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Renewable Energy Auctions

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1. ABSTRACT

The main objective of this study is to analyse and discuss renewable energy auctions, more specifically, the renewable energy auctions which took place in Spain in the years 2021 and 2022. In order to do so, first, renewable auctions are set in the framework of the alternative incentive systems for renewable generation, as auctions are not the only incentive system which has been used. These include feed-in tariffs, the rate of return regulation and green certificates. Following this, the case of renewable auctions in Spain will be studied, paying special attention to the auction design and market rules, and taking into account the changes made from past auction models to the newest auction design. The study will continue by incorporating the auction data from the four auctions taking place within the years 2021 and 2022. Finally, the methodology of the analysis will be explored and then these results will be thoroughly analysed and the main differences seen in the 2021 and 2022 renewable auctions in Spain will be explained, in particular, the increment in price bids and the reduction in the number of auction winners.

2. INTRODUCTION

Humans have always cared about themselves more than they have cared about anything else. We can see that in our everyday life, in the mountains of trash accumulated in our seas, in the foggy clouds that surround our busiest and most populated cities, in the hundreds of animals we have driven to extinction, and the list could go on. I believe it is the time to understand that taking care of ourselves also means taking care of our planet. There will be no future generations if there is no place in which future generations can thrive. While there are many different areas which are in need of curative actions which will allow us to progress as a civilization, economics has made an initiative in trying to solve this problem. This can be seen through the implementation of different incentive systems to promote clean/renewable energy.

Affordable and clean energy is goal number seven on the 2030 Agenda for Sustainable Development put into practice by all United Nations country members. This is only one of the seventeen Sustainable Development Goals (SDG) listed in this agenda. This particular SDG focuses on the ability to “ensure access to affordable, reliable, sustainable, and modern energy for all” by trying to complete certain set targets for different years up until 2030 (United Nations, 2023).

Renewable energy is therefore slowly on its way to try to become the future of our main energy production source. Of course, this is a long lasting and difficult objective to be achieved and therefore quite a few plans of action have been set worldwide to reach it. In the case of the European Union, there is currently a goal set forth for the year 2030 which consists of having at least 38-40% of all energy consumption in the EU to be from renewable sources (European Commission, 2021b).

The European Union also has reached certain agreements/pacts, which go hand in hand with the target mentioned above. An example of this is the European Green Deal. Presented on the 11th of December of 2019, the European Green Deal is a multi-targeting objective which focuses on the improvement of the European Union's economy by incentivising a transition into a cleaner, greener and more sustainable economy (European Commission, 2021a).

Just a few of the areas in which the Green Deal focuses on are the renewable energy targets, improvements in transportation, changes in the environment and oceans, the agricultural sector, etc. (European Commission, 2021a). In reference to current energy consumption, "more than 75% of the EU's greenhouse gas emissions" come from the energy sector (European Commission, 2023). Therefore, the EU's goal is to diminish 55% of net greenhouse gas emissions, as compared to the 1990 levels, by the year 2030. Another goal is to achieve zero net greenhouse gas emissions by 2050 (European Commission, 2021a). This European Green Deal is part of a 2030 Climate Target Plan that also incorporates other elements such as the Paris Agreement which includes aims like trying to keep increasing global temperatures below 2ºC (European Commission, 2020).

In this context, the goal of this study is to analyse and discuss renewable energy auctions, focusing on the ones which took place in the years 2021 and 2022 in Spain. To have a clear understanding of different incentive systems which are used to promote renewable energy sources, alternative incentive systems such as feed-in tariffs, the rate of return regulation and green certificates will be studied. The advantages and disadvantages of each will be analysed. Renewable energy auctions will also be studied from a theoretical point of view. Later on, under this theoretical framework, the study will delve in deeper into the case of Spain. The design of auctions will be analysed and the differences between the old and new design models will be mentioned, taking into account the advantages and disadvantages of the design elements. Afterwards, the auction data obtained in the two auctions from 2021 and 2022 will be presented and analysed, drawing the main takeaways from these. Finally, these results will be further analysed by combining the previous theoretical background and applying it to the results obtained from Spanish auctions. All information from this study has been obtained through bibliographical research.

The rest of the document is structured as follows. Section 3 incorporates the incentive systems. This section describes the main characteristics of each incentive system, setting the focus on renewable energy auctions, and presenting the advantages and disadvantages of each incentive scheme. Section 4 includes information about the auction system in Spain. Section 5 continues with the auction results obtained from the two auctions in 2021 and the other two in 2022 which took place in Spain, making observations and comparisons between the auction data from each year. Then, section 6 explores the methodology used in this study by incorporating auction theory. Section 7 leads into the analysis of the main data with a focus on production costs and size as well as the functioning of the wholesale electricity market in Spain. Finally section 8 concludes. Section 9 incorporates all the bibliography used in the study and section 10 details the appendix which shows data tables obtained from the auction results.

3. INCENTIVE SYSTEMS

It is of utter importance to reach the future's sustainability goals and establish new ways to push the economy in the right direction. While the vision of a greener future is very attractive, the economic agents responsible for the change are running quite a risk. The economy is uncertain and large investments are needed to create renewable energy production plants. That is why a firm incentive system for renewable sources is a necessity for future change. There are many different systems of incentives set in place worldwide. Sections 3.1-3.4 summarise their main characteristics, with special focus on auction systems (Section 3.4). Section 3.5 explores each incentive system's advantages and disadvantages.

3.1 FEED-IN TARIFFS

Feed-in tariffs are one of the incentive systems used by many countries all over the world. The feed-in tariff system or FIT is based on a contract which guarantees a profit for the full output of energy generated (the given currency per kilowatt hour (kW/h)) in a certain period of time (usually around 15 to 20 years) (Cory, Couture, & Kreycik, 2009). The guaranteed prices of the electricity depend on a range of factors spanning from the size of the installation, the type of technology used, the location of the project and the quality of the resource. The safety of guaranteed prices allows this system to be utilised by all types of investors like homeowners, small business owners, farmers, municipalities, etc. (Couture & Gagnon, 2010).

There are generally two approaches to FIT systems. The first is a "value-based" approach in which the "value" which is given to the energy produced is taken into account. The value which determines the FIT payments is estimated by defining the utility's avoided costs or by internalising the external costs of the power generation. Externalities would include effects on the environment and its quality or the effects on energy security. This value-based approach requires the task of quantifying the benefits the energy has for different agents (environment, utility, society). Value-based payments may not result in the necessary amounts to cover actual generation costs. This difficult process can lead to either a scarce total compensation or to an over-abundant total compensation which would generate cost inefficiency (Cory et al., 2009).

The second approach to FIT systems is the cost-based approach. In this case, the payments are estimated on the generation cost of the energy produced plus an extra profit which is set by the policymakers, the program administrators or the regulators. This approach allows for a reasonable and secure rate of return (Cory et al., 2009). This reduces the risk of investment in green energy and boosts its market (Couture & Gagnon, 2010).

Within the cost-based approach, there are two different types of tariffs. The first would be a fixed-price policy or feed-in tariff. Also called market-independent policies, these tariffs provide a predetermined price or payment for a given period of time which is independent from market price conditions. This reduces the risk for investors which can lead to a reduction in costs for the projects (Cory et al., 2009). The fixed price is usually determined by the cost of the technology used to produce and sell the electricity per kW/h (Couture & Gagnon, 2010).

On the other hand, the other type of tariff seen in the cost-based approach is the feed-in premium, or market dependent payment policies. In this case, the investor receives a payment for the electricity generated which is equal to the market prices plus a "premium" or extra payment above the market price. These added payments can either be non-variable or variable (Cory et al., 2009). Since market dependent policies such as these depend on market prices, inflation plays a part. When market prices change, a solution which has been applied is setting caps and floors on the premium payments so these are still in reasonable range if market prices shift, avoiding great losses for investors (Couture & Gagnon, 2010). For example, the cap and floor scheme for premium payments was introduced by Spain in 2007 (Cory et al., 2009).

3.2 RATE OF RETURN REGULATION

A very popular incentive system which has been used quite prominently in the past is the rate of return regulation (RoR). This is a method in which the price of electricity is assigned. The main reason the RoR system is put in place is because the prices that are set for the electricity distributed by the companies are fair for the company, since they recover the cost of producing it, but also for the consumers since prices cannot be out of orbit (Jamison, 2014).

The way that the RoR regulation works is that the regulator decides which is the correct amount for the company's rate base, cost of capital, operating expenses, taxes, depreciation and allowed returns (Liston, 1993) (Jamison, 2014). Given this, the company's costs are known and therefore the expected revenue that the company would need can be determined. Within the revenue is the allowed rate of return, which is an estimate of the cost of capital. The expected revenue which should be recovered by the company is controlled through a set of tariffs set by the regulator (Liston, 1993). There are five points which are taken into account when assessing what the rate of return will be for the company. These include the adequacy of the rate to attract capital, the incorporation of efficient management practices, measuring the consumer rationing of services, the rate's stability and predictability and finally how fair the rate is to investors (Jamison, 2014).

An important aspect to mention is that the costs of generating electricity are higher when renewable sources are used. A factor which comes into play is the irregularity of the output generated. This leads to another problem which is the uncertainty of revenue production. Therefore, renewable energy projects have a greater risk for investors. All of the above play into the capital costs of these projects. With RoR regulation, effects similar to that of a subsidy are experienced. Capital becomes cheaper in relation to labour and cheaper capital becomes less expensive in comparison to higher-priced capital. Due to the fact that renewable energy is more costly than non renewable energy, the relative price of it also increases and this leads to firms under RoR regulation to invest less in renewable energy capital (Ohler, 2014).

There has been a lot of debate around the effects that RoR regulation has on the firm and for that it has received some criticism. This mainly relates to the efficiency which the regulation results in. One of the aspects which is taken into account is how costly the RoR regulation can really be. This can lead to inappropriate incentives in which the firm does not produce efficiently (Liston, 1993). The weak incentives to operate efficiently can be from two factors. The first one is the so-called Averch-Johnson effect. This occurs when the rate of return set by the regulator is actually higher than what is needed. This is done to make sure that shareholders keep investing, leading to unnecessary investments which result in the firm giving further returns to shareholders. For the second factor, the firm is less incentivised to produce efficiently because the efforts that they make to operate in an efficient manner and the managers' abilities cannot be perfectly observed by regulators (Jamison, 2014).

While the rate of return regulation was used in quite a lot of countries in the past, with time its use as a renewable energy incentive has diminished, to the point of being replaced by other types of incentives such as the price cap approach (Cambini & Rondi, 2010).

3.3 GREEN CERTIFICATES

Another type of incentive for renewable energy is the tradable green certificate scheme. This system is actually a market-based support system which is based on financial support given to renewable energy sources/businesses (Helgesen & Tomasgard, 2018). Like all support systems, the main goal is to promote renewable energy and to generate electricity from renewable sources in the most efficient way possible. Efficiency relates to generating the electricity at the lowest possible cost and also keeping consumer prices low as well. In comparison to other types of incentives schemes, this one promotes directly the electricity generated from renewable sources whereas other incentives might only promote the incrementation of capacity (Jensen & Skytte, 2002).

The system in place is simple: for every megawatt hour of energy produced through renewable sources, a tradable certificate is given to the generators, who can later sell this and invest further (Helgesen & Tomasgard, 2018). The certificates can be sold in a financial market specific for green certificates. Therefore, the price that the electricity producer actually takes into account is the market-based set price for the electricity plus the green certificate price itself (Jensen & Skytte, 2002). The demand for these green certificates can either be voluntary (if the firm would want to produce with green energy as a personal decision) or mandatory (quota system) (Helgesen & Tomasgard, 2018). In most cases, when the tradable green certificate scheme is used, it is usually accompanied by a quota system (Pérez de Arce & Sauma, 2016).

The quota system is one in which most of the time, the generators are obliged to produce a certain amount or fraction of electricity from renewable sources. The tradable green certificates come into play since they can be bought/sold in order to fulfil this quota requirement. This is crucial since penalties are issued to those producers that do not meet the quota minimum (Pérez de Arce & Sauma, 2016). Of course this also applies to consumers, which are obliged to meet a certain quota to obtain a minimum number of green certificates. The quota represents a certain amount of consumption which must come from renewable sources (Jensen & Skytte, 2002). Penalties can vary in form, they can range from a percentage amount which must be paid depending on the price of the certificate, to fixed amounts which depend on how many certificates were not acquired (Ciarreta, Espinosa, & Pizarro-Irizar, 2017).

Taking all of this into account, there are a few things which the authorities that set up the scheme have to bear in mind. These include the decision of imposing a mandatory quota obligation on market participants, the issuing of certificates to producers that are eligible of electricity generation, the recording of all tradable green certificates issued and the supervision of the ones traded, the cancellation of redeemed certificates as stated by the quota, and finally the imposition of penalties to agents that do not reach the quota requirement (Pérez de Arce & Sauma, 2016).

One of the most important aspects of setting a tradable green certificate scheme is choosing which entities will be submitted to the generation and consumption of renewable energy through the use of certificates (Kurbatova et al., 2019). While any participant in the electricity market may be chosen, only the most efficient producers of renewable sources are remunerated through this system (Jensen & Skytte, 2002). Of course, another difficult task is the establishment of prices for the certificates. This can be a disadvantage since it is quite difficult to set the price of the certificates for two reasons. The first is the degree of government intervention in the decision of prices. The second is due to the complexity of price formation when the electricity generated comes from different renewable sources. The prices of certificates must meet the price of the most expensive renewable source used within the scheme, in order to cover the cost of producing all types of renewable sources. Therefore, an average electricity price which covers energy derived from all renewable sources will lead to the deployment of cheaper renewable source options in order to maximise profits (Kurbatova et al., 2019).

However, the competition derived from the green certificate scheme makes sure that the supply price for certificates reflects the differential cost between renewable and non renewable energy. Since the certificate price is what is needed to ensure the desired use of renewable sources. So, in reality, this market provides policy makers, stakeholders and consumers with a price signal coming from the renewable energy technology used in the market (Jensen & Skytte, 2002).

3.4 RENEWABLE ENERGY AUCTIONS

An alternative market-based incentive system for renewable energy which is fairly new is the auction system (Anatolitis & Welisch, 2017). An auction is a hybrid instrument as it incorporates aspects from tariff-like schemes as well as energy quantity-based schemes. An auction represents a bidding process in which price and quantity of the good/s auctioned are decided. In the case of renewable energy auctions, the price and the quantity of the energy is determined through the bids made. The auction process allows prices to be set and therefore guaranteed, similar to a tariff-based scheme. However, the bidding process also makes sure that the production amount is set and that a specified amount of energy is actually generated (IRENA and CEM, Ferroukhi, Hawila, Vinci, & Nagpal, 2015).

