Energy saving obligations across three continents: contrasting approaches and results

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Abstract

One of the major energy efficiency strategies in the EU is a requirement that Member States establish energy efficiency obligation (EEO) schemes or alternative measures that would deliver a growing level of energy savings from measures delivered to end use energy customers. Sixteen Member States have adopted or plan to adopt such schemes, including six whose schemes predated the Energy Efficiency Directive and have longer-term results. At least two additional Member States are now considering EEO schemes, and the Commission is in the process of developing a revised Directive to take the schemes forward to at least 2030. In the US, similar obligations are called energy efficiency resource standards (EERS's) and have been adopted in 26 states, even in the absence of a federal mandate. Some of these have been in place for many years and on average have reduced electricity use by more than 10 %. In Australia, similar EEO policies have been adopted in three states plus the Australian Capital Territory. The New South Wales EEO scheme in Australia commenced in 2003 as part of a larger emissions trading scheme and was actually the first operational white certificate scheme in the world.

This paper summarizes and contrasts the different EEO schemes implemented across the EU, the US and Australia, looking at structure, motivations, results and lessons learned. We find that EEO schemes have been a generally successful policy in all three regions, saving a substantial amount of energy (more than 20 % in a few cases), cost-effectively (e.g., at costs generally less than half those of supply-side resources). In addition, we examine a number of leading questions that decision-makers face when considering whether and how to create an efficiency obligation on energy suppliers or their substitutes and offer recommendations that states, nations and the European Union should take into account when designing or improving energy saving obligations.

Introduction

One of the major energy efficiency strategies in the EU is a requirement that Member States establish energy efficiency obligation (EEO) schemes or alternative measures that would deliver a growing level of energy savings from measures delivered to end use energy customers. So far, 16 Member States have adopted or plan to adopt EEO schemes. Likewise, in the US, similar obligations are called energy efficiency resource standards (EERS's) and have been adopted in 26 states, even in the absence of a federal mandate. And in Australia similar EEO policies have been adopted in three states plus the Australian Capital Territory.

This paper, authored by efficiency experts from each of these continents, summarizes and contrasts the different EEO schemes employed, looking at motivations, structure, results and lessons learned. We begin with a short note on the metrics used to measure and report energy savings, then move on to a discussion on each continent, seeking to provide a flavour for the range of approaches and results across countries and states within each continent. Next we examine a number of leading questions that decision-makers face when considering whether and how to create an efficiency obligation on energy suppliers

or their substitutes and based on this review offer conclusions and recommendations that states, nations and the European Union should take into account when designing or improving energy saving obligations.

Energy Savings Metrics

There are three main metrics that are used to measure and report energy savings in EEO schemes. *Cumulative savings* are the savings that have been achieved from energy saving measures installed in a particular year plus all the savings achieved in that year from measures installed in previous years. *Lifetime savings* are the savings achieved from measures installed in a particular year plus all the savings that will be achieved in subsequent years over the lifetimes of the measures installed in that year[1]. Annual *incremental savings* are the additional savings achieved in a particular year from measures installed in that year, with no account taken of savings in previous or subsequent years. There is little consistency across EEO schemes in relation to which of these metrics are used.

Deeming of savings from specified small-scale energy saving measures is commonly used in EEO schemes in Europe and Australia and for some measures in the US. Savings are calculated on the basis of deemed (estimated) savings from the particular measure over a stated time period. Deeming introduces some inaccuracy into calculations of savings but scheme administrators accept these inaccuracies in the interest of eliminating the transaction costs that would be involved in measuring actual savings. Deemed energy saving values are usually updated regularly, using data from impact evaluations of representative samples of installations.

European Union

EEOS TODAY

EEO schemes are a critical element in advancing high-level European goals for an energy economy that is more efficient, uses more renewables, and is less polluting. When the Union's energy goals for 2020 were adopted in 2009, EEO schemes were in effect in only a small handful of Member States (MS's). By 2012, there were six well-established EEO schemes in place in Europe[2]. However, based on the experience in those six jurisdictions, and the experience with EEO schemes in the US and Australia, in 2012 the EU adopted a new Energy Efficiency Directive (the EED) (EC 2012), which included a mandate for greater energy savings in all MS's, and included specific directions to MS's to consider and potentially adopt EEO schemes for energy distributors and suppliers.

Each MS must calculate an energy savings target, and demonstrate how it will deliver the target between 2014 and 2020. The key provisions of the EED relating to EEO schemes are contained in Article 7, which requires each MS to set up an EEO scheme to "ensure that energy distributors and/or retail energy sales companies … achieve a cumulative end-use energy savings target by 31 December 2020." That target is nominally set at delivering *new incremental savings* each year from 2014 to 2020 of 1.5 % per year, across all sales to end-use customers, and with reference to sales in a three-year base period between 2010 and 2012. Because EU nations have over time adopted a variety of approaches to energy savings, and only a few had EEO schemes in place in 2012, Article 7 is flexible with respect to EEO schemes. Major flexibility mechanisms include the following:

- MS's are not actually required to establish EEO schemes for energy companies. They may establish "other policy measures" to deliver equivalent energy savings; these may include energy and carbon taxes designed to lower consumption, financing schemes, standards above EU minimums, and other tools to deliver end-use efficiency investments;
- If establishing an EEO scheme, each MS can assign the energy saving obligation to distribution companies, retail energy service companies, or some combination; any fuel can be covered;
- Transportation fuels may be included in the baseline for setting the energy saving target, or not, according to national choice;
- Up to 25 % of the overall obligation can be met (or avoided) by the use of several exemptions, including credits for "early actions" already taken before the beginning of the legal mandate.

These flexibility provisions and exemptions have resulted in a patchwork of EEO schemes and alternative compliance measures across Europe, which have had both positive and negative effects, including lowering overall performance from 1.5 % to approximately 0.75 % savings per year (Rosenow et al. 2016). Thus, while 2020 savings under the EED should theoretically be about 10.5 % of covered energy use (1.5 % per year for seven years), in practice, 2020 savings are likely to be about half this amount (not counting savings achieved in earlier years and via other EU-wide policies). Nevertheless, the EED has had substantial impacts. As of the end of 2016 there were 14 EEO schemes in place, with two additional MS's actively considering adopting an EEO scheme (see Table 2). EEO schemes are achieving moderate success. However, as might be expected with the launch of new initiatives, the pace of success across the MS's is uneven.

MOTIVATIONS

EEOs in Europe, as in the US and Australia, have been adopted for a variety of reasons. Denmark has had a well-established and successful EEO scheme aimed at climate, economic, and energy justice goals since 2006 predated by a demand-side management programme operational since 1995. An EEO was included in the 1999–2000 legislation liberalizing the electricity and gas sectors in Italy with the goals of reducing energy costs, improving competitiveness, and helping Italy to meet its obligations to reduce emissions under the Kyoto Protocol. After a delay, the Italian EEO scheme formally started in 2005 (ENSPOL 2015). The UK has had a series of EEO-style programmes covering both electricity and natural gas since 1994, in several

1. In some cases, a discount factor is applied to savings to be achieved in subsequent years.

2. Those were the Flanders region of Belgium, Denmark, France, Italy and the United Kingdom. Bulgaria also had an EEO scheme in operation but this is not generally reported on.

