



Rewarding energy efficiency for energy
system services through markets:
Opportunities and challenges in Europe



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Abbreviations and acronyms

Acronym	Description
BQDM	Brooklyn-Queens Demand Management Program
CE4ALL	Clean Energy for All Europeans
Con Ed	Consolidated Edison
DRIFE	Demand reduction induced price effect
DSO	Distribution system operator
EEOs	Energy Efficiency Obligation Schemes
ISOs	Independent System Operators
kW	Kilowatts
MW	Megawatts
NYPSC	New York Public Service Commission
P4P	Pay-for-performance
PBR	Performance-based regulation
PJM	Regional transmission organisation that coordinates the movement of wholesale electricity in all or parts of 13 US States and the District of Columbia
PPEC	Portuguese Plans for the Promotion of Efficiency in Electricity Consumption
SAVE	Solent Achieving Value from Efficiency
SCMZ	Social Constraint Management Zones
SSEN	Scottish and Southern Electricity Networks
USD	U.S. dollars



Executive summary

Energy efficiency provides value to energy systems in many ways. It reduces energy costs, avoids the need for costly capacity, lowers carbon emissions enabling environmental standards to be met more cheaply, avoids or defers the need for costly network upgrades and allows heating and cooling systems to be used more flexibly. These diverse value streams are often not recognised, with energy efficiency providers under-rewarded for the services they provide. As a result, fewer energy efficiency measures are undertaken, energy systems cost more to maintain, bill payers are worse off and, because of the non-energy benefits that energy efficiency provides, the wider society suffers. This report examines the mechanisms that are in place in the United States (U.S.) and Europe to reward energy efficiency as an energy system resource and draws conclusions for the focus of future efforts in the European Union (EU).

Dedicated energy efficiency markets are a proven way of rewarding energy efficiency. Energy efficiency is not dispatchable in the traditional sense; it is automatically dispatched alongside the load that it moderates. This means that energy-only markets cannot reward energy efficiency directly. However, the value that energy efficiency brings, in terms of lowering the marginal cost of meeting demand, was a key justification behind the setting up of Energy Efficiency Resource Standards in the United States. These Energy Efficiency Obligations (EEOs) on energy utilities to procure energy efficiency gains have also been developed in many European countries in recent years, often with a broader set of objectives beyond energy system efficiency. Some European EEOs employ market mechanisms that enable energy efficiency providers to produce and sell White Certificates to obligated parties. In some European countries, funds levied from bill payers have been used to set up centrally operated auction or tender mechanisms to directly procure energy efficiency improvements in a competitive environment.

Capacity markets should enable energy efficiency to compete on a level playing field. While capacity markets are not a first best solution to issues of electricity system adequacy and reliability, where they are in place, energy efficiency is often excluded either explicitly or implicitly from participating. The capacity markets in New England and the PJM areas in the U.S.



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are examples of markets where energy efficiency is allowed to be bid into auctions, with increasing amounts being cleared over the course of the last 10 years. However, the rules associated with the participation of energy efficiency need to be carefully designed to ensure a level playing field. Rules around the minimum size of bids can act to effectively exclude many efficiency actions, and assumptions around the length of time that efficiency measures can bid for can be severe.

Network operators should be regulated to align their incentives with energy system goals. If network operators were regulated through incentives aligned with societal goals, they would also reward energy efficiency for the services it provides. However, many network operators are faced with a disincentive to reduce load, where revenues are not decoupled from throughput. To address this, performance-based regulation (PBR) is needed to base rewards on outputs instead of inputs, so that network utilities are just as likely to invest in equivalently priced demand-side resources as supply-side equivalents. Given the lack of familiarity with energy efficiency programming amongst network operators, additional incentives to invest in the demand side are justified, at least in the short run. This was the approach taken in the Brooklyn Queens Demand Management Program in the United States and has been part of the inspiration for recent pilot programmes in the United Kingdom.

The adoption by the EU of the Energy Efficiency First principle puts the onus on the energy efficiency industry to prove its value. A key issue for the energy efficiency industry is to be able to produce energy efficiency-based demand reductions that system operators and network utilities can rely upon. As the energy sector and National Regulatory Authorities begin to implement the new elements of the 4th energy package, demanding that distribution network plans provide “transparency on the medium- and long-term flexibility services needed ... (and also) include the use of demand response, energy efficiency, energy storage facilities or other resources that [the] distribution system operator is using as an alternative to system expansion,” the energy efficiency industry and policymakers need to ensure that they are ready to respond. Similarly, as capacity mechanisms take steps to become “open to participation of all resources, including storage and demand-side management that are capable of providing the required technical performance,” energy efficiency service providers need to be able to show that energy efficiency resources can deliver at least as effectively as alternative options.



High quality measurement and verification are preconditions for market participation. System operators and network utilities, with their focus on system adequacy and reliability, need to be sufficiently satisfied, in turn, that energy savings are both adequate and reliable. In addition, as end-use electrification and intermittent renewable energy supply grow in importance, the value of energy efficiency varies increasingly by location, time of day and season. Recent developments in advanced metering infrastructure mean that more and more energy efficiency actions are open to more accurate and granular measurement, meaning that energy efficiency providers should be able to offer services based on metered energy consumption when and where it is most needed. A review of pay-for-performance programmes for energy efficiency will be the topic of the forthcoming deliverable 4.4 of the SENSEI project.



1 Introduction

Traditionally, energy efficiency has been supported across the European Union by dedicated policy instruments providing a combination of financial subsidies and regulatory push.¹ With the adoption of the 'Efficiency First' principle, as part of the Clean Energy for All Europeans (CE4ALL) package and its various legislative components, there are now emerging opportunities for elevating energy efficiency to an energy system resource.² This report looks at different aspects of the energy sector and identifies the opportunities for rewarding energy efficiency for the value it provides to the energy system.

In principle, energy efficiency has many of the characteristics of supply-side technologies:³ increasing energy efficiency is a means for providing energy services at the lowest cost, it helps with increasing the security of supply and it can alleviate congestion in the grid. There is no fundamental reason why energy efficiency could not (and should not) be rewarded for providing those benefits to the energy system. The problem is that there is no single actor that captures this value, making it difficult to monetise/exchange this value without either dedicated energy efficiency markets created through policy, or explicitly allowing energy efficiency to participate in other energy markets. Figure 1 highlights the many different value streams that electrical energy efficiency provides.

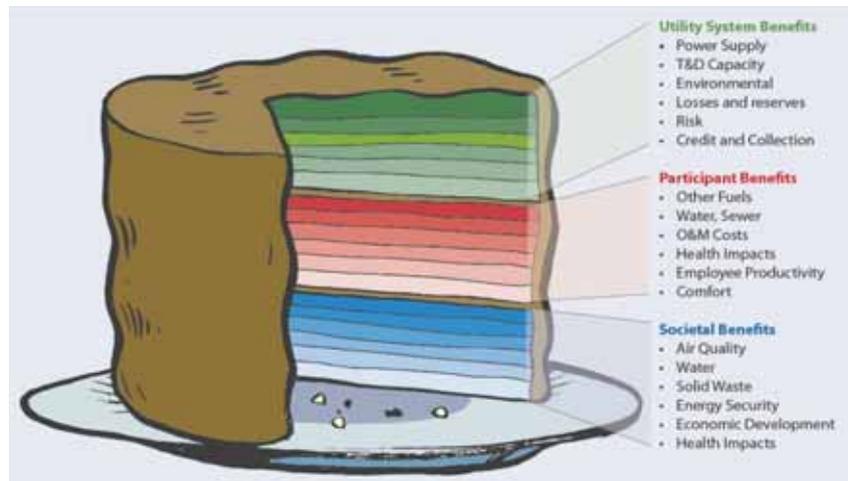
¹ Rosenow, J., Fawcett, T., Eyre, N., and Oikonomou, V. (2016). Energy efficiency and the policy mix. *Building Research & Information*. 44(5-6), 562-574.

² Pato, Z., and Rosenow, J. (2019). *Efficiency First in Europe's new electricity market design – how are we doing?* Proceedings of ECEEE Summer Study 2019

³ ACEEE.(2019). Energy Efficiency as a Resource [Webpage]. Retrieved from <https://aceee.org/topics/energy-efficiency-resource>



Figure 1: A “Layer Cake of benefits from electrical energy efficiency



Source: Lazar, J., and Colburn, K. (2013). *Recognizing the Full Value of Energy Efficiency*. Montpelier, VT: Regulatory Assistance Project. <https://www.raonline.org/knowledge-center/recognizing-the-full-value-of-energy-efficiency/>

Defining energy efficiency in the context of energy systems in transition

At its most basic level, energy efficiency can be defined as the ratio of output of performance, service, goods or energy, to input of energy.⁴ The energy input can be measured before its transformation in power generation or refining (primary energy), or after it is consumed (final energy). An energy efficiency improvement represents an increase in this ratio. Improvements in final energy efficiency tend to *reduce load* by reducing the amount of energy needed to deliver a given service level, for example through more efficient building fabric, lighting and appliances. **It is the set of actions that improves final energy efficiency that is the primary focus of the SENSEI project**, and these actions are often referred to as end-use efficiency, or simply “energy efficiency” for short.

⁴ European Union. (2012). Energy Efficiency Directive. Retrieved from <https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1399375464230&uri=CELEX:32012L0027>



Energy efficiency can provide benefits by enabling the services that society demands from energy systems (for example reliability, adequacy and environmental sustainability) to be met at lower cost. As such, energy efficiency is an energy system resource with benefits not limited to avoided energy, capacity and network costs; avoided environmental compliance costs (e.g., EU Emissions Trading System Allowance costs); and other avoided costs related to risk mitigation, bill collection and consumer credit. It also enables greater flexibility in energy consumption (e.g., in the case of building fabric improvements, allowing buildings to maintain temperatures for longer periods).

In electricity systems, the impact of increasing levels of intermittent renewables on the grid and the electrification of end-uses is to amplify these benefits in some locations and at particular times of the day and year, and to reduce them at others. Energy efficiency can also provide many other economic, social and environmental benefits beyond those that fall to the energy system.^{5,6} At the energy efficiency project level, the challenge is to stack these values without incurring prohibitive transaction costs.

Improvements in primary energy efficiency can be caused by improvements in final energy efficiency and through the more efficient transformation of primary energy into final energy (for example, through renewable electricity generation). *Load shifting*, for example through demand-side response and energy storage technologies, can improve primary energy efficiency by reducing the need for less efficient generation technologies to be deployed at times of high demand. **Onsite renewable generation, storage and demand-side response are not the primary focus of the SENSEI Project.** However, they are connected insofar as technologies or combinations of technologies, such as grid-interactive efficient buildings, may be energy efficient, renewable and capable of delivering load shifting services. In addition, mechanisms that allow energy efficiency to be compensated may be technology neutral, meaning that energy efficiency may compete against other ways of delivering energy system services.

⁵ IEA. (2014). Capturing the multiple benefits of energy efficiency. Paris, France: IEA/OECD. Retrieved from <https://webstore.iea.org/capturing-the-multiple-benefits-of-energy-efficiency>

⁶ Lazar, J., and Colburn, K. (2013). Recognizing the full value of energy efficiency. Montpelier, VT: Regulatory Assistance Project. Retrieved from <https://www.raponline.org/knowledge-center/recognizing-the-full-value-of-energy-efficiency/>



Most of the experience with treating energy efficiency explicitly as an energy system resource can be found in the United States,⁷ where for many years energy efficiency had the opportunity to compete with supply-side investments in a variety of settings. Naturally, our analysis draws heavily on the experience in the U.S. whilst pointing out the limitations in its transferability to the EU context.

