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Auctions for Renewable Energy Support II - First insights and results of the Horizon2020 project AURES II

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Design and results of recent renewable energy auctions in Europe

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An assessment of the design of the new renewable electricity auctions in Spain under an international perspective

Pablo del Río

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INTRODUCTION

The design of renewable auctions in the world and in Spain

Increasing the share of renewable energy is an essential part of the transition towards decarbonized energy systems. The European Union has acknowledged this by setting specific targets for renewables, and other countries, such as Spain, have followed suit. Part of this increase may come naturally as a result of the increasing competitiveness of these technologies: solar PV or wind are already cheaper than fossil-based alternatives. Others, such as offshore wind or bioenergy, still need support to become competitive. But, in all cases, and given the characteristics of energy markets in Europe (see *Papeles de Energía,* nº 6), all of them may still need some kind of regulatory support to ensure that the right investments are made. This is where auctions have, and will still play, a significant role, by providing certainty to investors, and resulting in lower costs for consumers.

However, for this to happen, auctions need to be designed in the right way. Many design elements need to be combined for the auctions to be effective (*i.e.* delivering on their goals), efficient (resulting in the lowest costs possible), and also to achieve other desirable objectives, such as actor or technology diversity. In recent years, many countries have implemented different auction designs, which are considered to have brought down support costs and increased deployment. However, some have also resulted in delayed or unrealised projects. Therefore, there is a need to assess and improve auction design and implementation in order to deliver the renewable energy goals stated for Europe and Member States.

The AURES II project, funded by the European Commission Horizon2020 programme, has investigated auction design options in a large detail, assessed their performance, and provided recommendations on their use. They have combined literature review, theoretical analysis, case studies, surveys, interviews, and empirical and quantitative methods such as econometric analysis and model simulations; and have also strongly involved relevant stakeholders. The project partners are CSIC, Technical University of Denmark, Eclareon, University of Exeter, Factor, Formicablu, Fraunhofer Institute for Systems and Innovation Research, Navigant, REKK, Takon, and TU Wien. In this issue of *Papeles de Energía* we present the major conclusions of the project.

First, **the whole AURES II** team offers some insights and results of project. The auctions analysed have been: Argentina, Canada, Chile, Denmark, Germany, Greece, Hungary, Mexico, Netherlands, Poland, Portugal, Slovakia, Ukraine and the UK. More details about the analysis can be found in a synthesis report which will be published soon, as well as in a companion paper in this issue.

The first result of the project has been a public database that covers more than 400 renewable energy auctions, which is being updated every six months. This database has been used to assess the coincidence of EU Member States' policy objectives and the auction design; and also the efficiency and effectiveness of these auctions. Regarding the first issue, the researchers found that 7 out of the 13 analysed countries had well-aligned objectives, three followed an ambitious strategy, and only two showed non-aligned objectives. Also, 10 out of the 13 countries showed a suitable auction design, able to meet the objectives. In terms of effectiveness and efficiency, they identified a list of design elements with a significant effect on the awarded prices: project size, financial prequalifications, realisation periods, auctioned technology competition, penalties, flexibility, multiple criteria, quotas, and the remuneration scheme. The project team has also analyzed the impact of COVID-19 on auctions, the effect of low competition on auction outcomes, and how to reduce the winner's curse.

AURES II has also looked at the impacts of auctions on supply chains, actor diversity, and technological innovation, and proposed recommendations on the design elements that promote them, such as public auction schedules and high frequency. They also concluded that there is no easy solution to promoting renewable energy communities through auctions, and that they should probably have to be promoted outside the auctions.

A very important element of renewables, given their high capital intensity, is the cost of capital. The project studied the impact of auction design on the cost of equity and debt, with mixed results. In general terms, auctions seem to improve financing conditions. They also found that contracts for differences have the most positive impact on financing conditions, but other design elements can results in an increase in the cost of capital, such as stringent bid bonds, or unrealistic project realisation deadlines. Finally, they also recommend Member States to focus on de-risking debt financing, since that would deliver the largest cost savings. De-risking auction design in the pre-bidding stage does not provide significant benefits in terms of cost reductions.

Another interesting topic assessed by the project is international, or cross-border, auctions, which are expected to become more relevant in Europe in the future (and may be necessary to achieve the overall EU objectives, and will contribute to lower costs). The researchers provide eight good practices on how to design these auctions and highlight and discuss other challenges.

The project also covers a very relevant discussion: tecnology-specific vs technology-neutral support, concluding that the latter may be more advisable.

As mentioned before, in a second paper, **Szabo *et al.*** present their analysis of the design and results of recent renewable energy auctions in Europe. The authors start by describing the major elements in auction design, and compares the choices in different European countries in this regard.

Most countries tend towards multi-technology auctions (with the Netherlands even including heat producers), probably as a consequence of EU regulations. However, in practice it seems rather difficult to organise technology neutral auctions which truly provide a level-playing field for the different technologies. Even if two technologies have a similar LCOE range, varying construction lead times, differing production patterns and, consequently, different reference prices will lead to distortions in auctions and, thus, one or the other technology will be disadvantaged.

In terms of the auctioned product, there is no consensus: both capacity and energy are auctioned. The same happens for capacity or budget constraints (which are considered simultaneously in Poland or Hungary). In most countries, support is paid as a premium, predominantly as a contract for difference. Pay-as-bid is also the most popular choice, but the support period varies from 8 to 20 years.

To increase the probability of timely project implementation, prequalification requirements are also quite common: most countries require titles for land use, or grid connection rights, and some even require environmental or building licenses (which can result in lower competition, as happened in Germany with onshore wind). In addition, most countries use two-stage (bid and realization) financial guarantees.

The results of European auctions present a mixed picture in terms of their effectiveness. Some were undersuscribed (*e.g.* onshore wind and bioenergy in Germany, or wind and PV in Greece), and also some winning projects have not been implemented or significantly delayed in the UK or the Netherlands. In Germany, realisation rates are high for PV and low for onshore wind. However, reliable figures are not available, and the authors encourage governments to put more effort into tracking and reporting them.

In terms of efficiency, auctions seem to have resulted in lower prices than previous support instruments, although some countries are experiencing increases for some technologies (onshore wind). Actor diversity is also an important outcome, which has been sought in different ways by different countries, with not very positive results.

Finally, **Pablo del Río**, from CSIC, probably the Spanish researcher with the largest knowledge in renewable energy auctions, offers his analysis of the recent Spanish auction, identifies its pros and cons, and compares them with international practice. In general terms, his conclusion is positive: The auction included many recommended design elements, such as flexibility in the volumes awarded, a reasonable schedule for future auctions, seller concentration rules, or a hybrid design that combines features of technology-specific and technology-neutral auctions. Other elements, however, should be improved for future auctions: a longer lead time to prepare the bids, geographical incentives, or promoting a more diverse set of actors. Del Río also proposes increasing the market exposure of the technologies, to improve their fit with market prices.

The three papers provide a rigorous and comprehensive overview of an instrument which will probably need to be used much in the future, although probably in an evolved format. For example, auctioning tons of CO_2 avoided, or renewable production with flexible storage, such as has been already done in the Netherlands or Portugal. The lessons from previous auctions will therefore be very valuable, and I do encourage readers to know more about them by reading the full papers.

INTRODUCCIÓN EDITORIAL

El diseño de subastas renovables en el mundo y en España

Aumentar la contribución de las energías renovables es un elemento esencial de la transición hacia un sistema energético descarbonizado. La Unión Europea lo ha reconocido al establecer objetivos específicos para las energías renovables, y otros países, como España, han seguido su ejemplo. Parte de este aumento puede ocurrir de forma natural, como resultado de la creciente competitividad de estas tecnologías: la energía solar fotovoltaica o la eólica ya son más baratas que las alternativas basadas en fósiles. Otras, como la eólica marina o la bioenergía, aún necesitan apoyo para ser competitivas. Pero, en todos los casos, y dadas las características de los mercados energéticos en Europa (ver *Papeles de Energía,* nº 6), todas ellas pueden necesitar todavía algún tipo de soporte regulatorio para asegurar que se realicen las inversiones adecuadas. Aquí es donde las subastas han tenido, y seguirán teniendo, un papel importante, ya que brindan certeza a los inversores y resultan en costes más bajos para los consumidores.

Sin embargo, para que esto suceda, las subastas deben diseñarse de la manera correcta. Muchos elementos de diseño deben combinarse para que las subastas sean efectivas (es decir, que cumplan sus objetivos), eficientes (que resulten en los costes más bajos posibles) y también para lograr otros objetivos deseables, como la diversidad de actores o de tecnologías. En los últimos años, muchos países han implementado diferentes diseños de subastas, que se considera que han reducido los costes del apoyo público y aumentado la penetración de estas tecnologías. Sin embargo, algunos diseños también han dado lugar a proyectos retrasados o no realizados. Por lo tanto, es necesario evaluar y mejorar el diseño y la implementación de las subastas para cumplir los objetivos de energía renovable establecidos para Europa y los Estados miembros.

El proyecto AURES II, financiado por el programa Horizon2020 de la Comisión Europea, ha investigado las opciones de diseño de subastas con gran detalle, ha evaluado su rendimiento y ha proporcionado recomendaciones sobre su uso. Han combinado revisiones de la literatura, análisis teóricos, estudios de caso, encuestas, entrevistas y métodos empíricos y cuantitativos como el análisis econométrico y simulaciones de modelos; y también han involucrado fuertemente a las partes interesadas relevantes. Los socios del proyecto son CSIC, Technical University of Denmark, Eclareon, University of Exeter, Factor, Formicablu, Fraunhofer Institute for Systems and Innovation Research, Navigant, REKK, Takon y TU Wien. En este número de *Papeles de Energía* presentamos las principales conclusiones del proyecto.

Primero, todo el **equipo de AURES II** presenta de forma resumida las principales conclusiones y resultados del proyecto. Las subastas analizadas han sido: Argentina, Canadá, Chile, Dinamarca, Alemania, Grecia, Hungría, México, Holanda, Polonia, Portugal, Eslovaquia, Ucrania y Reino Unido. Se pueden encontrar más detalles sobre el análisis en un informe de síntesis que se publicará pronto, así como en un documento complementario en este número.

El primer resultado del proyecto ha sido una base de datos pública que cubre más de 400 subastas de energías renovables, que se actualiza cada seis meses. Esta base de datos se ha utilizado para evaluar la coincidencia de los objetivos políticos de los Estados miembros de la UE y el diseño de la subasta; y también la eficiencia y eficacia de estas subastas. Respecto al primer tema, los investigadores encontraron que 7 de los 13 países analizados tenían objetivos bien alineados, tres seguían una estrategia ambiciosa y solo dos mostraban objetivos no alineados. Además, 10 de los 13 países mostraron un diseño de subasta adecuado, capaz de cumplir con los objetivos. En términos de efectividad y eficiencia, identificaron una lista de elementos de diseño con un efecto significativo en los precios adjudicados: tamaño del proyecto, precalificaciones financieras, períodos de realización, competencia de tecnología subastada, sanciones, flexibilidad, criterios múltiples, cuotas y esquema de remuneración. El equipo del proyecto también ha analizado el impacto de COVID-19 en las subastas, el efecto de la baja competencia en los resultados de la subasta, y cómo reducir la maldición del ganador.

AURES II también ha analizado los impactos de las subastas en las cadenas de suministro, la diversidad de actores y la innovación tecnológica, y ha propuesto recomendaciones sobre los elementos de diseño que las promueven, como los calendarios públicos de las subastas y la alta frecuencia. También concluyeron que no existe una solución fácil para promover las comunidades de energías renovables a través de subastas, y que probablemente deberían promoverse fuera de las mismas.

Un elemento muy importante de las renovables, dada su alta intensidad de capital, es el coste del capital. El proyecto estudió el impacto del diseño de la subasta en el coste del capital y la deuda, con resultados mixtos. En términos generales, las subastas parecen mejorar las condiciones de financiación. También encontraron que los contratos por diferencias tienen el impacto más positivo en las condiciones de financiación, pero otros elementos de diseño pueden resultar en un aumento en el coste de capital, como las garantías financieras estrictas o los plazos de realización de proyectos poco realistas. Por último, también recomiendan a los Estados miembros que se centren en reducir el riesgo de financiación de la deuda, ya que eso supondría el mayor ahorro de costes. Reducir los riesgos en el diseño de la subasta en la etapa previa a la licitación no brinda beneficios significativos en términos de reducciones de costes.

Otro tema interesante evaluado por el proyecto son las subastas internacionales o transfronterizas, que se espera que sean más relevantes en Europa en el futuro (y pueden ser necesarias para lograr los objetivos generales de la UE y además contribuirán a reducir los costes). Los investigadores proporcionan ocho buenas prácticas sobre cómo diseñar estas subastas y destacan y discuten otros desafíos.

El proyecto también afronta una discusión muy relevante: si el apoyo debe ser específico o tecnológicamente neutro, concluyendo que este último puede ser más recomendable.

Como se mencionó anteriormente, en un segundo artículo, **Szabo *et al.*** presentan su análisis del diseño y los resultados de las recientes subastas de energía renovable en Europa. Los autores comienzan describiendo los elementos principales en el diseño de subastas y comparan las opciones en diferentes países europeos a este respecto.

La mayoría de los países tienden a las subastas de múltiples tecnologías (y los Países Bajos incluso incluyen a los productores de calor), probablemente como consecuencia de las indicaciones de la UE. Sin embargo, en la práctica parece bastante difícil organizar subastas tecnológicamente neutrales que realmente proporcionen igualdad de condiciones para las diferentes tecnologías. Incluso si dos tecnologías tienen un rango de costes similar, los tiempos de construcción variables, patrones de producción diferentes y, en consecuencia, precios de referencia diferentes, provocarán distorsiones en las subastas y, por lo tanto, una u otra tecnología se verá en desventaja.

En cuanto al producto subastado, no hay consenso: se subastan tanto la capacidad como la energía. Lo mismo ocurre con las limitaciones de capacidad o presupuesto (que se consideran simultáneamente en Polonia o Hungría). En la mayoría de los países, la retribución se paga como una prima, principalmente como un contrato por diferencias. El pago por oferta (*pay as bid*) también es la opción más popular, pero el período de soporte varía de 8 a 20 años.

Para aumentar la probabilidad de implementación a tiempo del proyecto, los requisitos de precalificación también son bastante comunes: la mayoría de los países exigen títulos de uso de la tierra o derechos de conexión a la red, y algunos incluso exigen licencias ambientales o de construcción (lo que puede resultar en una menor competencia, como sucedió en Alemania con la eólica terrestre). Además, la mayoría de los países utilizan garantías financieras en dos etapas (licitación y realización).

Los resultados de las subastas europeas presentan un panorama heterogéneo en cuanto a su eficacia. Algunas no se suscribieron (por ejemplo, la energía eólica terrestre y bioenergía en Alemania, o energía eólica y fotovoltaica en Grecia), y también algunos proyectos ganadores no se han implementado o se han retrasado significativamente en el Reino Unido o los Países Bajos. En Alemania, las tasas de realización son altas para la energía fotovoltaica y bajas para la energía eólica terrestre. Sin embargo, no se dispone de cifras fiables y los autores animan a los gobiernos a esforzarse más en su seguimiento y comunicación.

En términos de eficiencia, las subastas parecen haber tenido como resultado precios más bajos que los instrumentos de apoyo anteriores, aunque algunos países están experimentando aumentos para algunas tecnologías (eólica terrestre). La diversidad de actores también es un resultado importante, que ha sido buscado de diferentes formas por diferentes países, con resultados poco positivos.

Finalmente, **Pablo del Río**, del CSIC, probablemente el investigador español con mayor conocimiento en subastas de energías renovables, ofrece su análisis de la reciente subasta española, identifica sus pros y contras y los compara con la práctica internacional. En términos generales, su conclusión es positiva: la subasta incluyó muchos elementos de diseño recomendados, como flexibilidad en los volúmenes adjudicados, un calendario razonable para futuras subastas, reglas de concentración de vendedores o un diseño híbrido que combina la especificidad con la neutralidad tecnológica. Sin embargo, se deben mejorar otros elementos para futuras subastas: un plazo más largo para preparar las ofertas, incentivos geográficos o promover un conjunto más diverso de actores. Del Río también propone aumentar la exposición al mercado de las tecnologías, para mejorar su ajuste con los precios del mercado.

Los tres artículos ofrecen una descripción rigurosa y completa de un instrumento que probablemente será necesario utilizar mucho en el futuro, aunque probablemente en un formato evolucionado. Por ejemplo, la subasta de toneladas de CO_2 evitadas, o la producción renovable con almacenamiento flexible, como ya se ha hecho en Holanda o Portugal. Para ello, las lecciones de subastas anteriores serán muy valiosas, y por tanto animo a los lectores a que conozcan más sobre ellas leyendo los artículos completos.

Auctions for Renewable Energy Support II - First insights and results of the Horizon2020 project AURES II*

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Abstract

The Horizon2020 project AURES II aims at ensuring the effective implementation of auctions for renewable energies in the EU Member States (MS). In recent years, auction schemes for the allocation of support for renewable electricity sources (RES) have been advancing rapidly across Europe. Auctions are considered to have brought down support levels and increased planning capability for RES deployment and state budgets. In some unfortunate cases, they have, however, also resulted in delayed or unrealised projects and increased uncertainty for project developers. A variety of auction designs are still being tested and introduced in EU MS, as well as foreseen by European legislation. Therefore, there is still a need for further assessment and improvement of national auction design and implementation to ensure the future success of RES auctions in Europe. Applying different qualitative and quantitative methods in the various work packages (WPs), the AURES II project partners have already drafted and published a large number of reports and studies. This article aims at comprehensively presenting these results and provide a first overview.

Key words: renewable energy, electricity, auctions.

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Applying different qualitative and quantitative methods in the various work packages (WPs), the AURES II project partners have already drafted and published a large number of reports and studies. This article aims at comprehensively presenting these results and provide a first overview.

1. WP2 MONITORING OF AUCTION IMPLEMENTATION

Work Package 2 (WP2) deals with empirical aspects and deriving insights from RES auctions in Europe and worldwide. More specifically, currently conducted as well as planned auction schemes have been evaluated in several case studies with lessons learnt and best practices identified.

So far, concluded auctions in the following countries have been analysed: Argentina, Canada, Chile, Denmark, Germany, Greece, Hungary, Mexico, Netherlands, Poland, Portugal, and the UK. In addition, one multi-national, technology-specific case study on CSP has been conducted. Furthermore, three planned auction schemes have been analysed: the Thor offshore wind auction in Denmark, Slovakia, and Ukraine.

The AURES II consortium will shortly publish a synthesis report on the case studies, highlighting the lessons learnt and best practice examples. Nevertheless, a first version of this synthesis report will be part of this Special Issue.

Case cooperations, in which the AURES II consortium provides recommendations on auction designs, have been successfully ongoing with policymakers in four MS that have ongoing auction implementation processes. These are Austria, Denmark, Germany, and Hungary.

2. WP3 AUCTION DATABASE AND EMPIRICAL INSIGHTS

The work carried out in WP3 contains the development of a comprehensive database on past and ongoing auction rounds in the EU, including their design, timing, and results. Based on these data, two empirical papers are currently being drafted. In addition, WP3 comprises several policy briefs that analyse current and emerging topics in the realm of renewable energy auctions.

Although a rising number of countries in and outside the EU have implemented auctions to support RES, no single, publicly available database exists which comprises information on the concluded auctions. Therefore, the AURES II consortium closed this gap by collecting and updating the available data on RES auctions in the EU (http://aures2project.eu/auction-database/)[1]. The result is a database that covers more than 400 distinct RES auction in 20 EU Member States from the years 2011-2021 and which is being updated every six months. The database includes information regarding implemented design elements, such as prequalification criteria, pricing rules, auctioned volume, the auction outcomes (*e.g.* awarded prices and volumes, level of competition, etc.), as well as the realisation rates of the awarded projects, among other elements.

Based on the data gathered in the AURES II auction database, two empirical studies are being drafted and soon to be published: the first one evaluates the EU Member States' RES policy objectives and the implemented RES auction designs and the second one examines the efficiency and effectivities of European RES auctions quantitatively.

