What role for energy efficiency auctions in the energy transition?

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Abstract

More and more European countries are turning to energy efficiency auctions as a way of delivering cost-effective energy savings. Germany, Portugal and Switzerland already have auctions or tender programmes in place. In 2021 Denmark launched its first energy efficiency auction, while Greece, Italy, Turkey and the United Kingdom are among the countries considering this mechanism.

This paper draws upon research undertaken for the Horizon 2020 ENSMOV project on the role of energy efficiency auctions in meeting EU Member States' energy savings obligations under Article 7/8 of the Energy Efficiency Directive, assessing the design features that affect eanergy savings, cost-effectiveness and strategic fit within energy efficiency policy frameworks. The paper considers the relative merits of energy efficiency auctions and energy efficiency obligation schemes in the broader context of the energy transition. On the one hand, meeting more ambitious climate change targets requires policy measures that can deliver significant quantities of energy savings. On the other, as energy efficiency measures become more expensive and complex year-on-year and Member States aim to implement the Energy Efficiency First principle, understanding the cost-effectiveness of energy efficiency actions will become increasingly important.

Introduction

Energy efficiency auctions are not a common part of energy efficiency policy frameworks. Subsidy programmes such as grants or tax rebates that offer a financial contribution towards investment costs, and energy efficiency obligation schemes (EEOS) that require utilities to deliver energy saving targets, have been much more popular. In Europe, Switzerland and Portugal are the only countries with long-running auction or tender programmes. However, in 2021, Germany introduced an auction (having piloted auctions since 2016) and Denmark replaced its EEOS with an auction. In addition, Greece, Italy, Turkey and the United Kingdom have all expressed an interest in developing auction mechanisms for energy efficiency.

In this paper we draw upon research carried out for the ENSMOV H2020 project,[1] surveying experiences in countries that have employed energy efficiency auctions, assessing their key design features and considering their role in meeting policy objectives in the period to 2030; and we also compare them with EEOS.

1. ENSMOV (Enhancing the Implementation and Monitoring and Verification practices of Energy Saving Policies under Article 7 of the Energy Efficiency Directive [EED]) runs from 2019 to 2022. It aims to facilitate and expand sharing of knowledge and experience amongst Member States to enable the better design and implementation of energy efficiency policy measures. As part of the project, we undertook a gap analysis to help select the topics of focus. One of the gaps identified was the need for knowledge-sharing on auction policy design, given the growing interest amongst Member States in setting up energy efficiency auctions. An online workshop was held in September 2021 featuring presentations from Switzerland, Portugal, Denmark and Greece (ENSMOV, 2021). The ENSMOV project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 840034.

What is an energy efficiency auction?

An energy efficiency auction is a mechanism for the allocation of (public) funds to energy efficiency projects and programmes. Potential projects or programmes must bid for funds, with the probability of success depending on the relative cost-effectiveness of their bids: this is usually defined as the subsidy required to deliver a unit of the desired policy objective (most commonly energy savings). All the case study auctions described in this paper are one-shot, sealed-bid, discriminatory auctions (Klemperer, 2004), in that bids are submitted once, are not visible to other bidders and, if successful, receive their bid, i.e. the auctions "pay-as -bid", as opposed to "pay-as-clear" auctions in which a uniform price is paid to all winning bidders.

Energy efficiency auction case studies

SWITZERLAND

The Prokilowatt scheme in Switzerland has been running since 2010. Prokilowatt is funded by a levy on electricity consumption and pays for electricity savings. More than 20 of the most common end-use technologies are eligible for funding.

Two separate auctions are available: one for large projects in industrial enterprises, and another for programmes that aggregate smaller projects at the level of small businesses and households. The auction for programmes was put in place to ensure that funds would be available for smaller projects outside the industrial sector that would otherwise be unable to bear the costs of bidding individually.

Bids are ineligible if the expected payback period is less than four years.[2] The programme subsidises up to 30 % of investment costs. Subsidies are paid "as bid" after the project has been implemented and once the costs and savings have been verified by the programme administrator through an audit process. There is no penalty regime as such, but subsidies are reduced if either the savings or the costs are lower than expected in the applicant's bid. If the payback period is deemed to be less than four years during the verification process, no subsidy is provided. Winning bidders have one year in which to implement their projects.

The payback criterion is just one element of policy design aimed at ensuring the additionality of the scheme – i.e. ensuring that, as far as possible, public funding is used to support actions that would not have taken place without the policy measure. The scheme also requires that projects support the best available technologies (as defined by the programme administrator), that the energy efficiency actions are not required by law, and that the actions have not already been undertaken before the award of funding.

The full budget is only allocated in auction rounds in which bids worth at least 120 % of the budget are received (Radgen, 2016). In 2022, a variation on the 120 % rule is being implemented through week-long auction rounds in which projects compete against each other, plus 15 "virtual projects" stemming from the previous round. Following this competition, only 85 % of all bids are awarded funding (BfE, 2021).

