Investing EU ETS auction revenues into energy savings

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Abstract

The overall objective of this study is to analyse the effects of using EU ETS auction revenues to stimulate investments in energy savings in three key target sectors, i.e. Households, Tertiary and Industry (including both ETS and non-ETS industrial installations). The scenarios used refer basically to the situation before the recent agreement on the Energy Efficiency Directive (EED) and include (a mixture of) different policy options to enhance energy savings in the target sectors, in particular (i) reducing the ETS cap, (ii) introducing an Energy Efficiency Obligation (EEO) for energy suppliers or distributors, and/or (iii) using ETS auction revenues to support additional (private) investments in raising energy efficiency.

In order to meet this objective a variety of different policy scenarios have been defined and analysed by means of the '*Energy-Environment-Economy Model for Europe (E3ME)*'. The study presents and discusses a large variety of scenario modelling results by the year 2020 at the EU27 level. These results refer to, among others, energy savings, GHG emissions, the ETS carbon price, household electricity bills and to changes in some macro- or socio-economic outcomes such as GDP, inflation, employment or international trade. Finally, the study discusses some policy findings and implications, including options to enhance the effectiveness of some EE policies, in particular those having a potential adverse effect on the ETS carbon price.

Contents

Summary

S1. Objective and research questions

The overall objective of the present study is to analyse the effects of using EU ETS auction revenues to stimulate investments in energy savings in three key target sectors[1], i.e. Households, Tertiary and Industry.[2] More specifically, the major research questions of the present study include:

- What are the energy savings potentials in the target sectors up to 2020 under different policy scenarios?
- What are the investment needs and the required public support funding to meet these potentials?
- Are ETS auction revenues up to 2020 sufficient to cover the required public support funding?

  And, above all:
- What are the socioeconomic and environmental effects of the investments in additional energy savings under different policy scenarios at the EU27 and EU Member State levels?

To address the above, a slightly adjusted version of the '*Energy-Environment-Economy Model for Europe (E3ME)*', has been used to run and calculate different scenarios. In addition to the baseline scenario, three core policy scenarios[3] were developed as follows: (i) reducing the ETS cap, (ii) implementing an Energy Efficiency Obligation (EEO) for energy suppliers or distributors, and (iii) reducing the ETS cap combined with implementing an EEO. Model runs for these baseline and core scenarios were carried out to compare the environmental, macro- and socio-economic effects of the scenarios. Then, for each of these scenarios, estimations were made of the remaining energy

[1] Direct primary energy savings only, such that energy savings related to use of electricity in any sector are attributed to the power sector which is categorised under 'other sectors'.

[2] The industry sector includes both ETS and non-ETS industrial installations.

[3] These core scenarios - labelled 'intermediate' scenarios in the report - refer to the situation before the agreement on the Energy Efficiency Directive in 2012.

saving potential to 2020, the public and private investment that would be necessary to achieve it[4] and the auction revenues which would be available to provide this public funding. Model runs were also completed for four parallel 'investment' scenarios, identical to the baseline and core policy scenarios, but with the added assumption that investment potential identified in the baseline and core scenarios is actually achieved. A further four 'alternative policy' scenarios, variants of the above scenarios, were designed and modelled to analyse the effects of energy efficiency investments on ETS versus non-ETS related fuels and the effects of setting aside EUAs to neutralise the impact of reduced energy demand on the ETS carbon price.

S2. Main policy findings and implications

S2.1 Effects of lowering the ETS cap from 21% to 34%

Reducing the ETS cap from 21% to a 34% GHG reduction by 2020 relative to 2005 results in a higher ETS carbon price which, in turn, leads to slightly lower power demand by electricity end-users (as a result of higher power prices), lower fossil fuel use in the ETS sectors (including both industry and power generation) and, hence, to less energy related GHG emissions in these sectors. Moreover, it results in higher ETS auction revenues which can be used to support additional EE policies to realise cost-effective energy savings (those that pay for themselves over time) or to fund other socially beneficial measures. On the other hand, the pass-through of the carbon price leads to, on balance, higher household electricity bills, lower real incomes, less consumer spending, reduced industrial competitiveness, less employment and a lower GDP (although most of these impacts are relatively small in terms of percentage changes, monetary values can be significant).

For example, lowering the ETS GHG cap from 21% to 34% by 2020, results in an increase in the electricity price across the EU from, on average, 107 to 119 €/MWh. While power use is hardly affected by the higher electricity price (due to a relatively low price elasticity of power demand), the power bill increases by € 61 per annum for an average household and by € 34 billion for all power consumers across the EU27. On the other hand, the more stringent ETS cap and the resulting higher ETS carbon price do have an impact on power sector emissions, which decline by 71 $MtCO_2$. Combining the two effects, we can calculate that, when moving from the baseline to this lower cap scenario, the total power bill for energy end-users increases, on average, by € 487 per tonne CO_2 reduced in the power sector, which is several times more expensive than the ETS carbon price paid by power providers – or the marginal costs of CO_2 reduction – which increases from approximately 17 to 80 €/tCO_2.[5] It should be observed, however, that total ETS emissions in this scenario decline by 165 $MtCO_2$, while auction revenues from the power sector increase from approximately € 19 billion to € 88 billion in 2020

4 It is assumed that implementation of the policies or regulation defining each scenario (e.g. EEO) do not require public funding.

5 The high carbon price of 80€/tCO_2 in 2020 for this particular scenario reflect the particular modelling assumptions used in that the ETS target is adjusted with no accompanying policy; in addition this modelling was carried out before the full extent of the recession was known. More recent analysis using the E3ME model has found that the tighter ETS cap would result in a carbon price of €40-45/t CO_2, lower than found here, taking account of recent policy developments, lower projections for fuel prices and the overhang of allowances from Phase II. The effects of the high carbon prices are discussed in Section 6.

from which energy end-users may benefit through higher government expenditures and/or lower taxes.

S2.2 Effects of greater end-use energy efficiency

While raising carbon prices will result in some decrease in energy demand, there are many non-price barriers to energy efficiency that prevent greater uptake of energy savings measures – even those that are cost-effective (i.e. pay for themselves over time). Alternative, more direct policy options can help overcome these barriers and realise greater energy savings. These include measures such as introducing an Energy Efficiency Obligation (EEO) and/or using public funding to support efficiency programmes, as illustrated by scenarios in this study. ETS auction revenues could be used to support (private) investments in enhancing energy efficiency. Direct measures such as these are not exclusive, and can be implemented in tandem to support strong EE programmes. Besides reducing energy related emissions, another advantage of such measures is that they reduce household energy bills – and, hence, enhance real incomes, notably of less privileged households. Clearing prices are lowered for two reasons: first, lower demand enables the market to clear lower in the generators' bid stack, and second, lower demand lowers the ETS carbon price, which also lowers power clearing prices in competitive markets. Moreover, such measures usually have some beneficial macro- or socio-economic outcomes, such as reducing dependency on fuel imports, enhancing employment, mitigating inflation or stimulating (cleaner) economic growth. On the other hand, such measures reduce government revenues from ETS auctioning while a lower carbon price implies a lower incentive (or a higher public subsidy need) for investing in low-carbon technologies such as CCS or renewables.

For the scenario which introduces a 1% p.a. energy efficiency obligation (EEO)[6] to the baseline, the power bill is reduced by € 40 per annum for an average household and by € 16 billion for all power users across the EU27. This, along with the decline in power sector emissions of 21 $MtCO_2$, gives an average benefit in terms of lower power bills of € 754 per tonne CO_2 reduction in the power sector. These benefits are very significant despite the fact they are accompanied by a 1% increase in the average carbon intensity of power generation, a halved ETS carbon price and, hence, a corresponding decrease in ETS auction revenues.

S2.3 Combining a tighter carbon cap with greater efficiency

When an EEO is combined with a tighter carbon cap (of 34% by 2020)[7], the additional energy savings due to the EEO abate some of the strong impacts of lowering the ETS cap only, i.e. it reduces the increase in the ETS carbon price from 80 €/tCO_2 to 65 €/tCO_2 in 2020, and it reduces the total power bill from € 34 billion to € 14 billion and the increase in the average household bill from € 61 to € 10 per annum (through both lower power prices and lower electricity use).

[6] Scenario 2Ai

[7] Scenario 2Bi

S2.4 Carbon revenue recycling adds substantial benefits

In cumulative terms, the required public funding for aggressive energy efficiency investments in the three target sectors varies between € 47 billion in the baseline scenario to € 23 billion in scenario 2Bi (34% cap, plus 1% p.a. EEO and sufficient investment to meet full EE potential). In annual terms, these figures amount to € 5.9 billion and € 2.9 billion, respectively. For the modelled period 2013-2020, the total ETS auction revenues at the EU27 level are generally more than sufficient to cover the public support needs to realise the remaining energy savings potentials in the target sectors up to 2020. Even for the EEO scenarios which result in a lower carbon price and, hence, lower auction revenues – there is still a significant surplus of these revenues which could cover further investment in remaining potential.

The modelling in this study clearly shows that additional EE policy measures that reduce the use of ETS related fuels and emissions consequently reduce the ETS carbon price. This mitigates electricity price impacts for end-users. Of course, if the cap remains unchanged, a lower ETS price resulting from energy efficiency investments will result in added emissions or additional energy use elsewhere under the scheme, or at least add to the total of banked, unused allowances. Other exogenous factors -- e.g. recession or new renewable energy capacity coming on stream -- can reduce the ETS price too. While some of them (e.g., a deeper recession) are obviously undesirable, a lower carbon price resulting from increased efficiency in the use of energy clearly is a positive outcome.

A lower carbon price will also lower national ETS auction revenues and, hence, lower public funding available to support renewables, EE policies, or to mitigate impacts on industry and low-income households. In some respects this is not a real problem – if carbon prices and power prices are lower, then the need for ETS mitigation support in industry and households is also lower. In other cases, lower carbon revenues would require adjustments to programs that were going to be dependent upon them.

S2.5 Where should efficiency investments be targeted?

Modelling that compared the effects of EE investments in the ETS sector to EE investments in the non-ETS sector, showed that it makes little difference in which sector the investments are made (at least at a level of additional EE investments of € 10 billion per annum over the years 2013-2020) . As regards impact on total primary energy savings, total GHG emissions or total CO_2 emissions, the results are quite similar. The macro- and socio-economic effects, including GDP, consumption, investments, exports, imports, employment and real household incomes, are also positive and very similar. In terms of ETS carbon prices and ETS auction revenues, however, there is a significant difference between the two options. Focusing all of the additional efficiency investments on the ETS sectors reduces carbon emissions (by 54 Mtoe) and carbon prices and auction revenues towards zero. Focusing additional efficiency investments on the non-ETS sector fuels reduces emissions (by 52 Mtoe) but not carbon prices or revenues. The best approach seems to be focusing public efficiency investments on both ETS and non-ETS related fuel savings.

Finally, comparison of energy efficiency investments in the ETS sector versus reliance on the carbon price alone to drive carbon reductions in the ETS sector, reveals that the effects of carbon pricing on energy savings and CO_2 emissions reduction are substantially enhanced if (i) the revenues of carbon pricing are used to support extra energy savings investments, and (ii) the resulting decline in the ETS carbon price – i.e. due to the additional EE investments – is nullified by setting aside a certain amount of emission allowances. This will, of course, also accelerate progress towards the long-term objective of lowering GHG emissions in line with Europe's 2050 goals.

S2.6 Results in the context of lower carbon prices

This analysis is based on carbon prices that in early 2013 would be considered very high. The baseline EU ETS price of €20-25/tCO_2 now looks unlikely to occur, and the estimated price of 80€/tCO_2 for a 30% target very unlikely to occur. The reasons for the high carbon prices in the scenarios are:

- Timing of the analysis – the modelling was carried out in 2011, based on data sets and a baseline that were formed in 2009, before the full extent of the crisis and subsequent recession were known.
- Assumptions about other policy – although the EU's renewable targets are met, it is assumed that the ETS alone must meet the carbon targets. The Energy Efficiency Directive and more recent Member State policies are not included in the scenarios.
- The overhang of allowances from Phase II was not included in the analysis and there was only limited scope for CDM use.
- High baseline fossil fuel prices meant that a high carbon price was required to have a significant relative effect on total fuel costs.

Analysis with the E3ME model carried out in 2012 showed a carbon price around 40€/tCO_2 was required to meet the 30% GHG reduction target in 2020. More recent developments suggest that this reduction could be achieved at an even lower price .

This raises the question of how relevant the model results are to the current policy position. Clearly if there is an EUA price of zero, there will not be revenues to pay for investment in energy efficiency. Indeed, any scenario in which the allowance price becomes zero is of questionable benefit to the EU.

However, assuming that the EUA price is greater than zero (meaning that the cap on emissions is lower than what can be achieved through energy efficiency alone), then the important interactions between energy efficiency policy, the ETS and the wider economy remain unchanged, and the qualitative conclusions from the modelling are also unchanged. Under present conditions we would expect a reduction in magnitude of all impacts and, the available funding from auctioned ETS allowances would also be reduced.

As there will clearly be further uncertainty in future carbon prices, this issue illustrates the importance of determining an integrated policy approach to achieving the best outcome, both in economic terms and in providing a long-term investment signal through a stable EUA price. Both the ETS cap and the contribution of energy efficiency to meeting this cap would need to be reviewed periodically.

S2.7 Summary

In summary, the scenarios in this study illustrate the dynamics of the ETS - with interplay between key variables such as the carbon price, energy demand, ETS emissions and power bills – and suggest that an optimal policy mix will be needed to achieve the policy objective of delivering carbon emissions reductions at least cost to society, including maximising positive co-benefits such as growth in GDP and employment while minimising increases to end-user power bills. This study demonstrates the benefits of complementing the ETS with targeted investment in energy efficiency, and leveraging carbon revenues to achieve carbon reductions, which could add significant efficiency gains with revenues of just 2 or 3 EUR per ton. Such efficiency investments would lower energy bills for households and businesses, moderating concerns over fuel poverty and competitiveness related to high energy prices. In turn, this would give , policy-makers further options to deepen CO_2 reductions through lower caps, and to maintain predictable and positive carbon prices through additional tools such as price floors and set-asides of EUAs.

1

Introduction and policy context

The Emissions Trading Scheme (ETS) is a cornerstone instrument of the EU to achieve the objective of reducing its GHG emissions by 20% in 2020, compared to 1990. In addition to reducing GHG emissions, the EU ETS is also one of the instruments providing some incentives to saving energy, both directly by raising the costs of using fossil fuels by ETS participants (i.e. power generators and energy-intensive industries) and indirectly by passing through the emissions trading costs to end-users' electricity prices. Although the mix of EU and Member State policies – including the EU ETS – seems at present to be able to reach the EU's GHG mitigation objective by 2020, it seems to fail achieving one of its other central energy and climate policy objectives, i.e. reaching 20% energy savings by 2020 through end use energy efficiency, compared to 2007 baseline projections.

By early 2011, it was expected that with the policies and measures then in place, the EU was on track to achieve only half of its 20% energy efficiency objective for 2020. In response, the European Commission (EC) proposed a new Energy Efficiency Directive (EED) with policies that would close about three quarters of the energy savings gap, and a Transport White Paper with measures that would account for the remaining part to close the gap towards 20% energy savings by 2020 (EC, 2011d and EC, 2012).

At the time when the EC proposal for a new EED was launched, June 2011, it was expected that only about half of this (non-binding) target would be achieved (EC, 2011d). The overall purpose of the draft EED was to close this gap between expected and targeted energy savings.

After a heavy debate, the EU politicians finally reached an agreement on the EED in June 2012. Due to the compromises that were needed to reach this agreement, the expected impact of the EED has been reduced to achieve 17% rather than the 20% energy savings targeted for 2020 (Voogt and Dubbeld, 2012).

Starting from 2013, a large and rising share of EU ETS allowances (EUAs) will be auctioned, resulting in auction revenues of billions of Euros to MS governments. One of the options to use (part of) these revenues is to invest them in policy programmes to stimulate investments in energy savings and, hence, to reach the EU 2020 target in this respect. Besides encouraging energy savings, this option may also have a variety of other effects such as reducing EUA prices, carbon abatement costs and consumers' energy bills, thereby enhancing both energy end-users benefits and social welfare.

Against this background, the overall objective of the present study is to analyse the effects of using EU ETS auction revenues to stimulate investments in energy savings in three key target sectors, Households, Tertiary and Industry (including both ETS and non-ETS industrial installations). These scenarios refer basically to the situation before the recent agreement on the EED and include (a mixture of) different policy options to enhance energy savings in the target sectors, in particular (i) reducing the ETS cap, (ii) introducing an Energy Efficiency Obligation (EEO) for energy suppliers or distributors, and/or (iii) using ETS auction revenues to support additional (private) investments in raising energy efficiency.

More specifically, the major research questions of the present study include:

- What are the energy savings potentials in the target sectors up to 2020 under different policy scenarios?
- What are the investment needs and the required public support funding to meet these potentials?
- Are ETS auction revenues up to 2020 sufficient to cover the required public support funding? And, above all:
- What are the socioeconomic and environmental effects of investment in additional energy savings under different policy scenarios at the EU and Member State levels?

The structure of the present report is as follows. Chapter 2 outlines the methodology of the study by defining and explaining the different scenarios analysed as well as the E3ME model to assess these scenarios. Chapter 3 presents and analyses the results at the EU level. Finally, Chapter 4 provides a summary and comparison of the major results, mainly by means of presenting and analysing some comparative graphs of the scenarios considered in this study.

2

Methodology

In order to address the objective and research questions outlined in the previous chapter, the following steps and activities have been undertaken:

- Defining four so-called '*Intermediate Scenarios*' or '*Pre-EE-Investment Scenarios',* i.e. four different policy scenarios - including the baseline scenario – which result in different levels of energy use, GHG emissions and other, socioeconomic outcomes up to 2020;
- Estimating energy savings potentials, investment needs and public funding. For each intermediate scenario, we have estimated the remaining or updated, cost-effective energy savings potentials in 2020 for the three target sectors (Industry, Households and Tertiary), as well as the (private) investment needs and the required public support to achieve these potentials;
- Defining four '*Energy Efficiency Investment Scenarios'*, i.e. the four policy scenarios defined under step 1 including the assumption that the additional EE investments, estimated under step 2, will be realised in the period up to 2020;
- Defining four '*Additional Policy Scenarios*'. In order to address some specific policy research questions we have defined four additional scenarios which are all variants of the scenarios indicated above;
- Applying the model E3ME. In order to assess the above-mentioned scenarios and, hence, to address our research questions, we have used a slightly adjusted version of the '*Energy-Environment-Economy Model for Europe (E3ME)*' and, subsequently, analysed the results of the model scenarios.

These steps are further explained briefly below.

2.1 The intermediate scenarios

As noted, we have defined four intermediate scenarios, including:

- The baseline scenario (1Ai);
- The EU GHG stretch scenario (1Bi);
- The Energy Efficiency Obligation scenario (2Ai);
- The EU GHG stretch and Energy Efficiency Obligation scenario (2Bi).

The distinguishing features of these scenarios include:

- Whether the EU GHG emissions reduction target is set at 20% (option A) or 30% (option B) in 2020, compared to 1990;
- Whether the implementation of a so-called '*Energy Efficiency Obligation*' (EEO) in all EU Member States is excluded from the scenarios (Option 1) or included in the scenarios (option 2). We have ignored, however, all other policy options proposed or recently agreed as part of the EED (for an assessment of the proposed options, see EC, 2011e and 2011f).

Combining these two features results in the definition of the four intermediate scenarios indicated in **Table 1**. These scenarios are further explained below.

