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# Costs and Benefits of Energy Efficiency Obligation Schemes

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# 1. Introduction

In 2009, the European Union adopted high-level goals for renewable energy, energy efficiency, and greenhouse gas reductions with targets set toward the year 2020. This was followed in 2012 by adoption of the Energy Efficiency Directive (EED) (2012/27/EU), which included as a major component a requirement for Member States to create Energy Efficiency Obligations Schemes (EEOs) on energy companies or equivalent alternative measures, and those provisions have now been in effect for three years. In 2016, as European institutions consider how to meet clean energy and climate goals toward 2030 and beyond, it is important to understand how the Energy Efficiency Directive can be renewed and extended. This paper is a review of the main characteristics of some of the leading EEOs in Europe and the United States, and is intended to answer basic questions as to scope and scale, and to inform European policymakers as they consider extending the EED beyond 2020.

The purpose of this report is to explore the full range of costs and benefits of EEOs that need to be considered in future impact assessments. This report presents our initial findings on the costs, bill impacts, and multiple benefits of EEOs under Article 7 of the EED.

The report presents data from five Member States: the United Kingdom, Denmark, France, Italy, and Austria. Data from Ireland are not available at the date of this report, and Ireland therefore has not been analysed; however, data are expected later in 2016. Data from countries outside the European Union are included for comparison: the United States (states of California and Vermont). Table 1 presents the key design features of the EEOs analysed in this study.

**Table 1. Key Design Features of EEOs Compared in This Study**

	Period Analysed	Target (as Defined)	Target (kWh/y/capita)	Sector	Obligated Parties
United Kingdom	2008-2012	293 Mt CO <sub>2</sub> (lifetime)	81	Residential sector	Energy suppliers (electricity and gas)
France	2011-2014	460 TWh cumac	66	All sectors except for actions in facilities subject to the ETS	Energy suppliers (electricity, gas, LPG, district heating, and transport fuels)
Denmark	2015	12.2 PJ (final energy)/y	603	All sectors except transport	Energy distributors
Italy	2006-2014	2015: 6.2 Mtoe	97	All sectors	Energy distributors
Austria	2015-2020	159 PJ	187	All sectors but mandatory minimum share for residential sector (40%)	Energy suppliers (all fuels including motor fuels and biomass)

Vermont <sup>1</sup>	2012-2014	274,000 MWh electric savings; 41.9 MW summer peak demand reduction; 155,000 MMBtus gas savings*	186	Residential, commercial, industrial, agricultural	Energy distributors (electric and natural gas utilities)
California <sup>2</sup>	2010-2012	6,966 GWh 1,537 MW 151.3 million therms of natural gas*	115	Residential, commercial, industrial, agricultural	Energy distributors (investor-owned electric and natural gas utilities <sup>3</sup> )

\*Savings targets for Vermont and California are set in terms of annual energy savings<sup>4</sup>

Data have been presented in comparable format to facilitate drawing conclusions on the impact of EEOs across different programmes. In order to provide information in a clear, summary format, we have had to incorporate certain assumptions or specific methodological approaches. For example, the costs of EEOs are assumed to be distributed evenly among consumers, even though in reality the situation is more nuanced. Also, the methodologies used by the countries analysed to estimate and report costs and savings are not fully consistent:

- **Discounting.** Some countries discount energy savings, whereas others do not.
- **Free-riders.** Estimates for free-ridership vary across the different countries.
- **Lifetimes.** The lifetimes of the measures are not always the same, even for the same measure.
- **Units.** Differing units of savings from different mixes of fuels and conversions to kilowatt-hour (kWh) equivalents.
- **Evaluation methods.** Some of the evaluations are *ex ante*, others are *ex post*. The rigour of the evaluations is not the same across all countries analysed.

There is no possibility of adjusting the reported energy savings in a meaningful way without considerable effort that would involve reviewing the assumptions for each country made when calculating the savings from specific technologies.

<sup>1</sup> The savings targets and data for Vermont represent those for Efficiency Vermont, the state's energy efficiency utility, which is responsible for delivery of most of the electric savings under the state EEO, and is funded principally through revenues collected from electricity customers by electric distribution companies.

<sup>2</sup> CPUC, 2015.

<sup>3</sup> There is also a separate obligation on publicly owned utilities, which accounts for about 25 percent of demand in California.

<sup>4</sup> Efficiency Vermont, 2014.

Despite the methodological challenges and uncertainties involved in a comparative analysis of EEOs, the overall results of this report are robust. Even if the adjustments meant that the costs of EEOs were to be higher by a factor of two to three, the benefits from EEOs would still significantly outweigh the costs.

## 2. Cost of Energy Efficiency Obligation Schemes

EEOSs incur a cost, as does any other energy efficiency (or supply) policy. Those costs can be classified as:

- **Programme cost.** This includes all of the costs to the obligated parties required to meet their targets. Most of this cost consists of grant payments to customers to partly or in some cases fully fund energy efficiency measures. In addition, the obligated parties also spend money on administering the scheme internally, marketing measures, commissioning contractors, reporting, and so on. This cost element is the main focus of the report.
- **Societal cost.** This includes both the cost to the obligated parties and the additional costs incurred by customers who participate. For example, if a programme offers a €500 incentive to defray a €1500 cost to insulate a loft, the societal cost for a customer persuaded to insulate their loft by the rebate is the full €1500 (a €500 programme rebate plus another €1000 incurred by the participating customer). Estimating this cost requires obtaining detailed data on the efficiency measures installed, which is beyond the scope of this project. Instead, we provide a summary of the available evidence.
- **Administrative cost.** This is a subset of EEOS costs, typically borne by regulators or their designees, to establish the rules for an EEOS, oversee the implementation of the EEOS (at a high level), verify/estimate/evaluate what the EEOS actually achieved, and report on its results. This study reports on this cost as well.
- **Start-up cost.** This is a one-off cost for setting up the EEOS. Typically the start-up costs would include the establishment of new procedures, guidelines, training of staff, consultations, and so on. Where available we present data on start-up cost.

Below, the main findings regarding the cost of EEOSs are presented. Data quality and reliability is very high for some countries (e.g., the United Kingdom), but there are uncertainties around the estimates for more recent EEOSs (e.g., Austria). For each country, the assumptions and key sources are provided in the appendix to this report.

### 2.1. Summary

Text Table 2 summarises the costs of implementing EEOSs. EEOSs drive investment in energy efficiency through dedicated funds collected by energy companies, either as a special charge or as part of the cost of doing business. These funds leverage private investment in various ways. For example, they help overcome barriers to energy efficiency by reducing the cost or payback time for various energy efficiency measures. A common rule of thumb is that every €1 of funding will leverage €2 to €3 of private investment.<sup>5</sup> In reality, the contribution of dedicated energy company funds to driving energy efficiency projects will vary, and depends on the types of measures and customers supported.<sup>6</sup> For example, an EEOS supporting households in fuel poverty will be characterised by a higher contribution from obligated parties than an EEOS focusing on the able-to-pay market. This is because those customers face higher market barriers—fuel-poor households are usually only able to make a limited (if

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<sup>5</sup> See, for example, Molina (2014), which found that “[...] the ratio of participant costs to program costs ranges from 25% to 262%, and the simple average is 141%. In other words, for every \$1 invested by the program administrator, participants are estimated to spend on average an additional \$1.41 on efficiency upgrades.”

<sup>6</sup> For an analysis of the leverage effect of EEOSs in the United Kingdom, France, and Denmark, see Rohde et al., 2014.

any) contribution to the overall investment cost and are also less likely to identify themselves as qualifying for receiving certain measures.<sup>7</sup>

Table 2 includes the annual costs of delivering on EEOs for all obligated energy companies in each Member State and in Vermont and California in the United States. It further summarises the share of administrative costs as a percentage of overall energy company costs (excluding the contributions made by beneficiaries).

**Table 1. Company Cost and Administrative Cost of EEOs**

	Time Period	Energy Company Costs (Million euros/y)	Energy Company Costs (euros/capita/y)*	Administrative Costs (% of overall programme costs)
United Kingdom	2008-2012	1,052	16	0.2
Denmark	2015	185	33	0.3
France	2011-2013	390	6	0.4
Italy	2014	700	12	1.4
Austria	2015	95	11	Not available yet
Vermont	2012-2014	39	62	4.91
California	2010-2012	742 <sup>8</sup>	19	?

Source: See individual sections on countries

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

## 2.2. Programme Cost

The costs to the energy companies vary significantly depending on the country, ranging from €185 million per year in Denmark to more than €1 billion per year in the United Kingdom. This is largely a result of:

- The different size of the countries in terms of the number of consumers;
- Variations in the ambition of the target; and
- Interaction with other policy instruments.

The third point refers mainly to the French case, in which consumers can blend funds from both the EEOs and the French tax rebate scheme Crédit d'Impôt Transition Énergétique in order to finance energy efficiency improvements in domestic buildings. This means that funds from EEOs have to cover a smaller share of the total investment cost, which lowers the cost of EEOs in France significantly compared to other countries where this is currently not an option.<sup>9</sup>

<sup>7</sup> Rosenow, Platt & Flanagan, 2013.

<sup>8</sup> Total programme expenditure over 3 years (\$2.5 billion)/3, converted into euros. It does not include expenditures relating to codes and standards (\$30 million), and low-income programmes (\$669 million). See CPUC, 2015.

<sup>9</sup> For a detailed analysis of the interaction of the EEOs in France and tax rebates, see Rohde et al., 2014.

A more meaningful indicator for the comparison of costs is the share of the cost of EEOs of the average energy bill, which is provided in the section on bill impacts.

Table 3 demonstrates the cost to the obligated parties in terms of cost per kWh (lifetime) and compares this to the average cost per supplied kWh (weighted average of retail price).

Overall, this study found that the cost-effectiveness of the EEOs analysed is very high. The cost to the obligated company per kWh of energy saved in Europe is approximately 0.4 to 1.1 euro cents, which is significantly less than the cost of energy.<sup>10</sup> The costs in the US examples chosen, and in many US EEOs, are higher. However, the US figures are likely to be higher because issues such as free-riders are addressed more robustly when programme-driven energy savings are calculated, which in turn leads to a higher cost per accredited kWh. Also, energy efficiency obligations continue to be cost-effective based on a number of approaches to evaluating the costs and benefits of energy efficiency programmes and measures, as described below.

**Table 2. Comparison of Costs of EEOs Across Selected Countries (Unit Cost of Saved Energy)**

	Time Period	Weighted Average EEOs Cost of Lifetime Energy Savings (euro cents/kWh)	Weighted Average Retail Prices of Comparable Energy Supply for Relevant Sectors (euro cents/kWh)
United Kingdom	2008-2012	1.1	10
Denmark	2015	0.5	13
France	2011-2013	0.4	9
Italy	2014	0.7	9
Austria	2015	0.5	8
Vermont, US	2012-2014	3.2*	11.57
California, US <sup>11</sup>	2009-2011**	2.1	12.24

*Source: For cost of EEOs, see sections on individual countries; average cost per kWh supplied from Eurostat (2015); energy consumption data used for calculating weighted average from ODYSSEE Database.*

\* Preliminary figure – needs to be verified. Includes both electricity and natural gas and fuel oil savings.

\*\* Note these data are for a different set of years, as the cost to the energy companies is not available for the 2010-2012 period.

<sup>10</sup> It is worth noting that the cost per kWh supplied to the consumer is higher than the “avoided cost” of energy to the energy company. On the other hand, the total system benefits from efficiency, including such factors as environmental benefits, lower line losses, lower reserve requirements, and lower peak power prices, are delivered to energy systems and to the public generally, not just to the participating efficiency customers.

<sup>11</sup> See LBNL, 2014.