By 2020, the scheme had supported more than 700 projects and programmes. Seventy-five per cent of the savings were made through the installation of more efficient lighting, motor systems, cooling systems, pumps, circulating pumps and ventilation systems. The scheme has disbursed or reserved EUR 270 million in subsidies at an average rate of 2.6 cents per kilowatt-hour (kWh) of electricity saved (Bisang, 2021). The average price of electricity was around 20 cents per kWh in the residential sector and 16 cents in the business sector in December 2021 (Global Petrol Prices.com, 2022). Average funding rates were around 20 % of investment costs during the 2014–2017 period and fell to as low as 13 % in 2018, meaning that the subsidies are leveraging between 5 and 7.5 times their amount in private investment (Radgen et al., 2018). The observed combination of average subsidy per kWh and leverage rate (of between 1:5 and 1:7.5), in conjunction with the minimum payback criterion, suggests that the scheme has been successful in supporting energy efficiency actions that would not have been taken without it and that are cost-effective from a societal perspective, while avoiding over-subsidisation.

GERMANY

The current German auction scheme began as a pilot in 2019 and was expanded into a full scheme with a five-year lifespan in 2021, funded through the federal budget. It is a technology-neutral funding competition that is open to all energy saving concepts. It supports up to 60 % of investment costs and offers a maximum of EUR10 million per project, in absolute terms, while payback (without funding) must be longer than four years (Bundesanzeiger, 2021). There is no maximum subsidy rate per kWh; projects are only supported, however, if their subsidy rate is cost-effective relative to other bids and still in the available budget. Subsidy rates are calculated in terms of euros per tonne of carbon dioxide (CO_2) saved and are paid "as bid." Winning bidders have 36 months in which to complete their projects.

The competition followed a previous pilot programme (STEP up!) which ran from 2016 to 2019 and built lessons learned from each bidding round into improved scheme design (Langreder et al., 2019). Despite incremental improvements throughout the pilot process, the scheme failed to deliver any competition in any of its six calls.

Building on this experience, the new pilot competition began with a relatively small budget. In the first call in 2019, the budget was oversubscribed by requests for funding, with EUR 15 million worth of bids against a budget of EUR7 million. In the event, only 8 out of 34 projects could be funded. Winning bids requested subsidy rates of between EUR190 and EUR390 per tonne of CO_2 saved. After 11 calls between April 2019 and September 2021, in November 2021 the budget was raised to EUR15 million per round for the period to 2026 (BWK, 2021).

DENMARK

The most recent auction scheme to launch has been in Denmark, run in-house by the Danish Energy Agency. Beginning in late 2020, it (partly) replaces an EEOS which ended in 2020. The auction scheme will run until at least 2029. The auction is financed through public funds, with a budget of EUR464 million, and is designed to deliver approximately 60 % of Denmark's current EED energy savings obligation. The scheme

2. The payback criterion means that bids are ineligible if the cost of the energy efficiency investment is outweighed by the quantity of the electricity saved, multiplied by the price of electricity, before the end of the fourth year following the energy efficiency action.

aims at achieving EED-compliant energy savings among all business end uses and energy carriers, with all sectors eligible except for road transportation, shipping and information technology. Four or five web-based auctions are envisaged each year, with each auction round lasting three weeks from the opening of the bidding window to the announcement of successful bids (Broberg, 2021).

Bids are only accepted for individual projects from energy end-using enterprises (not from intermediaries) and are subject to a price cap of 1 cent per kWh saved per year. This compares with average prices of electricity of 29 cents per kWh in the household sector and 7 cents per kWh in the non-household sector in the first half of 2021 (Eurostat, 2021). Energy savings are calculated using meter data before and after project completion, accounting for the expected lifetimes of the equipment installed and the EED requirement that savings be additional to EU law such as ecodesign.[3] Winning bidders have 27 months to complete their energy efficiency projects, with payments being made "as bid" upon satisfactory completion. No penalty regime is in place, but if projects do not realise their anticipated energy savings, subsidies are reduced in proportion to the savings achieved. Winning bidders must provide status reports every six months so that allocated funds can be redeployed if projects have not proceeded as initially anticipated.

The scheme launched during the COVID pandemic. The Danish Energy Agency believes that this has made potential bidders less willing to make investments, including in energy efficiency, and they are therefore less likely to participate in the first few auctions. Only around 50 % of the budget allocated to auctions in 2020 and 2021 was actually awarded to winning bids, reflecting the socioeconomic conditions at the time. With fewer bids than budgeted for, competition was limited, and bids were typically clustered at or close to the price cap (Broberg, 2021).

PORTUGAL

The Portuguese Plan for Promoting Efficiency on Energy End-use (PPEC) is a tender scheme. It shares some of the characteristics of an auction, in that funds are disbursed according to the quality of bids received, but the criteria are not limited to the subsidy per unit of energy saved.

The PPEC scheme began in 2007 and has evolved over seven periods, with the current period running across 2021 and 2022 with a budget of EUR 23 million. Bidders are known as "promoters," as the energy savings cannot be achieved on their own energy use. Bids can come from electricity and gas utilities, consumer organisations, energy agencies, municipal associations, business associations, research centres and educational institutions.

The scheme is segmented into six separate funding pots. This is to ensure participation across different types of bidders and interventions among a diverse set of end users. Three different end-user segments cover the installation of energy-efficient equipment ("tangible measures") in households, industry and agriculture, and services and commerce. A separate pot is reserved for information provision and energy audits ("intangible measures"). In addition, two further pots, one for tangible and another for intangible measures, are reserved for non-utility bidders.