Table 1: Distinguishing features of intermediate scenarios

		EU GHG emissions reduction target in 2020, compared to 1990	
		20%	30%
EU energy efficiency regulation	Excluding an Energy Efficiency Obligation (EEO)	1Ai (baseline)	1Bi
	Including an Energy Efficiency Obligation (EEO)	2Ai	2Bi

The baseline scenario (1Ai)

The baseline scenario (1Ai) is based on the PRIMES 2009 Reference scenario published by DG Energy (EC, 2010d). For this study, the E3ME model has been calibrated against the PRIMES 2009 scenario and matches its published trends (growth rates) in energy production and consumption over the period 2010 to 2020.

According to the Energy Efficiency Directive (EED), the EU primary energy consumption should be lowered by 20% compared to baseline projections for 2020 from the PRIMES 2007 scenario. This scenario projected a total EU primary energy use of approximately 1842 Mtoe in 2020 and, hence, this use was targeted to be reduced by about 368 Mtoe to a level of 1474 Mtoe in 2020 (see second column of **Table 2**).

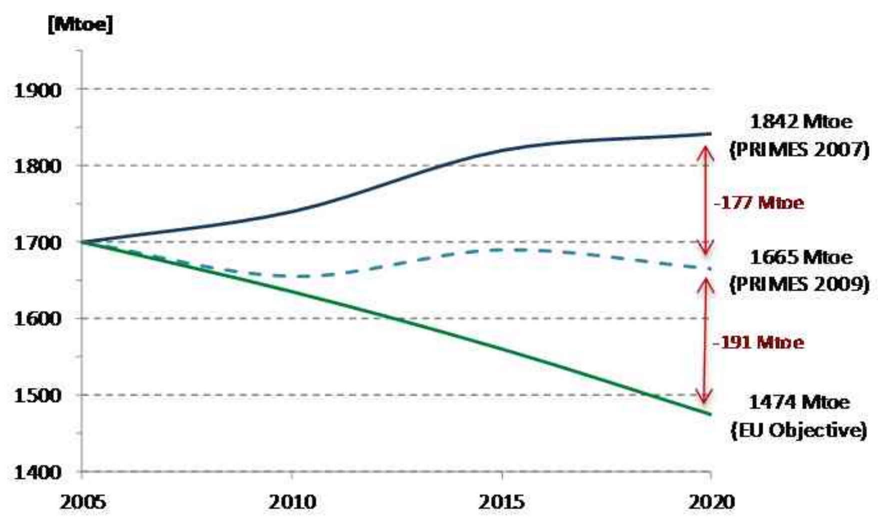
The PRIMES 2009 Reference scenario, however, presented an update projection of total primary energy use in 2020 amounting to 1665 Mtoe. This lower figure, compared to the 2007 projections, was mainly due to the impact of the economic crisis since 2008, the (expected) higher energy prices up to 2020 and the implementation of additional energy savings policies across EU Member States since 2007. As a result, the remaining gap to meet the EU energy saving target was significantly reduced from 368 to 191 Mtoe in 2020 (third column of **Table 2**; see also **Figure 1**). As the projections assume, however, that the renewables targets will be met and that the ETS induced energy savings will occur, then the missing difference of 191 Mtoe equates to the energy savings that must arise from the implementation of additional energy saving policies.

Table 2: Energy use projections for the year 2020 according to different PRIMES scenarios

[in Mtoe]	PRIMES 2007 Baseline Scenario	PRIMES 2009 Reference Scenario	PRIMES 2010 Energy Efficiency Scenario
Gross Inland Consumption	1968	1782	1795
Non-Energy Uses	125	117	117
Primary Energy Consumption	1842	1665	1678
20% Reduction Target	1474	1474	1474
Remaining Gap to Target	368	191	204

Source: EC (2008, 2010d and 2011b)

Figure 1: Trend projections and targets of EU27 primary energy use in 2020



For the Impact Assessment of the proposed Energy Efficiency Directive (EED), DG Energy made use of an even more recent, updated scenario, i.e. the PRIMES 2010 Energy Efficiency Scenario that included a more recent set of implemented policies. Compared to the PRIMES 2009 Reference Scenario, the updated projections for total energy use and, hence, the remaining 'energy savings gap' in 2020 are only slightly higher, i.e. 1678 and 204 Mtoe, respectively (see last column of **Table 2**).

However, as the PRIMES 2010 Energy Efficiency Scenario has not been made publicly available for use in this project, we have used the PRIMES 2009 Reference Scenario as the basis for constructing our baseline scenario (1Ai). The major policy features of this baseline scenario include:[8]

- It meets the 20% GHG emissions reduction target for the EU27 in 2020;
- It meets the 20% renewable energy target for the EU27 in 2020;
- It does not include an Energy Efficiency Obligation or any other additional policy measure proposed by the EED;
- It fails to meet the primary energy consumption target proposed by the EED by about 191 Mtoe in 2020, i.e. more than half of the original target based on the PRIMES 2007 scenario.

The EU GHG stretch scenario (1Bi)

Scenario 1Bi builds on the baseline scenario 1Ai. The distinguishing feature of scenario 1Bi is that the EU GHG emissions reduction target is enhanced from 20 to 30% in 2020. In order to reach this target, the EU ETS cap is reduced more or less proportionally by 34% below 2005 ETS emission levels, compared to -21% for the ETS cap in scenario 1Ai (following EC, 2010a). Given the ambition of this scenario, extra CDM credits are introduced in the ETS carbon market to account for half of the additional reduction in ETS emissions. It is important to note, however, that all other policies remain as in the PRIMES 2009 reference case. It is also left open whether and how the more ambitious GHG target will be reached in the non-ETS sectors. Therefore, compared to the baseline, the main difference of scenario 1Bi is that the ETS cap is significantly reduced (including additional CDM credits), resulting in a proportionally large increase of the ETS carbon price.

The Energy Efficiency Obligation scenario (2Ai)

Scenario 2Ai also builds on the baseline scenario 1Ai, but this time the distinguishing feature is that an Energy Efficiency Obligation (EEO) for energy suppliers or distributors to the sectors Households and Tertiary is introduced in all EU27 Member States. The EEO obliges MSs to require energy suppliers or distributors to realise savings each year in all end-use sectors at an amount of 1.5% per annum of their deliveries to customers or to introduce other policies which will have an equivalent effect. This target includes the energy savings effects of other, already existing measures which continue to have an impact in the 2014 to 2020 period and, hence, that the additional impact of the EEO is likely be less than 1.5% per annum and will vary across EU Member States, depending on the rate of the energy savings effects of these existing measures. We also make the assumption that energy suppliers or distributors in each MS contribute 1.0% towards the 1.5% per annum objective, and that there can be no trading of energy savings between energy suppliers or distributors in different Member States. In addition, we assume that the EEO is introduced in January 2014.

The EU GHG stretch and Energy Efficiency Obligation scenario (2Bi)

Scenario 2Bi is a mixture of the scenarios 1Bi and 2Ai in the sense that it is characterised by both an EU GHG emissions reduction target of 30% in 2020, similar to scenario 1Bi – with similar implications for the ETS cap and CDM offsets – and the implementation of an Energy Efficiency Obligation identical to the EEO in scenario 2Ai.

[8] See Appendix A for a more detailed overview of the policies included in the PRIMES 2009 Reference scenario.

2.2 Energy saving potentials, investment needs and public funding

For each of the intermediate scenarios outlined above, the following input variables have been estimated at both the EU27 level and the individual Member State level:

- The currently remaining energy savings potentials up to 2020 for the three target sectors of this study (Households, Industry and Tertiary);
- The (private) investment needs to achieve these potentials;
- The public funding or support assumed to be needed in order to induce these (private) investments.

The methodology to achieve these input variables is explained briefly below, while more extensive explanations are provided in Appendix B and Appendix C.

Energy saving potentials

The estimation of the energy savings potentials for the present study builds on the so-called 'Fraunhofer study' for the European Commission (EC) on the energy savings potentials in EU Member States (Eichhammer et al., 2009). The Fraunhofer study provides estimates of energy savings potentials for the period 2005-2020 for three types or cases of potentials, i.e. the so-called Low Policy Intensity (LPI) case, the High Policy Intensity (HPI) case and the Technical Potentials case. These potentials are detailed for end-use sectors, for fuel and electricity use, and for different applications.

In addition, we have used the more recent 'Ecofys study' for the European Climate Foundation (ECF) on "*Energy Savings 2020: How to triple the impact of energy savings policies in Europe"* (Wesselink et al., 2010) and the Regulatory Assistance Project (RAP) study on "*The upfront investments required to double energy savings in the European Union in 2020" (*Wesselink et al., 2011). In the Ecofys study (Wesselink et al., 2010), which is based on the Fraunhofer study, potentials have been defined with regard to the HPI case most of the time, but sometimes resemble the Technical Potentials case. The Ecofys figures are not as detailed as those provided by the Fraunhofer study. For this study, it has been assumed that the missing Ecofys figures are generally in line with those for the HPI case.

The Fraunhofer/Ecofys potentials are defined against the Primes 2007 Baseline scenario for the period 2005-2020. As explained in Section 2.1, however, an updated Primes 2009 Reference scenario was published in 2009 which includes early impacts of the economic crisis, the implementation of more recent EU and MS energy savings policies, and the (expected) higher energy prices up to 2020. Compared to the PRIMES 2007 scenario, this leads to a lower trend for energy consumption up to 2020. As a result, part of the savings potentials identified by Fraunhofer/Ecofys is already used in the Primes 2009 scenarios due to the higher energy prices and the extra policy measures. Therefore, the estimates for the energy savings potentials have been updated, using the increase in energy-intensity per sector as a proxy for the extra savings.

For the purposes of this study it is assumed that only part of the updated and available energy savings potentials can actually be realised in the time frame to 2020. For example, if policy makers use the ETS auction revenues to realize the savings potentials this is only possible from about 2013 onwards, firstly because the revenues start streaming in that year and, secondly, because it takes some time to set up measures to stimulate extra savings. As a result, only part of the energy savings potentials can actually be realised in scenarios with EE measures such as an EEO. The part not realisable was estimated per category of potentials, based on saving options not applied over the past years and lost permanently (e.g., new dwellings built but not in accordance with the Fraunhofer/Ecofys standards up to 2013) and options for which the period up to 2020 is too short to realize the potential (e.g. new industrial processes; for more details, see Appendix C).

Per category of energy savings potentials, an effective starting year was assumed that defined the part to be realized up to 2020. After this second correction, the remaining energy savings potentials in the baseline scenario 1Ai equal 40-50% of the original potentials estimated by Fraunhofer/Ecofys. For the other three intermediate scenarios, estimates of the updated energy savings potentials are even lower since a part of the potentials available in the baseline scenario is already realised due to the introduction of the Energy Efficiency Obligation and/or the increase in the EU GHG mitigation target from 20 to 30% in 2020 and the resulting increase in the ETS carbon price (for further details, see Section 3.2 and Appendix B). It is assumed that the latter do not need public support and nor do existing regulations in the baseline which are yet to be implemented by 2020. Only additional energy saving potential that is achievable before 2020 and that needs public support is included in these potential estimates. Beyond 2020 there remains further energy saving potential but the scope of this study is restricted to a 2020 timeframe

Investment needs

In order to estimate the additional investment needs to achieve the updated energy savings potentials up to 2020, it must first be specified whether investments are really needed to realize the potential. For instance, for good housekeeping measures or behavioural changes no, or few, investments are needed. In the Ecofys study and underlying Fraunhofer study no good housekeeping savings without investments are specified. In the Ecofys/Fraunhofer study of 2011, dedicated to investment needs for reaching the savings target of 20%, it is not mentioned whether part of the savings are realized without investments (Wesselink et al., 2011). In the present study it has been assumed that for the sectors Households and Tertiary investments are always needed to achieve energy savings; for Industry it is assumed that part of the savings (10-20%) are realised through good housekeeping.

The total investments to realize the updated savings potentials are calculated using an amount of Euros per Ktoe saved. Average figures per sector were taken from the Ecofys/Fraunhofer 2011 study, taking the mean value from the range specified. The figures have been differentiated for different categories of savings potentials, keeping the average figures in line with those of Fraunhofer/Ecofys (for further details, see Section 3.2 and Appendix B).

Public funding requirements
The Fraunhofer/Ecofys potentials are claimed to be cost-effective, meaning that over the life time of savings measures the annual energy cost savings compensate for the investment costs annualised by means of a (social) discount rate. This rate, however, is often lower that the (market) rate usually applied by private energy users. This difference in social versus private discount rates – or other barriers to private energy savings investments – may justify some public funding of these investments (assuming that no other measures to address these barriers and to stimulate these investments have already been implemented).

In order to estimate the public funding or support assumed to be necessary to induce the (private) investments to realise the updated energy savings potentials in the target sectors up to 2020, a default rate of 20% of gross investments has been assumed. For some parts of energy savings, however, no or less funding has been assumed, e.g. for good housekeeping in industry. Therefore, the average subsidy rate may vary across the target sector analysed (see Section 3.2 and Appendix B for further details).

2.3 The energy efficiency investment scenarios

In addition to the four intermediate scenarios (1Ai, 1Bi, 2Ai and 2Bi), four corresponding '*Investment Scenarios*' have been defined (labelled 1Av, 1Bv, 2Av and 2Bv, respectively, where the letter 'i' refers to 'intermediate' and the letter 'v' to 'investment). The investment scenarios are characterised by the same policy features as their respective intermediate scenarios (as outlined in Section 2.1). The only difference between the respective intermediate and investment scenarios is that for the investment scenarios we assume that the estimated investments required to achieve the updated energy savings potentials in the target sectors are realised over the period up to 2020 with the help of carbon revenues, which provide the 20% public funding requirement to stimulate these savings. In contrast, in the intermediate scenarios these investments are not realised. Therefore, the difference in outcomes between the investment scenarios and the respective intermediate scenarios is solely due to including these investments in the investments scenarios.

2.4 The additional policy scenarios

Finally, in order to address some specific policy issues, we have defined four '*Additional Policy Scenarios*'. One of these issues is the question of whether there is a difference in outcomes between stimulating additional energy savings investments in the ETS versus the non-ETS sectors – and whether stimulating such investments in ETS sectors makes sense at all - given the interaction effects of these investments with the fixed ETS cap and the resulting impact on the ETS carbon price.

Therefore, we have defined two policy scenarios, one in which a fixed amount of public funding to stimulate additional energy savings investments (€ 10 billion per annum, in current prices, over the period 2013-2020) is focussed solely on the ETS sectors (called scenario 1Ae) versus one in which a similar amount of public support is concentrated only on stimulating such investments in the non-ETS sectors (called scenario 1An). In all other respects these two scenarios are similar to the baseline scenario 1Ai, so – in terms of the impact of the investments mentioned – they can not only be compared to each other but also to the baseline scenario.

Other, related issues which are presently discussed – among others in the European Parliament – include the potential impact on the ETS carbon price of additional energy savings measures, including the Energy Efficiency Directive (EED) and the Energy Efficiency Obligation (EEO) in particular, and notably whether this impact could or should be compensated by a so-called 'set aside' of EU ETS allowances (EUAs) and, if yes, by how much? Therefore, we have defined two other additional policy scenarios:

- *Scenario 1As*. This scenario is similar to the scenario 1Ae mentioned above, i.e. the baseline scenario including annually € 10 billion of public funding focussed on stimulating additional energy savings investments in the ETS sectors. The only difference in this scenarios is that we have set aside an estimated amount of EUAs (i.e. actually reducing the ETS cap by a similar amount) in order to neutralise the potential impact of these investments on the ETS carbon price. By comparing the results of scenario 1As to those of 1Ai, we are able to analyse the effects of such a set aside on a variety of socioeconomic and environmental outcomes.
- *Scenario 2At*. This scenario is similar to the Energy Efficiency Obligation scenarios (2Ai), i.e. the baseline scenario including an EEO, as outlined in Section 2.1. The only difference in this scenario is that we have set aside an estimated amount of EUAs in order to neutralise the potential impact of this EEO on the ETS carbon price. By comparing the results of scenario 2At to those of 2Ai, we are able to analyse the effects of such a set aside on a variety of socioeconomic and environmental outcomes.

Table 3 provides a summary overview of the distinguishing features of the scenarios analysed in the present study.

2.5 The E3ME model

In order to assess the scenarios defined above, we have used the *Energy-Environmental-Economy Model for Europe (E3ME)*, developed by Cambridge Econometrics (CE). E3ME is a computer-based model of Europe's economic and energy systems and the environment. It was originally developed through the European Commission's research framework programmes and is now widely used in Europe for policy assessment, forecasting and research purposes.

Table 3: Summary overview of distinguishing features of scenarios analysed

Scenario acronym	Main features			
	EU GHG reduction target in 2020, compared to 1990	Energy Efficiency Obligation in all EU27 Member States by 2014?	Additional energy savings investments in target sectors?	Set-aside of EU ETS allowances?
Intermediate scenarios				
1Ai	20%	No	No	No
1Bi	30%	No	No	No
2Ai	20%	Yes	No	No
2Bi	30%	Yes	No	No
Investment scenarios				
1Av	20%	No	Yes	No
1Bv	30%	No	Yes	No
2Av	20%	Yes	Yes	No
2Bv	30%	Yes	Yes	No
Additional policy scenarios				
1Ae	20%	No	Yes, but only ETS related sectors	No
1An	20%	No	Yes, but only non-ETS related sectors	No
1As	20%	No	Yes, but only ETS related sectors	Yes
2At	20%	Yes	Yes, both ETS and non-ETS related sectors	Yes

The structure of E3ME is based on the system of national accounts, as defined by ESA95, i.e. the Eurostat System of Accounts 1995 (EC, 1996), with further linkages to energy demand and environmental emissions. The labour market is also covered in detail, with estimated sets of equations for labour demand, supply, wages and working hours. In total there are 33 sets of econometrically estimated equations, also including the components of GDP (consumption, investment, and international trade), prices, energy demand and materials demand. Each equation set is disaggregated by country and by sector.

The version of E3ME used in this project includes a historical database that covers the period 1970-2009 and the model projects forward annually to 2050 (Chewpreecha and Pollitt, 2009). The main data sources are Eurostat, DG ECFIN’s AMECO database and the IEA, supplemented by the OECD’s STAN database and other sources where appropriate. Gaps in the data are estimated using customised software algorithms.

The other main dimensions in this version of the model are:

- 29 countries (the EU27 member states plus Norway and Switzerland);
- 42 economic sectors, including disaggregation of the energy sectors and 16 service sectors;
- 43 categories of household expenditure;
- 19 different users of 12 different fuel types;
- 14 types of air-borne emission (where data are available) including the six greenhouse gases monitored under the Kyoto protocol;
- 13 types of household, including income quintiles and socio-economic groups such as the unemployed, inactive and retired, plus an urban/rural split.

Typical outputs from the model include GDP and sectoral output, household expenditure, investment, international trade, inflation, employment and unemployment, energy demand and CO_2 emissions. Each of these is available at national and EU level, and most are also defined by economic sector.

The econometric specification of E3ME gives the model a strong empirical grounding and means it is not reliant on the assumptions common to Computable General Equilibrium (CGE) models, such as perfect competition or rational expectations. E3ME uses a system of error correction, allowing short-term dynamic (or transition) outcomes, moving towards a long-term trend. The dynamic specification is important when considering short and medium-term analysis (e.g. up to 2020) and rebound effects, which are included as standard in the model's results.[9]

Figure 2 illustrates the linkages within the E3ME model with regard to the effects of energy efficiency investments in Households (upper chart) and Industry covered by the ETS (lower chart). In order to avoid, however, that these charts become too complicated they show only the main linkages and effects, notably in the Households diagram. For instance, this diagram does not specify the effects of EE investments on electricity use which – similar to the effects of EE investments in the Industry diagram – would have subsequent impacts on the ETS carbon price.

