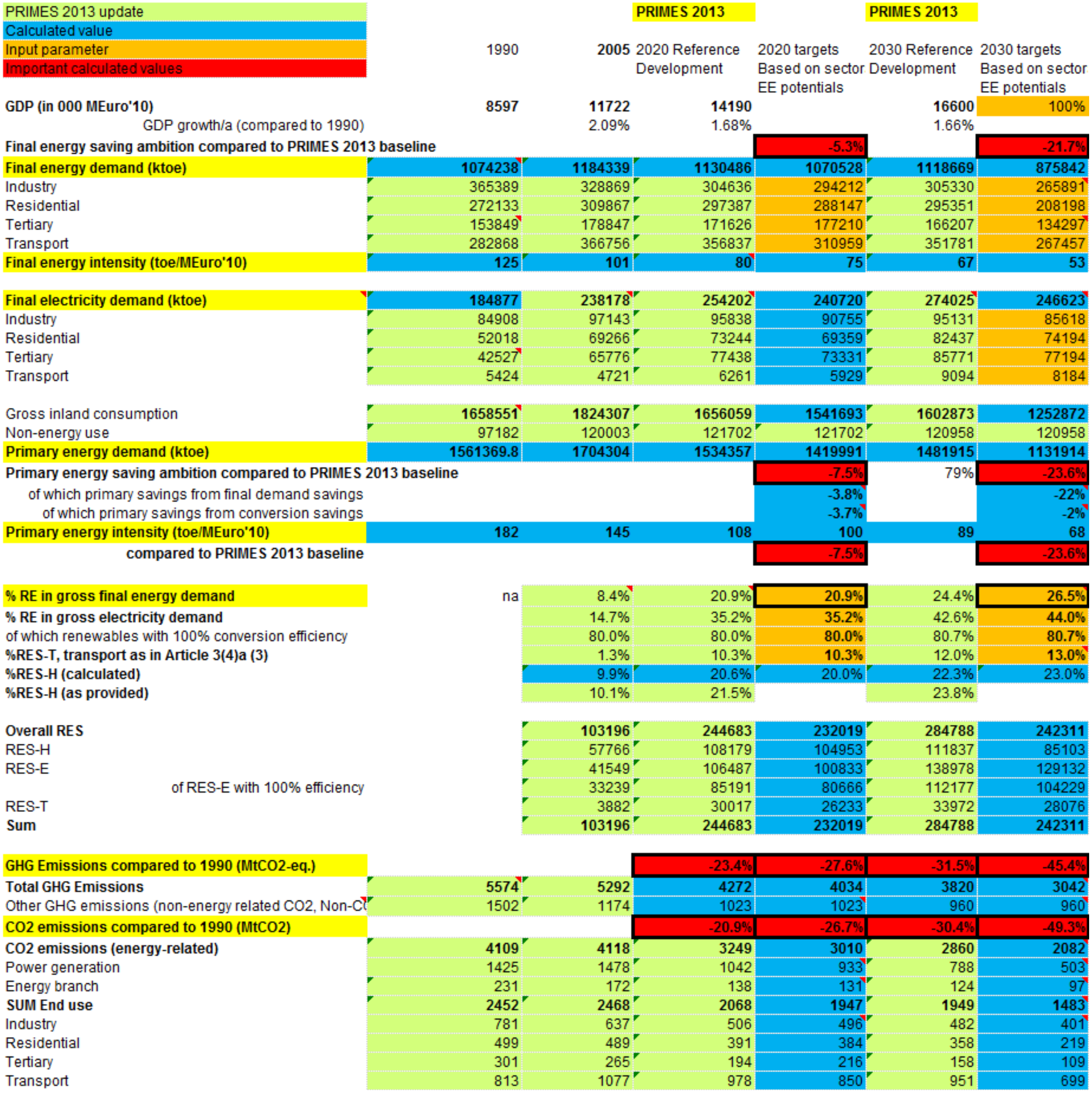
[35] Note that 2012 was a comparatively mild year compared to the average of the previous decade.

If the same metric is used for the 2030 potentials as for the 2020 target (that is, reference to the PRIMES 2007 baseline), then the percentage savings in the HPI in 2030 amount to 38% (see Table 41).

5.7.4 The 2030 potentials in primary energy terms and in terms of GHG savings

This section presents the 2030 potentials in primary energy terms and in terms of GHG savings compared to 1990 (see also Table 46 and the explanations in sections 5.6.6 and 5.7.2). Fossil power generation was set at an average level of 50% compared to a level of 35% at the EU average today. We calculated three variants, see Table 49 to Table 51).

Table 49: Primary energy savings and GHG savings in the HPI scenario (EU27) in 2030, 100% realization of economic potentials (HPI), 27% renewable (44% RES-E in gross electricity generation), 41% thermal power efficiency