To be accepted into the tender evaluation, bids for tangible measures must first satisfy two positive tests: that they save primary energy and that they have a positive net present value – i.e. that the benefits to society outweigh the costs to society (including avoided greenhouse gas emissions). Tangible measures are then evaluated by the Portuguese Energy Regulator (ERSE) according to a cost-benefit analysis and the level of investment in equipment in the total cost (a criterion designed to prioritise measures with relatively low administration costs). ERSE evaluates intangible measures according to their ability to overcome market barriers; the quality of presentation[4]; and equity, innovation and ease of implementation criteria. Separately, the Portuguese government's General Directorate of Energy and Geology (DGEG) evaluates all the bids according to their compatibility with government policy objectives. DGEG criteria include geographic coverage, alignment with national energy policy, support for the development and implementation of energy efficiency, the diversity of promoters, and coordination with other policy instruments. The scores of ERSE and DGEG are combined; bids are ranked; and bids are accepted until the funding pots have been exhausted.

The scheme has evolved over time, with tenders now run on a biennial basis to allow promoters to focus on the delivery of projects and learn lessons from one round before bidding in another. Funding is limited to 95 % of costs and EUR 400,000 for intangible measures and 75 % of cost and EUR800,000 for tangible measures. Subsidies are paid "as bid"; the average subsidy paid for energy savings across tangible measures in the 2017–2018 period was 1.4 cents per kWh (Sousa, 2021). This compares with average prices of electricity of 21 cents per kWh in the household sector and 10 cents per kWh in the non-household sector in 2018 (Eurostat, 2021).

Countries considering auctions

GREECE

In 2019, the Greek government announced, through its National Energy and Climate Plan, its intention to design and implement energy efficiency auctions to facilitate the achievement of Greece's energy efficiency targets (Hellenic Republic, 2019). The introduction of auctions aims to improve the cost-effectiveness of the Greek energy efficiency policy portfolio, putting in place a permanent structure for implementing energy efficiency actions more generally. Until now, Greece has initiated both EEOS and alternative measures to fulfil its energy savings obligations. Nevertheless, the various programmes within the framework of the alternative measures are designed individually without common rules and objectives, and this has led to the implementation of energy efficiency interventions with dif-

3. This is done by ensuring that energy savings are not calculated simply by comparing energy consumption before and after the energy efficiency action; instead, the impact of ecodesign on the market for energy-using products and equipment is taken into account when calculating the counterfactual against which metered energy consumption is compared.

4. The "quality of the presentation" criterion is evaluated by assessing the existence, clarity, objectivity and justification of the information included in the application. Applications with insufficient quality are those that, for example, do not describe the process of implementing the measure clearly, do not justify the values and assumptions presented, are not coherent, or include systematic errors. A such this could be thought of as a proxy for the extent to which one can trust the information presented and the subsequent implementation of the measure.

ferent levels of cost-effectiveness. Alongside the Greek EEOS, the initiation of energy efficiency auctions aims to foster the development of energy efficiency services through both market-based mechanisms (Tourkolias, 2021).

A special committee was established in 2020 through a ministerial decision (YPEN/ΔDEPEA/42625/279), tasked with proposing the regulatory framework for conducting the energy efficiency auction in Greece. The main responsibilities of the committee consist of:

- Mapping the barriers and limitations for the development of the regulatory framework;
- Determining the type and characteristics of the auctions to be held;
- Identifying eligible participants;
- Developing the measurement and verification procedures;
- Preparing the legislative framework; and
- Monitoring and assessing the initial rounds of the energy efficiency auctions when they take place.

The committee has proposed a seven-step procedure for the effective conduct of energy efficiency auctions in Greece.

The development of the legislative framework started with the adoption of Law 4843/2021 (FEK 193/A/20-10-2021), which harmonises the national context with the EED. A ministerial decision will be adopted specifying the various design elements of the scheme. The Renewable Energy Sources Operator and Guarantees of Origin (DAPEEP SA) was appointed as the responsible authority for the coordination of the scheme, while the Centre for Renewable Energy Sources will carry out the control and verification activities.

At this point, cost-effectiveness is the only award criterion. The most cost-effective bids will be supported with a predefined percentage of public aid until the available public budget is exhausted. Successful bids may receive some advance payment.

The energy efficiency auction will aim to minimise administrative cost and bureaucracy, while ensuring transparency and fair competition to achieve the most cost-effective interventions. Although the initial focus of the auctions will be on the delivery of final energy savings, the potential for switching to primary energy savings as the delivery metric will be considered in order to facilitate a level playing field with renewable energy sources (Tourkolias, 2021). The planned provision aims to promote further market penetration for renewable electricity production, mainly photovoltaic (PV) systems. The rationale for this would be that the costs per kWh of bids will be improved considerably, which will allow the implementation of less cost-effective energy efficiency interventions, such as building envelope improvements. PV installations would be ineligible on their own – they would need to be combined with energy efficiency actions generating final energy savings. It should be noted that all renewable energy technologies for heating and cooling will be eligible since they lead to final energy savings (mainly heat pumps).

The first pilot programme will focus on enterprises in the tertiary and industrial sectors and has a planned public budget of EUR30 million. The preparation of the secondary regulatory framework will be finalised in mid-2022, and the initiation of the pilot energy efficiency auction is expected by the end of 2022.

ITALY

In Italy, discussions over adopting an energy efficiency auction scheme began some years ago, mainly in relation to the difficulties faced by the white certificate mechanism in 2017–2018 (Di Santo et al., 2019). Since auctions have been used for renewable energy sources since 2012, the introduction of a similar measure for energy efficiency could benefit from this experience and know-how regarding procedures. However, energy efficiency projects are more complex to deal with than renewable energy projects, both in terms of their measurement and verification, and of the variety of actions that can generate energy savings. Thus the evaluation of the opportunity to move forward with an auction scheme has taken some time, during which feedback has been gathered from auction schemes adopted in other countries.