In summary the key strengths of E3ME lie in three different areas:[10]

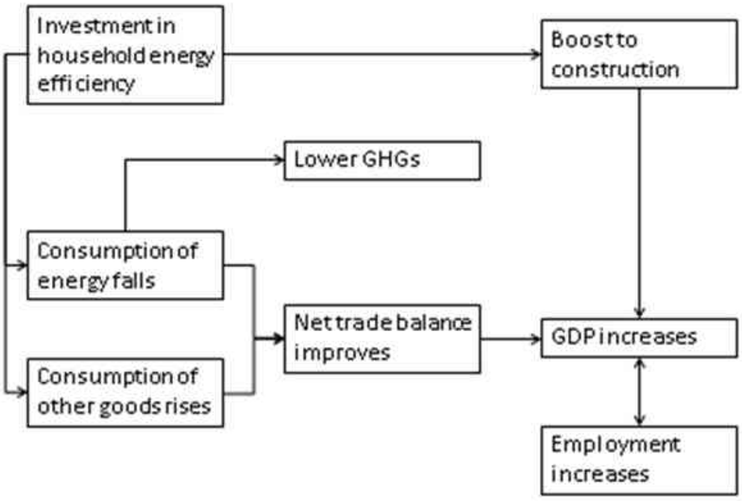
- The close integration of the economy, energy systems and the environment, with two-way linkages between each component;
- The detailed sectoral disaggregation in the model's classifications, allowing for the analysis of similarly detailed scenarios;
- The econometric specification of the model, making it suitable for short and medium-term assessment, as well as longer-term trends;

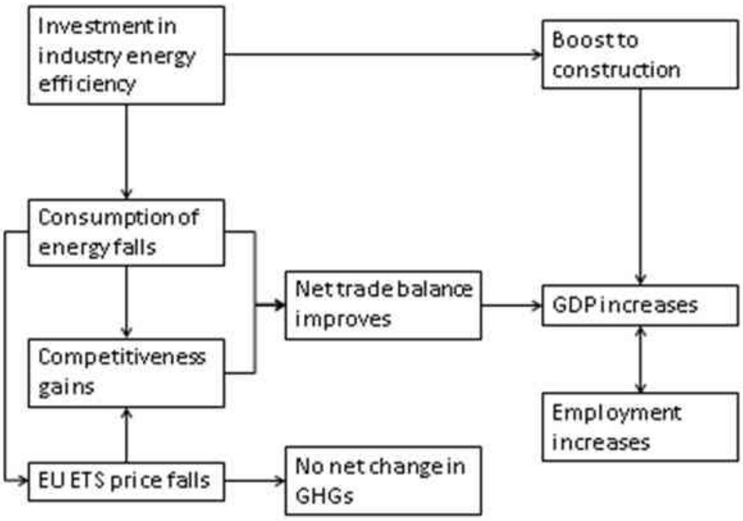
This makes E3ME a suitable tool to use for running and assessing the scenarios described in the previous sections. The results from this exercise are presented and analysed in the following chapter.

[9] Rebound effects occur where an initial increase in efficiency reduces demand, but this is negated in the long run as greater efficiency lowers the relative cost and increases consumption. See Barker et al. (2009).

[10] For further details on the model, see Pollitt (2010) and other information included in the E3ME website: http://www.e3me.com

Figure 2: E3ME linkages regarding effects of EE investments in Households (upper chart) and in Industry covered by the EU ETS (lower chart)





3

Major results at EU27 level

This chapter presents and discusses the major results at the EU27 level of the scenarios outlined in the previous chapter. These results refer in particular to (i) energy use and savings at the sectoral level, (ii) GHG emissions and the ETS carbon price, (iii) scenario outcomes of the power sector, and (iv) other socio-economic results such as the effects of the various scenarios on GDP, employment, incomes and international trade.

The results are mainly presented in summary tables and analysed in some detail, first of all for the intermediate scenarios (Section 3.1). Subsequently, we present our estimates of the energy savings potentials up to 2020, the investment needs and the public support to achieve these potentials (Section 3.2). Next, we analyse our results for the EE investment scenarios (Section 3.3), and finally for the additional policy scenarios (Section 3.4).

Unless stated otherwise, all results in this chapter refer to the EU27 level in 2020.

3.1 Intermediate scenarios

The baseline scenario (1Ai)
As noted, our baseline scenario has been calibrated and matched to the PRIMES 2009 Reference scenario. Consequently, our baseline scenario shows similar results with regard to the projected total primary energy use in 2020 (1665 Mtoe) and the remaining ‘energy savings gap’ (191 Mtoe), given the overall EU target to reduce total primary energy use to 1474 Mtoe in 2020 (**Table 4**). In 2020, our baseline scenario includes an ETS carbon price of 16.5 €/tCO_2, total EU GHG emissions of 4309 MtCO_2e, a power price of 107 €/MWh and an average house-hold power bill of € 678 per annum (**Table 5** and **Table 6**).

Table 4: Intermediate scenarios (EU27): Primary energy use and energy savings by sectors in 2020 (in Mtoe)

	1Ai	1Bi	2Ai	2Bi
Industry	181	161	186	165
Households	212	210	195	193
Tertiary	94	93	85	84
Sub-total target sectors	*487*	*464*	*466*	*442*
Other sectors	1178	1155	1170	1149
Total EU27	*1665*	*1620*	*1636*	*1592*
Target 2020	1474	1474	1474	1474
Energy savings gap	191	146	162	118
Additional energy savings, compared to baseline scenario 1Ai				
Industry	0	20	-5	16
Households	0	2	17	19
Tertiary	0	1	9	10
Sub-total target sectors	*0*	*23*	*22*	*45*
Other sectors	0	23	8	29
Total EU27	*0*	*45*	*29*	*73*

The EU GHG stretch scenario (1Bi)

In scenario 1Bi the EU GHG mitigation target is increased to 30% in 2020. As explained in Section 2.1, this is translated in a proportional reduction of the ETS cap – by 30 % in 2020, compared to 2009 ETS emissions – and an increase in offset credits by half of the resulting additional ETS emissions reduction, while all other policies are assumed to remain similar to those of the baseline scenario. As a result, the (endogenous) ETS carbon price (where the model incorporates carbon price dynamics, particularly vis-à-vis energy demand and explained in more detail below) increases from 16.5 €/tCO_2 in the baseline to 80.0 €/tCO_2 in scenario 1Bi, while CO_2 emissions in the ETS decline from 2002 to 1837 MtCO_2 and total EU GHG emissions from 4309 to 4121 MtCO_2 (**Table 5**).

It should be stressed that the carbon price of €80/t CO_2 does not represent our current assessment of the cost of meeting the 30% target but is designed to illustrate the potential of extra investment, described below. More recent and detailed analysis of ETS prices and revenues, using the E3ME model, suggests that a carbon price in the range of €40-45/t CO_2 would be sufficient to meet the target (Vivid Economics, 2012). The main reasons for the difference are:

- the more recent analysis includes more recent (and more negative) data on Europe's economies and energy consumption;
- recent data and projections of energy prices are lower than previously, meaning that any increase in EU ETS price has a larger proportional impact on total energy costs and therefore also on behavioural response;
- the recent analysis also includes additional policies that have been implemented;
- EUA's carried over from Phase II have been included in the recent calculations.

While there clearly remains considerable uncertainty about the outcome for the carbon price, lower carbon prices in the scenarios with a 30% GHG reduction target would not alter the main conclusions from this analysis, namely that there are sufficient revenues for investment in energy efficiency and that the economic impacts will generally be small.

The additional emission reductions are partly accomplished by extra energy savings, in particular in the industrial ETS sectors. The higher carbon price raises the energy costs relatively the most in Industry because the base energy prices are relatively low compared to other sectors. Therefore, most of the extra savings are found for Industry (about 20 Mtoe in 2020). For the sectors Households and Tertiary only the electricity price increases – due to the pass-through of the higher ETS carbon prices – and extra saving are much lower (about 2 and 1 Mtoe, respectively; see **Table 4**).

Overall, in scenario 1Bi, the additional energy savings in 2020 amount to 23 Mtoe for the three target sectors as a whole, while the other sectors contribute to extra energy savings of 23 Mtoe. Therefore, total energy savings amount to 45 Mtoe, resulting in a remaining energy savings gap of 146 Mtoe in 2020 (**Table 4**).

Table 5: Intermediate scenarios (EU27): GHG emissions and ETS carbon price in 2020

	1Ai	1Bi	2Ai	2Bi
In absolute values				
GHG emissions ($MtCO_2e$)	4309	4121	4232	4044
CO_2 emissions ($MtCO_2$)	3672	3498	3596	3422
CO_2 emissions ETS sectors ($MtCO_2$)	2002	1837	2002	1837
CO_2 emissions non-ETS ($MtCO_2$)[a]	1670	1661	1594	1585
ETS carbon price (2008 prices; €/tCO_2)	16.5	80.0	9.0	65.2
In % change, compared to the baseline scenario 1Ai				
GHG emissions		-4.4	-1.8	-6.2
CO_2 emissions		-4.7	-2.1	-6.8
CO_2 emissions ETS sectors		-8.2	0.0	-8.2
CO_2 emissions non-ETS[a]		-0.6	-4.6	-5.1
ETS carbon price		381.1	-45.7	292.1

a) Excludes non-energy related emissions

Due to the increase in the ETS carbon price, scenario 1Bi results in an increase in the electricity price from, on average, 107 to 119 €/MWh.[11] **While power use is hardly affected by the higher electricity price, the power bill increases by € 61 per annum for an average household and by € 34 billion for all power consumers across the EU27**. On the other hand, the more stringent ETS cap and the resulting higher ETS carbon price do have an impact on power sector emissions, which decline by 71 $MtCO_2$. This implies that, when moving from the baseline to the scenario 1Bi, **the total power bill increases, on average, by € 487 per tonne CO_2 reduced, while the ETS carbon price – or the**

[11] The increase in the electricity price may vary significantly across EU Member States depending on the structure of their power sector, in particular the carbon intensity of the marginal power plant setting the electricity price (Sijm et al., 2008).

marginal costs of CO_2 reduction – increases from approximately 17 to 80 €/tCO_2 (**Table 5** and **Table 6**). It should be observed, however, that total ETS emissions in this scenario decline by 165 MtCO_2, while auction revenues from the power sector increase from approximately € 19 billion to € 88 billion in 2020 from which energy end-users may benefit through higher government expenditures and/or lower taxes.

In scenario 1Bi, as well as in all other following scenarios, almost all of the energy savings and emission reductions in the so-called 'other sectors' originate from the power sector, with the exception of the 'B' scenarios where, in order to meet the lower ETS cap, a major part of the energy savings also comes from the aviation sector (which is part of the ETS).

Table 6: Intermediate scenarios (EU27): Power sector results in 2020

	1Ai	1Bi	2Ai	2Bi
Power price (in €/MWh)[a]	107	119	105	116
Total power use (in TWh)	3198	3153	3108	3071
Total power bill (in billion €)	341	376	326	356
Average household power use (in MWh)	4.0	4.0	3.8	3.8
Average household power bill (in€)	678	739	638	689
Power sector emissions (in MtCO_2e)	1179	1108	1158	1091
Carbon intensity of power production (in KgCO_2/MWh)	369	351	373	355
Changes compared to baselinescenario 1Ai				
Change in average household power bill (in€)		61	-40	10
Change in total power bill (in billion€)		34	-16	14
Reduction in power sector emissions (in MtCO_2e)		71	21	87
Change in total power bill per tonne CO_2e reduced (in €/tCO_2)		487	-754	162

a) Average power price for households and industry. For households only, the average power price is almost 60 per cent higher. Household electricity prices increase comparatively less than other sectors due to the fact that tax makes up a larger proportion of the household electricity price.

The Energy Efficiency Obligation scenario (2Ai)

In scenario 2Ai an Energy Efficiency Obligation is introduced, which refers only to the consumption of gas and electricity in the sectors Households and Tertiary. As a result, the energy use in these sectors declines by some 26 Mtoe in 2020. The implementation of the EEO, however, reduces the ETS carbon price from 16.5 €/tCO_2 to 9.0 €/tCO_2 in scenario 2Ai. This is due to the fact that the EEO results in a reduction in power use in the sectors Households and Tertiary and, hence, to less energy use and less related emissions in the ETS covered power sector (although less significant than in the previous scenario, i.e. strengthening the EU ETS cap).

Due to the lower ETS carbon price, however, energy use in Industry becomes cheaper and, therefore, *increases* by 5 Mtoe. Overall, due to the EEO, energy use declines, on balance, by almost 22 Mtoe in the three target sectors, by nearly 8 Mtoe in the other sectors – i.e. predominantly in the power sector – resulting in a remaining energy savings gap of about 162 Mtoe up to 2020 (**Table 4**).

Due to the EEO, CO_2 emissions in the non-ETS sector are significantly lower in this scenario, compared to the baseline as well as to the previous scenario (i.e. strengthening the EU ETS cap). Compared to the latter scenario, however, emissions in the EEO scenario are higher in terms of both CO_2 emissions in the ETS sector, total EU27 CO emissions and total EU27 GHG emissions (**Table 5**)

As mentioned above, the EEO leads to a reduction in power use and related emissions. Note, however, that the decrease in total power sector emissions is slightly less significant than the decrease in total power use, implying that – due to the lower ETS carbon price and the resulting switch to more carbon intensive power generation – the average carbon intensity of power generation in 2020 increases slightly from 369 $KgCO_2$/MWh in the baseline scenario to 373 $KgCO_2$/MWh (**Table 6**).

In addition to the induced lower power use, the EEO also results in a lower power price (due to the pass through of a lower ETS carbon price). Overall, in scenario 2Ai, **the power bill is reduced by € 40 per annum for an average household and by € 16 billion for all power users across the EU27**. As power sector emissions decline by 21 $MtCO_2$, scenario 2Ai **leads to a *decrease* of the EU27 power bill implying on average a benefit in terms of lower power bills of € 754 per tonne CO_2 reduction**. Therefore, on the one hand, the EEO scenario 2Ai results in less energy use and lower energy bills at the EU27 and household levels. On the other hand, however, it results in a 1% increase in the average carbon intensity of power generation, a halved ETS carbon price and, hence, a corresponding decrease in ETS auction revenues.

The EU GHG stretch and EEO scenario (2Bi)
As scenario 2Bi combines the distinguishing features of the two previous scenario (i.e. both a 30% GHG mitigation target and an EEO), it provides a cumulative mix of the outcomes of these scenarios. Overall, it results in significant energy savings in Industry, Households and Tertiary totalling about 45 Mtoe for these three target sectors as a whole. In addition, it leads to substantial energy savings in the other sectors of the EU, thereby reducing in total the energy savings gap by 73 Mtoe to a remaining target level of 118 Mtoe in 2020 (**Table 4**).

In addition it results in a reduction of GHG emissions, including power sector emissions, by some 6% - relative to the baseline – and an ETS carbon price between the two 'extremes' of the two previous scenarios, i.e. about 65 €/tCO_2 (again likely to be an over-estimate given more recent developments). Compared to the baseline, this higher carbon price results in an increase in the power price by approximately 8%. However, as power use decreases by some 5%, the power bill **is increased by €10 per annum for an average household and by € 14 billion for all power users across the EU27**. (**Table 5** and **Table 6**).

Other socioeconomic outcomes
Table 7 presents some other, socioeconomic outcomes of the baseline scenario (in absolute terms) and the three other intermediate scenarios (in % change compared to the baseline). In scenario 1Bi, the tightening of the ETS cap to a 34% reduction compared to 2005 CO_2 emissions levels, as opposed to 21% in the baseline, causes the EU allowance price to increase almost five-fold to 80 €/tCO_2 in 2008 real terms which has some negative economic consequences. More specifically, the increase in the EU

carbon price causes some end-user price increases, which lead to the erosion of real incomes and therefore consumer spending. Export volumes are reduced because of the impact on competitiveness, but in contrast import volumes are also reduced because of reduced fossil fuel imports and the reduction in real incomes. Overall, there is an emissions reduction from the EU ETS sectors, although we assume that additional CDM credits are required to meet the overall target and so the reduction in domestic EU ETS emissions is only 8% compared to the baseline. The overall impact in 2020 at the macroeconomic level results in a reduction to GDP of 0.3% (€ 46.3 billion) by 2020, with some sectors impacted more than others by higher costs.

Table 7: Intermediate scenarios (EU27): Other, socioeconomic outcomes in 2020

	1Ai	1Bi	2Ai	2Bi
	[Absolute values]	[% change compared to baseline scenario 1Ai]		
GDP (2000; billion €)	15443	-0.3	0.4	0.1
Consumption (2000; billion€)	8710	-0.4	0.3	-0.1
Investment (2000; billion €)	4041	-0.1	0.9	0.8
Exports (2000; billion €)	8298	-0.5	0.3	-0.1
Imports (2000; billion €)	8113	-0.4	0.3	0.0
Consumer prices (2008 = 1.0)	1.2	0.9	0.0	0.7
Employment (million)	233	-0.1	0.2	0.1
Real household incomes (2000; billion€)	10833	-0.5	0.2	-0.2
Final energy demand (Mtoe)	1204	-2.8	-3.2	-5.9

In contrast to tightening the ETS cap, the introduction of an Energy Efficiency Obligation in scenario 2Ai has largely positive socioeconomic effects. These positive results occur for two main reasons:

1. At an aggregate level there is a shift in spending from imported fossil fuels to the construction and engineering activity related to the investments in energy savings;
2. Because of the EE improvements, there is a shift from consumers' expenditure on fossil fuels to all other goods and services which have a higher domestic value added labour content.

In scenario 2Bi, the combination of a tighter EU ETS cap and an Energy Efficiency Obligation has a substantial impact in terms of reducing final energy consumption and GHG emissions by 2020. Moreover, the positive impact of the EEO-induced investments outweighs the negative impact of the higher ETS allowance price (which itself is offset as a result of the EEO), and so there are some modest socioeconomic benefits as a result of this policy scenario.

3.2 Energy savings potentials, investment needs and public funding

For each intermediate scenario in 2020, we have estimated remaining energy savings potentials in the sectors Households, Tertiary and Industry at the EU27 level, as well as the investment needs and required public funding to realise these potentials (as outlined briefly in Section 2.2, with further details in Appendix B and Appendix C).

Table 8 presents the results in terms of the estimated remaining energy savings potentials in the target sectors in 2020. As expected, the potentials are largest in the baseline scenario, i.e. totalling almost 74 Mtoe of energy savings potentials of which about half in the sector Households. In scenario 1Bi, with a high ETS carbon price, the total potentials are significantly reduced, in particular in the industrial (ETS) sector.

In scenario 2Ai, with an EEO targeted to the sectors Households and Tertiary, energy savings potentials are even further reduced, notably in these sectors. Finally, total remaining energy savings potentials are smallest – only 33 Mtoe – in scenario 2Bi, which combines an EEO with a relatively high ETS carbon price.

Table 8: *Intermediate scenarios (EU27): Remaining energy savings potentials in target sectors in 2020 (in Mtoe)*

	1Ai	1Bi	2Ai	2Bi
Industry	20.9	4.7	20.9	6.1
Households	37.0	33.2	22.2	20.7
Tertiary	15.6	13.5	6.6	6.4
Total	73.5	51.5	49.7	33.3

Table 9 provides the results of estimating the investment needs and the required public funding to deliver the remaining energy savings potentials in **Table 8**. The left part of **Table 9** shows the estimated amount of the investment needs both in cumulative terms over the period 2013-2020 as a whole (upper part of the table) and in annual average terms for this period (lower part). In cumulative terms, the total investment needs for the three target sectors vary between € 293 billion in the baseline scenario to € 151 billion in scenario 2Bi. In annual terms, these figures amount to € 37 billion and € 19 billion, respectively.