### 2.2.1. Cost of EEOs in the United States

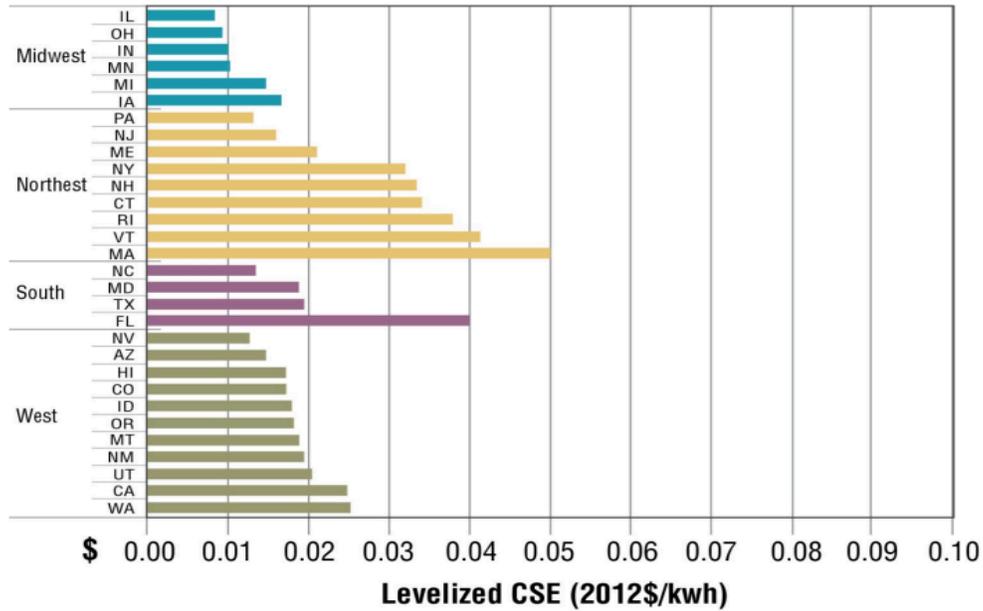
It is worth making a few notes regarding the experience with EEOs in the United States. First, measuring the cost per kWh saved to the obligated company provides a worthwhile perspective into how much it costs to deliver energy savings. However, most US jurisdictions use an even more comprehensive analysis of costs and benefits by calculating the “total resource cost” or “societal cost” of energy efficiency.

Second, the costs to the obligated entity of delivering energy savings can vary widely, as illustrated in Figure 1. The figure represents the levelised cost to the obligated party of delivering a kWh of energy savings. The costs vary owing to the design of different state policies. More expensive costs of delivery will often reflect inclusion of energy efficiency programmes geared toward the fuel-poor and more comprehensive “whole-house” approaches to energy efficiency that address various end-uses at once. Perhaps even more important, the costs of delivery reflect the “aggressiveness” of the overall savings targets. The first increment of savings is often the cheapest, followed by increasingly expensive savings. For example, the state with the largest cost per unit of savings in Figure 1, Massachusetts, got electricity savings equal to close to three percent of annual sales last year.

It is worth noting that in these US states, costs are almost universally higher than those we have found for the European Union. Some likely explanations are:

- There tends to be much more rigorous evaluation of actual savings.
- Many states focus on net rather than gross (i.e., they adjust for additionality/free riders), including eliminating entirely certain measures (e.g., CFL lighting) when programmes have succeeded in transforming the market for that product.
- The cost figures in Figure 1 for the United States are just for electricity savings, whereas the EU numbers come from multiple fuels and are expressed as kWh equivalents.
- There may be shorter measure life assumptions.
- The costs in the United States are levelised, meaning that there is discounting involved, whereas in the European Union not all countries discount energy savings.
- US programmes tend to include special focus on low-income households (only some European EEOs do) and on delivering high-value savings (e.g., peak load reduction), which might be more costly, but which are also more valuable than generic savings.
- The depth of savings being achieved in the most expensive states is much greater than in most of the EU examples.

**Figure 1. Cost of EEOs in US States**



Source: LBNL, 2014.

Table 4 demonstrates the difference in costs to the obligated party of delivering energy efficiency in different customer segments and levelised costs that account for savings over time.

**Table 3. Levelised Cost per Customer Segment**

Sector	Levelised CSE (6% Discount) (\$/kWh)
Commercial and industrial	0.021
Residential	0.018
Low-income	0.070
Cross sectoral/other	0.017
National CSE	0.021

Source: LBNL, 2014.

### 2.2.2. Comparison of EEOs Cost to Typical Energy Bill

EEOs typically cost about one to five percent of the average energy bill (see Table 5). Those figures do not account for the cost savings, but simply represent the costs that are passed on to consumers by the energy companies through increased energy bills.

In reality, both participating and non-participating consumers benefit from EEOs through *reduced* energy bills owing to the energy cost savings delivered via reduced consumption. This is discussed in detail in the section “Benefits of Energy Efficiency Obligation Schemes to Consumers.”

**Table 4. Comparison of Costs of EEOs Across Selected Countries (Share of Energy Bill)**

Cost as Share of Average Energy Bill			
	<i>Household Sector</i>	<i>Industry Sector</i>	<i>All Sectors</i>
<b>United Kingdom</b>	2%	N/A	N/A
<b>Denmark</b>	2%	5%	N/A
<b>France</b>	N/A	N/A	0.5% to 1.0%
<b>Italy</b>	1%	Not available	Not available
<b>Austria</b>	Not available yet	0.9% to 1.4%	Not available yet
<b>Vermont, US</b>	6%	6%	N/A
<b>California, US</b>	1.5%	1.4%	N/A

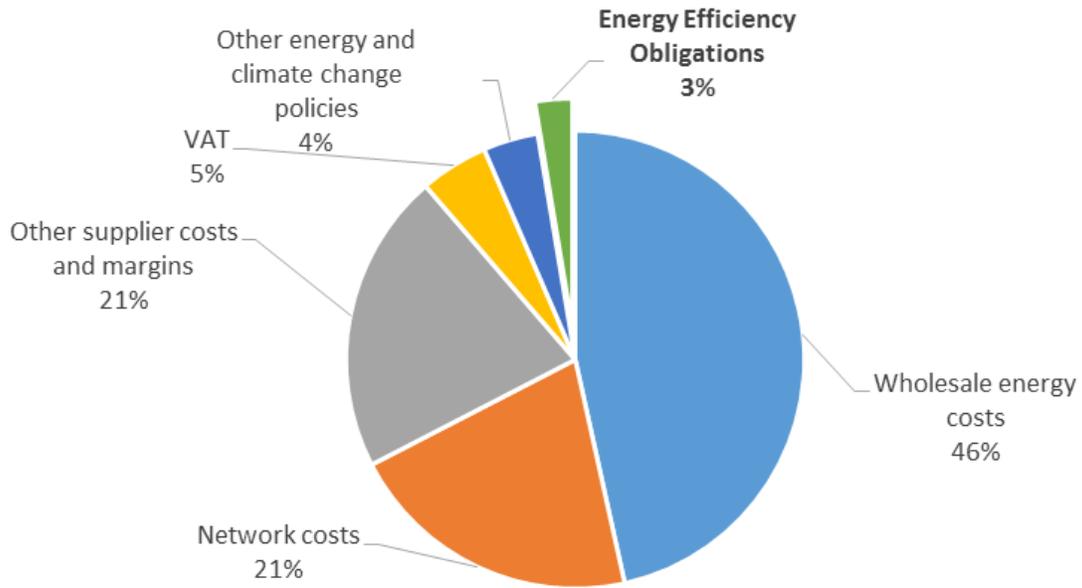
*Source: Calculated by authors based on cost data, Eurostat (2015) and data from the Odyssee Database.*

The costs to end consumers have been calculated by assuming 100 percent cost pass-through. In practice, however, because obligated parties operating in fully liberalised markets can pass on the costs at their own discretion, they may spread the cost unevenly across customers, putting the burden primarily on those customers who tend not to switch suppliers. One attempt to model how this might work in practice found that “non-switchers” could pay as much as 35 percent more EEOs costs compared to “switchers” on direct debit tariffs.<sup>12</sup> Obligated parties may also decide to only pass through a proportion of the costs in order to remain competitive. Owing to the commercial sensitivity of data on pricing, it is not possible to analyse the way in which obligated parties actually pass through the cost. For comparative purposes, the best assumption that can be made therefore is that the costs of EEOs are passed through 100 percent to consumers.

Data on the breakdown of energy bills in selected countries also illustrate the comparatively low cost of EEOs in contrast to different bill items. Below is an illustration of the share of different bill items in the United Kingdom, indicating that EEOs are the smallest item of the energy bill.

<sup>12</sup> Preston, White, & Guertler, 2010.

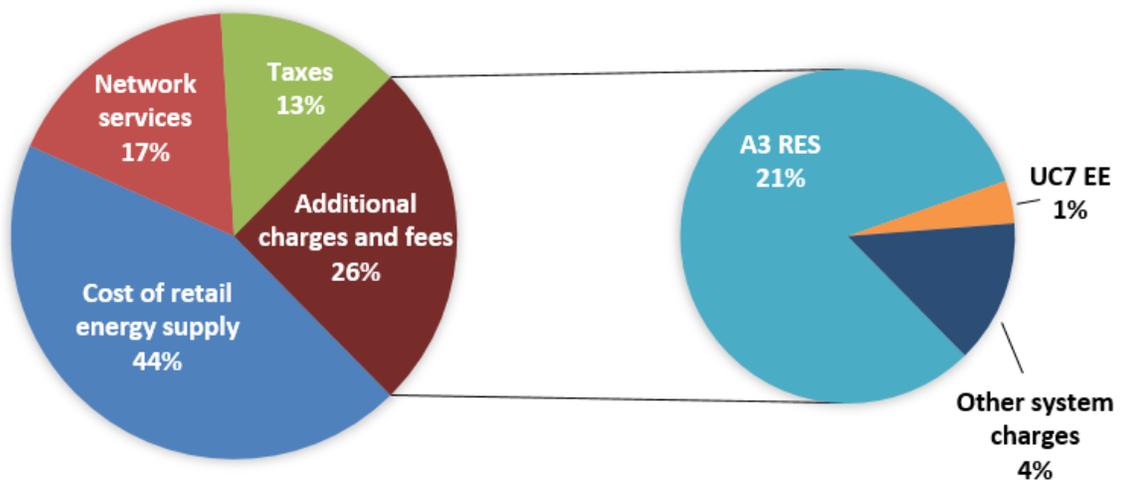
**Figure 2. Breakdown of the Average Household Energy Bill in the United Kingdom (2014)**



Source: DECC (2014a)

A breakdown of the average household energy in Italy supports the data from the United Kingdom with a cost for EEOS of one percent of the annual household bill.

**Figure 3. Breakdown of the Average Household Energy Bill in Italy (IV Quarter 2015)**



Source: [http://www.autorita.energia.it/it/consumatori/bollettatrasp\\_ele.htm](http://www.autorita.energia.it/it/consumatori/bollettatrasp_ele.htm)

## 2.3. Societal Cost

Data on the societal cost defined as the sum of the costs to the obligated parties and the costs to the participants in the programme are not readily available and require detailed surveys on the contributions from beneficiaries to individual energy efficiency measures.

Alternatively, societal costs can be estimated by applying a leverage factor. Typically, because programmes leverage additional investments by consumers, the societal costs are two to three times as high as the cost to the obligated parties. A recent study of several EEOs in the United States suggests that the societal costs are 241 percent on average of the cost to the obligated parties—for example, a programme that costs suppliers €1 billion per year has societal costs of €2.4 billion per year.<sup>13</sup>

An investigation into the British, French, and Danish schemes into the leverage effect of EEOs<sup>14</sup> can be used to estimate societal costs compared to the programme costs.

- United Kingdom: 187 percent of cost to obligated parties in 2002 to 2005 and 144 percent in 2005 to 2008 (residential sector only)
- France: 137 percent
- Denmark: 300 percent of obligated parties' costs (industry sector only)

Note that these data only relate to the direct costs of programme measures (i.e., the financial contributions) and do not include hidden cost such as time and hassle. There are very few examples of hidden cost estimates, including one from the United Kingdom, in which they have been estimated at about two-thirds of programme costs.<sup>15</sup>

## 2.4. Administrative Cost

What are counted as administrative costs differ somewhat from one programme to the next; however, in general, administrative costs include the following:

- Allocating the government-set energy savings target between obligated energy companies;
- Determining accreditation process for energy savings;
- Issuing technical guidance on eligible measures;
- Accrediting energy savings;
- Putting in place mechanisms to track any transfer or trade of savings; and
- Monitoring and verification.

For most EEOs analysed, the administrative costs constitute a small fraction—less than one percent—of the total programme costs (excluding the contributions made by the beneficiaries). Notably the Italian scheme incurs the highest share of administrative cost, which is most likely a result of the high share of traded certificates and the associated administrative effort. Previous analysis by Bertoldi et al (2010) has shown that trading increases the administrative burden owing to additional costs involved in setting up

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<sup>13</sup> See Molina, 2014.