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Table 1. Energy savings of selected European EEO Schemes.

	Time period	Final Energy Savings per Year (ktoe)	Incremental Annual Savings Rate Compared to Total Final Energy Consumption	Sector
United Kingdom	2008–2012	237	0.5 %	Household sector
Denmark	2015	291	3.0 %	All sectors excluding transport
France	2011–2013	377	0.4 %	All sectors
Italy	2015	500	0.4 %	All sectors

Source: Rosenow and Bayer (2016); modified incremental annual savings in percent for Denmark based on Bach (2017).

phases. Initially, the UK's EEO policy was driven by economic considerations around least-cost planning (Rosenow 2012). In recent years, a major focus of the UK EEO schemes has been carbon reductions, but this aspect of the EEO policy has now been cut back, with a smaller EEO scheme today focusing largely on alleviating fuel poverty in low-income households. In France, where the power system is overwhelmingly nuclear, the focus of the EEO policy has been on reducing energy intensity generally, reducing wasteful consumption of natural gas, and assisting low-income households, rather than reducing emissions.

Whatever the historic reasons for adopting EEOs, in Europe today, end-use efficiency is seen as an integral component of the Union's comprehensive climate and energy package, which includes delivering economic savings; improved energy security through reduced need for imports, especially from political rivals such as Russia, and potentially unstable providers in the Middle East; lowering carbon dioxide emissions; and improving consumer welfare including reducing fuel poverty. In 2016 the European Commission delivered a package of energy and climate proposals in support of a stronger "Energy Union," with an "Efficiency First" policy as a key component, and a foundation for each of the other pillars of the proposed Energy Union package (EC 2016).

RESULTS

It is important to recognize the substantial energy savings delivered by the first generation EEOs in Europe, before considering the pace of savings expected under all of the EEO schemes underway since passage of the EED. There are data on the energy savings of long-running EEO schemes (summarised in Table 1) and typically schemes incrementally save around 0.5 % of total final consumption each year of operation for those sectors covered by the obligation. Denmark is an exception and official estimates indicate incremental annual savings of about 3 % per annum compared to total final consumption.

Table 2 sets out the national savings targets and expected savings rates for each MS, together with the fraction of total energy savings that 14 MS's now expect to deliver through their EEO schemes. Across the Union, between 2014 and 2020, EEOs are expected to deliver greater savings than any other type of policy measure, and about one-third of all savings needed to meet the economy-wide savings goal (see Figure 1). This is despite the fact that only 3 % of all policy instruments used by MS's to comply with Article 7 of the Energy Efficiency Directive are EEOs (Forster et al. 2016). Across the entire EU, including those MS's without EEOs as well as those with EEOs, the EEOs now planned will reduce energy use by about 0.25 % per year (one-third of the 0.75 % per annum), achieving total savings in 2020 of 1.8 % (one-third of the 5.25 % 2020 savings discussed above).

LESSONS LEARNED

Considering European experience with both the historic EEO schemes, and those launched since 2012, as well as substantial experience with "alternative mechanisms" under the EED, a large number of lessons have been learned. Perhaps the two most important lessons are what might be termed *discipline*, and *flexibility*:

- Public policy discipline is necessary to achieve savings goals. The EU has had high-level efficiency goals at least since 2006, and a specific savings target for 2020 since 2009. Yet most MS's were failing to deliver consistent cost-effective savings programmes, and by 2012 it was apparent that policy efforts would need to triple their impact to meet the 20 % savings target for 2020 (Fraunhofer and Ecofys 2010). The mandate provided by the EED has been, and will be, crucial to delivering a greater share of Europe's cost-effective savings potential in the coming decade.
- Flexibility is also a key to delivering efficiency across the different energy systems of the EU. Some MS's – for example, Germany and Denmark – have opposed a "one size fits all" mandate for EEO schemes in every MS. Denmark has implemented a very successful savings programme through a legally-enabled but largely voluntary set of agreements with energy suppliers in different sectors. Germany has achieved substantial savings through its energy efficiency fund, which is crucially supported by dedicating carbon auction revenues to efficiency investments – a powerful strategy to leverage carbon revenue to reduce emissions while lowering energy bills for households and the nation as a whole.
- It takes years to build successful EEO schemes. While energy savings will begin to deliver benefits almost immediately, it may take years for successful EEO schemes to deliver cumulative savings large enough to convince decision-makers that efficiency investments are an essential part of a nation's infrastructure planning. Multi-year commitments are essential to EEO success. The initial size of the EEO target and the speed at which the target can be increased is limited by the capacity of the supply chain to deliver the energy savings. In MS's with little experience it is likely that a staged approach of implementing EEO schemes will be

Table 2. Sum of expected savings (and percentage to be delivered by EEO Schemes) for each Member State (all values in ktoe cumulative savings, 2020).

Member State	EED target (ktoe)	Sum of expected policy savings (ktoe)	% of expected savings to be delivered by EEO Schemes
Austria	5,200	9,146	42 %
Belgium	6,911	7,155	Not applicable
Bulgaria	1,943*	1,943	100 %
Croatia	1,295	1,295	41 %
Cyprus	242	243	Not applicable
Czech Republic	4,564	5,170	Not applicable
Denmark	4,130	4,130**	100 %
Estonia	610	611	Not applicable
Finland	4,213	8,819	Not applicable
France	30,574	31,130	87 %
Germany	41,989	44,484	Not applicable
Greece	3,333	3,333	Planned
Hungary	3,396	***	Not applicable
Ireland	2,164	2,243	48 %
Italy	25,502	25,830	62 %
Latvia	851	851	65 %
Lithuania	1,004	1,044	Not applicable
Luxembourg	515	515	100 %
Malta	56	67	14 %
Netherlands	11,512	11,270****	Under study
Poland	14,818*	14,818	100 %
Portugal	3,376	3,408	Not applicable
Romania	5,817	5,863	Not applicable
Slovakia	2,284	2,287	Not applicable
Slovenia	945	945	33 %
Spain	15,979	14,361*****	44 %
Sweden	9,114	11,513	Not applicable
UK	27,859	37,799	21 %
Total	230,195	250,274	34 %

** Target not explicitly notified, value is derived from the submitted information by the Member State.*

*** Danish obligations under the energy policy agreement are considerably higher than required by Article 7, with savings expected from the obligations by 2020 of 7,908 ktoe. Thus, the savings stated represent an underestimate of the total savings from this policy.*

**** Hungary did not yet notify savings for its policy measures.*

***** The Netherlands notified ranges of savings for (groups of) policy measures.*

****** Excludes 1,619 ktoe of savings notified by Spain in related taxation measures, as these arise in 2013, so cannot count towards the 2014–2020 saving period.*

Source: Adapted from Forster et al. (2016). "Not applicable" in this chart means that the MS did not have an EEO in place in 2016.