The right part of **Table 9** presents similar estimates for public funding assumed to be required to support the estimated (private) investment needs and, hence, to induce these investments and so to achieve the resulting energy savings potentials (for details see Section 2.2, as well as Appendix B and Appendix C). **In cumulative terms, the required public funding for the three target sectors varies between € 47 billion in the baseline scenario to € 23 billion in scenario 2Bi. In annual terms, these figures amount to € 5.9 billion and € 2.9 billion, respectively.**

Table 9: Intermediate scenarios (EU27): Investment needs to achieve energy savings potentials in target sectors in 2020 (in billion€)

	Investment needs					Required public funding			
	1Ai	1Bi	2Ai	2Bi		1Ai	1Bi	2Ai	2Bi
Cumulative needs over the period 2013-2020									
Households	180	163	111	104		28.8	26.1	17.7	16.5
Tertiary	68	61	33	32		12.5	11.6	6.6	6.4
Industry	45	12	45	15		5.9	0.1	5.9	0.4
Total	293	236	189	151		47.3	37.9	30.2	23.4
Average annual needs over the period 2013-2020									
Households	22.5	20.4	13.9	13.0		3.6	3.3	2.2	2.1
Tertiary	8.5	7.6	4.1	4.0		1.6	1.5	0.8	0.8
Industry	5.6	1.5	5.6	1.9		0.7	0.0	0.7	0.1
Total	36.6	29.5	23.6	18.9		5.9	4.7	3.8	2.9

Finally, **Table 10** compares the estimates of the ETS auction revenues in the intermediate scenarios to the estimates of the public funding requirements to meet the energy savings potentials in the target sectors up to 2020. ETS auction revenues have been estimated by multiplying the annual ETS carbon price by the annual amount of EU allowances (EUAs) that the power sector needs to cover its emissions over the third trading period, 2013-2020. Hence, it is assumed that:

- In all EU27 Member States the power sector has to cover all its emissions by surrendering EUAs bought at a public auction, thereby abstaining from the fact that (i) the power sector in Central and Eastern Europe will continue to receive a significant but declining share of its necessary allowances for free (i.e. 70% in 2013, declining to zero in 2020), and (ii) the power sector may also buy an eventual surplus of allowances allocated for free to the industrial sectors on the secondary EUA market.
- In all EU27 Member States the full amount of EUAs destined for the industrial sectors will continued to be allocated for free up to 2020.

Table 10 shows that over the period 2013-2020 as a whole **total ETS auction revenues at the EU27 level are generally more than sufficient to cover the public support needs to realise the remaining energy savings potentials in the target sector up to 2020.** In the baseline scenario, for instance, auction revenues are estimated at, on average, € 18 billion per annum and the public funding needs at € 6 billion, resulting in a 'surplus' or balance of ETS auction revenues of € 12 billion per annum. This surplus is substantially higher in scenario 1Bi (i.e. € 81 billion per annum), predominantly due to the higher ETS carbon price in this scenario. But **even in scenario 2Ai – where the implementation of the EEO leads to a lower carbon price and, hence, to lower auction revenues – there is still a significant surplus of these revenues**, partly because of the lower remaining energy savings potentials in the target sectors and, therefore, the lower public funding needs to realise these potentials.

It should be emphasized that the estimated auction revenues in **Table 10** refer to the intermediate scenarios. Realising additional energy savings in the ETS sectors, however, reduces the ETS carbon price and, hence, the auction revenues as will be outlined in the next section when discussing the results of the investment scenarios. In addition, this section will also make some other qualifications to the estimates of both the auction revenues and the public support needs presented in **Table 10**.

Table 10: Intermediate scenarios (EU27): Comparison of ETS auction revenues and public support needs to meet energy savings potentials in target sectors up to 2020 (in billion €)

	ETS auction revenues		Public support needs		Balance	
	Cumulative 2013-2020	Annual average	Cumulative 2013-2020	Annual average	Cumulative 2013-2020	Annual average
1Av	144.4	18.1	47.3	5.9	97.1	12.1
1Bv	685.9	85.7	37.9	4.7	648.0	81.0
2Av	114.0	14.3	30.2	3.8	83.8	10.5
2Bv	615.6	76.9	23.4	2.9	592.2	74.0

3.3 Investment scenarios

As explained in Chapter 2, including the estimated amounts of public funding and the resulting additional energy savings investments in the four intermediate scenarios (1Ai, 1Bi, 2Ai and 2Bi) leads to the respective investment scenarios (1Av, 1Bv, 2Av and 2Bv). The performance of these investment scenarios is summarised in **Table 11** up to **Table 16** and is briefly discussed below.

For each investment scenario, **Table 11** presents the additional energy savings due to the extra energy efficiency investments, compared to the respective intermediate scenarios. For the three target sectors as a whole, these savings vary from 19 Mtoe in scenario 2Bv to 51 Mtoe in 1Av. Moreover, scenario 2Bv results in additional energy savings in the other sectors amounting to 24 Mtoe (see bottom part of, **Table 11**).

In addition, **Table 11** shows the combined energy saving effects for each investment scenario compared to the baseline scenario, i.e. the total energy saving effects of the extra EE investments and raising the ETS cap/introducing the EEO. For the three relevant scenarios (1Bv, 2Av and 2Bv), these effects vary from 53 to 64 Mtoe for the three target sectors as a whole, and from 22 to 37 Mtoe for the other sectors.

Table 11: Investment scenarios (EU27): Primary energy use and energy savings by sectors in 2020 (in Mtoe)

	1Av	1Bv	2Av	2Bv
Industry	175	170	175	169
Households	177	179	174	174
Tertiary	83	85	81	80
Sub-total target sectors	*436*	*434*	*430*	*424*
Other sectors	1153	1141	1155	1141
Total EU27	*1590*	*1576*	*1587*	*1566*
Target 2020 (baseline)	1474	1474	1474	1474
Energy savings gap	116	102	113	92
Additional energy savings, compared to baseline scenario 1Ai				
Industry	6	11	6	11
Households	35	33	38	38
Tertiary	11	10	14	14
Sub-total target sectors	*51*	*53*	*57*	*64*
Other sectors	24	37	22	37
Total EU27	*75*	*89*	*78*	*99*
Additional energy savings, compared to each respective intermediate scenario[a]				
Industry	6	-9	10	-4
Households	35	32	21	19
Tertiary	11	8	5	4
Sub-total target sectors	*51*	*31*	*36*	*19*
Other sectors	24	14	14	8
Total EU27	*75*	*43*	*49*	*26*

a) That is scenario 1Av to scenario 1Ai, scenario 1Bv to scenario 1Bi, etc.

In order to assess the net effectiveness of the additional EE investments, **Table 12** provides a comparison of the estimated energy savings potentials in the four intermediate scenarios and the realised energy savings in the respective investment scenarios. The left part of the table provides data on energy savings realised with an endogenous carbon price, i.e. determined within the model by input variables such as the level of EE investments. The right part shows similar data with an exogenous carbon price, i.e. fixed at a level before the additional EE investments are made.

The first or upper part of **Table 12** presents data on the energy savings potentials up to 2020 before additional EE investments are made to achieve these potentials. The second part provides the energy savings realised after the investments have been implemented. The third part gives the balance or difference between the savings potentials and the savings realised, while the fourth part expresses the savings realised as a percentage of the potentials. Subsequently, the table shows the endogenous carbon price on the left and the exogenous carbon price on the right. The endogenous price takes into account the effect of EE investment on the carbon price. The exogenous carbon price is fixed at the level before extra investments are made. Finally, the bottom line indicates the % change in GDP for each respective scenario.

Table 12: Comparison of energy savings potentials and energy savings realised by additional EE investments, with an endogenous versus exogenous ETS carbon price

	Endogenous carbon price				Exogenous carbon price			
	1Av	1Bv	2Av	2Bv	1Av	1Bv	2Av	2Bv
Energy savings potentials (in Mtoe)								
Industry	20.9	4.7	20.9	6.1	20.9	4.7	20.9	6.1
Households	37.0	33.2	22.2	20.7	37.0	33.2	22.2	20.7
Tertiary	15.6	13.6	6.6	6.4	15.6	13.6	6.6	6.4
Target sectors	73.5	51.5	49.7	33.2	73.5	51.5	49.7	33.2
Energy savings realised (in Mtoe)								
Industry	5.9	-9.1	10.4	-4.4	16.4	2.5	14.9	2.0
Households	35.0	31.7	21.0	19.1	35.5	32.6	21.2	19.6
Tertiary	10.9	8.5	4.6	4.2	11.2	9.0	4.7	4.5
Target sectors	51.4	30.5	35.7	18.6	62.8	43.6	40.6	25.8
Balance: energy savings potentials minus energy savings realised (in Mtoe)								
Industry	15.0	13.8	10.5	10.5	4.5	2.2	6.0	4.1
Households	2.0	1.5	1.2	1.6	1.5	0.6	1.0	1.1
Tertiary	4.7	5.1	2.0	2.2	4.4	4.6	1.9	1.9
Target sectors	22.1	21.0	14.0	14.6	10.7	7.9	9.1	7.4
Energy savings realised as a share of energy savings potential (in %)								
Industry	28.2	-193.4	49.6	-72.8	78.6	52.7	71.1	33.4
Households	94.6	95.5	94.5	92.5	95.9	98.1	95.6	94.7
Tertiary	69.9	62.2	69.5	65.8	71.9	66.4	71.4	70.1
Target sectors	69.9	59.3	71.8	55.9	85.5	84.7	81.6	77.8
ETS carbon price (in €/tCO_2)								
Before investments	16.5	80.0	9.0	65.2	16.5	80.0	9.0	65.2
After investments	0	35.9	0.0	35.1	16.5	80.0	9.0	65.2
GDP (% difference from respective intermediate scenario)								
	0.74	0.78	0.42	0.48	0.67	0.62	0.41	0.40

In the first instance, one would expect that if the additional EE investments are indeed implemented to achieve the energy savings potentials, the balance between these potentials and the savings realised would be close to zero and the share of savings as a percentage of potentials near to 100%. **Table 12** shows, however, that this is generally not the case. For instance, in scenario 1Av, with an endogenous carbon price, the balance between savings potentials and realisations in the target sectors is overall 22 Mtoe, i.e. on average about 70% of the potentials in the target sectors is actually realised. In scenario 1Bv, this share is even approximately 60%.

How can these deviations between expectations/potentials and realisations be explained? A major reason, as indicated before, is that additional EE investments focussing on ETS related fuel savings result in a reduction in ETS emissions and, hence, in a lowering of the carbon price. For instance, in scenario 1Bv, the carbon price is reduced from 80 to 36 €/tCO_2 due to the extra EE investments, in particular those investments resulting in a reduction of direct energy use and related emissions in the power and industrial ETS sectors.

Due to the lower carbon price and, hence, a pass-through of lower carbon costs to the electricity price, energy use in ETS sectors and electricity consumption by end-users actually becomes cheaper and, therefore, energy demand increases. This increase in energy use partly nullifies the initial energy savings due to the extra EE investments. In scenario 1Bv, energy use in Industry even *increases* on balance by 69.1 Mtoe, predominantly due to the substantial fall in the carbon price before and after the additional EE investments.

The impact of the induced lower carbon price can be illustrated by fixing the carbon price exogenously at the level before the extra investments are made (see right part of **Table 12**). For instance, in scenario 1Bv, by fixing the carbon price at a level of 80 €/tCO_2, energy savings in Households increase from 32 to 33 Mtoe, while in Industry energy use shifts from an *increase* of 9.1 Mtoe to a *decrease* of 2.5 Mtoe. Overall, by fixing the carbon price, the balance between energy savings potentials and realisations in scenario 1Bv declines from 21 to 8 Mtoe for the three target sectors as a whole, while the rate of realisations as a share of potentials increases from 59% to 85%. **More generally, across the four scenarios, Table 12 shows that this rate increases from some 60-70% in case of an endogenous carbon price to about 75-85% in case of an exogenous carbon price.**

Another reason why the actually realised energy savings are, on balance, lower than the EE investment related potentials is that the **extra EE investments result in a higher GDP and a lower energy bill, and some of these savings are spent on other, energy-using activities ('rebound effects').** For instance, the bottom line of **Table 12** shows that GDP is about 0.5-0.8% higher in the investment scenarios, compared to the respective intermediate scenarios.[12] As total primary energy use in the target sectors amount to almost 500 Mtoe in 2020, this implies that the impact of a higher GDP amounts to some 2-4 Mtoe, assuming a linear relationship between GDP and energy use in the target sectors (see also **Table 14** below, which illustrates the impact of additional EE investments on lowering electricity bills).

Table 13 provides the impact of the investment scenarios on GHG emissions in 2020. Compared to the respective intermediate scenarios, this impact ranges from 0.0% for CO_2 emissions of the ETS sectors in scenarios 1Bv and 2Bv to -6.6% for CO_2 emissions of the non-ETS sectors in scenarios 1Av. It should be noted, however, that the impact of the extra EE investments on particularly the CO_2 emissions in the ETS sectors has been significantly reduced in scenarios 1Av and 2Av – and even nullified in scenarios 1Bv and 2Bv – due to the existence of a fixed ETS cap and the resulting decrease in the ETS carbon price. Compared to the respective intermediate scenarios, the decrease of the ETS carbon price due to the extra EE investments amounts to 55% and 46% in scenarios 1Bv and 2Bv, respectively, and even 100% in scenarios 1Av and 2Av. Therefore, **additional EE investment which reduces ETS related emissions has a decreasing impact on the ETS carbon price that, in turn, partly or even fully nullifies the impact on total ETS emissions but also, as noted above, on related energy use.**

12 Note that the increase in GDP is generally higher under an endogenous carbon price, i.e. when the carbon price is lower due to the extra EE investments.

Table 13: Investment scenarios (EU27): GHG emissions and ETS carbon price in 2020

	1Av	1Bv	2Av	2Bv
In absolute values				
GHG emissions ($MtCO_2e$)	4096	4008	4088	3977
CO_2 emissions ($MtCO_2$)	3489	3410	3471	3370
CO_2 emissions ETS sectors ($MtCO_2$)	1929	1837	1941	1837
CO_2 emissions non-ETS ($MtCO_2$)[a]	1560	1572	1530	1533
ETS carbon price (2008; €/tCO_2)	0.0	35.9	0.0	35.1
In % change, compared to the baseline scenario 1Ai				
GHG emissions	-4.9	-7.0	-5.1	-7.7
CO_2 emissions	-5.0	-7.1	-5.5	-8.2
CO_2 emissions ETS sectors	-3.6	-8.2	-3.0	-8.2
CO_2 emissions non-ETS[a]	-6.6	-5.8	-8.4	-8.2
ETS carbon price	-100.0	116.0	-100.0	111.0
In % change, compared to each respective intermediate scenario[b]				
GHG emissions	-4.9	-2.8	-3.4	-1.7
CO_2 emissions	-5.0	-2.5	-3.5	-1.5
CO_2 emissions ETS sectors	-3.6	0.0	-3.0	0.0
CO_2 emissions non-ETS[a]	-6.6	-5.3	-4.0	-3.3
ETS carbon price	-100.0	-55.1	-100.0	-46.2

a) Excludes non-energy related emissions.
b) That is scenario 1Av to scenario 1Ai, scenario 1Bv to scenario 1Bi, etc.

Table 14 presents the results of the investment scenarios for the power sector in 2020. Compared to the respective intermediate scenarios, the extra EE investments lead to, in general, lower power use and lower power prices. As a result, the power bill in 2020 is significantly reduced, ranging at the EU27 level from € 28 billion in scenario 2Av to € 54 billion in 1Bv and, at the average household level, from € 68 in 2Av to € 140 in 1Bv. Moreover, due to the extra EE investments and the resulting lower power use, GHG emissions in the power sector are reduced by 31 $MtCO_2e$ in scenario 2Bv to 92 $MtCO_2e$ in 1Av. This implies that the EU27 power bill decreased by, on average, € 505 per tonne CO_2 reduction in scenario 1Av and by € 1125 per tonne in 2Bv (see bottom part of Table 14).

Table 14: Investment scenarios (EU27): Power sector results in 2020

	1Av	1Bv	2Av	2Bv
Power price (in €/MWh)[a]	101	108	102	108
Total power use (in TWh)	2916	2987	2921	2967
Total power bill (in billion €)	295	322	298	321
Average household power use (in MWh)	3.5	3.5	3.5	3.5
Average household power bill (in€)	563	599	570	602
Power sector emissions (in $MtCO_2e$)	1087	1060	1099	1061
Carbon intensity of power production (in $KgCO_2/MWh$)	373	355	376	357
Changes compared to baseline scenario 1Ai				
Change in average household power bill (in€)	-115	-79	-108	-76
Change in total power bill (in billion €)	-46	-20	-44	-20
Reduction in power sector emissions (in $MtCO_2e$)	92	119	80	118
Change in total power bill per tonne CO_2e reduced (in €/tCO_2)	-505	-165	-549	-171
Changes compared to each respective intermediate scenario[b]				
Change in average household power bill (in€)	-115	-140	-68	-86
Change in total power bill (in billion €)	-46	-54	-28	-34
Reduction in power sector emissions (in $MtCO_2e$)	92	48	59	31
Change in total power bill per tonne CO_2e reduced (in €/tCO_2)	-505	-1125	-477	-1125

a) Average power price for households and industry. For households only, the average power price is almost 60 per cent higher.
b) That is scenario 1Av to scenario 1Ai, scenario 1Bv to scenario 1Bi, etc.

Hence, from a power bill perspective, reducing power sector emissions through stimulating EE investments seems to be a more attractive strategy than by means of reducing the ETS cap and, thereby, increasing the ETS carbon price. As noted, however, promoting EE investments that reduce ETS/power sector related emissions has a decreasing impact on the ETS carbon price that, in turn, nullifies the impact on total ETS emissions but also reduces the impact on related energy use. That is, as long as the ETS cap is fixed – and the ETS carbon price is higher than zero – such investments result in shifting GHG emissions (and related energy use) across ETS sectors rather than reducing overall ETS emissions.

Therefore, a more useful approach in the long run might be a mixed package of both increasing the ETS carbon price (by lowering the ETS cap) and using part of the ETS auction revenues to stimulate investments in energy savings, including electricity savings. This mitigates the effects of a tighter ETS cap on the ETS carbon price and, both directly and indirectly, on the household power bill. This is actually the approach implemented in scenario 1Bv, compared to the baseline scenario 1Ai.

More specifically, these model results suggest that reducing the ETS cap only (i.e. scenario 1Bi) increases the ETS carbon price from 17 €/tCO_2 to 80 €/tCO_2, the average power price from 107 €/MWh to 119 €/MWh, the average household power bill from €

678 to € 739, while energy savings amount to 23 Mtoe for the three sectors as a whole. However, **reducing both the ETS cap and using part of the ETS auction revenues to stimulate energy/electricity savings (i.e. scenario 1Bv), *mitigates* the increase in the ETS carbon price from 17 €/tCO_2 to 36 €/tCO_2 rather than 80 €/tCO_2 and the average power price from 107 €/MWh to 108 €/MWH, *decreases* the average household power bill from € 678 to € 599 per annum, while energy savings double to about 53 Mtoe for the three target sectors as a whole.**

Table 15 presents the outcomes of the investment scenarios for the other, socioeconomic variables in 2020. Compared to each respective intermediate scenario, the changes in these variables are generally positive, and more significant in scenarios 1Av and 1Bv compared with 2Av and 2Bv (because the amount of extra EE investments in 1Av and 1Bv is higher; see **Table 9**). The main exception concerns the variable *final energy use*, which is reduced significantly by 2.9% in scenario 2Bv up to 8.2% in scenario 1Av (see bottom line of lower part of **Table 15**).

