COMPARISON OF CFD RELATED BEST PRACTICES ACROSS EUROPE

REKK

17. 04. 2024

Lead author: Alfa Diallo; contact: alfa.diallo@rekk.hu

Authors: András Vékony, Bettina Dézsi, Katalin Varga, László Szabó, Mária Bartek-Lesi

17.04.2024

Tel.: +36-1-482-5153

E-mail: rekk@rekk.hu

TABLE OF CONTENTS

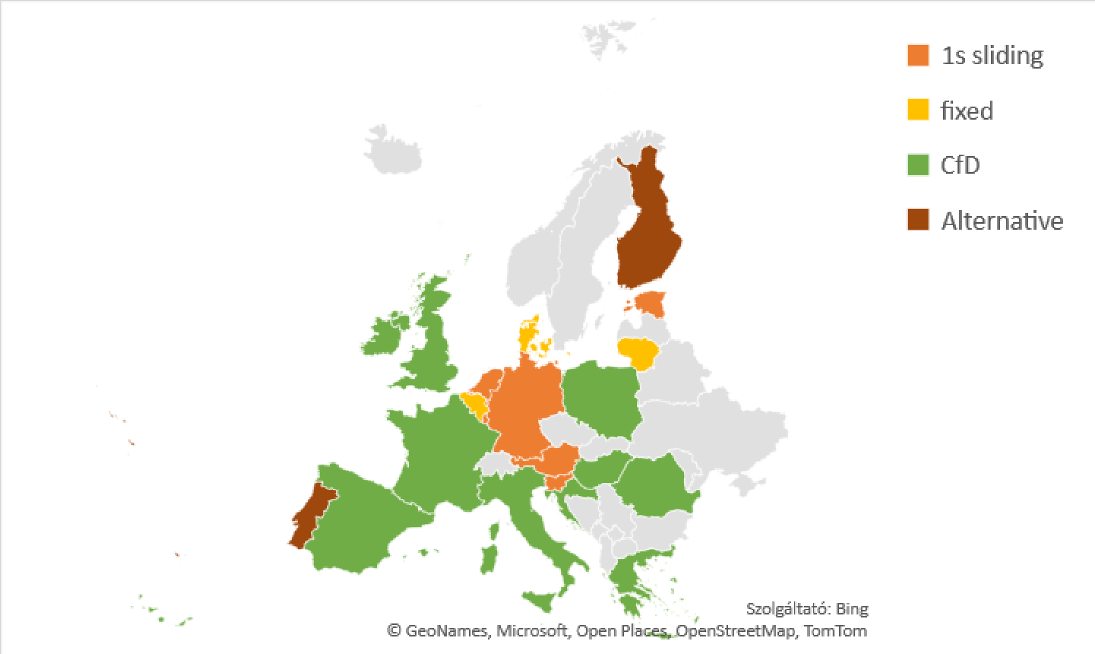
1 Introduction

Austria has introduced renewable auctions in 2022, however the current scheme can be considered as a limited success, as in 2023 only 35% of the auctioned capacities in terms of budget were contracted for large-scale PV installations[1]. Additionally, the country operates a hybrid remuneration scheme which can be considered mainly as a one-sided feed-in premium (FIP) but has elements of the two-sided contract for difference (CfD) as well. The EU Electricity Market Design (EMD) reform plan, however, proposes the mandatory appliance of CfDs for renewable support in all member states[2].

Therefore, the main aim of this report is to collect good and bad practices in association with optimal CfD design based on European experience. It is important to highlight that this report does not provide country-specific recommendations for Austria, however, the main considerations discussed can serve as a good starting point for further improving the Austrian premium scheme.

The analysis consists of two main parts. The first part is a high-level cross-country comparison of 8 European countries using CfDs.

FIGURE 1: APPLIED REMUNERATION SCHEMES WITHIN THE EUROPEAN UNION & UNITED KINGDOM



Source: Bettina Dézsi (2023): Auctions in EU member states, current trends, and changes [3]

The countries selected for the comparison are France, Greece, Hungary, Ireland, Italy, Poland, Spain, and the United Kingdom. After the high-level country comparison, three case studies

[1] https://www.pv-magazine.com/2023/11/29/limited-success-for-large-scale-pv-auctions-in-austria/
[2] https://www.consilium.europa.eu/en/policies/electricity-market-reform/
[3] https://rekk.hu/downloads/events/Dezsi_REKK_Auctions%20in%20EU%20MS.pdf

are presented on Hungary, Spain, and the UK, which provide a more in-depth analysis about the countries' premium systems.