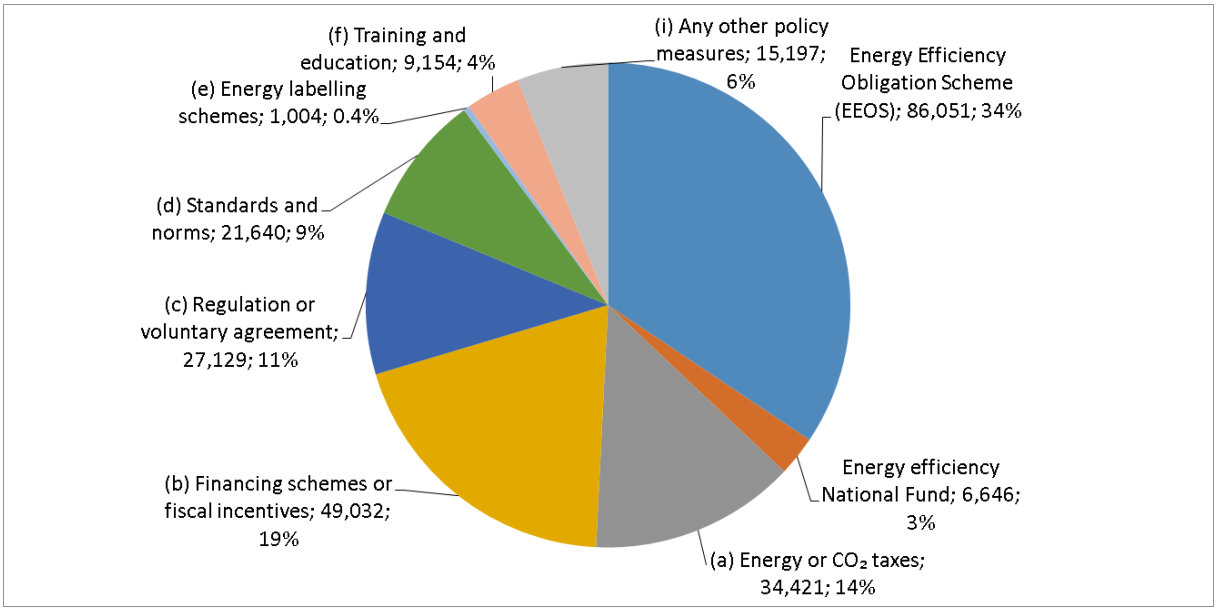

Figure 1. Breakdown of ex-ante energy savings, based on notified savings by type of policy measure for EU-28 over period 2014–2020 (figures in ktoe). Source: Forster et al. (2016).

more successful as it allows the supply chain to develop and grow with increasing targets. Experience from existing EEO schemes suggests that the target can be increased relatively quickly.[3]

- High-quality assessment and programme evaluations are essential to long-term success, and to public understanding of the values that the EEO schemes can deliver. In the US, most EEO schemes are overseen by the transparent and independent processes of the state public utility commissions, and a tradition of detailed oversight has been applied to the EEO schemes that utilities deliver. Europe does not have this regulatory tradition, and there is still a relatively weak system for reviewing and, where necessary, correcting EEO scheme delivery systems and savings claims, particularly with regard to free-riders (Rosenow et al. 2016). Most of the savings calculations are based on deemed savings which are reviewed and adjusted periodically through impact evaluations. The degree of rigor of those evaluations differs amongst MS's.
- Whilst frequent modifications of EEO schemes are important for continuously improving the schemes, any changes have to be managed carefully. Radical changes to the EEO policy in the UK have led to a steep decline in energy savings after 2013 (Rosenow and Eyre 2013) and also increased the complexity of the EEO scheme significantly.
- New EEO schemes need to avoid unnecessary complexity. The Polish scheme has suffered from a complex tendering mechanism that ultimately led to the failure of the EEO policy to deliver on its objectives and resulted in the complete redesign of the scheme (ENSPOL 2015).
- The available data on the costs of EEO schemes indicate a high cost-effectiveness. European EEO schemes programme costs are around €0.004–€0.011 (USD $0.004–$0.012) per kWh lifetime savings; well below the costs of supplied energy. The total costs of EEO schemes (including programme participants' contributions) are likely to be less than €0.03 (USD $0.03) per kWh lifetime savings (Rosenow and Bayer 2016).

United States

EEOS TODAY

In the US, EEO policies are generally referred to as Energy Efficiency Resource Standards (EERS's). Presently 26 US states have such standards, including two states with combined energy efficiency and renewable energy targets (see Figure 2). Energy efficiency programmes have been pursued by some electric and gas utilities in the US since the 1970s, and as early as 1990, some states (e.g., Vermont) required utilities to acquire all cost-effective efficiency resources (VT PSB 1990). The first purely numerical target was adopted by the state of Texas in 1999 and the most recent by New Hampshire in 2016. We count states as having an EERS if the targets extend at least three years, funding is authorized to meet the targets, and there are consequences if the targets are not met. Most EERS's were adopted over the 2004–2011 period as shown in Figure 3. In the US such standards have been adopted by state legislatures in some cases and by state regulators in other states (when permitted by state law). In several states, legislation requires utilities to require "all cost effective energy efficiency" and regulators determine savings targets based on this general guidance. All of the EERS's apply to

3. In the UK the target was doubled in 2005 and in 2008 followed by another increase of 20 % (of the 2008 target) in 2009. In France, the target was increased by 640 % from the period 2006–2009 to 2011–2014. The target from 2015–2017 is almost 100 % larger than the 2011–2014 target. In Italy the yearly targets increased by 100 % every year from 2005 to 2007, almost by 300 % from 2007 to 2008 and then increased by an average 20 % until 2016. In Denmark, the target increased by 100 % from 2006–2009 to 2010–2012 and increased by 75 % in 2013.

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electric utilities and about half also apply to natural gas utilities, with each utility required to save their own fuel (none of the US standards explicitly permit tradeoffs of savings between electricity and natural gas, although in a few states fuel oil and propane savings can count towards electricity or natural gas goals). All of the EERS's apply to all or nearly all retail sales (a few states exclude the very largest customers who are presumed to pursue energy efficiency on their own). Nearly all of the EERS's specify annual incremental savings to be achieved as a percent of annual electricity or natural gas sales. The stringency of state targets varies enormously from a low of 0.1 % per year incremental savings in Texas to a high of 2.9 % per year incremental savings in Massachusetts. In two states there is a combined energy efficiency and renewable energy goal; in all the rest the EERS only covers energy efficiency (although in most of these states there are separate renewable energy requirements). There have been proposals to establish a national EERS, but these have not gotten very far in the US Congress.