With the ministerial decree "D.M. 21 maggio 2021" setting new rules for the white certificate scheme, the basis for an auction scheme was finally introduced. The decree states that the auction scheme will be adopted because of the need to obtain savings in addition to the ones produced by white certificates, to comply with 2030 targets. The operational rules of the policy will be defined and launched in 2022 with a dedicated decree.

The main points defined so far are:

- The scheme will work as a "pay as bid" auction and will aim to incentivise and promote energy savings.
- Bids will be based on the economic value per saved tonne of oil equivalent (expressed as final energy consumption).
- The economic value of the accepted bids will be granted for a period depending on the type of energy efficiency projects, and the yearly incentive will thus be equal to the product of the economic value (per tonne of oil equivalent) awarded during the auction and the eligible additional yearly energy savings, delivered for the defined lifetime duration.
- The economic value set as the basis of the auction will consider the price trend of white certificates on the spot market and the specificities of the technology or type of project awarded, as well as the positive environmental externalities generated.
- The types of eligible energy efficiency measures will be defined in the coming decree. In principle there are no restrictions in terms of sectors and types of intervention.
- Access to the auctions will be granted to companies and public bodies that make investments in energy efficiency.
- Incurred costs will be covered through electricity and gas tariff components.[5]

Although the scheme is being introduced through the same decree that sets the rules for white certificates, the savings generated from the auctions will not be related to the white certificate

5. The fact that the costs of the scheme are covered by electricity and gas tariffs does not necessarily mean that eligible projects are limited to savings from these energy sources. Thus, there is the possibility that other fuel savings will also be paid for through electricity and gas tariffs. However, the vast majority of projects generate electricity or gas savings. To introduce tariff components for other fuels, which are not regulated by the energy authority, would be complex and not justified by the amounts of money involved.

obligation and will not be traded on the same market. This has been one of the points most discussed by stakeholders, with some asking for the two schemes to be linked to ensure liquidity for the white certificate spot market. This is a reasonable idea in cases where the energy efficiency measures admitted to the auctions are also eligible for white certificates, even if it would introduce some complexity in the management of the two schemes. On the other hand, many stakeholders have proposed using the auction scheme for energy efficiency measures that cannot be effectively promoted through the white certificate scheme. In these cases, the white certificate scheme would not suffer from competition from the auction scheme. It is possible that the hammer price in the auction (the highest accepted bid) might be linked to the price in the white certificate programme. This, and many other issues, will be defined in the decree to come.

TURKEY

The Turkish National Energy Efficiency Action Plan (NEEAP) 2017–2023 envisages a mechanism involving annual auctions based on the cost per tonne oil equivalent of anticipated energy savings, to support projects developed by end users to improve energy efficiency. Sectors eligible to bid include the manufacturing industry, commercial and service buildings, transport and agriculture. Separate auctions are planned for different sectors to ensure fair competition. Support would be allocated within the budget in ascending order of projects ranked by unit cost per tonne oil equivalent. The auctions are intended to encourage bidders to produce creative, innovative, cost-effective project proposals (Republic of Turkey, 2018).

The legislative framework and technical infrastructure were expected to be developed between 2018 and 2020, with the first auctions to be held in 2021. The NEEAP also envisaged the development of an EEOS. However, at the time of writing there are no regulations for either the scheme or the auctions. Part of the delay may be related to uncertainty over the funding source for the auction. The NEEAP refers to the budget being provided from the development of a "national financing mechanism for energy efficiency." This financing mechanism has also yet to be developed, but it could rely on the setting-up of the EEOS. If energy companies' obligations are not satisfied, the NEEAP suggests that penalties could be a source of finance for the national energy efficiency fund, which in turn could support the auctions.

UNITED KINGDOM

The UK government announced in its Net Zero Strategy that it will consult on a scheme to help small and medium-sized enterprises overcome barriers to energy efficiency take-up and meet regulatory standards on buildings performance (HM Government, 2021). This announcement follows a call for evidence in 2019 in which the Department for Business, Energy and Industrial Strategy (BEIS) asked respondents for their views on different options for a support scheme for small and medium-sized enterprises, including an energy efficiency auction or competitive tendering scheme, and an EEOS. Answers to questions related to the pros and cons, programme design, and funding of auctions were summarised in 2020 (BEIS, 2020).

Some respondents thought that auctions could be more flexible and technology neutral than EEOSs and could encourage innovation (not relying on preapproved lists), allowing better value for money. Those in favour of auctions also felt that they could boost the energy efficiency market more than an EEOS could. Conversely, other respondents highlighted the potential for peaks and troughs dependent on the size and frequency of the auctions, the potential for large market players to dominate, and the likelihood that the additional risks to participants could keep prices artificially high.

With respect to auction design, some respondents recommended targeting auctions at those with the greatest need for support by using minimum payback periods, as in the Swiss auction. Some respondents preferred open (technology-neutral) auctions, while others preferred combinations of closed and open auctions to ensure a range of measures are funded. The importance of linking payment to robust measurement and verification regimes was noted, while the risk of low take-up was also raised, with calls to follow the Swiss example of ensuring competition by not always allocating budgeted funds to bidders (see above).