As stated above, the aim of this report is to discuss how energy efficiency can be rewarded for the value it provides through non-traditional (market) mechanisms. Our analysis does not include financial support programmes that offer subsidies for energy saving measures. Instead, this analysis focuses on a range of mechanisms that reward energy savings and/or load reduction rather than specific measures. This includes capacity markets, the procurement of network services at the distribution level, and dedicated energy efficiency programmes, such as Energy Efficiency Obligations Schemes (focusing on White Certificate trading) and energy efficiency auctions. The report identifies and analyses successful examples of where energy efficiency has been rewarded as an energy resource in the EU and the U.S. to demonstrate how energy efficiency is already being compensated today and what lessons can be learned from this experience. Finally, the report delivers an analysis of the market and regulatory conditions that would be required to enable energy efficiency to be rewarded for the benefits it delivers to the energy system.

Essentially, there are two types of markets that can be distinguished: **a)** dedicated energy efficiency markets created through policy (this includes White Certificate markets and energy efficiency auctions), and **b)** energy services markets used to procure capacity and network services (this includes capacity mechanisms and tendering for network services to avoid or defer expansion investments).

The report is structured as follows: First, in **section 2**, opportunities for rewarding energy efficiency in energy markets are discussed. **Section 3** examines the procurement of network

⁷ Molina, M. (2014). *The best value for America's energy dollar: A national review of the cost of utility energy efficiency programs*. Washington, DC: ACEEE. Retrieved from <https://aceee.org/research-report/u1402>



services. **Section 4** assesses the role that dedicated energy efficiency markets can play set up by policy. Finally, **section 5** provides conclusions of our work and a set of policy recommendations for end users from the field of policy and practice, including the need for energy efficiency to be able to prove that it is as reliable as supply-side alternatives. This requirement raises the prospect that pay-for-performance programmes, in which energy efficiency is rewarded for delivering energy savings based on metered energy consumption, may have a greater role to play in the future.



2 Energy service markets

There are different types of energy service markets, including wholesale energy markets and capacity markets. Energy efficiency can deliver value that can be monetised in each market, but the ability to directly reward this value varies.

2.1 Energy efficiency and wholesale markets

Energy efficiency does not participate in wholesale markets as it is not a dispatchable resource (unlike generation and demand-side response).⁸ However, energy efficiency has an indirect impact on wholesale markets. Through lowering demand, it results in lower wholesale market prices, an effect called the demand reduction induced price effect (DRIPE).

The reduction in wholesale market prices is sometimes only a fraction of a percent, but at an aggregate level even small reductions in price can lead to significant avoided costs to consumers.⁹ Studies from the U.S. show a range of values for DRIPE:

- New England: 1.25-2.5% reduction in off-peak price, and a 1.5-2.75% reduction in peak price for every percentage reduction in load;¹⁰

⁸ Even though energy efficiency cannot be dispatched in the traditional sense, it does have added value because, by definition, it is dispatched automatically alongside the load that it moderates, correlating with load in a predictable way.

⁹ Baatz, B., Barrett, J., and Stickles, B. (2018). *Estimating the value of energy efficiency to reduce wholesale energy price volatility*. Washington, DC: ACEEE; Chernick, P., and Plunkett, J.J. (2014). *Price effects as a benefit of energy-efficiency programs*. Proceedings of the 2014 ACEEE Summer Study on Energy Efficiency in Buildings 5, pp. 57–69. Washington, DC: ACEEE; Exeter Associates. (2014). *Assessment of the Costs Avoided through Energy Efficiency and Conservation Measures in Maryland*. Retrieved from <https://s3.amazonaws.com/ilsag/AvoidedEnergyCostsinMaryland1.pdf>

¹⁰ Synapse Energy Economics. (2018). *Avoided Energy Supply Costs in New England: 2018 Report*. Retrieved from <https://www.synapse-energy.com/sites/default/files/AESC-2018-17-080.pdf>



- Illinois and much of the Midcontinent ISO territory: 1% reduction in load could reduce Illinois energy prices by 2%.¹¹

There is currently no mechanism to reward energy efficiency directly for providing this cost saving to consumers, but in the U.S. it is taken into account in some states when undertaking cost-benefit analyses and calculating the appropriate amount of energy efficiency investment by utilities.¹² It also forms part of the justification for the introduction of dedicated energy efficiency programmes funded through energy bills discussed later in this report. To the best of our knowledge, studies so far have not quantified either the DRIPE or cost-benefit practices that account for this impact in Europe.

2.2 Energy efficiency in capacity markets

Some system operators have launched capacity markets in recent years, in addition to their markets for energy and ancillary services. The principal purpose of capacity markets is to ensure that adequate capacity will always be available to meet load, including peak periods. Forward-looking capacity markets usually procure capacity on a three- to five-year time horizon. Capacity markets are not used to purchase energy, but seek to ensure that adequate capacity, *i.e.*, the ability to meet energy demand, will be available to serve expected load. (Generators actually dispatched in future time periods will also be paid in the energy market for the energy they produce and sell.) In capacity markets, system operators (and ultimately consumers) pay for the reassurance that reliability will be maintained and reserve margins will be adequate, while some peak prices may also be reduced. The amount of capacity that is estimated to be needed in the future is set by the system operator based on projected load and the desired reserve margin; for this reason, a committed reduction in future load lowers the amount of generation capacity needed, and helps meet capacity requirements just as a power plant does. A “negawatt” is just as valuable as a “megawatt” in the context of a capacity market, as long as the energy efficiency savings can be considered to be as reliable as qualifying generation, *i.e.* that the system operator

¹¹ Kenneally, P., and Stanfield, R. (2014). Natural Resources Defense Council Comments on 2015 Draft Energy Procurement Plan: Analysis of energy DRIPE in Illinois. Chicago, IL: Illinois Power Agency. Retrieved from <https://www2.illinois.gov/sites/ipa/documents/nrdc-comments.pdf>

¹² ComEd (2015). DRIPE around the country. Retrieved from: https://s3.amazonaws.com/ilsag/DRIPE_Around_the_Country_2-16-15.pdf



can be adequately confident that the savings will be delivered. While pay-for-performance (P4P) is not a pre-condition for participation in capacity markets, it does hold out the future prospect of efficiency projects being compensated for something much closer to their actual impacts on the grid. An increase in the certainty associated with energy efficiency performance could make energy efficiency more attractive to system operators.

2.3 Background on capacity markets and energy efficiency

When these markets were first introduced in New England (U.S.) in 2006-08, efficiency and demand response advocates rightly pointed out that actions taken on the demand side to lower demand were just as valuable – and sometimes more valuable – than actions that could be taken on the supply side to add new generation capacity to meet load requirements in peak periods, or when reserve margins are tight for other reasons, such as an unplanned generator outage.¹³ Consequently, some capacity markets have been designed by independent system operators (ISOs) to permit demand response and efficiency assets to compete directly alongside conventional supply-side resources in the auctions set up to procure capacity on a forward-looking basis. The examples in the U.S. are the ISO-New England, PJM and New York-ISO capacity markets, with ISO-New England and PJM having the most experience authorising end-use energy efficiency to bid into their forward capacity markets.¹⁴

These markets invite customer-based resources to compete against conventional generation resources in order to assure that there will be adequate reserve margins to meet power system reliability requirements in future time periods. These demand-side resources fall into two categories: demand response and end-use energy efficiency. Demand response resources are customer-based responses that system operators can call on to improve reliability quickly, and

¹³ The topic was evaluated in the New England Demand Response Initiative, a six-state collaborative, in 2001-03, leading to numerous recommendations to strengthen energy efficiency and demand response in the New England region. See: RAP and Raab Associates. (2003). *Dimensions of demand response: Capturing customer-based resources for New England's power systems and markets*. Retrieved from www.raponline.org/knowledge-center/dimensions-of-demand-response-capturing-customer-based-resources-in-new-englands-power-systems-and-markets/?_sf_s=dimensions+of+demand+response

¹⁴ Neme, C., and Cowart, R. (2014, 12 September). *Energy efficiency participation in electricity capacity markets: The U.S. experience*. Montpelier, VT: The Regulatory Assistance Project. Retrieved from www.raponline.org/document/download/id/7303



over a relatively short period of time (*e.g.*, load reduction by turning off equipment, adjusting thermostats in office buildings, dimming lighting in retail buildings, etc). Energy efficiency resources are reductions in customer load resulting from improvements in end-use technologies that deliver savings when those technologies are used. While these improvements do reduce aggregate load in various ways, including during peak periods, they are not specifically callable by the system operator. Examples include replacing inefficient chillers and motors with more efficient models, replacing incandescent lighting with LEDs, and substituting high-efficiency heat pumps for traditional resistance electric heating. Because demand response and energy efficiency resources have different characteristics and serve to improve reliability in different ways, the rules governing how they can participate in capacity auctions are tailored differently, as they are for generation resources of different types.

2.4 Experience in the United States

The system operator serving New England has substantial experience enrolling efficiency resources in their capacity auctions.¹⁵ As can be seen in Figure 2, experience has led to an increasing role for efficiency in these markets over time, with 2,224 megawatts (MW) of efficiency clearing the market for delivery beginning in 2019.¹⁶ In New England's capacity market, energy efficiency resources are characterised either as "on-peak energy efficiency" or "seasonal energy efficiency," and both types can participate in the auction. "On-Peak energy efficiency" refers to measures that will provide demand reductions during peak hours (*i.e.*, 1 pm to 5 pm) on working days between June and August, and during peak hours (*i.e.*, 5 pm to 7 pm) on working days in December and January. "Seasonal energy efficiency" refers to resources that are defined more by weather conditions (*e.g.*, cold winter days, hot spells in the summer, etc.) than by average hours of operation. Together, these two types will provide 6% of the total capacity cleared for delivery in 2019/20. The PJM system operator has also had substantial experience with demand response and energy efficiency bidding into their capacity markets. However, energy efficiency has played a much smaller proportionate role in the PJM capacity market than it has in New England. For example, in the most recent auction for delivery in

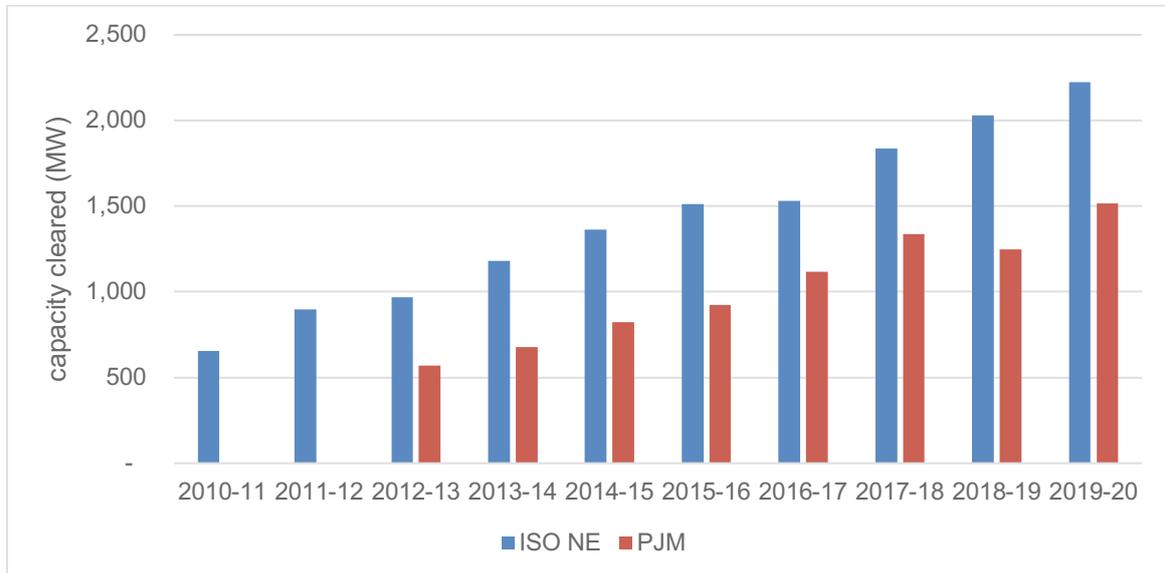
¹⁵ Neme and Cowart, 2014

¹⁶ Liu, Y. (2017). Demand response and energy efficiency in the capacity resource procurement: Case studies of forward capacity markets in ISO New England, PJM and Great Britain. *Energy Policy*(100), pp. 271-282.