Renewable energy auctions are also known as *"demand auctions"* or *"procurement auctions"*. The general way of describing how these auctions work is as follows: the government reconciles different electricity generators in order to participate in the auction to install a certain amount of renewable source energy capacity/production (IRENA and CEM et al., 2015). There are sometimes pre-qualification criteria that must be met by the developers in order for them to be able to participate in the auction (Niskala, 2017). Nevertheless, the project developers submit different bids which correspond to the price per unit of electricity (price per kilowatt-hour) that they would need to get paid in order to carry out the project (IRENA and CEM et al., 2015). The auctions are usually done three or four times a year, so the project developers only receive this "support" or subsidy at certain intervals of time unlike the FiT system (Niskala, 2017).

Later on, the government chooses which project would be more convenient and for that they evaluate different aspects apart from the price (IRENA and CEM et al., 2015). The bids are ordered from lowest to highest and the developer with the lowest bid will win. There can be one or multiple winners, meaning that each developer could obtain a specific percentage of the total capacity being auctioned if the whole amount were to not be completed by one sole project (Niskala, 2017). Once the winning bid/s is selected, a power purchasing agreement is made between that developer and the government (IRENA and CEM et al., 2015).

Of course, an auction has certain design elements, and depending on the particular design it can be more or less successful as well as efficient. The first thing that is taken into account is the auction demand. This represents the decision on how much volume is auctioned, whether it will be specific to a certain technology or project, etc. Secondly, the qualification requirements are specified. The requirements refer to which suppliers will be allowed to participate in the auction, the different features they have to adhere to and the necessary documentation that must be provided in order to take part. Thirdly, the winner selection process, which is sorted through the bids made and the rules set for this procedure. Finally the sellers' liabilities are considered. This incorporates the characteristics of what is being auctioned plus making sure that there are certain obligations and responsibilities set for the awarded projects (IRENA and CEM et al., 2015).

The objective is always to construct an efficient auction. As the EU Commission has stated before: "A well-designed auction can lead to significant competition between bids revealing the real costs of the individual projects, promoters and technologies, thus leading to cost-efficient support levels, and limiting the support needed to the minimum" (Toke, 2015).

In order to do this, Niskala (2017) has summed up six basic elements that an auction must have in order to achieve efficiency. These elements are gathered from his investigation of renewable energy auctions through the use of interviews:

1. Incentives - what is offered and awarded
2. Pre-qualification criteria
3. Auction mechanism that is used
4. Post-auction procedure - deadlines, penalties, rights of winners
5. Participating institutions - designer and auctioneer, responsible actor for contracting agents etc.
6. Organisation of above elements - making sure all of the above are in accordance of one another

While what has been described up to now is just a general understanding of the operation of renewable energy auctions, there are many other aspects which can be taken into account when holding an auction. Depending on the auctioneer's needs or preferences, an auction can be made more specific by incorporating certain features, as seen above. The following list contains some of the particular characteristics that an auction can have:

- Price caps/ceiling or floor prices
- Prequalification criteria or multi-criteria auctions

- System specific, volume specific, price specific and model specific auctions
- Technology specific and project specific auctions

Price caps/ceiling or floor prices:

Ceiling prices or floors are prices that are set by the auction maker. If bids are over or under that set price then the bids are ruled out. These price caps can be of use when trying to eliminate strategic bidding among the project developers (Niskala, 2017). The target price set is quite important since it affects the level of competition as well as the diversity in technology for technology neutral auctions (Anatolitis & Welisch, 2017).

Prequalification criteria or multi-criteria auctions

Prequalification criteria refers to any type of condition the auctioneer can set which bidders have to comply to. This narrows down the selection process since many project developers which might not initially qualify will not be able to enter the auction. Additionally, the auction can have multi-criteria features. An example of this would be to evaluate projects which generate more jobs with a higher value (Anatolitis & Welisch, 2017).

Model specific auctions and price mechanisms:

Auctions can have many different characteristics depending on what is given importance to in each case. For example, an auction could be either system specific, volume specific, price specific or model specific.

System specific auctions refer to whether an auction is a static or dynamic auction. A static auction is one characterised by having one bid submitted from each project developer. However, the bids each developer makes are not public to the rest of competitors. On the other hand, in a dynamic auction, bids are made over different rounds and therefore each project developer has the opportunity to bid more than once and adapt strategies as they see how the auction price changes as well as how the competing bids vary (Auction designer).

Volume specific auctions refer to what is being auctioned off. Whether this is a single-item auction or a multiple-item auction. Volume metrics refer to how what is being auctioned off is actually done. The volume can either be set capacity based, generation based or budget based. A capacity based metric specifies the total amount of megawatts auctioned (MW). An electricity based metric specifies the total amount of megawatts per hour bid (MW/h). Lastly, with a budget-based metric, an overall amount of support is given (€) (del Río & Kiefer, 2019).

Auctions can also have different pricing systems. Two very common examples of this would be the pay-as-bid (PAB) system and the uniform system. In the case of the PAB system, as clearly as its name says, the winning bidder is paid exactly the amount that the bid they made was. On the other hand, under uniform pricing, all bidders get the same amount of support. This is determined by either the lowest not accepted bid or the highest accepted one (Anatolitis & Welisch, 2017).

Finally, auctions can also be modelled in a particular way. There are many types of auction models, to name a few: English auctions, Dutch auctions, first-price and second-price sealed bid auctions, ascending or descending clock auctions and reverse auctions. There are even hybrid auctions (Ghazali, Ansari, Mustafa, & Zahari, 2020). Another aspect to keep in mind is that auctions can also have various phases. A two-stage model auction is also another option. In this case, there is a pre-auction which specifies the necessary qualifications required, ruling out various candidates. Then there is another auction where the winner/s are selected (IRENA and CEM, 2015).

As can be seen, auctions can be designed in many different manners and depending on what characteristics are valued above others, certain features of the design will go better accordingly with each other. For example, in the case of single-item static auctions, pricing mechanisms such as the first and second price sealed bid auctions go better in accordance. On the other hand, if a single item is being auctioned off in a dynamic auction, this one is likely to have an English or Dutch pricing mechanism. In multiple-item static auctions the pricing mechanism corresponds to either uniform or PAB pricing systems. In these cases, each project developers' bids are usually handed in a sealed envelope and the final price paid is the lowest bid which got rejected or the highest accepted bid. Lastly, in multiple-item dynamic auctions the pricing system could be either an ascending or descending clock mechanism (Auction designer).

<u>Technology specific auctions:</u>

Auctions which can be all of the above mentioned can also be tech-specific. This is because an auctioneer might feel the need or might have the preference to want to "favour" a certain renewable energy source and its corresponding technology. This happens when in a certain area or country a given energy source is chosen to be more prominent due to advantageous characteristics of the land, which means they get promoted. Of course, there are also multi-technology auctions. In these cases it can be said that there are many tech-specific auctions which are held side by side (IRENA and CEM et al., 2015).

Another source of specificity among auctions can be the project-specific aspect. In the cases of these auctions, there is competition among bids for a particular project that the government has chosen. Here, the government takes most of the burden as they are the one to choose site locations, grid connections, etc. (IRENA and CEM et al., 2015).

Renewable energy auctions have been implemented by many countries in the last years, however this is not to say that the incentive system is perfect.

Auctions have various strengths. First off, auctions allow for flexibility. The different design possibilities, as mentioned before, can allow the possibility to meet many different goals and objectives for each case/government. This means that each country's economic situation, the economic structure of the energy sector, the level of maturity of the electricity market and the amount of renewable energy generated can be taken care of because a specific design can be created to adapt to each of those key points (IRENA and CEM et al., 2015).

Secondly, an auction also leads to a real price discovery. This is due to the competitive aspect of the auction. The competition met with a structured and transparent process leads to the elimination of information asymmetries between the auctioneers (whether these are government or other agents) and bidders. This of course relates to the cost-effective part of the mechanism, which allows for a reduced price of the electricity (IRENA and CEM et al., 2015).

Thirdly, with auctions, there is a greater certainty that the prices and quantities will be guaranteed. The auctioneer and bidders know the quantity that is required and also know which price will be the cut-off price before the auction starts. This leads to greater security for bidders and auctioneers alike. As it has been mentioned before, the quantity and price is set in a market-based mechanism (IRENA and CEM et al., 2015).

On a final note, auctions are transparent and have established commitments. Both bidders (winners) and auctioneers know the content of the contract that they will sign and they also know the liabilities (IRENA and CEM et al., 2015). For example, if the agreement is not followed by any of the parties involved, penalties are assured (Ghazali, Ansari, Mustafa, & Zahari, 2020). The commitment to the agreement made is specially important to investors as remuneration will not be affected in any form even if the market were to change (IRENA and CEM et al., 2015). The transparency also allows for lower prices since there is a reduced risk in market manipulations and so consumers are likely to pay a fair amount for the energy generated.

Not surprisingly, renewable energy auctions also have their weaknesses. One of them is the transaction costs that bidders experience. The costs are in reference to the requirements that must be met for the participation in the auction, which might leave smaller sized contenders out of them. This is crucial since one of the strengths of auctions is competition. If some of these bidders are excluded from auctions due to cost, this means that there is less competition and therefore it could lead to market manipulation or market power (IRENA and CEM et al., 2015).

However, auctioneers also suffer transaction costs. An auction is a difficult tool to implement in comparison to other incentive systems, the design of it alone requires much effort. This complexity increases transaction costs for those doing (managing) the auction. Nevertheless, it has been studied that these costs are insignificant when compared to the benefits that an auction could facilitate. For example, initial auction costs could be easily covered with succeeding auctions (IRENA and CEM et al., 2015).

Finally, other weaknesses which are experienced in renewable energy auctions are underbidding and delays. This is where the winner's curse comes into play. Some bidders can overestimate due to excessive confidence about the evolution of technology costs or the penalties which might be set and therefore this can lead to some projects being delayed or not delivered. It should be noted that this occurs even when penalties are set (IRENA and CEM et al., 2015).

3.5 ADVANTAGES AND DISADVANTAGES OF EACH SYSTEM

In order to see comparatively the different incentive systems used for renewable energy sources, the following table focuses on the pros and cons of each incentive system.

Table 1. Advantages and disadvantages of each incentive system

Incentive Systems	Advantages	Disadvantages
Feed-in tariff	- can lead to greater investment, and more diverse investment, due to more reliability - lower cost of capital - stability of revenue can help out smaller projects - fixed prices can help with renewable energy market volatilities	- distortion of electricity prices (since changing market conditions are not taken into account) - same prices offered regardless of demand (fixed)
Feed-in premium	- supply is given at peak demand periods (higher prices), increases efficiency - less administrative intervention is needed, only premiums are decided	- lower cost efficiency compared to fixed tariffs (generation costs) - greater uncertainty for investors due to incapability of exact market price predictions for the future - risk of over/under compensation due to shifts in market conditions
Rate of return regulation	- fair prices for electricity generators and consumers	- less investment in renewable sources due to higher generation costs - costly regulation - Averch-Johnson effect
Green certificates	- promotes directly electricity generation, instead of capacity - price signal for renewable energy technology used in market	- only most efficient electricity generators are remunerated - difficult to set price of certificates - cheaper renewable sources are employed
Renewable Energy auctions	- flexibility - real price discovery - prices and quantities are guaranteed - transparency and commitment	- transaction costs bidders experience - transaction costs for auctioneers - underbidding and delays (winner's curse)

Source: (Couture & Gagnon, 2010) and own elaboration.

4. AUCTION SYSTEMS IN SPAIN

After having analysed all of the incentive systems which are used for renewable energy sources, specifically having focused on renewable energy auctions, the following section will expand on the latter. The section will be centred around renewable energy auctions and their design in the case of Spain. Spain is part of the Iberian Electricity Market (MIBEL, Mercado Ibérico de la Electricidad).

The first renewable energy auctions held in Spain occurred in January 2016 and May and July of 2017. The design of these auctions was affected by a series of characteristics and goals that the Spanish energy market had then. It was mainly a response to the high tariff deficit and high retail prices at the time, as well as the 2020 Renewable Energy targets set. For these auctions, what was of great importance was the effectiveness of the projects, meaning that they would be built, and the minimization of costs (del Río & Kiefer, 2019).

These auctions' designs were influenced by a regulatory framework which passed in the Spanish law in 2013/2014. Through these laws, the project developers would obtain the market price plus a complementary remuneration. The added remuneration's purpose was to cover two costs. One referred to the investment costs which were not retrieved through sales (remuneration for investment) and they were paid all throughout the use of the plant during its regulatory life. The second referred to the operational costs of the plant, for those which had costs above the average electricity price. The remuneration payment depended on the plant type and could not exceed a certain amount. It also should be noted that in the auctions only the remuneration for investment was provided (del Río & Kiefer, 2019).

However, the Spanish Government decided to publish an Integrated National Energy and Climate Plan (PNIEC) which included an auction design for the period 2021-2030. Through this plan different energy targets will be achieved, some of these are: a reduction in greenhouse gas emissions of 21% in respect to those in 1990, a final energy consumption with 42% corresponding to renewable energy sources, a 39.6% of improvement in energy efficiency and finally, electricity generation of which 74% is from renewable sources. The 2030 goal is to deploy 120 GW of renewable energy. The plan also expects to result in an added 57 GW increase in capacity during the given period. It is important to note that auctions are planned to be the main instrument used in renewable energy technology support (del Río & Kiefer, 2019).

The specific design features are detailed below:

1. <u>Volume:</u>
   The volume metric set for old and new auctions is the capacity-based one (3000 MW). This allows for better signals for equipment manufacturing firms for what is needed to build the projects early on. However, it does leave uncertainty on the total costs of the support given. Capacity-based metrics are also the most popular volume setting in auctions worldwide. Nevertheless, in future auctions, generation-based volume metrics can also be used, considering however, that a certain amount of energy is produced by a given time. The good thing about this metric is that it gives certainty on support costs. In spite of that, the effectiveness cannot be observed until the end of the remuneration period (del Río, 2021).

Both in the old and new auctions, the volume is published before the auction, like in many other places. The advantage of this is that it encourages participation and improves competition, which all lead to lower costs. Equipment manufacturers are also better signalled by this. The con is that this can also facilitate strategic bidding (del Río, 2021).

There are two additional features which come into play after the initial volume is set. The first is regarding the volume offered, which must be 20% higher than the volume of product being auctioned. If this does not occur then the volume auctioned is reduced after bids are made in order to meet this rule. The second is the ability to increment the volume auctioned if there are bids which are considered attractive. This feature was also present in the old auctions. Surprisingly enough these two tweaks are not common in auctions elsewhere (del Río, 2021).

