D2.1-PT, December 2019

Auctions for the support of renewable energy in Portugal

Main results and lessons learnt

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D2.1-PT, December 2019, Renewable Electricity Auctions in Portugal

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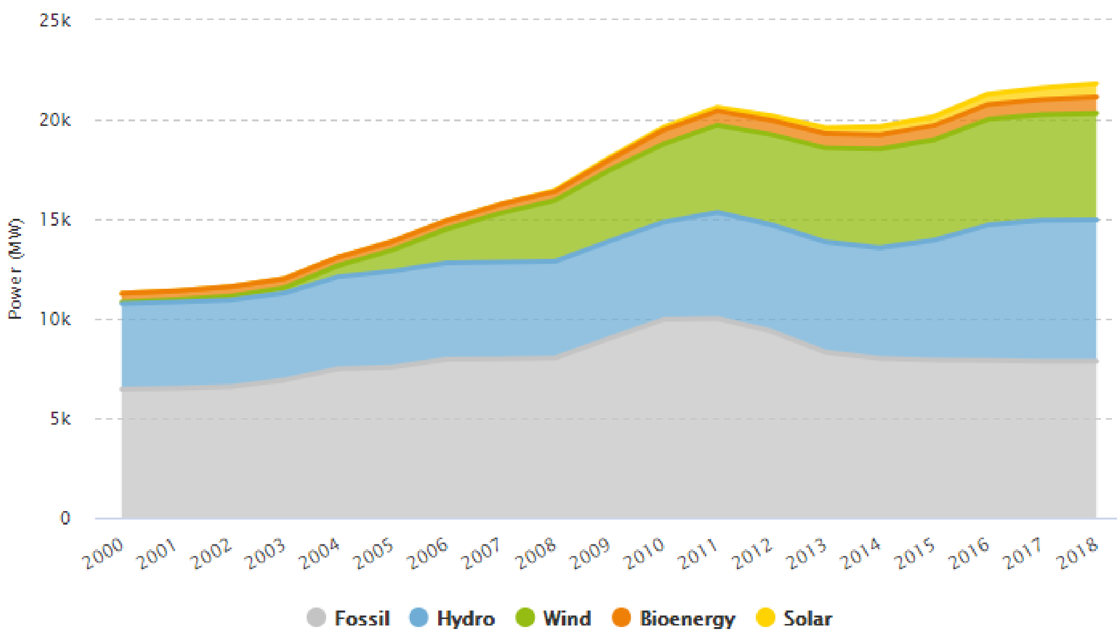
1 Characteristics of RES-E auctions in the country

1.1 Goals of the government with organizing auctions

Over the last to two decades Portugal's electricity sector has undergone significant expansion and structural reorganization. Portugal is not starting from zero but has relied on renewable generation for some time. Still, the country continues to further advance the development of a clean and sustainable electricity system.

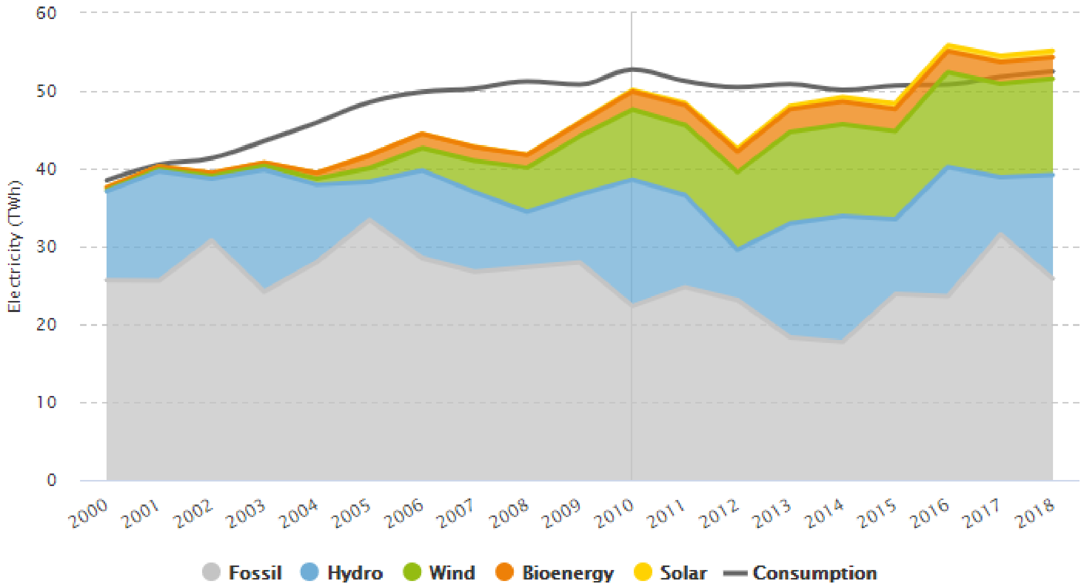
The near doubling of generation capacity since 2000 is attributable to growth in wind, bioenergy and solar starting in the mid-2000s, complementing existing hydro capacities. From Figure 1 it can be seen that fossil fuel-based capacities grew until 2011, when a paradigm shift took place and Portugal began phasing out some of these capacities. From 2005 until 2014, the share of fossil-based generation has been declining, and although utilization of fossil fuels grew again in the 2015-2017 period, data from 2018 shows that it had accounted for only 47,7% of the total generation (Figure 2). These fossil-based capacities comprise shares of approximately 40-40% natural gas and coal, 17% fossil cogeneration, with the rest being oil. (APREN, 2019a)

Figure 1. Evolution of installed capacities by sources in Portugal



Source: DGEG, APREN's analysis (APREN, 2019b)

Figure 2. Evolution of electricity generation in mainland Portugal



Source: APREN, REN (APREN, 2019c)

The deployment of RES-E projects has experienced considerable momentum over the last two decades, positioning Portugal as one of the leaders in the EU. Both RES-E installed capacity and generation have doubled between 2005 and 2016, following a 6-7% average annual growth rate (**Fehler! Verweisquelle konnte nicht gefunden werden.** 1). With additional capacity of 5124 MW, wind energy has experienced the biggest increase over the period (five-fold), before starting to plateau in the last few years. Solar has also been stagnant at much lower deployment levels. By 2016, 462 MW of installed solar capacity produced 822 GWh of electricity, representing only 3.5% of RES-E capacity and 3% of RES-E generation in that year.