2018/19, energy efficiency provided just 1% of the cleared bid capacity, while demand response provided roughly 7%.¹⁷

Figure 2: Amount of end-use energy efficiency cleared in the ISO New England and PJM capacity markets¹⁸



The striking difference between the proportions of capacity resources supplied by energy efficiency in New England compared to PJM has two main causes. First, a close look at the auction rules reveals that it matters how energy efficiency resources are defined, which peak periods are projected by the system operator to be most important to address, and how many years a cleared resource will be paid for reducing load. PJM’s rules for energy efficiency bidding in the capacity market are less attractive to energy efficiency providers than those in New England, where efficiency resources can bid in for more years of their lifetimes. A second difference is that, on average, the New England states have more ambitious obligations than the states in the PJM market. Since utilities and efficiency entities in New England have strong portfolios of energy efficiency measures to deliver, they have a greater quantity of energy efficiency capacity to bid into the capacity auctions.¹⁹

¹⁷ Liu, 2017.

¹⁸ Liu, 2017.

¹⁹ Neme and Cowart, 2014.



Table 1: A comparison of the ISO-New England and PJM capacity markets from the perspective of energy efficiency

Regulatory factors affecting proportion of efficiency resources clearing capacity auction	ISO – New England	PJM
Lifetimes	Resources can be bid until end of operable life	Limited to four years
Utility obligations	Relatively strong obligations	Relatively weak obligations
M&V	IPMVP	IPMVP
Impact of under-performance penalties	Modest	Strong

Source: Adapted from Liu, Y. (2017). Demand response and energy efficiency in the capacity resource procurement: Case studies of forward capacity markets in ISO New England, PJM and Great Britain. *Energy Policy* 100(2017) 272-282.

2.5 Capacity market reform in Europe.

According to the recast Electricity Regulation, capacity markets in the EU should only be introduced as a last resort to address adequacy problems that cannot be solved through the removal of market distortions. There are several capacity mechanisms in 15 Member States.²⁰ The Electricity Regulation and Directive also make clear that demand-side resources such as demand response and energy efficiency must be able to compete with generation on par:

²⁰ ACER. (2019). *ACER market monitoring report 2018 – Electricity wholesale markets volume*. Retrieved from https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Market%20Monitoring%20Report%202018%20-%20Electricity%20Wholesale%20Markets%20Volume.pdf



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security of power supply is no longer about generation adequacy but rather about resource adequacy, which can be served by both supply and demand resources.

Article 18b of the Electricity Regulation reconfirms that demand-side resources need to be treated equally with supply-side resources in capacity mechanisms requiring that they “be open to participation of all resources, including storage and demand-side management that are capable of providing the required technical performance.” Member States with adequacy concerns must set up a plan for market reform that will eventually lead to the elimination of capacity mechanisms (Art 18a). This plan “should enable self-generation, energy storage, demand-side measures and energy efficiency by adopting measures to eliminate any identified regulatory distortions” (Art 18). The Commission will review the implementation plans and decide whether the measures planned for market reform are sufficient. National Regulatory Authorities will report on implementation annually.²¹

The six most recent capacity markets approved by the Commission in early 2018 are open to all types of resources that can provide capacity services.²² This is in line with the new market design adopted by the European Union in 2018. However, the mere acceptance of demand response and energy efficiency bids in the auctions does not necessarily mean that demand resources are on an equal footing with supply. The following example demonstrates why this can be the case using a recent and very prominent example from the UK.

2.6 Example: The UK capacity market

The UK’s capacity market is a mechanism designed to ensure that sufficient future capacity will be available to meet the recently adopted reliability standard. Capacity providers, including

²¹ European Union. (2019). Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity. Retrieved from <https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ%3AL%3A2019%3A158%3ATOC&uri=uriserv%3AOJ.L .2019.158.01.0054.01.EN G>

²² European Commission. (2018). *State aid: Commission approves six electricity capacity mechanisms to ensure security of supply in Belgium, France, Germany, Greece, Italy and Poland* [Press release]. Retrieved from http://europa.eu/rapid/press-release_IP-18-682_en.html



those providing demand response, can bid in auctions to receive capacity payments, which are based on the auction clearing price. It is widely accepted that demand response and energy efficiency can provide additional capacity requirements, often at much lower cost than some conventional supply-side alternatives. However, the current design of the capacity market does not reflect the true value of demand response and efficiency—only a small share of total capacity was awarded to demand response in the first auctions. This is largely because the auction market rules discriminate against demand response (and energy efficiency). The first barrier is the different treatment of demand-side resources: in the Four Year Ahead Auction, new generation assets are eligible for capacity contracts extending over more than a decade and up to 15 years, whereas demand response investments are given only a one-year capacity contract. Because demand response providers must incur the transaction costs of finding and enrolling demand response customers, and installing demand response and energy efficiency technologies (although the benefits of energy efficiency and demand response will accrue over several years), the capacity market rules make demand response programs unprofitable for the majority of potential demand response providers. The second barrier is the minimum capacity size in the capacity market: currently, the minimum capacity size is 2 MW. This is significantly more than in other established capacity markets, such as PJM and ISO-NE in the United States, where the minimum size is 100 kW.²³

The design of the UK capacity market eventually led to a court ruling in November 2018. The EU's General Court annulled the European Commission's decision to approve Great Britain's Capacity Market Mechanism. Tempus Energy, a UK-based demand response company, accused the Commission of approving the mechanism without properly assessing if it was designed to be technology neutral. Tempus claimed that the mechanism discriminates against demand response by allowing it only to bid for one-year contracts, whereas generators – mainly fossil fuel operators – can bid for contracts lasting for three or even 15 years. This restriction deteriorates the business case for demand response, considering the transaction cost of finding and enrolling consumers to be aggregated, and installing the required information technology infrastructure for providing reliable service. In addition, some design features, such as the 2 MW minimum bid size and the large bid bond requirement in t-4 auctions (auctions which procure

²³ Neme and Cowart, 2014.



resources four years in advance of their deployment), discriminate against demand response, which generally comes in smaller (and more flexible) increments and is provided by aggregators that often lack the access to financial assurances, which are not, in fact, necessary.²⁴ Apart from the immediate suspension of further auctions in Great Britain, this ruling might have ramifications for the approval of new requests for capacity mechanisms. Following an investigation, in October 2019, the European Commission approved the reinstatement of the UK capacity market, and noted that the UK government was planning a number of changes to the design of the auctions, including a lowering of the minimum capacity threshold for participating in the auctions and access to long-term contracts.²⁵

2.7 Lessons learned

Five important lessons have emerged from these experiences:

- First, by driving investments in end-use efficiency, energy efficiency programmes demonstrably contribute to lowering peak demands on power systems, and those reductions can lower both the total quantity of supply-side capacity needed to provide reliable service, and the clearing price that is paid to all resources through the capacity auction, lowering the cost of resource adequacy to consumers. The main purpose of capacity auctions is to use a market mechanism to drive down the cost of providing projected system capacity needs. By opening the auction to energy demand-side resources, the cost of meeting system adequacy goals can be substantially lower than it would have been if only supply-side resources were permitted to compete. For example, in the first capacity auction held in ISO New England in which demand-side resources were permitted to bid, it was estimated that demand-side resources lowered total costs by USD 280 million, with energy efficiency alone responsible for approximately one third of the demand-side savings.²⁶ Following a later auction in PJM, PJM's independent market

²⁴ Bright, S. (2018). *Expert view: What does the General Court view mean for Great Britain's Capacity Market?* ClientEarth. Available at: www.clientearth.org/expert-view-what-does-the-general-court-ruling-mean-for-great-britains-capacity-market/

²⁵ European Commission. (2019, 24 October). *State aid: Commission approves the British Capacity Market scheme* [Press release]. Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/IP_19_6152

²⁶ Jenkins, C., Neme, C., and Enterline, S. (2009). *Energy efficiency as a resource in the ISO New England forward capacity market*. ECEEE 2009 Summer Study Proceedings



monitor concluded that demand-side resource participation had reduced total consumer costs for capacity by as much as USD 12 billion in a single auction period. Most of the capacity savings came from the demand-response assets, but a meaningful share came from energy efficiency capacity bid into this market. This highlights the point that energy efficiency and demand response participants are delivering substantial windfall gains to non-participants; compensating them appropriately would encourage more cost-effective demand-side participation.

- The second lesson is that there is no single or simple method for including energy efficiency resources in capacity markets. The rules for assigning capacity values to energy efficiency resources, and the terms under which they can be paid, can make a very large difference in how well they will perform in a capacity auction. In addition, climatic and system variables will mean that different capacity markets will require different capacity load profiles.
- Third, the prices paid in capacity markets are by themselves insufficient to cover the full costs of the obligations that deliver these benefits. This is not surprising. Resources that clear in a capacity auction are paid only for the capacity (or capacity reduction) that they deliver, not the amount of cost savings that they confer on end-use customers by reducing their energy requirements and lowering clearing prices. Indeed, neither demand- nor supply-side resources rely solely on capacity payments. Efficiency Vermont estimates that it receives less than 10% of the cost of energy efficiency programmes in Vermont (U.S.) back from the ISO New England capacity market.
- Fourth, the rules governing the auctions do not permit pre-existing energy efficiency measures to bid into the forward capacity market, as their impact on demand simply shows up as a reduction in the systemwide demand projection, so no payment is made for them. Pre-existing generators, on the other hand, are paid to continue to be available during the period covered by the auction. The decision on whether to include efficiency resources in the baseline forecast (as is the case of the French capacity market, for example), or as resources that can continue to bid into capacity auctions is critical. Both options are possible. It has been argued in the PJM context that efficiency resources should not be



able to bid, since future efficiency is now being included in load forecasts.²⁷ On the other hand, aligning the payment for efficiency services with the beneficiaries, in this case the system operator, better aligns market incentives, as well as making it more likely that efficiency gains will be supported in the long term, and providing an upfront stream of payments to efficiency aggregators. It is important, however, that if efficiency is allowed to bid in auctions, the amount of capacity procured reflects this.

