D2.1-EL, December 2019

# Auctions for the support of renewable energy in Greece

Main results and lessons learnt

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# D2.1-EL, February 2020, Auctions for the support of renewable energy in Greece

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# 1 Characteristics of RES auctions in the country

## 1.1 Greek electricity and energy sector

In 2018, the Greek electricity generation mix was still dominated by fossil fuels, which constitute around 69% (coal 34%, oil 9%, and natural gas 26%). Renewable energy sources (RES) provided around 31% of the electricity generation, with onshore wind being the dominant RES technology (see left-hand side of Figure 1). The right-hand side of Figure 1 provides details on the installed capacity of the various RES technologies. Onshore wind constitutes with around 3.4 GW more than half of the installed RES capacity in Greece, with PV coming second with 2.7 GW (incl. 0.4 GW of small-scale PV appliances ≤ 10 kW). The remaining RES technologies (hydro, biogas-biomass, hybrid plants and CHP) play - with a total cumulative capacity of around 0.7 GW - only a minor role in Greece.

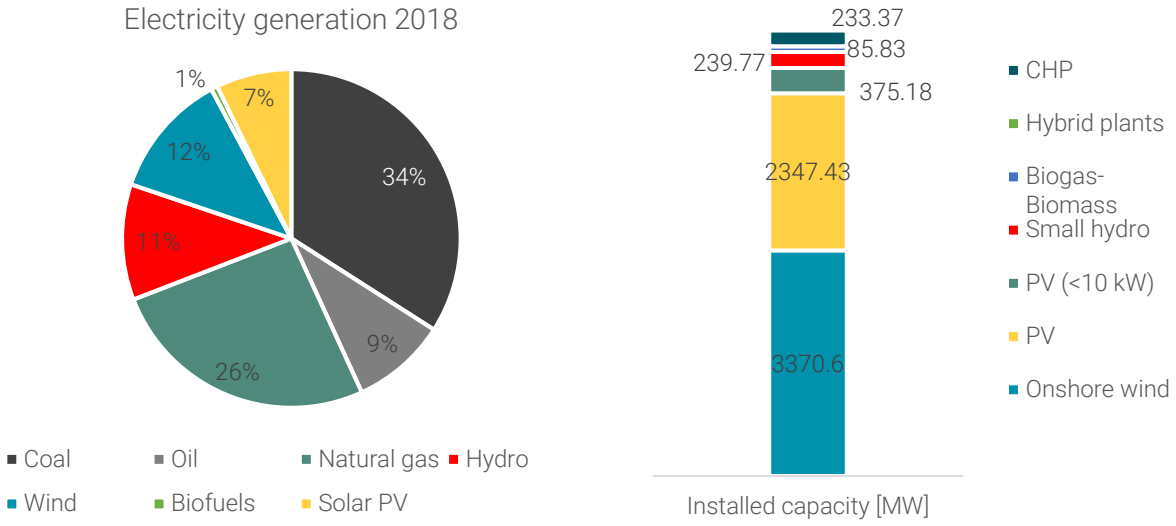


Figure 1: Electricity generation in 2018 and installed capacity 2019 (in October 2019), Source: LAGIE/DAPEEP, http://www.lagie.gr/fileadmin/groups/EDSHE/MiniaiaDeltiaEL/2019-06_SEPT__OCTOB_2019_DELTIO_ELAPE_v1.0_11.12.2019.pdf

The RES share in the gross final energy consumption has been steadily rising over the past years, starting from around 7.2% in 2004. In 2018, Greece has reached a RES share of 18.002% of its gross final energy consumption[1], thus already achieving its European 2020 RES target. As Figure 2 shows, two developments led to this result: 1) energy provision from RES has been steadily rising from 1,522 ktoe in 2004 to 3,000 ktoe in 2018, and 2) the gross final energy consumption fell significantly from its peak of 22,800 ktoe in 2008 to 16,700 ktoe in 2018 (a decrease of more than 25%) due to Greece's economic crisis.

To put these figures into perspective: Greece's National Renewable Energy Action Plan (Ministry of Environment, Energy and Climate Change 2010), which was published in July 2010 and thus based on modelling and calculations prior to the economic crisis, estimated a final energy consumption of around 23,216 ktoe in 2018 (39% higher than the actual value) and 24,114 ktoe in 2020. This decrease made it easier for Greece to reach its 2020 target.

[1] https://ec.europa.eu/eurostat/databrowser/bookmark/f4c6d3bb-c934-4f65-b22a-d0e789640a12?lang=en

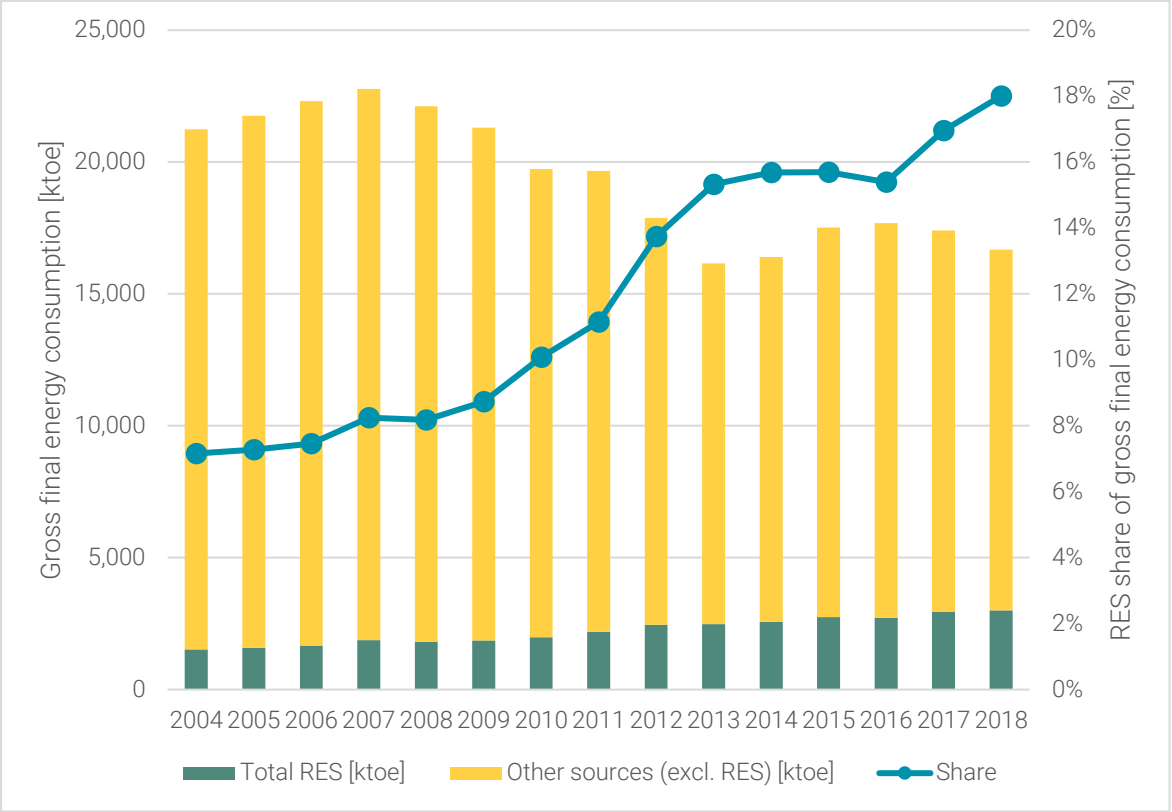


Figure 2: RES share in the gross final energy consumption in Greece for the years 2004-2018, Source: https://ec.europa.eu/eurostat/web/energy/data/shares

Greece's financial and economic crisis, which started in 2009, led to the economic adjustment programme (EAP) with the European Union, the International Monetary Fund, and the European Central Bank in 2010, which had a significant impact on the electricity market structure. Besides a general liberalisation of product markets, the EAP foresaw an increase in competition and divestment of state-owned assets in the energy sector, a goal that has been reaffirmed in the second (2012) and third (2015) EAP, as well. Therefore, Greece is currently undergoing a deep transformation of its electricity sector towards more liberalisation (IEA 2017).

Since 2007, all electricity customers in the interconnected system can officially choose an alternative supplier. Nevertheless, competition is rather limited, since the state-owned incumbent utility "Public Power Corporation S.A." (PPC) still dominates the market with a share of almost 80% (January 2019) (HAEE 2019).

Another key feature of the Greek electricity system is that Greece is divided into a major, interconnected zone (comprising mainland Greece and a couple of islands), and 28[2] non-interconnected islands (NIIs) each of which constitutes an autonomous power system. In our study, we focus exclusively on the interconnected zone, since only 7% of the total Greek RES capacity is located on the NIIs and - although plans exist to conduct RES auctions in these special locations - no concrete plans have been published yet.