In the first forthcoming paper, Hanke and Anatolitis (forthcoming) collected the stated RES policy objectives of EU member states that have an auction scheme

1 Currently, the database can be downloaded as an Excel- file from the AURES II website: http://aures2project.eu/auction-database/. An interactive version of the database is currently being developed.

in place. In a first step, they summarised the objectives (*i.e.* effectiveness, cost efficiency, support cost efficiency, green growth, security of supply, and actor diversity) and identified the relationship between these objectives theoretically. Based on these relations, they were able to assess whether countries followed a consistent strategy when drafting their RES policy objectives. The results indicate that 7 out of the 13 analysed countries had well-aligned objectives, three followed an ambiguous strategy, and only two showed non-aligned policy objectives. One country followed a "neutral" strategy, stating only one objective. In the next step, the authors examined whether the countries in focus designed their RES auctions according to their objectives. Based on insights from auction theory and on each country's chosen auction design elements retrieved from the AURES II auction database, the authors concluded that 10 out of the 13 countries actually showed a suitable auction design. In contrast, three countries could improve their schemes by adapting their auction designs to their stated objectives.

In the second forthcoming paper, Anatolitis, Azanbayev and Hanke (forthcoming) use the data of the auction database to conduct an econometric analysis to quantitatively identify the impact of various RES design elements on awarded prices in RES auctions. Using a panel data regression model, they were able to show that prices dropped significantly over the years. Furthermore, besides observing the significant impact of financing conditions and RES share in a country, they identified a list of auction design elements with a significant effect on the awarded prices: project size, financial prequalifications, realisation periods, auctioned technology, competition, penalties, flexibility, multi-criteria auctions, quotas, and the remuneration scheme. These findings can support policymakers in designing efficient auction schemes. Nevertheless, some of the results contradict the predictions of auction theory, such as financial prequalifications or penalties decreasing the awarded prices, and should be further researched.

To date, three policy briefs have been published by the AURES II consortium, which provide timely analyses on selected auctions to keep stakeholders up to date on new developments:

Impact of COVID-19 on Renewable Energy Auctions: In May 2020, in the first AURES II policy brief, Wigand *et al.* (2020) analysed the impact of the (starting)

COVID-19 pandemic on RES auctions and derived recommendations for policymakers on how to deal with these challenges. Four major impact areas have been identified: 1) the Covid-19 pandemic leads to decreased energy demand, which results in potentially lower short-term demand for RES and potentially more EU Member States meeting their 2020 RES targets without additional policy action. 2) Disruptions in global supply chains and national permitting procedures might endanger project realization and increase accrued penalties. Several EU Member States had already prolonged realization deadlines while others have postponed or cancelled auctions. 3) Higher RES financing risks were observed due to an increased country and policy risk. 4) Falling wholesale market prices posed significant challenges for projects without market premiums with sufficient floor prices (*e.g.* merchant plants and plants with a low fixed premium).

Besides advocating that climate-friendly economic stimuli packages should increase public clean energy spending and access to finance, the authors recommended that policymakers should extend the realisation deadlines of awarded projects and in upcoming auctions. Furthermore, policymakers should allow for longer award periods and should increase the digitalisation of auction procedures. Lastly, the adjustment of auction schedules could be considered, but policymakers should avoid downward auction volume revisions.

How (not) to respond to low competition in renewable energy auctions: In this second policy brief, Hanke and Tiedemann (2020) analysed possible ways on how to deal with a lack of competition in RES auctions that leads to higher awarded prices and argued against the use of endogenous rationing. They argue that if the reason for the supply shortage is based on the auction design itself (strong disadvantages for one bidder group), then it is a good idea to change the auction design, including possible interventions for the disadvantaged bidders, to achieve a more favourable outcome. If the technology itself cannot generate enough supply, multi-technology or cross-border auctions can be helpful to fill the volume with supply from other technologies or countries without supply shortages. Another option is to reduce the auction volume temporarily and to add the missing volumes to future auctions when the supply side has recovered. Nevertheless, the authors argue that in no case the reduced auction volume or the ceiling price should be determined endogenously within the auction, but only administratively prior to the auction. While short-term improvements may be possible with endogenous rationing, long-term effects such as missing renewable energy targets prevail. Endogenous rationing not only decreases social welfare and increases costs but also damages the market in the long term by further weakening the supply side and generating unwanted market distortions. This has been proven theoretically, experimentally, and with real-world examples.

The 2020 Nobel Prize for Economics and its connection to AURES II: In this third policy brief, Ehrhart, Ott and Hanke (2020) presented the work of Robert Wilson and Paul Milgrom, the 2020 laureates of the Nobel Prize for Economics. Robert Wilson extended the assumption of private values in auctions, *i.e.* that each bidder only knows the good's value to them and that different bidders have different values, by introducing common values. In a situation with a common value, the good has the same value for every bidder, but no bidder knows this value exactly. The value may depend on future developments, *e.g.* market prices, which are the same for all bidders but unknown at the time of the auction. An auction of this good may lead to the so-called "winner's curse": even if the bidders estimate the common value correctly on average, the bidder who misjudged the value the most will win and will most likely realise a loss. Paul Milgrom, Wilson's former PhD student, analysed a more general model that incorporates the two extreme cases of common and private values and provided insights into how more information in the auction process help reduce the winner's curse. In both AURES and AURES II, the consortium further investigated the findings of the two laureates both theoretically and experimentally to help reduce the risk of the winner's curse and to improve the design of auctions for RES.

3. WP4 EFFECTS OF AUCTIONS ON THE RES SECTOR

WP4 focuses on three aspects of the effects of auctions and auction design on the RES sector, *i.e.* including impacts on supply chains (focusing on market concentration in this sector), actor diversity (the impact on energy communities) and technological innovation.

It is often argued that a key feature of auctions is the competitive pressure created on the overall value chain, and indeed on all actors of the RES sector. Moreover, it is often argued that auctions can induce a reduction in the level of actor diversity (AD) in some segments of the value chain, and especially in the project development sector. Auctions may favour certain types of actors over others, and this may lead to increased levels of market concentration (MC)[2].

Del Río *et al.* (2020) empirically analysed: 1) the impacts of different auction design elements (DE) on MC in the project development and component manufacturing segments of the RES value chain; 2) The relative impact of auctions (as compared to other (contextual) factors influencing the value chain) on MC in those two segments. Country and technology case studies were undertaken based on an expert-elicitation protocol (structured interviews with key experts) in four countries (Spain, U.K., Peru and South Africa).

Certain design elements stand out as having a consistently strong positive (increasing) or negative (decreasing) impact on the number and diversity of project developers and component manufacturers; impacts that are observed in all four countries of analysis. The use of transparent publicly-disclosed auction schedules, as well as conducting auctions with high frequency, are clearly considered to be elements that increase both the number and diversity of actors in project developer and component manufacturer value chain segments. The opposite is true for all kinds of prequalification requirements. Specifically, when prequalification requirements –whether financial, technical or related to bidder experience– are stringent (as opposed to lax), they tend to reduce both the number and diversity of actors in project developer and component manufacturer value chain segments.

In general terms, interviewed experts held a range of diverging views as to whether auctions, auction design elements, or context conditions, are most important in terms of shaping the number and diversity of actors in the two value chain segments of interest. Context conditions and related factors were found to affect the number and diversity of project developers and component manufacturers in an overall neutral or positive way. However, in some countries auctions themselves

2 MC is defined as the distribution of a given market among the participating companies. MC reflects both the number of firms within the market/sector (and/or participating in the auction) and the diversity of those firms (*i.e.* the degree of heterogeneity with respect to the size of those firms).

were not regarded as the major determinant of MC in the two considered stages of the value chain.

Amazo *et al.* (2020) aim to provide an overview of the impact of auctions on renewable energy communities (RECs) and assess measures to support these market actors in or outside auctions. According to article 12 (16) of the Renewable Energy Directive (REDII), a RECs is “a legal entity: (a) which, in accordance with the applicable national law, is based on open and voluntary participation, is autonomous, and is effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by that legal entity; (b) the shareholders or members of which are natural persons, SMEs or local authorities, including municipalities; (c) the primary purpose of which is to provide environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates, rather than financial profits”. The REDII acknowledges the importance of RECs and requires Member States to consider the specificities of these market actors when designing support schemes.

RECs can foster the local acceptance and ownership of renewable energy development. As indicated by Amazo *et al.* (2020, p. 26), “RECs can support renewable energy development in various ways, for example by increasing local participation in planning and decision-making processes, as well as local benefits through project ownership. Furthermore, local engagement processes of RECs can facilitate the land acquisition process and thus ease the often-challenging pre-development of sites, particularly for new wind projects”. Despite their importance, RECs face special challenges in auctions compared to administratively-set remuneration schemes, which is related to their limited project portfolio and size. “Participating and winning in an auction requires significant expertise and access to capital, which smaller actors do not have to the same degree as large, experienced renewable energy developers” (Amazo *et al.*, 2020, p. 26).

From their analysis, Amazo *et al.* (2020) broadly conclude that there is no easy solution to promote RECs in the context of auctions. Most importantly, the authors find out that measures to address the impact of auctions on RECs can be taken either inside the auction (as in Germany or France) or outside the auction (as in Denmark). Measures within the auction include lower pre-qualification requirements, longer realization periods, citizen participation bonus and a different pricing rule (*e.g*. uniform pricing instead of pay-as-bid, PAB). However, while promoting RECs, these measures inside the auction rules may lead to distortions in the auction (Amazo *et al*., 2020, p. 27).

In contrast, measures outside the auction, such as exempting RECs from the auction and a guarantee fund, can help address financing risk and the allocation risk and "interfere considerably less with the auction compared to preferential treatment or the exemption from auctions. Denmark's experience shows the uptake of this measure depends on the sufficiency of the guaranteed volume, and the limits of a measure's effectiveness in reversing a trend towards actor consolidation" (Amazo *et al*., 2020, p. 27).

Another topic addressed in WP4 is the impact of auctions on technological innovation. Innovation in general and, more specifically, innovation in renewable energy technologies (RETs) will be a critical component of the energy transition (IEA, 2020). Del Río and Kiefer (2021) analyse the impact of auctions on technological innovation in RETs. Deployment policies, such as auctions, will not only have impacts on deployment itself (*e.g*., on diffusion) but on previous stages of the innovation process as well (*e.g*., invention and innovation). However, attention has not been paid so far in the auction literature to how auctions and auction design elements influence innovation in RETs. Del Río and Kiefer (2021) cover this gap by providing a first contribution on this issue and exploring the impacts of auctions and auction design elements on technological innovation. An analytical framework on the mechanisms linking diffusion-driven technological innovation and auctions and their design elements, which merges the insights from different approaches, is provided and a preliminary empirical analysis to identify the perception of key stakeholders on the topic is carried out. Based on theory and on those perceptions, the authors put forward some research proposals to be investigated in future research.

The authors follow an exploratory analysis based on a literature review and an exchange of views on the main aspects (actors, variables, relationships between variables and causal links) with different relevant stakeholders knowledgeable of both innovation processes in RETs and auctions (and their design elements). The authors put forward the following research proposals, to be further investigated in the future:

- The design of the auction (different design elements) may affect innovation through several key channels: impact on private R&D through a greater profit margin and the expectation that there will be a market for the technology (*i.e.*, where manufacturers and technology developers can sell their technology), impact on technology diffusion (learning effects) and impact on the competitive pressures faced by manufacturers and technology developers to reduce costs or increase revenues.
- The negative effects on innovation from lower profit margins in auctions and lower levels of market creation for RETs compared to administratively-set FITs may offset the positive effects on innovation from greater competition in auctions. Whether this is so for all RETs and auctions depends on the technologies, the design of the auction and the details of the administratively-set remuneration to which the comparison is made.
- Auctions will be one of the factors influencing innovation in RETs, but probably not the main one. Many other policy (e.g., technology-push policies) and non-policy factors (*e.g.*, the pressure to reduce costs as a result of international competition in a globalised sector) influence innovation, and probably to a larger extent.

4. WP5 IMPACTS OF AUCTIONS ON COST OF CAPITAL

The aim of WP5 is to evaluate the effects of auctions and auction design on RES project financing, *i.e.*, the cost of capital of RES projects and to suggest auction designs that are compatible with the usual financing practices of RES projects. The final goal is to provide policy recommendations in terms of design element choices that reduce the risks and improve the financing conditions.

This is a crucial issue, since the costs of capital are one of the most significant cost factors of RES projects, due to their typically very high capital intensity. However, this issue remains to date under-researched. Indeed, the reduction in different auction design elements (DE) of wind and solar PV in the last decades can partly be attributed to reductions in financing costs (Egli, Steffen and Schmidt, 2018).

Đukan *et al.* (2019) map out the potential effects that auctions might have on financing conditions of RES projects, focusing on the market effects of introducing auction schemes and the effects on financing of individual design elements. Therefore, its main purpose is to identify possible causal relationships between auctions and their impact on financing conditions for renewable energy projects.

The authors systematically explore possible impacts of different drivers (exogenous and endogenous) on financing conditions for investments in new RE assets. The drivers are endogenous (renewable energy policy and auction design) and exogenous (such as economy-wide effects, monetary policy and the structure of the capital market, among others). Three main dimensions of (direct and indirect) impact are considered: financing type (project financing vs. balance sheet financing), project phase (the project development lifecycle) and actor type. Financing conditions are defined as "both the ability to source financing for an investment and the cost of sourcing it" (Đukan *et al.,* 2019, p. 10). The authors analyse "effects via indicators related to 'cost of capital' on the one hand, and indicators related to 'loan conditions' on the other. We thus differentiate seven different impact indicators: weighted average cost of capital (WACC), cost of equity, cost of debt, debt-to-equity ratio, hurdle rate, debt service coverage ratio (DSCR) requirements and loan maturity" (Đukan *et al.*, 2019, p. 10).

The work relies mainly on qualitative research methods and the methodology is based on three steps: 1) a literature review of auction design and financial theory literature; 2) semi-structured interviews with seven industry professionals, with a background in financing renewable energy investments and/or project development; and 3) a validation workshop with industry stakeholders at the Wind Europe conference in Bilbao in April 2019 (Đukan *et al.,* 2019). The authors warn that their findings should be considered as hypotheses that need further research and validation rather than conclusions.

The results from this report can be summarized in five main categories:

1) *Cost of equity and hurdle rates experience both downward and upward pressure from auctions*. Growth limitations and competitive pressure induced by auctions may force project owners to accept lower profit margins, *i.e*. lead to a reduction in hurdle rates. On the other hand, the new risks faced by these owners in the auction may lead to higher risk premiums. In addition, "auctions may also lead to a decrease in support payments to individual projects, making them more dependent on volatile market revenues, potentially causing an increase in cost of equity" (Đukan *et al.,* 2019, p. 6). The impact on different types of actors can be expected to be different. In particular, small actors would probably be more negatively affected, leading to a reduction of actor diversity. The impact of some design elements is discussed. Some could be expected to affect the risks, the cost of financing a project and the willingness or capability to finance it.

2) *Debt financing is most likely impacted more by the remuneration scheme than by other auction designs*. The authors expect the support design in auctions to lead (under certain circumstances) to more difficult and expensive project financing[3]. They find that "two-sided Contract for Difference (CfD) schemes (which provide a fixed remuneration independent of the market price) have the most positive impact on loan financing conditions since they provide the most predictable revenues" (Đukan *et al.* 2019, p. 6).

3) *Auctions may change the investor landscape, through their diverging effects on actors, influencing actor diversity.* One of the main findings of this report is that auction schemes affect the investor landscape by creating new market conditions. Interestingly, the new market conditions have an impact on actor diversity, because "Unlike larger actors (such as utilities) that have diverse cash flows and easier access to capital, smaller project developers do not necessarily have the resources to diversify, and the risks they are exposed to could lead to greater financial distress" (op. cit., p. 49).

3 In addition, "the higher competitive pressure of auctions might also be reflected in the banking business, and potentially lead to a small decrease in debt margins" (Đukan *et al*., 2019, p. 48).

4) *Auctions are a policy tool that, depending on its specific implementation, can be a barrier to RE financing, but also provide market stability.* On the one hand, auctions can improve the stability of support schemes which could be positive for financing, both on the equity and debt side. Some design elements would be highly positive in this regard, including fixed auction volumes, long-term schedules (with well-defined rounds in terms of frequency) and contractual commitments between auction winners and a governmental institution.

5) *The impact on financing depends on individual designs and market circumstances*. The authors stress that the impact on financing depends on individual designs and market circumstances. Regarding the former, CfD would have a positive effect on the cost of capital, but stringent bid bonds, unrealistic project realisation deadlines, unclear auction volumes, low auction round frequency, among others, could have a negative effect. Regarding the latter, other factors beyond auction design may have a greater influence on the costs of capital and financing, including country risks, monetary policy or regulatory barriers.

Đukan and Kitzing (2021) investigate the effects of the shift to auctioning on the costs of capital and financing conditions for onshore and offshore wind. They use the results from Đukan *et al.* (2019) as a first step and then proceed with the analysis by including more interviewees and focus groups with experts involved in financing wind energy projects in Europe to verify the analysed potential effects. The authors find that auctions create a competitive environment that pressures the industry into accepting higher risks and lower returns. Banks have reduced debt margins, while large investors decreased hurdle rates and equity returns, despite additional risks from auctions, such as uncertainty about future award prices, allocation and qualification risks. The risk of being awarded support and incurring sunk costs makes smaller bidders averse to participating in auctions. Despite increased price risk, project financing conditions have improved: the competitive pressure driven by project sponsors seems to lower financing costs and hurdle rates and reduce the cost of capital for offshore projects.

Roth *et al.* (2021) provide qualitative and quantitative insights intended to contribute to a better understanding of renewable energy financing in the European Union both in auction and non-auction environments. The results of the interviews conducted by the authors between December 2019 and April 2020 show that there is still a considerable gap between EU Member States regarding their WACC values for wind and PV projects[4]. However, most EU countries reduced their WACC dramatically since 2014, as well as their Costs of Debt and Costs of Equity. The analyses show that multiple reasons are behind the observed reduction in the WACC apart from lower interest rates, technology improvements, and lower country risks: "1) capital is not only raised from EU sources, but it is also flowing from international sources, which could generate spillover effects in EU countries where the costs of capital are higher than the costs of international investments; 2) the non-standard monetary policy of the European Central Bank after the 2008 crisis has resulted in abundant capital which triggered lower loan fees and increased competition for business cases; 3) new market players, such as energy-intensive companies, are under political and regulatory pressure to green their portfolios and are consequently shifting to different auction design elements (DE) through, for example, corporate PPAs, which could add more competitive pressure on the market" (Roth *et al.,* 2021, p. 5). The results of an econometric analysis performed by the authors confirm the findings of the interviews: the main driver of the WACC is the country risk, but experiences with renewables are also significant. The introduction of auctions did not increase the WACC, rather the opposite was true: increasing experiences in auctions different auction design elements (DE) to have a dampening effect on the WACC. An interesting finding is that remuneration schemes that reduce the exposure to market risks tend to have a decreasing effect on the WACC.

To estimate the effects of different financing conditions on support costs, the authors develop a cash flow model that calculates minimum bid levels and debt shares, given several optimisation constraints. Based on this, they find that Member States should mainly focus on de-risking debt financing, as this would deliver the largest support costs savings and WACC reduction. The authors argue that, instead of additionally/marginally decreasing cost of debt, de-risking policies should also aim at increasing loan maturities and debt size. Such debt de-risking could be best achieved by adopting remuneration schemes that decrease the

4 A data note describing the accumulated data on the cost of capital is currently being drafted and will be published soon.

volatility of the projects cash flows, such as CfD. Furthermore, they also find that de-risking the cost of equity –through relaxing pre-qualification requirements, reducing bid bonds, prolonging realisation rates etc.– would not yield very large additional benefits in terms of support cost reduction. Therefore, policymakers should de-risk auction designs in the pre-bidding stage –decrease bid bond levels, relax pre-qualification requirements etc.– only if they have policy goals other than cost-efficiency, such as increasing actor diversity (Roth *et al.*, 2021, p. 5).

5. WP6 INTERNATIONAL AUCTIONS

In contrast to national auctions, international auctions are auctions in which projects from more than one country can participate, *i.e.,* projects located outside of the auction-conducting country can participate and compete for support (Ehrhart *et al.,* 2019). There are several good economic reasons for the implementation of cross-border auctions, including better use of natural resource potentials in Europe, higher market values[5], lower cost of capital and higher competition (von Blücher *et al.,* 2019).

These auctions have not been used by Member States, except for the PV auctions between Germany and Denmark in 2016, although the picture might change in the future, given several EU energy policy developments: the new 2030 RES governance, voluntary opening of national support schemes under the REDII, the new "Financing Mechanism" and renewables Projects of Common Interest (von Blücher *et al.,* 2019, p. 5).

Cross-border auctions are still perceived to be complex to design and burdensome to implement. The aim of WP6 is to define and analyse design questions specific to cross-border auctions from a theoretical and an empirical perspective and to provide concrete design recommendations to policymakers.