Table 1.: Past evolution of RES, and particularly solar, in Portugal

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Share of RES in gross final energy consumption (%)	19.5	20.8	21.9	23.0	24.4	24.2	24.6	24.6	25.7	27.0	28.0	28.5
RES-E installed capacity (GW)	6.37	7.04	7.61	8.30	8.91	9.56	10.51	10.91	11.10	11.53	12.11	13.11
RES-E gross production (TWh)	14.38	15.54	17.29	18.45	20.11	22.61	24.79	25.19	25.90	27.29	27.88	28.90
PV installed capacity (MW)	2	3	24	59	115	134	172	238	296	415	447	462
Gross production PV (GWh)	3	5	24	41	160	211	280	393	479	627	796	822

Source: Government of Portugal (2019b)

Portugal aims to be carbon neutral by 2050, intending to reduce CO2 emissions (without LULUCF) by 17% by

2030, from 2005 levels. According to the Government of Portugal (2019b), the National Energy and Climate Plan 2030 (NECP) will be the main energy and climate policy instrument for the period 2021-2030. To meet the strategic vision and associated targets, eight objectives were established for the 2030 horizon in the draft NECP (Government of Portugal 2019b). One of those outlines a path of diversification through sustainable endogenous RES-E aiming for 47% of gross final energy consumption in 2030, up from 28.5% in 2016 and 31% in 2020 (the target for that year). The government aims to increase the RES share in electricity generation from 68% in 2020 to 80% in 2030 and to 100% by 2050.

The following activities are outlined in the draft NECP, and are meant to promote the production of electricity and heating and cooling from renewable energies:

- Promote the decarbonisation of the electricity production system, including the phase-out of coal-fired power plants by 2030.
- Accelerate the production of energy from renewable energy sources, with greater focus on solar.
- Promote the use of renewable systems for heating and cooling.
- Stimulate investment for the national production of advanced biofuels from waste and endogenous resources.
- Promote electrification in all sectors of the economy.
- Stimulate the acquisition and use of district heating from renewable energy sources.
- Implement mechanisms promoting and simplifying investments, and review of the electricity tariff model.
- Create a favourable regulatory environment for new market players, including local energy communities.
- Optimise, simplify and revise the legal and regulatory framework for licensing.
- Implement instruments for the sharing of costs associated with grid connection capacity reinforcement mechanisms.
- Foster investment in energy transition and introduce innovative mechanisms.
- Stimulate RDI in storage, low-carbon technologies, hydrogen and other 100% renewable fuels.
- Licensing times are set to be optimized with a one-stop-shop for installations contributing to decarbonisation, including renewable energy production units and respective storage.

The government of Portugal (2019b) states that, "with the goal to significantly increase the installed renewable energy capacity for the production of electricity in order to achieve the national targets and objectives, an auction scheme for RES-E production, with a focus on solar, will be implemented". On its website, the government justifies the choice of this instrument (government of Portugal 2019b): Given "the strong demand of production licenses, the scarce grid capacity, auctions are the best way to satisfy such demand, accelerating the realization of investments in new capacity, prioritizing the projects with the lowest costs and with greater guarantees of being deployed, allowing a better coordination between the process of issuing of production licenses and investments in new grid capacity".

The government articulates four advantages of a competitive and efficient auction scheme which:

1. provides visibility of prices and quantities in the long-term;
2. reduces risks for producers which, in turn, reduces the cost of capital and, thus, leads to lower prices;
3. allows for flexibility in the design of the grid connection capacity allocation mechanism;
4. and improves the efficiency in the allocation of costs, leading to a prioritization of the locations with a better cost-benefit rating.

The draft NECP also prioritizes solar energy given its low cost and abundance (Government of Portugal 2019a). Installed solar capacity should reach 1.9 GW in 2020 and 8.1 or 9.9 GW by 2030 (depending on the scenario).

1.2 Main pillars of the RES-E support policy in Portugal

The evolution of the Portuguese RES-E regulation and support schemes have a long history with several different regimes. As elaborated in the AURES I project, between 2006-2008 Portugal's renewable support scheme involving renewable auctions was one of the first in Europe (del Rio, 2016). This had been a multi-criteria auction for wind and biomass capacities, where bid prices formed a small fraction (20%) of the total score alongside factors such as job creation and local business development (del Rio, 2016).

For PV a guaranteed feed-in tariff system was in place until 2012, but because of the large renewable share the government eliminated this support scheme for renewable energy. Since then renewable electricity sources participated in the wholesale electricity market without any support. In 2015 a unique support regime was established, remunerating two types of power plants - very small capacities (UPP) and auto producers (UPAC) (RES Legal, 2019).

With the technological gains and abundance of solar irradiance, utility scale PV power plants were deployed in the absence of governmental support through private PPAs. Construction of the first subsidy-free installation started in 2018, a 28.8 MW PV plant in the Alentejo region, holding a 10-year PPA with Axpo Ibéria. However, for the operator it had been challenging to integrate the new installations into the grid. In response to the dearth of connection points, a new regulation was put forth in 2018 (Portaria n° 62/2018), according to which connection point assignment is to be based on a lottery. The grid operator REN also introduced an investment plan with a budget of 814 million EUR for the period 2017 to 2027, approved by the regulator in 2018 and to be reviewed every two years. While the plan's intentions were commendable, it only reckoned with a PV capacity expansion of 1.3 GW, which was less than the permits already issued in 2018 (Everoze.com, 2018). The lottery system was revised in 2019 (Decree Law, 2019/76) under a new renewable auction scheme approved by the European Commission.