[2] https://www.deddie.gr/en/themata-tou-diaxeiristi-mi-diasundedemenwn-nisiwn/agora-mdn/ilektrika-systimata-mdn/

## 1.2 RES support policy

The EU's Directive 2009/28/EC (European Commission 2009) foresees a binding RES target of 18% in Greece's gross final energy consumption in 2020, which has already been achieved in 2018.

In 2010, Greece decided to raise its ambitions and established the following overall and sectoral RES targets for 2020 in Law 3851/2010:

- 20% RES share in gross final energy consumption (2018: 18.002% - not reached)
- at least 40% of gross final electricity consumption (2018: 26.01% - not reached)
- at least 20% of gross final energy consumption for heating and cooling (2018: 30.18% - reached)
- at least 10% of gross final energy consumption in transportation (2018: 3.83% - not reached)

To reach its targets, Greece started supporting RES via a feed-in tariff (FIT) in 2006, which boosted solar PV deployment significantly. In 2014, due to the financial crisis and an increasing deficit in the RES special account, the Greek government retroactively adjusted the FITs for all existing PV, wind, small hydro and CHP installations downward in 2014 (Law 4254/2014). In addition, Greece halted the licensing of new PV installations during 2012-14, since the target of 2,200 MW of installed PV by 2020 had already been reached. These developments led to a great uncertainty in the RES sector, and together with the decreased support levels, only a marginal amount of PV power plants had been installed from 2014 on. Greece eventually closed the FIT support scheme in the end of 2015 (IEA 2017).

On 9 August 2016, the government published Law 4414/2016, which introduced a new support scheme for RES (and CHP) in Greece starting retroactively from the 01.01.2016.

In December 2019, Greece published its 2030 RES targets in the final National Energy and Climate Plan (Ministry of Environment and Energy 2019). Among other provisions, these foresee the following objectives by 2030:

- At least 35% RES share in gross final energy consumption
- At least 60% of gross final electricity consumption
- At least 40% of gross final energy consumption for heating and cooling
- At least 19% of gross final energy consumption in transportation

To reach these shares, the following RES capacities are foreseen to be installed in 2030:

- 7.05 GW of wind
- 7.66 GW of PV
- 4.32 GW of other RES

## 1.3 Objectives of RES auctions

The Law 4414/2016 states the following objectives, among others: 1) complying with EU regulation (EEAG), 2) establishing a new RES support scheme that fosters RES market integration and deployment in the most efficient way regarding costs and benefits for the society, 3) materialising the natural resources and 4) achieving Greece's 2020 RES targets.

Therefore, the law introduced auctions as the main instrument to determine the level of support for (large-scale) RES. More concretely, due to the economic crisis, the government's main goal is to reduce the (support) costs for the deployment of RES which can be considered the main driver for implementing auctions and can be seen as the main motivation behind several auction design elements used in Greece.

## 1.4 Design elements of RES-E auctions

Although the main auction design elements are described in Law 4414/2016, the specific design of each RES tender is published in secondary legislation by either the Ministry of Environment and Energy and the auctioneer, namely the Greek Regulatory Authority for Energy (RAE).

The Ministry of Environment and Energy publishes the yearly amounts of capacity (per technology) to be auctioned until 2020 (Ministerial Decision APEEK/A/F1/oik.172859 2018; Ministerial Decision YPEN/DAPEEK/34495/1107 2019; Ministerial Decision YPEN/DAPEEK/11163/409 2020). Based on these figures, the Greek Regulatory Authority on Energy (RAE) publishes an initially auctioned volume and the relevant tender materials prior to each auction round.

The auctioning procedure in Greece can be considered quite unique: in the first stage, RAE invites bidders to submit applications with their projects' volumes (no bid prices yet). After reviewing the applications regarding their eligibility and the prequalification requirements, qualified bidders are invited to participate in the second stage of the auction. Before the second stage, in case the initially proposed volume is not oversubscribed by a certain threshold (e.g. 40%), RAE decreases the auctioned volume according to the submitted volumes of qualified projects to comply with the threshold in order to ensure enough competition in the auction. The qualified bidders then compete in a 30 min dynamic auction for the support. During this auction window, starting from a predefined ceiling prices ("Reference Tariff"), bidders can decrease their bid prices. After the 30 min, the ranking of individual bids is fixed and each awarded participant receives their individual bid (the outcome is similar to a static pay-as-bid auction).

Successful bidders then sign a contractual agreement with DAPEEP (former LAGIE) to receive operating support on top of their electricity market income for 20 years. Furthermore, in order to foster RES market integration and to comply with EU regulation, namely the "Guidelines on State aid for environmental protection and energy 2014-2020" (European Commission 2014), the Law implemented a two-sided sliding feed-in premium with a monthly reference period as the main remuneration scheme for large-scale RES projects over 500 kW (3 MW for wind).

Until now, 13 auction rounds in five auction windows have been conducted. By default, Greece conducts technology-specific auctions, although in April 2019, a pilot multi-technology auction for onshore wind and PV has been concluded.

Table 1: Main characteristics of auctions and framework conditions

| Characteristics | Description |
|---|---|
| Name of auction scheme | New Support Scheme of Renewable Energy and CHP Plants |
| Contractual counterparty | The Regulatory Authority for Energy (RAE) is conducting the auction. The contractual counterparty was the Hellenic Electricity Market Operator (LAGIE), which was renamed to RES & Guarantee of Origin Operator (DAPEEP) in June 2018. |
| Technology focus and differentiation (eligible technologies) | The following technologies have an obligation to participate in an auction procedure to receive support:<br>• Onshore wind ≤ 60 kW<br>• Onshore wind 3 MW < Capacity ≤ 50 MW<br>• Onshore wind > 50 MW<br>• PV 0.5 MW ≤ Capacity ≤ 20 MW<br>• PV > 20 MW<br>• Group of two or more onshore wind projects (with a common grid connection) > 50 MW<br>• Group of two or more PV projects (with a common grid connection) > 20 MW |

| | |
|---|---|
| | • Group of at least one onshore wind and at least one PV project (with a common grid connection) > 50 MW<br><br>All other RES technologies are exempted from the auctions and are eligible for an administratively-set FIP/FIT, due to concerns of insufficient competition.<br><br>Small-scale PV projects (< 0.5 MW) and onshore wind projects between 60 kW and 3 MW are eligible for an administratively-set FIT/FIP. Auctioning small-scale onshore wind appliances is foreseen due to the fact that those projects smaller or equal to 60 kW do not need a generation license. RAE fears that a high number of projects will be built throughout the country without the possibility to control their deployment.<br><br>The three last categories (grouped technologies) are exclusively included in the multi-technology auctions. It can been assumed that those have been implemented to enable smaller projects (with the same grid connection point) with individual licenses and permits to participate in the multi-technology auctions as one project and thus to increase competition in this auction segment. |
| Lead time before auction | Auctions are announced 1-2 months prior to the deadline for the submission of applications. |
| Min./max. size of project | Depending on the respective auction:<br><br>Pilot PV auction (November 2016)<br>Category I<br>PV: ≤ 1 MW<br>Category II<br>PV: 1 MW < capacity ≤ 10 MW<br><br>Technology-specific auctions (July and December 2018)<br>Category I<br>PV: 0.5 MW ≤ capacity ≤ 1 MW (but projects smaller than 0.5 MW are allowed to participate on a voluntary basis)<br>Category II<br>PV: 1 MW < capacity ≤ 10 MW<br>Category III<br>Onshore wind: 3 MW < Capacity ≤ 50 MW<br><br>Multi-technology auctions (April 2019)<br>PV: > 20 MW<br>Onshore wind: > 50 MW |

| | |
|---|---|
| | Technology-specific auctions (July and December 2019)<br>Category I<br>PV: 0.5 MW ≤ Capacity ≤ 20 MW (but projects smaller than 0.5 MW are allowed to participate on a voluntary basis)<br>Onshore wind: 3 MW < Capacity ≤ 50 MW |
| What is auctioned? | Capacity (both in technology-specific and multi-technology auctions) |
| Budgetary expenditures per auction and per year | Undefined |
| Frequency of auctions | At least once a year until 2020 |
| Volume of the tender | Pilot PV tender in 2016: 40 MW<br><br>Overall volumes defined for the period 2018-2020:<br><br>PV: 900 MW<br>Onshore wind: 900 MW<br>Multi-technology (PV + onshore wind): 800 MW<br>Total: 2,600 MW |
| Costs related to grid connection/access | The successful bidder pays for the grid connection, as well as any additional works needed for the connection of the RES plant by the TSO/DSO. Further details are specified in each grid connection offer/agreement.<br>No priority is given to RES power plants in terms of grid connection. |
| Balancing and profile costs | As long as no intra-day market is in place, bidders do not bear any balancing responsibilities.<br>However, as soon as the intra-day market is functioning, all relevant RES projects (incl. those that were awarded in an auction before this date) are responsible and have to pay for balancing. |