<sup>14</sup> Rohde et al, 2014.

<sup>15</sup> See, for example, DECC, 2012a.

and running trading platforms, although in a system with broad sectoral coverage, there may be good reasons for including trading provisions.

## 2.5. Start-Up Cost

Data on start-up cost are limited. However, where data are available the evidence suggests that start-up costs are small.

In the case of the Community Energy Saving Programme (CESP), which operated in the United Kingdom from 2009 to 2012, the start-up costs were estimated to be of a similar range as the annual operating costs (~€500,000),<sup>16</sup> which is equivalent to 0.3 percent of the total programme cost per year. Start-up costs for the Energy Company Obligation, which was implemented in 2013, have been estimated at about half of the anticipated annual running cost (€1,700,000).<sup>17</sup> This amounts to 0.1 percent of the estimated annual programme cost.

## 2.6. Comparison to Previous Analyses of the Cost of EEOs

The findings of this analysis are corroborated by previous academic studies. A comprehensive analysis of the EEOs in the United Kingdom, France, and Italy,<sup>18</sup> analysing data up to 2009, found very similar values in terms of cost per kWh of saved energy. The cost of the French scheme was estimated at 0.4 euro cents/kWh of saved energy, which is the same value that was calculated in this study. For the United Kingdom, the estimate was 0.7 euro cents/kWh of energy saved (based on older *ex ante* rather than *ex post* data)—that is, somewhat lower than the 1.1 euro cents/kWh estimated as part of this study. Another academic assessment of the U.K. scheme<sup>19</sup> estimates the cost to be 0.7 euro cents/kWh of energy saved (also based on *ex ante* figures) but because the savings have been revised downwards by the UK government recently our estimate of 1.1 euro cents/kWh is higher. Only for Italy, the estimates based on previous data of 0.1 euro cents/kWh of energy saved are significantly lower than the results of this study. However, analysis as part of the ENSPOL project<sup>20</sup> supports the (more recent) estimate provided in this study. A reason for the different results for Italy could also be the changing mix of technologies used to deliver the EEOs in Italy. Initially, energy efficient lighting in the residential sector made a significant contribution to the overall savings. In more recent years the system has shifted to measures predominantly in the industry sector.

The study team did not identify previous estimates for Denmark, but the results appear to be consistent with experience from other countries. Because the Austrian scheme just started to operate in 2015, no comparative data exist yet. However, the magnitude of the costs per kWh of energy saved is supported by the data from the other countries.

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<sup>16</sup> DECC, 2009.

<sup>17</sup> DECC, 2012.

<sup>18</sup> Giraudet, Bodineau, & Finon, 2012.

<sup>19</sup> Rosenow & Galvin, 2013.

<sup>20</sup> ENSPOL, 2015.

### 3. Benefits of Energy Efficiency Obligation Schemes to Consumers

EEOs can contribute to significant reductions in energy consumption. This ultimately results in bill savings as the cost of EEOs are far exceeded by the energy cost savings.

#### 3.1. Impact on Energy Consumption

Table 6 demonstrates the impact of EEOs on final energy consumption in selected Member States and countries. The reduction of final energy consumption per year is expressed in both absolute values and as a percentage of the average energy consumption in the relevant period and sectors.

**Table 5. Impact of EEOs on Energy Consumption**

	Time period	Final Energy Savings per Year (ktoe)	Incremental Annual Savings Rate Compared to Final Energy Consumption	Sector
United Kingdom	2008-2012	237	0.5%	Household sector
Denmark	2015	291	4.2%	All sectors
France	2011-2013	377	0.4%	All sectors
Italy	2015	500	0.4%	All sectors
Austria	2015	136	0.9%	Household and industry sectors
Vermont, US	2012-2014	10	1.7%	All sectors except transport
California, US	2010-2012	384	1%	All sectors except transport

Source: See individual sections on countries

The savings from EEOs in Denmark are notably high in comparison to the other countries. The Danish National Energy Efficiency Action Plan (NEEAP) states that free ridership could apply to up to 80 percent of measures in buildings and 50 percent in industry.<sup>21</sup> Independent analysis suggests similar proportions of free riders.<sup>22</sup> While some adjustments to the savings estimates are made, the high degree of free-ridership can partly explain the high savings figures in Denmark compared to the other jurisdictions.

<sup>21</sup> Danish Energy Agency, 2014b

<sup>22</sup> Bundgaard et al., 2013.

## 3.2. Economic Value of Energy Savings

The impact on energy consumption links to the impact on bills, although a specific reduction in energy consumption does not necessarily translate directly into the same amount of bill savings. This is because bills include both variable and fixed costs and energy suppliers are likely to recover fixed costs by raising unit prices. On the other hand, as energy savings can avoid marginal investment costs, which are usually higher than average embedded costs, bill savings from efficiency could be larger than efficiency's share of total system resources. Both price and non-price benefits have been measured in many individual studies, but there is no universal method that would allow us to estimate the exact bill impact of reduced consumption across the jurisdictions analysed in this report, so we assume that a one-percent reduction in energy use results in a one-percent reduction in energy bills for the purpose of this report.

The impact of EEOs on bills can be roughly divided into two categories: the direct impact on bills of participating consumers, and the indirect impact on bills across all consumers, described in the next paragraph. Over time, EEOs should be designed to ensure that all consumers within all consumer classes (residential, industrial, commercial, tertiary) have the opportunity to benefit directly from EEOs. At the same time, the indirect effects on bills can also be substantial and all customers benefit—both participants and non-participants in energy efficiency programs.

The indirect impact on bills refers to the savings that result from avoided investments in generation, transmission, and distribution infrastructure. These avoided costs result from the decreased demand for energy achieved through energy efficiency programs and measures. They are often referred to as “system benefits,” as opposed to “non-energy benefits” discussed in more detail in section 4 on the multiple benefits of EEOs.

It is worth pointing out that in the case of EEOs, consumers are paying for energy savings through their energy bills in the same way that they pay for energy consumption. This is a reasonable approach when one considers that energy efficiency provides energy services, the same as energy supply: rather than providing megawatt-hours, however, energy efficiency provides *negawatt*-hours. In considering the impact on bills, therefore, it is useful to keep in mind that the proportion of bills that accounts for energy efficiency programs is not purely an additional cost, but rather often represents a lower-cost alternative to the higher cost of energy supply and delivery.

## 3.3. Net Benefits to Consumers

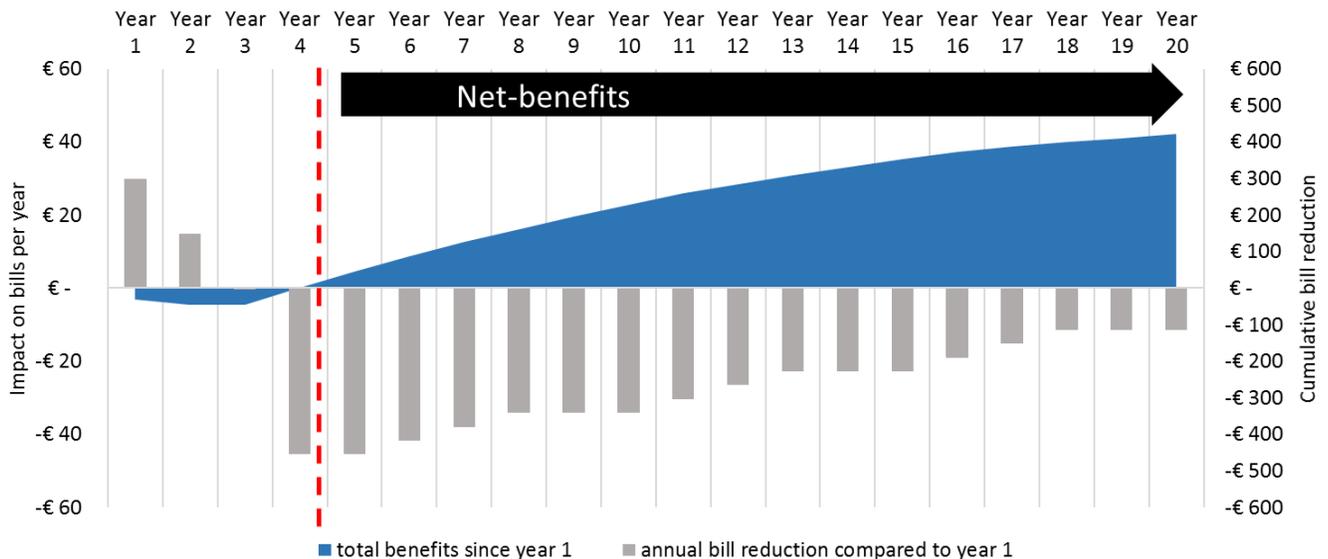
The net benefits to bill payers can be modelled over time. Initially the total energy bill may increase if the cost of EEOs and higher unit prices exceeds short-term savings from avoided energy and any alternative supply-side investments that would have been made. However, even if there are no immediate system savings, over time consumers' bills are reduced, resulting from the energy savings generating net benefits after a few years.

For a fictitious case, this effect is illustrated in Figure 4. Although not a real-world example, the data for the example are based on typical characteristics of EEOs in Europe, and therefore are a realistic reflection of the cost savings to expect from EEOs over time. The case is based on the following:

- Three-year operational period and termination thereafter;
- Assuming no EEOS in place before;
- Only applies to household sector;
- Average delivered “new” savings of one percent each year;
- Average cost as share of total energy bill of three percent;
- Split of lifetimes of measures: 25 percent 5 years, 25 percent 10 years, 25 percent 15 years, and 25 percent 20 years; and
- Average annual household energy bill of €1,500.

After five years the modelled EEOSs generate net benefits as indicated in the graph. Over 20 years the benefits exceed the cost by more than a factor of four.

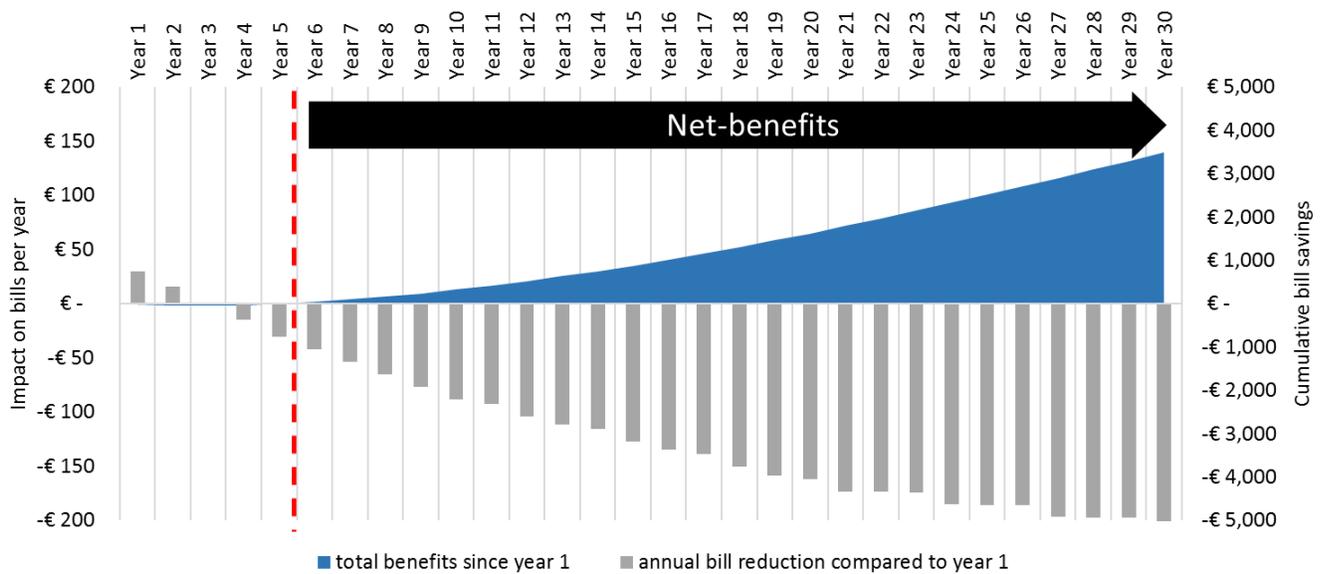
**Figure 4. Illustrative Long-Term Impact of EEOSs on Energy Bills**



*Source: Authors' illustration*

This positive result becomes much more significant if the EEOS is not ended after a short initial period, but is continued over a long time period. Assuming a continuous efficiency programme (or a succession of EEOSs) over 30 years and the same split of lifetimes of measures of 25 percent 5 years, 25 percent 10 years, 25 percent 20 years, and 25 percent 30 years, the long-term benefits are significant, with total bill savings of close to €4,000 over the 30-year period and a reduction of the average annual energy bill of 17 percent (Figure 5).