2. <u>Frequency of auctions and schedules:</u>
   The new auctions have been scheduled with deadlines, numbers of rounds, expected capacity and technologies. This feature is a clear sign of longer-term commitment to renewable energy, it reduces sunk costs of participation and also reduces the risk for investors. Lower investment risk can easily lead to lower support costs. Another advantage is the reduction of aggressive bidding in the first rounds, knowing that several rounds would be scheduled. This is not the approach which is taken in the old auctions or in the majority of countries. The reason for this is because un-scheduled auctions provide more flexibility for auctioneers and changing market conditions. The established frequency rate will be at least annual auctions (del Río, 2021).

3. <u>Lead times:</u>
   This represents the period between the announcement of an auction and the time when bids are submitted. The time given for the new auctions, like in the old ones, will be 3 months. The lead times must be long enough that participants have time to prepare the bids but not too long that the auctions are delayed (del Río, 2021).

4. <u>Technological diversity:</u>
   For the new auctions, the Spanish auctions will adopt a hybrid design which features both technology-neutral (TN) and technology-specific (TS) auctions. Even though in past auctions, TN, TS and MT (multi-technology) auctions were done, TN and TS have some advantages. TN auctions lead to lower costs, if that were the goal, through the competition of all tech and therefore leading to the cheapest tech and lower bids. TS auctions on the other hand, create a greater diversification of sources. This can help with the reduction of indirect costs since complementary technologies can be promoted. These types of auctions are preferred when having the goal of creating a local industry. The reason for that is because different technologies have different features and it is very difficult to design an auction which is neutral for all technologies (del Río, 2021).

5. <u>Geographical diversity:</u>
   Both old and new auctions have been geographically neutral (no incentive to locate

the project somewhere given). Geographic neutrality lowers direct generation costs since the locations with best characteristics are exploited first (del Río, 2021).

6. Actor and size diversity:
   Actor diversity is specifically targeted in the new plan. This refers to having smaller actors and a greater variety of participants in general. Smaller sized actors (smaller installations) are also encouraged in the new auctions, only projects lower than 5 MW will be excluded. Actor diversity lowers the risk of collusion and also ensures that there is not one actor dominating the market, which leads to more attractive prices. Smaller renewable energy projects can help with distributed generation, they can reduce losses by being closer to consumption points or they can lower the environmental impact. Therefore there are quite a couple of advantages to this decision. Even though actor-neutral auctions can lead to lower direct costs and a greater certainty that projects are built. Worldwide, actor-neutral auctions are more common (del Río, 2021).

7. Prequalifications:
   Similarly to past auctions, the new ones will have a prequalification of 60 €/kW minimum to participate in the auction. This amount is given back after the project has been pre-allocated. On top of that a registration of 60€/kW in the Economic Regime of Renewable Energies is also required, however it also is returned after a certain point. Another prequalification in place is the presentation of a supply-chain plan which represents the socioeconomic impact of the project. Prequalification practices are popular in auctions from most countries (del Río, 2021).

8. Seller concentration rules (SCR):
   This refers to the minimum number of participants, mainly so that one sole bidder cannot receive all of the market share. In the case of the new auctions, no more than 50% of the total volume auctioned off can be awarded to the same actor. This feature is new to Spanish auctions but it will encourage competition and result in a higher number of actors in the auction. Similar to old auctions, many countries worldwide do not incorporate this characteristic in auctions (del Río, 2021).

9. Remuneration type:
   The remuneration type in new auctions will be generation based (€/MWh) instead of capacity based (€/MW) as it was in older auctions. Generation-based remuneration type auctions are more effective as maintenance of plants and greater efficiency are encouraged. Not like in the case of capacity based remuneration type auctions where the amount remunerated is independent of the amount of electricity generated (del Río, 2021).

10. Remuneration form:
    Since the remuneration type is generation based, the way to pay project developers can either be through a FiT or FiP system. In the case of Spanish auctions, a variable feed-in premium remuneration scheme has been chosen (del Río, 2021).

11. Selection criteria:
    The Spanish government has chosen a price-only criteria for the new auctions. This means that the only thing which guarantees an awarded project is the low price, no other characteristics, as job creation could be, are looked at. This increases the simplicity as well as the transparency of the auctions (del Río, 2021).

12. Auction format:
    The new auctions will be multi-unit auctions. This is also the case in most countries worldwide. Having multi-unit auctions can lead to higher efficiency in auctions and also reduces the risk of non-completion of projects (since the volume auctioned would be diversified) (del Río, 2021).

13. Auction type:
    New and older auctions have been static auctions. A few advantages of these auctions are their simplicity and their means of reducing collusion. In the case of multi-unit auctions, static auctions are seen to diminish aggressive bidding since the bidders are not aware of what others are doing and therefore are less conditioned by them (del Río, 2021).

14. Pricing rules:
    Previous auctions in Spain have had uniform pricing. However, as is the case in many other countries, the new auctions will have PAB pricing. A key point of this pricing scheme is the simplicity of it. Apart from that, this pricing scheme might help with the problem of over-remuneration (del Río, 2021).

15. Ceiling prices and minimum prices:
    Ceiling prices are to be implemented in the new auctions. However, they will be disclosed at the auction and not before in order to avoid prices close to the ceiling price, or the so-called anchorage effect. Likewise, a minimum price may also be set and will also be confidential until the auction is held.

16. Realisation periods:
    The time given for the building of the projects has been established as 3 years for photovoltaic plants and 4 years for wind on-shore plants. Realisation periods must be established appropriately since long periods may lead to ineffectiveness or risk of low bids. On the other hand, short periods might create difficulties with building permits or project financing. The given time periods are within the worldwide realisation period averages (del Río, 2021).

17. Penalties:
    Penalties are of high importance when designing an auction. Non-aggressive penalties might lead to inefficiencies, incompletion of projects, or lead to underbidding. While penalties that are too aggressive might discourage participants or lead to excessive bids. Therefore, the auction will enforce bid bonds when the project is not built and there will also be a penalty for failing to provide the minimum amount or energy of the auction when a maximum delivery date is reached. If the minimum energy is not delivered, during that intermediate period, there will be a

penalty of 5€/MWh (del Río, 2021).

Table 2 provides a summary of the auction design features:

Table 2. Auction design features for the Spanish case

Auction design features	**Spain**
Volume	Capacity-based (3000 MW)
Frequency and schedules	Scheduled
Lead times	3 months
Technological diversity	TN and TS auctions
Geographical diversity	Geographically neutral
Actor and size diversity	Actor specific
Prequalifications	- 60€/kW as minimum - supply-chain plan with socioeconomic impact of project
SCR	No more than 50% of the total capacity auctioned can be awarded to a single actor
Remuneration type	Generation based (€/MWh)
Remuneration form	Variable FiP
Selection criteria	Price-only
Auction format	Multi-unit
Auction type	Static
Pricing rules	Pay-as-bid (PAB)
Ceiling and minimum prices	Could be set, confidential
Realisation periods	3-4 years
Penalties	- Bid bond penalty if project is not built - Penalty for failure of provision of minimum amount of energy by delivery rate - During the intermediate period until the delivery date, failure to provide minimum energy amounts will be penalised with 5€/MWh

Source: (del Río, 2021) and own elaboration.

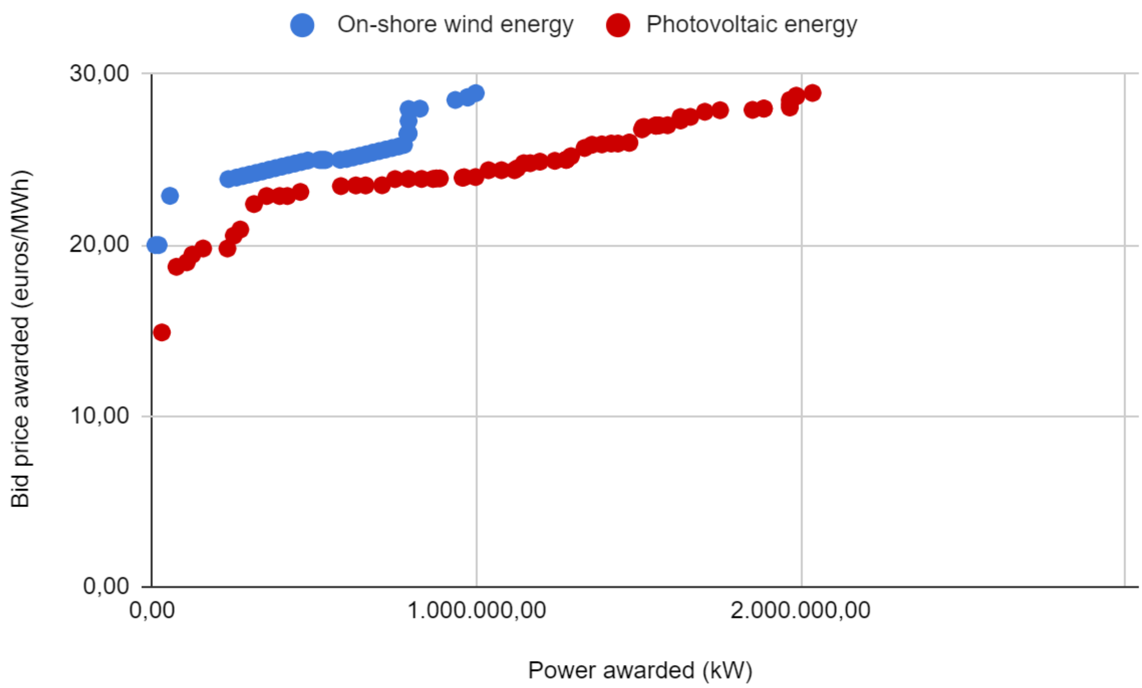
5. DATA

In this section, the results from past auctions in Spain will be displayed and explained. The auctions analysed for this study are the ones which occurred in 2021 and 2022. More specifically, the auctions which took place on the 26th of January and the 19th of October in the year 2021, as well as those that took place on the 25th of October and the 22nd of November in 2022. Afterwards, some conclusions will be drawn from this empirical data. All the information from these auctions has been obtained from data published by the Ministerio para la Transición Ecológica y el Reto Demográfico (Ministerio para la Transición Ecológica y el Reto Demográfico, 2021 & 2022).

5.1 AUCTIONS IN THE YEAR 2021

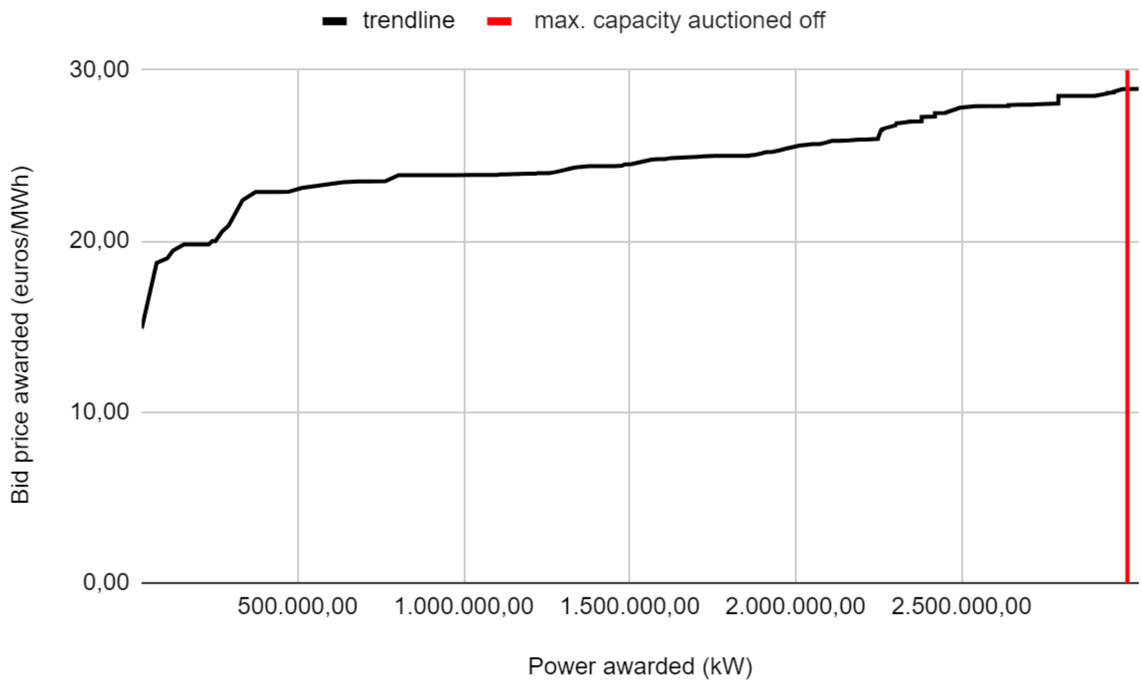
The data displayed in the following graphs has been collected from *Table A.10* and *Table B.10* from the appendix. These show the aggregate supply curves of different renewable sources at the time of the auctions that took place in 2021.

Graph 1. Results from the auction on the 26th of January, 2021



Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, Disposición 1251 del BOE núm. 24 de 2021) and own elaboration.

Graph 2. Results from the auction on the 26th of January, 2021, technology not specified



Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, Disposición 1251 del BOE núm. 24 de 2021) and own elaboration.