Table 2: General auction design.

| Design elements | Description |
|---|---|
| Auction format | Two-stage, multi-unit, dynamic auction |
| Auction procedure | The Greek auctions are conducted in two stages:<br><br>1st phase: prequalification stage<br><br>Bidders submit their application to participate in the auction, including their projects' volumes and the required documentation. Although such a procedure is common in many auction designs, in Greece this is regarded as an individual stage, since based on the total capacity of applications, the auctioned volume is determined by RAE.<br><br>2nd phase: dynamic auction<br><br>The actual auction takes place as a dynamic auction, in the "Yankee" format, which is a variation of the Dutch auction format. Starting from a pre-defined and published Reference Tariff (can be considered the ceiling price), bidders can decrease their bid |

| | |
|---|---|
| | prices in a 30 min bidding window. Each awarded bidder receives their individual bid price (similar to pay-as-bid). |
| Pre-qualification requirements<br>- Financial | In order to participate and to receive the support in case of an award, the bidder needs to provide two guarantees:<br><br>Bid bond (before the auction takes place):<br><br>All interested bidders have to provide a financial guarantee which amounts to 1% of the total investment expenditures. RAE considers typical investment costs of 1000 €/kW for PV and 1250 €/kW for onshore wind. Therefore, the bid bonds are:<br><br>PV: 10 EUR/kW<br><br>Onshore wind: 12.5 EUR/kW<br><br>Completion bond (for awarded bidders):<br><br>All awarded bidders have to provide a total of 4% of the investment costs (which includes the already provided bid bond of 1%) as a completion bond within 15 days after the results of the auction have been published. Based on the typical investment expenditures, the completion bonds (excl. the bid bonds) are as follows:<br><br>PV: 30 EUR/kW<br><br>Onshore wind: 37.5 EUR/kW |
| Pre-qualification requirements<br>- Material | Generation license issued by RAE (with small-scale PV projects up to 1 MW and onshore wind projects up to 60 kW being exempted), which is valid for 25 years.<br><br>Grid connection agreement (or final/binding grid connection offer). |
| Auction volume | The yearly auction volumes (2018-2020) are set by Ministerial Decree. Based on those values, RAE determines the auctioned volume per auction round, which is then adjusted according to the submitted volumes. |
| Pricing rule | Pay-as-bid |
| Price limits | Pilot PV auction:<br>• Category I (PV ≤ 1 MW)<br>  ○ 104 EUR/MWh<br>• Category II (PV with 1 MW < capacity ≤ 10 MW)<br>  ○ 94 EUR/MWh<br><br>Technology-specific auctions:<br>• Starting from the December 2018 auction: Arithmetic average between the average awarded bid price and the ceiling price of the preceding auction round of the same technology/category |

| | |
|---|---|
| | Multi-technology auction:<br>• The lowest out of the highest awarded prices of both the large-scale PV and onshore wind auctions in the preceding technology-specific auctions, reduced by 1%<br>• In April 2019: 64.72 EUR/MWh |
| Support period | 20 years (for PV and onshore wind) |
| Favourable treatment of specific actors | No favourable treatment for specific actors inside the auction design.<br>(But onshore wind energy community projects under 6 MW and PV energy community projects under 1 MW qualify for an administratively-set support and thus do not need to participate in the auction procedure.)<br>Nevertheless, dividing the PV segment into two categories (in the Pilot PV auction and the 2018 rounds) for small- and large-scale projects can be considered a favourable treatment of small-scale projects which probably wouldn't have been able to compete with their large-scale counterparts. |
| Realization time limit | The realisation periods depend on the projects' sizes<br><br>Pilot PV auctions:<br>18 months if ≤ 1MW<br>24 months if > 1MW<br><br>In the permanent scheme starting 2018:<br><br>PV:<br>12 months if ≤ 1 MW<br>15 months if 1 MW < capacity ≤ 5 MW<br>18 months if > 5 MW:<br><br>Onshore wind:<br>24 months if ≤ 10 MW<br>36 months if > 10 MW<br><br>For both technologies: + 6 months, if the power plant is connected to the Transmission System via a new substation |
| Penalties | Penalties for non-realisation by the end of the respective realisation period include:<br>• Cancellation of award/support agreement<br>• Withholding of the bid and completion bonds (in favour of the RES Special Account)<br>• Possible cancellation of generation license and/or grid access agreement/offer |
| Form of support auctioned | Large-scale RES projects receive their support in form of a two-sided contract-for-difference, which foresees a mandatory participation of the projects in the wholesale electricity market (incl. balancing responsibility).<br>Until the end of 2019, this applied to RES projects larger or equal to 0.5 MW (3 MW if onshore wind). |

| | |
|---|---|
| | Law 4643/2019 decreased the thresholds to 400 kW for all new projects of all technologies, starting in December 2019.<br><br>Two-sided contract-for-difference (CfD)<br>• Support = Awarded price in auction - reference wholesale price<br>• Payback to the RES Special Account if market value is greater than the awarded price<br>• No support in periods when wholesale prices of 0[3] occur for more than two consecutive hours<br><br>Smaller projects receive their support through a feed-in tariff and thus do not have the obligation to participate in the wholesale electricity markets. |
| In case of premium schemes describe the method of reference wholesale price calculation | Reference wholesale price calculation: Technology-specific market value with a monthly reference period<br><br>The reference value for PV and onshore wind is calculated for each month taking into account the generation patterns of the respective technology. Thus, the total, hourly electricity generation of a certain technology is multiplied with the respective hourly wholesale electricity market price. The resulting values are summed up for the entire month and then divided by the entire, monthly generation of the respective technology, thus resulting in the weighted, average wholesale price of the technology (Ministerial Decision APEIL/A/F1/oik.187480). |
| Support level adjustments | No. |
| Other | Participation fees foreseen in the auctions:<br><br>500 EUR for PV ≤ 20 MW<br>1000 EUR for onshore wind ≤ 50 MW<br>5000 EUR PV > 20 MW and onshore wind > 50 MW (multi-technology auctions) |

[3] It should be noted that at the Greek Electricity Exchange, no negative prices can occur. Thus, 0 EUR/MWh is the lowest price possible.

# 2 Evaluation of the auction results

This chapter provides an overview of the auction outcomes and analyses the Greek auction scheme with regard to 1) static efficiency, i.e. if the projects with the lowest LCOE have been awarded, and support cost efficiency, i.e. if support costs have been minimised to the extent possible, and 2) effectiveness, i.e. if the auctioned volumes were awarded and if the successful projects were actually commissioned.

## 2.1 Static efficiency

The Greek auctions can be considered a success with regard to driving down the levels of RES support and thus the costs for consumers, which can be considered the major objective of the new support scheme. This chapter will provide an overview of the auction outcomes (subchapter 2.1.1) and will then analyse in detail the impacts of the auction design on the static and support cost efficiency (subchapter 2.1.2).

The following Figure 3 provides an overview of the average, the minimum and maximum awarded prices, as well as the respective ceiling prices (right-hand scale). Furthermore, on the left-hand scale, the initially auctioned volume by RAE, the submitted volume in the 1st stage of the auction and the actually awarded volumes can be observed.