**Figure 5. Long-Term Bill Impacts of a 30-Year EEOs**



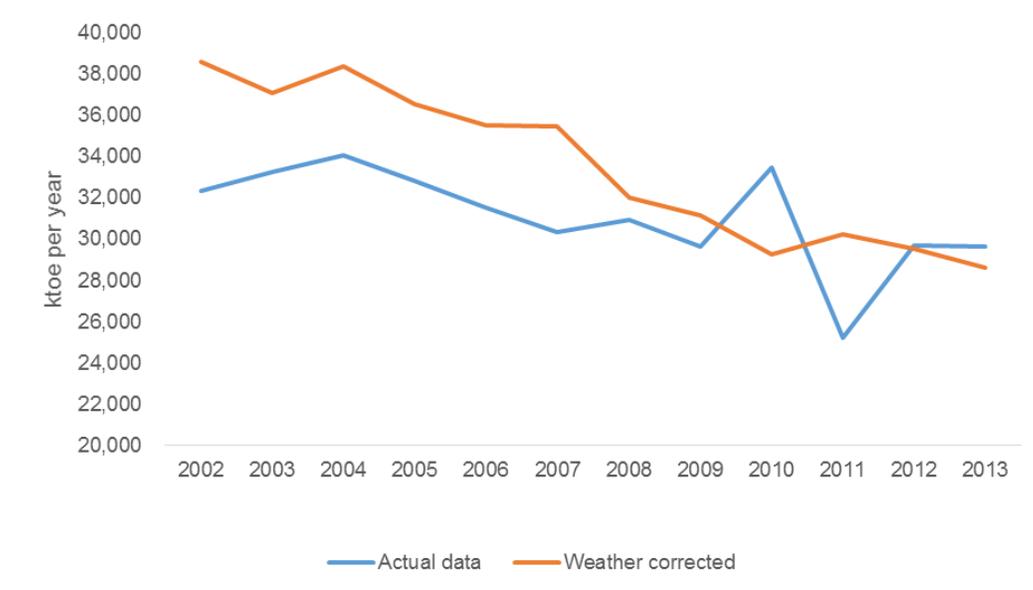
*Source: Authors' illustration*

### 3.4. Evidence on Long-Term Trends and EEOs

For the longest existing EEOs in Europe, there is now good evidence that EEOs have contributed to significant reductions in energy consumption. For example, total household energy use in the United Kingdom decreased by 19 percent between 2000 and 2014, despite a 12-percent increase in the number of households, a 9.7-percent increase in population,<sup>23</sup> and an increase in the average property size. On average, individual households now use 37 percent less energy than they did in 1970, with the bulk of this decrease occurring since 2004. Between 2004 and 2011, total household gas consumption decreased by 5 percent per year on average, or approximately 3.6 percent per year after temperature correction (Figure 6).

<sup>23</sup> DECC, 2012b.

**Figure 6. Gas Consumption by U.K. Households (2002-2013)**



Source: DECC (2014b)

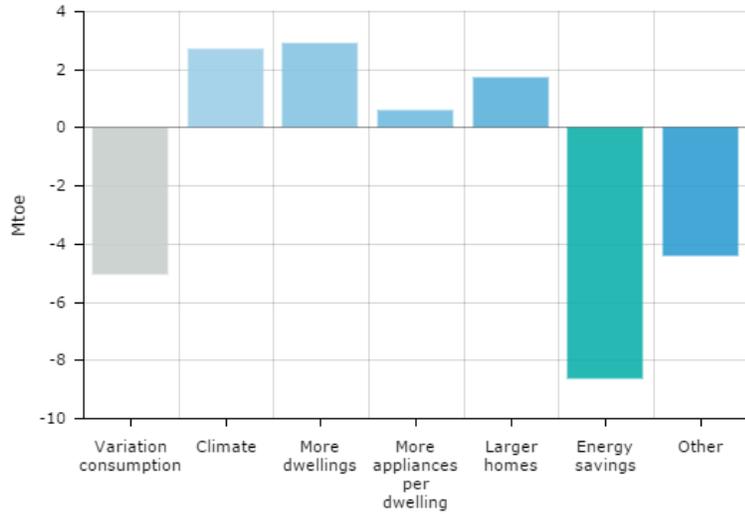
These changes in consumption were driven by changes in the number and size of households, income, average internal temperature, and the changing stock of appliances, together with investment in energy efficiency measures. Although it is not straightforward to estimate the relative contribution of each, the Centre for Economics and Business Research<sup>24</sup> estimates that energy efficiency measures provided the greatest contribution to the reduction in gas consumption. Specifically, approximately two-thirds of the reduction in household gas consumption between 2006 and 2009 (4.9 percent per year) was attributed to energy efficiency, of which 36 percent was attributable to insulation, 36 percent to condensing boilers, and the remainder to behavioural change. As the majority of these measures were subsidised by the supplier obligations, it appears likely that those were the primary drivers of energy savings over this period.<sup>25</sup>

Analysis by the Odyssee-MURE team, a pan-European research project, confirms that the majority of the downward trend is due to energy savings. EEOs have not delivered all of the UK's energy savings, but they are the most important factor in delivering them (Figure 7).

<sup>24</sup> Centre for Economic and Business Research, 2011.

<sup>25</sup> The figures provided by the Cavity Insulation Guarantee Agency on the delivery rates more or less match the figures of cavity walls installed with CERT funding. There are no data for other types of energy efficiency available, but anecdotal evidence suggests that most of the market was dependent on CERT, which is also evident from the drop of the installation rates of loft insulation after CERT ended.

**Figure 7. Estimated Contributors to the Change in U.K. Household Energy Consumption (2004-2012)**



Source: *Odyssee Decomposition Facility*

In this graph, the variation of the households' energy consumption between 2004 and 2012 is influenced by:

- Climatic effect: climatic difference between these two dates;
- More dwellings: change in number of occupied dwellings;
- More appliances per dwelling: electrical appliances, central heating;
- Larger homes: change in floor area of dwelling for space heating;
- Energy savings: as measured from ODEX, the indicator developed by the Odyssee project; and
- Other effects: mainly change in heating behaviours.

## 4. Multiple Benefits of Energy Efficiency Obligation Schemes

### 4.1. Introduction

There is an emerging body of evidence on the multiple benefits of energy efficiency.<sup>26</sup> In addition to the more obvious energy and network savings, those multiple benefits include a wide range of impacts, from air quality improvements to health care savings and fiscal benefits.

Although the data on the costs and energy savings of EEOs are relatively comprehensive, allowing for cross-national comparisons, the picture for multiple benefits is more mixed. There are some good quality case studies providing a detailed quantification of multiple benefits of specific EEOs. This report draws on those examples where appropriate, rather than attempting to provide comparable figures on the multiple benefits generated by EEOs for all of the countries analysed in the previous sections, as these data are simply not available yet. The evidence that exists clearly shows that the multiple benefits of EEOs are significantly higher than the mere energy bill savings.

### 4.2. Defining the Multiple Benefits of EEOs

As any other energy efficiency policy instrument, EEOs deliver significant multiple benefits. Owing to increased awareness and research on this issue, the recent International Energy Agency (IEA) landmark report on energy efficiency dedicates a whole section solely to the multiple benefits of EEOs.

The multiple benefits of EEOs can be grouped into three distinct categories:<sup>27</sup>

- 1) **Participant benefits.** Those are the benefits that accrue directly to the participating individual households and businesses that install energy efficiency improvements.
- 2) **Utility system benefits.** Those are the benefits that accrue to the energy system through reduced costs in providing energy services to end-users.
- 3) **Societal benefits.** Those are the benefits that accrue more broadly to society—the community, the region, the nation, or the planet—rather than to a specific energy system.

Using these three categories, an overview of common multiple benefits from EEOs is provided in Figure 8.<sup>28</sup>

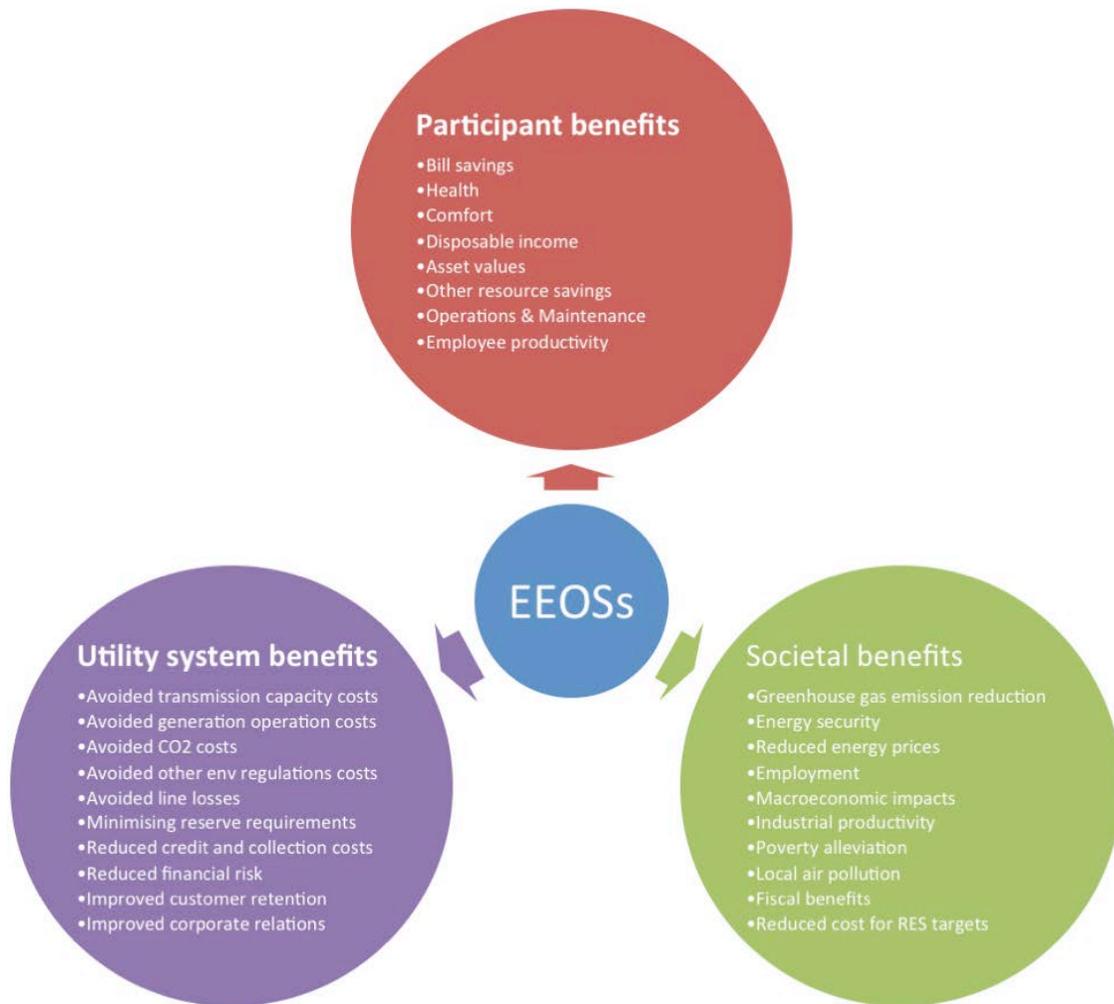
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<sup>26</sup> IEA, 2014a.

<sup>27</sup> Lazar & Colburn, 2013, and Cluett & Amann, 2015.

<sup>28</sup> Note that this is by no means a comprehensive list and there are additional benefits that do not feature in the graph.