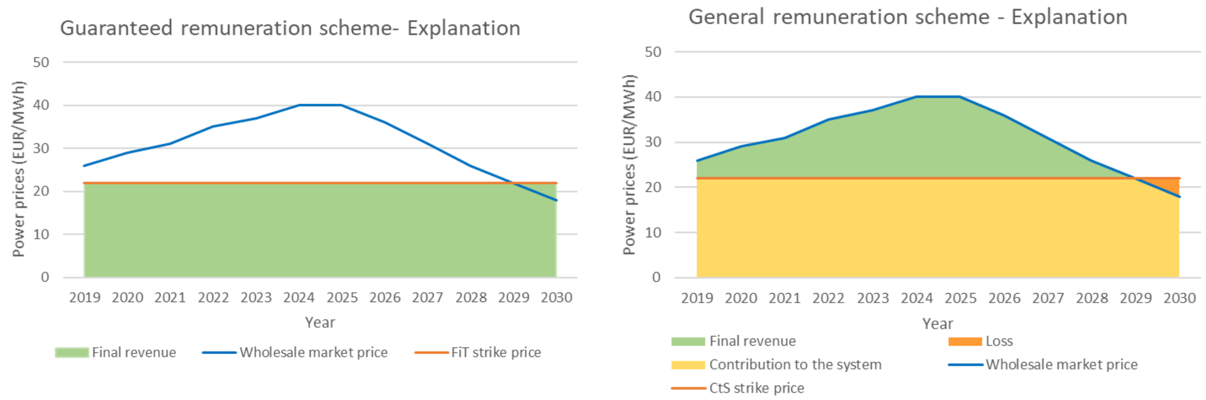
The European Commission also approved a support scheme for biomass plants in January 2019, aiming to reduce risks of forest fire stemming from the use of forest residues as fuel, which will incentivize forest owners to keep their areas clean. The supported installations will produce electricity and combined heat and power of up to 60 MW capacity in the mainland and 10 MW for single plants (Morais, 2019). The 15-year feed-in-premium has a budget of 320 million EUR. The scheme is supplemented with an environmental tariff premium (PDIF) to support biomass produced in critical forest areas (European Commission, 2019).

1.3 Design elements of RES-E auctions

The dynamic, zone specific auction, implemented exclusively for PV in July 2019, was the largest so far conducted in the country. The next solar tender (700MW) and a separate auction for energy storage are expected to take place in Q1 2020. The tender offers bidders the choice between a "guaranteed remuneration" or a "general remuneration". Under the guaranteed remuneration, participants bid for a discount (%) from a given tariff level (at around 45 EUR/MWh) to receive a two-sided sliding premium (CfD) for 15 years. Under the general remuneration, bidders receive the market remuneration for 15 years, but they offer payments to the electricity system operator.

The functioning of the two support schemes is summarized in Figure 3. 2 using illustrative values. In the guaranteed remuneration scheme (left hand side) the project developer receives a fixed price, i.e., a fixed revenue independent of the market price. In the general remuneration scheme (right hand side) the situation is much more complex. The producer pays a fixed contribution, so the net unitary benefit (revenue minus the contribution per MWh) is heavily dependent on the actual market price. If the market price is higher than the fixed contribution, then the net unitary benefit of the producer is the difference between the two prices (green). However, it is possible that the producer realizes a loss (even without the cost of production being considered) if the market price is lower than the contribution. In this sense the contribution scheme bears higher risks for the producers with the opportunity for greater gains.

Figure 3.: Revenues in the guaranteed and general remuneration schemes (illustrative example)



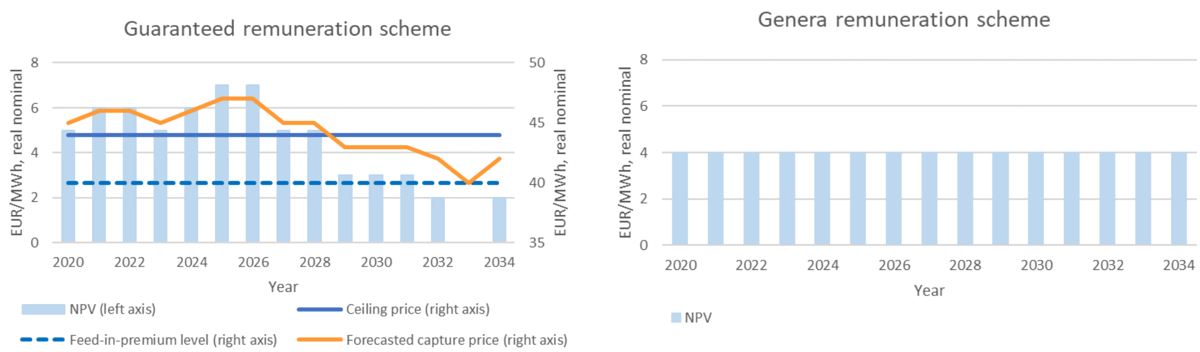
Source: Lainez (2019)

The two bidding frameworks coexisting in one auction framework makes the Portuguese auction unique. For every potential producer it is possible to make a bid in the general or in the guaranteed remuneration scheme, and bids placed in the two auction frameworks are competing with each other.

The two types of remuneration can be compared through the common unit of the Net Present Value (NPV). It should be noted that the NPV is calculated from the viewpoint of the government and not the producer, so the bid with the highest associated NPV wins the auction. In this sense throughout the auction the revenue of the government is maximized for the 15 years-long support period. The differing calculation methods are summarized in Figure Figure 4..

In the case of the general remuneration system the calculation of the NPV is straightforward (right hand side), the discounted sum of the contribution value (light blue bar) offered by the bidder for the support period of 15 years. The regulator uses a 3.6% discount factor. To the contrary, the calculation is much more complicated for the guaranteed remuneration scheme (left hand side). According to the auction rules a reference price is defined for each batch serving as a ceiling (dark blue line) and bidders enter the lowest percent of this reference price they are willing to accept, leading to a feed in premium level (blue dotted line).

Figure 4.: NPV calculation for the general and the guaranteed remuneration scheme (illustrative example)



Source: Silva (2019)

The Portuguese regulatory authority also makes a wholesale price forecast with a market model for the 15-year support period. This price forecast is adjusted with the Portuguese PV plant time profile, resulting in a forecasted capture price (orange line) that can be considered as a special price for PV. The NPV (light blue bars) is calculated as the discounted sum of differences between the forecasted capture price and the premium. The same discount factor is used in the general remuneration scheme, but the revenues are discounted with an additional risk factor, meaning that the auction design favours producers who choose the riskier general remuneration scheme.[1]

It important to highlight that the Portugal PV auction is a dynamic auction which incorporates several rounds of bids. The process is an "ascending clock" type of auction (increasing NPV) and the number of rounds is not fixed, but dependent on the bidding behaviour of the participants. In each round the participants place bids in one of the remuneration schemes which is translated into NPVs. If the volume offered by producers in each round is higher than the volume auctioned at the given lot, a new round of offers will follow with higher NPVs than the previous round. This process continues as long as the offered volume remains higher than the auctioned volume. If the offered volume is less or equal than the auctioned volume in any round, then the auction ends.