Both the high-level country comparison and the case studies focus on three main issues:

- The optimal implementation of CfDs, which is the main focus of the report. While CfD systems have many advantages, it has one major disadvantage: it provides limited incentives for market participants to consider market price signals in their operation. This is less of an issue for intermittent generators, as they have limited capability to adjust their production without storage, however, can lead to major inefficiencies in the case of dispatchable RES power plants such as biomass or hydro storage.
- The second focus of the analysis is to analyse how market integration is possible for dispatchable RES.
- Finally, from the second half of 2021, electricity market prices increased drastically, resulting in many established renewable technologies reaching a level of maturity where they no longer needed support to operate profitably. Therefore, from 2021 onwards, market-based solutions, especially power purchase agreements (PPAs) between producers and electricity consumers or utilities, rapidly started to gain ground. This, however, raised the question of how auctions and PPAs can coexist, whether they are more like competitors or supplementary solutions for RES deployment. Thus, the third topic of the report is to analyse the relationship between auctions and PPAs in the selected countries.

2 High level country comparison

2.1 General auction design

Auctions in Europe tend to be very heterogenous with respect to their design[4], meaning that by analysing countries applying CfD-based support allocation, not similar systems are compared. For example, most CfD systems are purely auction-based support measures, but some countries operate administrative CfD for smaller capacities, such as Hungary[5], or for technologies that are not allowed to participate in tenders, such as in Greece. However, focusing on auctions, there are still significant differences in their design present. Table 1Table summarizes the most important design elements in the eight countries analysed.

TABLE 1: HIGH LEVEL OVERVIEW OF THE AUCTION SYSTEMS OF THE 8 COUNTRIES OF INTEREST

	Eligible technologies	Technology specificity	Size-based division within the auction	Auctioned product	Average number of auction rounds per year
France	PV, wind, bioenergy, hydro	Technology specific[6]	Yes	Capacity	4[7]
Greece	PV, onshore wind	Multi-technology[8]	Yes	Capacity	N/A
Hungary	All RES technologies	Multi-technology	Yes	Energy & Budget	1[9]
Ireland	All RES technologies	Multi-technology	No	Energy	1
Italy	PV, onshore wind, hydro, sewage treatment gas	Technology basket[10]	Yes	Capacity	3

[4] https://op.europa.eu/hu/publication-detail/-/publication/e04f3bb2-649f-11ed-92ed-01aa75ed71a1/language-en
[5] Although it is still part of the regulation, this support type is not available in practice.
[6] Since the end of 2022 in parallel with the technology specific tenders a multi-technology round is introduced as well.
[7] Various number of rounds for different technologies between 1-4 per year.
[8] Technology specific tenders were organised for small-scale PV projects.
[9] No auction has been organised since 2022.
[10] There is a separate auction basket for PV and wind, and another for hydro and sewage treatment gas.

Poland	All RES technologies	Technology basket[11]	Yes	Energy & Budget	1
Spain	PV, onshore wind, bioenergy, hydro	Hybrid[12]	No	Capacity	2[13]
United Kingdom	All RES technologies	Technology basket[14]	No	Budget	0.5[15]

Source: Aures II auction database[16] and websites of the auctioneers

Most auctions allow all or almost all of RES technologies to participate. The technology focus of the auctions varies considerably from country to country. In some countries, such as Hungary, Greece, or Ireland, only PV and wind projects win at the auctions in practice, while in others, such as the United Kingdom, Italy or Poland, the auctions can be regarded as more diverse in terms of winning technologies. This is mainly determined by the fact that at what extent different technologies are allowed to compete against each other.

There are also major differences in whether energy, capacity or budget is auctioned, without clear best practice. Most of the analysed auctions favour small projects through separate tenders (except for Spain and the UK) and organise yearly auctions (except for France and Italy).

These differences make it difficult to compare the different CfD designs, as several outcomes or performance measures can be the result of other elements of the auction design unrelated to CfDs.