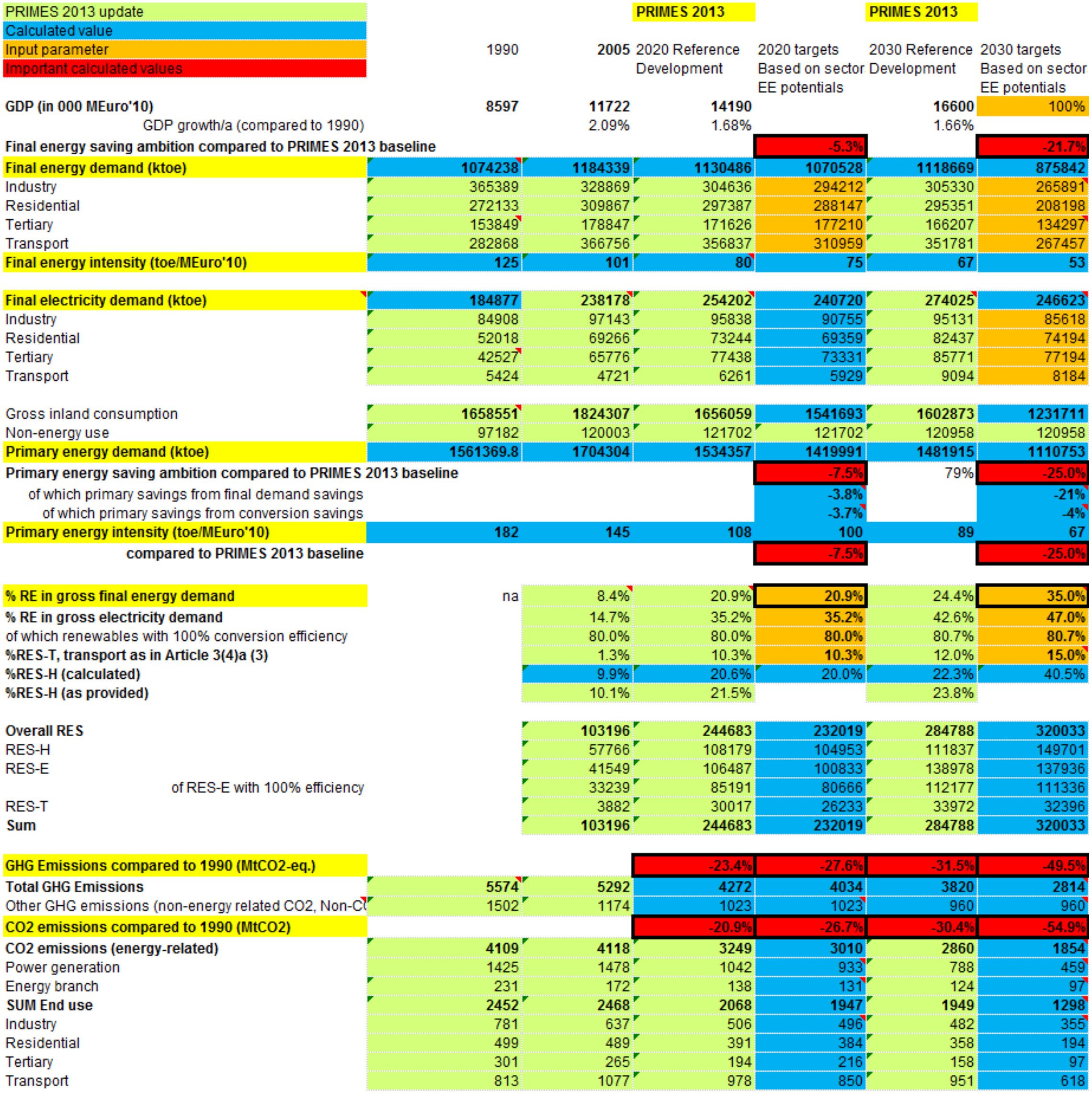


PRIMES 2013 update
Calculated value
Input parameter
Important calculated values

	1990	2005	PRIMES 2013 2020 Reference Development	2020 targets Based on sector EE potentials	PRIMES 2013 2030 Reference Development	2030 targets Based on sector EE potentials
GDP (in 000 MEuro'10)	**8597**	**11722**	**14190**		**16600**	100%
GDP growth/a (compared to 1990)		2.09%	1.68%		1.66%	
Final energy saving ambition compared to PRIMES 2013 baseline				-5.3%		-21.7%
Final energy demand (ktoe)	**1074238**	**1184339**	**1130486**	**1070528**	**1118669**	**875842**
Industry	365389	328869	304636	294212	305330	265891
Residential	272133	309867	297387	288147	295351	208198
Tertiary	153849	178847	171626	177210	166207	134297
Transport	282868	366756	356837	310959	351781	267457
Final energy intensity (toe/MEuro'10)	**125**	**101**	**80**	**75**	**67**	**53**
Final electricity demand (ktoe)	**184877**	**238178**	**254202**	**240720**	**274025**	**246623**
Industry	84908	97143	95838	90755	95131	85618
Residential	52018	69266	73244	69359	82437	74194
Tertiary	42527	65776	77438	73331	85771	77194
Transport	5424	4721	6261	5929	9094	8184
Gross inland consumption	**1658551**	**1824307**	**1656059**	**1541693**	**1602873**	**1252872**
Non-energy use	97182	120003	121702	121702	120958	120958
Primary energy demand (ktoe)	**1561369.8**	**1704304**	**1534357**	**1419991**	**1481915**	**1131914**
Primary energy saving ambition compared to PRIMES 2013 baseline				-7.5%	79%	-23.6%
of which primary savings from final demand savings				-3.8%		-22%
of which primary savings from conversion savings				-3.7%		-2%
Primary energy intensity (toe/MEuro'10)	**182**	**145**	**108**	**100**	**89**	**68**
compared to PRIMES 2013 baseline				-7.5%		-23.6%
% RE in gross final energy demand	na	8.4%	20.9%	**20.9%**	24.4%	**26.5%**
% RE in gross electricity demand		14.7%	35.2%	**35.2%**	42.6%	**44.0%**
of which renewables with 100% conversion efficiency		80.0%	80.0%	**80.0%**	80.7%	**80.7%**
%RES-T, transport as in Article 3(4)a (3)		1.3%	10.3%	**10.3%**	12.0%	**13.0%**
%RES-H (calculated)		9.9%	20.6%	20.0%	22.3%	23.0%
%RES-H (as provided)		10.1%	21.5%		23.8%	
Overall RES		**103196**	**244683**	**232019**	**284788**	**242311**
RES-H		57766	108179	104953	111837	85103
RES-E		41549	106487	100833	138978	129132
of RES-E with 100% efficiency		33239	85191	80666	112177	104229
RES-T		3882	30017	26233	33972	28076
Sum		**103196**	**244683**	**232019**	**284788**	**242311**
GHG Emissions compared to 1990 (MtCO2-eq.)			-23.4%	-27.6%	-31.5%	-45.4%
Total GHG Emissions	**5574**	**5292**	**4272**	**4034**	**3820**	**3042**
Other GHG emissions (non-energy related CO2, Non-C	1502	1174	1023	1023	960	960
CO2 emissions compared to 1990 (MtCO2)			-20.9%	-26.7%	-30.4%	-49.3%
CO2 emissions (energy-related)	**4109**	**4118**	**3249**	**3010**	**2860**	**2082**
Power generation	1425	1478	1042	933	788	503
Energy branch	231	172	138	131	124	97
SUM End use	**2452**	**2468**	**2068**	**1947**	**1949**	**1483**
Industry	781	637	506	496	482	401
Residential	499	489	391	384	358	219
Tertiary	301	265	194	216	158	109
Transport	813	1077	978	850	951	699

For the conversion to primary energy terms we assumed for renewables a level of 27% in gross final energy consumption as proposed by the EU Commission as a minimum level (see Table 49). Primary energy reaches -23.6% compared to the PRIMES 2013 baseline. **By realising the economic potentials for energy efficiency GHG emissions are reduced by more than 45%**.

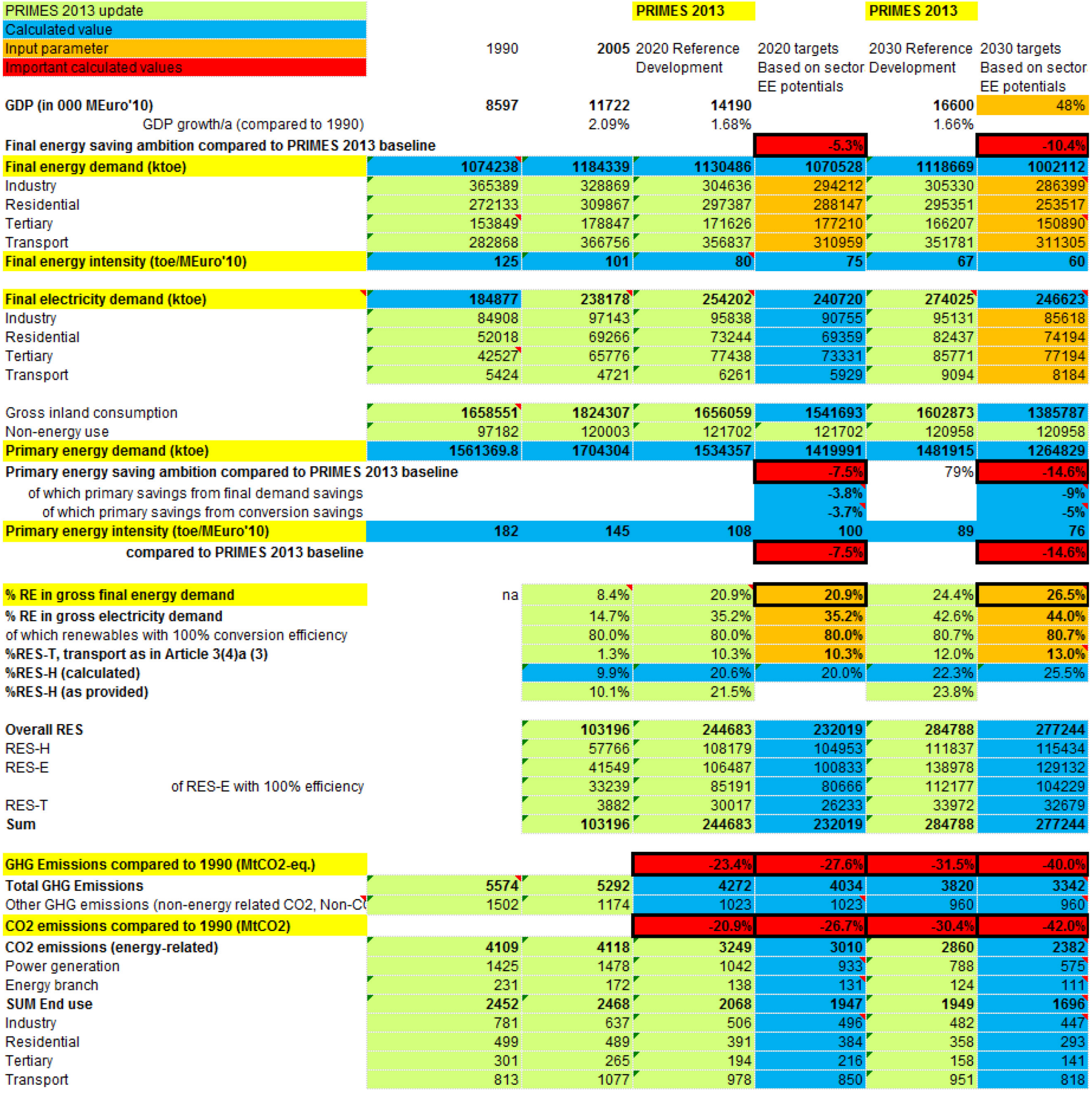
Table 50: Primary energy savings and GHG savings in the HPI scenario (EU27) in 2030, 100% realization of economic potentials (HPI), 35% renewable (47% RES-E in gross electricity generation), 43% thermal power efficiency, enhancement of decentral Combined Heat and Power Generation CHP