Within the 2019 auction round, 24 batches were defined, each belonging to one of five different geographical areas (Algarve, Alentejo, Lisboa e Vale do Tejo, Centro, Centro/Alentejo) with very high and similar solar irradiation levels. Volumes vary from 10 MW in several batches to 200 MW in Lot 18, totalling 1.4 GW[2].Batches feature at least one but often more injection points (for example 7 connecting substations in Batch 1 and 13 in Batch 10). The reserve prices differ according to the area. Table Table 2.summarises the main characteristics of the auction and Table Table 3.presents the general auction design.

Table 2.: Main characteristics of auctions and framework conditions

Characteristics	Description of the auction
Characteristics of the national electricity market	Portugal and Spain have integrated their electricity markets into a single Iberian Electricity Market, MIBEL, sharing a common spot market operator, OMIE, which has been operating in both countries since July 2007, and a forward market operator, OMIP, launched in July 2006 (IEA 2016, p.87).
Name of auction scheme	Procedimento concorrencial, sob a forma de leilão electrónico, para atribução de reserva de capacidade de injeção na rede elétrica de serviço público para energia solar fotovoltaica (Leilões solar PT)
Contractual counterparty (auctioneer? provider of support?)	The market operator OMIP organises the auction. The awarding institution is the Portuguese State, through the Directorate General for Energy and Geology (Direção-Geral de Energia e Geologia)
Main features (e.g. cross-border auction?/multinational auction?)	Dynamic auctions with Pay-as-bid (PAB). Bidders can opt for a "Guaranteed remuneration" or a „General remuneration" compared by NPV.
Technology focus and differentiation (eligible technologies)	Technology-specific auction (only PV can participate).
Lead time before auction	The auction procedure was published on June 6th, 2019. Application deadline: July 5th, 2019 Auction process: July 25-29th 2019 Publication of results: August 10th 2019

[1] For more details of the assumptions and methodology of the forecasting see Portuguese Government (2019c).
[2] However, only 1150 MW were awarded, since in lots 12 and 17 only 1 and 0 bidders participated, respectively, which was below the threshold required by the auctioneer to award any capacity.

Min./max. size of project	”There is a minimum bid volume requirement of 10 MW, for those intending to connect to the distribution network, or 50 MW, for those intending to dispatch to the transmission network” (Portuguese Government 2019a, p.4).
What is auctioned? Auctioned bids (in terms of budget, electricity or installed capacity)	Auctioned product: Grid access capacity in specific injection points. Auctioned bids are for installed capacity (MW). There are two types of remuneration: 1) GUARANTEED REMUNERATION. The price incorporated in the bid corresponds to a discount (expressed as a %) on the reference tariff level that is set by the government for each auctioned batch. 2) GENERAL REMUNERATION. The compensation value (expressed in EUR/MWh) will be paid to the National Electrical System (Portuguese Government 2019a, p.3).
Budgetary expenditures per auction and per year	Budgetary expenditures are undefined.
Frequency of auctions	Undefined, a 700 MW PV auction, and a separate auction for storage capacities will be held in 2020.
Volume of the tender	Capacity (1400 MW)
Costs related to grid connection/access	Grid connection costs fall on the awarded bidder.
Balancing and profile costs	Producers are responsible for the scheduling and payment of deviations and access tariffs. Successful bidders may provide ancillary services to system operator (Poyry 2019).

Table 3.: General auction design

Design elements	Description
Auction format	Zone-specific, multi-unit auction
Auction procedure	Price-only, dynamic auction. Pay-as-bid (PAB) “The auction is won by the participants that offer the best bid according the criterions that determine what is the most economically advantageous result for the contracting entity. This corresponds to the price that was offered by the participant converted into a net present value (NPV), expressed in EUR/MWh, as explained in the Bidding Regulation. The NPV is determined as follows: (i) Each “guaranteed remuneration” bid value is measured according to an estimated annual solar energy production over 15 years. The positive or negative cashflow is discounted by 4.9% which is a general discount rate (3.6%) increased with a risk factor[3].

[3] As put by Silva (2019, p.9), bidders offer a discount percentage to the reference tariff. The fixed tariff (reference minus discount) is compared against a forecasted capture price (which is the average wholesale price weighted by a specific solar generation). A fixed tariff below forecasted captured price leads to a surplus in the system and a fixed tariff above the forecasted captured price leads to a deficit in the system.

	(ii) Each "general remuneration" bid value is a positive cashflow for the contracting entity during the 15 year period. This cashflow is valued with a 3.6% discount rate" (Portuguese Government 2019a, p.4).
Pre-qualification requirements - Financial	In order to participate, the bidder has to present a bid bond of 10000 EUR/MW. A performance bond of 60000 EUR/MW is required from the awarded bidders.
Pre-qualification requirements - Material	Beyond the deposit of a guarantee, the interested parties must submit information concerning the company and the person responsible for representing the company during the auction, as well as a 0,003 EUR/MWh payment contributing to the costs of holding the auction (Portuguese Government 2019a). Awarded bidders have to comply with some requirements. • Land rights: 6 months - not connected to the right to the grid connection • Obtaining the production license: 18 months with an environmental analysis or 12 months if not. • Urban operation licence: 24 or 18 months. • Production License: 36 or 30 months.
Auction volume	Capacity (1400 MW), 1150 MW awarded (see below).
Pricing rule	Pay-as-bid (PAB)
Award procedure	Dynamic auction with Pay-as-bid (PAB).
Price limits	Five areas are defined, and the 24 batches are classified within them (in turn, a batch may entail several injection points). A ceiling (reserve prices) is set per zone for each of the two remuneration alternatives, ranging from 44.9 EUR/MWh to 45.24 EUR/MWh for guaranteed remuneration and from 0.01 to 0.05 EUR/MWh for the general remuneration option. Under the guaranteed remuneration alternative bidders offer a discount on the aforementioned tariff.
Support period	15 years
Favorable treatment of specific actors	No
Realization time limit	36 months
Penalties	Penalties for non-realisation of projects include the withholding of the performance bond (60000EUR/kW). Failure to get the land rights in time (15% of the bid bond), the production license (25% of the bid bond),