Von Blücher *et al.* (2019) assess various design options for cross-border auctions and provide practical guidance for Member States seeking to implement them.

5 Higher market values compared to the values of domestic RES power plants can lead to a significant decrease in support payments.

This report identifies three basic models of cross-border auctions which go from a low to a higher intensity of cooperation: Countries may choose to conduct unilateral, mutual cross-border auctions or joint auctions (see Table 1). The authors observe a trade-off between the transaction costs of preparing the cross-border auction (lowest under unilateral cross-border auctions, which are the simplest) and economies of scale (highest under multilateral auctions).

Von Blücher *et al.* (2019) also find that the support scheme design must be the same for all participants of a cross-border RES auction to allow for comparison of bids and thus effective bid selection. However, the conditions under which project developers can realise RES projects differ between countries due to the national specific regulatory and market conditions. These aspects cannot easily be aligned in the context of a cross-border auction, as they reflect a broader regulatory and political context. The authors propose three key options to level regulatory differences: 1) Adjusting bids by the cost impact of the regulatory framework; 2) Implementing quotas to limit the distributional effects of these differences, and; 3) Aligning the regulatory framework. They recommend refraining from levelling differences artificially in order to tap into the full efficiency potential of the auction. However, if differences need to be addressed, they recommend to consider quotas as they are the most straightforward solution to the challenge (*i.e.*, option number 2 above).

Table 1

Basic models of cross-border auctions

Models	Explanation
Unilateral auction	Both countries conduct auctions but only one country opens its support scheme to foreign projects
Mutual opening	Both countries open their auction schemes, either sequentially or in parallel
Joint auction	Two countries implement a common auction scheme, open to projects from both countries

Sources: von Blücher *et al.* (2019), Ehrhart *et al.* (2019).

The authors propose 8 good practices of cross-border auction design[6] and highlight and discuss other challenges in cross-border auctions[7].

A more formal (theoretical) analysis of the (support costs and allocative) efficiency of different types of cross-border auctions is performed in Ehrhart *et al.* (2019), which refer to different intensities of cooperation as in von Blücher *et al.* (2019). In addition to Separate auctions, the aforementioned three types of cross-border auctions are considered: Unilateral Auctions, Mutual Auctions and Joint Auctions. The authors perform auction-theoretic modelling. They conclude that Joint Auctions can achieve both allocative efficiency and moderate award prices (support cost efficiency). However, a complex implementation process and necessary bi-lateral coordination might make this option difficult to realise. Implementing this type of auction is quite complicated due to a high degree of cross border integration and regulatory coordination (Ehrhart *et al.,* 2019, p. 30). Sequential Mutual Auctions, *i.e.*, when the open auctions are conducted one after another and with enough time in between the auctions and not within a very short time frame, lead to similar outcomes, but with less administrative effort, since both participating countries can choose their own auction design. The remaining design choices all show a low probability of allocative efficiency and might lead to higher awarded prices. More generally, the analysis shows that parallel auctions (where project developers must choose in which auction they want to participate and cannot participate in both) tend to decrease the efficiency of a support scheme. Based on their theoretical analysis, the authors recommend Sequential Mutual Auctions when designing cross-border auctions since they combine "the benefits of relatively straightforward implementation with the allocative efficiency of a Joint Auction" (Ehrhart *et al*., 2019, p. 35).

6 These good practices include: 1. Bids need to be comparable. 2. Adapt design to cross-border context. 3. Check cross-border applicability of all design elements. 4. Keep it simple. 5. Take care to not exacerbate differing conditions of participation for bidders. 6. Ensure RES deployment while limiting transaction costs. 7. Give sufficient consultation and bid preparation time. 8. Reduce the administrative complexity.

7 These other challenges include: the interactions of cross-border with national auctions (recommending that the auction schedules should be synchronised with a view to provide a continuous pipeline and avoid boom and bust cycles in the RES industry), the design of a suitable premium, the allocation of the costs and benefits, the practical implementation of cross-border auctions and the disbursement of funding and data transfer.

In turn, von Blücher *et al.* (2020) show the basic functioning of one pooled cooperation mechanism which is effectively a cross-border auction, the EU RES financing mechanism (ERFM). This is an instrument to support and ensure the cost-effective target achievement at the EU level, as provided in Article 33 of the Governance Regulation. Under the ERFM, Member States may choose to make voluntary financial contributions to the mechanism (contributing Member States). The mechanism subsequently implements a RES auction which determines support levels and allocates grants to RES projects in hosting Member States, which also choose to participate voluntarily. The hosting Member States transfer the RES target statistics from these RES installations back to the mechanism, which then redistributes the RES statistics to the contributing Member States according to their share of financial contributions.

The report shows that the ERFM provides an effective tool to aggregate RES cooperation among Member States, thereby increasing the cost-effectiveness of RES support. The ERFM can be tailored to Member State preferences, as they define whether they want to participate and under which conditions. Some recommendations are provided: retaining parts of the RES statistics for hosting Member States (*e.g.* 80/20) in order to increase their acceptance, providing support in the form of upfront investment aid and adopting multi-item, static, pay-as-bid auctions in which the auctioned good is capacity, with required financial pre-qualification / bid bonds and sufficient realization periods to cover country differences in project development lead times.

Bartek-Lesi *et al.* (2020) give an overview of the most important factors influencing the set-up of a cross-border auction between Hungary and possible partner countries using the Green-X model to assess the likely impacts. The results show that Hungary would be the host country in cooperation with Austria and the contributing country with Romania, while cooperation with Slovakia would lead to only small changes in RES-E deployment. Slovakia was chosen as the hypothetical partner country for this case study. The case study compared the tender design of the two countries to provide recommendations on how to harmonize to a cross-border relationship regarding the size of plants eligible for support, the prequalification requirements used in the opened auction, the dilemma on the type of feed-in premium (FIP) to be used and on setting the market reference price for the winners in the host country, the setting of the length of the project realization periods and the setting of penalties. The Green-X modelling results suggested that the cooperation with Romania could bring the highest benefits for Hungary which can be evenly distributed to make the relationship mutually beneficial. However, it is not yet clear when and how Romania will shift to an auction scheme. Another option for Hungary is to consider participation in the EU's renewable energy financing mechanism.

Kerres *et al.* (2020) examine how the Contracting Parties (CPs) of the Energy Community can participate and benefit from cross-border renewable energy cooperation. It focuses on cross-border auctions and joint projects as the key instruments for the CPs to cooperate with each other and with EU Member States. The policy brief reviews the benefits, rationales and necessary considerations for cross-border cooperation, i.e. both from the perspective of the hosting and the contributing party. The report introduced each instrument and pointed out the associated benefits and risks. The policy brief concludes that cross-border cooperation with and amongst the CPs is possible. The regulatory framework includes various instruments, each characterized by certain benefits and risks. The authors argue that, subject to the design of the legal framework, a variety of instruments for cooperation between EU Member States and the CPs could be available, assigned to two tracks of cooperation: Cooperation via joint projects (possibly supported by funding from the Connecting Europe Facility) and national cross-border auctions and cross-border auctions via the EU financing mechanism. Cross-border auctions were examined in detail. In this context, a key issue meriting further attention is the CPs' varying stages of liquid day-ahead wholesale market development and implementation of market-based support schemes. This report suggests two main (transitional) solutions until all CPs have implemented liquid day-ahead wholesale markets on which to base premium calculation: the use of fixed premiums or the use of sliding premiums with proxy reference market prices. Different regulatory frameworks require adaptation of support scheme design: 1) if the hosting party has a wholesale market, then any support scheme design is feasible; 2) if the hosting party does not have a wholesale market yet, intermediary solutions are necessary until all Contracting Parties have wholesale markets.

6. WP7 THE FUTURE OF AUCTIONS

The framework conditions for renewables support continue to evolve. Thus, WP7 covers the implications of combining several RES technologies in one auction applying theoretical and empirical approaches, and more specifically, contributing to the discussion on technology-specific versus technology-neutral support. In addition, both the generation costs of renewables as well as the market environment in which they operate are likely to change until 2030. Thus, the WP furthermore explores the future role and design of auctions under changing electricity systems.

In a forthcoming paper, Hanke (forthcoming) conducted several rounds of experiments to examine whether it is advisable to conduct auctions with more than one technology. She shows that it is indeed favourable for an auctioneer (concerning prices as well as efficiency considerations) to include different technologies in one joint auction instead of conducting different auctions for different technologies. Nevertheless, it should be kept in mind that technologies should be able to compete at least on a basic level and that possible side effects, such as the elimination of one technology from the market, might occur. Further, the recommendation is to conduct pay-as-bid auctions, as these tend to generate lower prices combined with a lower risk of bankruptcy for bidders estimating their costs too low while still generating a comparable level of efficiency as uniform pricing.

In their report, Woodman and Fitch-Roy (2020) have developed four qualitative scenarios on the future energy systems and have examined the role auctions will play in those. The scenarios, which are characterised by the level of flexibility and decentralisation of the energy system, show that the status quo model of RES auctions is unlikely to be the dominant route to market by 2030. The only scenario where we would observe this, if all progress in transforming and pluralising the energy systems stalled (similar to the proposed "Leviathan" scenario[8]). Nevertheless, the authors do not argue that RES auctions will disappear entirely. Private, municipal, or community tenders for PPAs, are likely to grow

8 The Leviathan scenario is characterised by low flexibility and low decentralisation of the energy system.

in importance, requiring new and innovative auction designs that minimise transactions costs. The lessons learnt through Europe's roll-out of national scale support auctions may be valuable here. Finally, given both the urgency of the challenge of tackling climate change and the challenges of coordinating RES build-out with supply chain development and grid expansion, a regulatory role of some kind exists in all scenarios. Whether it is standardising auctions models and contracts or directing geographical density, public policy will continue to play a role in the buying and selling of renewable electricity for the near future.

Furthermore, two more reports are currently being drafted in this WP. The first one will provide an overview of the use of multi-technology auctions in the EU. It will cover descriptive statistics of their outcomes and compare the results to their technology-specific counterparts. Furthermore, the report will include several short case studies on multi-technology auctions.

The second report will give guidance to policymakers on how to design auctions in the changing energy systems of the future. Based on the identified scenarios in Woodman and Fitch-Roy (2020), the authors will derive explicit policy recommendation on possible auction design considerations.

7. WP8 MODELLING

WP8 aims to facilitate the topical analyses undertaken in other WPs with in-depth model-based quantitative assessments. These modelling activities provide further insights into interactions between the various WPs. Additionally, modelling plays an important role in the case cooperations with the member states in WP2.

In their policy brief, Resch, Geipel and Liebmann (forthcoming) analyse and model the need for and impact of RES cooperation across the EU in the 2030 context, practically done by establishing European and/or Cross-Border RES auctions. The findings are based on insights gained from the forward-looking model-based analyses where different scenarios for meeting (and exceeding) the EU's overall 2030 RES target have been derived. The 2030 RES ambition has been modelled both in accordance with past agreements taken (*i.e.* National Energy and Climate Plan (NECP) ambition to achieve an EU RES share of at least

32 %) and under consideration of the needs arising from the European Green Deal. The first finding is that, in order to achieve the NECP ambition of at least 32 % by 2030, only a limited number of MSs requires RES cooperation to meet their 2030 planned RES deployment. Summing up, the nationally planned RES shares for 2030 lead to an EU RES share of approx. 33.6 %, although strong differences in the RES ambition of individual MS can be observed. Modelling shows that, without RES cooperation, only an EU RES share of 33.0 % appears feasible, since some MSs would fail to achieve their planned RES share using only domestic resources. Allowing for RES cooperation would, in turn, assure that the planned deployment (33.6 %) can be reached across the whole EU. On the other hand, a strong increase of the RES ambition at short notice (by 2030), *e.g.* through the Green Deal, causes a strong demand for RES cooperation across the whole EU. Assuming an increase of the 2030 EU RES target to (at least) 40 %, the modelling activities revealed that without RES cooperation only an EU RES share of 37.8 % appears feasible – whereas with RES cooperation the planned deployment (40 %) can be reached. Thus, the conclusion can be drawn that, under these new framework conditions, EU-wide RES cooperation appears essential for achieving a stronger RES uptake at short notice (*i.e.* by 2030).

Apart from the above-identified needs for RES cooperation, there are several benefits of RES cooperation: Firstly, RES cooperation facilitates a levelling of country-specific risk for RES investors. Secondly, a (more) fair effort sharing can then be triggered by RES cooperation and, thirdly, it can be expected that this decreases the overall cost for reaching ambitious future RES targets, which was confirmed by the modelling. More specifically, cross-border RES action can reduce support expenditures for new RES installations (*i.e.* installed post-2020) by 23 % to 38 % percentage points compared to the default case where no such cooperation was presumed. Furthermore, the authors found out that targeted policies offering technology-specific incentives tailored to individual needs, done *e.g.* by use of dedicated RES auctions for feed-in premiums, appear highly beneficial for triggering a cost-effective uptake of RES in the electricity sector. Cost savings in the range of 28 % to 42 % have been identified when comparing average support under targeted RES policy approaches (*e.g.* RES auctions) with umbrella policy approaches (*e.g.* technology-neutral RES quotas with certificate trading).

Diallo and Kitzing (2020) examined technology bias between renewable power plants in technology-neutral auctions, caused by applying the same auction rules for the technologies that have very different characteristics. Four RES technologies (PV, onshore wind, offshore wind, and biomass) were evaluated using a quantitative model, which was used to determine LCOEs, bid prices, and social values of the technologies. Concerning the different design elements, the authors were able to formulate rather general and rule of thumb type of policy recommendations. The main reason behind this is that the bias is sensitive to the initial setup in terms of design elements[9]. Therefore, a case-by-case analysis is required to determine the effect of a design element change on the bias. The outcomes show that, while a change of the support period or the introduction of grid integration costs and environmental harm compensation may heavily influence average bias between technologies, the effects are more moderate when changes in granted realisation period or in balancing payment responsibility are applied, and almost negligible if changes in the timing of the auction within a year occur. Remuneration scheme design is a very important determinant as well, but there is no clear hierarchy identifiable which compares two-sided sliding premiums and fixed premiums. Both schemes are though clearly leading to a lower risk of technology bias than one-sided sliding premiums, as in several setups where a technology is mature enough to survive without support, one-sided premiums may result in very high biases. An additional very important conclusion of the report is that allocative and general efficiency do not necessarily occur simultaneously. This is due to the fact that by comparing two designs, it is often the case that a given setup results in allocative efficiency, but in terms of general efficiency it fares worse than another allocative inefficient auction setup.

Furthermore, three more reports are forthcoming in this WP. The first one examines by when a possible phase-out of RES support appears feasible for RES electricity in general and at technology level. The second one will conduct a model-based assessment of economic aspects of RES auctions illustrating the impact of improved financing conditions on the support needed to finance

9 This can result in the fact that the same change in the design (for example increasing support period from 15 years to 20), may increase the average bias in one setup and decrease it in another.

the required RES uptake. Finally, the last forthcoming report will provide all technical details of the modelling activities carried out in the AURES II project.

8. CONCLUSION

The first AURES project laid the groundwork for auctions in the renewable electricity sector (see Mora *et al.,* 2017). AURES II expands this knowledge by analysing the effects of auctions on the RES sector, technological innovation and project financing, and by examining the topics of multi-technology and cross-border auctions, changing electricity systems, as well as community projects in detail. It also builds a detailed database of auctions in the EU.

Although the work in WP7 has already shed some light, we believe the next step will be to analyse how renewable energy auctions will evolve in the future: will we see greater collaboration between member states? Or even EU-wide RES auctions? Will auctions expand to other energy-related fields besides the electricity sector: allocating support for hydrogen production, (district) heating networks, or in the transport sector? Will they be increasingly used by the private sector: big multi-national companies using auctions to procure corporate (green) PPAs in an efficient and effective manner? Or even smaller energy communities that aim to procure green electricity?

Whichever form auctions will take, we believe they will still play a crucial role in a future, sustainable energy system.

REFERENCES

Amazo, A., von Blücher, F., Lotz, B. and Jakob, M. (2020). *Auctions and renewable energy communities.* Deliverable D4.2 of the EU-funded AURES II project. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/02/AURES_II_D4_2_energy_communities.pdf

Anatolitis, V., Azanbayev, A. and Hanke, A.-K. (forthcoming). How to design efficient renewable energy auctions? – Empirical insights from Europe.

Bartek-Lesi, M., Szabó, L., Dézsi, B., Resch, R., Liebmann, L. and Geipel, J. (2020). *Proposal for a cross-border auction design for Hungary.* Deliverable D6.3-HU of the EU-funded AURES II project. Deliverable D6.3-HU of the EU-funded AURES II project. Retreivable from: http://aures2project.eu/wp-content/uploads/2020/11/AURES_II_D6_3_Hungary.pdf

Diallo, A. and Kitzing, L. (2020). *Technology bias in technology-neutral renewable energy auctions*. Deliverable D8.2 of the EU-funded AURES II project. Retreivable from: http://aures2project.eu/wp-content/uploads/2021/02/AURES_II_D8_2_bias_technology_neutral_auctions.pdf

Đukan, M., and Kitzing, L. (2021). The impact of auctions on financing conditions and cost of capital for wind energy projects. *Energy Policy,* 152.

Đukan, M., Kitzing, L., Brückmann, R., Jimeno, M., Wigand, F., Kielichowska, I., Klessmann, C. and Breitschopf, B. (2019). *Effect of auctions on financing conditions for renewable energy - A mapping of auction designs and their effects on financing.* Deliverable D5.1 of the EU-funded AURES II project. Retreivable from: http://aures2project.eu/wp-content/uploads/2019/06/AURES_II_D5_1_final.pdf

Egli, F., Steffen, B. and Schmidt, T. (2018). A dynamic analysis of financing conditions for renewable energy technologies. *Nature Energy,* 3, pp. 1084-1092.

Ehrhart, K.-M., Ott, M. and Hanke, A.-K. (2020). *The 2020 Nobel Prize in Economics and its connection to AURES II*. Deliverable D3.4 of the EU-funded AURES II project. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/12/Nobel_AURES_II_2020.pdf

Ehrhart, K-M., Hanke, A-K., Anatolitis, V. and Winkler, J. (2019). *Auction-theoretic aspects of cross-border auctions.* Deliverable D6.2 of the EU-funded AURES II project. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/02/MultiAuctions_final_anv.pdf

Hanke, A.-K. (forthcoming). Designing Auctions for Renewable Energy Support - Experimental Analysis of Multi-Technology Auctions.

Hanke, A.-K. and Anatolitis, V. (forthcoming). How to achieve the objectives of renewable energy policy? – Evidence from auction designs in the European Union.

