Costs and benefits of energy efficiency obligations: a review of European programmes

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Abstract

The economics of energy efficiency programmes, including their costs and benefits, have been subject to considerable academic debate lasting well over three decades now. However, robust data on the cost-effectiveness of different types of energy efficiency policy instruments is still scarce. A recent investigation into economic instruments supporting energy efficiency by the International Energy Agency concluded that 'very few thorough evaluations of economic instruments in energy efficiency policy are available that would facilitate benefit-cost ratio comparisons'.

In this paper, we contribute to filling this gap by reviewing the costs and benefits of a specific type of policy instrument that recently gained significant traction in Europe – Energy Efficiency Obligations (also known as White Certificates). Following the introduction of the EU Energy Efficiency Directive in 2012 the number of EEOs in Europe has grown from five schemes to now 16 EEOs in operation or planned across the EU. There is now an emerging body of evidence on the costs and benefits of Energy Efficiency Obligations covering a wider range of EU countries, which offers an opportunity to improve our understanding of the economics of Energy Efficiency Obligations. In this paper we draw on this new data and provide a) a comparative analysis of the costs and benefits of Energy Efficiency Obligations in a number of European countries, b) discuss the uncertainties and challenges around calculating the costs of Energy Efficiency Obligations, and c) provide a categorisation of the multiple benefits often overlooked in cost-benefit-analyses with selected quantified examples.

Introduction

The economics of energy efficiency programmes, including their costs and benefits, have been subject to considerable academic debate lasting well over three decades now (Allcott and Greenstone 2012; Blumstein et al. 1980; Geller 1997; Gillingham et al. 2006, 2009; Hausman and Joskow 1982; Jaffe and Stavins 1994a, 1994b; Jaffe et al. 2004; Joskow and Marron 1992; Metcalf 1994; Sutherland 1996). Yet, consensus on which programmes are most cost-effective and under which circumstances appears to be a long way off, even though the discussion is moving in the right direction. In essence, the two poles of the argument can be stylised as 'technological optimism' and 'economic pessimism' (Sorrell et al. 2004) and it is unlikely that full agreement will ever be reached given the fundamental differences between the perspectives.

Robust data on the cost-effectiveness of different types of energy efficiency policy instruments is still scarce. In the past, most of the peer-reviewed literature providing data on the costs and benefits of programmes focused on the US (for an overview see Gillingham et al. 2006), which is a result of regulatory requirements for this data to be collected, a practice that is less common elsewhere. A recent investigation into economic instruments supporting energy efficiency by the International Energy Agency (IEA 2012, p. 14) concluded that 'very few thorough evaluations of economic instruments in energy efficiency policy are available that would facilitate benefit–cost ratio comparisons'.

In this paper, we contribute to filling this gap by reviewing the costs and benefits of a specific type of policy instrument that recently gained significant traction in Europe – Energy Efficiency Obligations (EEOs) (also known as White Certificates or Energy Efficiency Resource Standards). Globally, there are now more than 50 EEOs operating (Lees and Bayer 2016). About half of them are located in the US, which is also the origin of this type of instrument that was established in California after the energy crisis (York et al. 2012). Following the introduction of the EU Energy Efficiency Directive in 2012, the number of EEOs in Europe has grown from five schemes to now 16 EEOs in operation or planned across the EU (Rosenow et al. 2016).

Whereas data on the schemes in the US is abundant, a recent review for example provides data for 20 US states for electricity programmes and for 10 US states for gas programmes (Molina 2014), the picture in Europe is very different. Even though there is now a rich literature on the economics of European EEOs (Farinelli et al. 2005; Langniss and Praetorius 2006; Mundaca 2007; Mundaca and Neij 2009; Mundaca et al. 2008; Oikonomou et al. 2008; Perrels 2008; Sorrell et al. 2009) most of it is theoretical and does not provide cost-effectiveness data.