	the license for urban operations (15%) and the production license (15%).
Form of support auctioned	Two-sided sliding feed in premium, or fixed contribution to the network operator
In case of premium schemes describe the method of reference wholesale price calculation	-
Support level adjustments	No adjustments for inflation.
Transferability of support right	Non-transferrable.
Other	In case there is a single qualified bidder, "the corresponding batch will be withdrawn from the auction. However, the single bidder in question will be given the opportunity to acquire the desired batch should its offer correspond or surpasses the average weighted NPV as compared to the prices of all the other batches won during the auction" (Portuguese Government 2019a, p.2). Any single bidder cannot be awarded more than 50% of the total capacity being auctioned but up to 100% in a given batch.

1.4 Evaluation of the auction framework

Four important (design) elements of the Portuguese auctions need to be evaluated to highlight the scheme's uniqueness (or rarity) compared to other European auctions:

1. The general logic of the auction;
2. Bidders compete in two parallel remuneration schemes;
3. Grid connection capacity for fixed batches are auctioned;
4. Dynamic auction.

First it is important to evaluate the Portuguese auction design itself. Renewable auctions in Europe tend to be based on the thinking that renewable power plants require remuneration on top of market price. Additionally, in the framework of competitive markets, auctions are economically the most efficient means to determine which projects should be supported.

In the Portuguese auction the maximum price producers can obtain is lower than the actual market price in both schemes. This reflects the aim to support PV power plants through the allocation of scarce connection capacities rather than remuneration. Additionally, auctions may provide certainty on the incomes for the PV plants and so make them more bankable. In economic terms, because of the very low ceiling prices, the Portuguese auction results in a significant welfare redeployment from producers to consumers in the form of payments to the system operator. Because of the design, at the end of the 15 year-long "support period" the revenue of the producers will probably increase. This represents a characteristic of the Portuguese auction that highlights an interesting point: If due to the maturity of the technology, or for any other reason for that matter, prices obtained in the auction are lower than the wholesale price, the nature of a renewable auction can significantly change.

The second important question to ask is whether it is effective to operate two parallel renumeration systems within the same auction, assuming that the primary technical aim of the auction is to maximise the NPV for the government. As has been presented before, in order to calculate the NPV for the guaranteed remuneration scheme, future wholesale prices must be modelled. If this forecast is not accurate, auction results will be greatly distorted.

In order to prove this, an illustrative example for two prospective power plants in the Portuguese auction scheme is presented. For simplicity, it is assumed that the supporting period is just one year (2020) without a discount and a risk factor, and there is no differentiation between the forecasted wholesale price and the forecasted strike price for PV. Table Table 4.summarizes this calculation.

Table 4.: Schematic example for inefficiency if future price forecasts are not accurate

	Real / Forecast	Wholesale price 2020 (EUR/MWh)	Bid types	Bids (EUR/MWh)	NPV (EUR/MWh)	Winner
I.Project	real	70	Guaranteed	25	45	I. Project
II. Project			General	40	40	
I.Project	forecasted	60	Guaranteed	25	35	II. Project
II. Project			General	40	40	

Source: Authors' own calculation

The first two rows present the real-world outcome for the future, while the second two rows show the auction results based on the future forecasted prices. In this illustrative calculation two producers compete in a given batch for the same capacity (assume 10 MW). One of them is participating in the fixed remuneration scheme bidding an equivalent to 25 EUR/MWh, while the other participant enters the general remuneration scheme with a contribution of 40 EUR/MWh.

The regulatory office forecast wholesale price is 60 EUR/MWh for 2020. Based on the auction rules the NPV value for the first project is 35 EUR/MWh and 40 EUR/MWh for the second. Based on the decision criteria, the second project would win the auction.

But in 2020 the real wholesale price is 70 EUR/MWh, not the forecasted 60 EUR/MWh. If the forecast would have been correct at the time of the auction (70 EUR/MWh), the NPV of the first project would have increased to 45 EUR/MWh, exceeding the second project's 40 EUR/MWh. In this sense Project I should have won the auction.

This simplified example within the framework of the Portuguese auction shows that the auction yields an efficient outcome only to the extent that the future wholesale price forecast is accurate. Inaccurate projections can elevate bid portfolios that do not demonstrate the "real" highest NPV values and lead to suboptimal outcomes. Keeping in mind that forecasts are never perfectly accurate, we suggest that in the upcoming auctions only one of the two parallel auction schemes should be used. Still it is important to highlight that the underlying idea that producers can decide whether they or the government take on the risk is very innovative.

As a third point it is also important to highlight that potential producers are competing for fixed locations. Expectations for fixed zone auctions are mixed according to the theoretical literature (del Rio et al, 2015). Because of the fixed location it is possible that the costs for producers will increase, as for example landowners in the zone have larger market power, because they are aware of the fact that their land is needed to complete a project. On the other hand, the fixed site can also reduce risks and transaction costs for producers, which creates downward price pressure. The outcome in this current Portuguese case will be investigated further with the presentation of the auction results.

Finally, Portugal's PV auction was dynamic while in Europe most auctions tend to be static. Greece has experience with dynamic auctions, but their approach differed significantly from the Portuguese system. In Greece, a fixed time period was assigned for participants to compete, while in Portugal the number of rounds was decided endogenously. Unfortunately, information regarding the results of the different rounds is very limited, as only the final results are publicly available. As a result, in this case study it was not possible to make an analysis about the dynamic nature of the Portuguese auction.

2 Evaluation of the auction results

Of the 1400 MW of PV auctioned, 82% (1150 MW) was awarded: 75% (862 MW, 15 projects) under the guaranteed remuneration option and the other 25% (288 MW, 9 projects) under the general remuneration alternative. The difference can be explained by batch 12 (150 MW) in which only one bid was submitted and batch 17 (100 MW) in which no bid was submitted[4]. Capacity was awarded in 22 of the 24 batches.