**Figure 8. Multiple Benefits of EEOs**



*Source: Authors' illustration based on IEA (2014a)*

Despite the diversity of benefits, most evaluations that are currently carried out in Europe focus on one benefit only—bill savings. This is often compared to the cost of EEOs. A more comprehensive analysis would need to incorporate a much wider suite of benefits, acknowledging the value of monetising these broader benefits from a policymaker's perspective as well as recognising that people invest in energy efficiency for a multitude of reasons rarely limited to saving energy costs.<sup>29</sup>

<sup>29</sup> See, for example, Fuller et al., 2010.

## 4.3. Selected Multiple Benefits of EEOs and Examples

### 4.3.1. Participant Benefits

#### **Bill Savings**

The previous analysis illustrates that bill savings on their own often outweigh the cost of EEOs substantially. In addition to the bill savings realised by customers participating in energy efficiency programmes, these programmes also deliver bill savings across all customers and customer classes. These savings are attributable to the effects of energy savings programmes on the wholesale price of electricity in competitive markets.

Because energy efficiency programmes reduce overall demand for electricity, they are associated with lower clearing prices in wholesale power markets. They can also reduce the clearing price of capacity in capacity markets, where they exist. These lower clearing prices translate into lower retail electricity prices for all consumers, not just those who have reduced their consumption through energy efficiency programmes. The effect of energy savings on wholesale power prices is important to take into consideration when analysing the costs and benefits of EEOs. Analyses from the United States have indicated that these savings can be considerable. For example, this effect is estimated to have saved electricity customers in New England an average of 3.44 US cents/kWh in 2013.<sup>30</sup>

#### **Health**

When delivering energy efficiency measures in buildings, EEOs deliver important health benefits, such as reduced respiratory disease symptoms and lower rates of excess winter mortality.

The Impact Assessment of the last phase of EEOs in the United Kingdom dedicates a whole section to health impacts but states that there is “currently no set methodology for estimating and attributing health impacts of the installation of heating and energy efficiency measures, and any resulting increase in indoor temperatures.”

However, evidence from other energy efficiency programmes provides estimates of the benefits of energy efficiency retrofits (Box 1).

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<sup>30</sup> This effect is referred to as “DRIPE” (demand response induced price effect). In this context, the term “demand response” includes programmatic end-use energy efficiency. In fact, analyses conducted for New England have consistently found considerable DRIPE savings owing to the market effects of energy efficiency programmes, largely state-level EEOs. See Synapse Energy Economics, 2013.

### Box 1. Example of Health Benefits from the United States (Vermont) and the United Kingdom

A 2007 review of the Vermont Weatherization programme determined that health and safety improvements added an additional \$1044 in project cost, while returning benefits worth \$2,372, including \$1,421 owing to fewer illnesses.<sup>31</sup>

A comprehensive evaluation of the costs and benefits of the Warm Homes scheme in Northern Ireland concluded that for every €1 spent on energy efficiency, 42 cents was recouped by the health service.<sup>32</sup>

Recognising the significant health benefits of improved thermal efficiency, the U.K. government trialled the prescription of high-efficiency boilers, with the result that medical appointments for those receiving a boiler dropped by 60 percent.<sup>33</sup>

### Comfort

Closely linked to health benefits, improved comfort is an important benefit of and motivator for undertaking energy efficiency improvements. Particularly where homes are under-heated, energy efficiency improvements allow the occupants to increase indoor temperatures at no additional cost. In addition, draught-proofing reduces draughts in the buildings, making it more comfortable to live in, even if indoor temperatures are not changed.

The value of increased comfort can be measured more easily compared to health benefits. A simple approximation is to use the retail price of the energy savings that homeowners are willing to forego for improved comfort, although the “true” value of comfort is likely to be much greater.

### Box 2. Example of Comfort Benefits from the United Kingdom

For the last EEOs in the United Kingdom (ECO), the government estimated that comfort benefits of close to €5 billion could be delivered by the scheme—this is equivalent to up to 30 percent of the value of the bill savings.<sup>34</sup>

The previous Impact Assessment of the extension of CERT, the scheme in place from 2008 to 2012, provides similar figures, with comfort benefits of more than €4 billion equivalent to almost half of the value of bill savings.<sup>35</sup>

<sup>31</sup> Allen, 2015.

<sup>32</sup> Liddell, 2008.

<sup>33</sup> GM Journal, 2016.

<sup>34</sup> DECC, 2012a.

<sup>35</sup> DECC, 2010.

## **Asset Values**

Energy efficiency improvements increase the asset value of buildings and facilities. There is now evidence that suggests that properties with a higher efficiency rating achieve higher sales prices compared to other properties.

### **Box 3. Example of Increased Asset Values from Australia and the Netherlands**

Australia uses a 0 to 10 star rating to reflect the level of thermal efficiency of a house, with 0 stars indicating very poor performance (the building shell does practically nothing to reduce the discomfort of hot or cold weather), and 10 representing a home that is unlikely to need any artificial heating or cooling. The rating system has been found to correlate with home values. Each half star increase on the scale was found to be associated with a 1.23-percent increase in housing price in 2005, and a 1.91-percent increase in housing price in 2006 (holding all other variables constant). In other words, the higher the efficiency rating, the higher the market value of the house.<sup>36</sup>

In the Netherlands, there is a premium associated with properties that demonstrate high levels of energy efficiency, with a 2.8-percent higher transaction price for properties with an A, B, or C certificate.<sup>37</sup>

## **Operations & Maintenance**

Energy-efficient buildings and technologies usually require less maintenance than less efficient options.

For example, building owners who install more modern, energy-efficient heating, ventilation, and air conditioning systems will have reduced maintenance costs, which can be particularly beneficial to landlords who have multiple tenants. LED lighting has a much longer lifetime than incandescent and compact fluorescent light bulbs. This means that multiple lamp replacements are avoided, which leads to cost savings in the commercial sector or public sector (for example, lighted street signals) where paid staff deal with the replacements.<sup>38</sup> The savings can also be significant in the manufacturing sector, where more energy-efficiency equipment and processes can result in reduced operations and maintenance costs, and where improving operations and maintenance procedures can lead to additional savings.

Analysis by the American Council for an Energy-Efficient Economy (ACEEE) provides three case studies in which reduced maintenance costs have been quantified, ranging from three percent to 150 percent of the value of the bill savings.<sup>39</sup>

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<sup>36</sup> Government of Australia, 2008.

<sup>37</sup> Brounen et al.

<sup>38</sup> Lazar & Colburn, 2013.

<sup>39</sup> Cluett & Amann, 2015.

#### Box 4. Example of O&M Benefits from Vermont

Efficiency Vermont calculated the net lifetime economic benefits and costs of electric and thermal efficiency investment in 2014. The operations and maintenance savings amounted to \$30.7 million (about €27.3 million), and accounted for a quarter of total benefits. Put another way, the lifetime O&M savings were equivalent to nearly 40 percent of the total costs of energy efficiency programmes (utility costs + participant and third-party costs), and nearly equal to the participant and third-party investment costs.<sup>40</sup>

#### *Other Participant Benefits*

There are other participant benefits that EEOs provide, which have not been analysed in detail as part of this study.

- **Employee productivity improvements.** Upgrading air-conditioning systems and lighting to more efficient technologies can result in increased employee productivity owing to a healthier work environment.
- **Resource savings.** In some cases, energy efficiency improvements also lead to savings of other, non-energy resources. For example, low-flow showerheads reduce both the amount of energy used for hot water provision and the amount of water that must be withdrawn, treated, and delivered to homes for showering. Similarly, energy-efficient technologies used in industrial processes often reduce resource use and waste.
- **Disposable income.** Because of the bill savings, participants typically have the benefit of a higher disposable income.

#### 4.3.2. Utility System Benefits

Utility system benefits include avoided or deferred investments in generation, transmission, and distribution capacity. They also include reduced reserve requirements, risk mitigation in terms of resource diversification and hedging for fuel price volatility, and avoided CO<sub>2</sub> permit costs for power generating facilities that are within a carbon tax or cap-and-trade regime. The magnitude of the avoided investment often depends on the share of energy-efficiency measures that reduce demand during peak hours, as well as the location on the power system of end-use energy savings. For example, energy savings in an area with over-burdened or “congested” transmission or distribution lines will be more valuable in terms of helping to avoid costly upgrades.

No studies have been identified for EEOs in EU Member States that quantify cost savings, owing to the avoidance of production, transmission, and distribution capacity.

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<sup>40</sup> See Efficiency Vermont, 2014, p. 4.

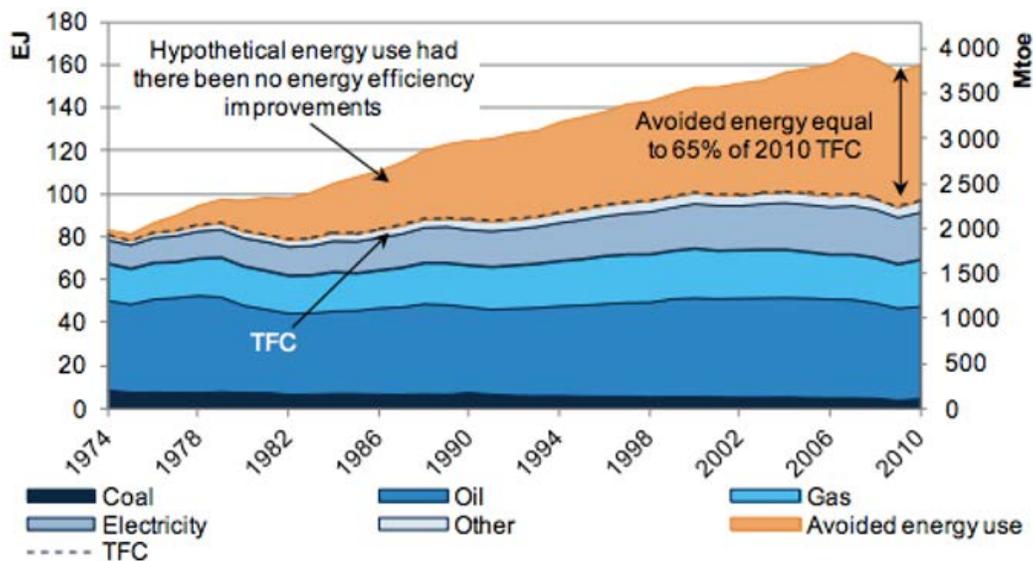
### Box 5. Example of Avoidance of Production, Transmission, and Distribution Capacity from Germany

Although not focussed on EEOs in particular, a recent study on the benefits of energy efficiency for the German power sector demonstrates significant cost savings—one saved kWh of electricity would lead to reduced electrical system costs of between 11 and 15 euro cents.<sup>41</sup> The same applies to savings from an EEOs.

#### Avoided Generation

As illustrated earlier in this paper, delivering a kWh of energy savings is generally significantly cheaper than delivering a kWh of energy. EEOs and other end-use energy efficiency programmes deliver significant benefits in the form of avoided generation costs, including avoided energy costs (the reduction in the amount of energy that must be purchased by suppliers to meet end-user demand) and where applicable, avoided capacity costs (such as in the US capacity markets in ISO-NE and PJM markets). Recent analysis by the IEA illustrates the volume of generation capacity avoided through energy efficiency programmes in 11 member countries:

Figure 9. The “First Fuel”: Avoided Energy Use From Energy Efficiency in Eleven IEA Member Countries



Source: <http://www.iea.org/Textbase/npsum/EEMR2013SUM.pdf>

\*The 11 countries are Australia, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Sweden, the United Kingdom, and the United States.

Although it is difficult to monetise the monetary savings resulting from these avoided energy costs, there are examples on a smaller scale where this has been done. For example, in New England, the

<sup>41</sup> Wunsch et al., 2014.

avoided energy costs in 2013 of energy-efficiency programmes were calculated to be 7.64 US cents per kWh.<sup>42</sup> If the avoided capacity costs were counted, this figure rises to 9.65 US cents per kWh. This is compared to an average wholesale electricity price of 5.6 US cents per kWh in the same year.<sup>43</sup>

### ***Avoided Line Losses and Deferred or Avoided Investments in Network Infrastructure***

Energy-efficiency obligations and other end-use energy-efficiency programmes can defer the need for investment in transmission and distribution systems and reduce congestion on existing lines, which reduces line losses and the corresponding need for additional generation to serve consumer demand.