When it came to funding, on equity grounds most respondents preferred public funds to be drawn from general taxation, as opposed to a levy on energy consumption. As for the level of funding, many respondents advocated a set level of co-funding by small and medium-sized enterprises, ranging from 40 % to 70 %. Some suggested that the level of co-funding should be bid for, as in the Swiss and German models.

At the time of writing, we await a proposal from the government on how an energy efficiency scheme for small and medium-sized enterprises could be designed.

The UK earlier piloted an energy efficiency auction between 2015 and 2018. The scheme was different in that it focused only on the delivery of winter peak electricity capacity savings, in an attempt to allow energy efficiency resources to provide "negawatts" and thereby avoid the need for more expensive supply-side resources, procured through a capacity market. Projects needed to have at least a two-year payback to qualify for the auction and be able to deliver avoided capacity in the following winter season. A minimum project size of 100 kW was required for the first phase, reduced to 50 kW for the second phase to allow for a greater diversity of projects. The scheme awarded only GBP 6 million (EUR7 million) to 31 projects across its two phases, with almost all projects being LED lighting installations. While the evaluation of the scheme suggested that it had provided value for money, the relatively low number of participants and high rate of drop-out between registration of interest, application submission and bidding suggested that the costs and constraints of the scheme were off-putting to potential bidders. Indeed, the limited time available to formulate a new project for application (that would satisfy the additionality criteria for the scheme), the complexity of the application process and the requirements around certainty of delivery were all deemed to be factors limiting participation (BEIS, 2019). These factors should be closely considered in the design of any new scheme

Analysis

Many of the design issues policymakers face are the same across auctions and other policy measures. For example, the source of funding, the calculation method for energy savings, whether to have minimum payback periods, and the design of monitoring

and verification regimes are important aspects of any energy efficiency support measure. On the other hand, the mechanism for establishing subsidy rates is a central and particular aspect of auction design that deserves some attention.

MECHANISMS FOR ESTABLISHING SUBSIDY RATES

The subsidy rate paid to winning bidders can be established in different ways: "pay-as-clear" or "pay-as-bid". In "pay-as-clear" auctions, all successful participants receive the subsidy rate bid by the last accepted or first rejected bidder. This method should elicit true bids (actual willingness to accept a subsidy rate) from all bidders, avoiding strategic bidding behaviour and leading to economically efficient outcomes (Oren, 2010). This is because an overly high bid would risk being unsuccessful, whereas true bids will benefit from economic rents (OABC in Figure 1): the difference between bidders' willingness to accept a subsidy (OBC) and the subsidy rate that clears the auction (A) (see Figure 1). Capacity markets, such as those run in the US by PJM[6] and the New England Independent System Operator, use this method, with demand-side resources, including energy efficiency, able to bid for the provision of electricity capacity alongside supply-side alternatives (Liu, 2017).

EEOSs with competing utilities that can trade compliance, particularly those with white certificate programmes in which the market cost of energy savings to obligated parties is visible, should yield similar outcomes to "pay-as-clear" auctions in which a given quantity of energy savings must be procured. In these schemes, utilities should pass on the clearing price of achieving their obligations to bill-payers, as any economic rents have an associated opportunity cost – the opportunity to sell energy savings to other utilities at the market price.

The subsidy rates in the energy efficiency auctions assessed in this paper all use the "pay-as-bid" method, meaning that each successful bid receives its offer. At least in one-off or pilot auctions, this method reduces the risk that, with limited participation, a steep supply curve of bids results in a price at or close to the price cap being paid to all winning bidders, protecting the value for money of using public funds. However, in the long run, with repeated auctions, this method risks strategic behaviour by bidders, potentially leading to an elevation and flattening of the supply curve of energy efficiency bids. Having observed previous auction rounds, bidders willing to accept a subsidy lower than the expected hammer price would be expected to increase the subsidy rates demanded. In this scenario, the energy efficiency bid curve (JGFK) would deviate from the energy efficiency supply curve (OCBK) (see Figure 2).

Policymakers choosing between a "pay-as-bid" auction and a "pay-as-clear" auction must trade off the expected benefits from subsidy discrimination (paying lower subsidy rates to bidders willing to accept a lower subsidy) (AGJ), which enable a subsidy budget to procure a greater quantity of energy savings, against the expected costs of subsidy rate inflation across all bids (BFG), which reduces the quantity of energy savings that can be procured (see Figure 2).

In addition, policymakers with broader economic efficiency concerns should consider the likelihood that, for a given quantity of procured energy savings, some less cost-effective actions, with a willingness to accept subsidy between the true clearing price and the hammer price (in the range DH), will receive support, while other more cost-effective actions may not, if their strategic bids are above the hammer price. Such an outcome would not represent an efficient allocation of resources and could outweigh the narrower net benefits from subsidy discrimination, should these exist.

Efforts to ensure competition among bidders in a "pay-as-bid" auction can also have negative consequences. In Switzerland – where bidders know that even if an auction round is undersubscribed (the sum of subsidies bid for is less than the budget) not all the bids will be accepted – this appears to have led to a reduced level of participation. Following Switzerland's introduction of the "120 % rule" (whereby budget rationing is applied if bids add up to less than 120 % of the budget) in 2013, the supply of bids declined continuously from 180 % of budget to just 60 % by 2018. This dynamic effect is predicted in the auction-theoretic literature, which shows that, with endogenous rationing (i.e. with the budget rationed depending on the volume of bids) in a series of auctions with participation costs, the highest-cost bidders will choose to withdraw their participation. With each succeeding auction, as participation wanes, hammer prices will decline and more bidders will withdraw in a vicious circle of non-participation (Hanke et al., 2020).