Hanke, A.-K. and Tiedemann, S. (2020). *How (not) to respond to low competition in renewable energy auctions.* Deliverable D3.4 of the EU-funded AURES II project. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/06/AURES_II_Policy_Brief_End_Rationing.pdf

Kerres, P., Lotz, B., von Blücher, F., Wigand, F., Taso, N., Trhulj, J. and Buschle, D. (2020). P*olicy brief: Renewables cross-border cooperation in the Energy Community.* Deliverable D3.4 of the EU-funded AURES II project. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/11/AURES_II_policy-brief_Energy-Community_final-version.pdf

Mora, D., Kitzing, L., Rosenlund Soysal, E., Steinhilber, S., del Río, P., Wigand, F., Klessmann, C., Tiedemann, S., Amazo, A., Welisch, M., Kreiss, J., Fitch Roy, O. and Woodman, B. (2017). *Auctions for renewable energy support - Taming the beast of competitive bidding. Final report of the AURES Project.* Retrievable from: https://backend.orbit.dtu.dk/ws/portalfiles/portal/142941994/aures_finalreport.pdf

Resch, G., Geipel, J. and Liebmann, L. (forthcoming). Policy brief on Modelling of European / Cross-Border RES auctions - Key insights from our model-based analyses on the need for and impact of RES cooperation in the 2030 context.

del Río, P. and Kiefer, C. (2021). *Analysing the effects of auctions on technological innovation.* Deliverable D4.3 of the EU-funded AURES II project. Retrievable from: http://aures2project.eu/wp-content/uploads/2021/04/AURES_II_D4_3_technological_innovation.pdf

del Río, P., Kiefer, C., Menzies, C., Marquardt, M., Fitch-Roy, O. and Woodman, B. (2020). *Effects of auctions on RES value chains*. Deliverable D4.2 of the EU-funded AURES II project. http://aures2project.eu/wp-content/uploads/2020/10/AURES_II_D4_1_effects_value_chain_upt.pdf

Roth, A., Brückmann, R., Jimeno, M., Đukan, M., Kitzing, L., Breitschopf, B., Alexander-Haw, A. and Amazo Blanco, A. (2021). *Report on survey results and cash flow simulations.* Deliverable D5.2 of the EU-funded AURES II project.

von Blücher, F., Gephart, M., Wigand, F., Anatolitis, V., Winkler, J., Held, A., Khubute Sekamane, J. and Kitzing, L. (2019). *Design options for cross-border auctions.* Deliverable D6.1 of the EU-funded AURES II project. Retrievable from: http://aures2project.eu/wp-content/uploads/2019/06/AURES_II_D6_1_final.pdf

von Blücher, F., Gephart, M., Wigand, F. and Resch, G. (2020). *The new renewable energy financing mechanism of the EU in practice.* Deliverable D6.3-EU of the EU-funded AURES II project. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/11/AURES_II_D6_3_EU.pdf

Wigand, F., Brückmann, R., Jimeno, M., von Blücher, F., Breitschopf, B., Anatolitis, V., Kitzing, L., Dukan, M., del Rio, P., Fitch-Roy, O., Szabo, L. and Menzies, C. J., (2020). *Impact of COVID-19 on Renewable Energy Auctions.* Deliverable D3.4 of the EU-funded AURES II project. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/05/AURES_II_Policy_Brief_Covid-19.pdf

Woodman, B. and Fitch-Roy, O. (2020). T*he future of renewable energy auctions - Scenarios and pathways*. Deliverable D7.3 of the EU-funded AURES II project. Retrievable from: http://aures2project.eu/wp-content/uploads/2021/02/AURES_II_D7_3_scenarios_v2.pdf

Design and results of recent renewable energy auctions in Europe*

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Abstract

The Horizon2020 project AURES II aims at contributing to the effective implementation of auctions for Renewable Energy Resources with research-based insights and policy recommendations. The paper focuses on the main design elements applied in the recent renewable auctions and their impact on the effectiveness and efficiency of renewable support allocation. Drawing on 10 European case studies, the analysis investigates whether there is a convergence in the auction design across countries, whether a general cost reduction trend can be observed, and looks at how successful previous auctions were in delivering contracted capacities. It also assesses the new trends and developments, and presents some emerging, innovative forms of auctions targeting carbon emission mitigation.

Key words: renewable energy, renewable energy auctions, auction design, policy assessment.

1. INTRODUCTION

The Horizon2020 project AURES II aims at ensuring the effective implementation of auctions. Its second Work Package (WP2) collects and analyses information on the recently realised and planned auctions in Europe and globally. The Work Package assessed 10 recently finalised RES auctions (six EU countries and four outside) and also assessed four planned auctions (three in the EU and one outside). WP2 also assessed technology focused case studies on off-shore wind development in Denmark and the concentrated solar plant (CSP) technology auctions in various countries. This paper summarises the findings of the AURES II case studies and the Synthesis report which gave a detailed overview

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of the results and conclusions drawn (Szabó *et al.*, 2021). We focus on the main design elements applied in the recent renewable auctions and the impacts on the effectiveness and efficiency of these auctions. Due to size limitations this paper covers the European auctions, although the AURES II project itself covered non-European auctions as well.

The paper is structured as follows. Section 1 characterises the European auctions and the most important design elements. In Section 2 we take a closer look at the main design elements facilitating project realisation of winning bids, as an important element of the auctions. Section 3 provides an economic assessment of the European renewable auctions from a static and a dynamic efficiency point of view. It also assesses the policy effectiveness of the renewable auctions and explores how auctions try to increase actor diversity. Section 4 concludes.

2. CHARACTERIZATION OF THE AUCTIONS AND THE MOST IMPORTANT DESIGN ELEMENTS

Even though until 2020 many European countries introduced auction-based support schemes, these tenders differ in many aspects of their design. There are limited number of consensual best solutions in the auctions, most of the countries are still in experimenting phase and change their auction setup regularly to improve effectiveness and efficiency. In this section several important features of renewable auctions will be defined and assessed. The main aim of this section is to highlight the main characteristics and make a comparison of the existing auction designs in Europe.

One of the most important features of the renewable auctions is their coverage, *e.g.* which technologies are allowed to participate. There are two main types of auctions: technology specific and multi-technology ones, the latter are also called technology neutral. In technology specific auctions only the same type of technologies compete, while in a multi-technology setup different technologies enter in the auction, such as a PV power plant versus a wind farm. Multi-technology auctions have different forms, with and without restrictions on the participation of technologies.

Another important aspect is the subject of the auction. The auctioned product can be power plant capacity (in MW) or produced electrical energy (MWh). Independently from the fact whether capacity or energy is auctioned, auctions can efficiently reduce support needs only if there is scarcity with respect to the winners (winning capacity or production) of the tender. Therefore, in all auctions a cap is included which creates scarcity and competition. There are two main types of auctions: the ones with volume and the others with budget cap. For auctions with volume cap either the total available generation capacity (MW) or the total required electrical energy (MWh) is limited. If a budget cap is applied, then in general the total support payment expected to be paid by the auctioneer (in monetary terms) is capped. It is also possible to use the two types of constraints in the same auction simultaneously.

The form of support can also greatly differ in auctions. There are three main types of support payments: the one-sided sliding feed-in premium, two-sided sliding feed-in premium (often called Contract for Difference, CfD) and fixed premium. In a sliding premium scheme, producers sell their product on the market and receive a support equivalent to the difference of the market price and the strike price of the auction. In the one-sided case if the market price is higher than the strike price of the auction, then the producer can keep the extra revenue, while in the two-sided case there is a pay-back obligation toward the auctioneer. In the fixed premium schemes, the producers also sell their electricity on the market and receive a fixed bonus on top of the market price for each sold MWh of energy independently of the price level. The pricing method may differ as well, where the two main types are pay-as-bid and uniform pricing auctions. In the pay-as-bid schemes all winning projects receive support based on their own individual bids, while if uniform pricing is applied, all winning projects receive the same strike price, usually the highest winning bid. The bid of the individual power plant can be determined in one round (static auctions) or in several subsequent rounds (dynamic tender).

An additional very important aspect of renewable auctions is whether producers compete for one (or more) specific predefined connections points, as the tender setup only allows connections to these predefined locations, or if it is possible to freely connect to the power system at any available connection point within the county. The former design is often referred as single unit or single item auction while the latter refers to multi-unit or multi-item auctions.

As a final point of comparison, auctions can differ greatly with respect to the time period, during which the wining projects receive support. The support period is often differentiated between technologies as well. Some setups aim to provide support until the end of the lifetime of the power plants, while others aim for significantly shorter periods.

Table 1 compares several European auction designs with respect to the above listed general criteria. The comparison is based on the results of the Synthesis Report of European renewable case studies of the AURES II project (Szabó *et al.* 2021). The investigated countries are Denmark, Germany, Greece, Hungary, the Netherlands, Poland, Portugal and the United Kingdom.

Table 1
Comparison of several European auction designs

	Denmark	Germany	Greece	Hungary	Netherlands	Poland	Portugal	United Kingdom
Technology focus	Offshore wind, nearshore wind, solar PV	Onshore wind, offshore wind, solar PV, biomass, technology-neutral innovation auction	Onshore wind and PV	All RES-E (wind ruled out by regulation)	ALL RES-E and RES-H, biogas Offshore wind has its own auction scheme	All RES-E	Solar PV	All RES Various technology baskets
Technology differentia-tion	Technology specific (offshore wind, solar) Multi-technology	Technology specific and multi-technology tenders in parallel	Technology specific, which was changed to multi-technology	Multi-technology (wind ruled out by regulation)	Multi-technology	Multi-technology with technology baskets	Technology specific	Multi technology, with baskets (mature technology, less mature technology, biomass)
Auction product	Capacity (MW): offshore wind Energy (MWh): PV and multi technology	Capacity (MW)	Capacity (MW)	Energy (MWh)	Energy (MWh)	Energy (MWh)	Capacity (MW)	Energy (GWh)

Table 1 (continued)

Comparison of several European auction designs

	Denmark	Germany	Greece	Hungary	Netherlands	Poland	Portugal	United Kingdom
Volume or budget cap	Volume cap: offshore wind Budget cap: PV and tech-neutral	Volume	Volume	Volume and budget cap	Budget cap	Volume and budget cap	Volume cap	Yearly budget cap (with separate capacity limit on biomass)
Form of support auctioned	For offshore wind two-sided sliding FIP, otherwise fixed FIP	Sliding FIP	Two-sided sliding FIP	Two-sided sliding FIP	Sliding FIP	Two-sided sliding FIP	Special support scheme, possible to choose between FIT or fixed contribution to the system	Two-sided sliding FIP
Pricing rule	Pay-as-bid	Pay-as-bid	Pay-as-bid	Pay-as-bid	Pay-as-bid	Pay-as-bid	Pay-as-bid	Uniform
Static vs dynamic	Static	Static	Dynamic	Static	Static	Static	Dynamic	Static
Single vs multi-unit	Single unit (offshore wind) multi-unit (all other)	Multi-unit	Multi-unit	Multi-unit	Single unit (offshore wind) multi-unit (all other)	Multi-unit	Single unit	Multi-unit
Support duration	For offshore wind it is based on supported energy (approximately 12-15 years), otherwise 20 years	20 years	20 years	15 years	Depends on technology, 8 (boilers), 12 (biogas) or 15 (solar, onshore wind) years	15 years but not beyond 2035	15 years	15 years

Source: Based on the findings of Szabó *et al.* (2021).

Several different types of auction were organized in Denmark until 2018, including offshore and nearshore tenders as well. On top of that in 2018 a technology specific PV tender, and a pilot multi-technology auction featuring onshore wind and PV were also organized. Similarly to Denmark, several parallel auction schemes operate in Germany. There were technology-specific tenders held for solar PV, onshore wind and biomass, but also multi-technology tenders for PV and onshore wind were organized. Since 2020, Germany organizes innovation auctions, which are multi-technology tenders in which projects with installed storage capacity can also participate. Until 2019 technology specific tenders were held in Greece, but in 2019 a pilot multi-technology setup for solar and onshore wind were introduced (Anatolitis, 2020). Hungary organized its first renewable auction in 2019 (Bartek-Lesi *et al.,* 2020). The tender is in theory a multi-technology auction, where all technologies can participate, however, because of the strict location regulations for onshore wind power plants in the country, wind farms are not able to enter. As a result, almost all participant of the tender were solar PV power plants.

The Netherlands operates a special multi-technology auction scheme since 2011 (Jacob *et al.,* 2019). The specialty lies in the fact that in the Dutch scheme not only electricity, but heat producers can participate, which is uncommon in the EU but presents a possible future evolution path for renewable tenders. In Poland, yearly auctions are held since 2016. In these tenders all renewable technologies can enter, however, based on technology, several different auction baskets were made, and power plants participating within the same basket can compete against each other. In Poland, onshore wind and PV participated in a common basket, and there were separate baskets for agricultural biogas, biomass power plants and for other renewable technologies. Portugal held its first PV auction in 2019, which was a technology specific tender aiming at large scale power plant (del Río *et al*., 2019b) The final country of the comparison is the United Kingdom, where multi technology auctions were organized in a similar manner as in Poland, with different technology baskets defined.

It is visible that most of the countries are shifting toward a multi-technology design. The reason behind this trend lies in the European regulation, as it requires technology neutrality from the Member States when designing new renewable support schemes. Therefore, countries with technology specific designs face a regulatory pressure to change their setups.

By comparing the auctioned products of the different countries, it is evident that there is no clear trend in Europe, since both capacity or energy are auctioned. In

Denmark for example, differences are present within the country, as for offshore wind the auctioned product was power plant capacity, while it was produced electricity in the solar and the pilot multi-technology tender. Approximately half of the investigated countries operate auctions where the product of the tender is capacity such as Denmark (offshore wind), Germany, Greece and Portugal, while in the other Member States, energy-based auctions are present.

Similarly, a diverse picture emerges by investigating capacity or budget constrains in the assessed countries. A single volume cap was used in the Danish offshore wind auctions, in the German, Greece and Portuguese tenders and in the biomass auction of the United Kingdom. Two countries, however, opted for single financial cap. In the Danish (non-offshore) auctions the maximum amount of support was set, while a slightly different version was used in the United Kingdom, where a yearly total budget cap was determined. Interestingly in two countries (Poland, and Hungary) a simultaneous volume and capacity cap were introduced. The advantage of this tender design is that neither the per unit support cost, nor the supported amount of capacity/energy can surpass the expectations of the auctioneer.

In contrast to the previously investigated design elements, there is a larger consensus in the form of support between the analyzed European countries. In most schemes, support was paid in a form of sliding premium, predominantly in the two-sided form. One important tendency, however, is that fixed premium systems become more and more popular in European auctions. The fixed premium scheme is more market oriented than the sliding premium as it follows the evolution of wholesale market price and does not provide fixed revenues for the power plants. Therefore, a fixed premium scheme was introduced for the non-offshore Danish tenders and in the innovation auction in Germany. Portugal introduced a very special support scheme where producers were able to choose between a two-sided sliding premium scheme or a fixed contribution payment to the system. In Portugal prices were significantly below wholesale prices, therefore unlike in many European auctions, producers did not compete for support, but for the possibility to complete their project, even though they are required to pay to the system, based on their production level.

The similarity of the auction designs is even stronger when considering the pricing rule, the dynamic and static nature of the bidding, or location specific issues of the investigated setups. Almost all countries organized pay-as-bid and static, multi-item auctions, which seem to be also the most common setup in Europe. Exceptions are the United Kingdom, which operates a pay-as-clear (uniform pricing) mechanism. A similar design was tested in Germany, but the country has changed to a pay-as-bid setup. Dynamic auctions were used in Portugal and Greece, where producers had the opportunity to submit multiple bids in different rounds. The dynamic nature of the auctions is difficult to evaluate, as usually there is not enough available information on the separate rounds, given that the auctioneer generally publishes only the final results. With respect to location, single item auctions were used by the Danish offshore and nearshore tenders, because connection to the grid is generally more expensive. On top of the offshore auctions, only the Portuguese tender was designed with fixed connection points, as producers were only allowed to compete for 24 predefined grid connection points.

The final assessed design element is the length of the support period. Different technologies usually have varying support length, and large differences are observable with respect to the same technologies between countries. The shortest support period was 8 years for boilers in the Netherlands, while the longest were the 20 years long support periods of the Greek, German and Danish tenders.

We can conclude that, with respect to design elements, the investigated European auctions are homogenous in several aspects, but heterogenous with respect to many other design elements. Most of the organized auctions were pay-as-bid, multi-item, and static tenders. However, no clear design convergence is observable in other dimensions. It seems that, as the result of the European regulation concerning the competition rules of renewable support, auctions tend to move from technology-specific setups to multi-technology designs. Additionally, as fixed premium seems to be more market oriented, mature auctions also tend to shift toward this support type. There are several other aspects, however, which remain completely heterogeneous, such as the auctioned product, the type of cap used in tenders, or the length of support period.

3. DESIGN ELEMENTS FACILITATING PROJECT REALISATION

In order to increase the probability of project realization and timely project implementation among the winning projects of renewable energy auctions, prequalification requirements and penalties are applied. As auction rounds are limited by their volume or budget, selection of bidders by material and financial prequalification criteria together with the applied penalties can help to reduce the risks of underbidding, delay and non-realisation.

Material prequalification requirements relate to the characteristics and status of the project and to the technical and financial capabilities of the project developer. As the table below shows, seven countries require titles for land use, while six countries claim secured grid connection. These conditions aim to ensure the appropriate conditions of grid connection, all necessary permits and licenses and the consent of all stakeholders. Selection of bidders by financial criteria is applied in Denmark and the Netherlands. The Netherlands is the first country in Europe asking for a feasibility study to improve the inadequate realisation rate of awarded projects.

Financial prequalification of the projects can be based on two kind of guarantees: bid bonds and realisation bonds (also called second bid bond, completion bond or performance bond). Bid bonds are placed before the whole auction procedure starts in order to ensure that the developer is committed to realize the project. Those bidders who do not win support get back their guarantees as the official results are published. If a winner refuses to enter into a support contract, the auctioneer retains the bid bond. Realization bonds are required in case of two-stage guarantee systems, where the winners pay this second bond, serving as a guarantee for a potential penalty in case of non-realization. All countries covered apply two-stage financial guarantees (sometimes a one-stage bid bond serves the role of both guarantees, such as the Danish and German onshore wind and biomass auctions and Dutch off-shore wind auctions, and in Poland) with the exception of the UK and the SDE+ scheme of the Netherlands. A softer incentive to pre-select committed bidders is a non-refundable participation fee, which is required in most countries.

The likelihood of implementation is also higher if a project is in a more advanced phase, therefore many countries require an environmental permit, building permit or production license. Some countries, like Germany and Greece demand relatively strict material and financial criteria at the same time. In other cases, material requirements can supplement to some extent financial guarantees, like in Poland, where bidders must hold building and environmental permits as well as grid connection agreements, but bonds are relatively lower than in other countries. Setting strict requirements and high penalties might lead to higher realisation rates, but at the same time results in higher risks for project developers. The prospect of high sunk costs, losing deposited securities or realising a lower than expected remuneration deter developers from entering the auction, which can lead to too strong preselection and, consequently, insufficient competition. However, there are examples when high rates of project realization are reached with less stringent prequalification criteria. This was the case in the German technology-specific PV auctions between 2015 and 2017, where above 90 % realisation rates were achieved. At the same time, onshore wind auctions were undersubscribed, as obtaining environmental permits had become difficult due to the resistance of the local population. For onshore wind project, less stringent material prequalification might increase the number of bidders, but the realisation rate could remain low. In this case, other policy instruments can provide a solution, as recommended by Sach, Lotz and Blücher (2019).

77 % of awarded capacities were built within the prescribed realization period in the 2016 smaller sized Polish PV/onshore wind auctions (up to 1 MW), where delayed projects were likely underbid due to the fierce competition (Diallo *et al.,* 2019). UK and the Netherlands do not apply financial guarantees but use stringent material prequalification requirements and high penalties. When requirements are easier to meet and the competition is weak, this setup is more likely to lead to low rates of implementation. In the UK, 15 out of 29 projects awarded in the AR1 auction missed their deadlines and 5 of them were not implemented. It shows that delays of project realisation cannot be perfectly influenced by prequalification requirements. In the case of several wind farms, the delay was caused by the opposition to the environmental impacts of the facilities, in some cases the contracts were terminated due to underbidding or for other unknown reasons (Woodman and Fitch-Roy, 2019).

Table 2

Material and financial pre-qualification requirements and prescribed realization period

	Pre- qualification requirements: material	Pre-qualification requirements: financial	Realization period
Denmark	No debt exceeding 100 000 DKK (EUR 13.4 million) In case of off-shore wind: former experience, minimum annual turnover, equity ratio of min. 20 % or investment grade credit rating are also required	Tech. neutral and PV auctions: retention penalty (completion bond) EUR 22.8/MWh (onshore wind: 75.1 EUR/kW; PV: 25.5 EUR/kW; off-shore wind: 98.3EUR/kW) Off-shore wind auctions: EUR 13.4 million; Nearshore: 79EUR/kW; 22.4 EUR/kW in case of Kriegers Flak	Off-shore: 48 months, onshore wind and PV: 24 months
Germany	Onshore wind and biomass: installations are eligible if they have obtained environmental permits PV: Proof of access to the site, adopted land use plan and eligibility of site for ground-mounted plants	Onshore wind: Bid bond (also completion bond) of EUR 30/kW PV: Bid bond- EUR 5/kW, completion bond - EUR 40/kW (EUR 20 in case of adopted land-use plan) Off-shore wind: Bid bond/completion bond – EUR 100/kW. Biomass: Bid bond/ completion bond of EUR 60/kW	Onshore wind: 24 months, PV, biomass: 18 months, Off-shore wind: 18 months after grid connection
Greece	Generation licence Grid connection agreement/offer	Bid bond - 1% of investment costs ~ EUR 10/kW in case of PV and 12.5 EUR/kW for onshore wind Completion bond - 4% of investment costs: ~ 30 EUR/kW for PV and 37.5 EUR/kW for onshore wind	PV: 12-18 months, Onshore wind: 24-36 months (depending on size)
Hungary	Basic information on the company and the plant Grid connection agreement	Bid bond: 1.5% of investment cost. (~11 EUR/kW) Completion bond: 5% (~36 EUR/kW - for PV)	36 months
Netherlands	Environmental and mining permit, feasibility study, geological survey, energy yield calculations, permission of the owner of land Financing plan and technical details are also required for off-shore wind	Bid bond only required for projects claiming more than EUR 400 million (not yet applied) Off-shore wind auction: bank guarantee required if bid is successful (~50 EUR/kW)	1.5 - 4 years depending on technology, 5 years for off-shore wind

Table 2 (continued)

Material and financial pre-qualification requirements and prescribed realization period

	Pre- qualification requirements: material	Pre-qualification requirements: financial	Realization period
Poland	Building permit, environmental permit, grid connection agreement, land use plan, schedule of works and expenditures, schematic drawing of the installation	One stage bid bond: 30 PLN (~EUR 7) /kW for existing and 60 PLN (~EUR 14) /kW for new plants returned for non-winners after bidding, and to winners after entering into operation	18 months for PV, 30 months for onshore wind, 72 months for offshore wind
Portugal	Information on the company and owners. For awarded bidders: land rights, production licence	Bid bond: EUR 10/kW, performance bond: EUR 60/kW	30-36 months
United Kingdom	Grid connection agreement, Planning permission, Supply chain approval (>300 MW)	No bid bond /realisation bond	~4-5 years, contracts are awarded for delivery time

Project realization is also affected by the prescribed maximum length of the realisation period. If it is too short, it makes more difficult for investors to realize their projects in time, as there is a higher risk of losing their financial guarantees and right to support. Long realisation periods can lead to many uncertainties influencing the investors, like the relative change on returns compared to other investment opportunities and market conditions can also change significantly. If investors expect significant cost reductions, this incentivises underbidding and can lead to non-realisation.