In general, compliance with EERS's is determined with bottom-up evaluations of each programme, adding up to total sav-

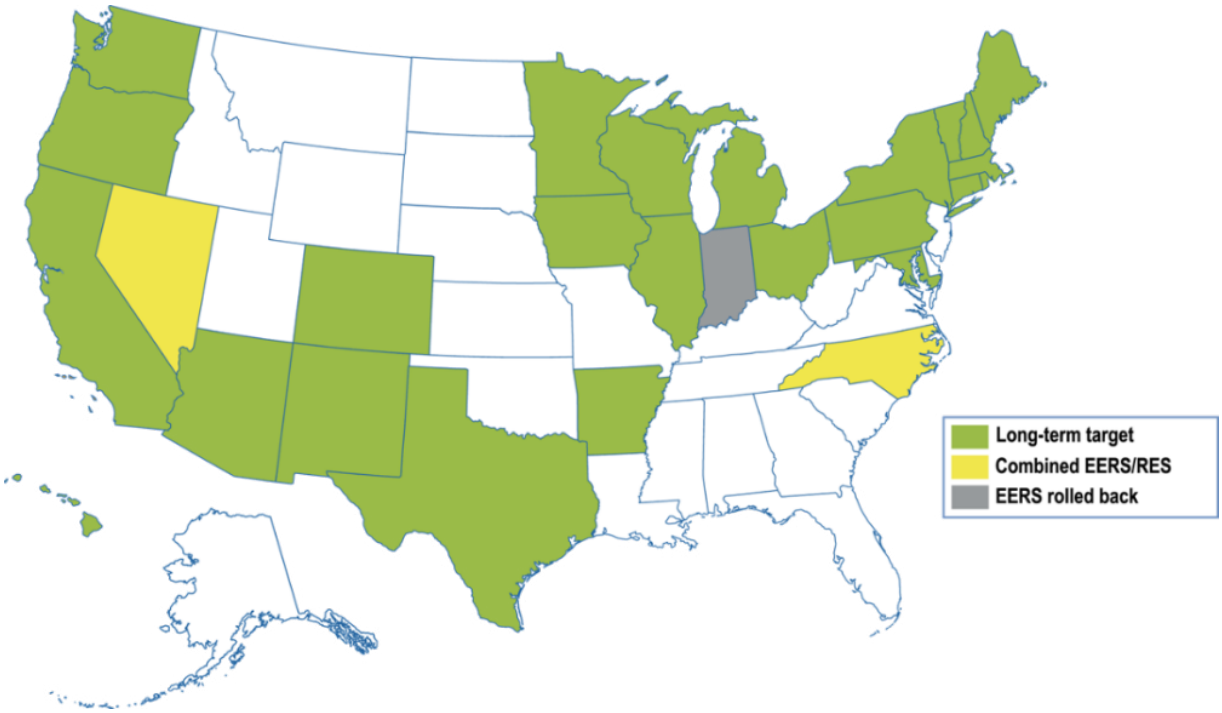

Figure 2. States with EERS's. Source: ACEEE.

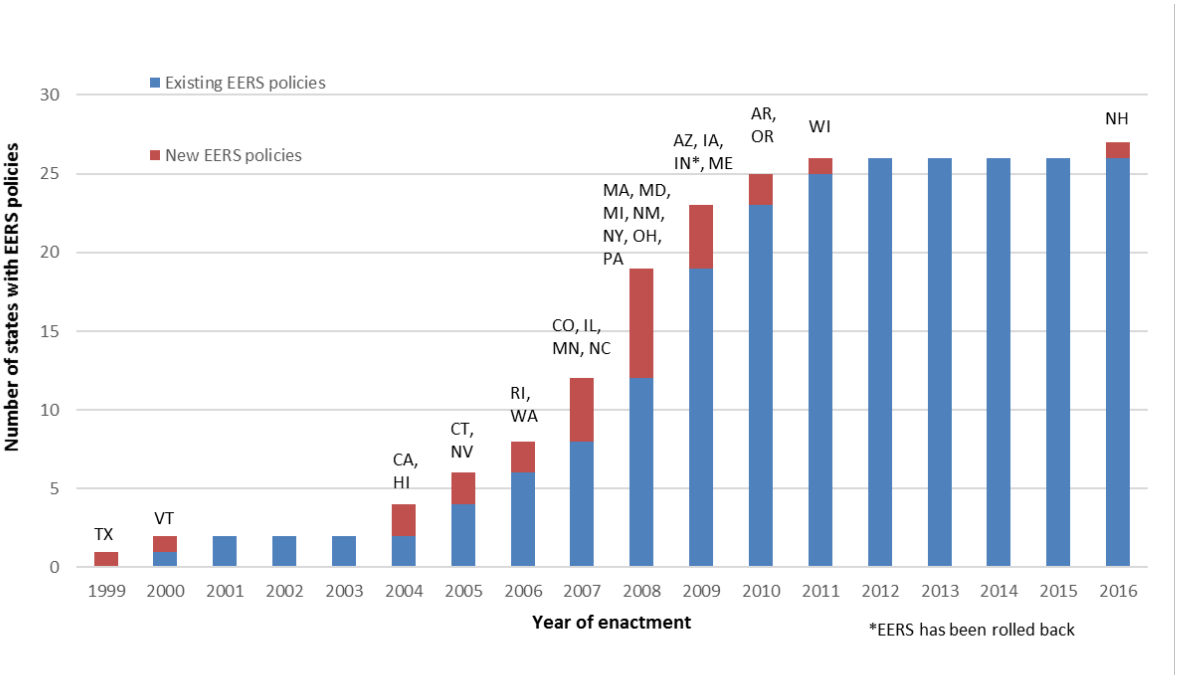

Figure 3. EERS's by year of adoption. Source: ACEEE.

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ings. Evaluations are often conducted by independent evaluators hired by utilities but reviewed by regulatory staff and their consultants, but in a few cases the regulators hire the evaluators. In the majority of states, targets are set in terms of net energy savings (net of what would have happened without any programmes – e.g. implicitly or explicitly adjusting for free riders and, in some cases, spillover) but in some states, gross savings are used, counting all savings by programme participants without any adjustments for free riders.

MOTIVATIONS

For the most part, states have adopted EERS's to reduce energy system costs and save consumers money. Many studies have shown energy efficiency programmes to cost utilities less per kWh than new generation. For example, Molina (2014) found that utilities on average spend about 3 US cents per kWh saved from energy efficiency programmes, which is generally less than half the typical cost of power from new generation sources, be they coal, nuclear, natural gas or renewable power (Lazard 2016). In recent years, several states have increased their EERS targets significantly as part of their strategy to reduce greenhouse gas emissions. Examples include Connecticut, Massachusetts, and Rhode Island (with new targets soon to be set in California).

The role of complementary policies has also been important. In the US, utilities are much more likely to be supportive of energy efficiency, including an EERS, if they receive (1) recovery of direct programme costs; (2) a way to ensure that fixed costs are fully recovered, even if sales go down, and (3) positive financial incentives to shareholders. These issues are discussed more extensively by Molina and Kushler (2015) and RAP (2011).

RESULTS

Table 3 presents state-by-state information on average electric and natural gas targets over the 2015–2020 period. As can be seen, the average electric target calls for achieving incremental savings each year of 1.28 % of electric sales, with natural gas targets just under half as high (0.66 % savings each year). As shown in the third and seventh columns ("covered sales"), in some states these targets apply to all electricity and natural gas sales, while in some states, the targets apply only to investor-owned utilities, with public utilities and electric cooperatives being exempted.