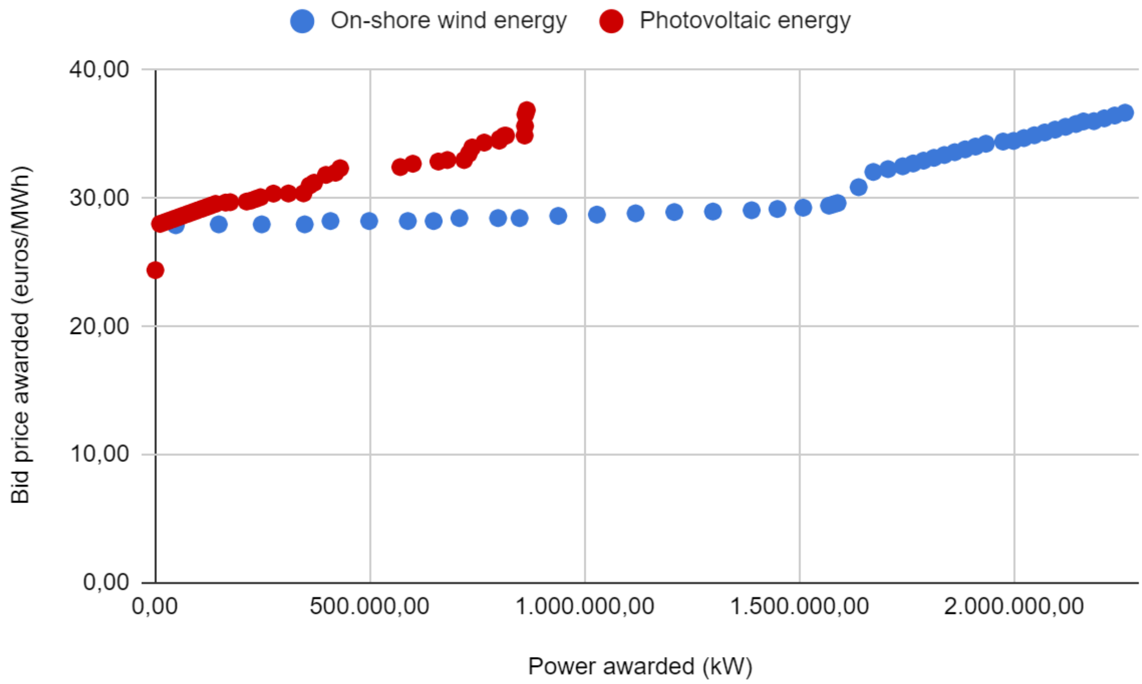
Graph 1 shows the aggregate supply curve of energy obtained from the first auction done in 2021 where 3.000 MW of power was auctioned off. In this auction, a total of 3.034.178,00 kW were awarded, therefore the total capacity set was reached, this can be seen in *Graph 2.*

What is clearly seen is that there were more awarded offers given to photovoltaic energy than to on-shore wind energy. It is also visible that on-shore wind energy had higher bid prices in comparison to photovoltaic energy. The bid with the lowest price given to on-shore wind projects was of 20 €/MWh for 10.000 kW. On the other hand, the lowest price bid awarded in photovoltaic plants was of 14,89 €/MWh for 30.000 kW. However, for the highest prices, on-shore projects had a maximum price of 28,89 €/MWh for 25.000 kW and photovoltaic plants had slightly higher price, 28,90 €/MWh for 50.000 kW.

For this particular auction, bid prices for both sources seem to fit into three categories. A small group of bidders have varying lower-level bid prices ranging from 14 to 22 €/MWh for photovoltaic plants and 20 to 23 €/MWh for on-shore wind energy. It should be mentioned that the group of bidders was comparatively bigger in the case of photovoltaic energy. On the other hand, the majority of bidders settle for a bid price ranging from 23-26 €/MWh in photovoltaic projects and from 24 to 26 €/MWh in on-shore wind ones.

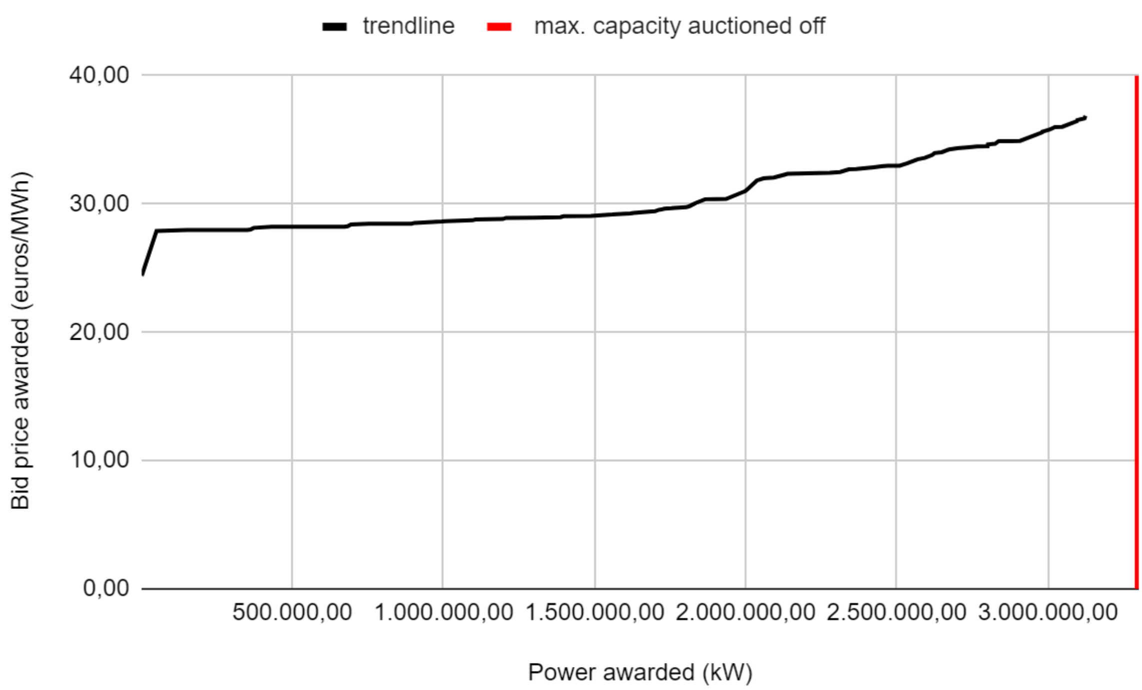
Finally, a large group of bidders (in both technologies) obtain a higher price which ranges from 27-28 €/MWh in both energies. The main difference between both supply curves can be observed here. As the change in prices awarded in photovoltaic energy is more progressive while in the case of on-shore wind energy there is a significant change in prices. It can be seen that the curve for solar PV becomes completely vertical and then continues to increase continuously in price.

Graph 3. Results from the auction on the 19th of October, 2021



Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, Disposición 17335 del BOE núm. 255 de 2021) and own elaboration.

Graph 4. Results from the auction on the 19th of October, 2021, technology not specified



Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, Disposición 17335 del BOE núm. 255 de 2021) and own elaboration.

The power being auctioned off in this auction was 3.300 MW, however only 3.123.770,00 kW were awarded, meaning that the total capacity set to be auctioned off was not reached, seen in *Graph 4*.

Completely contradictory to the first auction which occurred in the year 2021, in the supply curves analysed here, more offers were awarded to on-shore wind energy projects than photovoltaic ones. In this auction, it is also visible that overall, photovoltaic projects bid higher prices than on-shore wind. Although they do converge at the price range of approximately 27 €/MWh. The lowest price bid awarded for photovoltaic energy was 24,40 €/MWh for 1.500 kW and for on-shore wind it was 27,90 €/MWh for 49.000 kW. However, regarding the highest bid prices awarded for each source, they were very similar. Photovoltaic plants had a bid of 36,88 €/MWh for 3.250 kW and on-shore wind projects had a bid of 36,68 €/MWh for 24.200 kW.

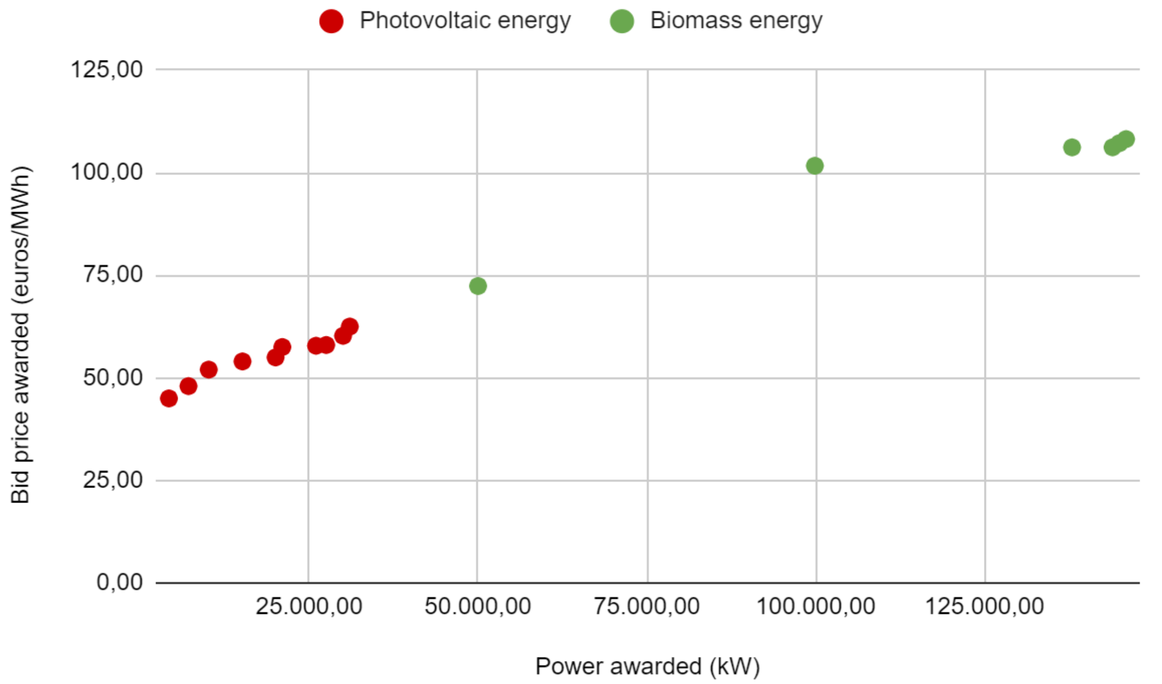
Another thing which can be mentioned of the supply curves of both sources in this auction is that they were very different. For the case of photovoltaic energy, it is observed that the curve can be separated into three sections. The first one consists of one sole bidder which turns out to have the lowest bid price awarded. The majority of bidders have bid prices ranging from 28 to 34 €/MWh. Finally, there is a small group of bidders which have increasingly higher-valued bid prices (vertical part of the supply curve).

In the case of on-shore wind energy, the increment in price bids is continuous. It can be said that bidders could be separated into two equal-sized groups. One group which places bid prices ranging from 27 to 30€/MWh. The other group places higher-valued bid prices ranging from 32 to 36 €/MWh.

5.2 AUCTIONS IN THE YEAR 2022

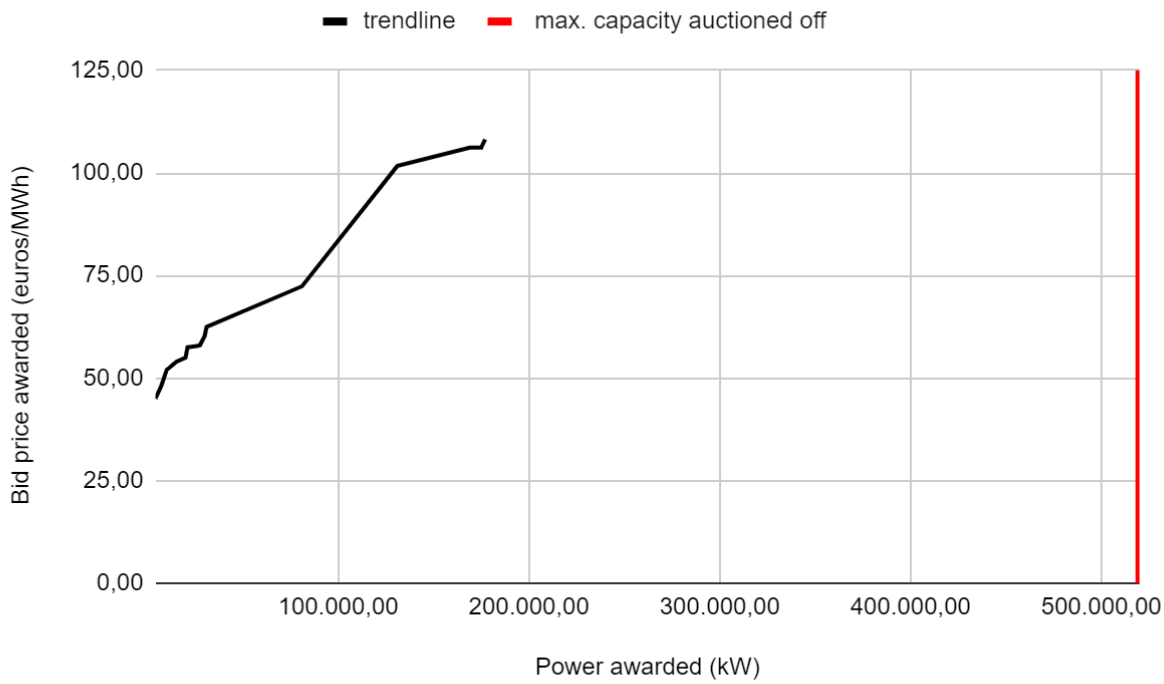
The data displayed in the following graphs has been recollected from *Table C.10* and *Table D.10* from the appendix. These again show the aggregate supply curves of different renewable sources from the auctions that took place in 2022.

Graph 5. Results from the auction on the 25th of October, 2022



Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, Disposición 17796 del BOE núm. 261 de 2022) and own elaboration.

Graph 6. Results from the auction on the 25th of October, 2022, technology not specified



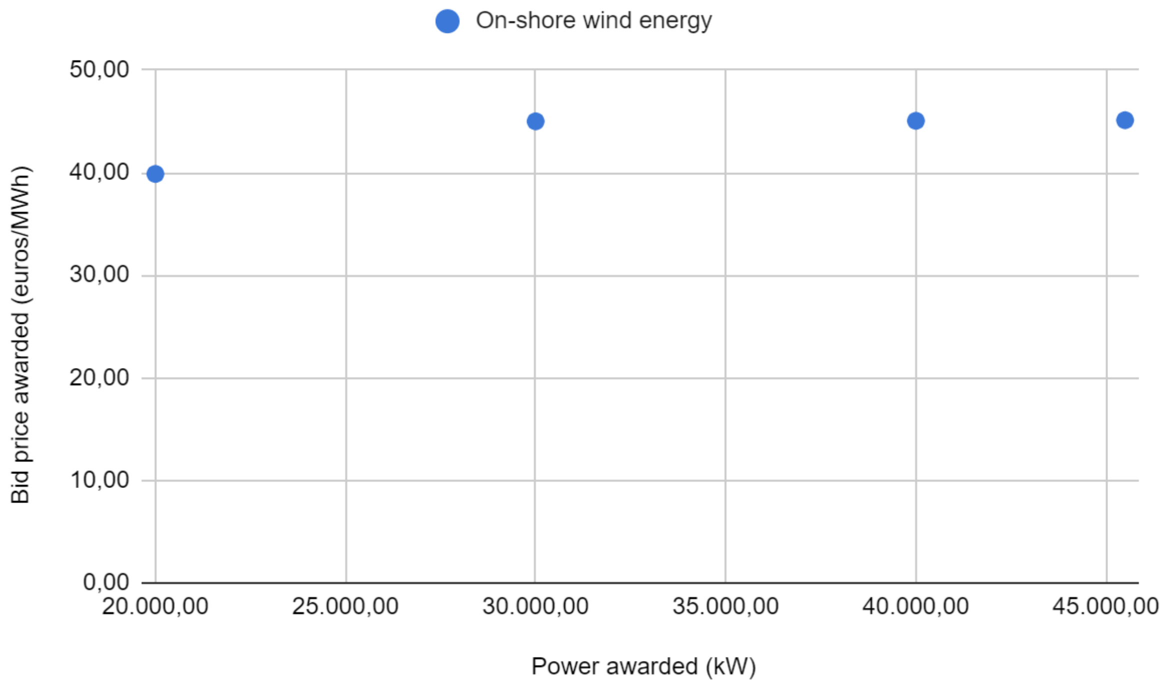
Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, Disposición 17796 del BOE núm. 261 de 2022) and own elaboration.