Deadlines can be general or vary by technology (*e.g.* in Germany, Greece, Poland, Netherlands). When deadlines reflect the specificities of a certain technology, they provide a level playing field, especially in case of multi-technology auctions. The shortest completion time-period among the analysed countries was 12 months for smaller sized plants in Greece and 18 months for larger capacities in Greece, Germany and Poland. Shorter realization periods are often associated with other criteria to incentivize more advanced projects to enter the auction.

Delayed completion can be penalised by the reduction of awarded support or by a shortened support period, which can be accompanied by the gradual loss of the completion bond. After a predetermined grace period, the award right is lost and completion bonds are confiscated, either in a staggered way (e.g. Denmark, Germany, Portugal) or in one sum (*e.g.* in Greece, Hungary, Poland). Each country sets different penalty levels, and in some cases developers do not lose the opportunity to finish the project even after a significant delay. In case of the highly competitive German onshore auctions of 2017, some project developers being awarded lower support levels have abandoned their projects despite the penalties to re-enter more recent auctions with lower competition and likely higher support (Sach, Lotz and Blücher, 2019).

Table 3

Penalties applied in the analysed European cases

Denmark	Technology neutral and PV auction: Retention penalty has to be paid related to non-connected capacity Off-shore: if less than 95% of capacity is connected to the grid, eligible production decreases by 0.1 TWh (near shore)/0.3 TWh (Kriegers Flak) for each subsequent 6-month period.
Germany	Onshore wind: From month 24: gradual loss of completion bond, award withdrawn after 30 months PV: From month 18 award decreases by EUR 3/MWh, after 24 months the penalty is EUR 50/kW Biomass: from month 18 gradual confiscation of completion bond, after 24 months award withdrawn Off-shore wind: Non-delivery at the milestones leads to withdrawal of award and losing the financial guarantee
Greece	In case of late or non-realisation: 1) cancelled support agreement, 2) withholding of bid and completion bonds, 3) possible cancellation of generation license and/or grid access agreement/offer
Hungary	Performance bond is lost in case of delay. If the project is not completed within 1 year after deadline, right for support is lost and investors cannot participate in renewable auctions for 3 years
Netherlands	Loss of bank guarantee (if it was required). Otherwise, project loses support right and is excluded from the scheme for 3 years
Poland	Cancellation of support if the deadline is missed, 3 years ban for participating in another auction, loss of bid bond is a possible fine for the manager of the energy company
Portugal	Missing realization milestones results in losing different portions of the bid bond
United Kingdom	Contract terminated if project fails to spend 10% of costs in 12 months, or operation delays 12-24 months after deadline. Exclusion from future auctions for 24 months

4. ECONOMIC ASSESSMENT OF THE EUROPEAN RENEWABLE AUCTIONS

Renewable auctions were assessed in various dimensions in the AURES II project, including the economic dimensions of effectiveness and efficiency of the auctions. In this section four dimensions, the policy effectiveness, static efficiency, actor diversity and dynamic efficiency are analysed.

4.1. Policy effectiveness

Under policy effectiveness we mean if the targeted RES capacity is actually contracted and realised in the auctions. The AURES II project measured the effectiveness in two dimensions. First, we analysed if the specific auction managed to cover the full targeted volume, or if it failed to achieve so. There could be various reasons for target under-achievement. The specific design of the auction could have reduced the attractiveness of the auction if developers judged it too complex or with high transaction costs, or the expected income from the future power generation was not sufficient to cover the risk adjusted costs of the investments. Other power market related factors could also contribute to this failure, *e.g.* the expected wholesale price trend or the present market distortions or uncertainty in the intraday or balancing markets would prevent investors to participate. As a second dimension of the policy effectiveness, we have assessed if the winning projects of the auctions are realised within the planned period.

Looking at the period of 2015-2020, the European renewable auctions present a mixed picture in the first dimension, as the table 4 illustrates.

Denmark and Germany are on the top of this list, as many of their auctions managed to reach 100 % coverage, meaning that the targeted volumes were contracted in the auctions. In Denmark, both analysed auctions were realised with success, based on the data on the offshore wind auctions. The exception is the Rødsand2 tender, where the original winner withdrew from the project and the site was retendered. There was also an issue with the Nearshore Areas wind tender, where Vattenfall asked for a three-year extension for the project realisation because of a setback with the Environmental Impact Assessment in the project. Although we can observe high coverage rates in most of the German auctions, we see a more mixed picture there. The PV auctions managed to cover the targeted volumes, even over-achieved it, due to the fact that the last accepted bids had a higher capacity than targeted. The four assessed multi technology auctions had similar success, achieving 100 % coverage of targets. But, in the case on the onshore wind tenders, a much smaller 71 % result was attained in the auctions of 2017-2020, and there were auctions with a result as low as 30 % in this respect. As a result of low interest from developers, onshore wind prices

Table 4

Minimum, avarage and maximum ratios of the offered and submitted volume/budget (whichever is relevant) in the analysed European case study countries by auctioned technologies

Country	Technology	Covered years	Min	Average (unweighted)	Max
Denmark	Offshore wind	2015-2016	0.97	0.99	1
Denmark	PV	2015	1.08	1.08	1.08
Germany	PV	2015-2020	0.84	1.02	1.36
Germany	Wind	2017-2020	0.3	0.71	1.02
Germany	Bioenergy	2017-2020	0.19	0.34	0.54
Germany	Multi-technology	2018-2020	1	1.03	1.05
Greece	PV	2016-2019	0.23	0.67	1.1
Greece	Wind	2018-2019	0.37	0.64	0.99
Greece	Multi-technology	2019-2020	0.73	0.73	0.73
Hungary	Multi-technology	2019	0.95	0.97	0.99
Netherlands	Multi-technology	2012-2020	0.59	0.92	1.01
Poland	Multi-technology (PV & wind)	2016-2018	0.51	0.86	1
Poland	Multi-technology (other new)	2018	0	0.11	0.3
Portugal	PV	2019	0.82	0.82	0.82
UK	Multi-technology (established tech)	2015	0.87	0.87	0.87
UK	Multi-technology (new tech)	2015-2017	0.58	0.72	0.86

Source: Szabó *et al.* (2021).

have been at the ceiling price levels since 2018. Similarly, for the four biomass auctions only 34 % of the planned capacities have been awarded in the period. Reduced interest in onshore wind auctions is partially attributable to significant capacity additions in the 2017 auctions, reducing the number of available mature projects, and also due to the lawsuits against onshore wind projects realised in the preceding period.

Slightly above 96 % of the auctioned volume was awarded across the six rounds in Greece between 2016 and 2019 if volume reduction is considered, covering 13 technology baskets. However, it is important to note the impact of volume adjustment mechanisms on the tenders. A volume adjustment mechanism is applied in Greece's two-phase procedure, where bidders communicate their intention to participate in the first phase, with volumes indicated and pre-qualifications fulfilled. The target is not reduced If the intended volume is above the targeted volume by more than 40 %. Otherwise, the targeted volume is cut in order to reach the 40 % oversubscription rate. 18 % to 25 % of 'lost volume' could be attributed to the mechanism in the various rounds, compared to the case if the adjustment was not applied.

Hungary had realised one auction round in 2019, where the full capacity of the tendered two size groups were awarded. A next auction realised in 2020 showed an oversubscription ratio above 5, and the target was fully covered as well. Similarly, in Portugal, we can see high coverage ratios, out of the 22 offered slots in 2019, only two did not have winning bids and 82 % of the offered capacities at the available sites were covered at very competitive prices.

In Poland, there were auctions with various baskets of technologies in the period 2016-2018, with varying degrees of success. In 2018, the larger sized PV and wind categories, the full targeted volume was contracted at a very competitive price, where only half of the dedicated budget was used. The smaller size category also reached its volume cap in the first two rounds (2016, 2017) but only 50 % in the 2018 round. The rest of the auction baskets (in biomass, hydro, geothermal and offshore wind technologies) were realised with moderate and low participation, with many baskets without any bids. In the case of the UK, it is quite difficult to evaluate the target achievement in the auction rounds, as separated yearly budgetary caps were used, and in many cases they were far from reaching the budgetary cap.

Concerning the second dimension in policy effectiveness (the realisation rates), these show a mixed picture. Even in those countries where auction started early, we can see limited available information on the realisation rates, with few countries reporting these numbers regularly. Reliable numbers are only available for an assessment of Germany, Denmark, the Netherlands and Greece, while Hungary, Poland and Portugal have not reached yet the end of their realisation periods in most of their auctions. In the UK, PV and wind projects have been delayed for several reasons, but most of them are still in the development stage. It is too early to assess UK biomass projects realisation rates but already a significant number of projects are no longer part of the CfD scheme because of bidding too low or not achieving the Milestone Delivery Date.

As a result of the low availability of reliable figures, we are still not able to draw any solid conclusions regarding the realisation rate criterion. There is only data for Germany, Greece, Denmark, the Netherlands and UK, and even within this group significant project delays are noticeable, *e.g.* in the UK and the Netherlands. In Germany, realisation rates are high for PVs and lower for onshore wind technology. With the limited information available, it is impossible to accurately assess the policy effectiveness of the auctions at this moment. Therefore, governments should place higher priority and effort on tracking and reporting realisation rates in the future.

4.2. Static efficiency

According to the widely accepted definitions on auction results, static efficiency is achieved if a predetermined target is fulfilled at the lowest possible overall cost. However, it is extremely difficult to estimate the lowest possible costs, with factors beyond the auction design like market prices, balancing and system integration costs, forecast obligations influencing auction bid prices. As a second best solution, it was examined whether auctions lead to lower prices over time compared to previous support levels, treating this as “efficiency gains”, mainly triggered by the reductions in technology costs. Several EU case studies of the AURES II project reported efficiency gains in terms of the contracted price or discounts achieved in the period of 2016-2020 compared to earlier periods.

However, in some instances, especially for Germany in the case of onshore wind auctions and the Netherlands in the 2018/2019 auction, prices were flat or even increasing. A common trend was that many countries with RES-E auctioning starting after 2016 experienced significant price drops in their initial auctions compared to the previous, administratively set support levels. This was the case in Greece, Hungary and UK, where this price drop is at least partially attributed to the introduction of the auctions. This showed that suitable auction design helped to correct many of the mistakes in the previous renewable support schemes (mainly feed-in tariff schemes), and the generated competitive setting of the auction and their design contributed to these static efficiency gains.

In the case of Poland, Greece and the Netherlands it is slightly more difficult to draw any solid conclusion on the static efficiency gains. Poland moved from a green certificate system to auctions, therefore support levels are more difficult to assess. The three auctions with smaller sized PV and wind had a rather stable average price of around 85 EUR/MWh between 2016 and 2018, which has only fallen more recently. In the Netherlands, support levels were mostly determined by one price-setting technology in the various years, which then heavily influenced the price of the other technologies, either driving down prices for more expensive technologies or allowing cheaper technologies to bid up to their ceiling price. In Greece, it is quite difficult to identify clear trends for the various technologies as many design elements changed between the auction rounds for small and large PV.

4.3. Actor diversity

Several countries apply design elements promoting the participation of smaller actors or the involvement of local communities in the ownership of projects, with the aim of increasing the level of competition and fostering the social acceptability of renewable investments. The social acceptability issue is more and more emphasized. The example of Germany shows that this dimension needs special attention, as many onshore wind projects were legally challenged in the country by citizens living in the neighbouring locations. With the foreseen dynamic increase of deployment of wind and PV technologies in most EU countries, this issue will become even more important in the future.

Providing preferential conditions to these actors is possible by setting reduced prequalification requirements, different pricing rules, a dedicated proportion of offered volume or budget, or offering special bonus on top of the price (Steinhilber and Soysal, 2016).

One solution to give higher opportunities to local actors is to have separate auctions for smaller sized capacities, which would enable these local actors to participate more easily in these tenders. Hungary, Greece, and Poland designed this type of auctions, where smaller plants can compete for a separate budget/supported volume. In the case of the Polish and the Hungarian schemes, there are separate categories for plants below and over 1 MW capacity. In Greece, there are two size categories for off-shore wind (below 60 kW and 3 MW – 50 MW), while PV projects could compete separately in the size categories of 0.5 – 1 and 1 - 20 MW (this separation was abolished in 2019). In multi-technology auctions, Greece allows groups of several small projects to compete as one project in case they have a common grid connection point to facilitate the participation of smaller installations. As regards material prequalification criteria, no generation licence is required from PV projects up to 1MW and wind projects up to 60 kW in Greece.

Denmark and Germany followed a separate pathway in promoting local communities. They are encouraged to participate through preferential treatment in the RES-E auctions. In Denmark, a compensation scheme is ensured for citizens if the value of their properties decreases due to nearby RES-E plants. Communities can benefit from funding to help restore the natural environment or install renewable systems in public buildings. There is also a possibility for local citizens to become co-owners in wind energy projects, as it is required by regulation to offer at least 20 % of the ownership shares of wind projects to local residents (González and Kitzing, 2019). The German auction system also provided preferential treatment for citizen cooperatives, although with a rather questionable impact. Wind cooperatives with at least ten private individuals having projects under 18 MW (6 turbines) received preferential treatment in the 2017 auction. They had lower material pre-qualification requirements (being able to participate at an earlier stage of planning), reduced bid bonds, and a longer realisation period (additional 24 months). Additionally, a uniform pricing rule was applied to them instead of pay-as-bid. Unfortunately, the special rules induced a misuse of the preferential rules, as many well-established developers set up local companies to enjoy the benefits, while the loose prequalification requirements led to more delays and risk of non-realisation. Therefore, the rules have been changed so that only the special pricing rules remained applicable to community projects (Sach *et al.,* 2019)

4.4. Dynamic efficiency

Auctions can ensure dynamic efficiency if they contribute to the improvement and cost reduction of immature technologies that strengthens their deployment over time. Due to the fact that many technologies have already reached a high deployment level, only moderate price decreases could be observed in the case of PV and onshore wind in mature markets already concluding several auctions. These are the most often auctioned RES-E types, and the costs of the latter have even increased in some countries due to the lack of suitable project sites (*e.g.* in Germany).

In order to be competitive, higher cost technologies are allowed to compete in separate baskets in many countries, *e.g.* biomass, biogas or geothermal plants in UK or Poland. Although these technologies cannot be considered immature either, according to the present technology knowledge they have probably less cost reduction potential. On the other hand, offshore wind projects, which also compete in technology specific and usually site-specific auctions, have shown more considerable cost improvements lately in the UK, Denmark and Germany, while in the Netherlands the latest projects even required zero support (see Szabó *et al.,* 2021 for further details).

As regards less established technologies, a new development is observable. Some auction schemes started to offer support to storage combined with weather-dependent renewable technologies, *e.g.* in the latest Portugal auction and in the innovation auctions of Germany. If these auctions become more common, they might accelerate the deployment and cost decline of storage facilities. The observed wide cost range for CSP technology in the auctions indicates significant cost saving potential for this technology, and with the right support mechanism and learning rates, well designed auctions could promote cost reductions in the future (del Rio *et al.,* 2019a).

5. CONCLUSIONS

5.1. Converging design?

Countries adopt those design elements in their newly established auction systems that proved to work well in RES-E auctions previously implemented in other countries. These include the requirement of financial prequalification criteria, mostly in the form of two-stage bonds (bid and realisation bonds) to increase realisation rates, the selection of winners via a static, sealed bid auction procedure mainly based on a pay-as-bid, price only selection criteria, pre-determined ceiling prices (often differentiated by technologies) and support periods ranging between 15 – 20 years.

For example, the auction schemes of UK, Poland and Hungary share the application of both budget and volume caps to keep support spending under control. Some countries create separate groups (baskets) for technologies having similar cost levels that can compete for a given amount of support, to provide opportunity for more diverse technologies. Others differentiate categories according to plant size (*e. g.* Hungary, Poland and Greece) to involve them also in auctions and giving them chances to win.

Countries differ in whether they apply volume limits in the form of energy (MWh) or capacity (MW). The form of support is mostly floating premiums, but some countries provide one-sided premiums (*e.g.* DE, NL), while others offer two-sided premiums (*e.g.* DK, ES, HU, PL, PT, etc.) thereby ensuring a fixed income level for the auction winners. Countries follow various approaches in setting non-financial pre-qualification criteria, mainly shaped by their national legal and regulatory frameworks related to new power generation capacities.

As regards the technology focus of renewable energy auctions, member states do not follow a general approach to ensure technology neutrality in line with the relevant EU state aid guidelines. The first auctions were designed to be technology specific *(e.g.* in Denmark and Germany) and even though more technologies were involved later, mainly due to convergence in levelised costs, separate auction rounds were held for different technology groups. Poland and Hungary announced their auctions as technology-neutral, but this neutrality was not fully ensured in any of these cases. In Poland, RES-E plants compete in various multi-technology baskets, while in Hungary, wind energy is practically banned by national regulation requiring unachievable conditions for the construction of new plants. The Dutch auction system was the closest to neutrality, as even renewable heat was included in the technology mix.

In practice it seems rather difficult to organise technology neutral auctions which truly provide a level-playing field for the different technologies. Even if two technologies have a similar LCOE range, varying construction lead times, differing production patterns and, consequently, different reference prices will lead to distortions in auctions and, thus, one or the other technology will be disadvantaged. This is also supported by the auction results, as in many cases (Hungary, Poland, Germany) a dominant technology took the majority of the auctioned volume.

5.2. Price trends

Due to the different design and technology focus, prices are hardly comparable across countries. Even if we look at auctions organised within the same country for the same technologies, no clear trend is observable. For example, German PV auction prices fell from 2016 to early 2018, but since then stagnated and even increased. The German case study showed a close correlation between the level of competition (measured as bid/auction volume) and the resulting prices. The upward price trend in the German onshore wind auctions started at the end of 2017 as competition dissipated, with prices approaching the ceiling price from the middle of 2018.

The substantial price drops in the first auctions following the switch from the previous, administratively set feed-in tariff levels have demonstrated the efficiency gains associated with competitive support allocation. However, in Central and Eastern Europe, despite significant price reductions compared to the previous FIT levels, margins remain high compared to the more mature RES-E auctions in Western European countries.

In some cases, the fall in auction prices can be partially explained by the accumulation of numerous projects 'in the pipeline'. This can either be the result of long periods without opportunity for developers to access support, or the upcoming introduction of restrictive measures limiting the chances of specific technologies ('last chance to go'). In Portugal, despite the opportunities to develop subsidy-free PV systems under private PPAs from 2018 due to the reduction of technology costs and the advantageous solar irradiance in the country, challenges to integrate new RES-E plants into the electricity system slowed down PV deployment. Therefore, the new zone-specific auctions introduced for PV technology in 2019, offering connection capacity and remuneration for 1400 MW, provided a new opportunity for developers, resulting in highly oversubscribed auctions in most bidding zones and low bid prices. In Hungary, after the abolishment of the administrative FIT system, there were no opportunities to apply for support from early 2017 to late 2019. The pilot auction organised after the long pause resulted in an oversubscription rate above 2 and low prices in the size category over 1 MW. The wind auction for projects above 1 MW in Poland was affected by a regulation severely restricting the development of onshore wind plants (so called Distance Act) and the draft Energy Strategy projected a minor role for onshore wind technology in the future power mix. Some wind projects which have already accessed their building permits considered this auction as a last chance to apply for support, leading to strong competition and a very low price of 46 EUR/MWh for the Central and Eastern Europe region (Diallo *et al.,* 2019).