The auction was heavily oversubscribed for almost all the batches. For the 1150 MW capacity, 10.19 GW offers were made, equivalent to approximately 10 times the auctioned amount. The lowest participation rate was in Batch 2 with two participants competing for 20 MW capacity. The largest oversubscription occurred in Batch 4 with 18 participants combining to offer 333 MW of capacity for an available 19 MW, 17.5 times the offer compared to an overall average of 8.5. More details can be found in Table Table 5.

While the guaranteed remuneration system was clearly more popular (7.78 GW offered), a significant number of players opted for the general remuneration scheme as well (2.14 GW). One reason for this can be attributable to the risk awareness of the producers. Even though bids under the guaranteed scheme were further discounted with a risk factor, more risk averse producers may have chosen the guaranteed remuneration. The second possible reasoning is that in general producers expect lower electricity prices than the forecasted strike price.

The low prices emerging from the Portuguese auction have captured international headlines. Under the "guaranteed remuneration" option, an average discount of 54.93% relative to the reference tariff was achieved (20.33 EUR/MWh), with a maximum bid of 31.16 EUR/MWh (batch 20) and a minimum of 14.76 EUR/MWh (batch 3). Under the "general remuneration" scheme, the outcome was an average contribution to the electricity system of 21.35 EUR/MWh, ranging from 26.75 EUR/MWh to 5.1 EUR/MWh. However, these values are not comparable since the producer receives support in the former and pays a fee in the latter. Rather, the NPV values of the projects, described earlier, provide for a basis of comparison. What is clear is that these prices are much lower than the current wholesale electricity price of 52 EUR/MWh of the Iberian electricity market (Table 5).

[4] However, in batch 12 there was an "administrative allocation" of 142 MW (with a tariff of 20.89 EUR/MWh and a discount of 53.73).

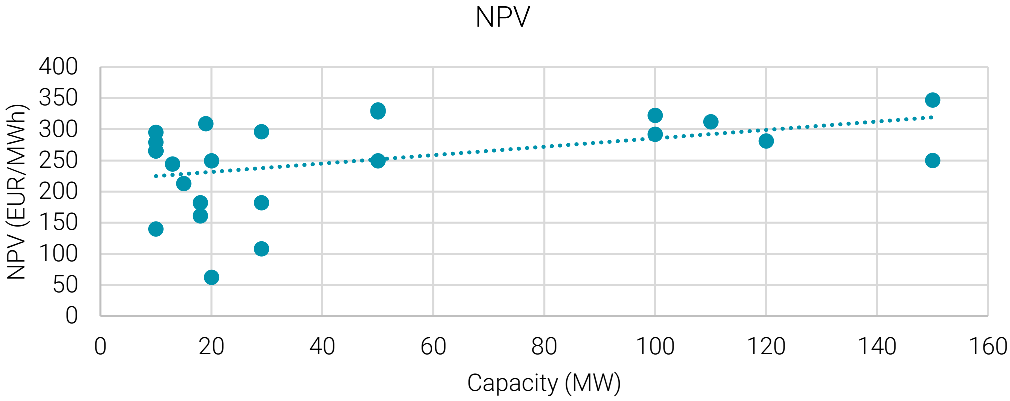
Table 5.: Summary of the results of the Portuguese PV auction

Batch	Volume participating (MW)	Volume awarded (MW)	Bidders participating	Bidders awarded	Nº of rounds	Type of rem. awarded	Bid awarded (EUR/MWh)	NPV (EUR/MWh)
1	110	10	11	Iberdrola	12	General	21,64	265
2	40	20	2	Iberdrola	1	General	5,1	62
3	2061	150	15	Akuo	10	Guaranteed	14,76	347
4	333	19	18	Prodigy	15	Guaranteed	18	309
5	220	10	22	Prodigy	14	Guaranteed	19,27	295
6	190	10	19	Prodigy	13	Guaranteed	20,63	279
7	155	29	6	Iberdrola	14	General	24,11	296
8	140	20	7	Iberdrola	11	General	20,33	249
9	30	10	3	Iberdrola	5	General	11,45	140
10	50	10	5	Iberdrola	12	General	21,56	265
11	100	50	4	Iberdrola	17	General	26,75	328
	308	50		Everstream		Guaranteed	16,37	331
12		0	1	-				
13	97	29	4	Expoentfokus	4	General	8,86	108
14	70	10	7	Prodigy	12	Guaranteed	22,16	265
15	850	100	9	Akuo	14	Guaranteed	19,78	292
16	480	120	4	Akuo	13	Guaranteed	20,73	281
17		0		-		Guaranteed		
18	1200	150	7	Aura	12	Guaranteed	23,46	250
		50		Neon		Guaranteed	23,47	249
19	108	18	6	Enerparc	7	Guaranteed	29,3	182
20	90	18	5	Aura	6	Guaranteed	31,16	161
21	209	15	8	Enerland	6	Guaranteed	26,57	213
		13		Made		Guaranteed	23,9	244
22	1081	110	10	Days of luck	16	General	25,46	312
23	2000	100	21	Power&Sol	16	Guaranteed	17,19	322
24	271	29	10	Prosolia	7	Guaranteed	29,38	182
TOTAL	10193	1150						

Source: Own elaboration from Government of Portugal (2019) https://leiloes-renovaveis.gov.pt/

Figure 5. illustrates the relationship between the size of the project and the final NPV values in order to identify the economy of scale in the Portuguese auction. It is an analysable question as auctioned capacities ranged from 10 MW to 150 MW. The figure suggests a positive relationship between the NPV and capacity, meaning larger projects tend to be cheaper, but the auction outcomes are also influenced by the intensity of competition. To determine the true effect of project size, the intensity of competition must be controlled for.

Figure 5.: Relationship between the NPVs and the size of the project for the different batches



With a simple regression (1), we attempt to explain the dependent variable NPV using two independent variables - the auctioned capacity (Volume) and the number of competitors that participated in the auction for the given batch (Competitors) - as a proxy for the intensity of competition. For the estimation, robust standard errors were used. In (2) we estimated the same regression, but included region fixed effects, in order to control for unobservable characteristics between the different regions where the auctions took place, such as weather conditions etc.