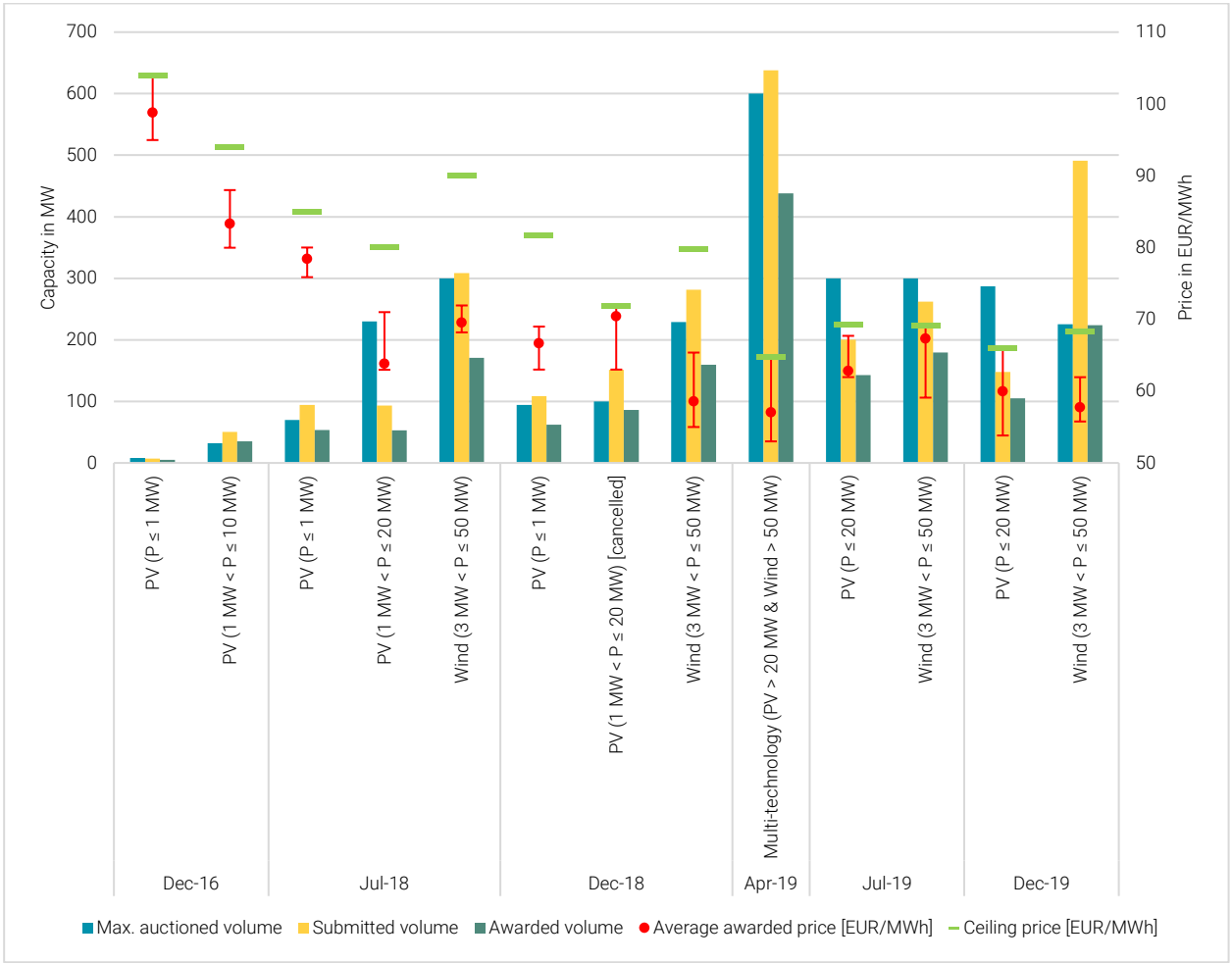


Figure 3: Overview of the Greek auction results, Source: own elaboration based on the results published by RAE

### 2.1.1 Auction results

The first pilot auctions in November 2016 resulted in an average awarded price of 98.78 EUR/MWh for the first category (small-scale PV ≤ 1 MW) and 83.3 EUR/MWh for the second one (large-scale PV between 1 MW and 10 MW). This constitutes a decrease of around 5% and 11% compared to the initial Reference Tariff (ceiling price). Compared to the results in other countries around the same time, such as the 69 EUR/MWh for large-scale PV in Germany in December 2016, the awarded prices still seem quite high[4]. Nevertheless, it should be noted that most projects belonged to Greek developers, who faced comparatively high cost of capital due to the overall financial and economic situation in the country and thus had to take higher levelised cost of capital (LCOE) into account when calculating their bid prices. The projects' WACC amounted to values of around 13-13.5% for PV and 12% for onshore wind in 2015, which decreased to 7-12% (PV) and 10-12% (wind) in 2016 (Angelopoulos et al. 2017).

Table 3: Overview of the Greek auction results, Source: own elaboration based on the results published by RAE

| Date | Technology | Max. auctioned volume [MW] | Submitted volume [MW] | Auctioned volume [MW] | Awarded volume [MW] | Average awarded price [EUR/MWh] |
|---|---|---|---|---|---|---|
| Nov-16 | PV (P ≤ 1 MW) | 8 | 6.79 | 4.8 | 4.79 | 98.78 |
| | PV (1 MW < P ≤ 10 MW) | 32 | 50.21 | 35.2 | 35.12 | 83.3 |
| Jul-18 | PV (P ≤ 1 MW) | 70 | 94.07 | 53.52 | 53.48 | 78.42 |
| | PV (1 MW < P ≤ 20 MW) | 230 | 93.44 | 53.4 | 52.92 | 63.81 |
| | Onshore wind | 300 | 308.68 | 176.39 | 170.92 | 69.53 |
| Dec-18 | PV (P ≤ 1 MW) | 94 | 108.4 | 61.95 | 61.94 | 66.66 |
| | PV (1 MW < P ≤ 20 MW) [cancelled] | 100 | 151.32 | 86.47 | 85.99 | 70.39 |
| | Onshore wind | 229 | 281.65 | 160.94 | 159.65 | 58.58 |
| Apr-19 | Multi-technology (PV > 20 MW & Wind > 50 MW) | 600 | 637.8 | 455.56 | 437.8 | 57.03 |
| Jul-19 | PV (P ≤ 20 MW) | 300 | 200.3 | 143.04 | 142.88 | 62.78 |
| | Onshore wind | 300 | 261.8 | 186.96 | 179.55 | 67.32 |
| Dec-19 | PV (P ≤ 20 MW) | 287.11 | 147.65 | 105.47 | 105.09 | 59.98 |
| | Onshore wind | 225.45 | 491 | 225.45 | 224 | 57.74 |

[4] Although, when comparing different countries, it should be taken into account that Greece uses a two-sided CfD, i.e. that generators are paying back when electricity market prices are above their awarded bid price. This means, that c.p., bid prices under a CfD scheme might be higher than under a one-sided sliding premium, under which bidders can keep additional market income and thus can bid lower (e.g. to increase their chances to be awarded).

In April 2018, the Ministry of Environment and Energy published the Ministerial Decision APEEK/A/F1/oik.172859 which provided an indicative auction schedule for the years 2018-2020. Thus, after a break of around 1.5 years after the first pilot auctions, RAE conducted the first permanent auction rounds in July 2018[5], this time including onshore wind. The first category, which consisted of small-scale PV plants smaller or equal than 1 MW, resulted in an average price of 78.42 EUR/MWh, which was 7.7% lower than the Reference Tariff and around 21% lower than the prices in the respective category in the pilot auction.

The large-scale PV auction (Category II), including projects from 1 MW up to 20 MW (compared to projects of only up to 10 MW in the pilot auction), led to an average awarded price of 63.81 EUR/MWh in the July 2018 auction. Compared to the Reference Tariff, this is a reduction of 20%, while the outcome is 23% lower than in the pilot auction. Looking at the awarded projects, none of those, and only two out of the overall 13 projects participating were actually larger than 10 MW (see below for a detailed analysis of the capacity limitations). Onshore wind achieved an average awarded price of 69.53 EUR/MWh, which constitutes a decrease of around 23% compared to the Reference Tariff.

In the second auction window of 2018 (December 2018), the decrease in awarded prices of small-scale PV and onshore wind continued: the auction for PV plants under 1 MW resulted in an average price of 66.66 EUR/MWh, which constitutes a further 15% decrease compared to the July 2018 round, while onshore wind achieved an average price of 58.58 EUR/MWh, which amounts to a 16% decrease.[6] In the category of large-scale PV projects between 1 MW and 20 MW, around 151 MW of power plants were admitted to the auction after the first stage. Nevertheless, in the actual dynamic auction procedure, only 12 of the admitted projects submitted a bid, while the remaining 15 projects with 65.33 MW (all belonging to SPES SOLARIS-SOLAR CONCEPT AE and SPES SOLARIS THREE AE) did not participate at all. Thus, the auction was in fact under-subscribed, as only 85.98 MW of projects participated, compared to the auction volume of 86.47 MW. RAE considered this to be a violation of the auction rules, and thus, based on the provisions in the call for tender, cancelled the auction due to a lack of competition. It should be noted, that SPES SOLARIS-SOLAR CONCEPT AE was able to secure the Reference Tariff of 71.91 EUR/MWh for their remaining four projects, which indicates that the 15 projects not participating in the auction were only submitted to ensure the competition threshold of 75% was reached. The onshore wind auction in December 2018 triggered a lot of interest with 282 MW of projects admitted to the auction, compared to an auction volume of 229 MW. This led to an average awarded price of 58.58 EUR/MWh, a decrease of around 16% compared to the July 2018 round.