🟩 PRIMES 2013 update			PRIMES 2013		PRIMES 2013	
🟦 Calculated value						
🟧 Input parameter	1990	**2005**	2020 Reference Development	2020 targets Based on sector EE potentials	2030 Reference Development	2030 targets Based on sector EE potentials
🟥 Important calculated values						
GDP (in 000 MEuro'10)	**8597**	**11722**	**14190**		**16600**	100%
GDP growth/a (compared to 1990)		2.09%	1.68%		1.66%	
Final energy saving ambition compared to PRIMES 2013 baseline				-5.3%		-21.7%
Final energy demand (ktoe)	**1074238**	**1184339**	**1130486**	**1070528**	**1118669**	**875842**
Industry	365389	328869	304636	294212	305330	265891
Residential	272133	309867	297387	288147	295351	208198
Tertiary	153849	178847	171626	177210	166207	134297
Transport	282868	366756	356837	310959	351781	267457
Final energy intensity (toe/MEuro'10)	**125**	**101**	**80**	**75**	**67**	**53**
Final electricity demand (ktoe)	**184877**	**238178**	**254202**	**240720**	**274025**	**246623**
Industry	84908	97143	95838	90755	95131	85618
Residential	52018	69266	73244	69359	82437	74194
Tertiary	42527	65776	77438	73331	85771	77194
Transport	5424	4721	6261	5929	9094	8184
Gross inland consumption	**1658551**	**1824307**	**1656059**	**1541693**	**1602873**	**1231711**
Non-energy use	97182	120003	121702	121702	120958	120958
Primary energy demand (ktoe)	**1561369.8**	**1704304**	**1534357**	**1419991**	**1481915**	**1110753**
Primary energy saving ambition compared to PRIMES 2013 baseline				-7.5%	79%	-25.0%
of which primary savings from final demand savings				-3.8%		-21%
of which primary savings from conversion savings				-3.7%		-4%
Primary energy intensity (toe/MEuro'10)	**182**	**145**	**108**	**100**	**89**	**67**
compared to PRIMES 2013 baseline				-7.5%		-25.0%
% RE in gross final energy demand	na	8.4%	20.9%	**20.9%**	24.4%	**35.0%**
% RE in gross electricity demand		14.7%	35.2%	**35.2%**	42.6%	**47.0%**
of which renewables with 100% conversion efficiency		80.0%	80.0%	**80.0%**	80.7%	**80.7%**
%RES-T, transport as in Article 3(4)a (3)		1.3%	10.3%	**10.3%**	12.0%	**15.0%**
%RES-H (calculated)		9.9%	20.6%	20.0%	22.3%	40.5%
%RES-H (as provided)		10.1%	21.5%		23.8%	
Overall RES		**103196**	**244683**	**232019**	**284788**	**320033**
RES-H		57766	108179	104953	111837	149701
RES-E		41549	106487	100833	138978	137936
of RES-E with 100% efficiency		33239	85191	80666	112177	111336
RES-T		3882	30017	26233	33972	32396
Sum		**103196**	**244683**	**232019**	**284788**	**320033**
GHG Emissions compared to 1990 (MtCO2-eq.)			-23.4%	-27.6%	-31.5%	-49.5%
Total GHG Emissions	**5574**	**5292**	**4272**	**4034**	**3820**	**2814**
Other GHG emissions (non-energy related CO2, Non-C	1502	1174	1023	1023	960	960
CO2 emissions compared to 1990 (MtCO2)			-20.9%	-26.7%	-30.4%	-54.9%
CO2 emissions (energy-related)	**4109**	**4118**	**3249**	**3010**	**2860**	**1854**
Power generation	1425	1478	1042	933	788	459
Energy branch	231	172	138	131	124	97
SUM End use	**2452**	**2468**	**2068**	**1947**	**1949**	**1298**
Industry	781	637	506	496	482	355
Residential	499	489	391	384	358	194
Tertiary	301	265	194	216	158	97
Transport	813	1077	978	850	951	618

For comparison purposes we used a level of renewable of 35% in gross final energy (47% RES-E) (see Table 50). This is a level which is at reach given the present path to the 20% target for renewable up to 2020. We combine this with an efficiency level of 43% for thermal power generation and the penetration of local CHP. Primary energy reaches -25% compared to the PRIMES 2013 baseline. **By realising the economic potentials for energy efficiency combined with a 35% renewable target GHG emissions are reduced by 49.5%.**

Table 51: Degree of realisation of economic potentials if 40% GHG reduction are to be achieved (EU27) in 2030, 27% renewables



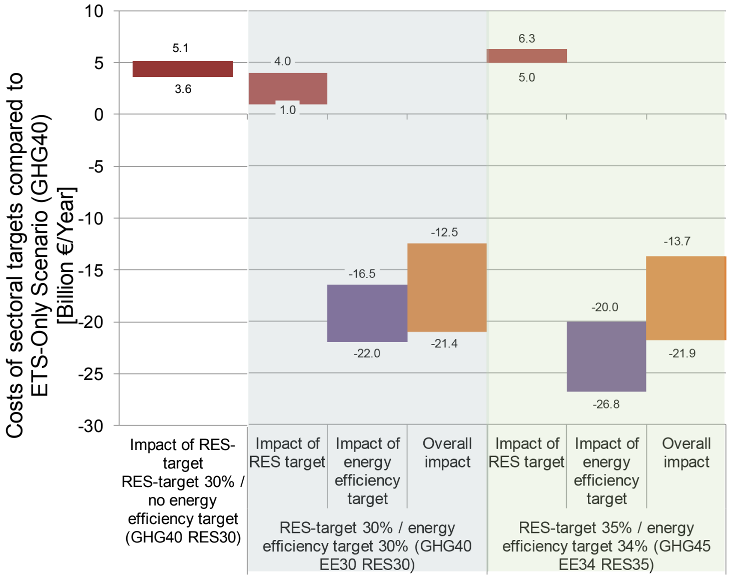
PRIMES 2013 update			PRIMES 2013		PRIMES 2013	
Calculated value						
Input parameter	1990	2005	2020 Reference Development	2020 targets Based on sector EE potentials	2030 Reference Development	2030 targets Based on sector EE potentials
Important calculated values						
GDP (in 000 MEuro'10)	**8597**	**11722**	**14190**		**16600**	48%
GDP growth/a (compared to 1990)		2.09%	1.68%		1.66%	
Final energy saving ambition compared to PRIMES 2013 baseline				-5.3%		-10.4%
Final energy demand (ktoe)	**1074238**	**1184339**	**1130486**	**1070528**	**1118669**	**1002112**
Industry	365389	328869	304636	294212	305330	286399
Residential	272133	309867	297387	288147	295351	253517
Tertiary	153849	178847	171626	177210	166207	150890
Transport	282868	366756	356837	310959	351781	311305
Final energy intensity (toe/MEuro'10)	**125**	**101**	**80**	**75**	**67**	**60**
Final electricity demand (ktoe)	**184877**	**238178**	**254202**	**240720**	**274025**	**246623**
Industry	84908	97143	95838	90755	95131	85618
Residential	52018	69266	73244	69359	82437	74194
Tertiary	42527	65776	77438	73331	85771	77194
Transport	5424	4721	6261	5929	9094	8184
Gross inland consumption	**1658551**	**1824307**	**1656059**	**1541693**	**1602873**	**1385787**
Non-energy use	97182	120003	121702	121702	120958	120958
Primary energy demand (ktoe)	**1561369.8**	**1704304**	**1534357**	**1419991**	**1481915**	**1264829**
Primary energy saving ambition compared to PRIMES 2013 baseline				-7.5%	79%	-14.6%
of which primary savings from final demand savings				-3.8%		-9%
of which primary savings from conversion savings				-3.7%		-5%
Primary energy intensity (toe/MEuro'10)	**182**	**145**	**108**	**100**	**89**	**76**
compared to PRIMES 2013 baseline				-7.5%		-14.6%
% RE in gross final energy demand	na	8.4%	20.9%	**20.9%**	24.4%	**26.5%**
% RE in gross electricity demand		14.7%	35.2%	**35.2%**	42.6%	**44.0%**
of which renewables with 100% conversion efficiency		80.0%	80.0%	**80.0%**	80.7%	**80.7%**
%RES-T, transport as in Article 3(4)a (3)		1.3%	10.3%	**10.3%**	12.0%	**13.0%**
%RES-H (calculated)		9.9%	20.6%	20.0%	22.3%	25.5%
%RES-H (as provided)		10.1%	21.5%		23.8%	
Overall RES		**103196**	**244683**	**232019**	**284788**	**277244**
RES-H		57766	108179	104953	111837	115434
RES-E		41549	106487	100833	138978	129132
of RES-E with 100% efficiency		33239	85191	80666	112177	104229
RES-T		3882	30017	26233	33972	32679
Sum		**103196**	**244683**	**232019**	**284788**	**277244**
GHG Emissions compared to 1990 (MtCO2-eq.)			-23.4%	-27.6%	-31.5%	-40.0%
Total GHG Emissions	**5574**	**5292**	**4272**	**4034**	**3820**	**3342**
Other GHG emissions (non-energy related CO2, Non-C	1502	1174	1023	1023	960	960
CO2 emissions compared to 1990 (MtCO2)			-20.9%	-26.7%	-30.4%	-42.0%
CO2 emissions (energy-related)	**4109**	**4118**	**3249**	**3010**	**2860**	**2382**
Power generation	1425	1478	1042	933	788	575
Energy branch	231	172	138	131	124	111
SUM End use	**2452**	**2468**	**2068**	**1947**	**1949**	**1696**
Industry	781	637	506	496	482	447
Residential	499	489	391	384	358	293
Tertiary	301	265	194	216	158	141
Transport	813	1077	978	850	951	818