- Finally, it is instructive to note that including energy efficiency in capacity market auctions provides a partial answer to the question “Is efficiency reliable?” The system operators who administer capacity mechanisms are highly focused on system reliability, and have high standards for resources that will be cleared for payment in a capacity market. Efficiency resources are paid only for demonstrating that they will reliably reduce load during system peak periods. Measurement and verification protocols for capacity programmes are stringent, but efficiency programmes have met these standards, and have demonstrated that they deliver capacity savings as well as energy savings in wholesale power markets.²⁸ P4P programmes are being experimented with as a way of providing more certainty to system operators.²⁹

This report assesses opportunities for rewarding energy efficiency for the value it provides to the energy system. As noted above, the funds that can be earned by energy efficiency resources in all-resource capacity markets are much less than the full cost of delivering those measures, and just a small fraction of the full value that the measures are delivering to participants and society more broadly.

In Vermont, where the obligation is adding savings of about 2.1% per year of electricity consumption, the programme’s capacity savings are bid into the New England ISO capacity

²⁷ Monitoring Analytics. (2016). *State of the market report for PJM*. Retrieved from www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2016/2016-som-pjm-sec5.pdf

²⁸ For example, after ex-post analysis of performance, the New England system operator concluded that, for planning purposes, efficiency resources will be available on a 100% basis, while real-time demand response is rated at 89% and generation availability is rated at 94.1% on average (Neme and Cowart 2014).

²⁹ Best, C., Brown, B., Fisher, M., and Wyman, M. (2019). Policy pathways to pay-for-performance. Presentation at IEPEC Conference 2019. Retrieved from https://www.iepec.org/wp-content/uploads/2019/08/3C-Policy-Pathways-to-Meter-Based-Pay-for-Performance---Carmen-Best_OpenEE.pdf



market, and the net revenues received are equivalent to about 10% of the overall programme costs.³⁰ Thus, while it is highly valuable to include energy efficiency and demand response in competitive capacity auctions, it would be unwise to count on the revenues from capacity markets to pay for the efficiency programmes in the first place. In New England and PJM, this is understood. States in these regions rely on their obligation mechanisms to ensure delivery of a growing energy efficiency resource, which can then be bid into the capacity market. Figures from New England show that 99% of capacity from energy efficiency is allocated to utilities with an obligation, suggesting that without obligations energy efficiency would not be able to compete in the current capacity market.³¹ However, from an investor perspective, a portfolio of energy efficiency projects that is deemed reliable enough to participate in a capacity market is also a portfolio that is reliable enough for investors to provide capital. This idea underpins a large part of the work envisaged in the SENSEI project.

³⁰ Neme and Cowart, 2014.

³¹ ISO-NE. (2015). *Annual forward capacity market auction acquires major new generation resources for 2018-2019*. Retrieved from www.iso-ne.com/static-assets/documents/2015/02/fca9_initialresults_final_02042015.pdf



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3 Procuring network services

Network investment is a costly business and the cost of an electricity network is directly linked to the level of peak demand expected across it. Therefore, cost-effective energy efficiency measures that reduce peak load will bring substantial benefits to transmission and, in particular, distribution network companies and eventually will bring lower network tariffs to consumers.

Network operators also procure network services as part of their operations, often through a bidding process. Considering so-called “non-wires solutions” as an alternative to network extension offers more options to meet higher peaks or to replace aging network elements.³² This may sound like common sense. However, typical approaches used to regulate transmission and distribution companies tend to reward capital investments owned by the operator and increases in “throughput” or the level of energy sold across the system. This means that, in many cases, energy efficiency measures would be harmful to their profitability. Network regulations that align national energy efficiency policy goals with network operators’ private financial interests are needed. This boils down to several regulatory design requirements: the removal of two major disincentives and the addition of incentives for energy savings.

First, the network company’s remuneration needs to be decoupled from its electricity sales, or in the case of a wires-only, unbundled distribution system operator (DSO), from the volume of electricity delivered. This is the case in many U.S. states, for example in California. Second, regulation needs to ensure that the network company is indifferent to the type of solution it applies to upgrade its operation to meet consumer expectations. In other words, regulation should not favour capital investment.

³²Neme, C., and Sedano, R. (2012). *U.S. experience with efficiency as a transmission and distribution system resource*. Montpelier, VT: Regulatory Assistance Project. Retrieved from <https://www.raponline.org/knowledge-center/us-experience-with-efficiency-as-a-transmission-and-distribution-system-resource/>



Apart from removing disincentives, network regulation can align the DSOs' interests with public policy goals. Performance-based regulation is an incentive-based regulatory framework that focuses on outputs rather than inputs. Most often, it is an extra layer of regulation applied over revenue-cap regulation, where the goals are integrated more consistently. PBR offers the prospect of higher returns if companies deliver services at a price and quality consistent with what society and customers want. A fundamental requirement of PBR is, therefore, to define outcomes that reflect public policy goals. Outputs need to be measurable, so that network companies can be held to account for delivery. They must also be credible, with appropriate rewards and penalties for over- or under-delivery.³³ Outputs will include traditional needs and services such as reliability and quality of supply, conditions for connection, customer satisfaction and safety, but can also include requirements to consult more widely in developing business plans and achieve stakeholder support for specific investments. In the future, PBR objectives should include outputs specifically related to the energy transition, with a focus enabling prosumerism, demand flexibility and energy efficiency.

3.1 Experience from the United States

Over the course of the last four decades, the deployment of energy efficiency resources in many U.S. jurisdictions has had the effect of avoiding USD billions in network investments. Indeed, in New York State alone, Consolidated Edison (Con Ed) reduced its projected transmission and distribution capital expenditures by over \$1 billion as a result of the impact of systemwide energy efficiency programmes on load forecasts. This is an example of passive investment deferral.³⁴

The leading example where network investment has been explicitly deferred through alternative, non-wires solutions in the United States is the Brooklyn-Queens Demand Management Program (BQDM) launched in 2014.³⁵ The original solution proposed by the local

³³Pató Z., Baker, P., and Rosenow, J. (2019). *Performance-based regulation: Aligning incentives with clean energy outcomes*. Manuscript in preparation. Brussels, Belgium: Regulatory Assistance Project.

³⁴ Neme and Sedano, 2012.

³⁵ Con Edison. *Brooklyn Queens Demand Management Demand Response Program* [Webpage]. Retrieved from www.coned.com/en/business-partners/business-opportunities/brooklyn-queens-demand-management-demand-response-program



utility Consolidated Edison to the New York Public Service Commission (NYPSC), at an estimated cost of \$1 billion, included building a new distribution substation, expanding an existing 345 kV switching station and constructing a sub-transmission feeder to connect the two stations. Instead, the Public Service Commission induced Con Edison to look at non-traditional investments by offering performance incentives in the utility remuneration scheme and accelerated depreciation of these non-traditional network investments (as short as 10 years).³⁶ Accordingly, Con Edison can receive up to 100 basis points above its authorised rate of return on BQDM programme investments: 45 basis points for achieving the proposed 41 MW demand reduction through alternative measures, 25 basis points for increasing the diversity of distributed energy resources in the marketplace, and 30 basis points for achieving a lower dollar-per-megawatt value than traditional investments. Each additional basis point represents 1/100th of a percentage point above the rate of return on investments that the utility is authorised by the regulator to pass through to end consumers.

The NYPSC approved open solicitation for demand-side solutions to reduce load by at least 52 MW for periods as long as 12 hours per day on peak summer days. Through an open request for information, it proposed to “seek multiple solution providers, so that multiple approaches and technologies can be evaluated to determine the best aggregate solutions.”³⁷ The BQDM included a wide array of options for reducing demand: 11 MW of non-traditional utility-side solutions, and 41 MW of customer-side solutions such as demand response, energy efficiency, storage, fuel cells and combined heat and power, in addition to 17 MW traditional solutions, such as

³⁶ Girouard, C. (2019, 11 March). BQDM program demonstrates benefits of non-traditional utility investments. *Utility Dive*. Retrieved from www.utilitydive.com/news/bqdm-program-demonstrates-benefits-of-non-traditional-utility-investments/550110/

³⁷ State of New York Public Service Commission. (2014). Petition of Consolidated Edison Company of New York, Inc. for approval of Brooklyn/Queens demand management programme. State of New York: New York. As cited in International Energy Agency. (2017). *Market-based instruments for energy efficiency*. Author. Retrieved from https://www.iea.org/publications/insights/insightpublications/MarketBased_Instruments_for_Energy_Efficiency.pdf



capacitor and load transfer solutions.³⁸ The solutions implemented through 2017 are shown in **Table 2**.

Table 2: Non-traditional solutions implemented through 2017

Customer-side savings (\$54M invested)		Utility-side savings (\$15.8M invested)	
Commercial Direct Install Program	10.7 MW*	Voltage Optimization	16.5 MW
Multi-Family Energy Efficiency Program	4.3 MW*	Distributed Energy Storage System	0 MW
Dynamic Resource Auction	3.29 MW	Total	16.5 MW
Residential Energy Efficiency Program	2.4 MW	The majority of demand reductions come from four programs: 1) voltage optimization; 2) the commercial direct install program (energy efficiency); 3) multi-family energy efficiency program; and the dynamic resource auction (demand response).	
Direct Customer Activity	0.03 MW		
Partnership with NYC Housing Authority	1.6 MW		
Combined Heat & Power	0.8 MW		
Fuel Cell	0.8 MW	*Note: These are contracted rather than verified savings. Total verified savings are 22.1 MW (for customer-side) through 2017 as there is a slight gap between contracted and hourly operational savings	
Total	23.92 MW		

Source: Utility Dive. (2019, 11 March). The BQDM program demonstrates benefits of non-traditional utility investments. Retrieved from: <https://www.utilitydive.com/news/bqdm-program-demonstrates-benefits-of-non-traditional-utility-investments/550110/>

These solutions were expected to defer the need for traditional infrastructure investment for at least seven years. The NYPSC approved a \$200 million budget, plus \$305 million for the traditional solutions, in December 2014. In July 2017, the NYPSC extended the BQDM programme beyond the initial three-year period, with no end date and no additional funding. As of 2017, Con Edison had only spent \$69.9 million on the BQDM programme, \$54 million for customer-side solutions, and \$15.8 million for utility-side solutions. It still has \$130.2 million that can be spent in the future. From this budget, the utility plans to continue procurement beyond the original 41 MW of customer-side electricity demand reduction solutions (projected to increase to 44.5 MW by 2021), and 11 MW of non-traditional utility-side solutions (projecting 18 MW by 2021). In 2019, Con Edison proposed — and the NYPSC subsequently gave its approval

³⁸ Smart Electric Power Alliance, Peak Load Management Alliance, and E4TheFuture. (2018, November). *Non-wires alternatives: Case studies from leading U.S. projects*. Retrieved from https://e4thefuture.org/wp-content/uploads/2018/11/2018-Non-Wires-Alternatives-Report_FINAL.pdf.