In April 2019, the first multi-technology auction, which was originally foreseen to already take place in 2018, was conducted. The auction resulted in an average awarded price of around 57 EUR/MWh. Out of the total awarded volume of 438 MW, PV projects were able to secure 371 MW, while the only wind project participating in the auction was awarded with a capacity of 67 MW. The auction resulted in very competitive prices, since PV projects were awarded at an average price of 56.5 EUR/MWh, lower than in all of the previous technology-specific auctions, while wind was awarded at 60 EUR/MWh. The outcome might be explained by the fact that Greece opened the multi-technology auction only for PV projects greater than 20 MW and for onshore wind projects larger than 50 MW, which are usually more competitive due to their larger size and thus economies of scale, compared to their smaller counterparts. These minimum thresholds are the exact maximum capacities for projects in the technology-specific auctions. When multi-technology auctions take place in parallel to technology-specific ones, bidders have the possibility to optimise between the auctions, which can then distort the outcome. By opening the two types of auctions for different technological segments/sizes, Greece circumvented this issue. Additional reasons for the lower awarded prices might have been that 1) it was the first auction for the large projects, thus participants might have wanted to gain access to the market and thus submitted very competitive bids, and 2) that there is only one more multi-technology auction with 500 MW foreseen in 2020, while the technology-specific auctions usually take place with a higher frequency and thus provide additional chances for project developers to be awarded.

[5] From a legal perspective these auctions can be considered a different scheme, since they were approved by the EU Commission in a different case.

[6] It should be noted, that in the 2018 auction rounds, Greece has implemented a 75% competition threshold, compared to the 40% in the pilot auction and in the 2019 rounds. For a detailed explanation of the competition rule, please refer to the info box in chapter 2.2.

In this multi-technology auction, an interesting provision of the Greek scheme can be observed: although PPC submitted a bid of 58 EUR/MWh for their 200 MW solar PV project, which was lower than most other bid prices (see Table 4), it was the only non-awarded project. This can be explained by the fact that if a project surpasses the auctioned volume, it is rejected and the next best project is awarded (if it fits in the remaining auctioned volume). In contrast, the German developer juwi split its 204 MW solar PV project into three smaller bids and was thus able to secure support (at significantly higher prices than PPC)[7].

Table 4: Outcome of the multi-technology auction in April 2019, Source: auction results published by RAE http://www.rae.gr/site/file/categories_new/about_rae/factsheets/2019/maj/1804?p=file&i=1

| Project | Capacity in MW | Bid price in EUR/MWh | Technology | Bidder | Award |
|---|---|---|---|---|---|
| HELIOTHEMA ENERGY S.A. | 60 | 53 | PV | EDF | Awarded |
| SE CHRONUS 14 Ltd. | 139.245 | 54.46 | PV | juwi | Awarded |
| SPES SOLARIS-SOLAR CONCEPT S.A. | 82.64 | 55.46 | PV | SPES Solaris | Awarded |
| SPES SOLARIS-SOLAR CONCEPT S.A. | 24.231 | 58.4 | PV | SPES Solaris | Awarded |
| Terna Energy S.A | 66.6 | 60 | Wind | Terna Energy | Awarded |
| SE CHRONUS 2 ΕΠΕ | 27.684 | 64.72 | PV | juwi | Awarded |
| SE CHRONUS | 37.376 | 64.72 | PV | juwi | Awarded |
| Heliaco Velos Ena S.A | 200 | 58 | PV | PPC | Not awarded |

The technology-specific auctions in July 2019, saw a change in the technological categories and the competition threshold. The two separate PV auctions were joint in a distinct PV auction for projects between 500 kW and 20 MW (open for projects smaller than 500 kW on a voluntary basis), thus constituting a single category. In addition, the competition threshold of 75% in the 2018 auctions was lowered to 40% in both the PV and wind category (as in the pilot and the multi-technology auction), since - according to a RAE representative - technology costs have fallen, leading to competitive prices in the previous auctions and thus the possibility of excessively high award prices was reduced. The average awarded price in the PV auction was 62.78 EUR/MWh which is almost at the same level as the July 2018 round for large-scale PV. In contrast, onshore wind resulted in an average price of 67.32 EUR/MWh, a price increase of around 15% compared to December 2018. This can be potentially attributed to the change in the competition threshold to an oversubscription of only 40%, which decreased the competition.

In the December 2019 auctions, the PV auction was once again undersubscribed (compared to the initially auctioned 287 MW), but due to the downward adjustment of the auction volume, the average awarded bid price of 59.98 EUR/MWh remained at a similar level as in the previous round. In contrast, the onshore wind auction was heavily oversubscribed (more than twice the initially auctioned volume), showing gradually increasing confidence and interest of investors in the Greek RES market.

[7] https://www.pv-magazine.com/2019/04/24/pv-hits-lowest-tariff-in-greeces-first-solar-wind-tender-e0-053/

### 2.1.2 Impacts of the auction design elements on the static and support cost efficiency

In general, the Greek auction can be considered successful in terms of static efficiency: the auctions drove down the levels of support and the overall support payments to generators and thus could save the consumers costs, one of the major objectives of the introduction of the auction-based support scheme. Nevertheless, it is worth looking at the following design elements of the Greek auction scheme which might have had a significant impact on the static and support cost efficiency.

#### Investor confidence

In general, it can be observed that the introduction of a new, stable support scheme has helped to strengthen investor confidence in the Greek RES market. Angelopoulos et al. (2017) state that the Law 4414/2016 provides a solid regulatory framework for RES deployment, mitigating overall risk perception. Furthermore, the authors argue that "the shift from guaranteed remuneration mechanisms to market-based support schemes for the newly developed RE projects constitutes a significant policy action for the considerable reduction of the policy design risk". Reducing the risk has helped to decrease the cost of capital, which in turn might have led to lower awarded prices and thus reduced support payments by the government (and thus increased support cost efficiency).

#### Grid connection costs

In Greece, successful bidders are responsible and bear the costs for connecting their project to the grid. The specific details are specified in the individual (final) grid connection offer or grid connection agreement, which are needed as a material prequalification to participate in the auction. Due to this regulation, these costs have to be internalised by the bidder and thus have an impact on the calculated bid price.

Bada and Perrakis (2012) quantified the average grid connection cost in their study from 2012 at 66,088 EUR/MW for onshore wind and for PV at 187,122 EUR/MW (when connected to the high voltage grid) and 121,665 EUR/MW for a connection to the medium voltage grid. Assuming a 20 year life of the projects, and a capacity factor of 24.9% for onshore wind and 16.9% for PV, we can calculate the following levelised grid connection costs:

Table 5: Overview of grid connection costs in Greece, Source: own elaboration based on Bada and Perrakis (2012) and Loumakis et al. (2019)

| | Onshore wind | PV (HV) | PV (MV) |
|---|---|---|---|
| Average CAPEX for grid connection [EUR/MW] | 66,088 | 187,122 | 121,665 |
| Life [a] | 20 | 20 | 20 |
| Capacity factor | 0.249 | 0.169 | 0.169 |
| Levelised grid connection costs [EUR/MWh] | 1.51 | 6.32 | 4.11 |

Therefore, Greek bidders have to take into account around 1.5 EUR/MWh for onshore wind projects and around 6.3 EUR/MWh for PV projects as a mark-up on their project's LCOE Including grid connection costs in the bids has certainly increased awarded prices (ceteris paribus) and thus support costs.

Furthermore, to sign the binding grid connection offer, which is needed to participate in the auction procedure, potential bidders have to provide the following financial guarantees to the relevant authority (TSO or DSO) (Law 4152/2013):

- 42 EUR/kW for the capacity ≤ 1 MW
- 21 EUR/kW for the capacity between 1 MW and ≤ 10 MW
- 14 EUR/kW for the capacity 10 MW and ≤ 100 MW
- 7 EUR/kW for the capacity > 100 MW

These payments are quite significant taking into account typical investment expenditures of 1000 EUR/kW for PV and 1250 EUR/kW for onshore wind. Thus, the guarantees for the grid connection surpass the amount for bid bonds and almost reach the values of the completion bonds.

These guarantees can have a significant impact on the competition and actor diversity in the auctions, since potential bidders, especially smaller ones, might not have the financial capacity to provide these amounts and thus are unable to obtain the grid connection agreement.

### Volume adjustment

In case of undersubscription and thus insufficient competition, the bidders would submit a bid price equal to the ceiling price, thus decreasing the support cost efficiency and probably the static efficiency of the auction. Therefore, the Greek auction design foresees a volume adjustment, which ensures sufficient competition during the auction procedure.

In general, volume adjustments after the auction takes place, should be avoided, since they might distort the supply of projects in the medium or long-term. Nevertheless, in the Greek format, bidders still have the possibility to adjust their bid to the circumstances during the auction.

Such a volume adjustment gives the incentive to bidders to participate with "fake" projects in the auction. In this case, bidders submit applications in the first stage of the auction for projects that have already obtained all the necessary licenses, but are not foreseen to be realised any time soon. This is a serious issue especially in Greece, since a lot of projects have been developed in the past years, but due to the retroactive cuts in FITs and the overall uncertain economic climate, many of those projects were not realised but still retained their licenses. This situation has already occurred in the cancelled December 2018 large-scale PV auctions, where several qualified projects did not submit any bid in the actual auction and which can be assumed were just participating to circumvent the volume adjustment for the "real" projects.