In Denmark, where no such endogenous rationing provision exists, auctions in 2021 were also undersubscribed – but this is thought to be related to the prevailing economic conditions (see section on Denmark above). With relatively little participation, bids were tightly clustered just below the price cap, as predicted in a "pay-as-bid" auction. However, theory would predict that, with a return to more normal economic conditions post-COVID, these relatively high prices should attract more potential energy efficiency bids and boost participation in future auctions.

COMPARISON BETWEEN AUCTIONS AND ENERGY EFFICIENCY OBLIGATION SCHEMES[7]

Both auctions and EEOSs offer the potential to deliver energy savings at relatively low cost to taxpayers or bill-payers, owing to their market-based aspects. Auctions can enable price discovery (as discussed above), while obligation schemes often require competing utilities to deliver energy savings, providing an incentive to minimise their programme costs (Rosenow et al., 2019). Where EEOSs have a liquid secondary market, such as in the Italian white certificate programme (where over 50 % of certificates are routinely traded on the spot market), the

6. PJM is a regional transmission organisation that coordinates the movement of wholesale electricity in all or parts of 13 US states and the District of Columbia. Originally, PJM was a shortened term for the Pennsylvania – New Jersey – Maryland Interconnection, however this no longer applies, even though the term PJM has remained.

7. A separate point of comparison between EEOSs and auctions (and grant programmes) relates to their treatment under state aid rules. Financial aid paid by obligated parties to businesses undertaking energy efficiency projects does not fall under state aid rules, but similar payments from Member State funding programmes to businesses may qualify as state aid, where the receiver is at an advantage compared to other competitors, competition could be influenced and trade between Member States affected. This could affect the design of auctions (and grant programmes) that might wish to fund projects over the de minimis amount of EUR200,000 and pay subsidies amounting to more than 30 % of investments (the percentage rises to 40 % for medium-sized enterprises and 50 % for small businesses).

Figure 1. Stylised representation of a "pay-as-clear" auction.

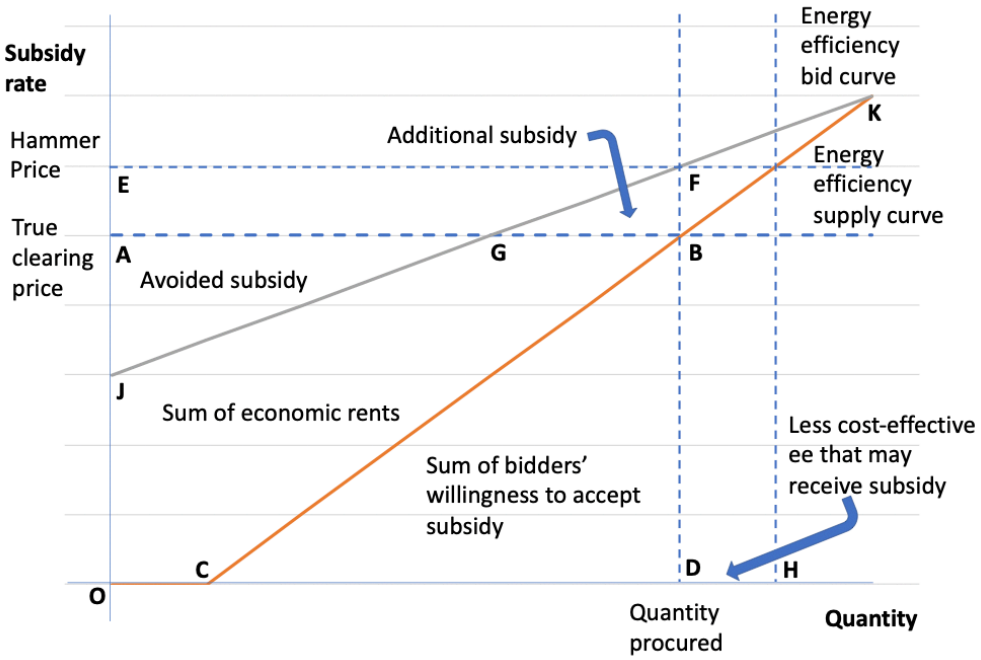

Figure 2. Stylised representation of a "pay-as-bid" auction compared to a "pay-as-clear" auction.

marginal cost to obligate parties can also be discovered. As a voluntary measure, auctions may be more politically acceptable, as participation is not legally binding. On the other hand, auctions have less certainty over their energy savings outcomes. Potential bidders may choose not to participate. An EEOS, as a regulatory measure, forces obligated parties to participate and enables a fixed goal to be achieved, subject to any buyout provisions that may enable obligated parties to pay a fee in lieu of directly making savings.

Depending on their design, both auctions and EEOSs can lead to economic rents (supernormal profits) for low-cost energy efficiency providers. With obligation schemes, such as the French and Italian white certificate schemes, shocks such as sudden increases in obligated parties' targets or the withdrawal of certificates from the market (as was the case when fraud was discovered in the Italian market) can lead to very high prices, extra profits for energy efficiency service companies, and an increase in the global costs passed through to bill-payers (Di

Santo, 2019).[8] This is analogous to the situation in a pay-as-clear auction with low liquidity and a steep energy efficiency supply curve (Figure 1). To avoid this type of outcome, policymakers need to address either the supply or the demand for energy savings within the scheme.