Table 15: Investment scenarios (EU27): Other, socio-economic outcomes in 2020

	1Av	1Bv	2Av	2Bv
In % change, compared to the baseline scenario 1Ai				
GDP	0.7	0.5	0.8	0.6
Consumption	0.5	0.3	0.5	0.4
Investments	1.6	1.2	1.9	1.6
Exports	0.5	0.3	0.6	0.4
Imports	0.5	0.2	0.6	0.4
Consumer prices	-0.1	0.3	0.1	0.4
Employment	0.4	0.3	0.4	0.4
Real household incomes	0.3	0.1	0.3	0.1
Final energy demand	-8.2	-7.1	-9.3	-8.6
In % change, compared to each respective intermediate scenario[a]				
GDP	0.7	0.8	0.4	0.5
Consumption	0.5	0.7	0.3	0.4
Investments	1.6	1.3	1.0	0.8
Exports	0.5	0.7	0.2	0.4
Imports	0.5	0.7	0.3	0.4
Consumer prices	-0.1	-0.6	0.0	-0.4
Employment	0.4	0.4	0.2	0.2
Real household incomes	0.3	0.6	0.1	0.3
Final energy demand	-8.2	-4.4	-6.3	-2.9

a) That is scenario 1Av to scenario 1Ai, scenario 1Bv to scenario 1Bi, etc.

Compared to the baseline scenario, however, the cumulative effects on final energy demand of the policy mix of stimulating extra EE investments and other measures (i.e. reducing the ETS cap and/or introducing an EEO) are substantially higher in scenario 1Bv (-7.1%), 2Av (-9.3%) and 2Bv (-8.6%; see bottom line of upper part of **Table 15**).

Table 16 presents the estimates of the ETS auction revenues over the years 2013-2020 versus the estimated public support needs to achieve the extra EE investments up to 2020 in the four investment scenarios. As remarked at the end of Section 3.2, due to the lower ETS carbon price in these scenarios – resulting from the additional energy savings and related CO_2 emission reductions in the ETS sectors – the auction revenues are substantially lower in the investment scenarios compared to their respective intermediate scenarios. However, the results show that even if the actual carbon prices were much lower in the scenarios with a 30% GHG reduction target, the revenues would still be able to finance the investment in energy efficiency quite easily.

Table 16: Investment scenarios (EU27): Comparison of ETS auction revenues and public support needs to meet energy savings potentials in target sectors up to 2020 (in billion €)

	ETS auction revenues		Public support needs		Balance	
	Cumulative 2013-2020	Annual average	Cumulative 2013-2020	Annual average	Cumulative 2013-2020	Annual average
1Av	28.6	3.6	47.3	5.9	-18.7	-2.3
1Bv	456.2	57.0	37.9	4.7	418.3	52.3
2Av	32.2	4.0	30.2	3.8	2.0	0.2
2Bv	455.8	57.0	23.4	2.9	432.4	54.1

Note that the above-mentioned decline in auction revenues over the third trading period (by approximately 34%) is less than the decline in the ETS carbon price in 2020 (by about 55%). This is due to the fact that the additional EE investments and the resulting energy savings/emissions reductions in the ETS sector gradually build up over the years 2013-2020 and, hence, the decline in the ETS carbon price also gradually builds up to 55% in 2020. On average, however, the decline in the carbon price is less over the period 2013-2020 and similar to the decline in the ETS auction revenues (i.e. 34%).

Similarly, note also that in scenario 1Av, ETS auction revenues are estimated at approximately € 29 billion over the years 2013-2020 (**Table 16**) while the carbon price in 2020 is estimated at zero (**Table 13**). This can be explained by the fact that the E3ME model **estimates for the carbon price are still positive for the first years of the period 2013-2020, i.e. 13 €/tCO_2 in 2013 declining steadily to zero in 2016 and beyond** (see also **Figure 8** in Section 3.5 below). Hence, there are substantial auction revenues during the first three years of the third EU ETS trading period, but no revenues during the last five years.

The fact that the average annual ETS carbon price in the E3ME model differs over the years 2013-2020 and declines to zero in the latter half of this period in scenarios such as 1Av and 2Av results from some design features of this model, which solves on an annual basis, and the specific scenario assumptions: (i) EUAs are allocated each year to the participating entities with no banking or borrowing of allowances between the years of the third trading period, and (ii) banking of EUAs of the third trading period for next trading periods is not allowed.

Nevertheless, despite the decline in the ETS auction revenues resulting from the extra EE investments, Table 16 shows that, in principle, these revenues are still adequate to cover the public funding needs to support these investments in three out of four of the investment scenarios. The exception is scenario 1Av, in which the auction revenues are estimated at, on average, € 3.6 billion per annum over the period 2013-220 and the public EE support needs at € 5.9 billion, resulting in a funding deficit of € 2.3 billion per annum.

Some qualification, however, can be added to the above-mentioned findings on the balance between ETS auction revenues and public EE funding needs:

- The observations made above assume that the ETS auction revenues will be available for funding public support of additional energy savings investments. The EU ETS Directive, however, recommends that 50% of the auction revenues ought to be spent on climate policy issues, but this share is not binding. Moreover, this percentage refers to all climate policy spending, both existing and new/additional, including other climate policy expenditures beyond stimulating EE investments, such as promoting renewables or other climate friendly technologies, financing climate adaptation measures, providing climate finance support to non-Annex I countries, or compensating end-users for ETS induced higher electricity prices. Hence, in practice, the amount of ETS auction revenues available for supporting additional EE investments may be substantially less than actually needed. On the other hand, if deemed either socially desirable or necessary, extra EE investments may also be supported from other government resources beyond – or rather than – ETS auction revenues.
- In some Member States, such as the Netherlands or the UK, earmarking of ETS revenues to funding of climate policy measures is not accepted. That is, government revenues and government expenditures are considered separately and, hence, ETS revenues become part of total government revenues used to finance government expenditures, including recycling ETS revenues to firms and households through lower taxes or social premiums. As indicated above, however, in such countries extra EE investments may be supported through funding from public revenues in general rather than from earmarking to specific ETS auction revenues.
- **Table 16** presents an aggregated picture for the EU27 as a whole. For individual Member States, however, the balance between ETS auction revenues and public support needs may look quite differently. For instance, auction revenues may be relatively low, notably in countries such as France or Sweden which have a relatively low share of fossil-fuelled power generation. On the other hand, public EE support needs may be relatively high in some Member States because there is a relatively large potential of energy savings potentials in the target sectors or because these savings need a relatively high level of support to be realised.
- The estimates of the auction revenues are based on the projection of a certain ETS carbon price. For instance, in the baseline – which is calibrated to the 2009 PRIMES scenario – the ETS carbon price is projected to become 17 €/tCO_2 in 2020. Due to the lasting economic crisis, however, the current (2012) ETS price is about 6-8 €/tCO_2 while price expectations for the coming years are similarly low. Hence, actual ETS carbon prices over the years 2013-2020 may be significantly lower than the model projected carbon prices underlying the estimates of the auction revenues presented in **Table 16**.

- The estimates of the public support needs are based on an assumed support rate of, on average, 20% of investment needs for most categories of energy savings in the target sectors (based on historical evidence). As the easiest energy savings have already been reached, however, additional energy savings may require a higher share of support and, hence, total public funding needs may also be higher.
- On the other hand, for some categories of energy savings it may to possible to implement more specific, smarter and, hence, cheaper forms of stimulating energy savings rather than providing 20% – or more – support to EE investment needs, for instance by means of regulation or other cost-effective ways of reducing barriers to energy savings. In these cases, if successful, public support needs will be lower.

3.4 Additional policy scenarios

As outlined in Section 2.4, in order to address some specific policy issues, we have defined four so-called '*Additional Policy Scenarios*'. The results of these policy scenarios are presented in **Table 17** up to **Table 22** and briefly discussed below.

Table 17 provides the scenario results in terms of primary energy savings. It shows that in scenario 1An (i.e. focussing additional EE investments on non-ETS related fuel savings total energy use in the target sectors is reduced by 54 Mtoe, predominantly in the sectors Households and Tertiary (energy savings in these sectors are from gas, coal and other fuels, but not electricity). In contrast, in scenario 1Ae (focussing extra EE investments on saving ETS related fuels), total energy use in the target sectors decreases by only 4 Mtoe. This is due to the induced lowering of the ETS carbon price – even to zero over the years 2015-2020 – which largely nullifies the energy savings in Industry due to the extra EE investments.

Including the other sectors (i.e. largely power sector), however, shows that their energy use decreases by 49 Mtoe in 1Ae but increases slightly in 1An. The energy savings by the other sectors in 1Ae are largely due to stimulating electricity savings in the target sectors, resulting in substantial fuel savings in the power generation sector.

Overall, total additional energy savings for all sectors in 2020 amount to 54 Mtoe in scenario 1Ae and 52 Mtoe in 1An. Therefore, with regard to realising energy savings in all sectors it seems to be slightly more efficient to focus a certain amount of public support on saving ETS related fuels rather than on saving non-ETS related fuels. However, focussing public support on ETS related fuels has a decreasing effect on the ETS carbon price, starting from 2013 and becoming zero already by 2015 in scenario 1Ae. This not only reduces the amount of ETS related fuel savings but may also have other adverse effects such as increasing the average intensity of power generation (see below).

In order to assess the impact of a lower ETS carbon price on energy savings, we have designed two additional policy scenarios, 1As and 2At. Scenario 1As is almost similar to scenario 1Ae. The only difference of scenario 1As is that we have set aside an estimated amount of EUAs in order to neutralise the potential impact of these investments on the

ETS carbon price, i.e. to maintain this price over the years 2013-2020 at the same level as in the baseline scenario 1Ai. **Table 17** shows that under these conditions, i.e. scenario 1As compared to 1Ae, energy savings in 2020 increase by 12 Mtoe in the target sectors (mainly in Industry) and by another 10 Mtoe in the other sectors.

Table 17: Additional policy scenarios (EU27): Primary energy use and energy savings by sectors in 2020 (in Mtoe)

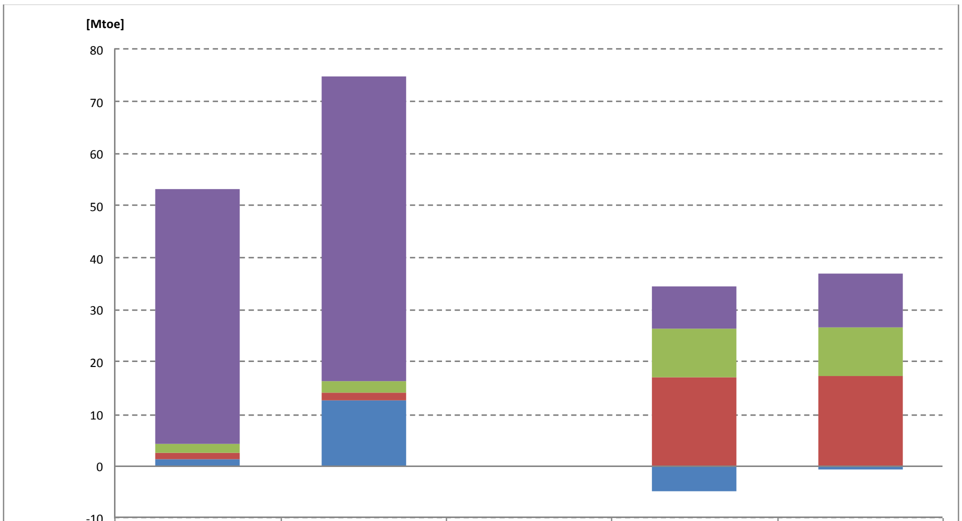
	1Ae	1An	1As	2At
Industry	179	180	168	181
Households	211	177	211	195
Tertiary	92	76	92	85
Sub-total target sectors	*483*	*433*	*471*	*461*
Other sectors	1129	1179	1119	1168
Total EU27	1611	1613	1590	1629
Target 2020	1474	1474	1474	1474
Energy savings gap	137	139	116	155
Additional energy savings, compared to baseline scenario 1Ai				
Industry	1	1	13	-1
Households	1	35	1	17
Tertiary	2	18	2	9
Sub-total target sectors	4	54	16	26
Other sectors	49	-1	59	10
Total EU27	54	52	75	36
Additional energy savings, compared to respective scenario[a]				
Industry			11	4
Households			1	0
Tertiary			0	0
Sub-total target sectors			12	4
Other sectors			10	2
Total EU27			22	7

a) That is scenario 1As to 1Ae and 2At to 2Ai.

Overall, total additional energy savings in all EU27 sectors in 2020 amount to 75 Mtoe in scenario 1As (i.e. focussing on investments in ETS fuel savings + setting aside EUAs to neutralise the depressing effect on the carbon price) against 54 Mtoe in scenario 1Ae (focussing on ETS fuel savings only) and 52 Mtoe in scenario 1An (focussing on non-ETS fuel savings only). Therefore, from an energy savings and long-term decarbonisation perspective, **the best approach seems to be focussing public support on stimulating investments in both ETS and non-ETS related fuel savings and setting aside a certain number of EUAs to neutralise the ETS price decreasing effect of such investments rather than focussing public support solely on stimulating either ETS or non-ETS related fuel savings.**

Table 17 shows that in scenario 2At, compared to scenario 2Ai, energy savings amount to 4 Mtoe in the target sectors (mainly Industry) and 2 Mtoe in the other sectors. These savings are lower than similar figures for scenario 1As, compared to 1Ae. The main reason is that the effect of the energy savings policies (either implementing an EEO or stimulating additional EE investments) on decreasing the ETS carbon price is far more significant in scenario 1Ae than in 2Ai. Therefore, the impact of neutralising this effect by means of setting aside EUAs on energy savings will be higher in 1As than 2At (see also **Figure 3**).

Figure 3: Impact of EUA set asides on energy savings per sector in 2020



	1Ae	1As		2Ai	2At
Other sectors	49	59		8	10
Tertiary	2	2		9	9
Households	1	1		17	17
Industry	1	13		-5	-1

Table 18 present the impact of the four additional policy scenarios on GHG emissions and the ETS carbon price in 2020. The most obvious, but not surprising differences between scenarios 1Ae and 1An with regard to these outcome variables include:

- Compared to the baseline scenario, CO_2 emissions in the non-ETS sectors increase slightly in scenario 1Ae (0.2%) but decrease substantially in scenario 1An (-9.5%).
- Due to focussing on ETS related fuel savings, CO_2 emissions in the ETS sectors decline significantly in 1Ae (-7.4%), far even below the ETS cap for the year 2020 in the baseline (i.e. 2002 $MtCO_2$). As a result, the ETS carbon price declines rapidly from 16 €/tCO_2 in 2012 to zero in the years 2015-2020. In scenario 1An, on the other hand, CO_2 emissions in the ETS sectors remain capped by the ETS and hence do not change (ex post), compared to the baseline. The ETS carbon price in 2020, however, increases from 17 €/tCO_2 in the baseline to 20 €/tCO_2 in 1An, mainly because the (large) additional EE investments result in additional economic growth and, hence, to higher ETS emissions ex ante (i.e. before they are capped through a higher induced ETS carbon price).

Table 18: Additional policy scenarios (EU27): GHG emissions and ETS carbon price in 2020

	1Ae	1An	1As	2At
In absolute values				
GHG emissions ($MtCO_2e$)	4154	4150	4086	4209
CO_2 emissions ($MtCO_2$)	3528	3513	3461	3574
CO_2 emissions ETS sectors ($MtCO_2$)	1854	2002	1790	1982
CO_2 emissions non-ETS ($MtCO_2$)[a]	1674	1511	1671	1593
ETS carbon price (2008; €/tCO_2)	0.0	20.0	16.5	16.5
In % change (compared to the baseline scenario 1Ai)				
GHG emissions	-3.6	-3.7	-5.2	-2.3
CO_2 emissions	-3.9	-4.3	-5.7	-2.7
CO_2 emissions ETS sectors	-7.4	0.0	-10.6	-1.0
CO_2 emissions non-ETS[a]	0.2	-9.5	0.1	-4.6
ETS carbon price	-100.0	21.2	-0.0	-0.0
In % change, compared to respective scenario[b]				
GHG emissions			-1.6	-0.5
CO_2 emissions			-1.9	-0.6
CO_2 emissions ETS sectors			-3.4	-1.0
CO_2 emissions non-ETS[a]			-0.2	-0.1
ETS carbon price			n.a.	83.3.

a) Excludes non-energy related emissions.
b) That is scenario 1As to 1Ae and 2At to 2Ai.

In order to neutralise the impact of the additional investments in saving ETS related fuels on the carbon price (in scenario 1Ae), we have estimated the amount of EUAs that need to be set aside (resulting in scenario 1As). For comparable reasons, we have estimated a similar set aside to neutralise the impact of implementing an EEO in scenario 2Ai, resulting in scenario 2At.

Table 19 shows the estimated amounts of set asides over the years 2013-2020. In scenario 1As, the set aside amounts to 34 $MtCO_2$ in 2013 and increases steadily to 240 $MtCO_2$ in 2020. Over the period 2013-2020 as a whole, the set aside amount to 1074 $MtCO_2$, i.e. on average 134 $MtCO_2$ per annum or 6.3% of the average ETS cap in this period. For scenario 2At, the estimated amounts of set asides are significantly lower, i.e. on average 41 $MtCO_2$ per annum or 1.9% of the average cap over the years 2013-2020.

Table 19: Additional policy scenarios: Estimates of EUA set asides

	Total 2013-2020 ($MtCO_2$)	Annual average ($MtCO_2$)	As % of average EU ETS cap 2013-2020
1As	1074	134	6.3
2At	328	41	1.9

Due to the set aside, the ETS cap in 2020 is actually reduced by 212 $MtCO_2$ to a level of 1790 $MtCO_2$ in scenario 1As, and by 20$MtCO_2$ to a level of 1982 $MtCO_2$ in 2At. As a result, CO_2 emissions in the ETS sector decline by 11% in scenario 1As, compared to the baseline, and by 1% in 2At (see **Table 18**).

Table 20: Additional policy scenario (EU27): Power sector results in 2020

	1Ae	1An	2As	2At
Power price (in €/MWh)[a]	99	107	101	106
Total power use (in TWh)	2786	3205	2790	3105
Total power bill (in billion €)	275	344	283	330
Average household power use (in MWh)	3.1	4.0	3.1	4.0
Average household power bill (in€)	490	684	500	678
Power sector emissions (in $MtCO_2e$)	1011	1182	1002	1155
Carbon intensity of power production (in $KgCO_2$/MWh)	363	369	359	372
Changes compared to baseline scenario 1Ai				
Change in average household power bill (in€)	-189	6	-179	0
Change in total power bill (in billion €)	-67	3	-59	-11
Reduction in power sector emissions (in $MtCO_2e$)	167	-3	177	23
Change in total power bill per ton CO_2e reduced (in €/tCO_2)	-398	-906[c]	-332	-481
Changes compared to each respective intermediate scenario[b]				
Change in average household power bill (in€)			10	40
Change in total power bill (in billion €)			8	4
Reduction in power sector emissions (in $MtCO_2e$)			9	3
Change in total power bill per ton CO_2e reduced (in €/tCO_2)			860	1692

a) Average power price for households and industry. For households only, the average power price is almost 60 per cent higher.
b) That is scenario 1As to 1Ae and 2At to 2Ai.
c) Note that this negative figure is not due to a change in the power bill but rather to an increase in power sector emissions.

Table 20 presents the power sector results in 2020 for the four additional policy scenarios. Compared to the baseline scenario, the main results include:

- In scenario 1Ae (investing in ETS related fuel savings), electricity bills decline significantly due to both a decrease in the average power price – mainly resulting from the pass-through of the induced lower carbon price – and a decline in electricity use. In addition, power sector emissions decrease substantially by almost 16%. In contrast, in scenario 1As (Id. + EUA set aside), the decline in electricity bills is less but the decrease in power sector emissions is higher, both due to the higher ETS carbon price resulting from the set aside.
- In scenario 1An (investing in non-ETS related fuel savings), the effects on the power sector are generally rather tiny. More specifically, power bills and sector emissions increase slightly due to a slightly higher power use.
- In scenario 2At (i.e. EEO-scenario 2Ai + EUA set aside), both power sector emissions and total electricity bills at the EU27 level decline significantly, compared to the baseline. Compared to scenario 2Ai, however, the stabilisation of the ETS carbon price at the baseline level results in a further reduction of power sector emissions but increases electricity bills significantly, in particular at the average household level.