### Dynamic auction format

The Greek auctions pursue a dynamic auction process, namely the "Yankee format". Under this format, bidders can submit bids up to the ceiling price ("Reference Tariff") and adapt those (only downwards) until the 30 min auction period is over. The auction is conducted on an auction platform, which is aimed to increase transparency and thus investor confidence in the procedure.

The question is whether the dynamic auction format had any advantage compared to a static one. In theory, dynamic auction formats reveal to the participants much more information and provide possibilities to learn about the costs and their competitors, since they can observe the others' behaviour. Due to this feature, dynamic auction formats can decrease the risk of the winner's curse, as bidders can decrease their prices gradually and can observe if their submitted price is awarded. In a static one, if bidders have calculated their bid price overly optimistic, they have no chance to re-adjust their price once submitted. In the Greek auctions, bidders can observe 1) if their projects are awarded, 2) the best/lowest awarded bid at any time, and 3) the remaining, available volume (see Figure 4).

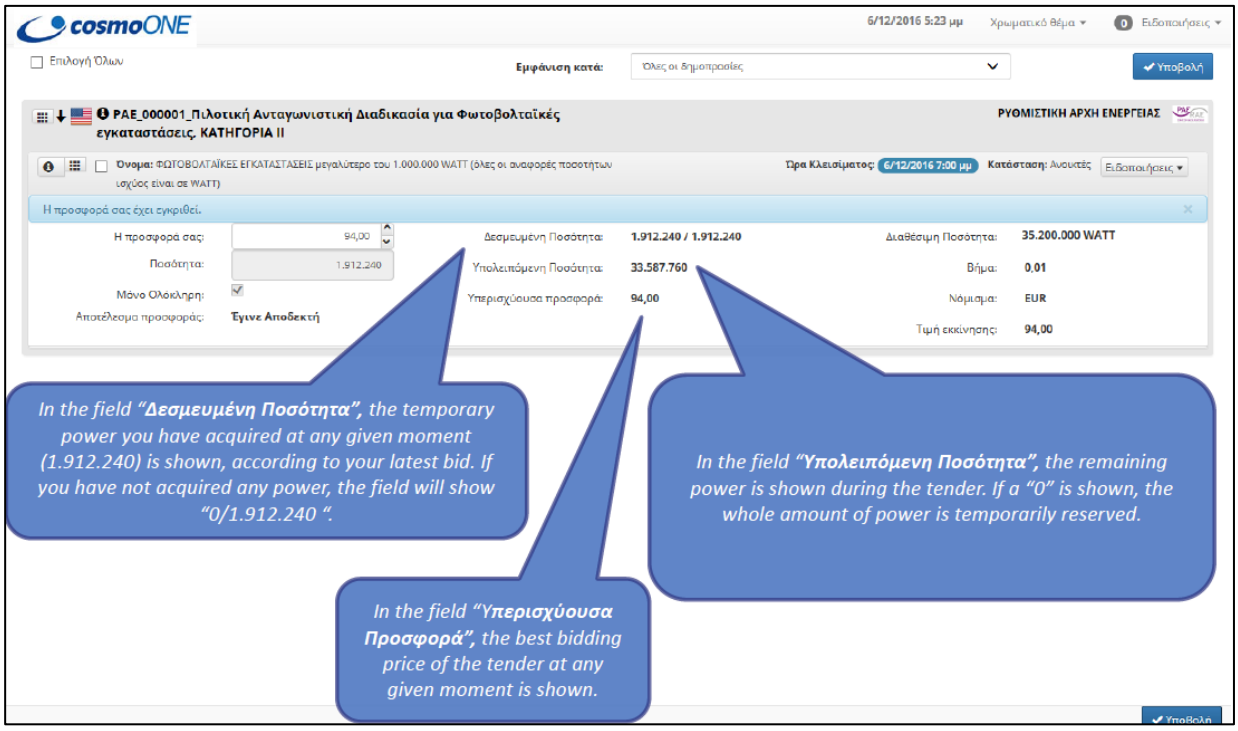


Figure 4: Screenshot of the tender screen in the Online Platform, Source: Papachristou, Kapetana (11/21/2017)

According to Papachristou (9/12/2018), successful projects in Category I seem to have had better strategies as they submitted less, but more effective bids. This indicates that unsuccessful projects might have participated in the auction with a "trial-and-error" strategy, which might be due to their lack of experience. The same applies to projects in the large-scale PV and onshore wind category.

The combination with the volume adjustment is independent from the auction format. In the Greek case, it is crucial that the bidders know *in advance* that the auction is always oversubscribed. Therefore, even under a static auction format, bidders would have been able to adjust their bids taking into account the level of competition in the auction.

In general, the dynamic auction format might have helped inexperienced bidders to avoid submitting unsustainably low bids ("winner's curse"), although it is not clear whether it led to lower prices compared to a static format.

### Determining the last awarded bid

In a price-only and multi-unit auction procedure, all the submitted (and qualified) bids are ranked based on their submitted bid prices, from the lowest to the highest. Bids are then awarded until the auctioned volume is surpassed by a bid. In this case, the auctioneer can either 1) award this project with its entire capacity, as e.g. in the German auction system, 2) award only part of the capacity up to the auctioned volume and propose to the relevant bidder to only realise this volume (e.g. in Denmark), or 3) reject the bid entirely, and optionally award a bid with a higher price, which still fits in the auctioned volume.

Greece opted for the third option, as the auction algorithm ranks the bids by price and awards the projects, until a bid surpasses the auctioned volume. This project is then rejected and the next one in the ranking is awarded, if it still fits into the remaining volume. This process is continued, as long as no projects is available that could fill in the remaining volume. Therefore, the awarded volume will never surpass the auctioned volume in the Greek auction scheme.

By preferring smaller projects that fit into the remaining capacity, rather than the cheapest ones, the auction design might fail to ensure static efficiency and definitely increases support cost expenditures, since the

more expensive projects might be awarded. This has actually happened in almost all of the conducted auction rounds, with the most significant impact in the multi-technology auction. Would the auction design still award the last bid completely, PPC (58 EUR/MWh) would have been awarded and would decrease the average awarded price from 57.03 EUR/MWh (awarded volume: 455.56 MW) to 55.92 EUR/MWh (awarded volume: 481.89 MW).

Furthermore, this approach gives bidders the incentive to split up their projects into smaller ones in order to increase their chances to be awarded with a comparably higher price (as their projects might still fit into the remaining auctioned capacity).

The Greek association of photovoltaic companies, HELAPCO, criticizes this approach as well, pleading to prefer larger projects with lower bid prices that surpass the auctioned volume instead of awarding the smaller, higher-priced ones (HELAPCO 2019).

### Size limitations

Another interesting feature of the Greek auction scheme is the differentiation of the between the technology-specific and multi-technology auctions in terms of size. As already stated in the State Aid Decision on Greece (European Commission 2018), the technology-specific auctions should foresee a maximum size for individual bids, so that competition is increased in the multi-technology auctions, which will be open for projects starting from this maximum size. Furthermore, as both auction types will run in parallel, this approach can help analysing the effects in the multi-technology auction.

In the technology-specific auctions, the onshore wind category remained unchanged in terms of size limitations throughout the several auction rounds, but the size limitations in the PV auction were adapted each year. During the pilot PV auction, two categories existed, one for small-scale projects up to 1 MW, and one for large-scale PV power plants with a capacity greater than 1 MW and up to 10 MW. In the 2018 PV auctions, the two categories still persisted, but the maximum size in the second PV segment was increased to 20 MW. The 2019 auctions implemented a single PV auction segment, comprising projects between 0.5 MW and 20 MW. Due to this number of adjustments, it is worth taking a deeper look into the impact on the static efficiency.

The increase of the maximum size from 10 MW (2016) to 20 MW (2018), only triggered marginal interest for the project developers to participate with larger projects. In the July 2018 auction, only two projects with a capacity greater than 10 MW (namely 14.99 MW) participated, but were not awarded. Even in the subsequent auction rounds, projects larger than 10 MW played a minor role both in terms of submitted, as well as awarded bids (see Figure 5).

In contrast, PV projects were very successful in the multi-technology auction, winning most of the auctioned capacity. Furthermore, those projects' capacities were mostly well above the 20 MW minimum. This might indicate that the Greek PV market mostly consists of a high number of projects under 10 MW and a small number of quite large power plants, which can reach capacities well above 100 MW.

Another reason for the high number of projects below 10 MW might be the mechanism that determines the last, awarded bid. The algorithm in the dynamic auction procedure automatically rejects bids that would surpass the auctioned volume and prefers instead smaller projects, even with a higher bid price. This has occurred in almost all auction rounds. This gives project developers the incentive to "split up" their project in several smaller, individual pieces to increase the chances of being awarded, as juwi has done in the multi-technology auction (see Table 4).