Table 6.: Explaining NPV with project size and the number of competitors with regression analysis

	(1)	(2)
VARIABLES	NPV	NPV
Volume	0.558**	0.483*
	(0.224)	(0.246)
Competitors	7.110***	9.971**
	(2.084)	(4.393)
Region effect	NO	YES
Observations	22	22
R-squared	0.493	0.582

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

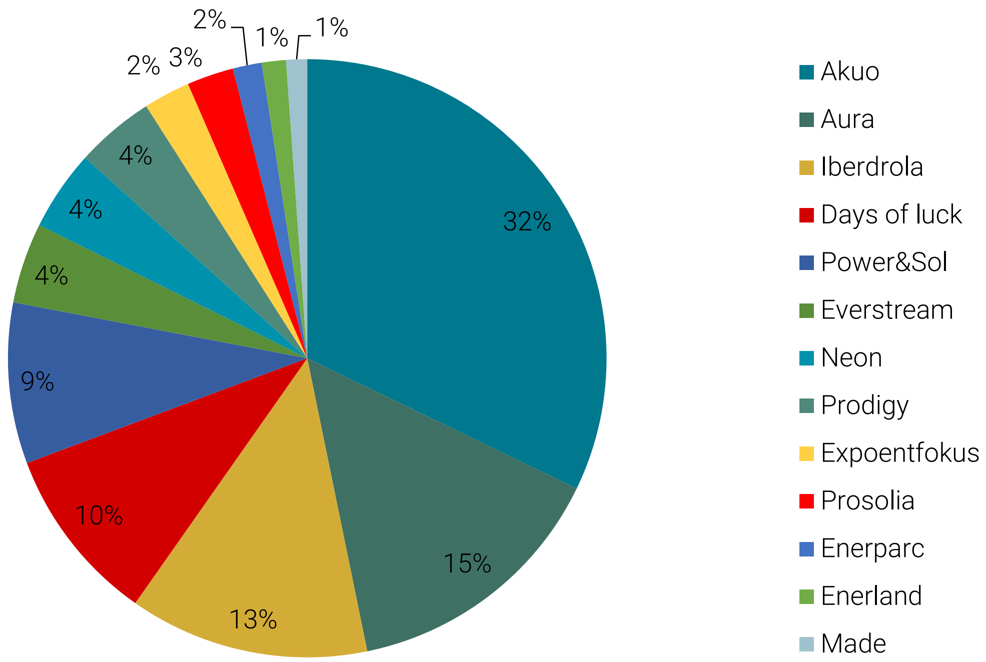
Source: Authors' own calculation

The regression shows that both Volume and Competition coefficients are positive and significant in both specifications which leads to two main conclusions. First, prices are favourable in all batches, but for those with higher levels of competition, NPV was higher. Second, it is possible to identify some economy of scale effects since prices for larger projects were generally lower than for smaller ones.

The low prices from Portuguese auctions are attributable to several factors. First, southern Portugal has excellent solar resources, with radiation levels above 1700 kWh/m^2 and even large areas with above 1900 kWh/m^2. Second, auctions were very competitive with the volume participating (10193 MW) 10 times the volume awarded. As mentioned previously, two of the 24 batches (12 and 17) were an exception. Additional reasons, based on Aurora (2019), comprise strategic behaviour of developers to secure a market share, expectations of high prices beyond the 15-year regulated period and speculative bids. However, the prohibition to sell the license and the 60000 EUR/MW performance bond renders the latter unlikely. It is also important to note that the fixed location of the batches does not seem to distort competition since participation was very high for almost all batches, but has probably reduced risk and transaction costs for producers, which was reflected in the lower price level. This system allows an optimal allocation of the generation with regards to existing transmissions capacity.

As a final point, 13 firms were awarded in the auctions. Some concentration can be observed, as the first four firms captured 70% of the volume awarded (Figure 6.), while incumbents such as EDP and Galp did not manage to secure winning bids.

Figure 6.: Share of auctioned capacities by companies



Source: Own elaboration from Government of Portugal (2019a)

3 Conclusions

On the basis of the evidence presented, the Portuguese PV auction begets several important conclusions. It can be labelled as a "2nd generation auction", completely different from renewable auctions across Europe usually organised to assign price support for renewable power plants. In Portugal, however, producers compete for the opportunity to connect to the grid. The ceiling prices for the auctions were lower than the current and expected wholesale electricity prices.

By taking a closer look at the auction it is evident that the auction design itself is one of the most innovative in Europe: a pay-as-bid dynamic tender for fixed batches with two parallel bidding schemes (guaranteed and general remuneration), which provided the participants with flexibility with respect to their project risk profile. It can be argued that the flexibility for producers to choose between the two schemes can make the auction more attractive and increase competition, which is an advantage of this design. On the other hand, this parallel scheme structure being dependent on long-term electricity price forecasting can lead to inefficient outcomes - if the forecast is not accurate the winning projects might not have the highest actual NPV value. For this reason, selecting either the guaranteed or the general remuneration scheme rather than the parallel use of both systems in the current format represents a potential way forward. It is also important to highlight, that the Portuguese auction had been a technology specific tender, given the competitiveness of the technology, and the vastly available solar resources of the country.

There are many positive characteristics to highlight with respect to the Portuguese auction. The high levels of transparency adopted throughout the auction procedure, whereby all relevant information was provided on the website, has probably also been a factor behind the large participation. The provision of information does not only refer to the documentation provided before the auction, but also with respect to its outcomes. However, it would help if documents would be made available not only in Portuguese, but in English as well. Furthermore, two interesting design elements in the Portuguese auction aim to ensure competition and avoid high concentration levels: the possible suspension of the auction procedure in a given batch with only one qualified bidder, and the rule that any single bidder cannot be awarded more than 50% of the total capacity being auctioned. Both may represent a case of "best practice" whose adoption may be recommendable for other schemes around the world. As a final point, the organized technology-specific auction was in line and will contribute to the strong focus on PV in the Portuguese NECP.