Table 3 also includes information on what was actually achieved in 2015. Electric savings averaged 1.17 %, and natural gas savings 0.54 %, of covered sales. If we include all sales, including those of public utilities not covered by a state's EERS, the adjusted targets are 1.09 % electricity savings and 0.59 % natural gas savings. Table 3 provides only an approximation of how well utilities have done in achieving their targets as the 2015 target is sometimes lower than the 2015–2020 average target and also state-data often combine several utilities, some of whom may exceed targets and some of whom fall a little short. While the states with targets achieved 1.17 % incremental electric savings of covered loads in 2015, the states without any targets achieved only 0.32 % incremental electricity savings (Berg et al. 2016), illustrating that targets are likely a powerful motivator.

Finally, Table 3 includes estimated cumulative electric savings in 2020 as a percent of 2015 electric sales. This latter figure includes savings from energy saving measures installed prior to 2015 that will still be saving energy in 2020 as well as anticipated savings in 2016-2020 assuming targets are met. As can be seen, by 2020 energy efficiency savings will reduce retail electric sales by an average of nearly 11 %, with savings of more than 20 % in two states (as noted earlier, most of these figures are for net savings).

LESSONS LEARNED

The above discussion illustrates that, on average, utilities are meeting their targets, with some even exceeding their targets while other utilities have fallen a little short. Over many years the savings from the targets are adding up to a substantial impact on energy sales. Downs and Cui (2014) more systematically examined implementation of US EERS's. They found that states with targets are generally on track to meet long-term savings targets. For example, they found that in 2012, 15 states met or exceeded their electricity savings targets and only one state met less than 80 % of its target. For natural gas, out of 13 states with 2012 targets, five states exceeded their target and six others achieved at least 90 % of their targeted savings. From their review of target implementation, they found several lessons learned:

- States should plan ramp-up periods to give programme administrators time to bulk up efficiency portfolios and account for regulator lag.
- In addition to targets, states should use complementary policies to encourage utilities to meet targets including sales true-ups (i.e., "decoupling" utility net revenues from sales volumes) and performance incentives.
- To capture all cost-effective efficiency available, states should set challenging targets and allow a range of eligible efficiency measures, including programmes to serve all customer classes.
- States should involve stakeholders in efficiency planning in order to smooth regulatory and legislative processes. Clear, transparent and consistent tests should be used in planning resource portfolios.

Australia

EEOS TODAY

In Australia, there are four EEO schemes in which governments have placed energy saving obligations on energy retailers. Two of these schemes enable trading in energy efficiency certificates (white certificates):

- the Energy Savings Scheme (ESS) in the State of New South Wales (NSW); and
- the Victorian Energy Efficiency Target (VEET) scheme in the State of Victoria.

The other two Australian schemes do not include certificate trading:

- the Retailer Energy Efficiency Scheme (REES) in the State of South Australia; and
- the Energy Efficiency Improvement Scheme (EEIS) in the Australian Capital Territory (ACT).

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Three of these schemes commenced in 2009 and the ACT one began in 2013, although in NSW there was a precursor greenhouse gas emissions trading scheme that began in 2003 and included an energy efficiency component. The current NSW scheme covers electricity retailers and includes the residential, commercial and industrial sectors and both electric and natural gas savings. The other three schemes cover both electricity and natural gas retailers and include residential and small business customers (plus medium businesses in the ACT).

The NSW and Victorian schemes allow implementation of energy saving activities by specialist third parties known as Accredited Certificate Providers (NSW) or Accredited Persons (Victoria). In these schemes, the respective scheme administrators accredit third parties to carry out specified energy saving activities and create white certificates which they then sell to obligated parties. Some large energy users also apply for accreditation to carry out energy saving activities at their own sites and create white certificates. Energy retailers, as obligated parties, can apply for accreditation to carry out specified energy saving activities themselves to meet their obligations. However, most energy saving activities in NSW and Victoria are carried out by accredited specialist third parties and the obligated energy retailers meet their obligations by purchasing white certificates from the third parties and then surrendering these certificates to the scheme administrator.

In the South Australian and ACT schemes, obligated energy retailers can elect either to carry out energy saving activities themselves or to engage the services of third parties to carry out the activities on their behalf without the creation of white certificates. Obligated retailers have generally chosen to engage third parties. The South Australian scheme administrator is not involved with these third parties and obligated energy retailers set their own criteria for engaging third parties. The ACT scheme administrator registers third parties, but this registration does not include assessing or authorising the energy saving activities they intend to carry out.

All Australian EEO schemes allow deeming of savings from specified small-scale energy saving measures and in most of the schemes the majority of savings come from energy savings measures with deemed energy savings. The NSW and Victorian schemes also include methodologies for measuring actual savings from installing large-scale energy saving measures.

In all the Australian EEO schemes, the relevant State governments provide no financial support to obligated energy retailers. In the early years of the NSW and South Australian schemes, before the introduction of retail competition in these states, the relevant state regulator allowed specified dollar amounts to be passed through to retail prices in recognition of the costs faced by the retailers in meeting their EEO targets. Following the introduction of retail competition, this cost is now treated by retailers as a cost of doing business in a competitive retail electricity market. It is generally expected that competitive pressures will encourage obligated retailers to source the lowest cost energy savings.

In 2012, the Australian federal government carried out a policy study on the development of a national EEO scheme, but this did not proceed beyond the initial study stage.

MOTIVATIONS

The main objective of all four Australian EEO schemes is to reduce greenhouse gas emissions. Therefore all Australian schemes initially denominated and reported savings in terms of emissions abated[4], usually expressed as tonnes of carbon dioxide equivalent (tCO_2-e). From January 2015, the South Australian scheme denominated and reported savings in energy terms (GJ). The energy savings corresponding to emissions abated can be calculated using emissions factors. There are different emissions factors for electricity savings (tCO_2-e/kWh) and gas savings (tCO_2-e/MJ). The emissions factors for electricity in each scheme are different, depending on the electricity generation mix in the geographical area covered by the scheme. Emissions factors for electricity may also vary over time as the generation mix changes.

The South Australian scheme also has a secondary objective to carry out energy audits and achieve energy savings in priority low-income households.

RESULTS

In all Australian EEO schemes, total savings over the lifetime of an energy saving measure are credited immediately after completion of the installation of the measure and any required verification of savings. Savings are reported on a cumulative and/or a lifetime basis. Reporting of savings on a cumulative or lifetime basis can make it difficult to compare savings across different schemes because some EEO schemes in other jurisdictions around the world report only annual incremental savings. It is possible to calculate annual incremental savings in some Australian schemes by dividing the achieved lifetime savings for each energy saving measure installed in a particular year by its deemed lifetime in years. However, these data are not publicly available for all Australian EEO schemes. Based on available data, including some data supplied by scheme administrators, our estimates of incremental annual savings for all four EEOs are provided in Table 4. Only the NSW EEO scheme publishes comparable data on cumulative savings, so data on cumulative savings are not included in Table 4. In the NSW scheme, actual cumulative savings during 2015, as reported by the scheme administrator, were 1,835 GWh. Total actual and forecast savings from 2009 to 2025 are 14,043 GWh. The annual cumulative savings start declining from 2015 onwards because the NSW scheme is currently scheduled to close in 2025 and obligated parties will start running down excess stocks of white certificates that they currently hold, while savings achieved through longer-lifetime measures progressively decline.