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— that the utility may earn 30% of the annual net benefits for future non-wires alternative projects.³⁹

3.2 Experience from the EU

In Europe, so far, energy efficiency has received limited attention from regulators and network companies as a grid resource. This is likely to change as the new market design element of the 4th Energy Package requires that distribution network plans “provide transparency on the medium- and long-term flexibility services needed ... (and also) include the use of demand response, energy efficiency, energy storage facilities, or other resources that the distribution system operator is using as an alternative to system expansion” (Art 32[3] of Electricity Directive). This is an important provision as distribution network development plans need regulatory approval and could be rejected if energy efficiency has not been considered explicitly. Distribution network development plans must be published and submitted to the national regulatory authority every two years. National Regulatory Authorities must ensure proper incorporation of demand-side resources into the distribution network development process and has a mandate to request amendments to the plans as necessary. The new European market design framework provides direction for implementing alternatives to network extension, both in network development and network operation. It is now up to the national regulators to embrace this concept and devise network regulation that not only removes disincentives to energy efficiency but creates sustained interest in pursuing this goal.

There is also practical experience with using energy efficiency as a network service. A good example is the Social Constraint Management Zones (SCMZ) initiative of Scottish and Southern Electricity Networks (SSEN)⁴⁰ in the UK. Instead of accommodating increasing electricity demand

³⁹ Girouard, 2019.

⁴⁰ Scottish and Southern Electricity Networks. (2019, 27 March). *SSEN scores a hat-trick at inaugural Network Awards*. Author. Retrieved from <http://news.ssen.co.uk/news/all-articles/2019/march/network-awards-2019/>; Coyne, B. (2019, 31 January). SSE Networks to bring households into demand-side response this summer. *The Energyst*. Retrieved from <https://theenergyst.com/sse-networks-to-bring-households-into-demand-side-response/>; Peachey, A. (2019, 5 February). SSEN introduces SCMZs into network operations. *Gas Power Heat Systems Network*.



by extending the capacity of the network, the SCMZ involves the procurement of “smart” or “non-wires” solutions in a number of locations in its network. The objective is to reduce load and contribute to the secure supply of power to consumers. Consumers and a variety of other suppliers who can deliver solutions to grid congestion, ranging from battery storage to energy efficiency, will be invited to offer flexibility services to the DSO within the identified regions in return for commercial rewards. According to the plan, demand response aggregators will not be necessary for participation. This allows the plan to include a broad range of participants. SSEN is still assessing whether to implement a minimum threshold, given that a DSO procuring flexibility services usually requires at least 100kW per provider.

SSEN plans to make the scheme attractive to customers in its commercial and delivery terms by eliminating penalties. Potential participants could include, for example, a housing association that has been planning to improve the insulation in its building stock to achieve the required standard assessment procedure ratings. By committing to this investment and focusing on the SCMZ area, the housing association can gain additional contributions toward the costs. Another example would be a local government that wants to promote energy efficiency measures in a given area. By identifying and promoting the kinds of steps customers may take, the local government can receive payments toward furthering the initiative based on performance and measurable energy performance improvements.⁴¹

SSEN reviewed potential regions for the initiative and initially selected three zones, shown in **Figure 4**,⁴² that have sufficient commercial value to proceed with a tender, beginning in summer 2019.

Retrieved from <https://networks.online/gphsn/news/1001441/ssen-introduces-scmzs-network-operations>; Scottish and Southern Electricity Networks. (2019, 4 February). *Maximising community opportunities and benefits through smarter electricity solutions*. Author. Retrieved from <http://news.ssen.co.uk/news/all-articles/2019/february/maximising-community-opportunities-and-benefits-through-smarter-electricity-solutions/>

⁴¹ Reid, S., Howison, A., and Edwards, C. (2018). *Social Constraint Managed Zone Workshop* [Presentation]. Retrieved from <https://new.theclaymoreproject.com/uploads/entities/1230/files/Events/Conference%202018/SSEN%20workshop.pdf>

⁴² Reid *et al.*, 2018.



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Figure 4: Constraint Managed Zones



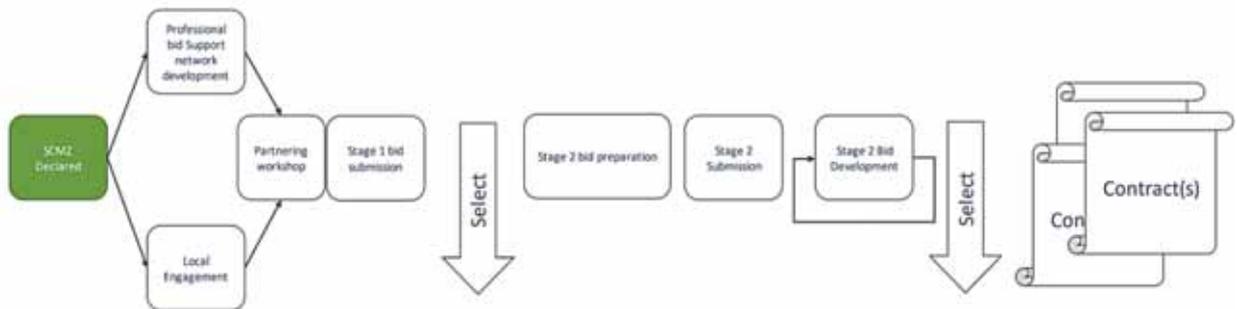
Source: Reid, S., Howison, A., and Edwards, C. (2018). Social Constraint Managed Zone Workshop.

Retrieved from (accessed July 2019):

<https://new.theclaymoreproject.com/uploads/entities/1230/files/Events/Conference%202018/SSEN%20workshop.pdf>

The process, depicted in **Figure 5**, will entail multistaged bidding preceded by partnering workshops where potential flexibility suppliers are invited to get involved.

Figure 5: The contracting process



Source: Reid, S., Howison, A., and Edwards, C. (2018). Social Constraint Managed Zone Workshop.

Retrieved from (accessed July 2019):

<https://new.theclaymoreproject.com/uploads/entities/1230/files/Events/Conference%202018/SSEN%20workshop.pdf>

The SCMZ initiative follows the encouraging outcomes of the Solent Achieving Value from Efficiency (SAVE) project, pioneered by SSEN in partnership with the University of Southampton,



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DNV GL and Neighbourhood Economics, from 2014 to 2019. The SAVE project, which involved 4,000 homes, tested four energy efficiency interventions to determine the extent to which energy efficiency measures can be a cost-effective, predictable and sustainable tool for managing peak and overall demand as an alternative to network reinforcement. In addition, the SAVE project produced a network investment decision tool that allows DSOs to assess and select the most cost-efficient methodology for managing electricity distribution network constraints. The process considers the effects of different types and degrees of energy efficiency interventions, as well as more traditional techniques for network reinforcements.⁴³ The project provides a blueprint for building closer relationships with customers and local stakeholder organisations by empowering them to better control their electricity consumption and, in turn, receive lower bills and achieve carbon reductions.

3.3 Lessons learned

Energy efficiency can reduce the costs of maintaining or expanding network service levels by deferring or avoiding the need to invest in more expensive network infrastructure. The BQDM Program is a prime example of this in practice.

Most regulatory frameworks currently do not reward investments by network operators in energy efficiency, or may even provide a disincentive for reducing load where revenues are not decoupled from throughput. To address this, PBR of network operators is needed to ensure that their incentives are aligned with the delivery of service levels at least cost. This means basing rewards on outputs instead of inputs, so that network utilities are indifferent between capital

⁴³ Scottish and Southern Electricity Networks. (2017, 21 December). *Project SAVE - network modelling tool. Report on development*. Author. Retrieved from https://save-project.co.uk/wp-content/uploads/2019/06/Network-Modelling-Tool_SDRC_7.2.pdf; Scottish and Southern Electricity Networks. (2014, December). *SAVE (Solent Achieving Value from Efficiency) Report 7.1 – SAVE Initial Network Model*. Author. Retrieved from https://save-project.co.uk/wp-content/uploads/2019/06/Initial-Network-Model_SDRC_7.1.pdf



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investment and “non-wires” alternatives with the same expected return in terms of service level. Many states in the U.S. have applied PBR in network regulation to good effect.⁴⁴

More pilot programmes are needed in the EU along the lines of the SCMZ pilots run by SSEN in the UK. These pilots have used geographically disaggregated data to identify where energy efficiency is most valuable, helped raise awareness amongst network companies of the opportunities for non-wires alternatives, and forged new links between network utilities, energy efficiency service providers and community-based organisations.

⁴⁴ Little, D., and Kadoch, C. (2017, 21 September). *Performance-based regulation: The power of outcomes*. Montpelier, VT: Regulatory Assistance Project. Retrieved from <https://www.raponline.org/knowledge-center/performance-based-regulation-power-outcomes/>



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4 Dedicated energy efficiency markets

Recognising both the benefits that energy efficiency can bring to energy systems by reducing costs and the market failures affecting energy efficiency take-up, policymakers can also set up dedicated energy efficiency programmes funded by bill payers. This approach was first taken in the United States in the 1980s where many states required utilities to engage in “Least-Cost Planning” or “Integrated Resource Planning.” In some instances, this meant procuring energy efficiency savings on an equal basis with supply-side resources.⁴⁵ The implementation by policymakers of these obligations on utilities expanded rapidly in the 2000s, and there are now over 50 of these types of measures worldwide (IEA, 2017).⁴⁶

Two dedicated levy-funded policy instruments create a market for energy efficiency where it is traded. Trading usually takes place between the bidder of energy efficiency projects and the buyer, who can be an obligated party as part of an Energy Efficiency Obligation purchasing White Certificates that certify energy savings and/or the entity in charge of an energy efficiency auction. Each type of mechanism is described below in turn.

4.1 Energy Efficiency Obligations (EEOs)

EEOs set a target (usually in terms of energy savings) that needs to be achieved by energy companies (the obligated parties). The energy companies obligated can be distribution companies, suppliers, retailers, or a combination. Across the world, a variety of approaches have been chosen.⁴⁷ Obligated parties have the freedom to achieve the target set for them through a range of means: they can deliver the target through providing energy efficiency measures directly to customers, they can work with intermediaries (e.g., trade bodies, municipalities,

⁴⁵ York, D., Witte, P., Nowak, S., and Kushler, M. (2012). *Three decades and counting: A historical review and current assessment of electric utility energy efficiency activity in the states* (No. U123). Washington, DC: American Council for an Energy-Efficient Economy

⁴⁶ Rosenow, J., Cowart, R., Thomas, S., Kreuzer, F. (2017): *Market-Based Instruments for Energy Efficiency. Policy Choice and Design*. IEA/OECD: Paris

⁴⁷ Rosenow *et al.*, 2017



managing agents, etc.), or they can in some circumstances purchase energy savings through a trading mechanism. In this case, so-called White Certificates are issued for energy savings achieved by those who deliver energy efficiency projects. Those certificates can then be traded in an open market.

Globally, the use of White Certificate trading has been limited and most EEOs do not comprise of this feature. The only countries where White Certificate trading exists are Australia (in two programmes at state level), Italy, France and Poland. Three existing White Certificate programmes from Europe (*i.e.*, Italy, France and Poland) are described here briefly.