In order to reach a level of 40% GHG reduction in combination with 27% reduction in renewables less than 50% of the economic potentials for energy efficiency need to be realised, neglecting the economic benefits that are combined with a full realisation of economic potentials for energy efficiency (see Table 51).

5.7.5 The cost/benefits of realizing the HPI Scenario

The overall economic benefits for realising the High Policy Intensity Scenario as described in this report are in the range of 22-27 billion Euro annually on average up to 2030 for targets in the range of 30-34%, for the LPI in the range of 13-14 billion Euro. These benefits can largely compensate for the /rather modest additional costs as compared to renewable if RES targets in the range of 30-35% are envisaged as compared to the presently envisaged 27%.

Figure 53: Net benefits from energy efficiency potentials as investigated in this report that may compensate for modest additional costs for renewables



- Range from RES-targets and energy efficiency targets results from different policy measures
- Additional average annual costs for RES- targets are moderate amounting from EUR 1 – 4 billion for a combined target of 30% for RES and 30% for energy efficiency
- Energy efficiency targets reduce costs of RES-targets and leads to overall economic savings ranging from -13 to -21 billion Euro

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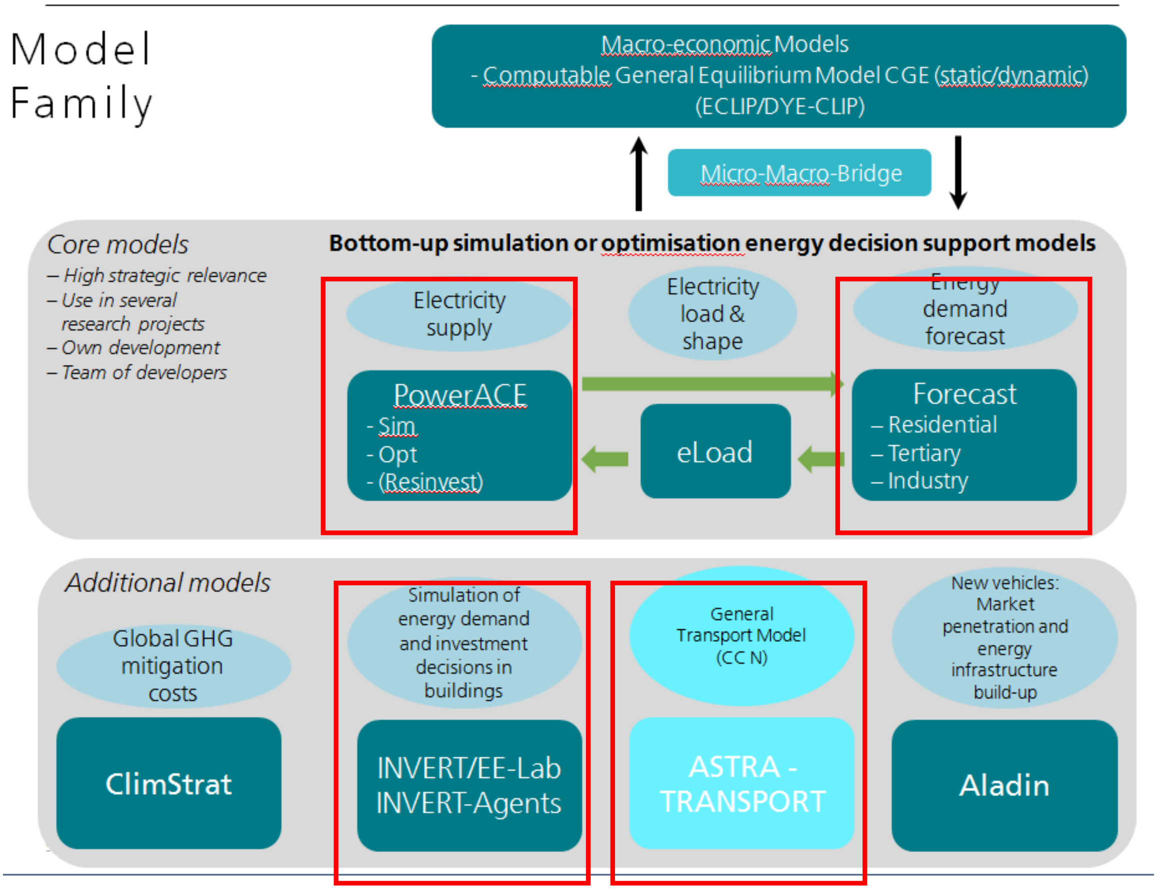
Annex 1 - Overview of in-house models

The following graph shows an overview of the in-house models run by Fraunhofer ISI and TU Wien. The ones used in this study are marked in red and described in more detail in the following:

Figure 54: Overview of bottom-up models used in the study



- **The Invert/EE-Lab model** (run by TU Wien) for residential and non-residential buildings. This is a dynamic bottom-up simulation tool. The basic idea of the model is to describe the building stock, heating, cooling and hot water systems on highly disaggregated level, calculate related energy needs and delivered energy, determine reinvestment cycles and new investment of building components and technologies and simulate the decisions of various agents (i.e. owner types) in case that an investment decision is due for a specific building segment.
- **The FORECAST platform** (run by Fraunhofer ISI), including an industrial model as well as the electricity uses in the residential and service sector. The industrial model distinguishes a large number of industrial processes as well as industrial cross-cutting technologies such as electric motors and motor applications.

- **The ASTRA transport model** (run by Fraunhofer ISI) provides potentials for the transport sector. In addition the model is coupled to the ASTRA macro-model which serves for all sectors to evaluate macro-economic impacts of policy options.
- **The PowerACE** model providing efficiency options, including renewable for the power sector. It is a European Simulation model for electricity markets which optimizes investment decisions in electricity generation technologies up to 2050, including for electricity imports from the MENA region.