Three comprehensive reviews of the costs and benefits of European EEOs were published between 2009 and 2012 (Bertoldi et al. 2010; Eyre et al. 2009; Giraudet et al. 2012) but those are dated as the data analysed in the papers relate to time periods before 2010 and only include three countries, the UK, Italy, and France. There is now an emerging body of evidence on the costs and benefits of EEOs covering a wider range of countries (the UK, Demark, France, Italy and Austria) which offers an opportunity to improve our understanding of the economics of EEOs.

In this paper, we draw on this new data, provide a comparative analysis of the costs and benefits of EEOs, discuss the uncertainties, and contrast it with evidence from the US. In the first section of this paper we describe the analytical approach taken before we carry out the analysis of the costs of EEOs in the second section. This is followed by an investigation into the benefits of EEOs and a final discussion section before we conclude.

Analytical approach

Table 1 presents the key design features of the EEOs analysed in this study.

Detailed descriptions of those schemes can be found elsewhere (e.g. ENSPOL 2015) and we will not repeat this information here. Instead, we focus on the economics of those programmes.

COSTS OF EEOS

EEOs incur a cost, as does any other energy efficiency policy. Following a common categorisation (Lazar and Coburn 2013), we classify the costs as:

- **Programme costs**: This includes the costs to the obligated parties required to meeting their targets. Most of those costs consist 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, marketing measures, commissioning contractors, reporting etc.
- **Societal costs**: This includes both the cost to the obligated parties (programme costs) and the additional costs incurred by customers who participate. For example, if a programme offers a €500 incentive to defray a €1,500 cost to insulate a loft, the societal cost for a customer persuaded to insulate their loft by the rebate is the full €1,500 (a €500 program rebate plus another €1,000 incurred by the participating customer).
- **Administrative costs**: This is a subset of EEOs costs, typically borne by regulators or their designees, to establish the rules for an EEO, oversee the implementation of the EEOS (at a high level), verify/estimate/evaluate what the EEO actually achieved and report on its results.
- **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 etc.

Table 1. Key design features of EEOs compared in this study.

	Period analysed	Target (as defined)	Target (kWh/year/capita)	Sector	Obligated parties
UK	2008–2012	293 Mt CO_2 (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)/year	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)

BENEFITS OF EEOS

EEOs deliver a variety of benefits. It is because of this that a recent IEA (2014) report dedicates a whole section solely on the multiple benefits of EEOs. The benefits of EEOs can be grouped into three distinct categories (Lazar and Coburn 2013):

- **Participant benefits**: Those are the benefits that accrue directly to the participating individual households and businesses that install energy efficiency improvements.
- **Utility system benefits**: Those are the benefits that accrue to the energy system through reduced costs in providing energy services to end-users.
- **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.

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 monetizing 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 (Fuller et al. 2010).

METRICS AND COMPARATIVE APPROACH

We discuss all the costs and benefits mentioned above. Because data on the wider costs and benefits is scarce our quantitative analysis focuses on the programme costs and participant benefits. We use negawatt costs in money spent per kWh saved as a result of EEOs as this metric is particularly useful for comparing such programmes (Gillingham et al. 2006) and commonly used across the world when assessing the costs and benefits of energy efficiency schemes. Negawatt costs can be compared to the cost of energy supplied to final customers (or megawatt costs) to establish if the programmes are cost-effective. We calculate negawatt costs in €/kWh fuel equivalent, i.e. all fuel types are converted to kWh in order to have one homogenous unit.

In order to provide information in a clear, summary format, we have had to incorporate certain assumptions or specific methodological approaches. Data have been presented in comparable format to facilitate drawing conclusions on the impact of EEOs across different programmes. This is particularly challenging as 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: Estimate for free-ridership vary across the different countries.
- Rebound effects: Those are taken into account to different degrees.
- 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 kWh equivalents.
- Evaluation methods: Some of the evaluations are ex-ante, others 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. The results of our analysis therefore need to be treated with some caution.