Table 21: Additional policy scenario (EU27): Other, socio-economic outcomes in 2020

	1Ae	1An	2As	2At
In % change, compared to the baseline scenario 1Ai				
GDP	0.5	0.4	0.4	0.3
Consumption	0.3	0.3	0.3	0.2
Investments	1.0	1.1	1.0	0.9
Exports	0.4	0.4	0.3	0.2
Imports	0.4	0.4	0.3	0.2
Consumer prices	-0.1	0.1	0.1	0.2
Employment	0.2	0.3	0.2	0.2
Real household incomes	0.2	0.1	0.1	0.0
Final energy demand	-4.9	-4.9	-5.8	-4.2
In % change, compared to respective scenario[a]				
GDP			-0.1	-0.1
Consumption			-0.1	-0.1
Investments			0.0	0.0
Exports			-0.1	-0.1
Imports			-0.1	-0.1
Consumer prices			0.2	0.2
Employment			0.0	0.0
Real household incomes			-0.1	-0.1
Final energy demand			-1.0	-1.0

d) That is scenario 1As to 1Ae and 2At to 2Ai.

Table 21 shows the socio-economic effects of the additional policy scenarios. Once again, these effects are generally small compared to the baseline, except the impact on investments (+1% in all scenarios) and, more significantly, on final energy demand (ranging from -4.2% to -5.8%). The specific impact of the EUA set asides in scenarios 1As and 2At on the presented socio-economic outcomes are even smaller and largely negligible, except the impact on final energy use (see lower part of **Table 21**, showing the socio-economic effects of scenarios 1As and 2At compared to the respective scenarios 1Ae and 2Ai).

Table 22: Additional policy scenarios (EU27): Comparison of ETS auction revenues and public support needs to meet energy savings potentials in target sectors up to 2020 (in billion €)

	ETS auction revenues		Public support needs		Balance	
	Cumulative 2013-2020	Annual average	Cumulative 2013-2020	Annual average	Cumulative 2013-2020	Annual average
1Ae	17.6	2.2	72.0	9.0	-54.4	-6.8
1An	172.1	21.5	72.0	9.0	100.1	12.5
1As	132.2	16.5	72.0	9.0	60.2	7.5
2At	142.0	17.7	30.2	3.8	111.8	14.0

Finally, **Table 22** compares the ETS auction revenues to the public support needs of the extra EE investments in the four additional policy scenarios. It shows that in scenario 1Ae (investing in ETS related fuel savings) auction revenues are rather low – on average, only € 2.2 billion per annum – and not sufficient to cover the EE support needs (€ 9 billion per annum).[13] This results from the induced lower carbon price in this scenario, falling rapidly from 16 €/tCO_2 in 2012 to zero in 2015 and beyond. In the other three scenarios presented in **Table 22**, however, auction revenues are more than adequate to cover EE public support needs, but similar qualifications apply to these revenues versus needs as made to comparable findings of **Table 16** in Section 3.3.

It is interesting to note that in scenario 1As and 2At the ETS auction revenues increase substantially compared to their respective scenarios, 1Ae and 2Ai, despite the significant decline in the number of EUAs auctioned in 2At and, particularly, 1As. This is due to the fact that this decline in number of EUAs auctioned is more than compensated by the induced increase in the ETS carbon price, stabilised at the baseline level. More specifically, while the auction revenues fall to, on average, € 14 billion per annum in 2Ai and even to € 2 billion in 1Ae – compared to € 18 billion in the baseline – they amount to € 17 billion and € 18 billion in scenarios 1As and 2At, respectively (see **Figure 4**).

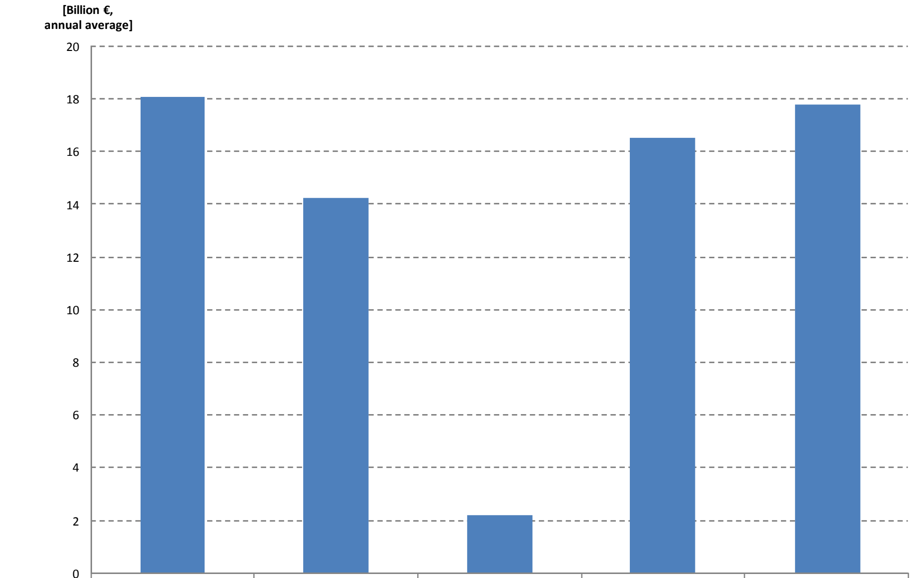
Cumulative effects of carbon pricing and extra EE investments on energy savings and CO_2 emission reductions

Figure 5 illustrates the cumulative effects on primary energy savings (upper chart) and CO_2 emissions reduction (lower chart) due to ETS carbon pricing and, subsequently, investing the auction revenues from carbon pricing into additional energy savings. The impact of ETS carbon pricing alone is depicted by the blue curve, representing the baseline scenario 1Ai compared to the so-called 'zero scenario (0Ai)' in which the carbon price is set at zero.

The cumulative effects of both carbon pricing and investing its revenues into energy savings are depicted for two scenarios, i.e. 1Ae and 1As. The red curve in **Figure 5** represents scenario 1Ae in which a fixed amount of public funding is used to support additional investments in energy savings in the ETS sectors only. For the EU27, the amount of public funding over the period 2013-2020 is, on average, about € 9 billion per annum (in 2008 prices).

13 All figures in Table 22 are expressed in constant 2008 prices. Consequently, the additional EE investments of € 10 billion per annum over the years 2013-2020 (in current prices) are approximately equal to an amount of, on average, € 9 billion per annum in constant 200 prices.

Figure 4: Impact of EUA set asides on ETS auction revenues, 2013-2020 (in annual average billion €)

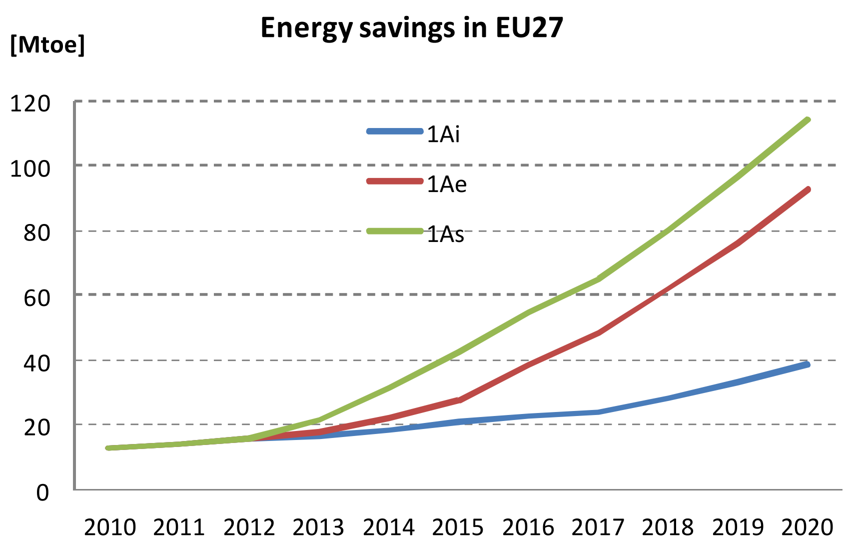


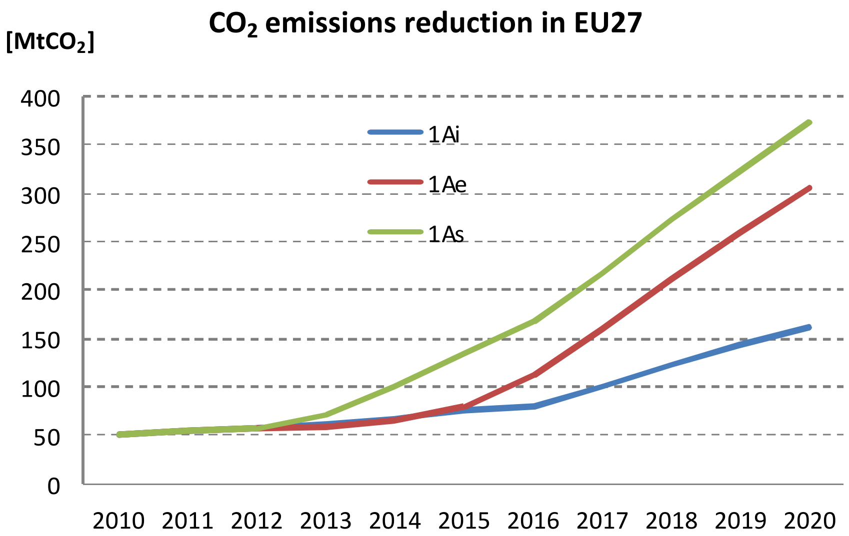
	1Ai	2Ai	1Ae	1As	2At
ETS revenues	18	14	2	17	18

Figure 5 shows that carbon pricing alone – at a baseline carbon price of 16.5 €/tCO_2 – results in total primary energy savings in the EU27 of almost 40 Mtoe in 2020. Using part of the carbon pricing revenues (i.e. a fixed amount of about € 9 billion per year over the period 2013-2020) as public funding to support investments in additional energy savings results in extra savings of almost 54 Mtoe and, hence, to total cumulative energy savings of about 93 Mtoe. Similarly, in terms of CO_2 emissions reduction, the effects amount to approximately 162 MtCO_2 (scenario 1Ai), 144 MtCO_2 (additional effect of scenario 1Ae) and 306 MtCO_2 (cumulative effects of scenarios 1Ai and 1Ae), respectively. Hence, the effects of carbon pricing in terms of primary energy savings and CO_2 emissions reduction are significantly increased if (part of) the revenues of carbon pricing are used to finance public support of additional investments in energy savings.

It should be noted, however, that due to the additional EE investments the ETS carbon price declines from 17 €/tCO_2 in scenario 1Ai to zero in scenario 1Ae. This price decrease has two implications. Firstly, the resulting ETS auction revenues in the EU27 are not sufficient to cover the substantial amount of public funding to support the investments in additional energy savings. Secondly, the red curve of **Figure 5** does not show the cumulative effects of a more or less stabilised (fixed) carbon price and, subsequently, investing the carbon pricing revenues into energy savings, but rather the overall effects of a reduced carbon price (due to the additional investments) on the one hand and investing a fixed amount of public support into energy savings on the other.

Figure 5: EU27: Cumulative effectson energy saving's (upper chart) andCO_2 emission reductions (lower chart) due to carbon pricing and investing carbon revenues from carbon pricing in energy savings





In order to avoid these implications, the green curve in **Figure 5** represents scenario 1As in which the carbon price is more or less stabilised at the baseline level by setting aside a certain number of EUAs over the period 2013-2020 (see Section 3.4). **Figure 5** shows that in this scenario the additional energy savings due to supporting extra EE investments by a fixed amount of public funding amount to about 75 Mtoe, compared to an amount of 39 Mtoe of energy savings in the baseline scenario due to carbon pricing alone. Hence, in terms of cumulative effects, the energy savings amount to 115 Mtoe in scenario 1As.

In terms of CO_2 emissions reduction, the impact of carbon pricing alone amounts to 162 $MtCO_2$, the additional effects of energy savings investments amount to 144 $MtCO_2$ in scenario 1Ae and 211 $MtCO_2$ in scenario 1As. Hence, the cumulative effects of both carbon pricing and EE investments amount to 306 $MtCO_2$ and 373 $MtCO_2$ in scenarios 1Ae and 1As, respectively.[14]

Therefore, it may be concluded that the effects of carbon pricing on energy savings and CO_2 emissions reduction are substantially enhanced if (i) the revenues of carbon pricing are used to support extra energy savings investments, and (ii) the resulting decline in the ETS carbon price – i.e. due to the additional EE investments – is nullified by setting aside a certain amount of emission allowances.

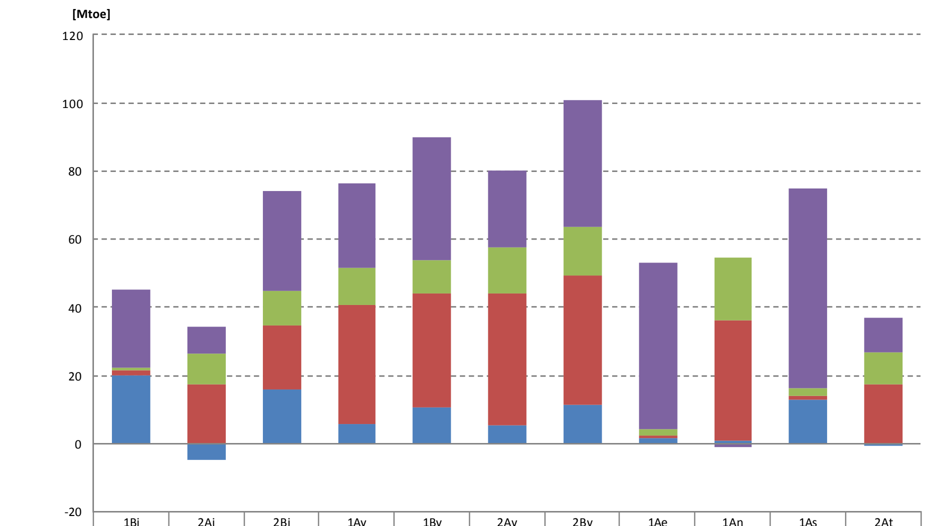
14 Note that in scenario 1Ae, there is a reduction in CO_2 emissions (and energy use) in the period 2013-2020 despite the existence of the ETS cap. This can be explained as follows. Due to additional EE investments the carbon price first declines to zero. Up to this point, additional EE investments do not reduce overall ETS emissions (and hardly energy use by ETS sectors). Beyond this point, however, further increasing EE investments does reduce overall ETS emissions (and energy use by ETS sectors), as there is no shifting anymore of emissions or energy use across ETS sectors within the cap. In scenario 1Ae the amount of additional EE investments is so large that the first part of these investments are not effective in reducing CO_2 emissions (and energy use) by the ETS sectors – and only reduce the ETS carbon price – while beyond this point, the second part of these investments do become effective.

4

Summary of EU27 results across all scenarios

This Chapter provides a summary and graphical comparison of the main scenario results at the EU27 level as discussed in the previous sections.

Figure 6: Energy savings in 2020 by sector and scenario (in Mtoe)



	1Bi	2Ai	2Bi	1Av	1Bv	2Av	2Bv	1Ae	1An	1As	2At
Other sectors	23	8	29	24	37	22	37	49	-1	59	10
Tertiary	1	9	10	11	10	14	14	2	18	2	9
Households	2	17	19	35	33	38	38	1	35	1	17
Industry	20	-5	16	6	11	6	11	1	1	13	-1

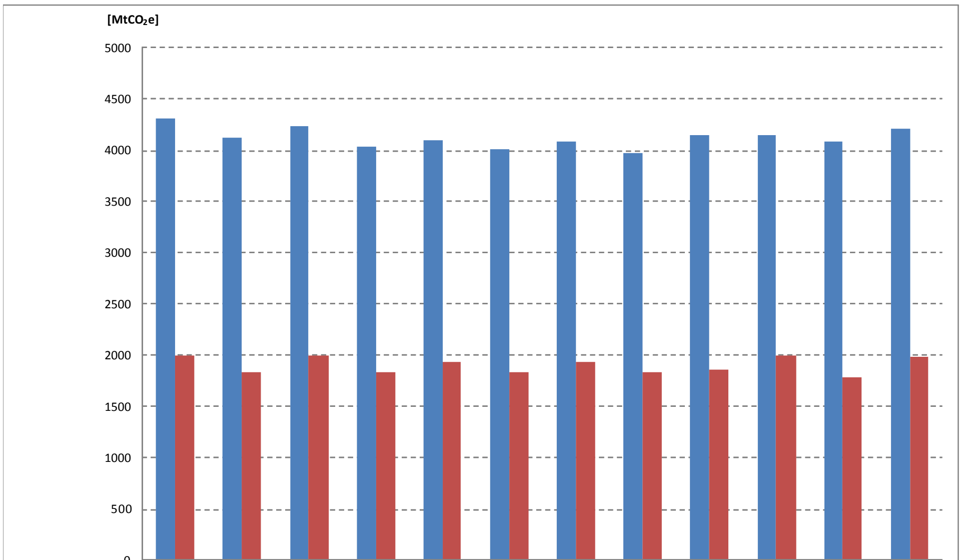
First of all, **Figure 6** shows an overview of the energy savings in 2020 by sector and scenario. Not surprisingly, the savings by sector vary widely across the scenarios considered:

- *Industry:* savings range from -5 Mtoe in scenario 2Ai (EEO, predominantly for Households and Tertiary) to 20 Mtoe in 1Bi (30% GHG reduction), mainly due to the level of the carbon price in these scenarios, i.e. 0 and 80 t/CO_2, respectively.

- *Households and Tertiary:* savings for Households vary between -1 Mtoe in 1Ae (investing in ETS related fuel savings) and 35 Mtoe in 1An (investing in non-ETS related fuel savings). Savings in Tertiary range from 2 Mtoe in 1Bi (lowering ETS cap) to 18 Mtoe in 1An (investing in non-ETS related fuel savings).
- *Total target sectors:* savings vary between 4 Mtoe in 1Ae to 64 Mtoe in 2Bv (30 GHG emissions reduction + EEO + extra EE investments).
- *Other (power) sectors:* savings range from -1 Mtoe in 1An to 62 Mtoe in 1As (investing in ETS related fuel savings + EUA set aside).
- *All EU27 sectors:* savings vary between 29 Mtoe in 2Ai (EEO) and 64 Mtoe in 2Bv.

Despite the mix of policy instruments in the investment scenarios (reducing the ETS cap/introducing an EEO + supporting additional EE investments to achieve remaining potentials), the energy savings potentials in the target sectors are not met in these scenarios, even not in scenario 2Bv which combines all three policy instruments. This is largely due to the decrease in the ETS carbon price, induced by the extra investments in saving ETS related fuels, and partly by the lower energy bills and higher GDP, induced by the extra EE investments and the lower carbon price ('rebound effects'). The adverse effects of a lower carbon price on energy savings can be reduced, or even fully nullified, by setting aside a number of EU emission allowances (EUAs) in order to neutralise the impact of EE measures on the carbon price.