Annex 2 – Detailed presentation of the models used in the study

FORECAST

Overview

The FORECAST modelling platform aims to develop long-term scenarios for future energy demand of individual countries and world regions until 2050. It is based on a bottom-up modelling approach considering the dynamics of technologies and socio-economic drivers. The model allows to address various research questions related to energy demand including scenarios for the future demand of individual energy carriers like electricity or natural gas, calculating energy saving potentials and the impact on greenhouse gas (GHG) emissions as well as abatement cost curves and ex-ante policy impact assessments.

Recent model applications

The model has been in recent years frequently applied to national as well as EU-wide studies. Some examples of recent EU-wide applications are as follows:

- Calculation of energy saving potentials in the industrial sector of the EU by member state until 2030 for DG ENER (Eichhammer et al. 2009)
- Contribution of energy efficiency to the EU 2050 climate protection scenarios for the German Environmental Ministry (Boßmann et al. 2012)
- Long-term electricity demand of the EU by member state until 2050 for all demand sectors (www.esa2.eu)
- Assessment of the impact of energy-efficiency policies on the electricity demand in the EU's tertiary sector by member state until 2035 (Jakob et al. 2012; Jakob et al. 2013)

Examples of national studies:

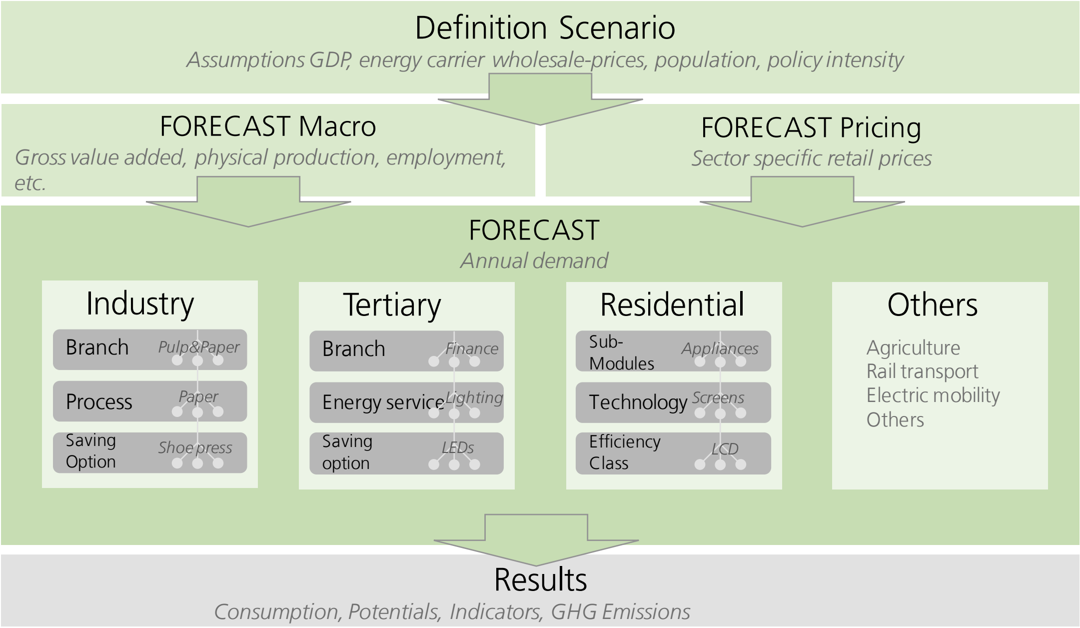
- Long-term climate policy scenarios for Germany in all demand sectors (Schlomann et al. 2011)
- Saving potentials and costs in German energy-intensive industries (Fleiter et al. 2012; Fleiter et al. 2013)
- Ex-Ante impact assessment of energy-efficiency policies in the Turkish residential sector (Elsland et al. 2013a)
- Ex-Ante impact assessment of energy-efficiency policies in the German residential sector (Elsland et al. 2013b)

For more information see www.forecast-model.eu

Model structure

The FORECAST platform comprises four individual modules, each representing one sector according to the Eurostat (or national) energy balances: industry, services/tertiary, residential and others (agriculture and transport). While all sector modules follow a similar bottom-up methodology, they also consider the particularities of each sector like technology structure, heterogeneity of actors and data availability.

Figure 55: Overview of FORECAST model structure



The list of selected input data as shown in the following table provides a broad idea of the level of detail of each module. Each sector requires sector specific activity data, like industrial production in the industry sector and the number of households in the residential sector. Furthermore, end-consumer energy prices play an important role in each sector as they are distinguished by energy carrier. The third group of input data, the technology characterisation also reflects data availability of the individual sectors. While in the industry and tertiary sector the model works with so-called energy-efficiency measures (EEMs), which represent all kinds of actions that reduce specific energy consumption, in the residential sector the stock of alternative appliances and the market share of different efficiency classes is explicitly modelled. In all cases, energy savings can be calculated and traced back to technological dynamics including cost considerations.

Table 52: Main input parameters of FORECAST

	Tertiary	Households	Industry	Agriculture
Main drivers	- No. of employees by sub-sector - Floor area per employee by sub-sector	- No of households - Building surface by type of building [m²]	- Physical production by process [t/a] - Value added by sub-sector [Meuro/a]	- Production output - Irrigated areas
Prices	- Energy prices	- Energy prices	- Energy prices - EUA Prices	
Technology data	**Energy Services:** - Technology driver - Installed power - Annual full load hours **Saving options:** - Saving Potential - Costs - Lifetime - Diffusion **Buildings:** - insulation levels - heating system efficiency and shares	**Appliance data by efficiency class** - Market share - Specific energy cons. - Lifetime - Standby power - Standby hours **Building related data:** - Insulation levels - Heating system efficiency Heating and lighting technology shares	**Processes:** - Specific Energy Cons. **Saving Options:** - Saving Potential - Costs - Lifetime - Diffusion **Buildings:** - insulation levels - heating system efficiency and shares	**Processes/Services** - Technology driver Specific energy demand - Saving potential

Modeling investment decisions

The bottom-up approach, which distinguishes individual technologies, allows modeling the diffusion of technologies as the result of individual investment decisions taken over time. For all types of investment decisions, the model follows a simulation approach rather than optimization in order to better capture the real-life behavior of companies and households.

Whenever possible, the investment decision is modeled as a discrete choice process, where households or companies choose among alternative technologies to satisfy a certain energy service. It is implemented as a logit-approach considering the total cost of ownership (TCO) of an investment plus other intangible costs. This approach ensures that even if one technology choice is more cost-effective than the others, it will not gain a 100% market share. This effect reflects heterogeneity in the market, niche markets and non-rational behavior of companies and households, which is a central capability to model policies. Still, the resulting technology development (and energy demand) is price sensitive.

The replacement of equipment/buildings/technologies is based on a vintage stock approach allowing to realistically model the replacement of the capital stock considering its age distribution. Some parts of the industrial and the tertiary sector are not using a vintage stock approach, due to the huge heterogeneity of technologies on the one hand and data scarcity on the other. Technology diffusion, however, is modeled based on a similar simulation algorithm taking heterogeneity and non-rational behavior into account.

Modeling policies

Modeling energy-efficiency policies is a core feature of the FORECAST model. The simulation algorithm and the vintage stock approach are well suited to simulate most types of policies.

Minimum energy performance standards (MEPS), e.g. for appliances or buildings, can easily be modeled by restricting the market share of new appliances starting in the year the standards come into force. See Elsland et al. (2013) and Jakob et al. (2013) for examples of ex-ante impact assessments of the EU-Ecodesign Directive.

Energy taxes for end-consumers can be modeled explicitly on the basis of more than 10 individual energy carriers (electricity, light fuel oil, heavy fuel oil, natural gas, lignite, hard coal, district heating, biomass, etc.).