It is difficult to calculate the costs of energy savings in the four Australian EEO schemes. There are two major factors causing this difficulty: non-disclosure of the costs of energy savings; and the crediting of lifetime energy savings immediately after the installation of a measure. Third parties and obligated energy retailers are not required to disclose their costs to acquire energy savings, so there is no information publicly available about these costs. It is possible to make estimates of the costs by using a proxy, either the average certificate spot

4. Though only the Victorian scheme denominated its EEO target in terms of emissions abated.

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Table 3. Summary of US state EERS results.

	Electric				Natural Gas		
State	Average Target	Percent Covered	2015 Achieved	Estimated 2020	Average Target	Percent Covered	2015 Achieved
Rhode Island	2.6%	99%	2.91%	21.3%	0.9%	100%	1.24%
Massachusetts	2.9%	86%	2.74%	21.9%	1.1%	88%	1.09%
Vermont	2.1%	100%	2.01%	19.6%	--	--	1.01%
California	1.2%	78%	1.95%	12.6%	0.6%	82%	0.75%
Maine	2.4%	100%	1.53%	15.9%	0.3%	100%	0.14%
Hawaii	1.4%	100%	1.52%	13.4%	--	--	0.00%
Connecticut	1.5%	93%	1.48%	13.2%	0.6%	100%	0.54%
Arizona	2.5%	56%	1.19%	17.4%	0.6%	85%	0.87%
Michigan	1.0%	100%	1.16%	8.9%	0.8%	100%	0.82%
Minnesota	1.5%	100%	1.15%	12.2%	1.5%	74%	1.09%
Illinois	0.7%	89%	1.13%	11.2%	1.1%	88%	0.47%
Oregon	1.3%	69%	1.09%	11.1%	0.4%	89%	0.93%
Washington	1.5%	81%	1.06%	11.8%	--	--	0.35%
New York	0.7%	100%	1.05%	6.9%	0.5%	100%	0.46%
Maryland	2.0%	100%	1.01%	12.5%	--	--	0.08%
Iowa	1.2%	74%	1.00%	10.6%	0.2%	100%	0.75%
Ohio	0.6%	89%	0.92%	8.8%	--	--	0.00%
Colorado	1.3%	57%	0.90%	8.8%	0.2%	72%	0.34%
Wisconsin	0.8%	100%	0.79%	7.5%	0.5%	100%	1.08%
Nevada	0.4%	62%	0.72%	5.8%	--	--	0.03%
Pennsylvania	0.8%	97%	0.64%	6.4%	--	--	0.02%
North Carolina	0.4%	99%	0.62%	4.4%	--	--	0.11%
Arkansas	0.9%	53%	0.61%	5.8%	0.5%	60%	0.52%
New Hampshire	0.9%	100%	0.59%	7.1%	0.7%	100.0%	1.12%
New Mexico	0.6%	68%	0.56%	6.7%	--	--	0.13%
Texas	0.1%	70%	0.18%	1.5%	--	--	0.00%
Average	1.28%	85.38%	1.17%	10.89%	0.66%	89.88%	0.54%

Source: Data generally from Berg et al. 2016. Percent covered comes from Downs and Cui 2014. Estimated 2020 savings calculated by S. Nadel, ACEEE, based on data in Berg et al. 2016 and prior-year editions and assuming a 10-year average measure life (from Molina 2014).

Table 4. Estimated incremental annual savings in GWh and as a percent of retail sales for the four Australian EEO schemes.

	2015 Incremental annual savings	
	[GWh]	[%]
New South Wales and Australian Capital Territory	237 (NSW) + 19 (ACT)	0.2%*
Victoria	324	0.3%
South Australia	31**	0.07%

** Final energy consumption only available for NSW and ACT combined.*

*** 311 GWh lifetime savings, assumed lifetime of 10 years.*

Information and data sources: Brazzale (2016), Crossley (2016), Department of Industry and Science (2015), Essential Services Commission of South Australia (2016), Essential Services Commission of Victoria (2016), Jacobs Group (2014), New South Wales Independent Pricing and Regulatory Tribunal (2016), New South Wales Office of Environment and Heritage (2016), Wild-River (2016).

price or the value of the penalties payable by obligated energy retailers who fail to achieve their energy saving (or emissions abatement) targets. Calculations using either the certificate spot price or the penalty as a proxy will necessarily overestimate the actual costs of acquiring energy savings since obligated parties usually obtain certificates at a lower cost through private bilateral transactions.

Using estimates of measure lifetimes and the estimated transaction costs of obligated parties, the relevant government policy agencies conclude that in NSW the average cost per lifetime kWh saved is USD $0.027 (New South Wales Office of Environment and Heritage 2016) and in the ACT it is USD $0.036 per lifetime kWh saved (Wild-River 2016). Estimates of costs in the other two state EEO schemes are not available.

LESSONS LEARNED

The four Australian EEO schemes are unique in enabling specialist third parties to acquire the majority of energy savings that are then sold to obligated energy retailers. This has stimulated the development of an energy services industry that was virtually non-existent before the establishment of the first NSW scheme in 2003. There is now a thriving industry of "certificate provider" firms in NSW and Victoria, and of firms that provide verified energy savings without certificates to obligated retailers in South Australia and the ACT.

The NSW and Victorian schemes complement only a handful of other schemes around the world that use white certificates to trade verified energy savings (Crossley et al 2012). In fact, the NSW scheme was the first operational white certificate scheme in the world, pre-dating the Italian scheme (Crossley 2008). The NSW and Victorian governments are not involved in certificate trading. The scheme administrators operate certificate registries, funded by a small charge per certificate, that record certificate creation, ownership, and change of ownership, but are not trading platforms. The majority of trading occurs through bilateral "over the counter" contracts between certificate providers and obligated retailers, with no price disclosure. A couple of white certificate spot markets, with public price disclosure, have been established by private companies. This method of organising certificate trading is at no cost to government and places the responsibility for managing trading on the parties involved. However, the lack of price disclosure in bilateral contract trading makes it difficult to estimate the actual costs of acquiring energy savings.

All four Australian EEO schemes make extensive use of deeming. Deeming can be open to abuse. In common with other EEO schemes around the world that use deeming, there was some abuse of deemed energy saving values in the early years of the NSW and Victorian schemes (Crossley 2008). In NSW, a large number of small energy saving products, such as compact fluorescent light bulbs and low-flow shower heads, were given away to consumers free of charge in return for the recipient signing a document transferring the white certificates associated with the product to the product provider. Surveys carried out by scheme administrators showed that many of these products were never actually installed. Over time, deeming rules were made more stringent and regulations were introduced requiring proof of installation before white certificates could be created.

There has also been some concern that the extensive use of deeming in the Australian EEO schemes leads to "cream skimming" where the favored energy saving measures are low cost and easy to install whereas other higher cost measures that could achieve deeper energy savings are ignored. The NSW government has identified this problem and in 2016 introduced rule changes that should lead to increased installation of measures that result in deeper energy savings.