On the supply side, policymakers can take steps to increase liquidity in the production of eligible energy savings – for example, by focusing effort on complementary policy measures that help to bring potential energy efficiency projects to the attention of bidders or obligated parties. Examples of this can be found in the French white certificate programme, where organisations are issued with white certificates based on their expenditure on supporting measures (Ministère de la Transition écologique, 2021a), and in the UK EEOS, where local authorities are encouraged to work with obligated parties to help find energy-poor households targeted through the scheme (Sunderland, 2021). In the short run, emergency supply-side measures can also be put in place. In Italy, after the sudden removal of fraudulent certificates from the market,[9] both a EUR250 cap on the reimbursement component for distributors and "virtual" certificates with no correspondence to real energy savings were introduced to dampen white certificate prices (Di Santo, 2019).[10]

On the demand side, policymakers can place limits on the costs per unit of energy savings borne by taxpayers or bill-payers which, if triggered, would reduce the demand for energy savings. This is common practice in both auctions and EEOSs. Auctions often have maximum subsidy prices, while some obligation schemes have buyout prices, at which obligated parties can choose to pay a fee per unit of energy savings, rather than delivering energy savings or purchasing them from other parties. In many schemes, these fees are paid into a fund that, in theory, may then be used for an energy efficiency auction, as is the case in Turkey (see above). However, in most cases the use of buy-out prices has tended to be quite low, as the prices have been set at levels that encourage the obligated parties to undertake energy efficiency measures at lower cost. For EEOSs with short (e.g. annual) compliance periods, banking and borrowing between periods can also act as a flexibility option to avoid excessive price swings. In Ireland, obligated parties in the 2014–2020 EEOS phase had to achieve at least 60 % of their obligation each year (except the final year of the phase) before being able to access the buyout price, with underachievement being added to their obligation in the following year (Strategic Energy Authority of Ireland, 2014). Auctions do not have this flexibility option, as regulators have no ongoing relationship with their participants.[11]

Empirically speaking, EEOSs overshadow energy efficiency auctions in terms of their number and size. Of the USD 11.5 billion invested globally as a result of EEOSs and auctions in 2015, 98 % was channelled through EEOSs, and the EEOSs were responsible for a similarly large share of energy savings (IEA, 2017). Since then the number and volume of investments of both types have increased, but EEOS still dominate. It remains difficult to compare the relative cost-effectiveness of the two types of instruments, given the small number of auctions and the variations between jurisdictions in terms of their energy efficiency potential, eligibility criteria and fuel, sector and end-user coverage. Notwithstanding these caveats, the IEA noted that the Portuguese tender scheme and Swiss auction had cost-effectiveness scores (average cent subsidy/kWh) within the range exhibited by EEOSs (IEA, 2017).

The much larger size of most of the existing EEOSs (in Denmark, France, Luxembourg and Poland they aimed to deliver the Member State's entire EED energy savings obligation) compared to auctions raises the question of whether auctions are capable of delivering the significant amount of energy savings required in the coming years. Only in Denmark has a Member State switched from an EEOS to a set of alternative measures, including an auction set to deliver 60 % of its EED energy savings obligation. It will be interesting to see how the Danish auction progresses over the coming years, and whether it is able to encourage sufficient bids.

Potential role for auctions in the energy transition

The EU's net 55 % emissions reduction target by 2030 and net zero target by 2050 require an increase in the rate of emissions reduction and, in turn, the rate of energy savings (EU Commission, 2020). The Fit for 55 Package translates this raised ambition into higher energy efficiency targets and an increase in the rate of energy savings required from national policy measures, with the EED Article 7 (now Article 8) proposed to increase from 0.8 % of final energy consumption saved per year to 1.5 % from 2024 (EU Commission, 2021). At the same time, the increases in public (or bill-payer) spending implied by these more stringent requirements will likely put more pressure on governments to ensure that subsidies are spent on cost-effective energy efficiency actions and that subsidy programmes provide value for money to taxpayers and bill-payers. Other European countries, such as the UK, have different legislative frameworks but face the same need to ramp up action and deliver value for money (HM Government, 2021). Finally, although energy and carbon pricing developments – such as the proposed extension of emissions trading to direct emissions from buildings and road transport (EU Commission, 2021a) and the proposed rebalancing of energy taxes (EU Commission, 2021b) – will make

8. In theory, the same issues will also apply in any EEOS that obligates competing energy retail companies and allows horizontal trading between obligated parties. However, without a spot market for white certificate trading, the marginal cost of complying with the obligation is not so visible, meaning that the opportunity cost of holding on to excess compliance (which should be passed on to consumers by profit-maximising businesses) cannot be calculated so accurately.

9. In 2017 around 1.3 million annual certificates were withdrawn as a result of uncovered frauds and of extended thorough checks, creating an undersupply for that year and the ones to follow, making it impossible for distributors to reach their minimum targets for the next few years.

10. The cap served to keep certificate prices under control. The other transitional measure was introduced as an alternative to the white certificate scheme's target reduction, with the assumption it would be possible to take measures to stimulate the supply in the following years. Obligated parties unable to purchase enough certificates in the market to cover their targets have the option to buy virtual certificates at a price higher than their reimbursement. These virtual certificates can be substituted with "real" certificates in the two years following their purchase, in order to recover the economic loss.