Information-based policies are generally the most complicated to model due to their rather “qualitative character”. The discrete-choice approach, however, allows to consider such qualitative factors. E.g. labeling of appliances resulting from the EU Labeling Directive can be modeled by adjusting the logit parameters and thus assuming a less heterogeneous market, in which a higher share of consumers will select the appliance with the lowest total cost of ownership. See for example Elsland et al. (2013).

EU emissions trading can be modeled in the form of a CO_2 tax for energy-intensive industries. The detailed technology disaggregation in the industrial sector considering more than 60 individual products allows to consider the scope of the EU ETS on a very detailed level (examples of products are: clinker, flat glass, container glass, primary and secondary aluminium, oxygen steel, electric steel, coke, sinter, paper, ceramics, ammonia, adipic acid, chlorine). See Fleiter et al. (2012) for a case study on the German paper industry taking EUA prices into account.

Database

The FORECAST database has improved continuously incorporating the results/extensions from the above-mentioned studies.

The main economic input like **energy balances, employment, value added** or **energy prices** are calibrated to most recent EUROSTAT statistics whenever possible. When such data was not available (prices for certain energy carriers) IEA data was used to fill the gaps.

In the following an overview of the main sources is provided by model segment for technology-related data not available in EUROSTAT:

Buildings and heating systems: Buildings Performance Institute Europe (BPIE), IEE project TABULA, IEA Building Energy Efficiency Policies (BEEP), IEE project EPISCOPE, ODYSSEE database, country specific research e.g. for heat pumps

Appliances residential sector: Ecodesign Directive preparatory studies, ODYSSEE database, market research data from GfK

Appliances tertiary sector: Ecodesign Directive preparatory studies and additional individual technology studies.

Industrial production: PRODCOM when possible, UN commodity production database, US geological survey, UNFCCC, industry organizations (World steel organization, CEPI, Cembureau, Eurochlor, etc.)

Industry cross-cutting technologies: various technology studies of which many are EU projects

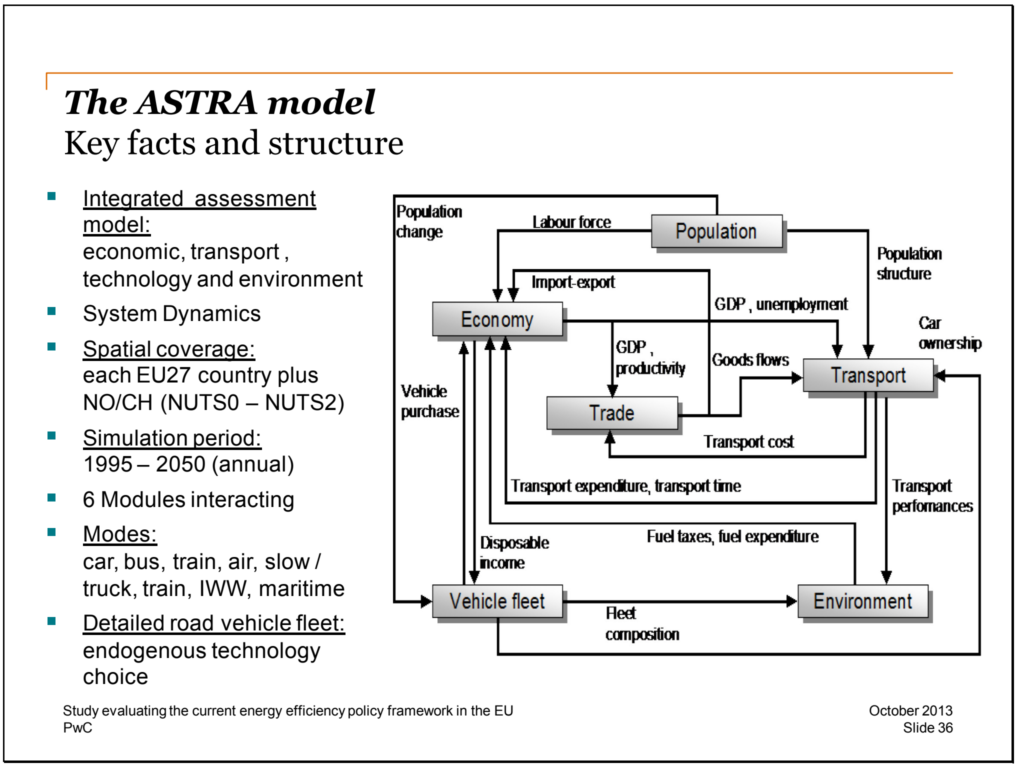
Industry process technologies: IPPC BREF studies, numerous technology/sectoral studies

Besides these sources, many more, even country specific sources, statistics and reports are used to feed the model database.

ASTRA Model for Transport

Simulating energy efficiency gains in transport

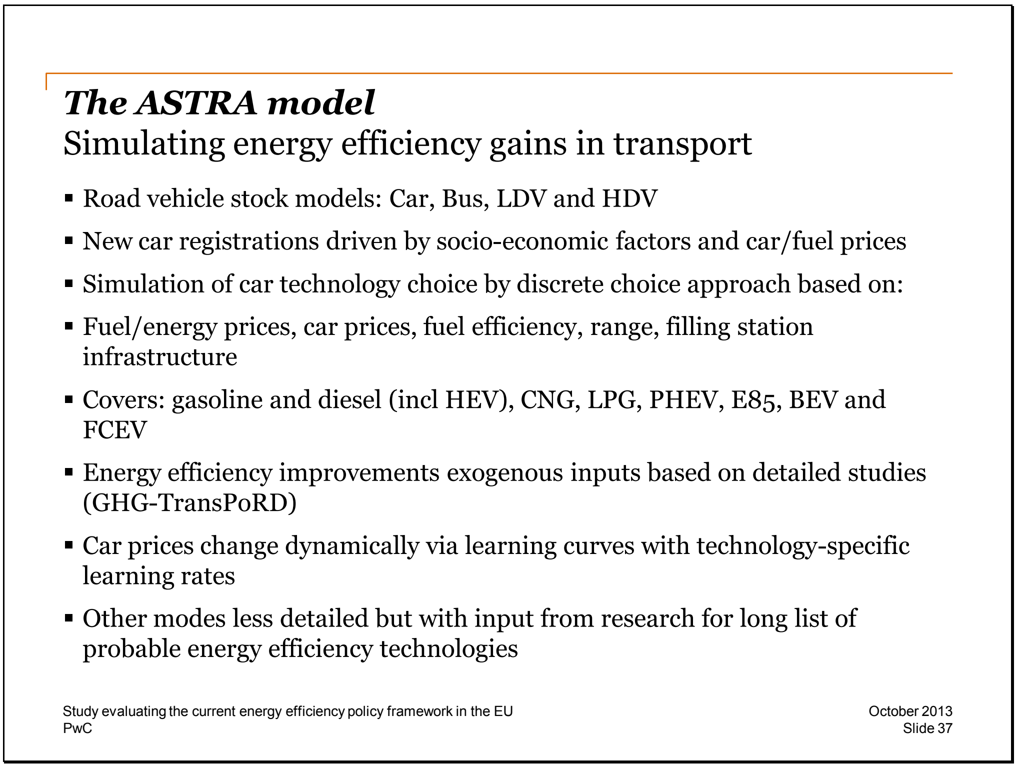
- Road vehicle stock models: Car, Bus, LDV and HDV
- New car registrations driven by socio-economic factors and car/fuel prices
- Simulation of car technology choice by discrete choice approach based on:
- Fuel/energy prices, car prices, fuel efficiency, range, filling station infrastructure
- Covers: gasoline and diesel (incl HEV), CNG, LPG, PHEV, E85, BEV and FCEV
- Energy efficiency improvements exogenous inputs based on detailed studies (GHG-TransPoRD)
- Car prices change dynamically via learning curves with technology-specific learning rates
- Other modes less detailed but with input from research for long list of probable energy efficiency technologies



The ASTRA model

Key facts and structure

- Integrated assessment model:
  economic, transport , technology and environment
- System Dynamics
- Spatial coverage:
  each EU27 country plus NO/CH (NUTS0 – NUTS2)
- Simulation period:
  1995 – 2050 (annual)
- 6 Modules interacting
- Modes:
  car, bus, train, air, slow / truck, train, IWW, maritime
- Detailed road vehicle fleet:
  endogenous technology choice