Based on the auction results, competition was strong. For the offered 1.4 GW capacity, more than 10 GW of offers were made. Yet competition was not equally intensive across batches, and with participation too low in two batches only 1.15 GW of total capacity was auctioned in the end. The winning investors have three years to commission their power plants and will pay the network contribution fee or receive the feed-in premium depending on the scheme for 15 years. Out of the 1.15 GW, 862 MW were assigned under the guaranteed and 288 MW in the general remuneration scheme. 32% of the awarded capacity was won by a single company, but the remaining capacity was distributed more evenly between 12 other firms. Incumbents of the Portuguese electricity market did not make any winning bids on the auction.

Competition led to low auction prices, with the average winning price of the guaranteed remuneration scheme a premium of 20 EUR/MWh and the lowest bid of 14.46 EUR/MWh, the lowest feed-in premium for PV ever in Europe. In the general remuneration scheme winners paid an average of 21 EUR/MWh for every MWh sold to the system operator. We can conclude that these prices are drastically lower than the wholesale market price.

Four possible reasons behind the low-price level have been identified. First, in Portugal PV technology has matured in recent years. This hypothesis is strengthened by the fact that after the termination of renewable support in the mid-2010s market players have sought to build new PV plants on a market basis without additional governmental support. The auction was organized in areas with very good solar resources and after an extended time without a scheme, demand was high. Second, the shortage of available connection points relative to the connection demand added to competition at the auction. Our analysis suggests that in batches where the competition was more intense, the NPV values were generally higher.

The third reason for high prices can be explained by economies of scale. The Portuguese auction was unique in the sense that the minimum capacity was 10 MW, but in some batches more than 150 MW capacity was auctioned. We also demonstrated that in those batches where the auctioned capacities were higher, the NPV was on average also higher. Finally, it seems that assigning fixed connection points to the winners reduced the uncertainty and pushed down the prices. From a system point of view, it is also a novel way to encourage the minimization of costs to integrate large amounts of variable renewables into the system. The zone-specific scheme suggests that this design element can be an appropriate measure to optimize constrained transmission infrastructure.

It is also worth mentioning that, although the prices achieved in the auction were very low, time will tell if the auction has been a success, as we have no information about the completion rates, so it is not possible to evaluate effectiveness. However, the Portuguese auction design can be considered as a successful innovation, with very good best practices that could be implemented in other countries of Europe. The auction also resulted in very low prices. Despite this success, some design elements should be revisited in the future, namely the parallel remuneration procedure.

Finally, it may be argued that the Portuguese auction highlighted a very important aspect of the possible future of renewable auctions. As renewable technologies become more and more competitive, auction results may fall below the wholesale price across Europe, similarly to Portugal. This may shift the auctions main aim from providing financial operational support, toward the allocation of scarce network connection capacities. In this framework, auctions can lead to the result that a significant part of producers' welfare is redeployed to the consumers. Also, many market players cannot complete their project who are not efficient enough to win in the auctions, on the other hand they would be competitive enough to enter the wholesale electricity market, without support. This fact puts a huge emphasis on the question as to how new grid connection capacities will appear on the market, as this factor seems to be a significant constraint for future renewable deployment.

4 References

APREN (2019a): 2019 Annual Yearbook, APREN – Asociacao de Energia Renovaveis, Available at: https://www.apren.pt/contents/documents/anuario-2019-aprenebook-v2-5562.pdf

APREN (2019b): Renewable Energies – Power, Available at: https://www.apren.pt/en/renewable-energies/power

APREN (2019c): Renewable Energies- Production, Available at: https://www.apren.pt/en/renewable-energies/production

Aurora Energy Research (2019). What happened in Portugal's recent record-breaking solar auctions? Aurora News Brief –August 2019

Bellini, E. 2019 Winners, projects, prices of Portugal's record PV auction. pv-magazine, August 9th 2019. https://www.pv-magazine.com/2019/08/09/winners-projects-prices-of-portugals-record-pv-auction/

Del Río, P. 2016. Auctions for renewable energy support in Portugal: instruments and lessons learnt. AURES report D.4.1-PT, March 2016. http://www.auresproject.eu/publications/auctions-renewable-energy-support-in-portugal-instruments-and-lessons-learnt

del Rio, Pablo (2016): Auctions for Renewable Energy Support in Portugal: Instruments and lessons learnt, AURES, Report D.4.1-PT, March

del Rio, Pablo; Haufe, Marie-Christin; Wigand, Fabian; Steinhilber, Simone (2015): Overview of desing elements for RES-E auctions, Aures, Report D2.2 (a)

European Commission (2019): State aid: Commission approves a EUR320 million scheme to support biomass energy installations close to forests at risk of fires in Portugal, Brussels, 8 January 2019, Available at: https://ec.europa.eu/info/news/state-aid-commission-approves-eu320-million-scheme-support-biomass-energy-installations-close-forests-risk-fires-portugal-2019-jan-08_en

Everoze.com (2018): Portugal goes subsidy-free – but will grid bottlenecks stop solar flowing? July, 2018, Available at: https://everoze.com/portugal-goes-subsidy-free/

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

Lainez, Karla (2019): Oversubscribed Portuguese solar auction achieves lowest FiT bid in Europe – under profitable levels?, ICIS Power Perspective

Morais, Lucas (2019): Portugal okays new guides for biomass plants, Renewables Now, 22 August 2019, Available at: https://renewablesnow.com/news/portugal-okays-new-guidelines-for-biomass-plants-666248/

Portuguese Government (2019a) INFORMAÇÃO SOBRE OS LEILÕES https://leiloes-renovaveis.gov.pt/

Portuguese Government (2019b). Portugal Integrated National Energy and Climate Plan 2021-2030. December 2018

Portuguese Government (2019c): Competitive Procedure for Allocation of Injection Capacity Reserve in the Public Service Electric Network for Photovoltaic Solar Energy, Program of procedure

RES Legal (2019): Portugal: Overview, Available at: http://www.res-legal.eu/search-by-country/portugal/

Silva, N. 2019. Portuguese solar PV auction. June 2019. Pöyry and Governo de Portugal.

Silva, Nuno (2019): Portuguese Solar PV auction, Pöyry, Presentation

AURES II is a European research project on auction designs for renewable energy support (RES) in the EU Member States.

The general objective of the project is to promote an effective use and efficient implementation of auctions for RES to improve the performance of electricity from renewable energy sources in Europe.

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