Discussion

Overall, this review across three continents shows that EEO schemes can save a large amount of energy cost-effectively. In Europe, MS's are typically saving 0.5 % of covered energy each year at an average cost of saved energy of about 0.5–1 Euro cent per kWh saved. In the US, savings in states with EERS's are averaging more than 1 % per year for electricity and 0.5 % per year for natural gas. The average cost is about 3 US cents per kWh saved. In both Europe and the US, the most aggressive countries and states are saving much more (nearly 3 % per year in Rhode Island and Massachusetts and about 3 % per year in Denmark). In Australia, three of the four EEO schemes are saving between 0.2 % and 0.3 % of covered energy each year. The small South Australian scheme is saving less than this, but this scheme has dual objectives to reduce greenhouse gas emissions and to deliver energy savings to low-income households. Limited data indicate a cost in Australia of 2.7–3.6 US cents per lifetime kWh saved. None of the three continents collect good data on cumulative savings, although available data in the US allow us to estimate that leading states will reduce electricity use by 10–20 % in 2020 due to energy efficiency savings. Comparable data to calculate cumulative savings are not available for the EU and for only one EEO scheme in Australia, indicating a need for improved data collection and reporting.

Based on this experience, in this section we attempt to answer a variety of questions policy makers face when they consider EEOs for their jurisdiction.

WHICH FUELS SHOULD BE COVERED AND WHO SHOULD BE OBLIGATED?

The choice of fuels covered by EEO schemes is driven primarily by the purposes for which the EEO is created. The original driver for EEOs in the United States was the desire to avoid expensive additions to the electric generation fleet in a period of rapidly-growing power demand, so electricity savings were the primary target of most EEO schemes. Later, as the benefits of electricity EEOs became well-known, decision-makers expanded the concept to natural gas utilities, which are now included in about half of the EEO schemes in the US. EEO schemes in Australia have focused on reducing GHG emissions, so they all cover both electricity and natural gas. In Europe, EEO schemes have taken a variety of approaches. Because avoiding carbon emissions and reducing reliance on imported fuels are also important goals in Europe, most EEO schemes (e.g., Italy and the UK) cover natural gas as well as electricity. The EED explicitly defines the energy savings targets as a percentage of all fuels in some MS's, a large fraction of buildings is heated through district heating systems, so some MS's (e.g., Austria, Denmark) have also included district heat. Unlike the US, seven EU MS's also include heating oil. France is unusual in covering all fuels, including district heat, heating oil and transport fuels, in

its EEO scheme. Even though transportation fuels comprise a large fraction of total energy use almost everywhere, very few programmes include them in EEO scheme coverage, leaving efficiency gains in this sector to be captured via vehicle fleet efficiency or emissions mandates, and public transport initiatives.

The obligation to deliver an EEO target usually follows logically from the choice of fuels. The dominant decision is to oblige energy companies to deliver energy savings, most often just across their own fuels, and among their own customers. In the US, in almost all cases, EEOs are limited to network industries, and most impose the obligation on distributors, who remain regulated entities even under conditions of retail supply competition. In contrast, in Australia and many EU countries such as Austria, Bulgaria, France, Ireland, Luxembourg, Poland, Spain and the UK, competitive retail suppliers are the obliged entities. Governments usually avoid putting obligations on relatively small energy providers, where administrative costs may be too high to justify the savings obligation. However, since pooling is always an option, this should not be a permanent bar to broader fuel coverage. For example, in a small number of US states (including Vermont, Maine and Oregon) the obligation is either borne by, or carried out by, an independent "efficiency utility" or regional public utility service organization working with pooled funds from different energy companies. In Texas and Australia, savings are actually delivered by numerous accredited third parties, demonstrating another pathway to EE delivery by actors other than large, regulated energy distributors and suppliers. The key lesson is that EEOs have been successful under a variety of coverage requirements and can be deliver substantial cost-effective savings whether the obligation is imposed on network companies, energy retailers, or "efficiency utilities".

HOW LONG SHOULD EEO SCHEMES LAST, AND WHO SHOULD BE SERVED?

Since energy savings grow slowly compared to supply-side options, it's important for both economic and environmental reasons to impose EEO mandates over rather long time frames. Longer obligation periods are also important in order to call forth long-term savings measures, such as HVAC replacements and building renovations, which are initially expensive but likely to be long-lived. Hard lessons have been learned in jurisdictions, including California, France and the UK, where obligations programmes have lived through "go/stop/go again" transitions. It is hard to develop consumer awareness and hard to build good energy efficiency businesses and financial supports in such conditions. The better practice, as now proposed for the renewal of the EED in Europe, is to presume that EEOs will continue for extended periods without facing multiple short-term stopping points.

Decisions regarding coverage among customer classes tend to be taken on political lines as much as, or more than, technical capabilities and the size of the savings reservoir. All EEO schemes studied serve the residential sector, but only a few, including notably the UK, are limited to that sector. Important savings opportunities exist among commercial and industrial customers, and most EEO schemes serve them as well. Energy intensive industries often seek to be excluded, especially from paying for EEOs and from receiving benefits from EEO schemes. There is strong evidence almost everywhere that cost-effective energy and carbon savings could be delivered in such industries (Goldberg et al. 2014); they should be, and most often are, included, sometimes with special conditions. It is also important to serve low-income households and households facing fuel poverty, both for reasons of equity, and to address objections that the bill increases needed to pay for EEOs are a form of regressive taxation. Many EEO schemes make special provisions and mandates to deliver savings to these households, even though in many cases it is more expensive and more administratively challenging to serve these households than to meet savings obligations in other customer sectors.

HOW IS THE ENERGY SAVINGS TARGET DESCRIBED?

There is great variety both in the nature and metric of the targets set across the EEOs in the US, Europe and Australia. The most common practice is for energy savings targets to be set in terms of final energy consumption, either in absolute terms (common in Europe) or as a percent of consumption (common in the US and in some Australian States). While programme designers are aware that end use efficiency will likely reduce both conventional and global warming emissions, EEOs have a number of other objectives as well, and most programme designs view emission savings as a by-product of the instrument, not its principal goal. A few EEOs have had targets set in CO_2e terms – notably the UK scheme (Rosenow 2012) and the Victorian scheme in Australia – but by far most savings targets are set in terms of energy savings.

An important lesson regarding the target metric is that EEOs are most effective when savings targets are set with a view to lifetime savings, not just first-year or immediate savings. This can be done in a variety of ways – lifetime savings targets (common in Australia), cumulative savings targets that factor in measure life (used in a few US states) or regulatory review to ensure that the majority of savings are from measures with long lives (also done in some US states). Schemes that count only short-term savings will provide strong incentives for short-lived measures, and little incentive for longer-term, sustainable investments that may be more expensive to install but are actually more cost-effective over the long run.

HOW CAN EEO SCHEMES BE PAID FOR, AND WHO PAYS?

The key feature of EEOs is that the obligation to deliver energy savings is borne by energy service providers or an entity acting on their behalf. Thus, for the most part, programme costs are paid by the obliged entities, and either directly or indirectly included in the costs of energy supply and delivery. This approach provides a revenue stream that is appropriately linked to energy consumption, but also spreads programme costs across society and among those who benefit from efficiency investments. Where the obligation is on regulated distribution companies, as is most often the case in the US, EEO costs are usually collected in distribution tariffs, either on a "rolled-in" basis like most other costs, or as an itemized bill element. In liberalized, competitive energy markets where the obligation is on energy retailers, such as in many EU countries and Australia, the cost is borne by competitive suppliers as a general cost of doing business, and may or may not be passed fully into retail prices – this is purely a business decision for each retailer. While this latter approach has the benefit of encouraging creative techniques to lower delivery costs, it also encourages providers to focus on a few low-cost efficiency measures rather than taking a comprehensive, long-term view of participating customers' savings opportunities.