Another important supposition is that the costs to end consumers have been calculated by assuming 100 % 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 supplier. One attempt to model how this might work in practice found that non-switchers could pay as much as 35 % more EEO costs compared to 'switchers' on direct debit tariffs (Preston et al. 2010). Obligated parties may also decide to only pass through a proportion of the costs in order to remain competitive. Due 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. The best assumption that can be made therefore is that the costs of EEOs are passed through 100 % to consumers.

For those EEOs where the obligation is placed on distributors (Denmark, Italy) cost-recovery takes place through regulated tariffs. The regulator reviews and approves cost estimates by the obligated parties and costs are added to the energy bill as a defined surcharge.

Comparative analysis of costs and benefits

COSTS OF EEOS

We analyse the costs of the selected EEOs alongside the four cost categories defined above.

Programme costs

Programme costs of EEOs in the EU are usually not reported by the energy companies unlike in the US where the obligated entities are required by law to provide the regulator with cost data on a regular basis. The only exception in Europe is the UK which introduced obligatory cost reporting in 2013. Therefore, programme costs need to be derived indirectly. For each of the five countries investigated we have been able to do this:

- UK: The final evaluation of the EEO period 2008–2012 included a section on programme costs based on self-reported costs by the energy companies (Ipsos MORI et al. 2014).
- Denmark: The costs to energy companies have been analysed in previous evaluations up to 2013 (Deloitte and Grontmij 2015). Data from the Danish Energy Agency provides more recent cost estimates for 2015 (Bach 2016).
- France: A ministerial report estimates the cost to energy suppliers per kWh (lifetime) saved at 0.4 Eurocent (Ministère de l'écologie, du développement durable et de l'énergie 2014). This figure is corroborated by the ENSPOL (2015) analysis which calculates a cost of 0.37 Eurocent/kWh. Over the period 2011–2014, the EEOS delivered energy savings of

390 TWh (lifetime) which implies total cost to the energy companies of 390 million Euro per year.

- Italy: A recent estimate by ENSPOL (2015) provides a cost figure of 700 million Euro per annum to the energy companies based on a cost estimate of 80 Euros/toe (lifetime).
- Austria: There are no existing evaluations of the Austrian scheme yet as it is a new scheme that started only in 2015. 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 is available for first year savings rather than lifetime savings (Energieinstitut der Wirtschaft 2015). 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, the figures are well within the range of existing EEOs where longitudinal cost data exists. Based on the assumption that 60 % of the savings will be delivered in the industry sector (40 % have to be delivered by law in the residential sector) and a savings target equivalent to 136 ktoe per annum (BGBI 2014), the total annual cost of EEOS are 95 million Euro.

Table 2 provides a summary of the programme costs for all five EEOs.

The costs to the energy companies vary significantly depending on the country ranging from 95 million Euro per year in Austria to more than 1 billion Euro per year in the UK. This is largely a result of:

a. the different size of the countries in terms of the number of consumers;

b. variations in the ambition of the target; and

c. interaction with other policy instruments.

Point c) refers mainly to the French case where consumers can blend funds from both the EEOs and the French tax rebate scheme Crédit d'Impôt Transition Energétique 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. For a detailed analysis if the interaction of the EEOS in France and tax rebates see Rohde et al. (2014).

On average, the five EEOs cost about 16 Euro per capita per year with France representing the EEO with the lowest cost of just 6 Euro per capita per year and Denmark the most expensive EEO amounting to more than 30 Euro per capital per year. The low cost per capita in France is largely a result of the interaction with tax rebates that complement the subsidies provided through the EEO.

Overall this study found that the cost-effectiveness of the EEOs analysed is high. The table below 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). The cost to the obligated company per

Table 2. Comparison of programme costs of EEOs.

	Time period	**Energy company costs** (million Euro/year)	**Energy company costs** (Euro/capita/year)*
UK	2008–2012	1,052	16
Denmark	2015	185	33
France	2011–2013	390	6
Italy	2014	700	12
Austria	2015	95	11

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

Source: Bach (2016); BGBI (2014); Deloitte and Grontmij (2015); Energieinstitut der Wirtschaft (2015); ENSOL (2015); Ipsos MORI et al. (2014); Ministère de l'écologie, du développement durable et de l'énergie (2014).