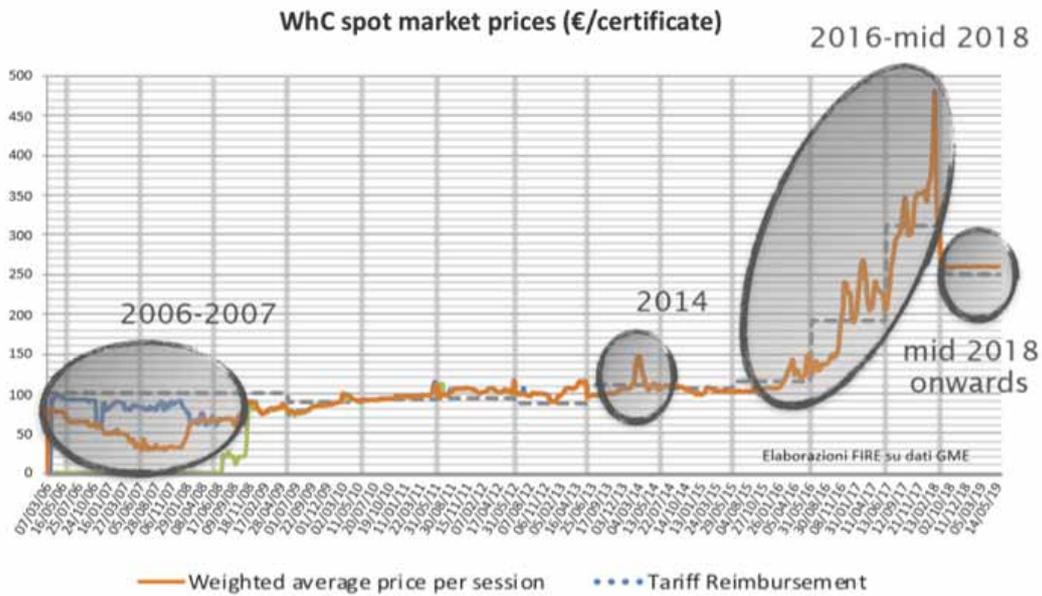
4.1.1 Italy

The White Certificates programme in Italy is the oldest EEO with this feature globally. The EEO is placed on distribution companies with more than 50,000 customers and it began in 2005. Each White Certificate represents one tonne of oil equivalent saved due to the interventions carried out. The exchange of White Certificates between obligated and eligible parties takes place on a dedicated platform managed by Gestore dei Mercati Energetici S.p.A., a public company owned by Gestore dei Servizi Energetici. The two options available for purchasing White Certificates are: **a)** through a spot market exchange mechanism, or **b)** through bilateral trading between parties.⁴⁸

⁴⁸Di Santo, D., & De Chicchis, L. (2019). *White Certificates in Italy: will it overcome the huge challenges it has been facing in the last three years?* Proceedings of the ecee Summer Study



Figure 6: White Certificate prices in Italy



Source: Adapted from Di Santo, D. (2019), *White certificates in Italy: lessons learnt in recent years*, presentation at IEA-RAP workshop.

Analysis of the costs of savings achieved shows a cost of 0.8 euro cents/kWh which is within the range of other European programmes supporting energy efficiency.⁴⁹

The significant increase in prices is due to multiple reasons. The rules around proving additionality have been tightened, projects with a payback period less than three years no longer qualify, and at the same time, it was discovered in 2017 that a significant portion of the savings were based on fraudulent claims made by companies set up solely for this purpose run by companies based outside of Italy. The government subsequently introduced a price cap in order to control the spiralling costs of the programme.⁵⁰

⁴⁹ Rosenow, J., and Bayer, E. (2017): Costs and benefits of Energy Efficiency Obligations: A review of European programmes. *Energy Policy*(107),53-62

⁵⁰ Di Santo, D. (2019). *White certificates in Italy: lessons learnt in recent years*. Presentation at IEA-RAP workshop, Paris, France. Retrieved from <https://www.iea.org/events/modernising-energy-efficiency-obligation-programmes>

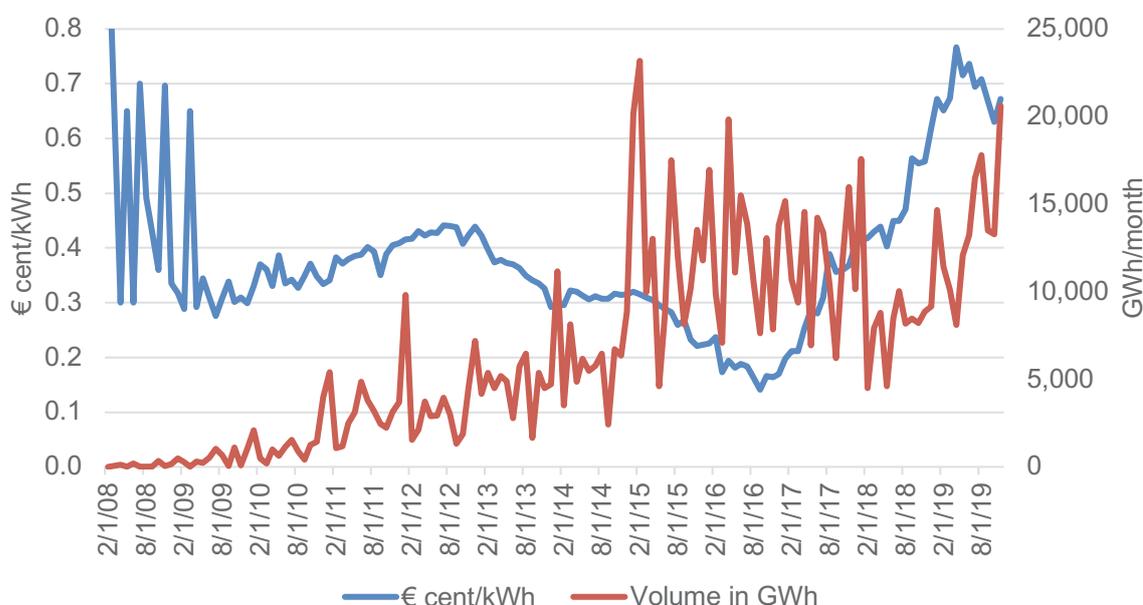


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4.1.2 France

France has used trading of White Certificates since 2008. After an initial period of heavily fluctuating prices, the price per kWh (lifetime savings) rose steadily until the end of 2012. After that, a period of declining White Certificate prices lasted until late 2016, with prices increasing since then. The volume of certificates traded increased steadily until early 2015 followed by a three-year period of stagnation and decline. Since mid-2018, traded volumes have increased significantly.

Figure 7: White Certificate prices and volume traded in France⁵¹



The average price per kWh of savings over the last year is 0.7 euro cents. This is well below the costs of energy in France.⁵²

⁵¹ Own creation based on data obtained from <https://www.emmy.fr/public/donnees-mensuelles?precarite=false>.

⁵² See also Rosenow and Bayer, 2017.

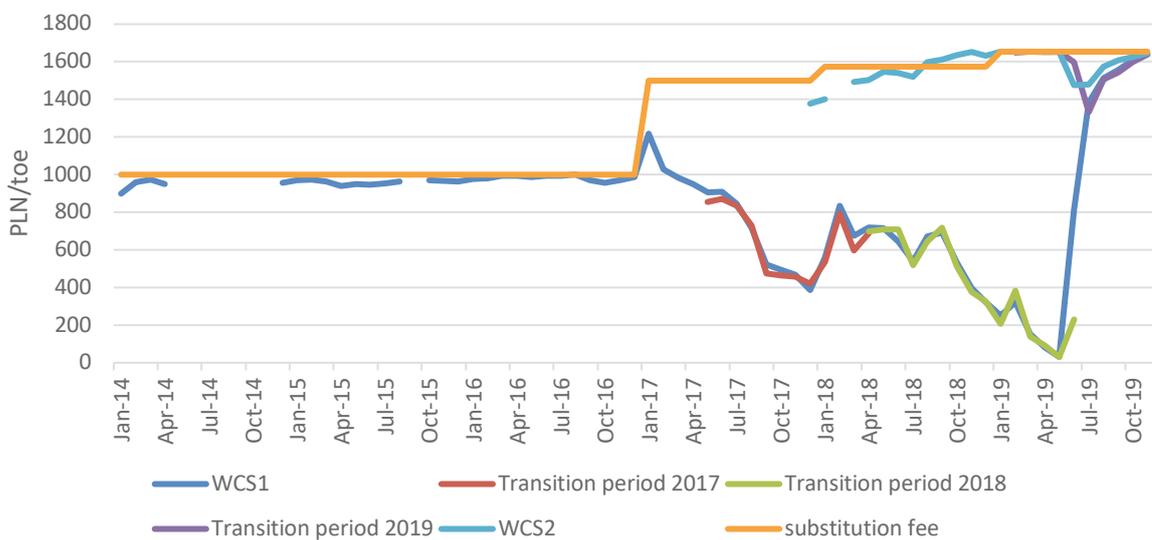


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4.1.3 Poland

Poland introduced an EEO with White Certificate trading in 2012 with mixed results. Overly complex procedures resulted in slow uptake and significant delays.⁵³ A further complication is the fact that there are several price indices for White Certificates that reflect certificates obtained in different years that are still in the market, making an assessment of the costs using price data not straightforward. This includes certificates issued during the transition period (*i.e.*, 2016-2017), some of which were only granted in 2019 for projects carried out in 2016/2017. Price data for the key indices is depicted in **Figure 4**.

Figure 8: Average price of certificates in Polish White Certificate market on Power Exchange



Source: Based on TGE. (2019). Statistical data: Periodic data for Certificates of Origin Register. Retrieved from <https://tqe.pl/statistic-data>

⁵³ Rosenow, J., Skoczkowski, T., Węglarz, A., Stańczyk, W., and Jędra, M. (forthcoming). *Evaluating the Polish White Certificate Scheme*.



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Per kWh of savings the price paid amounts to around 2.0-3.3 euro cents. This is within the typical range of programme costs observed in Europe — although toward the higher end of estimates for other countries — but still well above prices for most supplied energy carriers.^{54,55,56}

4.2 Lessons learned

On the supply side of energy efficiency, potential efficiency providers using White Certificate programmes face a number of market uncertainties. Those who would enter the market to deliver savings need time to create a business, fully understand the rules governing the programme, and then develop marketing and delivery routes to deliver savings, account for them and get them accredited. They often face markets where there are only a few buyers (*i.e.*, a small number of obligated entities), and they do not know in advance what the market value of a White Certificate is likely to be.⁴¹ If the government is writing the rules for the programme, they also face the regulatory risk that overall obligation levels and other rules may change at almost any time. This risk is not limited to trading programmes. Obligation and funding levels have seen sharp changes in many jurisdictions — for example, in the UK, where changes to the energy company obligation scheme led to a significant drop in the pace of insulation installations and an economic crisis for the companies that had been doing this work on behalf of obligated energy suppliers.⁴² Thus, even though in societal terms investments in energy efficiency are low-risk investments, and it is well understood that the efficiency reservoir is quite large and that obligation programmes should continue to build and grow over coming decades, the business model for companies entering a White Certificates market is still a risky one.