Graph 5 again shows the supply curves for renewable sources at the first auction that took place in 2022. In this case, the power auctioned off was for photovoltaic energy and biomass energy, however what was auctioned was different for each technology. Photovoltaic projects had a total of 140 MW, while biomass projects had 380 MW. Both of these capacity limits were not reached, photovoltaic energy was awarded 31.000,00 kW in total while biomass was awarded 146.000,00 kW. This can be seen in *Graph 6*.

As seen above, there were more offers from photovoltaic projects rather than biomass projects. What can be very clearly seen is that all biomass projects which were awarded had higher bid prices than those awarded to photovoltaic ones. This can be seen since the lowest bid price awarded for photovoltaic projects was 44,98 €/MWh for 4.200 kW, compared to 72,38 €/MWh for 50.000 kW awarded in biomass projects. For the highest awarded bid prices, photovoltaic projects reached a maximum of 62,50 €/MWh for 1.000 kW while biomass energy reached a peak of 108,19 €/MWh for 1.000 kW.

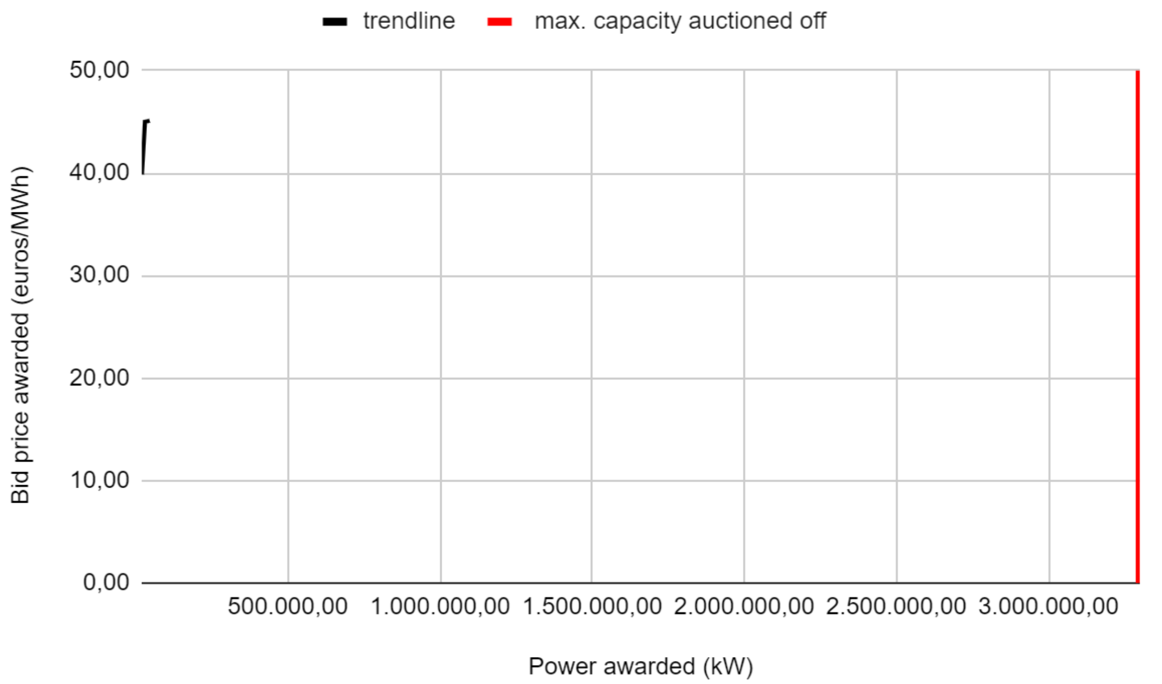
Nevertheless, both supply curves hold characteristics which are alike. Bidders can be separated into three sections. The first group have bid prices which range from 44 to 54 €/MWh in the case of photovoltaic energy and from 72 to 101 €/MWh in the case of biomass energy. The second group of bidders do not vary much in their bid prices, for example, in the case of photovoltaic projects they range from 57 to 58 €/MWh. While in the case of biomass projects, they stay at 106 €/MWh. However, it can be added that this group of bidders is greater in the case of photovoltaic energy. Finally, the last group of bidders place higher-valued bids which range from 60 to 62 €/MWh in photovoltaic energy and from 107 to 108 €/MWh in biomass. In both of these sources of energy, this last group is very small compared to the rest.

Graph 7. Results from the auction on the 22nd of November, 2022



Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, Disposición 20540 del BOE núm. 291 de 2022) and own elaboration.

Graph 8. Results from the auction on the 22nd of November, 2022, technology not specified



Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, Disposición 20540 del BOE núm. 291 de 2022) and own elaboration.

In comparison to the previous auction which took place in 2022 and the rest of the auctions from 2021, this particular auction only awarded offers for on-shore wind energy. The power auctioned off was 3.300 MW, as seen in *Graph 8*.

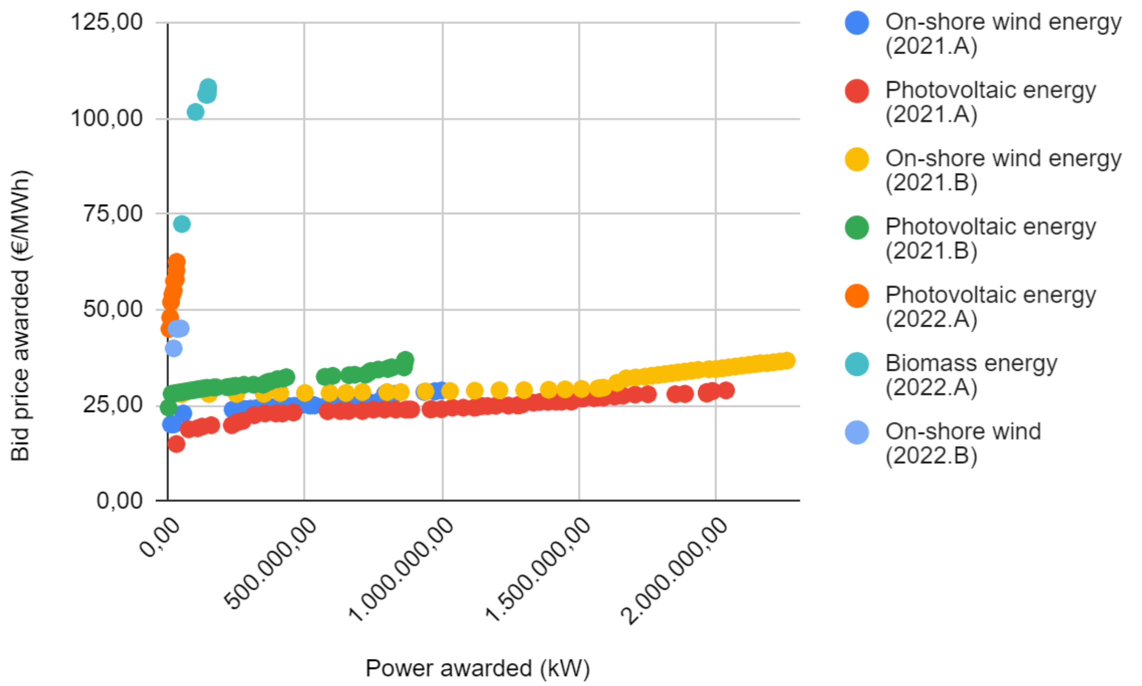
It can also be clearly seen that, similarly to the auction mentioned in *Graph 6,* this auction did not award much energy overall. The capacity limit set was nowhere near to being reached as the auction finalised, only 45.500,00 kW were awarded. There were only 4 bidders which were given a certain amount of energy for a given price in this second auction of 2022. The lowest awarded bid price was 39,88 €/MWh for 20.000 kW. On the other hand, the highest awarded bid price was 45,12 €/MWh for 5.500 kW.

As has been a pattern in the shape of the supply curves in past auctions, it can be said that the bid prices in this auction can also be separated into two groups. The first has greater differing bids which range from 39 to 45 €/MWh approximately. While the second group of bidders do not vary much in their bid prices, these range from 45,06 to 45,12 €/MWh.

5.3 FURTHER OBSERVATIONS: COMPARISON BETWEEN AUCTIONS

In this section, a few more details about the results obtained in the auctions occurring during the years 2021 and 2022 will be taken into account. The auction results will also be compared between one another, as the auctions differ significantly between years.

Graph 9. A recollection of all the auctions taken place in 2021 and 2022



Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, 2021 & 2022) and own elaboration.

<u>NOTE: .A subscripts refers to auctions done first in the year while .B subscripts refers to auctions done secondly in the year</u>

The main and most important differences observed in all of the auctions when looked at them side by side are three. The first being that while in both the first and second auctions of 2021 and the first auction of 2022 two energy sources are offered, in the case of the second auction occurring in 2022, only on-shore wind energy projects were subsidised.

The second and most surprising difference is the varying amounts of energy awarded in general between auctions in 2021 and 2022. In the year 2021, the renewable energy auction seems to be quite successful and there are many bidders/companies which are awarded with subsidies for their projects. However, as time passes, the total amount of renewable energy offers awarded decreases. The first auction of the year 2022 contains quite a few less bidders than its previous auction, but in the second auction of the same year this number dwindles down to just four bidders. It seems that the renewable energy auctions which took place in the year 2022 were not nearly as successful as its predecessors.

Finally, the last aspect that is taken away from *Graph 9* is the difference in the bids from 2021 and 2022. It can be seen that overall, the bid prices in 2022 were higher. These were in a price range of 40 to 110 €/MWh while the range for bids in 2021 was only around the range of 15 to 37 €/MWh.

The previously mentioned can be observed from *Graph 9*, however, it's better seen from *Tables 3,4,5* and *6* from the appendix. The following table lists the lowest, highest and average bid prices for each source in each year.

Table 3. Summary of lowest, highest and average price bids of each source in each year

			Energy source		
			On-shore wind	Photovoltaic	Biomass
Year	2021.A	Lowest bid price (€/MWh)	20,00	14,89	
		Average bid price (€/MWh)	25,31	24,83	
		Highest bid price (€/MWh)	28,89	28,90	
	2021.B	Lowest bid price (€/MWh)	27,90	24,40	
		Average bid price (€/MWh)	30,18	31,65	
		Highest bid price (€/MWh)	36,68	36,88	
	2022.A	Lowest bid price (€/MWh)		44,98	72,38
		Average bid price (€/MWh)		53,88	93,09
		Highest bid price (€/MWh)		62,50	108,19
	2022.B	Lowest bid price (€/MWh)	39,88		
		Average bid price (€/MWh)	42,78		
		Highest bid price (€/MWh)	45,12		

Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, 2021 & 2022) and own elaboration.

NOTE: .A subscripts refers to auctions done first in the year while .B subscripts refers to auctions done secondly in the year

One of the main takeaways from this table is that independently of the year, biomass energy projects have the highest average bid price awarded. This can be because biomass projects are more expensive and therefore require a higher investment/subsidy. Another thing to have in mind is that when comparing the average bid price of on-shore and photovoltaic energy in the auction from 2021.A, on-shore wind projects have a higher bid price relative to photovoltaic energy bids. On the other hand, for the auctions in 2021.B photovoltaic energy's average bid price is higher than that of on-shore wind. However, it can be seen that bid prices increased for both energy sources in the second auction of 2021. Finally, price bids for both photovoltaic and on-shore wind projects increased significantly from the auctions that take place in 2021 to the ones that take place in 2022. On-shore wind energy price bids increased by 41,72% while photovoltaic bid prices increased by 70,24% in this period.

6. METHODOLOGY

Having presented the results from the auctions which took place in 2021 and 2022, and after extracting the most important aspects from these results, this section will go on presenting the methodology for the subsequent analysis.

As can be seen in the section above, the key point is centred around the price of bids awarded for each amount of power in each auction. This analysis will focus on what features/occurrences make a bidder choose a certain price to bid. The analysis will also apply how this choice has been taken in the auctions from 2021 and 2022 and how it has affected the outcome. In order to carry out this analysis, a theoretical framework provided by auction theory will be used.

As seen in *Table 2* from section 4, the current renewable energy auctions in Spain, as well as those done in 2021 and 2022, are static type auctions and have pay-as-bid pricing rules. In other words, this type of auction would be considered a first-price sealed bid auction.

First-price sealed bid auctions (FPSB auctions) have the following mechanism: bidders submit one sole bid in a sealed envelope (or the electronic equivalent) within the established submittal period specified by the auction rules. As it is also mentioned in *Table 2*, the only category which is considered for the result deliberation process in Spanish auctions is price (Usategui Díaz de Otalora, 2020).

Of course, it should be mentioned that in this case, renewable energy auctions such as those in 2021 and 2022 in Spain actually consider bidders as sellers while the auctioneer (in our case the Government) is in truth "buying" / paying for a product/commodity (electricity) in order to distribute it to the final consumers (Usategui Díaz de Otalora, 2020). What the Spanish government is doing is, in simple terms, subsidising the renewable energy electricity sector by providing a stable flow of revenue to renewable projects.

Having understood this auction perspective, once envelopes are opened, the auctioneer or Government would choose to award a chosen amount of capacity, to the lowest price bids. Project developers or bidders will obtain exactly the price that they chose to bid (PAB system) (Usategui Díaz de Otalora, 2020).

Given that bidders will get exactly what they bid, they will never bid their exact cost. Bids below their cost of production will not be made due to the fact that they would not be able to produce the electricity and carry out the project. Bids will not be equal to their production cost given that bidders are willing to decrease their probability of winning in auction in exchange for a higher price. Therefore, in equilibrium, bidders in FPSB auctions will bid above their production costs (Usategui Díaz de Otalora, 2020).

This is where another part of auction theory comes in, risk analysis. There are three types of bidders regarding risk: risk neutral, risk averse and risk loving. Risk neutral agents do not mind much about the risk (probability) of winning/losing something. Risk averse bidders prefer to obtain something with certainty rather than have a larger probability of not getting awarded. Risk loving agents would rather obtain something (even if it's riskier) and will go to greater lengths to do that (even if there is a very low probability of actually winning the auction).