Table 3. Comparison of costs of EEOs across selected countries [unit cost of saved energy].

	Time period	**Weighted average EEOS cost of lifetime energy savings** (Eurocent/kWh (all fuels))	**Weighted average retail prices of comparable energy supply for relevant sectors** (Eurocent/kWh (all fuels))
UK	2008–2012	1.1	10
Denmark	2015	0.5	13
France	2011–2013	0.4	9
Italy	2014	0.7	9
Austria	2015	0.5	8

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

Table 4. Comparison of costs of EEOs across selected countries [share of energy bill].

	Cost as share of average energy bill		
	Household sector	*Industry sector*	*All sectors*
UK	2 %	N/A	N/A
Denmark	2 %	5 %	N/A
France	N/A	N/A	0.5 %–1.0 %
Italy	1 %	not available	not available
Austria	not available yet	0.9 %–1.4 %	not available yet

Source: calculated by authors based on cost data, Eurostat (2015) and data from the ODYSSEE Database.

Table 5. Comparison of administrative costs of EEOs across selected countries.

	Time period	Administrative costs (% of overall program costs)
UK	2008–2012	0.2 %
Denmark	2015	0.3 %
France	2011–2013	0.4 %
Italy	2014	1.4 %
Austria	2015	not available yet

Sources: DECC (2010) and ENSPOL (2015).

kWh of energy saved in Europe is around 0.4 to 1.1 Eurocents, which is significantly less than the cost of energy supplied to the customer.

EEOs typically cost about 1–5 % of the average energy bill (see Table 4). 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.

Societal costs

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 for the EEOs reviewed and require detailed surveys on the contributions from beneficiaries to individual energy efficiency measures.

Alternatively, societal costs can the estimated by applying a leverage factor. Typically, the societal cost are 2–3 times as high as the cost to the obligated parties. A recent study of several EEOS in the US suggests that the societal costs are 241 % on average of the cost to the obligated parties e.g. a programme that costs suppliers 1 billion Euros/year has societal costs of 2.4 billion Euros/year (Molina 2014).

An investigation into the British, French and Danish schemes into the leverage effect of EEOs (Rohde et al. 2014) can be used to estimate societal costs compared to the programme costs:

- UK: 187 % in 2002–2005 and 144 % in 2005–2008 (residential sector only) of programme costs.
- France: 137 % of programme costs.
- Denmark: 300 % (industry sector only) of programme costs.

Note that this data only relates to the *direct* cost (i.e. the financial contributions) and does not include hidden cost such as time and hassle. There are very few examples of hidden cost estimates including one from the UK where they have been estimated at about 2/3 of the programme costs (DECC 2012).

Administrative costs

What are counted as public administrative costs differ somewhat from one program 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.

This does not include the administrative costs to the obligated energy companies – this cost element is included in the programme costs and usually not reported on separately. Table 5[1] provides the estimated public administrative costs.

For most EEOs analysed the administrative cost constitute a small fraction – less than 1 % – of the total program 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

1. 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. We assumed an annual cost per employee of 80,000 Euro. 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 Euro from ADEME.

certificates and the associated administrative effort. Previous analysis by Bertoldi et al. (2010) has shown that trading increases the administrative burden due to additional costs involved in setting up and running trading platforms, although in a system with broad sectoral coverage there may be good reasons for including trading provisions.

Start-up costs

Data on start-up cost are limited. However, where data are available the evidence suggests that start-up costs are small. In case of the Community Energy Saving Programme (CESP), which operated in the UK from 2009 to 2012, the start-up costs were estimated to be of a similar range as the annual operating costs (~€500,000) (DECC 2009) which is equivalent to 0.3 % of the total programme cost per year. Start-up cost for the Energy Company Obligation, which were implemented in 2013, have been estimated at about half of the anticipated annual running cost (€1,700,000) (DECC 2012). This amounts to 0.1 % of the estimated annual programme cost.