There is also a trade-off on the purchasing or public side of the White Certificates market:

- On the one hand, a certificates market will work best when the attribute being sold is uniform in nature and where compliance with requirements can easily be tracked. In

⁵⁴ Eyre, N., Pavan, M., and Bodineau, L. (2009). *Energy company obligations to save energy in Italy, the UK and France: what have we learnt?* Proceedings of the European Council for an Energy Efficient Economy, pp. 429-439

⁵⁵ Giraudet, L.-G., Bodineau, L., and Finon, D. (2012). The costs and benefits of White Certificates schemes. *Energy Efficiency* 5, 179-199

⁵⁶ Rosenow, J., and Eyre, N. (2016). A post mortem of the Green Deal: Austerity, energy efficiency, and failure in British Energy Policy. *Energy Research & Social Science* 21, 141-144



carbon markets, for example, “a tonne is a tonne” and renewable energy certificates represent uniform production quantities, measurable in MWh or Therms. If energy savings can be traded via a simply-defined White Certificate (e.g., one MWh of reduced consumption = 1 White Certificate), an obligation scheme could operate through a comparatively large and liquid market of buyers and sellers.

- On the other hand, if programmes were limited to a single White Certificate commodity, it would fall far short of delivering the highest values that efficiency can deliver. Energy savings occur in many forms and deliver a variety of values. For example, value could come from savings in locations with distribution grid constraints, or for delivering savings to low-income households, or delivering savings that are highly coincident with peak loads on the grid. Considering the transaction and opportunity costs of many types of efficiency upgrades, it is usually important to recruit deeper savings in a customer location whenever the opportunity arises. Treating all savings as a uniform commodity would wash out those higher values, and providers would face a market that rewards only low-cost savings, not high-value savings.

For this reason, just as renewable energy certificates programmes often distinguish between photovoltaic renewable energy certificates and wind renewable energy certificates, White Certificate programmes face a need to create multiple types of White Certificates, or to create bonus schemes to add extra credits to certain types of savings. This has the effect of fragmenting what might be one large White Certificate market into multiple White Certificate sub-markets, which are smaller, likely to be less liquid, and likely to offer less price certainty to potential energy efficiency providers. Designers of a White Certificate trading system, like designers of renewable energy certificates trading systems, thus face an inherent tension between uniformity, larger scale and lower-cost savings on the one hand, and diversity, market splitting and potentially higher-value savings on the other hand. Programmes that reward all energy savings with the same White Certificate, tradable or otherwise, will incentivise the take-up of least expensive measures that are the most profitable and least risky way to earn White Certificates. If all savings are paid the same, the least expensive savings are the most profitable, and the least likely to lose money if the clearing price of certificates hovers near to the low-cost point. The issue has arisen in a number of programmes, including some of the most well-known White Certificate trading regimes.



In 2008 in Italy, three-quarters of all the White Certificates earned for electricity savings came from the use of compact fluorescent light bulbs.⁵⁷ The New South Wales White Certificates have been dominated by commercial lighting, which supplied 80% of all the White Certificates earned in New South Wales during 2012-13. In Victoria in 2012, more than 80% of the White Certificates registered came from standby power controllers.⁵⁸ In all of these cases, the White Certificate programme design rewarded the rapid roll-out of simple, relatively inexpensive efficiency measures. This is a good thing if cost-effective delivery of the cheapest possible energy savings is the policy intent. However, policy objectives often tend to be more complex, with policymakers wishing to see efficiency gains made in different parts of the economy and with a variety of technologies, some of which may deliver deeper energy savings. In these cases, policymakers have a number of ways in which market-based instruments, including White Certificates, can be adapted to deliver on a wider set of objectives. Trading adds an additional layer of complexity, and sometimes adds extra consumer costs to obligation schemes that may well exceed the market efficiency benefits that should theoretically be available from a transparent, fully open market for energy savings. In addition, the generation of White Certificates by third parties opens up programmes to the risk of fraudulent behaviour, *i.e.*, the claiming of Certificates for non-existent energy efficiency projects. This was the case in Italy, where large-scale fraud was discovered in 2017, causing the removal of a significant proportion of Certificate supply and a consequent tightening of market conditions.⁵⁹

4.3 Energy Efficiency Auctions

Renewable Energy Auctions have become a popular instrument to support renewable energy. Energy Efficiency Auctions use a similar mechanism, but instead of renewable energy they provide support for energy savings. So far, there are only very few dedicated Energy Efficiency

⁵⁷ Lees, E., and Bayer, E. (2016). Toolkit for energy efficiency obligations. Montpelier, VT: Regulatory Assistance Project. Retrieved from <https://www.raponline.org/knowledge-center/toolkit-for-energy-efficiency-obligations/>

⁵⁸ Lees and Bayer, 2016.

⁵⁹ Di Santo, D. (2019). *Management of rule changes and coping with fraud in the Italian White Certificate programme*; Presentation at IEA/RAP workshop: Modernising energy efficiency obligation programmes, Paris, France. Retrieved from <https://www.iea.org/events/modernising-energy-efficiency-obligation-programmes>



Auctions (Germany, Portugal and Switzerland). Recently, the Independent Electricity System Operator for Ontario, Canada announced that an Energy Efficiency Auction would be piloted in Ontario from mid-2020 focusing on peak savings.⁶⁰

Energy Efficiency Auctions use competitive bidding to procure energy savings. Usually, there is a fixed amount of funds that is available (unlike in capacity market auctions and White Certificate programmes). Auctions have been funded through levies on energy bills, general taxation revenues and ring-fenced carbon market revenues.

Bids are stacked based on the relative cost-effectiveness of the savings on offer. In some cases, criteria other than just cost per unit of savings are being used (for example in Portugal). But in all of the existing auctions, cost per unit of savings is a key — or the singular — criterion. This can be defined as the costs of savings obtained in year one after a measure is installed, or over the lifetime of the measures delivered.

Often, larger projects that benefit one end user can bid into auctions, as well as programmes where many smaller projects are bundled into a programme. The rationale behind aggregating smaller projects to programmes is that the transaction costs of dealing with multiple small-scale projects are too high to justify their inclusion in the auction on their own. The size of projects and programmes is often different.

In order to qualify for an auction, bidders usually have to fulfil certain requirements that may include:

- **Minimum and/or maximum bid size:** Using a minimum bid size helps to avoid multiple small projects or programmes receiving funds, and minimises transaction costs. Multiple

⁶⁰ IESO. (2019). Power perspectives: Today's challenges, tomorrow's opportunities. Retrieved from: <http://www.ieso.ca/-/media/Files/IESO/Document-Library/publications/2019-Power-Perspectives.pdf>



smaller projects can often be bundled into a programme. A maximum bid size prevents the awarding of most of the funds to a single bidder or to just a few bidders.

- **Monitoring and verification:** Bidders are required to have a robust plan for monitoring and verification for the projects or programmes for which they seek funding. The requirements may differ depending on the project/programme size, and whether the bid is for a project or programme.
- **Cost cap per unit of savings:** To ensure only cost-effective bids are accepted, auction designers often specify a limit for the allowable costs per unit of savings.
- **Cost cap as portion of investment cost:** In order to maximise private capital investment for the lowest amount of subsidy paid to bidders, programmes may cap the share of the total investment costs covered by the auction.
- **Minimum payback periods:** To ensure measures that have longer payback periods are supported through the auction.

Auctions often feature a range of “slots” differentiating by sector, technology, cost-effectiveness, etc. This reflects the multiple objectives of policymakers that want to support a range of energy efficiency interventions. An auction mechanism will also impose fewer costs on consumers, and will be most effective in generating savings, if its pricing structure differentiates between different types of savings and rewards more comprehensive treatment of efficiency opportunities. The price paid for energy savings should vary by both **1)** expected costs of different kinds of measures, and **2)** the depth of savings achieved. It also may vary to reflect other important values, such as tackling energy poverty, addressing peak loads, improving reliability in congested load pockets, and others. This can be achieved by establishing different auction tranches so that most comprehensive energy efficiency improvements do not have to compete directly against low-cost measures.

4.3.1 Switzerland

Since 2010, the Swiss Federal Office of Energy has been carrying out competitive tenders for energy efficiency with 11 auctions delivered so far. The programme is funded through a levy on electricity transmission, and only savings in electricity are eligible. Bidders include those who own individual facilities and project aggregators who bundle multiple smaller projects into a programme.



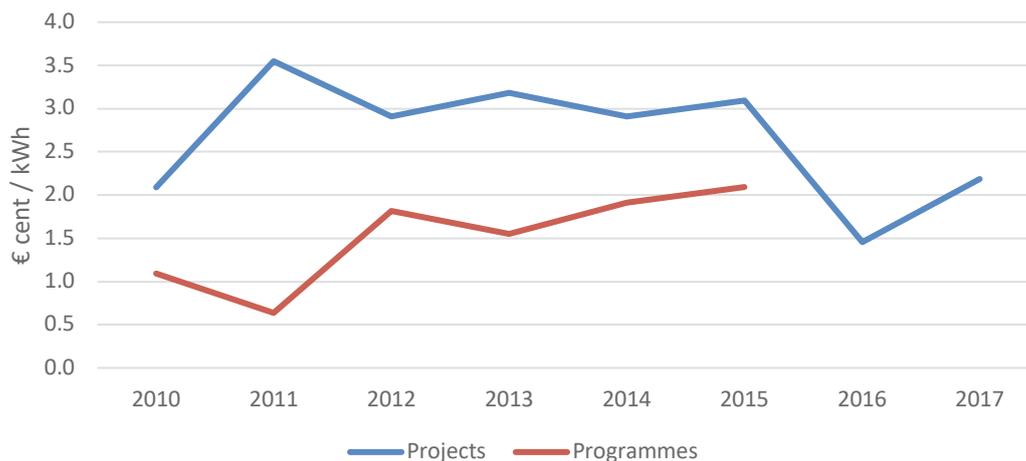
This project has received funding from the European Union’s Horizon 2020 Research and Innovation programme under Grant Agreement No 847066.

Projects bidding into the Swiss auction mechanism can only receive up to 30% funding as a portion of the total investment cost. The size of a project has to be between €18,000 and €18,000,000,⁶¹ and the size of a programme has to be between €136,000 and €2,729,000.⁶²

In Switzerland, the maximum price paid is 7 euro cents/kWh lifetime savings.⁶³ Successful bidders get access to the funds only after the measures have been realised and they can prove that this is the case.

Average prices per kWh range from 0.6 euro cents to 3.5 euro cents per kWh, with programmes delivering savings at a cheaper rate than projects.

Figure 9: Average cost of successful bids in the Swiss ProKiloWatt programme



Source: BfE. (2019). Monitoringbericht ProKilowatt – 2010 bis 2018. Retrieved from:

<https://pubdb.bfe.admin.ch/de/publication/download/7218.pdf>

⁶¹ BfE. (2019). Bedingungen für die Einreichung von Projekten 2020. Retrieved from: https://www.bfe.admin.ch/bfe/en/home/foerderung/energieeffizienz/competitive-calls-for-tenders-prokilowatt/_jcr_content/par/tabs/items/tab/tabpar/externalcontent.external.exturl.pdf/aHR0cHM6Ly9wdWJkYi5iZmUuYWRTaW4uY2gvZGUvcHVibGlijYX/Rpb24vZG93bmxvYWQvOTg2MC5wZGY=.pdf

⁶² BfE. (2019). Bedingungen für die Einreichung von Programmen 2020. Retrieved from: https://www.bfe.admin.ch/bfe/en/home/foerderung/energieeffizienz/competitive-calls-for-tenders-prokilowatt/_jcr_content/par/tabs/items/tab/tabpar/externalcontent.external.exturl.pdf/aHR0cHM6Ly9wdWJkYi5iZmUuYWRTaW4uY2gvZGUvcHVibGlijYX/Rpb24vZG93bmxvYWQvOTg1OS5wZGY=.pdf

⁶³ *Ibid.*



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4.3.2 Portugal

The Portuguese Plans for the Promotion of Consumer Efficiency in Electric Energy (PPEC) started in 2007 with six auctions run since then. The volume of funding available in the last call was €23 million and the requested funds amounted to €62 million.⁶⁴ Under this mechanism, several entities, among them electric utilities, may submit proposals of measures that contribute to the reduction of electricity consumption or peak load reduction. The programme has undergone several changes, including the requirement on beneficiaries of the auction to part-fund the implemented projects, limits to the amount of funding and the evolution of the criteria used for selecting bids in an auction. The programme is funded by a levy on electricity consumption.