Figure 7: Total EU GHG emissions and EU ETS emissions (in Mt CO_2e)



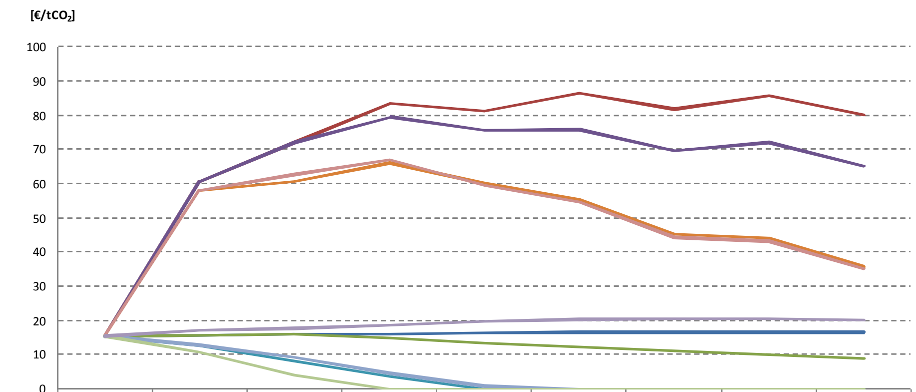
	1Ai	1Bi	2Ai	2Bi	1Av	1Bv	2Av	2Bv	1Ae	1An	1As	2At
Total GHGs	4309	4121	4232	4044	4096	4008	4088	3977	4154	4150	4086	4209
CO2 emissions ETS	2002	1837	2002	1837	1929	1837	1941	1837	1854	2002	1790	1982

Figure 7 shows the impact of the various scenarios on EU GHG emissions and total EU ETS emissions in 2020. Total EU GHG emissions vary from 4309 $MtCO_2$ in the baseline scenario 1Ai to 3917 $MtCO_2$ in 2Bv, i.e. minus 8% compared to the baseline.

In the baseline scenario for 2020, EU ETS emissions account for more than 46% of total EU GHG emissions. In those scenarios where the ETS carbon price is higher than zero, the ETS emissions are set by the cap, i.e. at a level of 2002 $MtCO_2$ in the 'A'-scenarios

(20% EU GHG reduction in 2020) and 1837 $MtCO_2$ in the 'B'-scenarios (30% target). However, in three 'A'-scenarios (1Av, 2Av and 1Ae), actual ETS emissions in 2020 have fallen below the cap, notably in scenario 1Ae (1854 $MtCO_2$), resulting in a carbon price equal to zero. Moreover, in two 'A'-scenarios (1As and 2At), the ETS cap in 2020 is actually reduced by setting aside a certain number of EUAs, for instance by 212 $MtCO_2$ equivalents in 1As. Overall, across all scenarios, EU ETS emissions range from 2002 $MtCO_2$ in the baseline to 1790 $MtCO_2$ in 1As, i.e. minus 11% compared to – and in addition to – the baseline.

Figure 8: ETS carbon price, 2012-2020 (in €/tCO_2)



	2012	2013	2014	2015	2016	2017	2018	2019	2020
1Ai	16	16	16	16	16	17	17	17	17
1Bi	16	61	72	83	81	86	82	86	80
2Ai	16	16	16	15	13	12	11	10	9
2Bi	16	61	72	79	75	76	70	72	65
1Av	16	13	8	4	0	0	0	0	0
1Bv	16	58	61	66	60	55	45	44	36
2Av	16	13	9	5	1	0	0	0	0
2Bv	16	58	63	67	60	55	44	43	35
1Ae	16	11	4	0	0	0	0	0	0
1An	16	17	18	19	20	20	21	21	20

Figure 8 shows the evolution of the ETS carbon price over the period 2012-2020 for all scenarios.[15] As expected, the carbon price is highest – and far above the baseline trend – in the four 'B'-scenarios (all with a more stringent ETS cap), in particular in scenario 1Bi (with no additional EE measures reducing the carbon price; see Section 3.1 for further discussion). In scenario 1An (investing in non-ETS related fuel savings), the carbon price moves slightly above the baseline trend, while in scenario 2Ai (introducing an EEO for Households and Tertiary), the carbon price declines slowly but steadily below the baseline trend but remains positive (>0) up to 2020. As noted, however, in three scenarios – 1Av, 2Av and 1Ae – the carbon price falls to zero, even amply before 2020.

15 The carbon price of the two 'EUA set aside' scenarios (1As and 2At) is not presented separately as, due to the set asides, the evolution of the carbon price in these scenarios is similar to the trend in the baseline carbon price of scenario 1Ai.

Figure 9: Change in average household electricity bill in the EU27 by 2020 (in €)

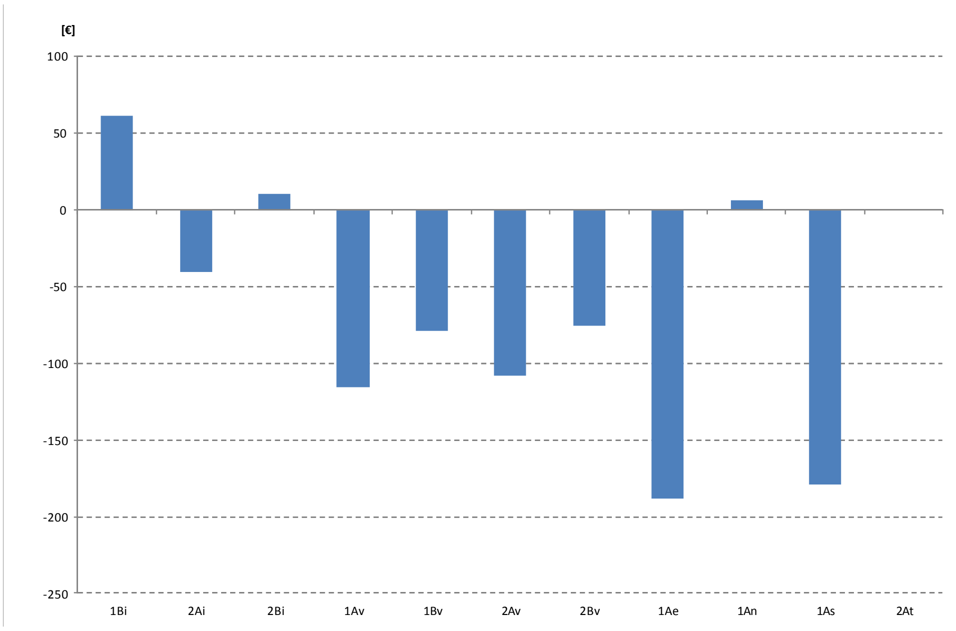
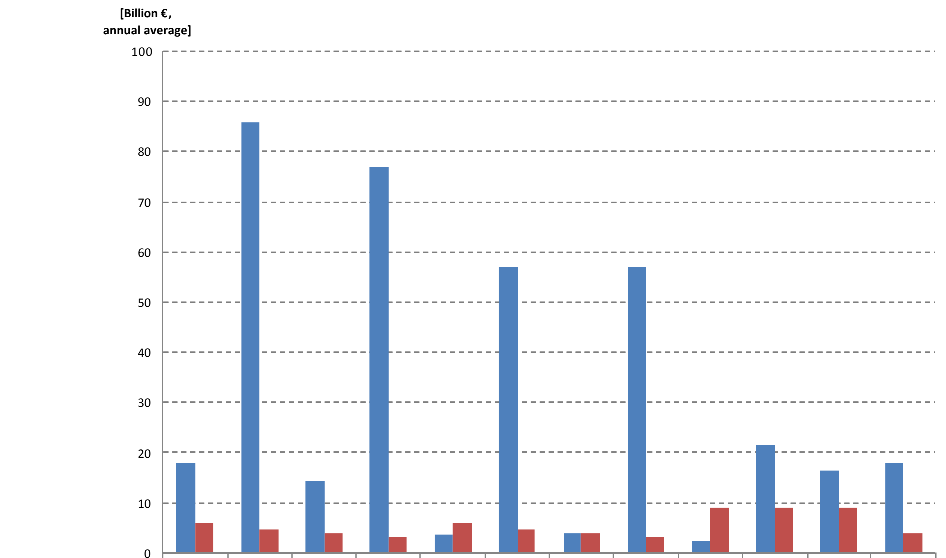


Figure 9 illustrates the change in average household electricity bills across the various scenarios, compared to the baseline. This change varies from an *increase* of € 61 in scenario 1Bi (due to the pass-through of the higher carbon costs) to a significant *decrease* of € 189 in scenario 1Ae (investing in ETS related fuel savings, resulting in less power use, a zero carbon price and, hence, a lower power price). As the average household power bill in 2020 amounts to € 678 in the baseline, these changes are equal to +9% and -28% of this amount, respectively.

Figure 10 compares the annual average ETS auction revenues versus the public funding needs to stimulate additional EE investments for achieving the remaining energy savings potential in the target sectors up to 2020. Annual auction revenues vary from € 2 billion in scenario 1Ae to € 86 billion in 1Bi (based on the carbon price above), while EE public support needs range from € 3 billion in scenarios 2Bi and 2Bv to € 9 billion in scenarios 1Ae, 1An and 1As.

Figure 10: EU ETS auction revenues versus EE public support needs, 2013-2020 (annual average, in billion €)



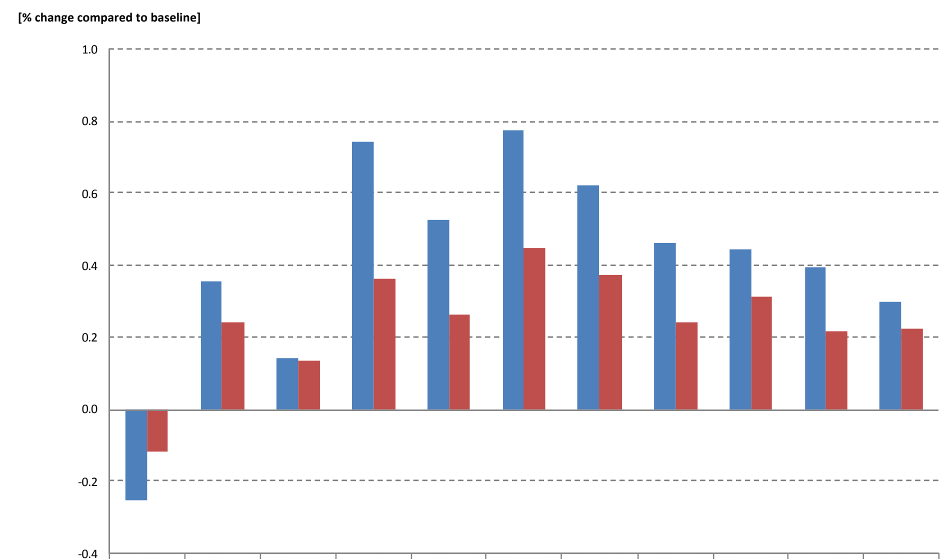
	1Ai	1Bi	2Ai	2Bi	1Av	1Bv	2Av	2Bv	1Ae	1An	1As	2At
ETS revenues	18	86	14	77	4	57	4	57	2	22	17	18
EE Public support needs	6	5	4	3	6	5	4	3	9	9	9	4

As expected, auction revenues are lower if the ETS carbon price is lower. Hence, revenues are usually significantly lower in the four EE investment scenarios, compared to the respective intermediate scenarios, due to the lower carbon price induced by the additional EE investments. On the other hand, public support needs are assumed to be more less linearly higher if the remaining energy savings potentials – and, hence, the EE investment needs – are higher.

Figure 10 shows that in 2 out of 12 scenarios (1Av and 1Ae), auction revenues are not sufficient to cover the EE public support needs, while in the remaining 10 scenarios revenues are usually many times higher than the support needs. In the intermediate scenarios, however, estimates of auction revenues are based on carbon prices before the EE investments are made and, hence, will be significantly reduced – to the investment scenario levels – once the EE investments are actually implemented and start reducing fuel use and related emissions in ETS sectors.

Moreover, several other qualifications can be made to estimating/earmarking auction revenues and EE public expenditures. For instance, actual auction revenues/EE support needs may be higher/lower, the balance between revenues and needs may vary significantly across individual EU Member States, national governments may oppose earmarking of ETS auction revenues to EE public expenditures, or they may prefer to use these revenues for a variety of other purposes, including recycling them back to Industry and Households.

Figure 11: Changes in GDP and employment in various scenarios, compared to the baseline (in %)



	1Bi	2Ai	2Bi	1Av	1Bv	2Av	2Bv	1Ae	1An	1As	2At
GDP	-0.3	0.4	0.1	0.7	0.5	0.8	0.6	0.5	0.4	0.4	0.3
Employment	-0.1	0.2	0.1	0.4	0.3	0.4	0.4	0.2	0.3	0.2	0.2

Finally, **Figure 11** shows the changes in GDP and employment in the various scenarios compared to the baseline. The only scenario in which these changes turn out to be negative, albeit small, is 1Bi, mainly because the tightening of the ETS cap results in an increase of the carbon price in 2020 compared to the baseline. This increase in the carbon price causes some end-user price increases, which lead to a reduction of export volumes – because of the impact on competitiveness – and to the erosion of real incomes and, hence, consumer spending.

On the other hand, the highest positive changes in GDP and employment – although also small – are achieved in scenarios 1Av and 2Av. These positive results occur for two main reasons;

1. **At an aggregate level there is a shift in spending from imported fossil fuels to the construction and engineering activity related to the investments in energy savings;**
2. **Because of the efficiency improvements in the long term, there is a shift from consumers' expenditure on fossil fuels to all other goods and services which have a higher domestic value added labour content.**

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Appendix A. Policies included in the baseline scenario

The baseline scenario used in this study is based on the PRIMES 2009 Reference Scenario (EC, 2010d). This Reference Scenario includes the following policies:

Regulatory measures – energy efficiency:

- Eco-design Framework Directive 2005/32/EC;
- Stand-by regulation 2008/1275/EC;
- Simple Set-to boxes regulation 2009/107/EC;
- Office/street lighting regulation 2009/245/EC
- Household lighting regulation 2009/244/EC;
- External power supplies regulation 2009/278/EC;
- Labelling Directive 2003/66/EC;
- Cogeneration Directive 2004/8/EC;
- Directive 2006/32/EC on end-use energy efficiency and energy services;
- Buildings Directive 2002/91/EC;
- Energy Star Program (a voluntary labelling programme).

Regulatory measures – energy markets and power generation

- Completion of the internal energy market;
- EU ETS directive 2003/87/EC as amended by Directive 2008/101/EC and Directive 2009/29/EC;
- Energy Taxation Directive 2003/96/EC;
- Large Combustion Plant Directive 2001/80/EC;
- IPPC Directive 2008/1/EC;
- Directive of the geological storage of CO_2 2009/31/EC;
- Directive on national emissions' ceilings for certain pollutants 2001/81/EC;
- Water Framework Directive 20000/60/EC;
- Landfill Directive 99/31/EC.

Transport

- Regulation on CO_2 from cars 2009/443/EC;
- Regulative Euro 5 and 6 2007/715/EC;
- Fuel Quality Directive 2009/30/EC;
- Biofuels Directive 2003/30/EC;
- Implementation of MARPOL Convention ANNEX VI.

Financial Support

- TEN-E guidelines (Decision 1364/2006);
- European Energy programme for Recovery (Regulation 2009/663/EC);

- RTD Support;
- State aid guidelines for Environmental Protection and 2008 Block Exemption Regulation;
- Cohesion Policy – ERDF, ESF and Cohesion Fund.

National measures
- Strong nation RES policies;
- Nuclear.

More details can be found in EU Energy Trends to 2030 – Update 2009 (EC, 2010d).

Appendix B. Estimation of energy savings potentials, investment needs and public funding

For each of the four intermediate scenarios (1Ai, 1Bi, 2Ai and 2Bi), the following input variables have been estimated at both the EU27 level and the individual EU Member State level:

- The updated or remaining energy savings potentials up to 2020 for the three target sectors of this study (Households, Industry and Tertiary);
- The (private) investment needs to achieve these updated potentials;
- The public funding or support assumed to be needed in order to induce these (private) investments.

The methodology to achieve these input variables is explained below, including some results (see also Sections 2.2 and 3.2 of the main text).

B.1. Energy savings potentials in the EU27

The Baseline scenario (1Ai)

The estimation of the energy savings potentials for the present study builds on the so-called ‘Fraunhofer study’ for the European Commission (EC) on the energy savings potentials in EU Member States (Eichhammer et al., 2009). The Fraunhofer study provides estimates of energy savings potentials for the period 2005-2020 for three types or cases of potentials, i.e. the so-called Low Policy Intensity (LPI) case, the High Policy Intensity (HPI) case and the Technical Potentials case. These potentials are detailed for end-use sectors, for fuel and electricity use, and for different applications.

In addition, we have used the more recent ‘Ecofys study’ for the European Climate Foundation (ECF) on “*Energy Savings 2020: How to triple the impact of energy savings policies in Europe”* (Wesselink et al., 2010) and the Regulatory Assistance Project (RAP) study on “*The upfront investments required to double energy savings in the European Union in 2020” (*Wesselink et al., 2011). In the Ecofys study (Wesselink et al., 2010), which is based on the Fraunhofer study, potentials have been defined with regard to the HPI case most of the time, but sometimes resemble the Technical Potentials case.

The Ecofys figures are not as detailed as those provided by the Fraunhofer study. For this study, it has been assumed that the missing Ecofys figures are generally in line with those for the HPI case.

The Fraunhofer/Ecofys potentials are defined against the Primes 2007 Baseline scenario for the period 2005-2020. As explained in Section 2.1, however, an updated Primes 2009 Reference scenario has been published in 2009 which includes the impact of the economic crisis since 2008, the implementation of more recent MS energy savings policies and the (expected) higher energy prices up to 2020. Compared to the PRIMES 2007 scenario, this leads to a lower trend for energy consumption up to 2020. As a result, part of the savings potentials identified by Fraunhofer/Ecofys is already used in the Primes 2009 scenarios due to the higher energy prices and the extra policy measures. Therefore, the estimates for the energy savings potentials have been updated, using the increase in energy-intensity per sector as a proxy for the extra savings. It has been assumed that the effect of higher energy prices and extra policy only takes effect as of 2012. Overall, this results in 20-30% lower estimates of energy savings potentials for the scenarios and sectors considered in this study (compared to the earlier estimates by Fraunhofer/Ecofys).

In addition, if policy makers indeed want to use the ETS auction revenues to realize the savings potentials this is only possible from about 2013 onwards, firstly because the revenues start streaming in that year and, secondly, because it takes some time to set up measures to stimulate extra savings. As a result, only part of the energy savings potentials can actually be realized. This part was estimated per category of potentials, based on saving options not applied over the past years and lost permanently (e.g., new dwellings not built according to the Fraunhofer/Ecofys standards up to 2013), saving options that can still be realized (e.g. refurbishment of existing buildings) and options for which the period up to 2020 is too short to realize the potential (e.g. new industrial processes; for more details, see Appendix C).

Per category of energy savings potentials, an effective starting year was assumed that defined the part to be realized up to 2020. After this second correction the remaining energy savings potentials in the baseline scenario 1Ai equal 40-50% of the original potentials estimated by Fraunhofer/Ecofys (see **Table 23** below).

The EU GHG stretch scenario (1Bi)

In scenario 1Bi, the target for EU GHG emission reduction in 2020 is 30% instead of 20%, resulting in a higher ETS carbon price (see Section 3.1). Consequently, the extra emission reduction is partly accomplished by extra energy savings, in particular in the industrial ETS sectors. The higher carbon price raises the energy costs relatively the most in industry because the base energy prices are relatively low compared to other sectors. Therefore, most of the extra savings are found for Industry (12% of its energy consumption). For Households only the electricity price increases – due to the pass-through of the higher ETS carbon prices – and extra saving are much lower (3% of household energy use up to 2020).