#### **Box 2. Examples of Avoided Transmission and Distribution Costs in the United States**

One illustration of the financial savings resulting from deferred investment costs comes from Consolidated Edison (Con Ed), the electric utility serving New York City and northern suburbs. Con Ed recently estimated that including the effect of its system-wide efficiency programmes in its 10-year forecast reduced capital expenditures by more than \$1 billion. Similarly, the New England Independent System Operator has identified over \$400 million of deferred investment in previously planned transmission investments in New Hampshire and Vermont beyond a 10-year planning horizon.<sup>44</sup>

### ***Minimising Reserve Requirements***

Reserve requirements in an electricity system represent a percentage of resources above demand, which is necessary to ensure reliable supply in case of emergency (for example, when a large power plant suddenly goes offline). For thermal systems, reserve requirements typically amount to 13–15 percent of demand at any given time. Power systems are built around the need to secure the required reserve margin at system peak.

End-use electricity savings save energy in all time frames, including (for many measures) during times of highest, or “peak,” demand. To the extent that end-use savings reduce this demand, they also reduce the total volume of reserves required to ensure system security. Peak-time energy savings result in more kWh savings of generation than kWh savings on the customer premises. End-use efficiency will always avoid transmission and distribution line losses, and thus is always more valuable than a one-for-one replacement of generated kWh; but during peak hours, line losses are even greater, so during peak hours, power generators must produce more power to deliver a kWh of energy to the end-user than during off-peak, owing to congestion and resulting inefficiencies in power lines.<sup>45</sup>

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<sup>42</sup> Avoided energy is based on avoided wholesale electric energy prices, the cost of renewable energy credits, and a wholesale risk premium. See Synapse Energy Economics, 2013.

<sup>43</sup> See ISO New England, 2014.

<sup>44</sup> Neme & Grevatt, 2015. Also see Neme & Sedano, 2012, and Lazar & Baldwin, 2011.

<sup>45</sup> In other words, “marginal line losses” increase with loading on grids. The increased losses are not proportional with load; on most AC systems, losses rise exponentially as delivery system loads rise.

The Regulatory Assistance Project has calculated that for each 1 kW of capacity saved at the end-user's premises during peak demand hours, 1.44 kW are saved in generation. The details, of course, will vary depending on the specifics of the power system.<sup>46</sup>

### ***Risk Mitigation***

Energy efficiency diversifies the supply of energy services by supplementing the resource mix with “negawatt hours.” Also, by lowering total consumption, often for many years, it reduces exposure to future fuel price volatility.

### **Box 6. Reduced Gas Dependence in the United Kingdom owing to Energy Efficiency**

Total household energy use in the United Kingdom decreased by 19 percent between 2000 and 2014, despite a 12-percent increase in the number of households, a 9.7-percent increase in population,<sup>47</sup> and an increase in the average property size. On average, individual households now use 37 percent less energy than they did in 1970, with the bulk of this decrease occurring since 2004. British Gas (Britain's largest gas supplier) calculated that for 2006 to 2010, energy-efficiency measures were responsible for 3.3 percent of incremental annual reductions in household gas consumption.<sup>48</sup>

### ***Avoided CO<sub>2</sub> Permit Costs***

In the European Union, electricity generators are mandated to participate in the EU Emission Trading System (ETS). Since 2013, sites covered by the EU ETS in the power sector are required to buy all their CO<sub>2</sub> permits rather than receiving them through free allocation. Alternatively, they can lower their emissions through (1) investing in energy efficiency and/or (2) switching to low-carbon fuels. The amount of permits power generators are required to buy depends on the volume of electricity generated. Demand-side energy-efficiency measures delivered by EEOs reduce electricity demand and thus reduce the need for power generators to acquire EU ETS allowances.

### **Box 7. Example of Avoided CO<sub>2</sub> Costs owing to EEOs in the United Kingdom**

The U.K. government estimates that, owing to the introduction of the last phase of EEOs (2013-2015), the Energy Company Obligation (ECO), about €2 billion worth of traded EU ETS allowances and €5 billion worth of non-traded carbons savings are avoided over the lifetime of the implemented measures.<sup>49</sup>

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<sup>46</sup> Lazar & Baldwin, 2011.

<sup>47</sup> DECC, 2012b.

<sup>48</sup> See Centre for Economic and Business Research, 2011.

<sup>49</sup> DECC, 2012a.

### **Other Utility System Benefits**

- **Avoided other environmental regulatory costs.** Increased end-use efficiency reduces the volume of electricity generated, which reduces air emissions, water discharges, and solid waste from fossil fuel extraction and generation. Avoiding those emissions may reduce environmental compliance costs for generators.
- **Reduced credit and collection costs.** For low-income customers, reduced energy bills are likely to increase their ability to pay, thus reducing the credit and collection costs accruing to energy companies.
- **Improved customer retention.** Providing efficiency services in addition to energy supply can improve customer satisfaction and, in turn, customer retention.<sup>50</sup>
- **Improved corporate relations.** Use of energy-efficiency activities for public relations, for example, as part of the CSR (corporate social responsibility) reporting.
- **Reduced prices in wholesale markets.** Lower demand for energy ultimately results in lower wholesale prices for energy commodities. This means that retail prices of energy are also reduced.

### **Box 8. Example of Utility System Benefits from Vermont**

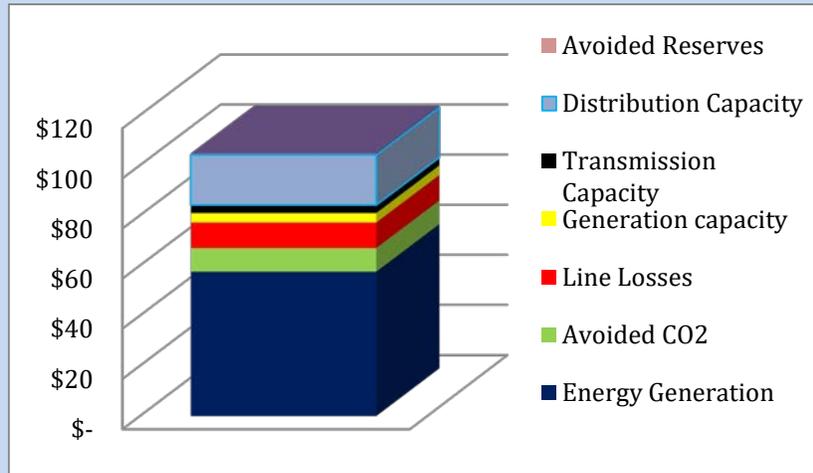
Several of the multiple benefits from the IEA report are reproduced below in Figure 10, illustrating the multiple benefits for the US state of Vermont in 2010. This graph reflects benefits solely arising from the effect of energy savings (i.e., reduced overall energy consumption) on the energy system. (For comparison, the levelised cost of the EEOS to end-use consumers [regulated prices in Vermont] was equivalent to \$39/MWh). In the Vermont example, the benefits to all electric customers exceed their annual contributions to the EEOS and that is without accounting for any benefits from renewable energy obligations, other fuel savings, health benefits, or other benefits.

Although the example of Vermont is one of benefits in a vertically integrated power sector, the benefits to the electricity provision and to all customers still apply in Europe, even though the electricity provision chain is no longer integrated.<sup>51</sup>

<sup>50</sup> See, for example: Electric Ireland, 2015.

<sup>51</sup> The IEA report also contains the results of the system level direct benefits resulting from deep investment in energy efficiency, which shows potential savings in the range of €10 to €21 billion per year by 2035 in German power generation and grid infrastructure costs.

**Figure 10. Multiple Benefits of EEOs Accrued to Vermont Energy Provision Chain in 2010, Expressed as levelised USD/MWh**



Thus, well-designed electricity EEOs can provide benefits to all consumers in excess of the costs of the EEOs; this EEOs cost on the bills is less than 40 percent of the energy provider benefits and less than the USD 47/MWh benefits that accrue to all non-participating customers.

### 4.3.3. Societal Benefits

#### *Greenhouse Gas Emission Reduction*

The IEA's 2050 mitigation scenarios<sup>52</sup> indicate that energy efficiency is the most important carbon reduction measure. Energy efficiency and reducing energy demand are the most efficient and cost-effective means to reduce carbon emissions. The most recent report from the Intergovernmental Panel on Climate Change (IPCC)<sup>53</sup> also allocates a key role to energy efficiency in all of their mitigation pathways.

<sup>52</sup> See IEA, 2014b.

<sup>53</sup> Edenhofer et al., 2014.

### Box 9. Example of Greenhouse Gas Emissions Reduction Benefits from the United Kingdom

In the United Kingdom, the government has monetised the benefits stemming from avoided greenhouse gas emissions attributable to EEOs. Using guidance on the valuation of CO<sub>2</sub> savings from the Interdepartmental Analysts' Group, the value of the avoided greenhouse gas emissions attributable to ECO have been estimated being worth up to €6.2 billion of non-EU ETS sector emissions and about €2 billion worth of traded EU ETS allowances.<sup>54</sup> Together, the value of the greenhouse gas emissions reduction is equivalent to 50 percent of the energy bill savings.<sup>55</sup> Similar figures have been produced for the extension period of CERT, with emissions reduction benefits amounting to about 45 percent of the energy bill savings.<sup>56</sup>

### Air Quality

Energy efficiency measures delivered by EEOs provide air quality benefits. As discussed earlier, this is a utility system benefit in that it reduces the cost of compliance with emissions standards. In addition, reduced air, water, and solid waste emissions from fossil fuel extraction and generation carry strong benefits to society.

### Box 10. Example of Air Quality Benefits from Around the World<sup>57</sup>

California: Energy efficiency programs in 2010 and 2011 saved 5,900 GWh of energy and avoided the construction of two power plants (Smart Energy Universe 2014), saving an estimated \$590 million in capital costs. The state has avoided the construction of about 40 power plants and their associated emissions since the late 1970s.

China: Efficient refrigerators and air conditioners have saved energy equal to the output of Three Gorges Dam, avoiding more than 374 million tonnes of coal from being burned.

European Union: Energy efficiency is responsible for one-third of SO<sub>2</sub> reductions achieved since the mid-1970s.

United Kingdom: Benefits from improved air quality valued at £1.2–£1.6 billion.<sup>58</sup> Similar figures have been produced for the extension period of CERT—the air quality impact of reduced emissions as a result of the CERT Extension is expected to be £989 million. This is mainly associated with the reduction in burning coal.<sup>59</sup>

<sup>54</sup> Because power plants are covered by the EU ETS, the traded emissions savings are also a utility system benefit.

<sup>55</sup> DECC, 2012a.

<sup>56</sup> DECC, 2010.

<sup>57</sup> James et al., 2014.

<sup>58</sup> DECC, 2012a.

<sup>59</sup> DECC, 2010.

## ***Employment***

Investing in energy efficiency compares very favourably with investing in other energy sectors in terms of local job creation impacts. Analysis by Pollin et al (2009) evaluating different economic stimulus options has shown that the employment creation from investing in energy efficiency is 2.5 to 4 times larger than that for oil and natural gas. A similar study by Wei et al (2010) has shown that the energy efficiency industry is about twice as labour-intensive compared to the fossil fuel-based energy supply sector per unit of energy saved/produced.

A recent review of more than 20 studies concluded that for every £1 million spent on energy efficiency, about 23 jobs are directly supported in the energy efficiency industry (Janssen and Staniaszek, 2012). Applying this ratio to the total expenditure by energy companies in the United Kingdom, Italy, France, Austria, and Denmark, and assuming a leverage factor of two, suggests that up to 100,000 jobs are supported by EEOs in those countries together.

## ***Macroeconomic Impacts***

In addition to the direct impact on jobs, there are macroeconomic benefits in the form of gross domestic product growth and indirect and induced jobs. In addition, consumers have more disposable income as a result of energy bill savings, which they invest in goods and services, creating additional jobs. These “ripple effects” of capital expenditure can be estimated using multipliers. Multipliers are measures of the way in which an increase in activity by one firm will lead to an increase in activity by other related firms. For example, the contractor for a new building buys concrete, the concrete subcontractor buys new tires for its trucks, all the firms’ workers spend their wages on food or consumer goods, and so forth. An illustration of this can be found in a recent paper assessing investment in building fabric insulation.<sup>60</sup> In general, the economic multipliers associated with investments in energy efficiency are superior to those associated with supply-side resources, especially so when a regional or national economy depends on imports for a substantial fraction of its energy supply.