Although difficulties in securing proper sites and grid connection for RES-E plants have long been a challenge for renewable developers, falling technology prices and advanced development stage in some countries can create bottlenecks to further RES-E deployment. Scarce electricity injection points in Portugal are allocated through RES-E auctions. The undersubscription and increasing price in the latest German onshore wind auctions is partially attributable to local opposition limiting available project sites. In Germany's technology neutral auctions, a 'distribution network component' is used to adjust the level of bid prices upwards or downwards depending on whether the project is planned on an area with more or less densely occupied network.

5.3. New directions in auctioning

The Dutch SDE + support scheme ended in the spring of 2020, to be replaced by a new scheme in 2020 called SDE++. This scheme aims at supporting greenhouse gas (GHG) emission mitigation instead of renewable generation, providing premiums (contracts for differences) for projects that can mitigate GHG emission at the lowest cost. Although renewable heat has been already included in the Dutch support system, renewable gas production and other carbon-reducing technologies are also eligible under the new scheme, such as the production of hydrogen through electrolysis and carbon capture and storage (CCS) decreasing industrial emissions. With the different technologies competing for the same budget, the strike prices of renewable projects will have to be expressed in EUR/ton CO_2eq avoided, requiring the development of specific price calculating methodologies for each technology.

Another novelty is the introduction of the so called 'Innovation auction' in Germany, targeting projects that combine weather-dependent renewable sources with facilities providing flexibility services (*e.g.* biomass plant or storage). The auction that offers a fixed premium attracted applications for 1095 MW against the targeted 650 MW. The winning prices ranged between 19.4 EUR/MWh and 55.9 EUR/MWh, allocated mostly to PV plus storage projects. The fixed premium aims to ensure that the combined facilities optimise their electricity supply, taking into account actual electricity prices.

REFERENCES

Anatolitis V. (2020). *Auctions for the support of renewable energy in Greece*. AURES II. Project, D2.1, February 2020. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/03/AURES_II_case_study_Greece.pdf

Bartek-Lesi, M., Dézsi, B., Diallo, A., Szabó, L. and Mezősi, A. (2020). *Auctions for the Support of Renewable Energy in Hungary*. AURES II Project, D2.1, June 2020. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/09/AURES_II_case_study_Hungary.pdf

Department for Business, Energy & Industrial Strategy, (DBEIS) UK (2019a). Contracts for difference (CfD): Budget Notice for the third Allocation Rounds. Retrievable from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/798885/Final_Budget_Notice_AR3.pdf

Department for Business, Energy & Industrial Strategy, (DBEIS) UK (2019b). Contracts for Difference Allocation Round 3 results. Retrievable from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/915678/cfd-ar3-results-corrected-111019.pdf

Department for Business, Energy & Industrial Strategy, (DBIES) UK (2020). Retrievable from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/885248/cfd-ar4-proposed-amendments-consultation.pdf

Diallo, A., Dézsi, B., Bartek-Lesi, M., Szabó, L., Mezősi, A., Szajkó, G. and Kácsor, E. (2019). *Auctions for the Support of Renewable Energy in Poland*. AURES II Project, D2.1, August 2019. Retrievable from: http://aures2project.eu/wp-content/uploads/2019/08/Polish-Auctions_final.pdf

EU (2014/C 200/01). Guidelines on State aid for environmental protection and energy 2014-2020. Communication from the Commission, 28.6.2014.

Garzón González, M. and Kitzing, L. (2019). *Renewable Energy Auctions in Denmark: A Case Study on Results and Lessons Learnt*. Department of Technology, Management and Economics Sustainability. Retrievable from: https://orbit.dtu.dk/en/publications/renewable-energy-auctions-in-denmark-a-case-study-on-results-and-

Jakob, M., Noothout, P., von Bluecher, F. and Klessmann, C. (2019). *Auctions for the support of renewable energy in the Netherlands*, AURES II. Project, D2.1, September 2019, http://aures2project.eu/wp-content/uploads/2019/12/AURES_II_case_study_Netherlands.pdf

del Río, P., Kiefer, C., Winkler, J. and Anatolitis V. (2019a). *Auctions for the support of renewable energy from Concentrated Solar Power (CSP)*. AURES II. Project, D2.1, December 2019. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/02/AURES_II_case_study_CSP.pdf

del Río, P., Lucas, H., Dézsi, B. and Diallo, A. (2019b). *Auctions for the Support of Renewable Energy in Portugal*. AURES II. Project, D2.1, December 2019. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/02/AURES_II_case_study_Portugal.pdf

Sach, T., Lotz, B. and Blücher, F. (2019). *Auctions for the support of renewable energy in Germany*. AURES II Project, D2.1-DE, December 2019. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/04/AURES_II_case_study_Germany_v3.pdf

Steinhilber, S. and Soysal, E. R. (2016). *Secondary objectives in auctions*, AURES Policy Memo 1, October 2016. Retrievable from: https://auresproject.eu/files/media/documents/policy_memo_1-_secondary_objectives_251016.pdf

Szabó, L., Bartek-Lesi, M., Dézsi, B., Diallo, A., Mezősi, A., Kitzing, L., Woodman, B., Fitch-Roy, O., del Rio, P., Resch, G., von Blücher, F., Wigand, F., Menzies, C. J. and Anatolitis V. (2021). *Auctions for the support of renewable energy: Lessons learnt from international experiences- Synthesis report of the AURES II case studies*. Aures II. Project, D2.1. (forthcoming).

WOODMAN, B. and FITCH-ROY, O. (2019). *Auctions for the support of renewable energy in the UK,* Aures II. Project, D2.1, September 2019. Retrievable from: http://aures2project.eu/wp-content/uploads/2019/10/AURES_II_UK_case_study.pdf

An assessment of the design of the new renewable electricity auctions in Spain under an international perspective

*Pablo del Río**

Abstract

In order to comply with its renewable energy targets, a new auction scheme has been adopted in Spain, and the first auction with the new scheme was conducted in January 2021. The design of the new auction implies a radical rupture with the previous auction scheme, on the basis of which auctions were organized in 2016 and 2017. The aim of this paper is to assess the design element choices made in the new auction scheme, identifying its pros and cons according to several criteria and goals, comparing them with the choices made in the previous auctions and with the international practice. The main conclusion is that the design elements of the new auctions are generally in line with international practice and are appropriate to achieve the goals set in the National Climate and Energy Plan (NECP). Nevertheless, some suggestions for changes in the scheme are provided.

Key words: auctions, renewable energy, policy, design, Spain.

1. INTRODUCTION

Given its alleged advantages in terms of cost-effectiveness, auctions have been chosen as the main instrument to support the deployment of renewable energy projects worldwide. As of 2019, 106 countries had organized at least one renewable energy (RE) auction, increasing from only 6 in 2005 (IRENA, 2019).

Spain is no exception in this regard. The country conducted three rounds of auctions under the same model between 2016 and 2017, and 8.7 GW were awarded. In order to comply with its renewable energy (RE) targets, a new auction scheme has been adopted in Spain, and the first auction with the new scheme was conducted in January 2021. The design of the new auction

* CSIC.

implies a radical rupture with the previous one. This paper aims to assess the design element choices made in the new auction scheme, identifying their pros and cons, comparing them with the previous choices and with the international practice.

It is obviously too soon to judge the effectiveness of the new auction scheme, although other aspects, such as the relatively low prices, are clearly positive. The auction awarded 3034 MW to solar PV and wind projects (2/3 and 1/3 of the awarded capacity, respectively) at a weighted average price of 24.47 €/MWh for solar PV and 25.31 €/MWh for onshore wind (see section 2).

The literature on RE auctions stresses the importance of their design in order to have a successful outcome. The comparison of the design elements adopted in the new auction scheme in Spain with the international practice and the analysis of the pros and cons of the auction is based on a database of auction design features built by the author (see del Río and Kiefer, 2021), the perception of some stakeholders (included in secondary material) and relevant institutions (including the Comisión Nacional de los Mercados y la Competencia, CNMC), economic theory and previous work carried out in the AURES and AURES II projects (for a summary of the results of both projects, see Mora *et al.*, 2017 and Anatolitis and del Río, 2021, this issue).

The analysis of the functioning of RE auctions in the world has captured the attention of academics (see del Río and Kiefer, 2021 for an overview) and non-academic institutions from around the world, in tandem with their worldwide implementation (see, *e.g.*, IRENA, 2015, 2019; CEER, 2020). The analyses of RE auctions in Spain have been scarce and focused exclusively on the previous auctions (see, *e.g.*, del Río 2016a, 2017b, 2018). Two exceptions are worth mentioning. On the one hand, the very general analysis by del Río and Kiefer (2019), which focuses on the main differences in approach between the previous auction scheme and the guidelines of the new one included in the National Integrated Energy and Climate Plan (NECP), at a time when the specifics of the design of the new auctions were unknown. On the other hand, and after taking into account the opinion of several experts, the Fundación Renovables published a report on July 2020, making recommendations for the design of the new auction (Fundación Renovables, 2020). This was also before the actual design features of the scheme were known, although some guidelines of the new scheme had already been published at that time in Royal Decree Law (RDL) 23/2020. Thus, this paper covers this gap in the literature.

Accordingly, the paper is structured as follows. The next section briefly discusses the main goals of the new auction in Spain and its main results. The design element choices in the auction are described and analyzed in section 3, while section 4 concludes.

2. THE NEW RENEWABLE ENERGY AUCTION IN SPAIN: GOALS AND RESULTS

Spain has adopted ambitious targets for the deployment of renewable energy sources in its NECP 2021-2030. Renewable electricity will need to account for 74 % of total electricity generation in 2030 which, in turn, is coherent with a trend towards a fully renewable electricity system in 2050. Since the share of renewable electricity was 43 % in 2020, a large effort has to be made, which implies the deployment of around 5 GW per year of new capacity in the next decade.

In addition to compliance with the international commitments on RE and decarbonisation, the goals of the government when organising the auction are (MITECO, 2020c): to facilitate the financing of new projects, avoiding the risk of "price cannibalisation" (which is due to a large penetration of renewable electricity); to transfer the savings in electricity generation costs stemming from the use of renewable electricity to consumers; to facilitate the planning of investments through a schedule that provides certainty to the whole value chain and to boost the green economy and facilitate the economic recovery. Furthermore, when reading all the prefaces of the different pieces of legislation which make up the regulatory framework of the new auctions, it is clear that there are also other important goals, including the promotion of a diversity of actors and project sizes and encouraging the market exposure of RE installations (see, *e.g.*, RD 960/2020).

The legal framework of the Renewable Energy Economic Regime (REER) in Spain, based on RE auctions, is developed by three pieces of legislation which were passed in 2020. It was habilitated by the RDL 23/2020. The Royal Decree RD 960/2020 regulated the juridical and economic regime of the REER. The Order TED/1161/2020 regulated the auction procedure and the features of the REER. In addition, the first auction under this new regulatory framework was set up on December 10th 2020 by a Resolution of the State Secretary for Energy. This Resolution includes the date for the conduct of the auction, the auctioned volume and the minimum reserves (quotas), the reserve price, the date when the installation must generate electricity, the date when the installation would no longer be supported (the expulsion from the REER) and the maximum delivery period. The auction was conducted on January 26th 2021.

Regarding the results of the auction, 3034 MW of RE capacity were awarded to 32 bidders[1]. The auction was oversubscribed, with 84 bidders bidding 9700 MW. However, it is obviously very early to tell about the project realization rates, which will only be known when the deadlines for construction are reached (February 2023 and 2024 for PV and on-shore wind, respectively). The auction has resulted in a weighted average price of 24.47 €/MWh for PV and 25.31 €/MWh for wind, which are 43 % below the estimation of long-term electricity prices (MITECO, 2021).

There have been 26 awarded bidders in solar PV. The concentration ratio of the largest three awarded bidders (CR3) is 37.1 %, with the largest awarded bidder capturing only 15 % of the total awarded volume. A greater concentration can be observed in the case of wind. There were 8 awarded bidders and the largest three awarded bidders accounted for 76 % of the awarded capacity, with the largest bidder having a share of 62.3 %.

Although all the RE technologies were eligible to participate (with minimum quotas of 1000MW for PV and wind), only two technologies were awarded. PV captured 2/3 of the awarded volume (2036MW) and wind captured the rest (998 MW). In addition to the technology-specific component (the minimum

1 See del Río and James (2021, forthcoming) for more details on the outcome of the auction.

reserves), there was a technology-neutral component (1000 MW) in this hybrid auction, which was fully captured by PV.

3. DESIGN ELEMENT CHOICES IN THE SPANISH AUCTIONS FROM AN INTERNATIONAL PERSPECTIVE

This section analyses the design element choices in the new auction scheme, which can be grouped into several categories. We follow the same structure for all the design elements: we describe the choices, briefly mention their pros and cons[2], identify the design elements in the new Spanish auctions and compare them with the design elements in the previous auctions in Spain as well as with the design choices in the rest of the world (see Annex 1). For each element, a synthesis of the assessment of the choice of design elements in the Spanish auction is provided.

When commenting on the design element choices in the Spanish auction, an important distinction should be made. Some design element choices are prescribed by RD 960/2020, whereas the Ministerial Order and the Resolution provide further details on the choices which have been made.

3.1. Volume

Regarding the category of auction volume, several subcategories should be considered. These include the auctioned product (or the metrics for volume setting), whether the volume should be disclosed before the auction (or not), its level (which can be "too high" or "too low") and whether there is some flexibility in setting this level (*ex post* adjustments).

- There are three possible *metrics* to set the volume auctioned in RE auctions: capacity (MW), generation (MWh) or budget (*e.g.*, million €). A generation-based metric provides certainty on support costs, but effectiveness cannot easily be assessed until the end of the remuneration period. In a budget-based metric,

2 The analysis of these pros and cons is based on del Río (2017a).

there is absolute certainty on the support costs, but the degree of electricity generation or capacity that will result from this budget is uncertain when the auction is launched. With a capacity-based metric, it is easy to assess the building of the renewable energy projects early in the process and it provides better signals to equipment manufacturing firms on the relevant market size, although there will be uncertainty on the total costs of support (see del Río, 2017a for a full discussion).

The volume has been set in capacity terms both in the new and old Spanish auctions. However, a generation volume can be set in the future in the new Spanish auctions. In addition, there is a requirement to provide a given amount of energy by a given date (see section 3.10). An overwhelming majority of countries have also chosen a capacity-based metric. The choice of a capacity metric is reasonable taking into account the aforementioned advantages, the international practice and the fact that the NECP trends are defined in capacity terms. Nevertheless, the option of generation would also make sense, given that the target for the share of renewables in total electricity generation is set in percentage terms (74 %). Notwithstanding, it is easy to translate one (capacity or generation) into the other.

- *Publication* of the auctioned volume provides certainty and transparency for potential investors. This encourages participation, enhances competition and, thus, reduces the support costs. It also provides a better signal to equipment manufacturers and facilitates local industry creation. However, potential bidders can also use this information strategically. The volume in the new Spanish auction is published *ex ante* (3000 MW) and this was also the case in the previous auctions, although the government included the possibility to increase the volume awarded in case of sufficiently low bids (see below). The volume is also generally published before the auction in other countries. Some countries have decided not to publish it in order not to provide too much information, discouraging strategic behavior and collusion, as in Brazil (Förster and Amazo, 2016) and South Africa (del Río, 2016b).

- Regarding the *level*, a too high volume may lead to low competition and high bids[3], whereas a too low volume would obviously mean that the speed of RE deployment would be low. It is clear that the volume in the Spanish auction was not high, given the oversubscription (9700 MW of submitted bids) and the resulting low prices (section 2). It may be argued that it has been too low, given that it was slightly below the NECP trend (5 GW/annually, not 3 GW as in this auction), that the last auction was conducted 3.5 years ago and also taking into account the needs of the supply chain[4]. However, usually the first auctions with a new model have a lower volume, since they are considered to be a "pilot" to test whether the auction works well in practice.

- Two possible ex post *adjustments* of the volume are considered in the Spanish auction. First, in order to encourage sufficient competitive pressure and a minimum competition level in the auction, the volume of product being offered should be 20 % higher than the volume of product being auctioned. If this is not the case, then the latter is reduced after all the bids have been submitted in order to comply with this requirement. Second, there is the possibility to increase the volume (up to 6 %, *i.e.* 3.180 MW) in case there are "attractive bids"[5]. This was also allowed in the previous auctions (although to a much greater extent, *i.e.*, by 1000 or 2000 MW). These volume adjustments seem reasonable, in order to avoid the detrimental effects of low competition (the first one) and, thus, high prices, and to benefit from low bids (the second one), but they are not common elsewhere. An exception is Greece, where a 40 % rule (recently increased to 75 %) exists (see Anatolitis, 2019; del Río, 2020). In the French auction for roof-top PV, if the tendered volume is not reached in a round, the higher bids are eliminated (up to 20 % of the volume of the submitted bids) (CEER, 2020).

3 This seems to have been the case in Germany with solar PV (see IRENA, 2019) and some rounds of the roof-top PV auction in France (see CEER, 2020).

4 For example, the Spanish Wind Energy Association (AEE) states that the 1000 MW of reserved volume for wind in the auction entails a lower work burden than the capacity of the sector, which is close to 4.000 MW/year (AEE, 2021).

5 See article 8.5 of RD 960/2020 and number 3.2 in the Resolution.

3.2. Schedule and frequency

In this case, two subcategories are worth considering: the decision on whether to set a schedule (or not) and the level of frequency (number of rounds per year). This distinction is important. A schedule of auctions implies a commitment to launch an auction at regular intervals. The alternative is to organize ad-hoc auctions. But, even if there isn't a schedule of auctions, these may be organized on a regular basis (*i.e.*, with a high frequency) and vice versa.

A *schedule* or a high frequency, *i.e.* a minimum of auction rounds per year, suggests a longer-term commitment to RE deployment over time, in addition to encouraging a supply chain. It reduces the sunk costs of participation if the required administrative permits can be used in successive rounds in case of not being awarded. This reduces the risks for investors, facilitates financing of projects and encourages participation in the auction, which would lead to lower generation and support costs. A schedule may also mitigate the existence of too aggressive bidding behavior in order to be awarded when there is a single round, which may lead to underbidding and underbuilding. Finally, an auction schedule provides certainty and a signal to the industry (equipment manufacturers) which may plan and adapt their strategies accordingly. On the other hand, a lack of schedule provides more flexibility to auctioneers, enabling them to adapt to changing circumstances.

A schedule has been set for the REER in the period 2020-2025 which includes indicative deadlines, the frequency of the rounds, the expected capacity and the envisaged technologies. Minimum capacity volumes for each technology in the period have been set[6]. This is also deemed an appropriate design element choice, and one which is in contrast to the previous auctions, which were organized on an *ad hoc* basis and also in contrast to most countries, which do not have a schedule of auctions (see Annex 1).

6 These are: 1) Wind: 1000 MW (for 2020), 1500 MW (in each of the years of the period 2021-2025); 2) PV: 1000 MW (in 2020), 1800 MW (in each of the years of the period 2021-2025); 3) CSP: 200 MW (in 2021), 200 MW (2023), 200 MW (2025); 4) Biomass: 140 MW (in 2021), 120 MW (2023), 120 MW (2025); 5) Other technologies: 20 MW (2021), 20 MW (2023), 20 MW (2025).

Regarding its *frequency*, setting minimum volumes per year and the existence of at least an annual auction are deemed appropriate choices. There is not a requirement to conduct a predetermined number of auctions, since this would reduce the flexibility for the government and could lead to a narrow market in a given round. CEER (2020) attributes the increase in prices in Germany's technology-neutral tenders to the existence of too many rounds (it was the only country that held two rounds each in 2018 and 2019) and suggests that it might be beneficial for countries to have fewer rounds (CEER, 2020, p. 40; see also IRENA, 2019). Nevertheless, the absence of an auction per year would lead to a detrimental stop-and-go process for the value chain.

3.3. Lead times

Lead times refer to the period between the announcement of the auction and the submission of bids. They need to be long enough so that potential participants may prepare their bids with enough time. However, the deadline to submit bids should not extend too long, since this delays the outcome of the auction (Fundación Renovables, 2020). In the new scheme, the RDL 23/2020 was published on June 23rd 2020, RD 960/2020 was published on November 3rd 2020, the Ministerial Order TED/1161/2020 was published on December 4th 2020, the Resolución of the State Secretary for Energy was published on December 10th 2020 and the bids had to be submitted on January 26th 2021. Therefore, bidders had a little bit more than a month (with Christmas holiday in the middle) to prepare their bids. This period can be deemed rather short, but it may be justified due to the urgency to conduct an auction in order to comply with the 2020 milestone. According to the Council of European Energy Regulators (CEER), in most European countries, "bidders have between one and six months to prepare the requisite documentation for submission", *i.e.* between the announcement of the submission dates and the moment when they have to submit their bids (CEER, 2020, p. 14). Therefore, 3 months seems to be an appropriate lead time. In the previous auctions, the periods were quite similar to this one.