### Segmentation of PV auctions

Moreover, it is worth looking into the effect of the segmentation of the PV category into small- and large-scale projects. In the pilot PV auctions, as well as in the 2018 PV auction rounds, PV was auctioned in two different segments, namely one for small-scale projects below or equal 1 MW (no obligation to obtain a production license by RAE) and projects above 1 MW and up to 10 MW/20 MW. Although in the first two auction rounds, the small-scale PV competitions resulted in comparably higher prices, the second auction in 2018

achieved prices similar to its large-scale counterpart. Consequently, RAE proposed to join these two segments together into a single category, which happened in the two auctions in 2019.

Although it was expected that the small-scale appliances would be fairly competitive, the awarded projects in the 2019 auctions showed exactly the opposite (see Figure 5). While in the 2018 auctions small-scale projects were awarded around 53% (July 2018) and 62% (December 2018) of the overall awarded capacity for PV, their share in 2019 decreased drastically to 4.5% (July 2019) and 6.4% (December 2019).

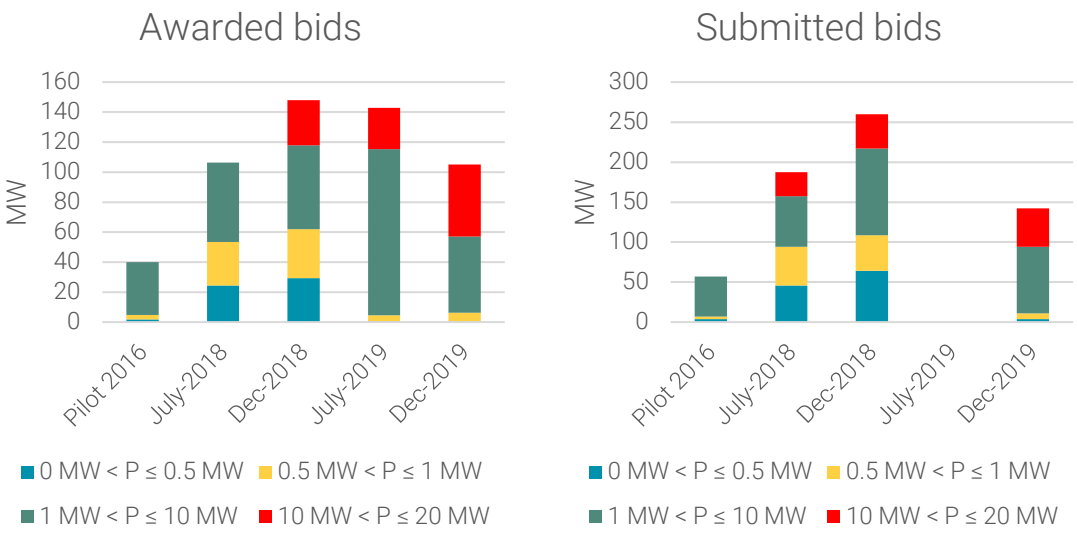


Figure 5: Overview of awarded and submitted bids in terms of capacity in the technology-specific PV auctions, Source: own elaboration

The main reason behind this outcome might be that small-scale projects are simply not as competitive as large ones. But how could the relatively low prices of the December 2018 auction be explained? Looking at the detailed results, the fact that several bids from the same bidder with the exact same capacity and similar bid prices were submitted, indicates that bidders might have split up their projects for the 2018 auctions. Thus they could participate in the small-scale segment, as they might have anticipated less strong bidders and thus could achieve higher prices for their projects.

Another interesting feature is the possibility for small-scale projects under 500 kW to participate in the auctions on a voluntary basis. First, it should be noted that those PV projects were eligible for an administratively-set FIT which was adapted annually to the average electricity market price (Table 6). Thus, the FIT level was in fact working as a floor price for these projects in the auction, since no bidder had the incentive to submit a lower bid. Therefore, at a first look, it seems unclear why several bids below 500 kW submitted prices of 65.99 and 66 EUR/MWh in the December 2019 auction, although they were eligible for a FIT of around 70 EUR/MWh (in 2020). An explanation could be that Law 4602/2019 prohibited individuals and companies to have more than two projects of the same technology receiving support in form of an administratively-set FIT/FIP. Thus, participating in the auction might be the only way to realise their already developed projects.

Furthermore, Law 4602/2019 introduced FITs for PV projects under 500 kW and for energy community projects smaller or equal than 1 MW. Greece connected the level of FITs to the auction scheme: the level of support is calculated as the weighted average of the average awarded prices of the three (technology-specific PV) auction rounds preceding the last one, increased by 5%. As of the 01 January 2020, when the new support scheme took effect, the FIT level was calculated as 70.30 EUR/MWh[8].

[8] http://www.lagie.gr/anakoinoseis/anakoinoseis/anakoinosi/article/1802/

Table 6: FITs for small-scale PV, Source: own elaboration based on Ministerial Decision YAPE/F1/1289/9012 & 1288/9011 and http://www.lagie.gr/fileadmin/groups/EDSHE/MiniaiaDeltiaEL/04_JUNE__2019_DELTIO_ELAPE_v1.0_30.08.2019.pdf, *Starting in 2020, the FIT is calculated based on the results of the technology-specific auctions (Law 4602/2019)

| | | 2016 | 2017 | 2018 | 2019 | 2020* |
|---|---|---|---|---|---|---|
| PV ≤ 100 kW | 1.2 * average wholesale electricity price of the previous year | 62.88 | 51.36 | 65.64 | 72.47 | 70.30 |
| 100 kW < PV < 500 kW | 1.1 * average wholesale electricity price of the previous year | 57.64 | 47.08 | 60.17 | 66.43 | |

## 2.2 Effectiveness

This study analyses two types of effectiveness: 1) awarding all of the auctioned volume (which corresponds to an a-priori effectiveness) and 2) the auctions achieving a high realisation rate of the awarded projects.

### 2.2.1 Auctioned and awarded volumes

The Greek Ministry has foreseen in its Ministerial Decree a total volume of 2.6 GW of RES to be auctioned in the period between 2018-2020 (see the following tables).

Table 7: Initial auction volumes for the years 2018-2020 in MW (published in April 2018), Source: Ministerial Decision APEEK/A/F1/oik.172859

| | | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| Onshore wind | Technology-specific | 300 MW | 300 MW + Residual capacity (not allocated in) 2018 | 300 MW + Residual capacity (not allocated in) 2019 |
| PV | Technology-specific | 300 MW | 300 MW + Residual capacity (not allocated in) 2018 | 300 MW + Residual capacity (not allocated in) 2019 |
| Multi-technology | Multi-technology | 400 MW | 400 MW + Residual capacity (not allocated in) 2018 | - |

Table 8: Auction volumes for the years 2019 and 2020 in MW (published in April 2019), Source: Ministerial Decision YPEN/DAPEEK/34495/1107

| | | 2019 | 2020 |
|---|---|---|---|
| Onshore wind | 3 MW < Onshore wind < 50 MW | 400 MW | 300 MW + Residual capacity (not allo-cated in) 2019 |
| | Onshore wind projects ≤ 60 kW | - | 20 MW |
| PV | 500 kW ≤ PV ≤ 20 MW | 430 MW | 300 MW + Residual capacity (not allo-cated in) 2019 |
| Location-specific auctions ( RES connected to "Makri- Poly-potamos subsea cable") | All PV and onshore wind sizes | To be determined. | - |
| Multi-technology | Multi-technology | - | 500 MW |

Table 9: Auction volumes for the year 2020 in MW (published in February 2020), Source: Ministerial Decision YPEN/DAPEEK/11163/409

| | | 2020 |
|---|---|---|
| Onshore wind | 3 MW < Onshore wind < 50 MW | 480 MW + Residual capacity (not allo-cated in) 2019 |
| | Onshore wind projects ≤ 60 kW | 20 MW |
| PV | 500 kW ≤ PV ≤ 20 MW | 300 MW + Residual capacity (not allo-cated in) 2019 |
| Location-specific auctions ( RES connected to "Makri- Poly-potamos subsea cable") | All PV and onshore wind sizes | To be determined. |
| Multi-technology | Multi-technology | 600 MW |

Looking at the awarded volumes, the trade-off of the Greek volume adjustment can be seen: although low prices have been achieved, the initial volumes intended to be auctioned by RAE (see Figure 3 and Table 3) have only been awarded in in the pilot PV auction in 2016 and in the onshore wind auction in December 2019. This is due to the fact that the actually auctioned volume in the second stage of the auction round has to be surpassed by 40% (in 2016 and 2019) or 75% (in 2018) by the submitted volumes, with the goal to create enough competition in the respective auction. The specific procedure of the Greek volume adjustment is presented in the following Info box 1.