## ***Poverty Alleviation***

EEOs are often used for the purpose of fuel poverty alleviation. Sometimes this is done by allocating a specified share of the measures delivered by EEOs to low-income households; in other instances, efficiency programmes are designed specifically to conserve energy in low-income or fuel-poor households. Good examples are:

- Ireland: Five percent of all savings have to be achieved in households classified as being in fuel poverty;
- United Kingdom: A large share of the savings had to be achieved in low-income households from the start of the EEOs in 1994;
- France: Obligated parties can support fuel poverty programmes as an alternative to delivering savings through the usual channels;
- Austria: Obligated parties receive a 1.5 uplift factor for savings achieved in low-income households;

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<sup>60</sup> Rosenow, Platt, & Demurtas, 2014.

- Vermont, United States: The rules governing the obligated efficiency utility include definite obligations to deliver savings to low-income households. In addition, there is a statewide Weatherization Assistance Fund, funded by all energy suppliers, including oil heat, propane, kerosene, and coal dealers, as well as electric and gas utilities. This programme is devoted entirely to driving renovations in low-income housing, and it works in conjunction with the efficiency utility in doing so; and
- California, United States: Utilities are required to spend a large share of the programme expenditure on insulation, energy education programmes, and energy-efficient appliances for low-income customers at no charge through Low-Income Energy Efficiency programmes.

### ***Energy Security***

Energy efficiency reduces the amount of energy consumed within an economy and therefore limits energy import volumes and dependence. Energy security is a goal within a number of energy efficiency obligations worldwide, including in China, Korea, and several US states and EU Member States (Denmark, Italy).<sup>61</sup> The European Commission has found that every 1 percent in additional (economy-wide) energy savings translates to a 2.6-percent reduction in natural gas imports.<sup>62</sup> Europe’s Energy Security Strategy recognises energy efficiency as a key risk mitigation measure for the energy sector: “Moderating energy demand is one of the most effective tools to reduce the EU’s external energy dependency and exposure to price hikes.”<sup>63</sup> As mentioned earlier, experience with energy efficiency obligations in the United Kingdom demonstrates the value of end-use energy efficiency in reducing gas consumption, and thus gas dependence. A recent study from ACEEE for the United States similarly emphasises the benefits to energy security of end-use efficiency programmes.<sup>64</sup>

### ***Fiscal Benefits***

Investments in energy efficiency deliver positive net-benefits to the public budget. Positive fiscal impacts are value-added tax paid by households taking up energy efficiency measures, income tax paid by employees working along the supply chain, additional corporate tax paid by the companies indirectly benefiting from the subsidies through reduced relative cost of the technologies they supply/install, and the avoided cost of paying unemployment benefits to workers who were not working previously. Most of the fiscal benefits are a result of increased employment. Those benefits outweigh forgone tax receipts from reduced energy consumption by far.<sup>65</sup>

Even though the potential benefits in terms of fiscal effects are substantial, programmes providing support to energy efficiency technologies may not necessarily be perceived in this way, given that the costs are concentrated and obvious to policymakers, whereas the benefits are dispersed and less well understood.

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<sup>61</sup> Regulatory Assistance Project, 2012.

<sup>62</sup> European Commission, 2014a.

<sup>63</sup> European Commission, 2014b.

<sup>64</sup> Young, Elliott & Kushler, 2012.

<sup>65</sup> Rosenow, Platt, & Demurtas, 2014.

### ***Reduced Cost for Meeting Renewable Energy Targets***

End-use energy savings reduce the costs of meeting renewable energy targets by reducing the overall volume of demand to be served. A recent study commissioned by Agora Energiewende and The Regulatory Assistance Project demonstrates this. In particular, the study found that a significant reduction in power consumption to 2050 could *reduce costs* on the power system on a mid- to long-term basis, even with greater use of renewable energy. Renewable energy on the whole is the biggest cost factor on the system, and also benefits from the greatest savings attributable to energy efficiency, accounting for half of financial savings by 2035 and some 70 percent of savings by 2050, when compared to a business-as-usual scenario.<sup>66</sup>

## **4.4. Accounting for the Multiple Benefits of Energy Efficiency in Europe**

International experience demonstrates the value of quantifying the multiple benefits of EEOs to the energy system, and to meeting important policy objectives. These include in particular:

- The benefit of energy efficiency as a demand-side alternative in the power system (that is, avoided generation, transmission, and distribution costs owing to energy efficiency);
- Improved air quality;
- Positive health effects;
- Long-term reduction in the level of low-income households without adequate heating and cooling; and
- Economic stimulus, including employment creation.

It is essential to account for the multiple benefits of energy efficiency when conducting cost benefit analysis in EU Impact Assessments. At a national level, Member States should consider modifying their methodologies for conducting policy assessments and evaluations to better reflect the full range of benefits beyond the mere bill savings. Some Member States have more experience with quantifying multiple benefits than others, and there are some valuable lessons that can be learned. Where data collection is burdensome and complex, the use of rough estimates (e.g., jobs created per million euros invested in energy efficiency) and/or adders (e.g., five-percent increase of the benefits to account for health improvements) is a simple option to include multiple benefits.<sup>67</sup>

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<sup>66</sup> The business-as-usual scenario assumes annual energy savings of 1.3 percent. Scenarios considered include annual energy savings of 2.1 percent, 2.4 percent, and 2.6 percent. See Wunsch et al., 2014.

<sup>67</sup> Cluett & Amann, 2015.

## 5. Conclusions

The analysis of this report shows that EEOs are highly cost effective based on the increasingly robust evidence base covering multiple countries in Europe and elsewhere. Within a few years of adoption, the benefits from EEOs far outweigh the costs. From a long-term perspective, EEOs can reduce energy consumption and bills substantially, delivering benefits to consumers who would otherwise be more exposed to volatile energy prices. Evidence from countries with long-running EEOs shows decreasing energy consumption over time, which corroborates our findings.

But EEOs also deliver a wide range of benefits in addition to reduced energy consumption and bill savings accruing to participants—they also deliver substantial, measurable savings across energy systems and to society as a whole. These benefits include health benefits, increased comfort, economic stimulus, employment creation, cost savings in transmission and distribution, avoided CO<sub>2</sub> allowance costs, and air quality improvements.

However, the current practice of largely ignoring those multiple benefits in cost-benefit analyses underestimates the true value of efficiency and sends potentially misleading messages. Methods for carrying out impact assessments and evaluations need to be adjusted to ensure realistic and complete accounting for the multiple benefits both at the EU and the national level.

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## Annex I: Data for Country-Level Calculations

The data that have been used for this analysis are presented for each country below. Note that the data are not in the same format and a number of adjustments and calculations were required in order to derive comparable figures on cost, bill savings, and energy demand reduction.

The structure for each country section contains the following elements:

- Cost to energy companies;
- Administrative cost;
- Energy savings; and
- Impact on bills.

### United Kingdom

#### Cost to Energy Companies

The final evaluation of the obligation period 2008 to 2012, called the Carbon Emissions Reduction Target (CERT),<sup>68</sup> provides data on the cost of the EEOs to the obligated energy suppliers in the United Kingdom. These data are presented in Table 7.

**Table 7. Cost to Energy Suppliers (Million euros)**

	April 2008 to March 2011	April 2011 to Dec 2012	Total	Average per Year
Administrative cost	65	86	151	32
Delivery cost	2,980	1,865	4,844	1,020
Total cost	3,045	1,950	4,995	1,052
Cost anticipated in Impact assessment	4,658	2,785	7,443	1,567
Difference from impact assessment	-35%	-30%	-33%	-33%

*Source: Ipsos MORI et al (2014)*

Notably, the costs to the energy companies of €1,020 million were significantly (33 percent) lower than originally anticipated in the impact assessment.<sup>69</sup> This is in line with historical precedents, because through innovative delivery and economies of scale, energy suppliers consistently delivered their targets more cheaply than anticipated.

<sup>68</sup> Ipsos MORI, CAG Consultants, University College London and Energy Saving Trust, 2014.

<sup>69</sup> DECC, 2012a.

## Administrative Cost

The administrative cost of Ofgem administering CERT amounted to about £1.7 million per year, which represents a share of the total programme cost of 0.2 percent.<sup>70</sup>

## Energy Savings

Energy savings for CERT are not directly reported because the target was set in million tonnes of CO<sub>2</sub> (lifetime). The final report on CERT by the regulator Ofgem provides the CO<sub>2</sub> savings achieved over the period April 2008 to December 2012.

**Table 8. Carbon Savings During CERT**

<b>Total carbon savings during CERT in million tonnes CO<sub>2</sub> (lifetime)</b>	296.9
<b>Carry over in million tonnes CO<sub>2</sub> (lifetime)</b>	37.8
<b>Actual savings in million tonnes CO<sub>2</sub> (lifetime)</b>	259.1

*Source: Ofgem (2013)*

A recent report by the National Audit Office<sup>71</sup> provides revised figures by DECC that indicate about 50-percent lower CO<sub>2</sub> savings than previously reported (Table 9). No detailed analysis is available in the public domain as to why the figures have been revised downward, but most likely factors such as reduced in-use factors taking into account up-to-date evidence on actual performance and rebound effects are the main reason for the revision.

**Table 9. Revised Carbon Savings During CERT**

<b>Annual carbon savings during CERT in million tonnes CO<sub>2</sub> (lifetime)</b>	26.24
<b>Length of CERT in years</b>	4.75
<b>Total carbon savings during CERT in million tonnes CO<sub>2</sub> (lifetime)</b>	259.1

*Source: Ofgem (2013)*

The impact assessment of the CERT extension period (April 2011 to December 2012) provides figures for energy savings that can be used to convert the CO<sub>2</sub> figures to energy savings.

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<sup>70</sup> DECC, 2010.

<sup>71</sup> National Audit Office, 2016.

**Table 10. Energy Savings in TWh (Lifetime) for CERT Extension Period**

Gas	Electricity	Oil	Coal	Total
294.11	35.33	23.34	20.66	373.44

Source: DECC (2010)

Applying the same TWh/CO<sub>2</sub> ratio to the CO<sub>2</sub> savings reported for the entire period of CERT results in 431 TWh (lifetime) saved. According to the Impact Assessment, the implicit average lifetime of measures was 38 years (i.e., the annual savings of CERT amounted to about 0.5 percent<sup>72</sup> of final energy consumption of the household sector based on the average energy consumption over the period 2008 to 2012).<sup>73</sup>

### Cost per kWh

Based on the public cost of €4,995 million for the entire programme and lifetime savings of 431 TWh, the cost per kWh is 1.12 euro cents.

### Impact on Bills

The average dual fuel bill over the period 2008 to 2012 was £1,265.

**Table 11. Average Dual Fuel Bill in the Household Sector (in £)**

	Gas	Electricity	Total
2008	700	508	1208
2009	776	501	1277
2010	724	474	1198
2011	778	497	1275
2012	857	512	1369
Average over period 2008 to 2012	767	498	1265

Source: Bolton (2014)

When splitting the cost of CERT over 26.7 million households,<sup>74</sup> its share of the average dual fuel bill in the period 2008 to 2012 was 2.3 percent.

<sup>72</sup> DECC, 2009b.

<sup>73</sup> DECC, 2015.

<sup>74</sup> ONS, 2014.

## Denmark

### Cost to Energy Companies

The cost to energy companies has been analysed in previous evaluations up to 2013.<sup>75</sup> More recent data have been identified for 2015 in Table 12.

**Table 12. Energy Savings Targets and Cost to Energy Companies**

	Annual Saving Target, 2015 (TJ)	Average Cost per Saved kWh (Annual) (ore/kWh)	Total Cost by Fuel (mln ore)	Final Consumption, ex. Transport (TJ)	Additional Cost per Unit of Fuel Consumed (ore/kWh)
Electricity	5,000	46.5	645.83	109,600	2.12
Natural gas	2,300	41	261.94	63,734	1.48
District heating	4,300	38.5	459.86	105,854	1.56
Oil	600	36.3	60.5	11,256	1.93
All	12,200	41.9	1,419.94	290,444	1.76

Source: Bach (2016)

Based on the above, the annual cost to energy companies amounts to €185 million.