The extra industrial savings due to the higher ETS price are such that they more or less equal the savings potential for this sector up to 2020. For the sectors Households and

Tertiary, the remaining potentials are still a considerable part of the original potentials (see **Table 23**). For the relevant end-use sectors together (excluding transport) the remaining savings potentials decrease to about 30% of the original Fraunhofer/Ecofys potential.

Table 23: Energy saving potentials at EU27 level per scenario and target sector (in Mtoe and in % of original Ecofys estimated potentials)

	Households	Tertiary	Industry	Total
	In Mtoe			
Primes-2007	79.2	34.5	46.4	160.1
Primes-2009	63.3	24.1	36.5	123.9
Scenario 1Ai	37.0	15.6	20.9	73.5
Scenario 1Bi	33.2	13.5	4.7	51.5
Scenario 2Ai	22.2	6.6	20.9	49.7
Scenario 2Bi	20.7	6.4	6.1	33.3
	In % of original Ecofys estimated potentials, based on Primes2007			
Primes-2007	100	100	100	100
Primes-2009	80	70	79	77
Scenario 1Ai	47	45	45	46
Scenario 1Bi	42	39	10	32
Scenario 2Ai	28	19	45	31
Scenario 2Bi	26	19	13	21

The Energy Efficiency Obligation scenario (2Ai)

In scenario 2Ai, an Energy Efficiency Obligation of 1.5% per year for energy companies is introduced which only refers to the sectors Households and Tertiary (see Section 2.1). It is assumed, however, that not all of the EEO will necessarily be additional: if there are already substantial energy savings in the baseline, e.g. 0.5% per annum, then we assume that the EEO will only contribute an additional 1.0% per annum savings in energy consumption in these sectors.

Compared to the estimated potentials, the extra savings due to the obligation are assumed to be relatively large in the sectors Households and Tertiary. After correcting potentials of scenario 1Ai for the EEO effect, the remaining savings potential for households is not more than one-third of the original Ecofys estimate (see **Table 23**)

The EU GHG stretch and Energy Efficiency Obligation scenario (2Bi)

The scenario 2Bi combines the preceding scenarios of an Energy Efficiency Obligation with the 30% GHG emissions reduction target. The effects of both policies will overlap, but not entirely. For the non-ETS sectors Households and Tertiary the 30% target mainly affects electricity use; the impact of the Energy Efficiency Obligation will focus mostly on heating. For industry, the impact of the 30% target is much larger than the EEO effect.

The resulting energy savings potentials as shares of the original Ecofys' estimated potentials are 26% for Households, 19% for Tertiary and only 13% for Industry (see **Table 23**).

B.2. Investment needs in the EU27

In order to estimate the additional investment needs to achieve the updated energy savings potentials up to 2020, it must first be specified whether investments are really needed to realize the potential. For instance, for good housekeeping measures no, or few, investments are needed. In the Ecofys study and underlying Fraunhofer study no good housekeeping savings without investments are specified. In the Ecofys/Fraunhofer study of 2011, dedicated to investment needs for reaching the savings target of 20%, it is not mentioned whether part of the savings are realized without investments (Wesselink et al., 2011). In the present study, it has been assumed that for the sectors Households and Tertiary investments are always needed to achieve energy savings; for Industry it is assumed that part of the savings are realised through good housekeeping.

The total investments to realize the updated savings potentials are calculated using an amount of Euros per Ktoe saved. Average figures per sector were taken from the Ecofys/Fraunhofer 2011 study, taking the mean value from the range specified. The figures have been differentiated for different categories of savings potentials, keeping the average figures in line with those of Fraunhofer/Ecofys.

Table 24 shows that total investment needs over the period 2013-2020 range from € 293 billion in the baseline scenario (1Ai) to € 151 billion in the scenario with 30% emission reduction and an Energy Efficiency Obligation (2Bi). On an annual basis, these figures amount to, on average, € 36.6 billion and € 18.9 billion, respectively.

Table 24: *Investment needs to achieve energy savings potentials in target sectors of the EU27 in 2020 (in billion €)*

	1Ai	1Bi	2Ai	2Bi
Cumulative needs over the period 2013-2020				
Households	180	163	111	104
Tertiary	68	61	33	32
Industry	45	12	45	15
Total	293	236	189	151
Average annual needs over the period 2013-2020				
Households	22.5	20.4	13.9	13.0
Tertiary	8.5	7.6	4.1	4.0
Industry	5.6	1.5	5.6	1.9
Total	36.6	29.5	23.6	18.9

B.3. Public funding needs

The Fraunhofer/Ecofys potentials are claimed to be cost-effective, meaning that over the life time of savings measures the annual energy cost savings compensate for the investment costs annualised by means of a (social) discount rate. This rate, however, is often lower that the (market) rate usually applied by private energy users. This difference in social versus private discount rates – or other barriers to private energy savings investments – may justify some public funding of these investments (assuming that no other measures to address these barriers and to stimulate these investments have already been implemented).

In order to estimate the public support assumed to be necessary to induce the (private) investments to realise the updated energy savings potentials in the target sectors up to 2020, a default rate of 20% of gross investments has been assumed. For some parts of energy savings, however, no or less funding has been assumed, e.g. for good housekeeping in industry. Therefore, the average subsidy rate may vary across the target sector analysed.

Table 25 shows that total investment needs over the period 2013-2020 range from € 47.3 billion in the baseline scenario (1Ai) to € 23.4 billion in the scenario with 30% emission reduction and an Energy Efficiency Obligation (2Bi). On an annual basis, these figures amount to, on average, € 5.9 billion and € 2.9 billion, respectively.

Table 25: Public funding needs to achieve energy savings potentials in target sectors of the EU27 in 2020 (in billion €)

	1Ai	1Bi	2Ai	2Bi
Cumulative needs over the period 2013-2020				
Households	28.8	26.1	17.7	16.5
Tertiary	12.5	11.6	6.6	6.4
Industry	5.9	0.1	5.9	0.4
Total	47.3	37.9	30.2	23.4
Average annual needs over the period 2013-2020				
Households	3.6	3.3	2.2	2.1
Tertiary	1.6	1.5	0.8	0.8
Industry	0.7	0.0	0.7	0.1
Total	5.9	4.7	3.8	2.9

The figures in **Table 25** can decrease when a smart stimulation system is introduced that lowers the amount of funding for the same amount of investments. However, the figures can also increase when it appears that more than 20% funding is needed to realize investments into expensive or complicated saving options.

B.4. Energy savings potentials, investment needs and public funding at the EU Member State level

The updated energy saving potentials per country and per sector have been calculated starting from the Fraunhofer database figures per country. These potentials have been corrected both for the Primes 2009 Reference scenario effects and for the time passed since 2005 up to 2013, using for each country the same approach and the same relative cuts as made for the EU27 as a whole (as explained in Section B.1 above).

Table 26 shows the total energy saving potentials for the sectors Households, Tertiary and Industry as a share of total energy end-use (including Transport) for each EU Member State in 2020. In the baseline scenario, the updated potentials up to 2020 are equal to about 4-6% of total energy end-use. In accordance with the earlier results at the EU27 level (as discussed above), the shares are (much) lower for the other scenarios.

Table 26: Updated energy savings potentials for the target sectors (Households, Tertiary and Industry) for each EU Member State in 2020 (in % of total energy enduse)

	1Ai	1Bi	2Ai	2Bi
Austria	6.1	4.2	4.2	2.8
Belgium	6.2	4.6	4.1	3.0
Bulgaria	6.0	3.7	4.3	2.5
Cyprus	3.9	3.0	2.5	1.8
Czech Republic	7.7	3.9	6.1	2.9
Denmark	6.3	4.7	4.0	2.9
Estonia	3.7	2.7	2.4	1.7
Finland	5.6	2.9	4.5	2.2
France	5.8	4.3	3.7	2.7
Germany	6.9	5.1	4.5	3.2
Greece	5.4	4.3	3.2	2.6
Hungary	5.0	4.0	3.1	2.4
Ireland	4.9	3.8	3.1	2.4
Italy	4.1	2.8	2.8	1.8
Latvia	3.8	2.7	2.6	1.8
Lithuania	4.8	3.1	3.4	2.1
Luxembourg	3.1	2.0	2.2	1.4
Malta	4.0	3.1	2.5	1.9
Netherlands	4.2	2.7	3.0	1.8
Poland	6.1	4.3	4.1	2.8
Portugal	4.8	3.2	3.4	2.1
Romania	4.9	3.5	3.2	2.2
Slovak Republic	4.6	3.5	2.8	2.1
Slovenia	7.7	3.8	6.3	3.0
Spain	4.7	3.0	3.4	2.0
Sweden	6.3	3.1	5.1	2.4
United Kingdom	4.7	3.4	3.0	2.1
EU27	5.5	3.8	3.7	2.4

For each country, the investment needs to realise the updated energy savings potentials are calculated using for each sector the average €/Ktoe figure which was found at the EU27 level. Therefore, the results per country show the same pattern as for the remaining potentials per country (e.g. high figures for the Czech Republic and Slovakia and low figures for Italy and the Netherlands).

Public funding per Member States follows from the EE investment needs and the average subsidy percentage per sector at the EU27 level. Given this straight away approach the sum over all countries equals the earlier found figure at the EU27 level (see **Table 27**)

Table 27: Public funding needs to achieve updated energy savings potentials in the target sectors per EU Member State in 2020 (in million €)

	1Ai	1Bi	2Ai	2Bi
Austria	1218	964	786	599
Belgium	1660	1368	1055	854
Bulgaria	449	332	298	206
Cyprus	58	49	36	30
Czech Republic	1206	754	861	475
Denmark	707	585	438	357
Estonia	96	80	60	49
Finland	749	469	539	299
France	6858	5707	4286	3520
Germany	10841	9005	6797	5566
Greece	1010	878	613	538
Hungary	787	673	481	412
Ireland	517	436	321	269
Italy	4183	3281	2690	2023
Latvia	152	122	97	76
Lithuania	183	140	120	86
Luxembourg	97	72	65	45
Malta	20	17	12	10
Netherlands	1443	1073	947	659
Poland	3014	2425	1907	1489
Portugal	685	523	448	324
Romania	1168	950	730	579
Slovak Republic	427	361	258	218
Slovenia	230	137	169	88
Spain	3472	2623	2281	1625
Sweden	1128	680	821	434
United Kingdom	4926	4045	3066	2466
EU27	47285	37751	30183	23296

Appendix C. Energy savings potentials, investment needs and public funding for buildings

This Appendix discusses some specific issues with regard to the estimation of energy savings potentials, investment needs and public funding for buildings (including the target sectors Households and Tertiary). These issues include:

- Saving potentials;
- Cost-effectiveness of savings;
- Correction for late start of implementation;
- Savings without investments;
- Specific investment per category of savings;
- Stimulation by funding or other means;
- Amount of funding needed per category;
- Alternative funding mechanism.

Saving potentials
As explained in Appendix B, the estimates of the updated energy savings potentials per end-use sector are based on the Fraunhofer study/database for the cases LPI (Low Policy Intensity), HPI (High Policy Intensity) and Technical (maximum potential). These cases are detailed for fuel and electricity use and for different applications (Eichhammer et al., 2009). Also available are more aggregated figures from the Ecofys study which is said to be based on the HPI figures, but sometimes shows figures that look more like the Technical potential (Wesselink et al., 2010).

In this Appendix, the Ecofys figures are used which are detailed as follows:

- For saving potential categories regarding electricity the HPI figures are used because overall electricity savings are the same for the Fraunhofer study and the Ecofys study;
- For other saving potential categories the HPI figures are scaled in such a way that the total potential is equal to the Ecofys figures.

Cost-effectiveness
The HPI/Ecofys potentials are claimed to be cost-effective, meaning that over the life time of saving measures the annual energy cost savings compensate for investment cost that are annualized by means of a discount rate. This discount rate is lower than usually applied by energy users (see Market versus HPI discount rates in **Table 28**). It is justified

by assuming that all kind of policies remove the barriers for investing in extra savings, in fact closing the gap between market rates and HPI rates.

One direct way to close the gap between the discount rates is using ETS auction revenues to subsidize investments for energy saving measures. The amount of subsidies needed can be calculated as follows. For Households the discount rate of 4% leads to yearly capital costs that are 77% of the capital cost for an 8% discount rate (see the column "ratio" in **Table 28** If market conditions prevail a subsidy that covers 23% of the investments is needed to attain the same capital costs as in the HPI case. Similarly, for Industry a subsidy of 62% can compensate for the higher market discount rate compared to HPI.

Table 28: Subsidy rate to attain the lower capital costs assumed for HPI saving potentials

		Market (LPI case)		HPI case		Ratio	Subsidy
	Life time	Discount rate	Annuity[a]	Discount rate	Annuity[a]	Annuity HPI/LPI	
	[years]	[%]	[€]	[%]	[€]	[%]	[%]
Households	15	8	11.7	4	9.0	77	23
Services	15	15	17.1	6	10.3	60	40
Industry	15	30	30.6	8	11.7	38	62

a) Based on an investment of € 100.

Source: Wesselink, et al., 2011).

Correction for late start of implementation

The Fraunhofer/Ecofys potentials regard the period from 2005 on and admit that less savings can be realized if implementation is delayed (Wesselink et al., 2011). Using ETS auction revenues to realize the savings potentials is only possible from about 2013 on. Due to this late start only part of the potentials can be realized. For different categories of energy savings potentials in the buildings sector, this has been assessed based on the following considerations:

A. Which saving options were not applied and are lost permanently?
B. Which saving options that were not realized up till now can still be realized?
C. For which saving options is the period up to 2020 too short to realize the potential?

Per category of energy savings potentials in buildings, these considerations apply as follows:

- *New dwellings*: Here consideration A is valid because new dwellings, once not build with extra savings cannot contribute to extra savings in 2020.
- *Conversion*: This regards mainly condensing boilers that are generally replaced every 15 years. Once not replaced by a condensing boiler the savings in 2020 are lost, thus consideration A.
- *Refurbishment existing dwellings*: The Fraunhofer study assumes an ambitious rate for refurbishment (e.g. 3% of existing dwellings per year), resulting in substantial savings. This rate has not been realized in past years but catching up is possible in principle. However, the refurbishment capacity should be built up which takes time. It will even be difficult to have the capacity in place for the regular 3% rate from 2013 on, let alone a rate of e.g. 5% for catching up. Therefore consideration A is

more relevant than consideration B, although consideration C applies for deep renovation.

- *Water heating*: This is often coupled to space heating when using a combi-boiler; thus consideration A is valid. For other systems, e.g. separate fuel based systems some catching up is possible, thus consideration B.
- *Household electric appliances*: The Fraunhofer study assumes extra savings for appliances due to the Ecodesign Directive that will specify minimum energy efficiency standards in the period up to 2020. However, the process is delayed and some savings are already lost and cannot be "repaired" before 2020, thus consideration A. It is not clear whether savings beyond the standard are assumed; here also consideration A is valid.
- *Heating new buildings*: Here consideration A holds, as for new dwellings, but with some catching up as the new buildings not built due to the economic crisis are built later and have the extra savings as assumed in the Fraunhofer study (consideration B).
- *Heating existing buildings*: Here the ambitious refurbishment rate has not been realized in past years. As for dwellings the refurbishment capacity has to be expanded substantially even to reach the assumed level in coming years. Possibly the rate could expand further up to 2020 to have some catching up (this mainly consideration A, and partly consideration B).
- *Office lighting*: Some catching up is possible if the replacement of old systems is speeded up, thus consideration B.
- *HVAC*: Coupled to refurbishment of buildings, thus same consideration B.
- *Street lighting*: Here some catching up is possible if replacement of old systems is speeded up, thus consideration B.

Savings without investments

In order to calculate investments it must be specified first whether investments are really needed to realize the potential. E.g. for good housekeeping measures no, or few, investments are needed (Wesselink et al., 2010 and 2011). Savings without investments in buildings are possible for:

- Heating existing dwellings;
- Water heating;
- Overall household electricity use;
- Heating of existing buildings;
- Office lighting.

Good housekeeping savings measures in business can yield 10-20% savings, but this is a one-time gain in a period of 20 years. For households the savings are in the range of 3-10%, but the higher figures ask for intensive efforts to change behaviour which raise the cost for government. Good-housekeeping is, in general, very cost-effective for the energy users and does not need subsidies, but some government money is often needed to overcome so-called 'hidden costs' to realize energy savings potentials in buildings.

Because the Ecofys study does not discuss energy savings in buildings due to behavioural changes, it is assumed that always investments are needed to realize the saving potentials.

Specific investments per category

The total investments per category of savings potential are calculated using specific investment figures in €/Ktoe saved. Average figures for buildings as a whole are available from the recent study by Ecofys (Wesselink et al., 2011). This study shows a large range for investment needs (€ 350-650 billion for about 100 Mtoe of energy savings). For the average specific investments the mean value has been taken (5000 €/Ktoe).

The figures must be diversified for the categories in the sectors Households and Tertiary, keeping the average figure in line with that of Fraunhofer/Ecofys. The following assumptions were made:

- *New dwellings*: Higher than average specific investments.
- *Conversion*: Relatively low specific investments for condensing boilers, but not very low due to the decreasing energy demand for space heating.
- *Refurbishment existing dwellings*: Average specific investments as this category represents the majority of savings and investments.
- *Water heating*: Less than average specific investments, in line with the condensing boiler figures.
- *Household electric appliances*: Rather low specific investments, but higher than in the past due to increasing efforts needed to realize extra savings.
- *Heating new buildings*: Higher than average specific investments, but lower than for households due to the economic considerations in the Service sector.
- *Heating existing buildings*: Average specific investments as it regards relatively costly refurbishment and this category contributes substantially to the total savings and investments for buildings.
- *Office lighting*: Relatively low specific investments when refurbishment is coupled to renovation.
- *HVAC*: Relatively low specific investments when refurbishment is coupled to renovation.
- *Street lighting*: Relatively low specific investments when refurbishment is coupled to renovation for traffic management reasons.

Stimulation by funding or other means

In the baseline scenario, savings are already stimulated by different types of policy measures, e.g. regulation for appliances and new dwellings, information for changing energy-use behaviour and subsidies on insulation of existing dwellings. In order to realize the extra savings potentials different additional policy measures can be applied per category of potential. However, the central objective of this study is to show the effects of spending ETS auction revenues on extra savings. To this end the variant with spending auction revenues on energy savings is compared to the baseline scenario, keeping all other policy measures the same. Therefore, in this study we have only analysed the opportunities for additional energy savings in buildings (i.e. in Households and Tertiary) to be achieved by additional public support (funded form ETS auction revenues) while ignoring alternative policies such as additional regulation or extra information/awareness campaigns.

If there is a lack of auction revenues, however, it seems sensible to give priority to categories of energy savings where there are no easy policy alternatives, such as regulation. Therefore it is still worth to specify possibilities for alternative stimulation:

- *Heating existing dwellings*: further regulation for insulation and boilers;
- *Heating new dwellings*: regulation for Near Zero energy dwellings;
- *Appliances and lighting:* further regulation?
- *Heating of existing buildings*: further regulation for insulation and boilers;
- *Office lighting*: further regulation?
- *Street lighting*: further regulation?

Alternative funding mechanisms
Instead of subsidies on investments, alternative stimulation systems can lower the amount of funding needed, e.g. a revolving fund providing soft loans. This solves at the same time the financing problem and the economic attractiveness of the saving measure. Especially for companies this approach can remove barriers and lower the high market discount rate that they normally use for saving investments.

Amount of funding needed
In order to calculate the public funding needs a default rate of 20% subsidy has been assumed. This is in line with current practices and the amount of subsidy to bridge the gap between market discount rates and the rate applied for the cost-effective HPI potentials (see **Table 28**). For Services bridging the gap between the market discount rate and the assumed HPI rate asks for more than 20% subsidy. Here the alternative policy measures indicated above can limit the subsidy to 20% instead of the higher figures in **Table 28**.

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