BENEFITS OF EEOS

Participant benefits

Table 6 demonstrates the impact of EEOs on final energy consumption in selected Member States. The reduction of final energy consumption per year is expressed in both absolute values and as a percentage of anticipated consumption under a BAU scenario.

The savings from EEOS in Denmark are notably high in comparison to the other countries. The Danish National Energy Efficiency Action Plan states that free ridership could apply to up to 80 % of measures in buildings and 50 % in industry (Danish Energy Agency 2014). Independent analysis suggests similar proportions of free riders (Bundgaard et al. 2013). Whilst 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.

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. There is no method that would allow us to estimate the exact bill impact of reduced consumption and we assume that a 1 % reduction in energy use results in a 1 % reduction in energy bills for the purpose of this paper.

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.

The net-benefits to bill payers can be modelled over time. Initially the total energy bill will increase due to the cost of EEOs and higher unit prices. However, 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 1. While 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:

- 3-year operational period and termination thereafter;
- assuming no EEOs in place before;
- only applies to household sector;
- average yearly savings of 1 %;
- average cost as share of total energy bill of 3 %;
- split of lifetimes of measures: 25 % 5 years, 25 % 10 years, 25 % 15 years and 25 % 20 years; and
- average annual household energy bill of 1,500 Euro.

After 5 years the modelled EEOs generates net-benefits as indicated in the graph. Over 20 years the benefits exceed the cost by more than a factor of 4.

Assuming a succession of EEOs over 30 years and a split of lifetimes of measures of 25 % 5 years, 25 % 10 years, 25 % 20 years and 25 % 30 years, the long-term benefits are significant with total bill savings of close to 4,000 Euro over the 30-year period and a reduction of the average annual energy bill of 17% (Figure 2).

Table 6. Impact of EEOs on energy consumption.

	Time period	Final energy savings per year (ktoe)	Reduction of final energy consumption per year	Sector
UK	2008–2012	237	0.5 %	household sector
Denmark	2015	291	4.2 %	all sectors
France	2011–2013	377	0.4 %	all sectors
Italy	2015	500	0.4 %	all sectors
Austria	2015	136	0.9 %	household and industry sectors

Source: based on national statistics in individual countries, see Rosenow and Bayer (2016) for details.

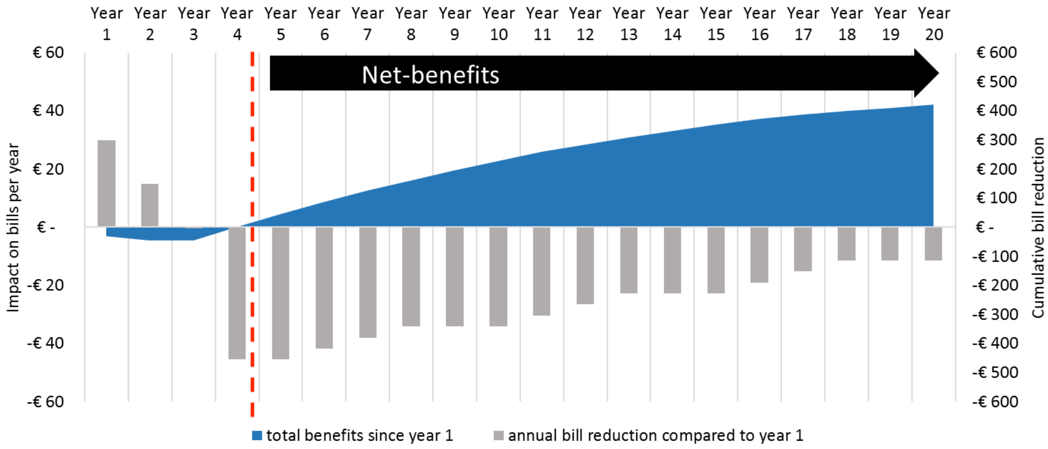

Figure 1. Illustrative long-term impact of EEOs on energy bills. Source: authors' illustration.