It is important to understand that PPEC is not a pure price-based auction, as several criteria are being used by the entity running the auction to select successful bids and price per kWh is just one of them.

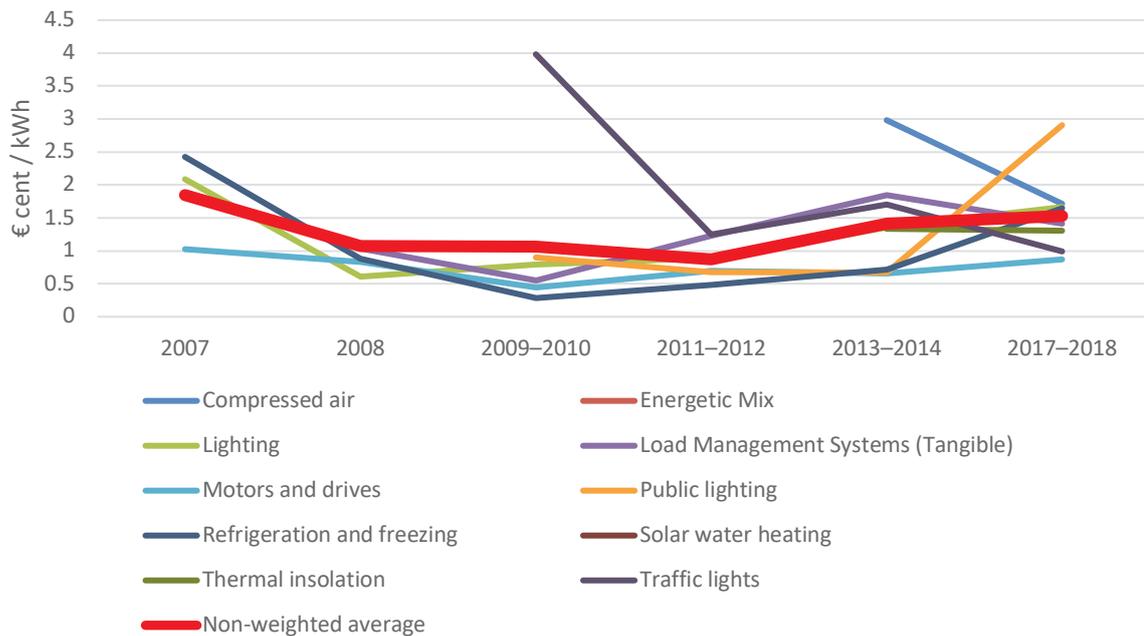
PPEC separates bidders into different groups: those with no association with the electricity sector; and those with or without associations with the electricity sector. For the first, bids are ranked altogether, regardless of the consumption segment they address. In the second, bids are ranked within the consumption segment they address. This is to ensure that all sectors benefit and no sector loses out.

Prices per kWh fluctuate between 0.3 and 4 euro cents/kWh, with the unweighted average ranging from 0.9 to 1.8 euro cents/kWh depending on the year.

⁶⁴ Sousa, J. L., and Martins, A. G., (2018). Portuguese Plan for Promoting Efficiency of Electricity End-Use: Policy, Methodology and Consumer Participation. *Energies*. Retrieved from: https://estudogeral.uc.pt/bitstream/10316/81043/1/energies_ppec_-11-01137-v2.pdf



Figure 10: Average cost of successful bids in the Portuguese PPEC auction



Source: Sousa, J. and Martin, A. (2018), Portuguese Plan for Promoting Efficiency of Electricity End-Use: Policy, Methodology and Consumer Participation, *Energies* 2018, 11(5), 1137 <https://www.mdpi.com/1996-1073/11/5/1137/htm>

4.3.3 Germany

Germany introduced a pilot energy efficiency auction, or competitive efficiency tender, in 2016, inspired in many ways by the Swiss programme described above. Called “STEP up!,” the three-year pilot programme aimed to select electrical energy efficiency projects with the best economic cost-benefit ratio (euro funding per kilowatt hour saved) from the pool of bids submitted in each of six rounds, subject to a maximum ratio of 10 euro cents/kWh (lifetime). In order to be selected, bids also had to have payback periods of more than three years without funding, and be expected to achieve savings for at least 10 years. As in the Swiss programme, both single projects and broader programmes (“collection projects”) could bid in separate categories.⁶⁵ However, unlike in the Swiss programme, the funds provided to the winning

⁶⁵ Langreder, N., Seefeldt, F., Brischke, L-A., and Chmella, T. (2019). *STEP Up! The competitive efficiency tender in Germany – step by step towards an effective new instrument for energy efficiency*, eceee Paper 3-251. Presented at the eceee Summer Study at Hyères, Presqu’île de Giens, France, 2019



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bidders were capped at 30% of the additional investment costs required to achieve a level of efficiency beyond that associated with current standards, as set out in the EU General Block Exemption Regulation.⁶⁶ Also, as part of the piloting process, the scheme had two types of tenders – open and closed – with the closed tenders focusing each round on different sectors or technology types. The scheme was funded through the German Energy Efficiency Fund and had a budget of €300 million.

The scheme struggled in the early rounds to attract bids. As few as 32 applications were submitted in the first three rounds, of which only 10 were accepted. With too few bids, there was no competition for the available funds. A stakeholder consultation into how to attract more bids led to some changes, including a reduction in the minimum funding amount (from €30,000 to €20,000 for an individual project, and from €250,000 to €100,000 for collective projects) for the third tender. Closed tender projects were also opened up to combined heat and power projects.⁶⁷ The final three rounds generated more bids and more of the budget was spent (€7.7 million in the fourth round), but the pilot did not come close to reaching a level that generated competition amongst bids for scarce funding.

In taking the auction programme forward, the German government made some changes based on learnings from the STEP Up! pilot. In 2019, a new pilot funding competition was launched which increased the maximum funding level to 50% of energy efficiency investment costs (with a maximum of €5 million per project). Because the competition is open to all sectors and enterprises, it was unnecessary to notify the European Commission from a State Aid perspective. The competition also switched to a € per tonne CO₂ savings metric and the payback (without funding) criterion was set at more than four years, meaning that the focus has switched to more ambitious projects with higher funding requirements for economic implementation. The total budget per call was reduced to €7 million and, following the experience in the “STEP Up!” pilot, no competition was held for collective projects. The first call was more successful and was

⁶⁶ European Union. (2014). COMMISSION REGULATION (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty, Official Journal of the European Union (OJEU), retrieved from: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0651>.

⁶⁷ Langreder *et al.*, 2019.



oversubscribed by 100%, with three-quarters of the bids rejected based on the competition over cost-effectiveness. A decision on whether to continue with the programme will be made after the conclusion of the new pilot.

4.4 Lessons learned

The experience with Energy Efficiency Auctions so far has been relatively scarce, with very few countries adopting this instrument. Where auctions have been adopted, the volume of savings delivered has been modest. It is therefore difficult to draw definitive conclusions on the performance of auctions and their ability to reward energy savings.

It is clear that auctions are, in principle, a very flexible policy instrument that can be adopted depending on the specific context in the jurisdiction where it is deployed. Considerations may be the structure of the economy, the maturity of the energy efficiency market, the existence of other energy efficiency instruments, the cost of different energy carriers, and the familiarity of the market to engage with a more complex energy efficiency support mechanism. The auction design can be adapted with technological progress and other changes in the economy and the market.

A strength of auctions is the discovery of the “real” price of energy savings, provided that the market is liquid and that there is sufficient competition. This addresses the information asymmetry that other energy efficiency programmes often face: when deciding on the level of support provided through grants, for example, there is a risk that too much or too little support is being offered, resulting in overcompensation of beneficiaries or underperformance of the programme respectively.

Another feature of auctions is that they result in a contract between two entities that clearly states the commitments and liabilities of each party. This type of structure can offer greater regulatory certainty to investors, minimising the likelihood that their remuneration would be challenged in the future even as the market and policy landscapes change.



However, auctions are normally associated with relatively high transaction costs, for both the bidders and the auctioneer, and are not always guaranteed to deliver the outcome desired, as demonstrated by the German “STEP Up!” pilot programme.

Dedicated energy efficiency markets have been set up to deliver on different objectives, dependent upon varying economic and political contexts, often independently of the specific needs of transmission and distribution system operators. A possible future direction for policy could be to actively involve transmission and distribution system operators in systemwide energy efficiency market design as a way of stacking value and avoiding the proliferation of separate funding mechanisms.



5 Conclusions and recommendations

Energy efficiency provides a diverse set of values to the energy system, some of which can be rewarded through mechanisms such as capacity markets and network procurement programmes and others which require dedicated energy efficiency programmes. To turn this set of values into bankable energy efficiency projects a number of steps need to be taken.

Where capacity markets are in operation, they should be designed to ensure that energy efficiency resources can compete fairly with other technologies. This means:

- ensuring that the rules around the minimum size of bids do not act to effectively exclude many energy efficiency actions; and
- allowing energy efficiency measures to continue to bid over their lifetimes, in the same way that supply-side measures do.

Network operators should be regulated to ensure that their incentives are aligned with societal goals and supported in the piloting of localised energy efficiency programmes. This means:

- Performance-based regulation that rewards outputs instead of inputs, so that network utilities are just as likely to invest in equivalently priced demand-side resources as supply-side equivalents; and
- additional incentives to pilot investment in energy efficiency measures to help prove the concept to utilities that traditionally have not operated in the area of energy efficiency.

Countries that do not currently operate energy efficiency obligation schemes or levy-funded energy efficiency programmes should consider developing these types of policy measures, given the benefits to the energy system that such programmes can bring.

Energy efficiency providers need to make improvements in evaluation, measurement and verification if they are to take advantage of forthcoming opportunities in the EU as National



Regulatory Authorities make changes to allow demand-side measures more access to energy system resources. In the context of the need to prove the adequacy and reliability of energy savings in different locations and at different times of the day and year, this means a move towards metering and payment for energy performance, as opposed to the installation of measures.

This report feeds into the rest of the SENSEI project by setting out the value that energy efficiency brings to the energy system, the mechanisms by which that value can be rewarded and the changes, at the policy, regulatory and industry level, that are needed to enable those rewards to be realised. In particular, the report (deliverable 4.1) sets the scene for:

- the identification of pay-for-performance rates utilities might offer (deliverable 4.3); and
- a review of pay-for-performance for energy efficiency programmes (deliverable 4.4).



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