### Administrative Cost

According to the ENSPOL report,<sup>76</sup> the administrative cost of the Danish EEOS amounts to €540,000 per year. This is equivalent to 0.3 percent of the total programme cost.

### Energy Savings

The annual energy savings of 12,200 TJ<sup>77</sup> is equivalent to a reduction of final energy consumption across all sectors of 4 percent.

The Danish Energy Agency estimates that the average lifetime of energy savings of the measures implemented under the Danish EEOS is at least 10 years, as written in the notification on Article 7 of the Energy Efficiency Directive to the European Commission.<sup>78</sup> This means the annual lifetime savings amounts to 122,000 TJ or 2,910 ktoe.

### Cost per kWh

Annual lifetime savings of 122,000 TJ are equivalent to 34 TWh. The public cost per year of €185 million results in a cost per kWh of 0.55 euro cents.

<sup>75</sup> Deloitte & Grontmij, 2015.

<sup>76</sup> ENSPOL, 2015.

<sup>77</sup> Bach, 2016.

<sup>78</sup> Danish Energy Agency, 2014.

## Impact on Bills

Based on the average unit price for the different fuels, the cost of the EEOS can be estimated in percent per unit of fuel.

**Table 13. Unit Price of Different Fuels and Share of Cost of EEOSs**

	Electricity— households	Electricity— industry	Gas— households	Gas— industry	Oil— households	Oil— Industry
Unit price (euro cents/kWh)	30.7	8.9	8.0	2.8	15.1	5.5
Share of cost of EEOs of unit price	0.9%	3%	2.5%	7%	1.7%	5%

Source: Bach (2016); Danish Energy Agency (2014a); Eurostat (2015)

The analysis shows that depending on the sector and the fuel, the increase per unit ranges from 0.9 percent to as much as 7 percent. Based on the final energy consumption in the household and industry sector, the total cost can be calculated.

**Table 14. Final Energy Consumption**

	Electricity (TJ)	Gas (TJ)	District Heating (TJ)	Oil (TJ)
Households	37046	26641	67957	13927
Industry	36799	29668	6187	36661

Source: Danish Energy Agency (2015)

Assuming 100-percent cost pass-through for the industry sector, the cost of the EEOS is estimated to be around 4.9 percent and for the household sector 1.6 percent. The difference between the two sectors is a result of lower energy prices in the industry sector.

## France

### Costs to Energy Companies

A recent ministerial report estimates the cost to energy suppliers per kWh (lifetime) saved at 0.4 euro cents.<sup>79</sup> This figure is corroborated by the ENSPOL analysis, which calculates a cost of 0.37 euro cents/kWh.<sup>80</sup>

<sup>79</sup> Ministère de l'écologie, du développement durable et de l'énergie, 2014.

<sup>80</sup> ENSPOL, 2015.

Over the period 2011 to 2014, the EEOS delivered energy savings of 390 TWh (lifetime),<sup>81</sup> which implies total cost to the energy companies of €390 million.

## Administrative Costs

Administrative costs for the French EEOS are not directly reported on but can be derived by an estimation based on the number of full-time employees. The ENSPOL project report provides this information. In addition to the staff cost of ADEME and PNAEE, every year the organisation responsible for developing the deemed savings scores, ATEE, receives €80,000 from ADEME.

**Table 15. Administrative Cost**

<b>Full-time employees in ADEME</b>	3.5
<b>Full-time employees in PNAEE</b>	14
<b>Assumed cost per full-time employee (euros/y)</b>	80,000
<b>Full-time employee cost (euros/y)</b>	1,400,000
<b>Subsidies to ATEE from ADEME (euros/y)</b>	80,000
<b>Total admin cost (euros/y)</b>	1,480,000
<b>% of total cost</b>	0.4

*Source: based on ENSPOL (2015)*

In total, the annual costs amount to 0.4 percent of the programme costs.

## Energy Savings

As stated above, over the period 2011 to 2014, the EEOS delivered energy savings of 390 TWh (lifetime).<sup>82</sup> In order to calculate the annual savings, the average lifetime of the installed measures is required. In the second period of the French EEOS, the average lifetime of measures was 14 years.<sup>83</sup>

**Table 16: Energy Savings**

<b>Savings 2011 to 2014 (TWh cumac)</b>	390
<b>Annual savings (TWh cumac/y)</b>	97.5
<b>Average lifetime (y)</b>	14
<b>Savings average per year over period 2011 to 2014 (TWh annual)</b>	7.0

*Source: ENSPOL (2015); Trauchessec (2016)*

<sup>81</sup> ENSPOL, 2015.

<sup>82</sup> ENSPOL, 2015.

<sup>83</sup> Trauchessec, 2016.

Most of the savings are delivered in three sectors:

**Table 17. Split of Energy Savings by Sector**

<b>Residential</b>	76.20%
<b>Service</b>	12.80%
<b>Industry</b>	6.90%

Source: ADEME (2014)

Applying this share, energy savings per sector can be derived.

**Table 18. Energy Savings by Sector**

Sector	Savings 2011-2014 (TWh Annual)	Savings 2011-2014 (ktoe)	Final Energy Consumption (ktoe)	Share of Final Consumption
Residential	5	456	43,678.90	1.0%
Service	1	77	22,997.30	0.3%
Industry	0	41	30,025.30	0.1%
<b>Total</b>	<b>7</b>	<b>574</b>	<b>96,701.50</b>	<b>0.6%</b>

Source: ADEME (2014); ENSPOL (2015); Trauchessec (2016); Eurostat (2015)

Based on the above, the average annual energy savings over the period 2011 to 2014 were equivalent to 0.6 percent of final energy consumption of the three main target sectors.

### Cost per kWh

A ministerial report estimates the cost to energy suppliers per kWh (lifetime) saved at 0.4 euro cents.<sup>84</sup>

### Impact on Energy Bills

The impact on energy bills is calculated for the residential sector below. This is based on the average household bill presented in Table 19.

**Table 19. Expenditure for Energy in the Household Sector**

<b>Average fuel bill (euros)</b>	1502
<b>Number of households</b>	25,253,000
<b>Total fuel cost (million euros)</b>	37,930

Source: Based on Tyszler et al (2013)

Applying the 76-percent share of the residential sector and assuming the same cost allocation, the total cost to the residential sector amounts to 0.8 percent.

<sup>84</sup> Ministère de l'écologie, du développement durable et de l'énergie, 2014.

## Italy

### Cost to Energy Companies

A recent estimate by ENSPOL<sup>85</sup> provides a figure of €700 million per annum to the energy companies based on a cost estimate of €80/toe (lifetime).

### Administrative Cost

The ENSPOL project<sup>86</sup> estimates that the administrative costs are in the range of €10 million, which is equivalent to 1.4 percent of the total cost.

### Energy Savings

Energy savings from the Italian EEOS are provided in the NEEAP. The notified savings for 2014 are equivalent to 500 ktoe.

### Cost per kWh

Based on the recent estimate by ENSPOL<sup>87</sup> of €80/toe (lifetime), cost per kWh of 0.69 euro cents can be derived.

### Impact on Energy Bills

Data on the additional cost arising from EEOS per unit of electricity and gas are provided in the ENSPOL report.

**Table 20. Cost of EEOS in Italy per Unit Supplied**

	Electricity	Gas
Additional cost per unit of fuel consumed (euro cents/kWh)	0.28	0.1

Source: ENSPOL (2015)

**Table 21. Cost of Energy in Different Sectors**

	Electricity	Gas
Household cost per unit of fuel consumed (Euro/kWh)	0.2	0.08
Industry sector cost per unit of fuel consumed (Euro/kWh)	0.09	0.03
Service sector cost per unit of fuel consumed (Euro/kWh)	0.2	0.1

Source: Eurostat (2015)

Note: Used mid-point figure for cost of energy in service sector in the absence of data.

<sup>85</sup> ENSPOL, 2015.

<sup>86</sup> ENSPOL, 2015.

<sup>87</sup> ENSPOL, 2015.

Based on the fuel consumption by sector and fuel type provided in Table 22, total expenditures for energy can be calculated.

**Table 22. Fuel Consumption by Sector and Fuel**

	Electricity	Gas
Households	5,760	18,074
Industry	9,920	9,680
Service sector	7,650	11,300

Source: Eurostat (2015)

Using the figures for the costs of EEOs per unit of fuel and the total energy expenditure in the different sectors, the bill impacts can be estimated.

**Table 23. Share of Cost of EEOs of Unit Price by Sector**

	Electricity	Gas	Whole Bill
Households	1.14%	1.31%	1.3%
Industry	2.97%	3.05%	3.0%
Service	1.65%	1.83%	1.7%
Total			2.0%

Source: Based on ENSPOL (2015) and Eurostat (2015)

## Austria

### Cost to Energy Companies

Prices on trading platforms for energy efficiency measures can be used as proxies for estimating the total cost for delivering savings in the industry and residential sector.

The price data are available for first-year savings rather than lifetime savings. Assuming a 10-year lifetime (which is typical for EEOs with a high share of savings in the industrial sector) and 15 years in the residential sector (typical for heating system measures but conservative for building fabric measures), the cost of the lifetime savings can be calculated. Even though the data for Austria represent only a short period of time compared with data for the more established EEOs, the figures are well within the range of existing EEOs where longitudinal cost data exist.

**Table 24. Cost of Energy Savings**

	Residential	Industry
Cost of energy savings (euro cents/kWh [first year savings])	6.8	5.5
Assumed lifetimes	15	10
Cost of energy savings (euro cents/kWh [lifetime savings])	0.5	0.6
Cost to energy companies (million euros)	43	52

Source: Based on Energieinstitut der Wirtschaft (2015)

Based on the assumption that 60 percent of the savings will be delivered in the industry sector (40 percent have to be delivered by law in the residential sector) and a savings target equivalent to 136 ktoe, the total annual cost of EEOS is €95 million.

### Administrative Costs

No estimates are available yet.

### Energy Savings

In the NEEAP, Austria provides the estimated savings to be delivered by EEOS by 2020. Assuming linear delivery to 2020, the annual savings delivered in 2015 can be estimated.

**Table 25. Energy Savings**

Savings in 2015 to 2020 (PJ)	159
Savings in 2015 (ktoe)	136
Assume 40% in residential (ktoe)	54
Assume 60% in industry (ktoe)	81

Source: Based on BGBl (2014)

Based on the above, the share of final energy consumption in each sector can be calculated.

**Table 26. Share of Final Consumption**

	Final Energy Consumption (ktoe)	Share of Savings of Final Consumption
All sectors	27,950	0.5%
Residential	6,586	0.8%
Industry	9,279	0.9%
Residential and industry	15,865	0.9%

Source: Based on BGBl (2014) and Eurostat data

## Cost per kWh

We assumed that 60 percent of the savings will be delivered in the industry sector, because 40 percent of the savings has to be delivered by law in the residential sector.<sup>88</sup> The cost per kWh (annual savings) in each sector are provided by the Energieinstitut der Wirtschaft (see above) and amount to 0.45 euro cents/kWh in the household sector and 0.6 euro cents/kWh in the industry sector when a lifetime of 15 years and 10 years is assumed, respectively. The weighted average is 0.51 euro cents/kWh.

## Impact on Energy Bills

To calculate the costs of the EEOS as a share of energy bills, the total expenditure in the industrial and residential sector is derived.

**Table 27. Energy Costs in Industry Sector**

	Unit Cost (euros/kWh)		Share of Final Energy Consumption	Total Energy Cost (Million euros/y)
<b>Electricity</b>	0.07		32%	2,524
<b>Gas</b>	0.03		34%	1,121
<b>Other fuels</b>	Not available		34%	1,878*

Source: Eurostat (2015)

Note: No cost figures for other fuels found, calculated prorata.

Based on the cost estimate for EEOS, this represents a share of the total energy cost to the industry sector of 0.9 percent (calculated by dividing the cost of EEOS by the total expenditure for energy).

For the residential sector, the amount of the average energy bill can be used to calculate total expenditure.

**Table 28. Energy Cost in Residential Sector**

<b>Average energy bill (euros/y)</b>	1,593
<b>Number of households (million)</b>	3.8
<b>Total cost of energy per year (million euros)</b>	6,004

Source: Austrian Energy Agency (2015)

<sup>88</sup> BGWI, 2014.