In FPSB auctions, bidders will base their bid on the probability of winning the auction as well as the surplus that they can obtain if they were to win. This surplus is calculated by subtracting from the actual bid price awarded the real expected costs the bidders would incur with the project. The surplus diminishes as the price bid decreases. The probability of winning depends on various things: the bids, the number of participants and the probability of winning that the participating agent believes that competing bidders have (beliefs on probability distributions of competitor bids) (Usategui Díaz de Otalora, 2020).

The probability that a bidder wins the auction increases as the bid price decreases, but the surplus increases as the price bid increases. Bidders are incentivised to bid higher to obtain a larger surplus, however they are also incentivised to bid lower prices in order to win the auction. Therefore, the bidder will choose as the final bid price the best combination between the surplus obtained and the probability of winning (Usategui Díaz de Otalora, 2020).

If we were to assume that the bidders in the auction were risk-neutral, this would mean that they only care for the average expected price that they can obtain, rather than focusing on the different amounts of surplus achievable (Usategui Díaz de Otalora, 2020).

When bidders are considered to be risk-neutral, the bids tend to get closer to the actual expected costs as the number of participants increases. The number of participants increases the level of competition, and bidders will have to take into account that there are more competitors which have price bids which might be lower than their own. Therefore, if more bidders participate in the auction, the auctioneer will end up providing subsidies which are much closer to the actual expected costs of each bidder. Similarly, when bidders are risk-averse, they care more about obtaining the awarded price than increasing their surplus. So risk averse bidders will tend to place bids which are closer in price to their true expected costs, in order to have the greatest chance at winning the auction (Usategui Díaz de Otalora, 2020).

Auction theory in part explains the reason how auction participants choose their bids. It shows that bid prices are always above the actual expected costs project developers incur. Nevertheless, there are other aspects which have to be looked at to understand this decision making process. For instance, production costs, size and external markets. These are the factors that will be explored in the empirical analysis conducted in section 7.

7. ANALYSIS

In this section, parting from the theoretical background explored in the methodology, the results obtained from the data in section 5 will be analysed. In order to do so, the focus will be on the costs carried out by the bidders and their firm size, as well as the existence of external markets and influences which affect the profitability of renewable projects.

7.1 PRODUCTION COSTS AND SIZE

A quite clear aspect which affects bidders when choosing what price to bid is their cost of production. The reason why bidders decide to participate in auctions is to receive a subsidy so they can carry out their energy projects. Therefore, production costs and the ability to cover them are of great influence when deciding their bids.

It can be seen in *Table 3* from section 5.3 that average price bids for photovoltaic energy and on-shore wind energy have increased significantly from 2021 to 2022. According to the research done by BloombergNEF, the cost of on-shore wind has risen by 7% while photovoltaic energy has risen 14%. This production cost increase is due to various factors, including material costs, freight costs and labour costs (Henze, 2022).

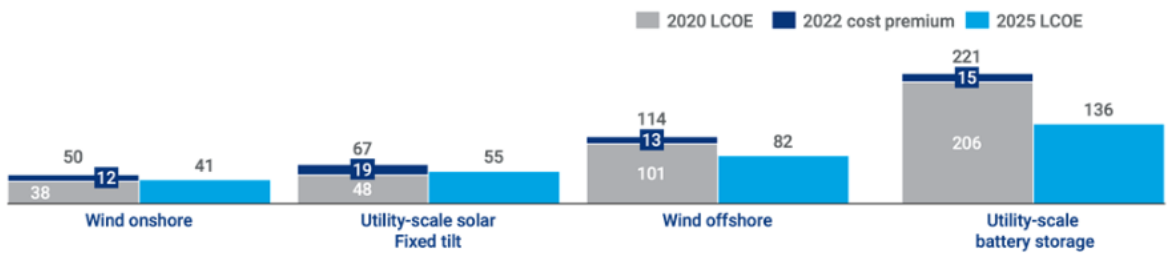
A way to measure these renewable energy costs on a global scale is by using the global Levelized Cost of Electricity (LCOE) estimates. The global LCOE "benchmarks conceal a range of country-level estimates that vary according to market maturity, resource availability, project characteristics, local financing conditions and labor costs" (Henze, 2022).

This LCOE is used to "assess and compare alternative methods of energy production" (CFI Team, 2023). It is mainly the "average total cost of building and operating the asset per unit of total electricity generated over an assumed lifetime" (CFI Team, 2023). In simpler terms, it sets the average minimum price at which electricity has to be generated in order to cover all of the project's production costs (CFI Team, 2023).

Also verifiable by looking at the case of Spain (*Table 3*), the estimates shown in BloombergNEF's research shows that the LCOE (levelized cost of electricity globally) price for on-shore wind and photovoltaic projects in the first period of 2022 was 45 €/MWh and 46 €/MWh respectively. Nevertheless, the development of on-shore wind and photovoltaic projects is still 40% cheaper than non-renewable energy sources (Henze, 2022).

It seems that LCOE estimates in general for all renewable sources increased by an average of 19% in 2022. This was due to supply chain bottlenecks as well as inflation of commodity prices, the struggle mentioned before about finding qualified labour is also part of the reason why there has been an increase (Shrestha, 2023). The following figure shows the average estimates of European LCOE values for electricity in 2022:

Graph 10. European average LCOE values (€/MWh)



Source: (Shrestha, 2023).

As it can be seen, both wind on-shore energy and photovoltaic energy costs have increased in 2022. On-shore wind energy's average European LCOE estimate increased by 12% from 2020's value, while the estimate for photovoltaic energy increased by 19% from 2020.

One of the reasons why the LCOE estimates have increased is due to the change in interest rates. As it can be seen in a press release featured by the European Central Bank on the 5th of May, 2023, interest rates for corporations increased. More specifically, at the beginning of June 2022, interest rates for firms were around 1.5%. However, by the end of December 2022 the cost of borrowing for companies had increased up to 3.5% approximately (European Central Bank, 2023). This clear increase in the cost of borrowing for firms definitely has a direct effect on the LCOE as it affects the costs of financing the renewable projects.

In the previous section it was observed that bid prices have increased from the year 2021 to the year 2022. However, another visible characteristic is that the number of winning bidders in the auction has tremendously dropped in comparison.

As seen, production costs have a direct effect on price bids. Nevertheless, this direct effect is also influenced by yet another characteristic, size, which is related to barriers to entry in this market. A larger electricity generating company might not have as many struggles as a relatively smaller or newer company might have when dealing with these increments in production costs. While larger firms might experience advantages when accessing auctions, newer or smaller firms might have bigger barriers to entry. For example, larger firms are considered to have profiles with less financial risk, so they face lower interest rates, making entry easier.

Firm size also affects another component which is part of auctions. This is diversification. Firms which are larger and can benefit from economies of scale, or have greater market power than smaller firms, have the possibility to diversify into different sources of renewable energy production. This is yet another benefit that can be of use when participating in the auctions. Given that small firms which are not specialised in more than one source of energy might not be able to participate in auctions which are technology-specific (and the technology auctioned off is not produced by them).

Production costs and how large the participating bidder’s firm is, definitely affects the price bid that will be placed by each bidder. It has been observed that there are various factors which have influenced the change in price bids in the two years analysed in this study. The dropping number of winning bidders in these auctions is closely linked to these changes as well.

Nevertheless, these changes in price bids, or increase in production costs, do not really explain the more than 30% increment which was commented on in section 5.3.

7.2 EXTERNAL MARKETS AND INFLUENCES

Something which is an alternative explanation to the changes in price bids between the years 2021 and 2022, as well as explaining in general how bidders actually choose their bids, is the existence of external markets.

There are two possible alternatives that bidders which are debating whether to go to auction or not could choose instead. If external markets have more attractive market prices, then bidders will choose to sell their electricity in these instead of going to Government auctions where the revenue they could obtain for the projects is less than what the markets will offer them.

There are two existing markets available for bidders. They could decide to sell in their local market or they could decide to venture into international markets. It is a possibility that an external international market can have higher average prices, more preferable conditions for investors (e.g. tax credits), or simply better overall market conditions. The latter could refer to certain requirements needed to enter the market, qualifications in order to carry out the projects, etc. As it has been mentioned previously, the barriers to entry are affected by the size of the firm. Certain firms (smaller/newer) might not have the capacity to delve into this option and will be limited to their geographic location. Larger or older firms have the advantage of notoriety which eases their way into international expansion.

Nevertheless, all firms can choose to go to the renewable auction, or to obtain their revenue from the wholesale electricity market. This is their standard alternative. This choice/concept is their cost of opportunity. Bidders can either participate in renewable energy auctions and obtain a certain price for their electricity, one affected by the auction's rules, or they can go to the wholesale market (pool) where there is a price for electricity subject to volatility.

The wholesale electricity market in Spain (or pool) is based on marginal pricing. The price for electricity generating firms is set by the last type/unit of electricity that is sold to cover the electricity demand. Therefore, the highest paid (most expensive) technologies set the price for electricity, while lower cost technologies such as renewable ones are the first / left at the bottom. The more expensive energy sources are usually gas based energies (combined cycle power plants) or hydraulic energy. The benefit for renewable sources is that the high prices which are set can incentivise investment in these lower-cost sources (Pinheiro de Matos & Murillo Gili, 2022).

In 2022, coal and gas based energy costs (gas is one of the energy sources which sets the marginal price) have increased. Gas-fired power increased up to 81 $/MWh in 2022 (Henze, 2022).

Pool market prices have a certain external influence on the average bid prices which are chosen by bidders in renewable auctions. As mentioned beforehand, bidders have the cost of opportunity of not going to the wholesale market when they decide to participate in auctions. Therefore, if the expectations for pool market prices are greater, as it happened when the pool prices went up in 2022, this will affect bidders' optimal strategy at the auction. Since they could sell electricity at a higher price in the market, when they participate in the auctions, bid choices will definitely cover the price that they could have obtained in the market, which would make for a logical reason to increase the bid prices chosen in Spain for both on-shore wind and photovoltaic energy in 2022.

It should be noted that the price that bidders get in auctions is assured, there is no risk of not getting that price, but the price that they could obtain in the wholesale market is quite volatile. For example, as considered before, when the bidder is risk averse, they would rather obtain a lower guaranteed price (going to auction) than risk going to the wholesale market.

Finally, another aspect which was mentioned in the last section is the number of participants in the auction, which dropped in the Spanish auctions of 2022. One of the reasons for this could be the external influences which come from economic uncertainty. The uncertainty perceived in both the wholesale market and the renewable auction regulatory processes makes investment riskier and therefore there will be less willing investors which would participate (Monforte, 2022).

Another reason could be the influence which setting a maximum price has. In the auction which took place in Spain on the 22nd of November of 2022, the Government set a maximum price of 45 €/MWh. This was in place given that anything above that price would be unfavourable for consumers. Due to high production costs and this making investment "shakier/riskier", most firms opted for bids above that maximum price (Monforte, 2022), decreasing the number of auction participants which were awarded subsidies.

There is a link between the existence of external markets and external influences and the bids that bidders choose when going to auction. This could be one of the alternative explanations to why average bid prices increased from the year 2021 to the year 2022. As well as explaining the diminished number of winning participants in the auction.

8. CONCLUSION

As it has been seen in the study, auctions are the incentive system that is currently in use to promote renewable energy sources in Spain. However, this has not always been the case, over the years other incentive systems have been used, and on an international scale there are still some alternative incentive systems which other countries have in place.

One of the most popular incentive systems used worldwide are feed-in tariffs and feed-in premiums. These guarantee a fixed/variable (depending on the case) profit which spans the time period of the project construction. Each option has their advantages and disadvantages and the decision on which should be used should be adapted to the necessities or particularities of the situation, taking into account their strengths and weaknesses.

Another incentive system used in the past quite prominently was the rate of return regulation. The incentive is based on setting the price of electricity (by the regulator) depending on the costs of producing it. This has received quite a lot of criticism in its late years of use, like its high costs, and for that it has been replaced by other incentive systems such as the price cap approach.

The third incentive system analysed are tradable green certificates. This system is based on rewarding those producers which use renewable energy sources with a certificate they can trade. Of course, most of the time, the certificates are paired with a quota system in order for consumers and producers to generate/consume a certain amount of electricity which is generated by renewable sources. If the quota is not reached, penalties are issued. One of the disadvantages of this system is that setting the certificate's price is quite difficult. Nevertheless, once it's set, certificates act as a price signal for the renewable technology used in the market.

Reaching the focus of the study, it can be seen that renewable energy auctions set the price and quantity of electricity generation for firms. The auction is based on electricity generators (bidders) which offer bids dependent on the costs of their firm. The revenue they should obtain from bids must be sufficient to cover all production costs. Therefore, the firm with lowest production costs (lowest bid) would be the winner (there can be multiple winners). Auctions are seen to be intricate incentive systems which depend mostly on their designs and objectives. Their efficiency also depends on their design, and therefore to reach certain objectives, many different design elements can be combined in one auction. One of the key points of this is that the design elements used in each auction must be in accordance with each other in order for the auction to be efficient. Only efficient auctions can really uncover the real expected production costs of firms by encouraging competition. Some of these design elements narrow down to the use of price caps or floors, the use of prequalification criteria, the design choices whether these are system specific, volume specific, price specific, model specific, technology specific or project specific.

Like all other incentive systems, auctions have disadvantages and advantages. Some of their strengths can be summarised by their flexibility, the ability to discover real prices, the guarantee of prices and quantities set and their transparency and commitment. However, auctions are considered to be costly for bidders as well as auctioneers. Another weakness that is encountered is that auctions can lead to the “winner’s curse”.

The design elements for the Spanish case have varied over the years. In the past type of auctions, the design was based on a few Government objectives such as effectiveness of projects and cost minimization. This led to auctions with a few particularities such as having bidders obtain the market price plus a complementary remuneration. However, there have been new design elements installed for the period of auctions to be completed in the years 2021 to 2030. These design elements have also been thought to accomplish new Government objectives. The main design elements refer to the following areas: volume, frequency of auctions and schedules, lead times, technological diversity, geographical diversity, actor and size diversity, prequalifications, seller concentration rules, remuneration type and form, selection criteria, auction format and type, pricing rules, ceiling and minimum prices, realisation periods, and finally, penalties.

Taking the auction design into account, we have seen that the results for the auctions taken place in 2021 and 2022 differ somewhat. In 2021, both auctions done in that year awarded subsidies to on-shore wind and photovoltaic energy. However, in the auctions from 2022, photovoltaic, biomass and on-shore wind energy projects were awarded. The main takeaways from these four auction results were based on the greatest differences between auctions from 2021 and 2022. These were the increment in price bids for photovoltaic and on-shore wind energy and secondly, the decreasing number of winning bidders in auctions from 2022 in comparison to those of 2021.