The ASTRA model
Simulating energy efficiency gains in transport

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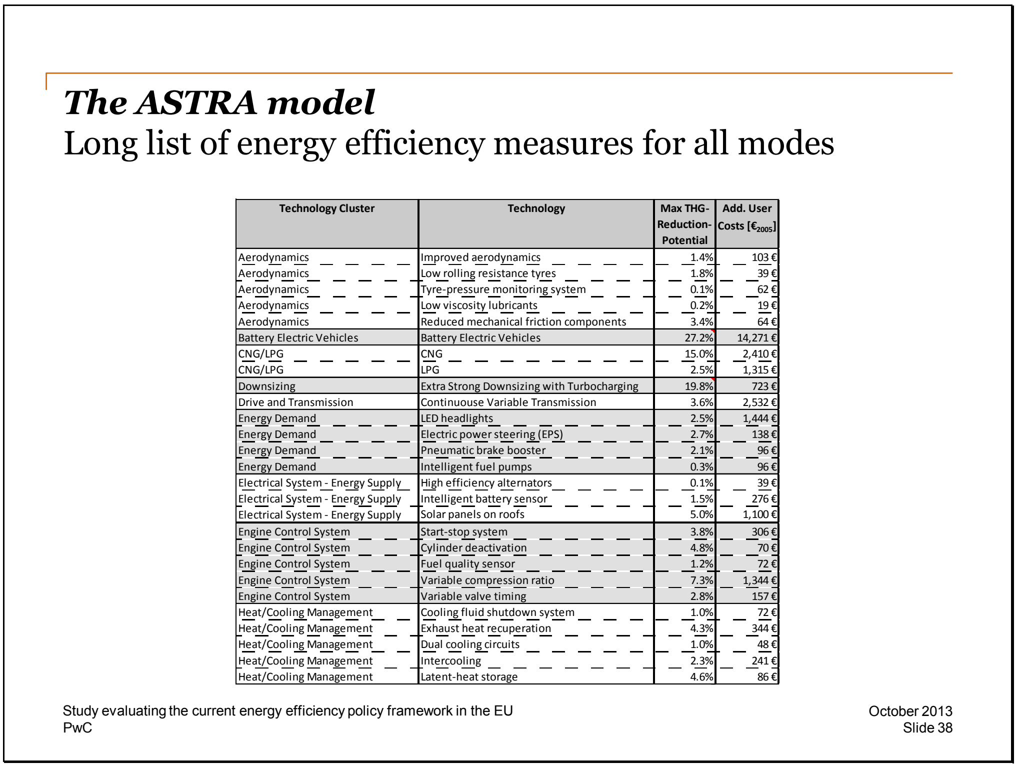


The ASTRA model
Long list of energy efficiency measures for all modes

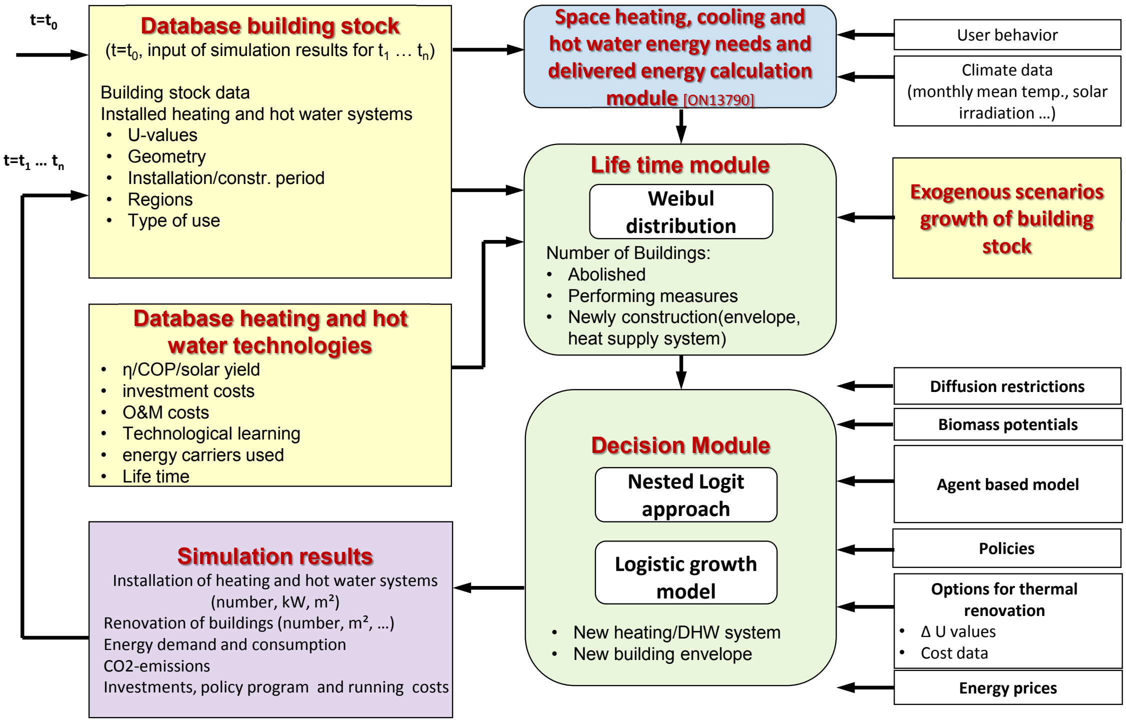
Technology Cluster	Technology	Max THG-Reduction-Potential	Add. User Costs [€$_{2005}$]
Aerodynamics	Improved aerodynamics	1.4%	103 €
Aerodynamics	Low rolling resistance tyres	1.8%	39 €
Aerodynamics	Tyre-pressure monitoring system	0.1%	62 €
Aerodynamics	Low viscosity lubricants	0.2%	19 €
Aerodynamics	Reduced mechanical friction components	3.4%	64 €
Battery Electric Vehicles	Battery Electric Vehicles	27.2%	14,271 €
CNG/LPG	CNG	15.0%	2,410 €
CNG/LPG	LPG	2.5%	1,315 €
Downsizing	Extra Strong Downsizing with Turbocharging	19.8%	723 €
Drive and Transmission	Continuouse Variable Transmission	3.6%	2,532 €
Energy Demand	LED headlights	2.5%	1,444 €
Energy Demand	Electric power steering (EPS)	2.7%	138 €
Energy Demand	Pneumatic brake booster	2.1%	96 €
Energy Demand	Intelligent fuel pumps	0.3%	96 €
Electrical System - Energy Supply	High efficiency alternators	0.1%	39 €
Electrical System - Energy Supply	Intelligent battery sensor	1.5%	276 €
Electrical System - Energy Supply	Solar panels on roofs	5.0%	1,100 €
Engine Control System	Start-stop system	3.8%	306 €
Engine Control System	Cylinder deactivation	4.8%	70 €
Engine Control System	Fuel quality sensor	1.2%	72 €
Engine Control System	Variable compression ratio	7.3%	1,344 €
Engine Control System	Variable valve timing	2.8%	157 €
Heat/Cooling Management	Cooling fluid shutdown system	1.0%	72 €
Heat/Cooling Management	Exhaust heat recuperation	4.3%	344 €
Heat/Cooling Management	Dual cooling circuits	1.0%	48 €
Heat/Cooling Management	Intercooling	2.3%	241 €
Heat/Cooling Management	Latent-heat storage	4.6%	86 €

INVERT Model for (Residential and Tertiary Sector) Buildings

Invert/EE-Lab is a dynamic bottom-up simulation tool that evaluates the effects of different promotion schemes (in particular different settings of economic and regulatory incentives) on the total energy demand, energy carrier mix, CO2 reductions and costs for space heating, cooling and hot water preparations in buildings. Furthermore, Invert/EE-Lab is designed to simulate different scenarios (price scenarios, insulation scenarios, different consumer behaviours, etc.) and their respective impact on future trends of energy demand and mix of renewable as well as conventional energy sources on a national and regional level. More information is available on www.invert.at or e.g. in (Kranzl et al., 2013) or (Müller, 2012).