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In addition to funding by obliged entities, a number of other financing schemes have the potential to magnify the positive benefits of EEOs. One important revenue source, still largely underutilized, is carbon auction revenue from carbon taxes or cap-and-trade programmes. Since end-use efficiency is a low-cost option for reducing emissions, dedicating carbon revenues to EEO schemes is a highly effective means to meet carbon goals and has been used in nine US states to greatly expand pre-existing EEO schemes (Cowart 2015). Europe has a much larger carbon market, but so far less than 13 % of revenues has been devoted to energy efficiency (Duwe and Velton 2016). Since the multiple benefits of energy efficiency are well-known, it should be possible to finance programmes from their real beneficiaries. For example, in some regional power markets in the US, efficiency programmes can bid against conventional generation to meet resource adequacy goals, and are paid just as generators are in those markets (Neme and Cowart 2014).

No matter how EEO schemes are paid for, it is important to place their costs in context. Even if an EEO scheme drew funding equal to as much as 8 per cent of billed revenues in an energy sector (higher than any fraction we have studied), this would still mean that 92 % of system revenue is being paid to support energy supply and delivery. And, provided that the EEO scheme is designed to deliver cost-effective savings, end-use customers as a whole would be reducing their energy bills rather than raising them, even with the EEO surcharge in place.

WHAT ARE THE POLITICAL AND ADMINISTRATIVE KEYS TO SUCCESS?

Politically, it is important to regularly document and promote the many benefits of EEOs – energy savings, pollution reduction, health benefits, jobs provided and economic development benefits. Energy efficiency has a wide array of benefits and individual policy-makers may care about different benefits. It is also helpful to maintain broad support for EEOs, working not only with the political party in power but also with major opposition parties so that support for EEO schemes is maintained, even when political power changes. Administratively, an agency or board should be assigned oversight authority and backed by staff or independent consultants (including academics) with appropriate expertise. This agency or board should provide oversight, but should not micromanage programme design or delivery routes. For example, the day-to-day scheme administrator should be provided with authority to make modest refinements to an EEO scheme without requiring the overseer's pre-approval. It is also useful to establish energy savings targets for a multiyear period (commonly at least three years in the US) so that programme implementers can plan ahead and also have some flexibility to "oversave" in some years if they fall a little short of savings targets in other years.

HOW IS QUALITY IMPLEMENTATION ASSURED?

Quality implementation of EEO schemes typically requires several attributes – regular programme evaluation, transparency, good programme oversight, and willingness to make improvements. Evaluation of energy savings and programme processes helps to determine how much energy is saved and how the EEO scheme can be improved. Common improvements will be revising deemed savings values (typically prospectively) to incorporate the latest impact evaluation results, and revisiting and often raising savings targets for future periods. Transparency makes programme details and data available to interested parties, providing opportunities to identify potential programme improvements, and helping to reinforce public awareness of the benefits of the scheme, particularly when compared to the cost of supply-side resources. (In some competitive markets full transparency may not be possible, as illustrated by Australia). And good oversight involves regular reporting to and review by government officials, often aided by technical experts they hire.

WHAT LEVEL OF ENERGY SAVINGS IS REALISTICALLY ACHIEVABLE OVER TIME – CAN SAVINGS DEEPEN EACH YEAR ACROSS DECADES, OR IS THE "HIGH-HANGING FRUIT" JUST TOO EXPENSIVE AND HARD TO REACH?

Experience in the US is that annual incremental savings for electricity of more than 2 % can be achieved, leading to cumulative savings by 2020 of 20 % in leading states. In the US, natural gas savings have been about half these levels. Denmark has saved even more. However, initial targets can and should be set lower and then ramped up over time as explained above for several EU MS's. In the US, targets for annual incremental savings typically start at 0.5 % savings or less in early years, ramping up to 1.0–1.5 % per year, and even to 2 % or 3 % per year in some states. In the US, natural gas targets typically top out at little more than 1 % per year. In the EU initial targets were typically set below 0.5 % but several MS's including Luxembourg and Poland decided to set initial targets higher than that. Luxembourg's approach of essentially copying the Danish scheme may enable it to deliver a higher initial target but we have doubts whether Poland will achieve its targets. All Australian EEO schemes have been gradually increasing their lifetime savings targets since the inception of the schemes.

So far, experience, in the US is that new savings opportunities continue to be developed and that savings rates can be achieved for more than a decade without increasing costs. For example, Baatz and Gilleo (2016) looked at some of the US programmes with the highest savings, finding that over the past seven years, average annual incremental savings increased about two-fold without any increase in the cost per kWh saved.

WHAT ARE THE EFFECTS OF ALLOWING TRADING OF SAVINGS AMONG OBLIGATED PARTIES AND THIRD PARTIES?

Whether explicitly or implicitly, eligible energy efficiency investments generate compliance credits (sometimes called energy efficiency certificates or white certificates) in EEO schemes. With regard to those credits, two different kinds of trading can occur: trading among obligated parties, and trading between obligated parties and independent third party efficiency providers who directly acquire energy savings by installing energy saving measures in end use customers' premises.

The first kind of trading is not uncommon and is permitted in Denmark, the United Kingdom, Italy, France, and Ireland. Trades are merely registered with the EEO scheme administrator so that compliance credit can be given to the purchasing entity and subtracted from the performance reports of the selling entity (Lees and Bayer 2016). This is less common in the US, where regulators seek to ensure that savings are delivered in the same service territories and among the same customers who are paying for the EEO scheme in their bills.

The second kind of trading is much less common. The chief examples are the white certificate trading schemes in Italy and in NSW and Victoria in Australia, the system of Standard Of-

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fers operated by the EEO scheme in Texas, and the Polish white certificate scheme.

In general, trading programmes have added complexity, and sometimes extra consumer costs to EEO schemes that may well exceed the market efficiency benefits that should theoretically be available from a transparent, fully open market for energy savings. The clearest example of this mismatch has occurred in Poland, which launched a complicated EEO scheme based on white certificates trading for the years 2013–2016. The programme design had many moving parts and sub-categories of savings targets, which – together with its short expected life of just three years – undermined its success. Just 3.8 % of the savings anticipated and hoped for was bid into the initial auction for this programme (ENSPOL 2015).

When specialist third parties are authorized to create white certificates and then sell the certificates to obligated parties, trading schemes can have significant economic benefits by stimulating the development of an energy services industry, as has occurred in NSW and Victoria in Australia.

Conclusions

EEOs have been a generally successful policy in all three regions we examine, saving a substantial amount of energy (more than 20 % in a few cases). These savings have generally been cost-effective, with costs generally less than half those of supply-side resources. Based on this positive experience, we make a variety of recommendations for policy-makers interested in developing new EEO schemes or improving existing ones.

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