Finally the exploration of these results, focusing on the explanation behind the two main changes in the results from the year 2021 to 2022, is seen through in three points. These are auction theory, production costs and size and external markets and influences. All of the stated below can explain the increase in price bids from 2021 to 2022.

Auction theory reveals that bidders will never bid below or equal to their production costs, and therefore this increases the price bids made in auctions. The bid price will depend on the bidder’s risk perspective and their preference between the surplus obtained or the probability to win.

Production costs and size are other aspects which directly influence the price bids set by bidders. Production costs increased in the year 2022, this was clearly seen by the LCOE estimate which was studied. These increments in cost were due to supply chain bottlenecks, inflating commodity/material prices, labour costs, freight costs and interest rates. This increase in costs leads to an increase in the price bids (in order to be able to cover the increment in cost).

However, firm size also affects the price bids. The way it is affected is by the barriers to entry. This can be a factor in two different ways. The first is through the barriers to entry experienced by smaller firms when accessing the financial market. The second is through the barriers to entry which appear when smaller firms are not able to diversify so easily as larger firms, which can isolate them in auctions which are technology specific.

Finally, bid prices are also affected by external markets and influences. The existence of the wholesale market influences the price bids made by bidders in auctions. This is due to the cost of opportunity. In the case of 2022, the wholesale market price expectations were higher, and therefore, bidders would have been able to obtain greater revenue going there. So, when choosing their price bids, this external influence is shown by the increment in price bids.

Finally, another external influence which could explain the lower number of winning bidders in 2022's auction could be due to two factors. One was regulatory uncertainty, which scares investment away. The second was maximum price levels set by the Government in the auction. Most bidders bid a price above these, and therefore there were less winning agents (4 bidders).

Closely related to this, one of the limits of this investigation is not going further and analysing how much the LCOE estimate really changed between 2021 and 2022 for Spain. This would allow for a clearer vision in the analysis. A deeper analysis would have also included other incentive systems alternative to auctions to have greater understanding of incentive systems and how use of them might have changed over the years on an international scale.

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10. APPENDIX

Table A.10. Results for the auction done on the 26th of January, 2021

Name of bidder	Technology	Bid price awarded (euros/ MWh)	Power awarded (kW)	Accumulated power awarded (kW)
IGNIS DESARROLLO, S.L.	Photovoltaic	14,89	30.000,00	30.000,00
IGNIS DESARROLLO, S.L.	Photovoltaic	18,73	45.000,00	75.000,00
EDP RENOVABLES ESPAÑA, S.L.U.	Photovoltaic	18,99	31.900,00	106.900,00
DESARROLLOS RENOVABLES EOLICOS Y SOLARES, S.L.	Photovoltaic	19,44	17.000,00	123.900,00
X-ELIO ENERGY, S.L.	Photovoltaic	19,80	33.300,00	157.200,00
X-ELIO ENERGY, S.L.	Photovoltaic	19,80	75.000,00	232.200,00
ENERFÍN SOCIEDAD DE ENERGÍA, S.L.U.	On-shore wind	20,00	10.000,00	242.200,00
ENERFÍN SOCIEDAD DE ENERGÍA, S.L.U.	On-shore wind	20,00	10.000,00	252.200,00
EDP RENOVABLES ESPAÑA, S.L.U.	Photovoltaic	20,55	19.600,00	271.800,00
IGNIS DESARROLLO, S.L.	Photovoltaic	20,91	20.000,00	291.800,00
X-ELIO ENERGY, S.L.	Photovoltaic	22,40	42.250,00	334.050,00
IBERENOVA PROMOCIONES, S.A.	Photovoltaic	22,87	39.000,00	373.050,00
IBERENOVA PROMOCIONES, S.A.	Photovoltaic	22,87	40.000,00	413.050,00
IBERENOVA PROMOCIONES, S.A.	Photovoltaic	22,87	24.000,00	437.050,00
ELAWAN ENERGY, S.L.	On-shore wind	22,88	35.000,00	472.050,00
GARNACHA SOLAR, S.L.	Photovoltaic	23,11	40.000,00	512.050,00
NATURGY RENOVABLES S.L.U	Photovoltaic	23,45	125.010,00	637.060,00
ENGIE ESPAÑA, S.L.U.	Photovoltaic	23,49	46.200,00	683.260,00
IGNIS DESARROLLO, S.L.	Photovoltaic	23,49	30.000,00	713.260,00
AKUO RENOVABLES, S.L.	Photovoltaic	23,50	50.800,00	764.060,00
GARNACHA SOLAR, S.L.	Photovoltaic	23,86	40.000,00	804.060,00
CAPITAL ENERGY, S.L.U.	On-shore wind	23,86	180.000,00	984.060,00
IBERENOVA PROMOCIONES, S.A.	Photovoltaic	23,87	41.000,00	1.025.060,00
IBERENOVA PROMOCIONES, S.A.	Photovoltaic	23,87	41.000,00	1.066.060,00
IBERENOVA PROMOCIONES, S.A.	Photovoltaic	23,87	35.000,00	1.101.060,00
EDP RENOVABLES ESPAÑA, S.L.U.	Photovoltaic	23,90	10.300,00	1.111.360,00
EDP RENOVABLES ESPAÑA, S.L.U.	Photovoltaic	23,90	10.800,00	1.122.160,00
GARNACHA SOLAR, S.L.	Photovoltaic	23,94	70.000,00	1.192.160,00
CAPITAL ENERGY, S.L.U.	On-shore wind	23,95	25.000,00	1.217.160,00
LIGHTSOURCE RENEWABLE ENERGY SP. DEVELOP. S.L.	Photovoltaic	23,97	5.044,00	1.222.204,00
ELAWAN ENERGY, S.L.	Photovoltaic	23,98	35.000,00	1.257.204,00
CAPITAL ENERGY, S.L.U.	On-shore wind	24,04	20.000,00	1.277.204,00
CAPITAL ENERGY, S.L.U.	On-shore wind	24,13	20.000,00	1.297.204,00
CAPITAL ENERGY, S.L.U.	On-shore wind	24,22	20.000,00	1.317.204,00
CAPITAL ENERGY, S.L.U.	On-shore wind	24,31	20.000,00	1.337.204,00

X-ELIO ENERGY, S.L.	Photovoltaic	24,38	40.000,00	1.377.204,00
X-ELIO ENERGY, S.L.	Photovoltaic	24,38	40.000,00	1.417.204,00
X-ELIO ENERGY, S.L.	Photovoltaic	24,38	40.000,00	1.457.204,00
CAPITAL ENERGY, S.L.U.	On-shore wind	24,41	20.000,00	1.477.204,00
ENGIE ESPAÑA, S.L.U.	Photovoltaic	24,49	8.530,00	1.485.734,00
CAPITAL ENERGY, S.L.U.	On-shore wind	24,50	20.000,00	1.505.734,00
CAPITAL ENERGY, S.L.U.	On-shore wind	24,59	20.000,00	1.525.734,00
CAPITAL ENERGY, S.L.U.	On-shore wind	24,68	20.000,00	1.545.734,00
CAPITAL ENERGY, S.L.U.	On-shore wind	24,77	20.000,00	1.565.734,00
FALCK RENEWABLES POWER 2, S.L.U.	Photovoltaic	24,79	20.000,00	1.585.734,00
FALCK RENEWABLES POWER 3, S.L.U.	Photovoltaic	24,79	20.000,00	1.605.734,00
CAPITAL ENERGY, S.L.U.	On-shore wind	24,86	20.000,00	1.625.734,00
NATURGY RENOVABLES S.L.U	Photovoltaic	24,88	30.000,00	1.655.734,00
DOMINION ENERGY, S.L.U.	Photovoltaic	24,93	45.920,00	1.701.654,00
GREEN CAPITAL POWER, S.L.U.	On-shore wind	24,95	20.000,00	1.721.654,00
ELAWAN ENERGY, S.L.	Photovoltaic	24,98	35.000,00	1.756.654,00
ELAWAN ENERGY, S.L.	On-shore wind	24,98	35.000,00	1.791.654,00
ENERFÍN SOCIEDAD DE ENERGÍA, S.L.U.	On-shore wind	24,98	5.000,00	1.796.654,00
ENERFÍN SOCIEDAD DE ENERGÍA, S.L.U.	On-shore wind	24,98	5.000,00	1.801.654,00
ENERFÍN SOCIEDAD DE ENERGÍA, S.L.U.	On-shore wind	24,98	5.000,00	1.806.654,00
ENERFÍN SOCIEDAD DE ENERGÍA, S.L.U.	On-shore wind	24,98	5.000,00	1.811.654,00
EDP RENOVABLES ESPAÑA, S.L.U.	On-shore wind	24,99	45.000,00	1.856.654,00
ENERGY INVESTMENT AND CONSULTANCY, S.L.U.	Photovoltaic	25,00	10,00	1.856.664,00
PLANTA FOTOVOLTAICA PIRÁMIDES II, S.L.	Photovoltaic	25,00	1.000,00	1.857.664,00
GREEN CAPITAL POWER, S.L.U.	On-shore wind	25,04	20.000,00	1.877.664,00
GREEN CAPITAL POWER, S.L.U.	On-shore wind	25,13	20.000,00	1.897.664,00
CANADIAN SOLAR SPAIN, S.L.	Photovoltaic	25,20	14.000,00	1.911.664,00
GREEN CAPITAL POWER, S.L.U.	On-shore wind	25,22	20.000,00	1.931.664,00
GREEN CAPITAL POWER, S.L.U.	On-shore wind	25,31	20.000,00	1.951.664,00
GREEN CAPITAL POWER, S.L.U.	On-shore wind	25,41	20.000,00	1.971.664,00
GREEN CAPITAL POWER, S.L.U.	On-shore wind	25,50	20.000,00	1.991.664,00
GREEN CAPITAL POWER, S.L.U.	On-shore wind	25,59	20.000,00	2.011.664,00
NATURGY RENOVABLES S.L.U	Photovoltaic	25,68	41.670,00	2.053.334,00
GREEN CAPITAL POWER, S.L.U.	On-shore wind	25,68	20.000,00	2.073.334,00
GREEN CAPITAL POWER, S.L.U.	On-shore wind	25,77	20.000,00	2.093.334,00
GREEN CAPITAL POWER, S.L.U.	On-shore wind	25,86	16.660,00	2.109.994,00
IBERENOVA PROMOCIONES, S.A.	Photovoltaic	25,87	23.000,00	2.132.994,00
ENGIE ESPAÑA, S.L.U.	Photovoltaic	25,89	30.360,00	2.163.354,00
PARQUE EOLICO ESCEPAR	Photovoltaic	25,94	28.800,00	2.192.154,00
PARQUE EOLICO PERALEJO	Photovoltaic	25,94	20.800,00	2.212.954,00
ELAWAN ENERGY, S.L.	Photovoltaic	25,98	35.000,00	2.247.954,00
ENERGY INVESTMENT AND CONSULTANCY, S.L.U.	Photovoltaic	26,00	10,00	2.247.964,00
EURUS DESAROLLOS RENOVABLES, S.L.U.	On-shore wind	26,50	10.000,00	2.257.964,00
EURUS DESAROLLOS RENOVABLES, S.L.U.	On-shore wind	26,51	4.000,00	2.261.964,00

GREEN CAPITAL POWER, S.L.U.	*On-shore wind*	*26,56*	*1,00*	*2.261.965,00*
HANWHA ENERGY CORPORATION EUROPE, S.L.U.	*Photovoltaic*	*26,77*	*39.000,00*	*2.300.965,00*
ALTER ENERSUN, S.A.	*Photovoltaic*	*26,90*	*3.220,00*	*2.304.185,00*
ALTER ENERSUN, S.A.	*Photovoltaic*	*26,90*	*5.000,00*	*2.309.185,00*
ELAWAN ENERGY, S.L.	*Photovoltaic*	*26,98*	*35.000,00*	*2.344.185,00*
RIOS RENOVABLES, S.L.U.	*Photovoltaic*	*26,99*	*5,00*	*2.344.190,00*
ENERGY INVESTMENT AND CONSULTANCY, S.L.U.	*Photovoltaic*	*27,00*	*10,00*	*2.344.200,00*
NRG PARK 2017 II, S.L.	*Photovoltaic*	*27,00*	*10.000,00*	*2.354.200,00*
EDP RENOVABLES ESPAÑA, S.L.U.	*Photovoltaic*	*27,01*	*25.800,00*	*2.380.000,00*
GREEN CAPITAL POWER, S.L.U.	*On-shore wind*	*27,26*	*1,00*	*2.380.001,00*
SOLAR BOLARQUE, S.L.	*Photovoltaic*	*27,29*	*40.000,00*	*2.420.001,00*
RIOS RENOVABLES, S.L.U.	*Photovoltaic*	*27,49*	*5,00*	*2.420.006,00*
AKUO RENOVABLES, S.L.	*Photovoltaic*	*27,50*	*30.400,00*	*2.450.406,00*
X-ELIO ENERGY, S.L.	*Photovoltaic*	*27,80*	*44.500,00*	*2.494.906,00*
HANWHA ENERGY CORPORATION EUROPE, S.L.U.	*Photovoltaic*	*27,89*	*47.000,00*	*2.541.906,00*
SOLARIA PROMOCIÓN Y DESARROLLO FOTOVOLTAICO, S.L.U.	*Photovoltaic*	*27,91*	*100.000,00*	*2.641.906,00*
GREEN CAPITAL POWER, S.L.U.	*On-shore wind*	*27,96*	*1,00*	*2.641.907,00*
ELAWAN ENERGY, S.L.	*Photovoltaic*	*27,98*	*35.000,00*	*2.676.907,00*
ELAWAN ENERGY, S.L.	*On-shore wind*	*27,98*	*35.000,00*	*2.711.907,00*
RIOS RENOVABLES, S.L.U.	*Photovoltaic*	*27,99*	*5,00*	*2.711.912,00*
SOLARIA PROMOCIÓN Y DESARROLLO FOTOVOLTAICO, S.L.U.	*Photovoltaic*	*28,05*	*80.000,00*	*2.791.912,00*
RIOS RENOVABLES, S.L.U.	*Photovoltaic*	*28,24*	*5,00*	*2.791.917,00*
RIOS RENOVABLES, S.L.U.	*Photovoltaic*	*28,49*	*5,00*	*2.791.922,00*
GREENALIA WIND POWER, S.L.U.	*On-shore wind*	*28,49*	*109.300,00*	*2.901.222,00*
NATURGY RENOVABLES, S.L.U	*On-shore wind*	*28,63*	*37.950,00*	*2.939.172,00*
GREEN CAPITAL POWER, S.L.U.	*On-shore wind*	*28,66*	*1,00*	*2.939.173,00*
Q-ENERGY TOROZOS, S.L.	*Photovoltaic*	*28,70*	*20.000,00*	*2.959.173,00*
RIOS RENOVABLES, S.L.U.	*Photovoltaic*	*28,74*	*5,00*	*2.959.178,00*
GREENALIA WIND POWER, S.L.U.	*On-shore wind*	*28,89*	*25.000,00*	*2.984.178,00*
ENEL GREEN POWER ESPAÑA, S.L.	*Photovoltaic*	*28,90*	*50.000,00*	*3.034.178,00*
Total				***3.034.178,00***

Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, Disposición 1251 del BOE núm. 24 de 2021) and own elaboration.