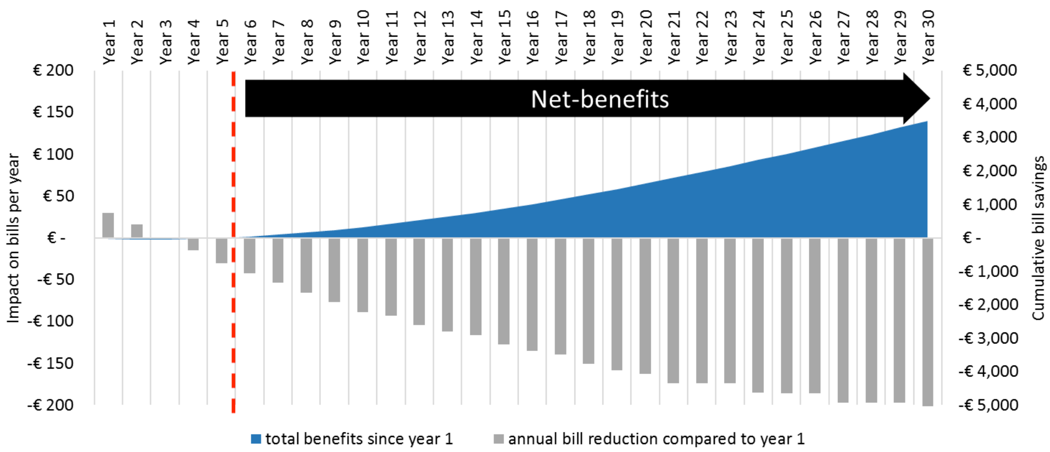

Figure 2. Long-term bill impacts of a 30-year EEOs. Source: authors' illustration.

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_2 allowance costs for power generating facilities that are within a carbon tax or cap-and-trade regime (Lazar and Coburn 2013). 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 due to the avoidance of production, transmission, and distribution capacity.

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 (Bayer 2015).

Reserve requirements in an electricity system represent a percentage of resources above demand, which is necessary to ensure reliable supply in cases of emergency (for example, when a large power plant suddenly goes offline). For thermal systems, reserve requirements typically amount to 13 to 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. Essentially, during peak hours power generators must produce more power do deliver a kWh of energy to the end-user than off-peak, due to congestion and resulting inefficiencies in power lines. (In other words, "marginal line losses" increase.)

Cost savings accrue also to the gas distribution network but we are not aware of analyses that quantify this effect. The scale of the gas grid and new investment can be reduced with lower gas consumption and operation and maintenance costs may also be lower. Recognising this, gas utilities in Ontario, Canada, are required to "provide evidence of how DSM has been considered as an alternative at the preliminary stage of project development" as part of all applications to construct gas infrastructure projects (Ontario Energy Board 2014).

In the EU, 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_2 allowances rather than receiving them through free allocation. Alternatively, they can lower their emissions through a) investing in energy efficiency and/or b) switch to low-carbon fuels. The amount of allowances 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. For example, the UK Government estimates that due to the introduction of the latest EES, the Energy Company Obligation (ECO), about €2 billion worth of traded EU ETS allowances are avoided over the lifetime of the implemented measures (DECC 2012).

Societal benefits

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. Closely linked to health benefits, improved comfort is an important benefit of and motivator for undertaking energy efficiency improvements. Particularly where homes are underheated, energy efficiency improvements allow the occupants to increase indoor temperatures at no additional cost (this of course reduces the amount of energy savings). 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. For the last EEOs in the UK (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 % of the value of the bill savings (DECC 2012).

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 (Fuerst et al. 2015).

Analysis suggests that energy efficiency improvements (including those delivered through EEOs) can increase energy security (Bayer 2015).