Info box 1: The Greek volume adjustment

In order to ensure sufficient competition, the Greek auction scheme foresees a (downward) adjustment of the auctioned volumes based on the total capacity of submitted bids/applications. Therefore, the auctions are conducted in two stages: The first one is the prequalification stage, which determines the eligible bidders, and based on their aggregated submitted volumes, the actual auction volume is determined. The second stage consists of the actual auction procedure.

Since the volume adjustment takes place in the first stage, we will have a closer look at the concrete procedure. RAE publishes a call for bids with an initial auction volume based on the relevant Ministerial Decision and the overall market conditions. Subsequently, interested bidders submit their application to participate in the auction, which includes their project's capacity, the required documentation for the material prequalification, as well as the bid bond. After reviewing the applications, RAE publishes a preliminary list of eligible bidders. After a certain period for legal actions by the applicants, the final list of eligible bidders is published by RAE. Based on their total submitted capacity and a specific threshold of oversubscription, RAE determines the final, actually auctioned volume.

The threshold foresees, that the auctioned volume is oversubscribed by at least 40% (75% in the 2018 auction rounds). That leads to two possible outcomes: 1) if the total submitted volume is (at least) 40% higher than the initial auctioned volume, it is retained. 2) If the total submitted volume is less than 40% higher, the auctioned volume is adjusted downwards, so that the 40% is achieved. As an example, in the July 2019 onshore wind auction, it was initially foreseen to auction 300 MW. Since only 261.8 MW of bids were eligible to participate, RAE finally only auctioned 187 MW, so that the 40% threshold is fulfilled.

In 7 out of 13 conducted auction rounds, the submitted volume actually surpassed the initially foreseen auctioned capacity. This poses the question, how much awarded volume was "lost" due to the volume adjustment, which could have actually been awarded in the respective auction rounds (see Figure 6). By December 2019, in total 1,117 MW of solar PV could has been auctioned by RAE[9], while only 543 MW have been actually awarded. Taking into account the individual auction rounds, a total of around 200 MW could have been additionally awarded, which constitutes around 18% of the initially auctioned volumes, simply if the volume adjustment wouldn't have existed. A total of 1,054 MW of onshore wind has been auctioned by December 2019, with 748 MW eventually awarded. Looking again at the "lost volumes", these are 268 MW, accounting for around 25% of the initially auctioned volumes.

[9] Please note that the multi-technology auction in April 2019 has been excluded from this analysis. First, there are no technology-specific shares/quotas assigned to the 600 MW auctioned volume and second, the outcome would remain the same without the volume adjustment.

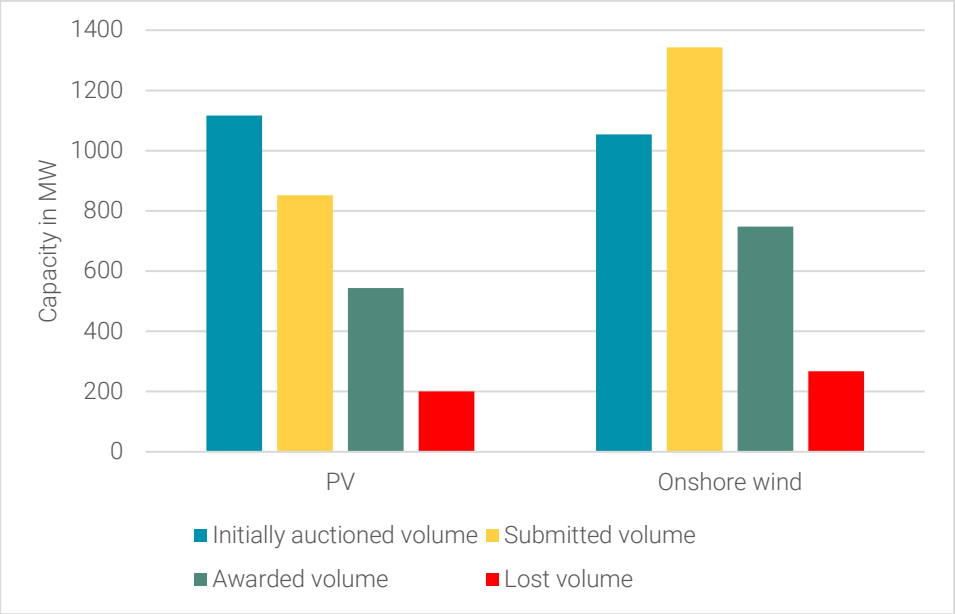


Figure 6: Comparison of "lost auction volume" which could have been awarded in the auctions. Source: own elaboration based on auction results

Moreover, the only exceptions in which the submitted volumes were lower than the initially auctioned demand were the July 2018 large-scale PV auction, the two technology-specific auctions in July 2019 (both large-scale PV and onshore wind), as well as the PV auction in December 2019.

Another significant reason for the comparably low number of (especially PV) projects participating in the auctions is the lack of production licenses. RAE is currently having troubles issuing those licenses - 1,891 of the 2,346 applications submitted since 2016 are still pending (PV Magazine 2020), while developers have to wait an average of 18 months for their application to be processed. In terms of capacity, around 8.3 GW of applications for PV projects await approval (PV Magazine 2019a, 2019b). Nevertheless, the newly formed government is planning to solve this issue by overhauling the current production licensing system. A new, more efficient licensing procedure will be introduced in which interested developers have to apply online and have to provide only minimal details of their project (e.g. generation capacity and location). This new and more efficient procedure will be open to all new and existing applications received since March 2018. In addition, the government aims to reduce the administrative burden for developers by reforming and streamlining the licensing procedure. With these measures, the government aims to increase the interest in the Greek RES market and thus the competition in the future PV auction rounds (PV Magazine 2020).

### 2.2.2 Realisation rates

Regarding the realisation rates, only the first pilot PV auction, as well as the projects in Category I of the July 2018 auction can be analysed, since project developers in the remaining auctions still have time to realise their projects. Nevertheless, the pilot PV auction was quite successful in terms of effectiveness, since most of the projects were actually built (RAE Announcement 2019a): 7 out of 8 (4.30 MW out of 4.80) from Category I (PV < 1 MW) and 8 out of 8 (the entire 35.12 MW) from Category II (1 MW < PV < 10 MW). In terms of actual realisation rates, Category I achieved 90%, while the large-scale PV Category II amounted to 100%. Furthermore, in Category I (PV < 1 MW) of the July 2018 auctions, all of the projects have been realised, thus a realisation rate of 100% has been achieved (RAE Announcement 2019b).

In the Greek auction scheme, successful bidders have to submit progress reports to RAE every 6 months after the announcement of the auction results, in which they describe their projects' development. These reports might have helped to achieve the timely and high number of realisations by increasing the pressure on the project developers. Furthermore, this approach can help RAE identify and possibly solve potential administrative barriers of the project developers.

# 3 Conclusions

- The Greek auction scheme was able to achieve a significant cost reduction compared to the previous administratively-set FIT scheme.
- Automatic volume adjustment: Part of the reason for the low awarded prices in Greece is the volume adjustment: the initially auctioned volume is adjusted downward based on the submitted bid volume, until a certain threshold of oversubscription (40% or 75%) is reached. This creates competition in the respective auction round which leads to lower awarded prices (at least in the short term).
- Nevertheless, the volume adjustment might hinder in the long term the target achievement, since a significant number of projects, which would be needed, is not awarded merely due to this feature.
- Determination of the last awarded bid: The mechanism of how to determine the last awarded bid is crucial for an efficient auction. In Greece's case, if a project surpasses the auctioned volume, the next one in the ranking (with a higher bid price) is selected if it fits in the remaining volume. This decreases presumably the static efficiency and certainly increases the support expenditures.
- Size limitations: Greece has implemented maximum sizes in the technology-specific auctions that do not overlap with the minimum sizes in the multi-technology auctions, which are open to large-scale projects. This increases the competition in the respective auction formats and avoids two schemes running in parallel for the same technological segment, which can have a negative impact on the auctions' efficiency.
- Segmentation of PV auctions: Dividing the PV auctions into two segments (small- and large-scale projects) can give an advantage to small-scale appliances, which would not have been awarded in a single category. Nevertheless, this might give bidders the incentive to artificially split up their projects into smaller ones in order to participate in the small-scale segment with presumably weaker bidders.
- Administrative issues: In Greece's case the delay in issuing generation licenses - a prequalification requirement for the auction - decreases significantly the number of participating projects. The low competition can then lead to low efficiency and higher support costs. This shows the impact of efficient administrative procedures outside of the actual auction design.
- In terms of realisation rates, the Greek auctions were very successful so far. The implementation of a 6-months progress report might have supported this development, since RAE can observe the development and might be able to support the project developer in case of administrative obstacles.

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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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