11. Both auctions and EEOSs can be segmented to achieve energy savings among priority sectors or recipients or through particular technologies. This reduces the overall cost-effectiveness of achieving energy savings (on narrow economic grounds, not accounting for any non-market impacts), but could increase the energy savings delivered per unit of subsidy, if the economic rents associated with the programme as a whole were reduced by more than the impact of the increased costs of delivering to separate market segments. The French, Irish and UK EEOSs have (or had) subtargets for delivery among energy-poor households, while the Swiss auction and Portuguese tender also segment their programmes.

energy saving more financially attractive, the increased level of energy savings ambition in the Fit for 55 Package will mean that less cost-effective energy savings will need to be taken up in order to meet climate and energy targets (Chan et al., 2021).

An increased focus on value for money would suggest that market-based instruments, such as EEOSs and auctions, are likely to grow in importance, continuing a trend observed over the last 15 years (Rosenow et al., 2019). However, the need to achieve more ambitious quantity-based energy savings targets, through the EED energy savings obligation, would suggest that obligation schemes, rather than auctions, may have a bigger role to play, at least over the period to 2030. While it is difficult to draw firm conclusions on the effectiveness of auctions in delivering on targets – given the small sample, the early and COVID-affected stage of the Danish auction, the relatively small size of the German auctions and the different legislative environment in Switzerland – evidence from all these countries shows that auction budgets have not always been exhausted. Crucially, as voluntary measures, auctions cannot guarantee participation, making the delivery of energy savings targets less secure. Theoretically, a government could guarantee to meet its own volume constraint, by auctioning subsidies with unlimited price constraints, i.e. obligating itself. This approach has never been tried. A half-way house involves the auctioning of the obligation to achieve a set volume of energy savings. This approach has been taken in Vermont, US, where the state ran a competition to be the energy efficiency utility, with associated energy savings obligations (IEA, 2017).

EEOSs, as regulatory measures, offer the possibility of guaranteeing energy saving outcomes, although, as we have seen, mechanisms to avoid costs to obligated parties (passed through to bill-payers) such as buyout prices can act to reduce energy savings if triggered. Although this might suggest that EEOSs are set to expand in number and size, this development would likely add more costs to energy bills. This could prove to be politically unsustainable, given the sensitivity of energy bills to exogenous shocks, particularly during the heating season (e.g. from the weather or geopolitics), and the regressivity of funding the achievement of policy goals through energy bills rather than through general taxation. In France, which has an overarching EEOS with white certificates covering all fuels, the programme is sufficiently ambitious to deliver on France's existing EED energy savings obligation. The additional subsidy costs associated with meeting the proposed increase in ambition of the EED could potentially be split between bill-payers and taxpayers through a combination of a more ambitious energy efficiency obligation target, aligned with the EED, and support for subsidy measures that would reduce the costs to obligated parties of meeting the target. This approach has been used previously in France, where tax rebates were available to end users alongside subsidies from the white certificate programme for some energy efficiency investments (IEA, 2017), while only the savings from the EEOS were reported to the European Commission to comply with the EED.

In a system in which the EEOS is the dominant policy instrument used to deliver energy savings, auctions could be used as a way of allocating complementary subsidies. This is already the case in some parts of the US, where capacity mechanisms in New England and the Midwest run by regional electricity system operators (PJM) allow energy efficiency actions to compete with supply-side options. The energy efficiency actions are also eligible to be counted towards utilities' energy saving targets (Liu, 2017).

Beyond 2030, progress on end-use electrification and decarbonisation is likely to create new policy objectives for energy efficiency. High-cost decarbonisation actions (including energy efficiency) in industry sectors may be inappropriate to fund through EEOSs; bill-payer-funded obligation schemes have tended to operate on the premise that everyone pays, and everyone has the opportunity to benefit. In this context, auctions could become a tool for governments to discover participants' willingness to accept subsidy in sectors in which costs are difficult to assess in advance. Meanwhile, if space heating (and cooling) moves to electricity through the widespread adoption of heat pumps, this will put new pressures on electricity grids, particularly at peak times during winter. In this context, EEOSs might be better focused on delivering energy efficiency solutions that reduce the overall costs of providing a reliable electricity grid. In California, US and Ontario, Canada, the obligations on energy utilities have already moved towards a focus on peak electricity consumption, given that states' climatic conditions and reliance on electrically powered cooling (Rosenow et al., 2020).

Conclusion

The increasing interest in Europe in auctions as a way of allocating energy efficiency subsidies raises questions about policy design and their place in the energy and climate policy mix. All the energy efficiency-only auctions use the pay-as-bid method, in an attempt to support more energy efficiency projects than would be the case under a standard subsidy scheme, in which a set subsidy rate is provided. This approach risks strategic behaviour by bidders, and the extent to which this undermines the achievement of policy objectives is unclear. The approaches taken in Switzerland to bolster competition should moderate these impacts. However, more evidence is needed, through effective policy evaluation by experts in the auction field.

The voluntary nature of auctions makes them attractive to policymakers wishing to avoid placing regulatory burdens on businesses, as with EEOSs. However, this makes auctions vulnerable to nonparticipation, which in turn could put the achievement of urgent energy and climate objectives at risk. The advantages of regulation through EEOSs, as quantity-based instruments, would appear to make them more likely to be favoured over the period to 2030.

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