Table B.10. Results for the auction done on the 19th of October, 2021

Name of bidder	***Technology***	***Bid price awarded (euros/MWh)***	***Power awarded (kW)***	***Accumulated power awarded (kW)***
TREBOL DESARROLLOS FOTOVOLTAICOS ESPAÑA, S.L.	*Photovoltaic*	*24,40*	*1.500,00*	*1.500,00*
REPSOL RENOVABLES S.L.U.	*On-shore wind*	*27,90*	*49.000,00*	*50.500,00*
GREEN CAPITAL DEVELOPMENT XXI, S.L.U.	*On-shore wind*	*27,97*	*100.000,00*	*150.500,00*
LA RASA ENERGY, S.L.U.	*On-shore wind*	*27,97*	*100.000,00*	*250.500,00*
LA RASA ENERGY, S.L.U.	*On-shore wind*	*27,97*	*100.000,00*	*350.500,00*
NEARCO RENOVABLES.	*Photovoltaic*	*28,01*	*10.775,00*	*361.275,00*
NEARCO RENOVABLES.	*Photovoltaic*	*28,14*	*10.775,00*	*372.050,00*
GREEN CAPITAL DEVELOPMENT 66, S.L.U.	*On-shore wind*	*28,23*	*60.000,00*	*432.050,00*
GREEN CAPITAL DEVELOPMENT 66, S.L.U.	*On-shore wind*	*28,23*	*90.000,00*	*522.050,00*
GREEN CAPITAL DEVELOPMENT XXXV, S.L.U.	*On-shore wind*	*28,23*	*90.000,00*	*612.050,00*
GREEN CAPITAL DEVELOPMENT XXXV, S.L.U.	*On-shore wind*	*28,23*	*60.000,00*	*672.050,00*
NEARCO RENOVABLES.	*Photovoltaic*	*28,27*	*10.775,00*	*682.825,00*
NEARCO RENOVABLES.	*Photovoltaic*	*28,40*	*10.775,00*	*693.600,00*
GREEN CAPITAL DEVELOPMENT 81, S.L.U.	*On-shore wind*	*28,46*	*60.000,00*	*753.600,00*
GREEN CAPITAL DEVELOPMENT 81, S.L.U.	*On-shore wind*	*28,46*	*90.000,00*	*843.600,00*
GREEN CAPITAL DEVELOPMENT XXI, S.L.U.	*On-shore wind*	*28,46*	*50.000,00*	*893.600,00*
NEARCO RENOVABLES.	*Photovoltaic*	*28,53*	*10.775,00*	*904.375,00*
GREEN CAPITAL DEVELOPMENT 97, S.L.U.	*On-shore wind*	*28,63*	*90.000,00*	*994.375,00*
NEARCO RENOVABLES.	*Photovoltaic*	*28,66*	*10.775,00*	*1.005.150,00*
GREEN CAPITAL DEVELOPMENT 103, S.L.U.	*On-shore wind*	*28,73*	*90.000,00*	*1.095.150,00*
NEARCO RENOVABLES.	*Photovoltaic*	*28,79*	*10.775,00*	*1.105.925,00*
GREEN CAPITAL DEVELOPMENT 119, S.L.U.	*On-shore wind*	*28,83*	*90.000,00*	*1.195.925,00*
NEARCO RENOVABLES.	*Photovoltaic*	*28,92*	*10.775,00*	*1.206.700,00*
GREEN CAPITAL DEVELOPMENT 141, S.L.U.	*On-shore wind*	*28,93*	*90.000,00*	*1.296.700,00*
GREEN CAPITAL DEVELOPMENT 142, S.L.U.	*On-shore wind*	*28,97*	*90.000,00*	*1.386.700,00*
NEARCO RENOVABLES.	*Photovoltaic*	*29,05*	*10.775,00*	*1.397.475,00*
GREEN CAPITAL DEVELOPMENT 160, S.L.U.	*On-shore wind*	*29,07*	*90.000,00*	*1.487.475,00*
GREEN CAPITAL DEVELOPMENT 97, S.L.U.	*On-shore wind*	*29,17*	*60.000,00*	*1.547.475,00*
NEARCO RENOVABLES.	*Photovoltaic*	*29,18*	*10.775,00*	*1.558.250,00*
GREEN CAPITAL DEVELOPMENT 103, S.L.U.	*On-shore wind*	*29,27*	*60.000,00*	*1.618.250,00*
NEARCO RENOVABLES.	*Photovoltaic*	*29,31*	*10.775,00*	*1.629.025,00*
GREEN CAPITAL DEVELOPMENT 119, S.L.U.	*On-shore wind*	*29,43*	*60.000,00*	*1.689.025,00*
NEARCO RENOVABLES.	*Photovoltaic*	*29,44*	*10.775,00*	*1.699.800,00*
GREEN CAPITAL DEVELOPMENT 141, S.L.U.	*On-shore wind*	*29,53*	*10.000,00*	*1.709.800,00*
NEARCO RENOVABLES.	*Photovoltaic*	*29,57*	*10.775,00*	*1.720.575,00*
GREEN CAPITAL DEVELOPMENT 142, S.L.U.	*On-shore wind*	*29,63*	*10.000,00*	*1.730.575,00*
ABEI ENERGY & INFRASTRUCTURE S.L.	*Photovoltaic*	*29,67*	*23.400,00*	*1.753.975,00*

NEARCO RENOVABLES.	Photovoltaic	29,70	10.775,00	1.764.750,00
NATURGY RENOVABLES S.L.U.	Photovoltaic	29,75	38.100,00	1.802.850,00
NEARCO RENOVABLES.	Photovoltaic	29,83	10.775,00	1.813.625,00
NEARCO RENOVABLES.	Photovoltaic	29,96	10.775,00	1.824.400,00
NEARCO RENOVABLES.	Photovoltaic	30,09	10.775,00	1.835.175,00
BRUC ENERGY, S.L.	Photovoltaic	30,37	30.000,00	1.865.175,00
BRUC ENERGY, S.L.	Photovoltaic	30,38	35.000,00	1.900.175,00
BRUC ENERGY, S.L.	Photovoltaic	30,39	35.000,00	1.935.175,00
REPSOL RENOVABLES S.L.U.	On-shore wind	30,87	49.000,00	1.984.175,00
BAYWA R.E. PROJECTS ESPAÑA, S.L.U.	Photovoltaic	31,00	13.950,00	1.998.125,00
NEARCO RENOVABLES.	Photovoltaic	31,22	10.775,00	2.008.900,00
IGNIS DESARROLLO S.L.	Photovoltaic	31,83	27.500,00	2.036.400,00
ENGIE ESPAÑA, S.L.U.	Photovoltaic	32,00	22.300,00	2.058.700,00
NEARCO RENOVABLES.	On-shore wind	32,06	34.200,00	2.092.900,00
NEARCO RENOVABLES.	On-shore wind	32,28	34.200,00	2.127.100,00
NEARCO RENOVABLES.	Photovoltaic	32,35	10.775,00	2.137.875,00
NATURGY RENOVABLES S.L.U.	Photovoltaic	32,44	140.000,00	2.277.875,00
NEARCO RENOVABLES.	On-shore wind	32,50	34.200,00	2.312.075,00
IGNIS DESARROLLO S.L.	Photovoltaic	32,70	29.110,00	2.341.185,00
NEARCO RENOVABLES.	On-shore wind	32,72	24.200,00	2.365.385,00
IGNIS DESARROLLO S.L.	Photovoltaic	32,87	59.500,00	2.424.885,00
NEARCO RENOVABLES.	On-shore wind	32,94	24.200,00	2.449.085,00
EDP RENOVABLES ESPAÑA, SLU.	Photovoltaic	32,99	20.910,00	2.469.995,00
EDP RENOVABLES ESPAÑA, SLU.	Photovoltaic	32,99	38.950,00	2.508.945,00
NEARCO RENOVABLES.	On-shore wind	33,16	24.200,00	2.533.145,00
NEARCO RENOVABLES.	On-shore wind	33,38	24.200,00	2.557.345,00
NEARCO RENOVABLES.	Photovoltaic	33,48	10.775,00	2.568.120,00
NEARCO RENOVABLES.	On-shore wind	33,60	24.200,00	2.592.320,00
NEARCO RENOVABLES.	On-shore wind	33,82	24.200,00	2.616.520,00
GREEN CAPITAL DEVELOPMENT 160, S.L.U.	Photovoltaic	33,97	8.000,00	2.624.520,00
NEARCO RENOVABLES.	On-shore wind	34,04	24.200,00	2.648.720,00
NEARCO RENOVABLES.	On-shore wind	34,26	24.200,00	2.672.920,00
IGNIS DESARROLLO S.L.	Photovoltaic	34,35	28.000,00	2.700.920,00
REPSOL RENOVABLES S.L.U.	On-shore wind	34,43	40.000,00	2.740.920,00
NEARCO RENOVABLES.	On-shore wind	34,48	24.200,00	2.765.120,00
TOTAL ENERGIES RENEWABLES IBERICA S.L.U.	Photovoltaic	34,50	35.000,00	2.800.120,00
ENERLAND GENERACION SOLAR 18 SL.	Photovoltaic	34,64	750,00	2.800.870,00
NEARCO RENOVABLES.	On-shore wind	34,70	24.200,00	2.825.070,00
FOTO-GENERACION TALIA, S.L.U.	Photovoltaic	34,88	10.500,00	2.835.570,00
TREBOL DESARROLLOS FOTOVOLTAICOS ESPAÑA, S.L.	Photovoltaic	34,89	4.500,00	2.840.070,00
NATURGY RENOVABLES S.L.U.	Photovoltaic	34,90	43.300,00	2.883.370,00
NEARCO RENOVABLES.	On-shore wind	34,92	24.200,00	2.907.570,00
NEARCO RENOVABLES.	On-shore wind	35,14	24.200,00	2.931.770,00
NEARCO RENOVABLES.	On-shore wind	35,36	24.200,00	2.955.970,00

NEARCO RENOVABLES.	*On-shore wind*	*35,58*	*24.200,00*	*2.980.170,00*
ENERLAND GENERACION SOLAR 18 SL.	*Photovoltaic*	*35,64*	*875,00*	*2.981.045,00*
NEARCO RENOVABLES.	*On-shore wind*	*35,80*	*24.200,00*	*3.005.245,00*
AV PAXAREIRAS, S.L.U.	*On-shore wind*	*36,00*	*17.600,00*	*3.022.845,00*
NEARCO RENOVABLES.	*On-shore wind*	*36,02*	*24.200,00*	*3.047.045,00*
NEARCO RENOVABLES.	*On-shore wind*	*36,24*	*24.200,00*	*3.071.245,00*
NEARCO RENOVABLES.	*On-shore wind*	*36,46*	*24.200,00*	*3.095.445,00*
ENERLAND GENERACION SOLAR 18 SL.	*Photovoltaic*	*36,54*	*875,00*	*3.096.320,00*
NEARCO RENOVABLES.	*On-shore wind*	*36,68*	*24.200,00*	*3.120.520,00*
BLACKSALT ASSET MANAGEMENT SLU.	*Photovoltaic*	*36,88*	*3.250,00*	*3.123.770,00*
Total				***3.123.770,00***

Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, Disposición 17335 del BOE núm. 255 de 2021) and own elaboration.

Table C.10. Results for the auction done on the 25th of October, 2022

Name of bidder	**Technology**	**Bid price awarded (euros/MWh)**	**Power awarded (kW)**	**Accumulated power awarded (kW)**
ENERLAND GENERACION SOLAR 22, S.L. UNIPERSONAL	Photovoltaic	44,98	4.200,00	4.200,00
ENERLAND GENERACION SOLAR 4, S.L	Photovoltaic	47,98	2.900,00	7.100,00
BREZOS DE TORMANTOS, S.A.	Photovoltaic	52,00	3.000,00	10.100,00
POWERTIS, S.A.U.	Photovoltaic	54,00	5.000,00	15.100,00
LONDRES 1908 SOLAR S.L.	Photovoltaic	54,98	4.900,00	20.000,00
HIDRODELTA, S.A.	Photovoltaic	57,50	1.000,00	21.000,00
ERASP SPAIN, S.L.U.	Photovoltaic	57,82	5.000,00	26.000,00
BREZOS DE TORMANTOS, S.A.	Photovoltaic	58,00	1.500,00	27.500,00
ERASP SPAIN, S.L.U.	Photovoltaic	60,24	2.500,00	30.000,00
HIDRODELTA, S.A.	Photovoltaic	62,50	1.000,00	31.000,00
HULLERAS DEL NORTE, S.A.	Biomass	72,38	50.000,00	81.000,00
DESARROLLOS RENOVABLES EOLICOS Y SOLARES, S.L.U.	Biomass	101,69	49.900,00	130.900,00
DESARROLLOS RENOVABLES ABIES, S.L.	Biomass	106,18	38.100,00	169.000,00
DESARROLLOS RENOVABLES ABIES, S.L.	Biomass	106,19	6.000,00	175.000,00
DESARROLLOS RENOVABLES ABIES, S.L.	Biomass	107,19	1.000,00	176.000,00
DESARROLLOS RENOVABLES ABIES, S.L.	Biomass	108,19	1.000,00	177.000,00
Total				**177.000,00**

Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, Disposición 17796 del BOE núm. 261 de 2022) and own elaboration.

Table D.10. Results for the auction done on the 22nd of November, 2022

Name of bidder	Technology	Bid price awarded (euros/MWh)	Power awarded (kW)	Accumulated power awarded (kW)
ELAWAN ENERGY, S.L.	On-shore wind	39,88	20.000,00	20.000,00
NEARCO RENOVABLES.	On-shore wind	45,01	10.000,00	30.000,00
NEARCO RENOVABLES.	On-shore wind	45,06	10.000,00	40.000,00
NEARCO RENOVABLES.	On-shore wind	45,12	5.500,00	45.500,00
Total				**45.500,00**

Source: (Ministerio para la Transición Ecológica y el Reto Demográfico, Disposición 20540 del BOE núm. 291 de 2022) and own elaboration.