3.4. Technological diversity

Regarding technological diversity, auctions can be technology-neutral (TN), when all renewable energy technologies are eligible to participate and be awarded, and technology-specific (TS) when only one technology is eligible to participate. In multi-technology auctions (MT), several of them can participate. TN auctions should be the preferred choice if minimization of support costs is the policy goal, since all technologies compete with each other and the cheapest ones are awarded, which could also lead to the lowest bids[7]. However, TS auctions lead to a greater diversification of energy sources, support for different RE value chains and different products. TS auctions could reduce the indirect costs (and, thus, lead to lower system costs) since different types of technologies which are complementary from an electricity system point of view (*i.e.*, variable and dispatchable) can be promoted. If the goal is to have a local industry, then TS auctions should also be preferred. It is difficult to design an auction which is really neutral for all technologies, since these have different features and, thus, are affected differently by the same prequalification requirements, realization periods and penalties.

According to RD 960 (article 3.2), a distinction in the auction can be made between the different generation technologies depending on their technical characteristics, size, dispatchability levels, locational criteria and technological maturity. A hybrid design (technology-neutral and technology-specific reserved capacities) has been adopted in Spain in this new auction. The Resolution includes two minimum reserves (1000 MW for solar PV and another 1000 MW for wind on-shore), in addition to the overall volume (3000 MW). Most auctions around the world are TS (Annex 1) and we do not know of any auction which includes this hybrid combination of TS and TN. The previous auctions in Spain were TS (January 2016), TN (May 2017) and MT (July 2017).

This hybrid design is quite innovative, since it allows simultaneously capturing the advantages of TS and TN auctions. However, we miss minimum reserves for

7 However, taking into account the principle of third-degree discrimination, some authors argue that technology-specific auctions may be more suitable if minimization of support costs is the goal (Mora *et al.,* 2017).

dispatchable technologies, although these are foreseen in the schedule every two years (2021, 2023, 2025). We also deem appropriate that demonstration projects are exempted from the auction scheme (article 3 in RD 960/2020), since the suitability of auctions has not been demonstrated for them.

3.5. Geographical diversity

Auctions can be geographically-neutral (there isn't any requirement or incentive to deploy the project in a given location) or not (the location is either pre-selected by the government or an incentive to locate in given places is provided). In auctions which are not geographically-neutral, the indirect and, thus, system costs are likely to be lower (since congestion in specific places and grid constraints would be taken into account when setting the locations) but the direct generation costs (LCOE) could be higher, since the best locations in terms of renewable energy resources would not necessarily be exploited first. Therefore, if the goal is to minimize the direct costs, then geographical neutrality would be a better choice, since usually only direct costs are considered in auctions. But if minimization of indirect generation costs (and system costs) is the goal, then it would be preferable to have geographical diversity, especially in countries with a weak grid. The auctions in Spain (both the previous and the new ones) have been geographically-neutral. The choice is balanced worldwide (see Annex 1). In the future, auctions with geographical incentives or geographically-specific auctions could be recommendable in order to reduce congestion and grid connection costs or to favour places which are particularly depressed or affected by the closing of coal power stations or mines and to avoid NIMBYsm. We believe that it might be better to have those location-specific auctions (*i.e.*, segmentation) rather than including adjustment factors in either the merit order or the remuneration to favor certain locations over others, since this reduces the transparency and simplicity of the auctions.

3.6. Actor and size diversity

In actor-neutral auctions, large actors are likely to dominate participation and awarding, since they are more likely to offer low bids (Jacobs *et al.,* 2020).

Compared to auctions which promote actor diversity (for example, by providing additional remuneration for smaller actors, or organizing contingents for them), actor-neutral auctions would lead to lower generation costs and support costs but, maybe, a higher likelihood that the projects will be built (if large actors are more professional firms with a long-standing experience in building renewable energy projects). However, a more diversified, less concentrated market has also positive economic features, *i.e.*, a lower risk of collusion. Having a large number of actors ensures that a given actor will not have a dominant position and the resulting prices will be more attractive (Fundación Renovables, 2020)[8]. Indeed, actor diversity is a policy goal in some countries (*e.g.*, Germany and Spain). A greater size reduces costs through economies of scale, but the small RE projects developed by citizens or SMEs show multiple benefits, such as encouraging distributed generation, the closeness to consumption points (which reduces losses), the lower need to develop electricity grids and a lower environmental impact than a large project (Fundación Renovables, 2020; Jacobs *et al.,* 2020).

Actor diversity is an explicit goal of the NECP and the auction regulatory package. According to RD 960, art. 8.13, "the particularities of RE communities can be taken into account in the definition of the criteria and the functioning of the auction so that they can compete with other participants in the market on equal conditions". Size diversity is also encouraged. In its article 3.2, the RD 960/2020 states that the ministerial order will be able to exempt small-size installations (<5 MW) and demonstration projects from the auction. In this case, the result of the auction can be used as a reference for their remuneration. However, as in the previous auctions, different sizes and actors have not been promoted in this auction. There has been neither a maximum size limit nor a promotion of RE communities in the new auction. However, this is understandable, since this was the first auction with the new scheme and the government probably wanted to know its functioning without being "polluted" with additional aspects which would not allow identifying the effects of the basic design on its results. It is important to acknowledge that, worldwide, the auctions which facilitate

8 For example, CEER (2020, p. 22) argues that one of the reasons for the lower level of competition in the latter German rooftop PV tenders was that, due to high competition at the start, smaller installations could have seen themselves as not competitive enough and did not participate further. This situation led to lower levels of competition and thus higher prices.

the participation of small actors are an exception, although most set project size limits (see Annex 1). We believe that, in the future, specific auctions for RE communities and small projects should be implemented in order to have a more diversified sector. In the case of small projects, a FIT with the remuneration being indirectly set in the auction may be a better alternative, given the usual difficulties of small actors to participate in the auction (see Jacobs *et al.,* 2020).

3.7. Prequalifications

Prequalification (or qualification) requirements in order to participate in the bidding procedure may be financial or material. The latter may fall on the bidder (*e.g.*, previous experience, a good financial record or economic guarantees) or the project (*e.g.*, pre-development of sites or possession of administrative permits) to mitigate the risk of non-realization. They are adopted in order to ensure the seriousness of bids and encourage the construction of projects[9]. However, if they are too stringent, they may reduce the incentive to participate in the auction (which affects competition) and, in addition, entail higher costs which are translated into higher bids. Therefore, they should be set at reasonable levels (neither too high nor too low) (del Río, 2017a).

In the new Spanish auction, and similarly to previous auctions, a guarantee for the participation in the auction of 60€/kW has been required. This is given back to the awarded bidders after the installation has been inscribed in the "pre-allocation registry". A guarantee for the registration in the REER of 60€/kW is also required. It is given back gradually after some milestones are accomplished: identification (name, location and capacity) of the installation (18€/kW, needed in six months), securing the construction permit (12€/kW, 12 months) and inscription in the "exploitation registry" (30€/kW, 1 month). In addition, the awarded bidders will need to present a supply-chain plan (a strategic plan which includes estimations on the socioeconomic impact of the installations). Virtually all countries include prequalifications in their design and the difference between them is the more or

9 Matthäus (2020) shows a positive correlation between the realisation rate of projects and the setting of qualifications (indeed, the author shows that qualification requirements is the design element with the largest effect on the effectiveness of the auction in his econometric model).

less stringent levels[10]. The prequalifications being adopted are deemed suitable ones. They retain a line of continuity with respect to the previous auctions, which proved to be adequate to favour deployment[11]. The combination of economic guarantees and material prequalifications (identification of the installation and building permit) is in line with the practice in many countries, although it is less stringent than in those countries which require a grid connection point.

3.8. Seller concentration rules (SCRs)

SCRs promote competition and the auction may be cancelled if there is not a minimum number of participants. A single actor may be prevented from capturing a very high share of the market. A SCR has been included in the Spanish auction. The maximum volume which can be awarded to the same firm can not exceed 50 % of the total volume being awarded (art. 8.6 RD 960/2020). Therefore, a bidder can not be awarded more than 1500 MW.

The concentration rule is deemed a proper one since "it will encourage competition in the electricity market, allowing the entry of a greater number of actors" (MITECO, 2020b, p. 18). It can be questioned whether 50 % is excessive and if a lower percentage could have been set (40 % or 30 %). This rule was non-existent in the previous Spanish auctions and it is not common worldwide, although some governments have set a required minimum number of participants and/or awarded bidders in the auctions (*e.g.*, in Colombia, Portugal, California, India and Poland) (see del Río, 2020; del Río *et al.,* 2015, 2020; Jacobs *et al.,* 2020).

3.9. Remuneration type

Remuneration can be provided for generation (MWh) or capacity (MW). Certainty on the total amount of support costs is greater with capacity-based remuneration,

10 Due to limitations on data availability, prequalification requirements are not analysed in del Río and Kiefer (2021).

11 In the first auction (2016), the economic guarantee was arguably too low (20€/kW), despite the recommendation of the CNMC to set it at 50€/kW (CNMC, 2015). This was corrected in the second (May 2017) and third auction (July 2017), which set the economic guarantee at 60€/Kw.

since this is provided initially (up-front) and for a given amount of MW. It is not necessary to wait decades to know the total amount of support provided (as with generation-based support). However, efficiency in RE generation is greater with generation-based support, because the efficient functioning of plants and their proper maintenance are encouraged. Capacity-based remuneration is provided irrespective of the amount of electricity generated. Remuneration in the new Spanish auction is provided for generation (€/MWh), in contrast to the previous auction, which was capacity-based (€/MW). This is a standard choice almost everywhere (see Annex 1). However, some authors argue that capacity (investment) should be supported rather than generation (operating support). For example, von Blücher *et al.* (2020, p. 18) argue that "operating support generally incentivizes plant output, since support is paid per kWh. In contexts where support payments make up major parts of the project revenues, this increases the effectiveness in terms of (generation) target achievement compared to investment support and thereby also the cost-effectiveness of support. However, as support shares in total revenues continuously decrease in the European Union, this argument becomes less relevant. This is specifically true for variable RES which tend to maximize production in any case, as they have close-to-zero operating costs. (…). A general disadvantage of operating support is that it has a distortive effect on the dispatch of RES installations and therefore creates adverse effects on market integration".

3.10. Remuneration form

Generation-based remuneration can be provided as a full payment (FIT) or through a premium top-up on the market price (FIP). Within FIPs, a main distinction is between fixed and sliding FIPs. Fixed FIPs are set once and do not alter. Thus, the total remuneration depends on the evolution of market prices. Sliding FIPs are calculated at regular intervals to fill the gap between the average market price perceived by all generators of a given technology and the strike price set in the auction. Sliding FIPs can be one-sided or two-sided (commonly known as contract-for-differences). FITs lead to the lowest risks for investors but do not encourage electricity generation at times when this electricity would be more valuable for the electricity system. Fixed FIPs are a better option for the market integration of RE, because electricity generators have an incentive to generate electricity at times when the system needs it most, *i.e.*, at times of peak demand when the electricity price is higher. Sliding FIPs entail a compromise between both goals (see Noothout *et al.,* 2016 for further details). Under the current EU regulation, support has to be provided in the form of a FIP (see article 4.3 of Directive 2001/2018). Therefore, the choice is restricted to sliding or fixed premiums.

In the Spanish auctions, a two-side sliding feed-in premium (CfD) has been chosen. The installation will participate in the day-ahead or intra-day markets and will receive a price for the energy delivered which will be calculated from the awarded price in the auction and the day-ahead market price according to the following formula (article 18 of RD 960/2020):

$$PR = AP + AF * (MP - AP)$$

Where PR is the price received by the installation, AP is the awarded price in the auction, MP is the day-ahead market price and AF is the adjustment factor. If PR is above MP, then there is a payment obligation for the market to the installation. If the PR is below the MP, then there is a revenue stream for the market (article 23 of RD 960/2020).

The installation has to deliver a given amount of energy within a certain period. If the auctioned product is capacity, then this energy is defined within a range given by the maximum and minimum energy of the auction and such energy is remunerated for 12 years, and can be sold in the market afterwards. The maximum and minimum energy would then be calculated according to the following formula: Maximum (minimum) energy of the auction = Capacity * Maximum (minimum) number of annual full-load hours * maximum delivery period (years)[12]. If the installation does not deliver the minimum energy, it is penalized.

12 The installations have to sell the minimum energy of the auction in the maximum delivery period (article 16 RD 960). This period is set by the Resolution (12 years for PV and wind) and starts on September 30th 2023 for PV and in September 30th 2024 for on-shore wind. For other technologies (not awarded), the period is: CSP (2024), off-shore wind (2025), rest of RE technologies (2025).

The end of the "energy of the auction" (and, thus, the end of the REER) for the particular installation takes place either when the maximum energy of the auction or when the maximum delivery period are reached. When the minimum energy of the auction is reached, the installation can quit the REER and sell the electricity in the market (even before the 12 years), and it would only receive the market remuneration (article 17 RD 960/2020). If the minimum energy is not reached, it can quit the REER and sell the electricity in the market, but there is a penalty for doing so (see article 20 in RD 960/2020).

The aim is to take into account the value of electricity (time-of-day diversity) and not only its price, in order to reduce the system costs. More and more countries are including design elements which allow them to consider the value of electricity (when and where it is produced). According to Lucas (2020), the market exposure of the awarded installations is guaranteed through the following provisions: 1) The installations have the obligation to bid in the day-ahead or intra-day markets with their best production forecast. 2) The installations will be able to participate in the adjustment and balancing services according to the applicable regulation, that is, on a level playing field with the rest of technologies. 3) The installations only sell under the REER a part of their energy (the maximum energy of the auction). After exiting the retributive mechanism, the rest of the energy which is generated by each installation during its useful lifetime can be sold in the market and at market prices. 4) Additionally, the Royal Decree envisages that, in given calls, it will be possible to include an additional element of market exposure, through a parameter called "percentage of market adjustment" or, as we call it, "adjustment factor (AF)".

The AF represents the percentage of energy which is remunerated at market prices (MP), with the rest being remunerated at the awarded prices (AP). It may range between 0 and 0.5 (0 % and 50 % in percentage terms). The aim of the AF is to encourage electricity generation in the most expensive hours of the day in order to reduce the price of electricity in those hours. This encourages the deployment of installations which are able to shift their production. The AF increases the remuneration received by the installation when the market price is above the award price and reduces it when it is lower (MITECO, 2020a, p. 24). When the market price of electricity is low, the remuneration is low. So, the lower the market price, the lower the received price. In contrast, the higher the market price, the greater the incentive to sell electricity in the market, because the payment obligation for the market is greater.

The AF is set by the Resolution, taking into account the maturity of the technologies, their competitiveness, their dispatchability, their generation profile and other technical characteristics, as well as the size of the installations. Two AFs are set: 25 % if the technology is dispatchable and 5 % if not. However, the AF for non-dispatchable RE technologies (0.05) is perhaps too low. Since the sale of electricity under the auction has only a 5 % exposure to the market price, it is highly independent from it. In line with CNMC (2020b), we would propose that it increases up to 0.25 (and to 0.50 for dispatchable technologies), in order for the installations to respond to the market price signal while simultaneously having foreseeable revenues (CNMC, 2020b).

We believe that the CfD option is a good choice, since it achieves the best balance between the aforementioned conflicting goals (lower investor risk and greater market exposure). In addition, many European countries have adopted this CfD mechanism, or a one-side sliding premium (see del Río and Kiefer, 2021 for details). In contrast to the previous auctions, this one allows the consumer to benefit from a lower electricity price from the penetration of RE in the market. This is the result of an indirect effect (the impact on the merit order due to a greater penetration of technologies with low variable costs, such as as RE technologies) and a direct one (since the lower price of energy resulting from the auction is integrated into the market, leading to an economic surplus). In contrast, the existing specific retributive regime (the previous auctions, see del Río, 2016a for details) does not allow to transfer the reduction of generation costs to the consumers (MITECO, 2020a, p. 21). As mentioned in RD 960/2020 (p. 5) "in those negotiation periods in which the last bid matched corresponds to technologies with high variable costs, the integration of renewables under the specific retributive regime does not lead to a reduction in the price received by the consumer, but rather to a profit for the installations with low variable costs".

A main effect of CfD (with respect to fixed FIPs) is that the risk for the project developers is reduced. However, this does not necessarily mean that, overall, the risks are reduced, since they may be transferred among actors (*e.g.*, a lower risk for investors at the expense of a higher risk for consumers). Some authors argue that, indeed, the risks are being transferred to the consumer (see, *e.g.,* Salmerón, 2020; Díaz, 2020; CNMC, 2020b).

3.11. Selection criteria

In price-only auctions, "the lowest bids" are the only award criterion. In multi-criteria auctions, price is the main criterion among other criteria (*e.g.* local content rules, industry or employment creation), which allow governments to achieve other goals besides "a low price". However, this is probably at the expense of higher bids. Multicriteria auctions are the exception, rather than the rule, especially in Europe (see Annex 1)[13]. This may be related to the higher simplicity and transparency of price-only auctions and the aforementioned higher bids in multicriteria auctions (Mora *et al.,* 2017). For the same reasons, we deem the choice for price-only auctions in the Spanish auctions an appropriate one. If the government wants to achieve non-price criteria, this should be done through the prequalification requirements, and not by including them in the merit order or in the remuneration.

3.12. Auction format

In a single-item auction, a single product is allocated to a single owner and the product cannot be split. In a multi-item auction, the auctioned product is split among different owners and bids are submitted for only part or the total auctioned amount (del Río, 2017a). The new Spanish auction is a multi-unit auction one (and this was also the case in the previous one). This is a standard choice worldwide for an auction such as the Spanish one, *i.e.*, with relatively high volumes and the participation of several (modular) tecnologies such as PV

13 One interesting exception is the French wind off-shore auction, where three key award criteria were weighted differently– price (80 %), occupancy of the area (11 %) and environmental impacts (9 %) (CEER, 2020, p. 36). In the PV tenders in France, the price offered by the bidders is not the only criterion. Other criteria such as the carbon footprint, the environmental relevance or the level of innovation are considered (CEER, 2020, p. 19).

and on-shore wind, and particularly in European countries, which do not have weak grids (see del Río and Kiefer, 2021). For most technologies, single-item auctions are not recommendable, for reasons of efficiency or diversification of the risk of non-compliance. Their use seems to be restricted to certain technologies for which spliting the auctioned volume in different projects is difficult or not convenient due to the existence of economies of scale (CSP or wind off-shore) or, as mentioned above, for countries with a weak grid, which makes it advisable to set the location, number and size of the projects (del Río, 2020).

3.13. Auction type

Auctions can be dynamic or static. In dynamic auctions, bidders interact with each other when submitting their bids, and can adjust them accordingly. In static (also called sealed-bid) auctions, bidders provide undisclosed bids to the auctioneer, who then ranks the projects accordingly. Sealed bid auctions mitigate the risk of collusion compared to dynamic ones. Dynamic auctions might be slightly preferable if effectiveness is the policy priority, since the information revealed during the process may reduce the risk of underbidding and, thus, underbuilding (del Río, 2017a). According to Fundación Renovables (2020), when several products are simultaneously auctioned, sealed-bid auctions would lead to less aggressive bidding behaviours by bidders, since they do not condition their bids if they do not see what is happening with the others, which would be the case under dynamic auctions.

The new (and previous) auctions in Spain have been static ones. This is a standard choice elsewhere, probably because of their simplicity and ability to mitigate the risk of collusion (see Annex 1). CNMC (2020a) calls the new auctions "repetition auctions", since they are conducted with a relatively high frequency. This favors the "learning of bidders as auctions are being conducted which, in practice, could increase the probability of collusory practices. Thus, under repetition auctions, it is recommendable to opt for a static auction format" (CNMC, 2020a, p. 13). Although dynamic auctions have been used in a few countries, del Río (2020) notes that there is a timid trend towards its use, for example in the recent auctions in Portugal and Greece.