Discussion

COMPARISON OF FINDINGS WITH PREVIOUS STUDIES

The findings of this analysis are corroborated by previous academic studies. A comprehensive analysis of the EEOs in the UK, France and Italy (Giraudet et al. 2012) 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 Eurocent/kWh of saved energy which is the same value that was calculated in this study. For the UK, the estimate was 0.7 Eurocent/kWh of energy saved (based on older ex-ante rather than ex-post data) – i.e. somewhat lower than the 1.1 Eurocent/kWh estimated as part of this study. Another academic assessment of the UK scheme (Rosenow and Galvin 2013) also estimates the cost to be 0.7 Eurocent/kWh of energy saved (also based on ex-ante figures). Only for Italy the estimates based on previous data of 0.1 Eurocent/kWh of energy saved are significantly lower than the results of this study. However, analysis as part of the ENSPOL project (ENSPOL 2015) 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 EEO 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.

DATA LIMITATIONS

Data quality and reliability is very high for some countries (e.g. UK) but there are greater uncertainties around the estimates for more recent EEOs (e.g. Austria). In particular, uncertainties arise due to free-ridership and it is likely that some of the estimates are too optimistic.

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 2–3 the benefits from EEOs would still significantly outweigh the costs.

COMPARISON WITH US SCHEMES

It is worth comparing the European experience with EEOs in the US. First, measuring the cost per kWh saved to the obligated company provides a worthwhile perspective into how much it costs to deliver energy savings. The costs to the obligated entities of delivering energy savings can vary widely. On average, the levelised cost per kWh saved was close to 2 Eurocents but the costs range from 0.8 Eurocent/kWh to more than 4 Eurocent/kWh (Billingsley et al. 2014).

The costs vary due to the design of different state policies. More expensive costs of delivery will often reflect inclusion of energy efficiency programs geared towards the fuel-poor and more comprehensive "whole-house" approaches to energy efficiency that address various end-uses at once. Perhaps even more importantly, the costs of delivery reflect the 'aggressiveness' of the overall savings targets and how long it has been running. The first increment of savings is the cheapest followed by increasingly expensive savings. For example, the state with the largest cost per unit of savings in the analysis by Billingsley et al., Massachusetts, got electricity savings equal to close to 3 % 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 EU. 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).
- The cost figures below for the US 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 US are levelised, meaning that there is discounting involved whereas in the EU not all countries discount energy savings.
- The depth of savings being achieved in the most expensive states is much greater than in most of the EU examples.

MULTIPLE BENEFITS

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 due to EE),
- improved air quality;
- increased energy security;
- 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 national level, Member States should consider modifying their methodologies for conducting policy assessments and evaluations to better reflect the range of multiple benefits beyond the mere bill savings. Some Member States have more experience with quantifying multiple benefits than others (especially the UK, see DECC 2009, 2010, 2012) 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 Euro invested in energy efficiency) and/or adders (e.g. 5 % increase of the benefits to account for health improvements) is a simple option to include multiple benefits.

Conclusions

The analysis of this report shows that EEOs in Europe are cost-effective based on the increasingly robust evidence base covering multiple countries in Europe with programme costs of up to 1.1 Eurocent/kWh lifetime savings. Data on the societal cost are scarce. Assuming leverage ratios of 2–3 the societal costs of EEOs in Europe appear to be less than 3 Eurocents/kWh lifetime savings, which is substantially less than the cost of supplied energy. Going forward, deeper energy efficiency improvements will need to be delivered and this will unavoidably increase the costs of EEOs over time.

There are, however, significant uncertainties around the cost and savings estimates of EEOs in Europe. This is a result of inconsistent evaluation practices and certainly less robust evaluation regimes compared to the US. Without considerable effort, it is not possible to harmonize the existing data fully. In the future, harmonized reporting of savings and costs would help with increasing the confidence in the costs and benefits of EEOs and allow for a more direct comparison between the programmes.

We have shown that EEOs also deliver a wide range of other benefits in addition to reduced energy consumption and bill savings accruing to participants, but also the energy system and society as a whole. This includes health benefits, increased comfort, economic stimulus, employment creation, cost savings in transmission and distribution, avoided CO_2 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 allow for accounting for the multiple benefits both at EU and national level.

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