The basic structure and concept is described in Figure 56.

Figure 56: Overview structure of Simulation-Tool Invert/EE-Lab



Invert simulation tool originally has been developed by Vienna University of Technology/EEG in the frame of the Altener project Invert (Investing in RES&RUE technologies: models for saving public money). In more than 30 projects and studies for more than 15 countries, the model has been extended and applied to different regions within Europe, see e.g. (Kranzl et al., 2012), (Kranzl et al., 2013), (Biermayr et al., 2007), (Haas et al., 2009), (Kranzl et al., 2006), (Kranzl et al., 2007), (Nast et al., 2006), (Schriefl, 2007), (Stadler et al., 2007). The last modification of the model in the year 2010 included a re-programming process and accommodation of the tool, in particular taking into account the inhomogeneous structure of decision makers in the building sector and corresponding distributions (Müller, 2010). The current state of the model relies on this new calculation-core (called EE-Lab) leading to the current version of the model Invert/EE-Lab.

The basic idea of the model is to describe the building stock, heating, cooling and hot water systems on highly disaggregated level, calculate related energy needs and delivered energy, determine reinvestment cycles and new investment of building components and technologies and simulate the decisions of various agents (i.e. owner types) in case that an investment decision is due for a specific building segment. The core of the tool is a myopical, multinominal logit approach, which optimizes objectives of "agents" under imperfect information conditions and by that represents the decisions maker concerning building related decisions.

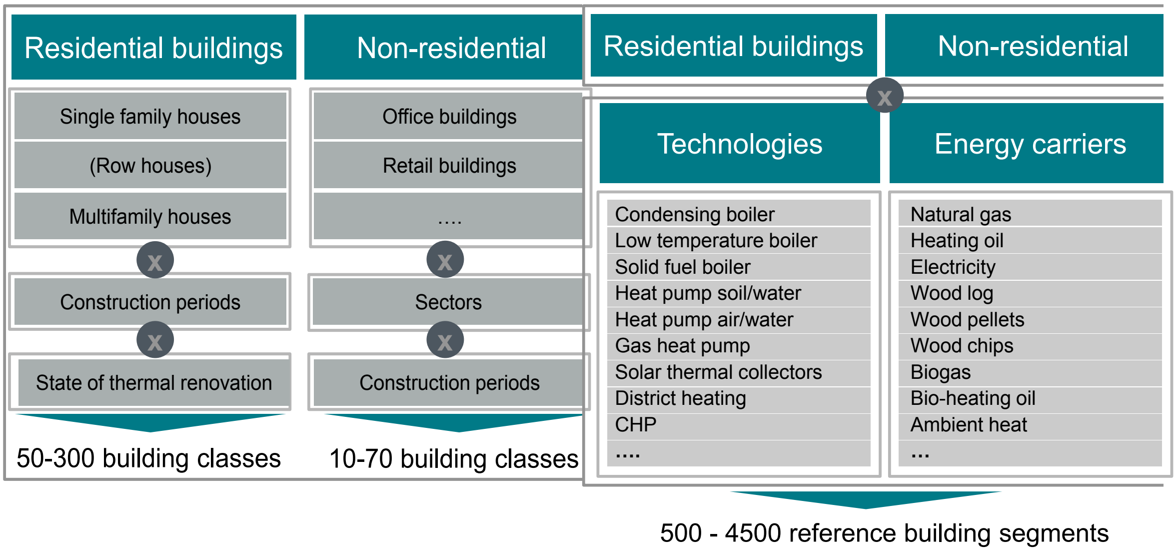
Coverage and data structure

The model Invert/EE-Lab up to now has been applied for the following countries: AT, DE, DK, GR, NL, PL, UK. Within the project ENTRANZE (see below) the model has been extended to all countries of **EU-28 (+ Serbia)**. A representation of the implemented data of the building stock is given at www.entranze.eu.

Invert/EE-Lab covers **residential and non-residential buildings**. Industrial buildings are excluded (as far as they are not included in the official statistics of office or other non-residential buildings).

The following figure shows the disaggregated modeling of the building stock within each country. The level of detail, the number of construction periods etc. depend on the data availability and structure of national statistics. We take into account data from Eurostat, national building statistics, national statistics on various economic sectors for non-residential buildings, BPIE data hub, Odyssee, which are finally summarized in the ENTRANZE database (www.entranze.eu).

Figure 57: Disaggregated modeling of the building stock within each country. Where relevant, climatic zones are taken into account within a country.



As **efficiency technologies** Invert/EE-Lab models the uptake of different levels of renovation measures (country specific) and the diffusion of efficient heating and hot water systems.

Basic approach and methodology

The core of the simulation model is a myopical approach which optimizes objectives of agents under imperfect information conditions and by that represents the decisions concerning building related investments. It applies a nested logit approach in order to calculate market shares of heating systems and energy efficiency measures depending on building and investor type. The following equation depicts the market share calculation as logit-model – in order to reduce complexity in the representation:

$$ms_{njb,t} = \frac{e^{-\lambda_b \cdot r_{njb}}}{\sum_{j=1}^{J} e^{-\lambda_b \cdot r_{njb}}}$$

$$r_{njb,t} = \frac{V_{njb,t}}{\sum_{j=1}^{J} ms_{njb,t-1} \times V_{njb,t}}$$

$\mathrm{ms_{njb}} = \mathrm{market\ share\ of\ alternative\ j\ in\ building\ b\ for\ investor\ type\ n\ at\ period\ t}$

$\mathrm{r_{njb}} = \mathrm{relative\ utility\ of\ alternative\ j\ in\ building\ b\ for\ investor\ type\ n}$

The model enables the definition of a various number of different owner types as instances of predefined investor classes: owner occupier, private landlords, community of owners (joint-ownership), and housing association. The structure is motivated by the different perspectives regarding building related investments. For instance, energy cost savings are only relevant for those owners which occupy the building. The corresponding variable relevant to landlords is a refinancing of energy savings measures through additional rental income (investor-tenant dilemma).

Owner types are differentiated by their investment decision behaviour and the perception of the environment, The former is captured by investor-specific weights of economic and non-economic attributes of alternatives. The perception relevant variables – information awareness, energy price calculation, risk aversion – influence the attribute values.

Outputs from Invert/EE-Lab

Standard outputs from the Invert/EE-Lab on an annual basis are:

- Installation of heating and hot water systems by energy carrier and technology (number of buildings, number of dwellings supplied)
- Refurbishment measures by level of refurbishment (number of buildings, number of dwellings)
- Total delivered energy by energy carriers and building categories (GWh)
- Total energy need by building categories (GWh)
- Policy programme costs, e.g. support volume for investment subsidies (M€)
- Total investment (M€)

Moreover, Invert/EE-Lab offers the possibility to derive more detailed and other type of result evaluations as well. Based on the needs of the policy processes we will have to discuss which other type of evaluations of the result data set might be required.

General approach of modelling policy instruments in Invert/EE-Lab

Invert/EE-Lab models the decision making of agents (i.e. building owner types) regarding building renovation and heating, hot water and cooling systems. Policy instruments may affect these decisions (in reality and in Invert/EE-Lab) in the following ways:

- Economic incentives change the economic effectiveness of different options and thus lead to other investment decisions. This change leads to higher market share of the supported technology in the Invert/EE-Lab (via the nested logit approach).
- Regulatory instruments (e.g. building codes or renewable heat obligations) restrict the technological options that decision makers have; limited compliance with these measures can be taken into account by limiting the information level of different agents regarding this measure (see next bullet point).

- Information, advice, etc: Agents have different levels of information. Lack of information may lead to neglecting of innovative technologies in the decision making process or to a lack of awareness regarding subsidies or other support policies. Information campaigns and advice can increase this level of information. Thus, the consideration of innovative technologies, knowledge about support programmes and compliance with regulatory standards increases.
- R&D can push technological progress. The progress in terms of efficiency increase or cost reduction of technologies can be implemented in Invert/EE-Lab.