3.14. Pricing rules

Under pay-as-bid (PAB) pricing, awarded bidders receive the price they bid for. Under uniform pricing, all bidders receive the same clearing price, *i.e.* the price of the last bid accepted or the first bid not accepted (Wigan, Föster and Amazo, 2016). There is an abundant literature on which pricing rule is preferable, although a consensus has not been reached (see Haufe and Ehrhart, 2015). Under simplified theoretical assumptions, both rules would lead to the same result, since both are allocative-efficient, as the product is awarded to the bidders with the lowest bids (Haufe and Ehrhart, 2018). In principle, bidders have a greater incentive to disclose their actual costs in uniform pricing, since their remuneration is independent from their bid (IRENA, 2015; Khan *et al.*, 2001; Vázquez, Rivier and Pérez-Arriaga*,* 2001). However, uniform pricing is not more incentive-compatible when bidders participate with more than one bid or in more than one auction, or their costs have a common component (Mora *et al.,* 2017). According to Haufe and Ehrhart (2018), a main advantage of PAB auctions is the simplicity in their implementation.

In practice, uniform pricing in RE auctions seems to have encouraged unexperienced bidders to submit very low offers (sometimes below their costs) in order to ensure that they are awarded (Wigan, Föster and Amazo, 2016). If the level of competition is very high, PAB may mitigate the risk of over-remuneration. However, it is unclear which option minimises the costs of support (see del Río, 2017a). In addition, the impact of the pricing rule on the realisation rate of RE projects is inconclusive in the empirical literature (Matthäus, 2020, see also the discussion in CNMC, 2020a). The pricing rule chosen in Spain has been the PAB rule. This is in line with the international experience (see Annex 1), but in contrast to the previous auctions in Spain.

3.15. Ceiling prices

Ceiling prices avoid the risks of high support costs in case of low competition levels and high bids. These prices should not be disclosed before the auction, because this would encourage bids which are marginally close to the ceiling (anchorage effect).

Article 8.4 of RD 960/2020 states that, in the Resolution of the Secretary of State for Energy, a ceiling price will be set, which may be confidential. In fact, such Resolution (number 8) states that the ceiling prices will be confidential, *i.e.* not published before the auction. For the reasons mentioned above, we deem this decision an appropriate one. The existence of ceiling prices is common in other countries (see Annex 1). Although some countries have decided not to reveal those maximum prices before the auction (in order to avoid the aforementioned "anchorage effect"), most countries do, since they may believe that this increases trasparency, the confidence of investors and their participation (del Río, 2017a).

3.16. Minimum prices

According to article 8 of RD960/2020, a minimum price can be set which may be confidential. A minimum price prevents that bids are below such a price and thus, it discourages underbidding. Although number 8 of the Resolution sets this price at 0 euros/MWh for this auction, the possibility that it has positive values in the future is appreciated. A few countries have adopted this design element in the past, including Italy, Cyprus and the Netherlands.

3.17. Realisation periods

The awarded projects should be built by a given date for reasons of effectiveness. The problem is to set the realization periods at appropriate levels. Too short periods may make it difficult to close the financing of projects or allow the project developers to obtain the necessary permits. Too long periods may lead to low bids (given the expectation of cost reductions of the technologies), but there is also a risk of ineffectiveness (if the projects are not built because the expected cost reductions do not materialize and projects are not profitable) (del Río, 2020). The realization periods are 3 years (for PV) and 4 years (for wind on-shore). The deadline for building the installation is February 2023 (for PV) and February 2024 (for on-shore wind). The date in which the maximum delivery period starts is September 2023 (PV) and September 2024 (for on-shore wind). We believe that this is an appropriate choice both for PV and for wind on-shore since they are periods which are neither too long nor too short. According to MITECO

(2020a, p. 20), 18 months are needed in order to build a PV project and 24 months are required to build a wind farm, although it may take longer due to administrative procedures. Thus, a longer deadline for wind projects is also deemed correct. According to del Río and Kiefer (2021), the average realization periods in the wind auctions worldwide have been 3.7 years, and 2 years for PV. Therefore, the aforementioned realization periods in the Spanish auction are normal ones.

3.18. Penalties

Countries usually choose a mix of strategies to discourage delays and non-realization of projects, including forbidding the participation in successive auctions, the enforcement of bonds, support reduction, reductions in support duration and penalty payments (Wigan, Föster and Amazo, 2016; del Río, 2017a). Setting the level of penalties is not an easy task, since too stringent ones would discourage participation and result in too high bids, but setting them too low would make them ineffective and underbidding and low project realization would be more likely with low penalties (Kreiss, Ehrhart and Haufe, 2017; Mora *et al.,* 2017), although high penalties are not a guarantee that the projects will be built (del Río and Linares, 2014). Striking a balance between pre-qualification requirements and penalties is of key importance, as well as adapting penalties to local circumstances (Wigan, Föster and Amazo, 2016). In early auctions, the lower prequalification requirements should be balanced by penalties[14]. In late auctions, lower penalty levels can be set, since prequalification requirements already incentivize bidders to be more "serious" (Mora *et al.,* 2017).

In the Spanish auction, the enforcement of bid bonds is the obvious most important penalty for failing to build the project, with some milestones in the middle (see section 3.7). But there is also a penalty for failing to provide the required energy (minimum energy of the auction) when the maximum delivery

14 Auctions can take place at different stages of the project development process. They could *e.g.* be conducted rather early in the project planning process (*early auctions*). Alternatively, projects can be required to wait until the permitting procedure concludes in order to participate in an auction (*late auctions*) (Mora *et al.,* 2017).

date is reached and automatic penalties of 5€/MWh for not reaching such minimum energy in the intermediate milestones (*e.g.*, every three years) apply (article 20 RD 960/2020 and article 19 of the Order TED/1161/2020). This is not an exceptional design element in the international practice. For example, in Brazil, there is a system of penalties for deviations of electricity production. Settlement rules to manage production deviations can help discourage developers from systematically over- or underestimating their generation expectations, and setting up early warning systems to identify delays at an early stage helps to constructively address delays in a timely manner (Wigan, Föster and Amazo, 2016).

The following table summarizes the design choices in the Spanish auctions and internationally.

Table
Summary of the design elements

Design element category	Design element choice	Auctions 2016-2017	New auctions (basic regulation)*	Auction January 26th 2021	International practice (most frequent)**
1. Volume	Volume auctioned (metric)	Capacity	Capacity or generation	Capacity	Capacity
	Volume auctioned (publication)	Yes	Yes	Yes	Yes
	Volume adjustments	Yes (large)	Yes	Yes (small)	No
2. Schedule and frequency	2. Existence of a schedule	No	Yes	Yes	No
	2. Frequency	Irregular (1 in 2016, 2 in 2017, none in 2018 and 2019)	At least once a year 2020-2025	January 2021	Variable

Table (continued)

Summary of the design elements

Design element category	Design element choice	Auctions 2016-2017	New auctions (basic regulation)*	Auction January 26^{th} 2021	International practice (most frequent)**
3. Lead times		2016: 1.5 months	1.5 month (December 10^{th} 2020, January 26^{th} 2021)		n.a.
4. Technological diversity		TS, TN and MT	TS or TN	Hybrid (a TS component and a TN component)	TS
5. Geographical diversity		Neutral	Neutral	Neutral	Mostly neutral
6. Actor and size diversity	Size diversity	Neutral	Diverse (possible exemption of small installations)	Neutral	Diverse
	Actor diversity	Neutral	Diverse (possible effect on RE communities)	Neutral	Neutral
7. Prequaification		1^{st} auction (January 2016). Inexisting material prequalifications, low economic guarantees 2ª and 3ª auctions (2017). Material prequalifications: identification of the project, building permit, higher economic guarantees	Economic guarantees, identification of the project, building permit	Economic guarantees, identification of the project, building permit	Stringent

Table (continued)

Summary of the design elements

Design element category	Design element choice	Auctions 2016-2017	New auctions (basic regulation)*	Auction January 26^{th} 2021	International practice (most frequent)**
8. SCR		No	Yes (<50%)	Yes (<50%)	Uncommon
9. Remuneration type		Capacity	Generation	Generation	Generation
10. Remuneration form		Capacity-based	CfD	CfD	FITs (sliding FIPs in Europe)
11. Selection criteria		Price (descuento Rinv)	Price	Price	Mostly price
12. Auction format		Multi-item	Multi-item	Multi-item	Mosty Multi-item
13. Auction type		Static	Static	Static	Static
14. Pricing rules		Uniform	PAB	PAB	PAB
15 Ceiling prices	Ceiling prices (existence)	Yes	Yes	Yes	Ceiling prices
	Ceiling prices (disclosure)	Disclosed	Possibility for confidentiality	Confidential	Disclosed ceiling prices
16. Minimum price		Yes	Possibility to set a minimum price	Yes (0€)	Uncommon
17. Realisation periods		Almost 4 years (2016 auction), 2.5 years (2017 auctions)	Yes	3 years (for PV) and 4 years (for wind on-shore)	Common
18. Penalties		Yes	Yes	Yes	Common

* As in RD960/2020.

** See Annex 1 and del Río and Kiefer (2021) for further details.

4. CONCLUSION

In order to comply with its renewable energy targets, a new auction scheme has been adopted in Spain, and the first auction with the new scheme was conducted on January 2021. The aim of this paper has been to assess the design element choices made in the new auction scheme, identifying its pros and cons according to several criteria and goals, comparing them with the previous choices and with the international practice.

There are two main conclusions from this paper. First, the design of the new auction implies a radical rupture with the previous auction scheme, on the basis of which auctions were organized in 2016 and 2017. Second, the design elements of the new auctions are generally in line with international practice and are appropriate to achieve the goals set in the NECP. However, some suggestions for minor changes in some design element choices have been provided throughout the analysis.

REFERENCES

Asociación Empresarial Eólica (AEE) (2021). El sector eólico valora los resultados de la subasta para el otorgamiento del Régimen Económico de Energías Renovables como un avance que permite áreas de mejora. 27 Enero 2021. Retrievable from: https://www.aeeolica.org/comunicacion/la-actualidad-eolica/4460-el-sector-eolico-valora-los-resultados-de-la-subasta-para-el-otorgamiento-del-regimen-economico-de-energias-renovables-como-un-avance-que-permite-areas-de-mejora

Anatolitis, V. (2019). Auctions for the support of renewable energy in Greece, in Report of the EU-funded AURES II project.

Anatolitis, V. and del Río, P. (2021). A brief overview of the AURES II project. *Papeles de Energía* (this issue).

Comisión Nacional de los Mercados y la Competencia (CNMC) (2015). Informe sobre la propuesta de Real Decreto por el que se establece una convocatoria para el otorgamiento del régimen retributivo específico a nuevas instalaciones de producción de energía eléctrica a partir de biomasa en el sistema eléctrico peninsular y para instalaciones de tecnología eólica y sobre la propuesta de orden por la que se regula el procedimiento de asignación del régimen retributivo específico en dicha convocatoria y se aprueban sus parámetros retributivos. 18 de junio de 2015.

Comisión Nacional de los Mercados y la Competencia (CNMC) (2020a). Acuerdo por el que se emite informe sobre el proyecto de Real Decreto por el que se regula el régimen económico de energías renovables para instalaciones de producción de energía eléctrica. Expediente nº: IPN/CNMC/014/20, 30 de julio de 2020.

Comisión Nacional de los Mercados y la Competencia (CNMC) (2020b). Acuerdo por el que se emite informe sobre la propuesta de orden por la que se regula el primer mecanismo de subasta para el otorgamiento del régimen económico de energías renovables y se establece el calendario indicativo para el periodo 2020-2025. Expediente nº: IPN/CNMC/043/20. 25 de noviembre de 2020.

Council of European Energy Regulators (CEER) (2020). *2nd CEER Report on Tendering Procedures for RES in Europe*. Ref: C20-RES-67-03, 17 November 2020.

Díaz, T. (2020). La CNMC quiere más riesgo en las futuras subastas de renovables. Retrievable from: https://www.eleconomista.es/empresas-finanzas/noticias/10746224/09/20/La-CNMC-quiere-mas-riesgo-en-las-futuras-subastas-de-renovables.html. EL ECONOMISTA 1/09/2020

Donoso, J. (2021). El tiempo de la energía fotovoltaica. *Cuadernos de la Energía,* 65, pp. 107-118.

Förster, S. and Amazo, A. (2016). Auctions for Renewable Energy Support in Brazil: Instruments and lessons learnt. AURES Report D4.1-BRA, March 2016.

Fundación Renovables (2020). *Construyendo las nuevas subastas de renovables.* Julio 2020.

González Moya, J. M. (2021). Las subastas renovables, vientos de cambio energético. *Cuadernos de la Energía,* 65, pp. 101-106

Haufe, M-C. and Ehrhart, K-M. (2015). Assessment of auction formats suitable for RES-E. Report of the EU-funded AURES project.

Haufe, M. C. and Ehrhart, K. M. (2018). Auctions for renewable energy support – Suitability, design, and first lessons learned. *Energy Policy,* 121, pp. 217–224.

IEA (2016). *Energy Policies of IEA Countries. Portugal, 2016 Review*. Available at: https://webstore.iea.org/energy-policies-of-iea-countries-portugal-2016-review

IRENA (2015). *Renewable Energy Auctions: A Guide to Design*. Abu Dhabi: United Arab Emirates.

IRENA (2019). *Renewable energy auctions. Status and trends beyond price*. Abu Dhabi: United Arab Emirates.

Jacobs, D., Grashof, K. Del Río, P. and Fouquet, D. (2020). The Case for a Wider Energy Policy Mix in Line with the Objectives of the Paris Agreement. Shortcomings of Renewable Energy Auctions Based on World-wide Empirical Observations. 2020, Energy Watch Group, World Future Council/Global Renewables Congress and Haleakala Stiftung. Retrievable from: https://www.renewablescongress.org/2020/12/study-on-re-auctions-the-case-for-a-wider-energy-policy-mix-in-line-with-the-objectives-of-the-paris-agreement/

Kahn, A., Cramton, P., Porter, R. and Tabors, R. (2001). *Uniform Pricing or Pay-as-Bid Pricing: A Dilemma for California and Beyond*.

Kreiss, J., Ehrhart, K.-M. and Haufe, M.-C. (2017). Appropriate design of auctions for renewable energy support – Prequalifications and penalties. *Energy Policy,* 101, pp. 512-520.

Lucas, H. (2020). Régimen Económico de Energías Renovables (Economic Regime for Renewable Energy). Presentation by Hugo Lucas, Head of Cabinet State Secretary for Energy for the *5th Regional Workshop of the EU-funded AURES II project*. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/11/2_AURES_II_5RW_Ministry_new_auctions_Spain.pdf

Matthäus, D. (2020). Designing effective auctions for renewable energy support. *Energy Policy,* 142, pp- 111- 462.

Ministerio para la Transición Ecológica y el Reto Demográfico (MITECO) (2020a). Main de RDL 23. Mmemoria del análisis de impacto normativo del Real Decreto por el que se regula el régimen económico de energías renovables para instalaciones de producción de energía eléctrica. 25/6/2020.

Ministerio para la Transición Ecológica y el Reto Demográfico (MITECO) (2020b). Memoria del análisis de impacto normativo de la propuesta de orden por la que se regula el primer mecanismo de subasta para el otorgamiento del régimen económico de energías renovables y se establece el calendario indicativo para el periodo 2020-2025 6/11/2021.

Ministerio para la Transición Ecológica y el Reto Demográfico (MITECO) (2020c). Régimen económico de energías renovables S.G. Energías Renovables. Presentation on 16th december 2020. Retrievable from: https://energia.gob.es/electricidad/energias-renovables/convocatorias/Documents/SEE_Presentacion_subasta_renovables_16dic2020_DEF.pdf

Ministerio para la Transición Ecológica y el Reto Demográfico (MITECO) (2021). El MITECO celebra la primera subasta renovable del periodo 2020-2025 para facilitar la acción climática y reducir la factura eléctrica. Press Note MITECO January 26th 2021. Retrievable from: https://www.miteco.gob.es/es/prensa/ultimas-noticias/el-miteco-celebra-la-primera-subasta-renovable-del-periodo-2020-2025-para-facilitar-la-acci%C3%B3n-clim%C3%A1tica-y-reducir-la-factura-el%C3%A9ctrica/tcm:30-522090

Mora, D., Kitzing, L., Rosenlund Soysal, E., Steinhilber, S., Del Río, P. *et al* (2017). *Auctions for renewable energy support - Taming the beast of competitive bidding.* Informe final del proyecto europeo AURES. Report D9.2, December 2017. Retrievable from: http://auresproject.eu/sites/aures.eu/files/media/documents/aures-finalreport.pdf

Noothout, P., De Jager, D., Tesnière, L. and Van Rooijen, S. (2016). *The impact of risks in renewable energy investments and the role of smart policies*. Report of the EU-funded DiaCore project.

del Río, P. (2016a). *Implementation of Auctions for Renewable Energy Support in Spain: A case study*. In Report of the EU-funded AURES project.

del Río, P. (2016b). *Implementation of Auctions for Renewable Energy Support in South Africa: A case study*. In Report of the EU-funded AURES project.

del Río, P. (2017a). Designing auctions for renewable electricity support. Best practices from around the world. *Energy for Sustainable Development*, 41, pp. 1-13.

del Río, P. (2017b). Designing auctions for renewable electricity support: the case of Spain. *Renewable Energy Law & Policy Review*, 8(2), pp. 23-37.

del Río, P. (2018). An analysis of the design elements of the third renewable energy auction in Spain. *Renewable Energy Law and Policy Review*, 8(3), pp. 17-30.

del Río, P. (2020). *Tendencias internacionales en el diseño apropiado de subastas para renovables. Fundación para la Sostenibilidad Energética y Ambiental.* (Funseam). Informe 8/2020. Retrievable from: https://funseam.com/wp-content/uploads/2020/10/082020_InformeFunseamDisenoApropiadodeSubastasparaRenovables.pdf

del Río, P. and Linares, P. (2014). Back to the future? Rethinking auctions for renewable electricity support. *Renewable and Sustainable Energy Reviews,* 35, pp. 42-56.

del Río, P., Haufe, M. C., Wigan, F. and Steinhilber, S. (2015). *Overview of desing elements for RES-E auctions*. Report D2.2 (a). Aures.

del Río, P. and Kiefer, C. (2019). The future design of renewable electricity auctions in Spain A comment. *Renewable Energy Law and Policy* 9(3), pp.39-50.

del Río, P. and Kiefer, C. (2021). Analysing patterns and trends in auctions for renewable electricity. *Energy for Sustainable Development*. Retrievable from: https://doi.org/10.1016/j.esd.2021.03.002

del Rio, P., Kiefer, C., Menzies, C., Marquardt, M., Fitch-Roy, O. and Woodman, B. (2020). *Effects of auctions on RES value chains*. Report D4.1 of the EU-funded AURES II project. Retrievable from: http://aures2project.eu/wp-content/uploads/2020/10/AURES_II_D4_1_effects_value_chain_upt.pdf del Río, P. and Menzies, C. (2021). *Auctions for the support of renewable energy in Spain*. Report of the EU-funded AURES II project (forthcoming).

Salmerón (2020). Las nuevas subastas de generación renovable en España. Retrievable from: https://www.aeqenergia.com/index.php/blog/las-nuevas-subastas-de-generacion-renovable-en-espana

Vázquez, C., Rivier, M. and Pérez-Arriaga, I.J. (2001). If pay-as-bid auctions are not a solution for California, then why not a reliability market? *The Electricity Journal,* 14, pp. 41-48.

von Blücher, F., Gephart, M., Wigand, F. and Resch, G. (2020). *The new renewable energy financing mechanism of the EU in practice A cooperation case study*. Deliverable D6.3 of the EU-funded AURESII project, August 2020

Wigan, F., Förster, S. and Amazo, A. S. T. (2016). *Auctions for renewable energy support: lessons learnt from international experiences*. Report of the EU-funded AURES project.

ANNEX 1.

Design element choices in the RE auctions worlwide (nº of auctions)

Design category	Design choices	Nº of auctions
Volume	Generation	7
	Budget	8
	Capacity	78
	Hybrid	1
Disclosure	Y	78
	N	5
Timing	Schedule	25
	No schedule	57
Tech. diversity	Neutral	13
	Multi	11
	Specific	75
Geo. diversity	Neutral	40
	Diversity	41
Actor div.	Neutral	75
	Diversity	11
Size diversity	Neutral	22
	Diversity	70
LCRs	Yes	21
	No	67
SCRs	Yes	16
	No	64
Information provision	Yes	10
	No	61
Remuneration type	Capacity	3
	Generation	86
	Hybrid	2

Design element choices in the RE auctions worlwide (nº of auctions) (continued)

Design category	Design choices	Nº of auctions
Remuneration form	FIT	58
	fFIP	6
	sFIP	24
	Other	5
Selection criteria	Price-only	73
	Multicriteria	18
Auction format	Multi-item	61
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