2.2 Specifics of CfD design

CfDs are characterised by several design elements, which are analysed in this report. The most important characteristic is how the reference prices are calculated, including the length of the reference period, and whether reference prices are weighted by produced quantity for intermittent generators. The second important element is whether the strike price itself is adjusted in some way, before being compared to the reference price. And finally, as CfD payments require pay-backs from the producers, it is worth examining whether it is possible to somehow avoid repayments (for example, by not entering into the contract with the official CfD off-taker in the initial phase). These features of the CfD scheme are summarised in Table 2 for the eight countries.

[11] Multiple technology baskets are incorporated. In some of these, more technologies compete against each other (for example PV and wind), while others are technology specific (agricultural biogas).
[12] The auction contains a multi-technology basket, but some technology-specific quotas are also applied.
[13] No auction has been organised since 2022.
[14] There is a basket for mature and another for developing technologies.
[15] Recently changed to yearly auctions.
[16] http://aures2project.eu/auction-database/

TABLE 2: MOST IMPORTANT CHARACTERISTICS OF CFD IN THE 8 COUNTRIES OF INTEREST

	Reference technology for reference price calculation	Reference period	Strike price adjustment	Possibility for delayed CfD payment
France	Technology specific for intermittent generation	Monthly	Bonus payment for solar if there are at least 15 hours with a price of 0 EUR/MWh in the year and PV did not produce in these hours.	Temporarily, in 2022, 18 month of market operation was allowed before entering the scheme.
Greece	Technology specific for intermittent generation	Monthly	No price modification	Until 03/2023, 24 months of market operation was allowed before entering the scheme.
Hungary	Technology specific for intermittent generation	Monthly	Indexation with inflation -1% point	Indefinite time of market operation is allowed before entering the CfD scheme, but once entered, it is not possible to leave.
Ireland	Not relevant[17]	Hourly for intermittent, yearly for dispatchable RES	Evaluation Correction Factor can be used to favour certain technologies, they are determined on a round-by-round basis	No information about the possibility to delay entry
Italy	Not relevant	Hourly	No adjustment	18 month of market operation is allowed before entering the scheme.
Poland	Technology specific for intermittent generation	Monthly	Adjusted with inflation	No possibility to delay entry into the scheme

[17] Because the reference period for intermittent generators is hourly, production-based weighted price is the same as unweighted price.

Spain	Not relevant	Hourly	Payment received is the weighted average of the bid price and the market price, weight of market price is higher for dispatchable producers	No possibility to delay entry into the scheme
United Kingdom	Not relevant	Hourly for intermittent, half-yearly for dispatchable	Adjusted with inflation	No information about the possibility to delay entry

Source: REKK data gathering based on interviews and national sources

There are two dominant trends in reference price setting across the countries. In the first case, the scheme does not differentiate between dispatchable RES technologies and intermittent generation. In this setup, the reference period is usually longer, e.g. one month, and the reference price is calculated as the production-weighted average of day-ahead market (DAM) prices for PV and wind technologies. Such a system is operated in Hungary, Poland, Greece, and France.

In Italy and Spain, the reference period is not differentiated by technology, but a universal hourly reference price is applied. This solution disincentivises the market integration of renewables, as dispatchable power plants are less motivated to follow price signals, and intermittent generators are not encouraged to install storage to earn extra profit. This is probably the reason for the strike price adjustment applied by Spain, to enhance the market integration of RES more.

In other countries, such as Ireland and the United Kingdom, the reference period for dispatchable and intermittent generation differs. For the latter category, an hourly reference period is applied, but for dispatchable RES a significantly longer half-yearly or yearly period is used. This leads to better integration of dispatchable RES but does not incentivise intermittent generators to think of solutions (such as installing storages) which allow them to follow price signals.

Bid price adjustment is not very common in the investigated countries, usually the bids are only adjusted with inflation, more complex adjustments only exist in Spain and were applied in the early rounds of the auctions in the UK.

As a final point, many CfD schemes allow late entry of the producers into the payment mechanisms, which in practice means that producers can avoid pay-back in the first couple of years by operating fully on the wholesale market. This issue gained relevance in 2021-2022, when wholesale market prices were significantly higher than any time in the previous decade, creating very good opportunities for RES producers with low marginal costs. Allowing late entry into the payment mechanism provides very good incentives for the producers, however, can result in significant revenue loss for the operator of the CfD scheme, which could have been used for grid development. Around half of the analysed countries allowed late entry at some point in the crisis, but this option was already phased out in France and Greece, although it is still allowed in Italy and Hungary.

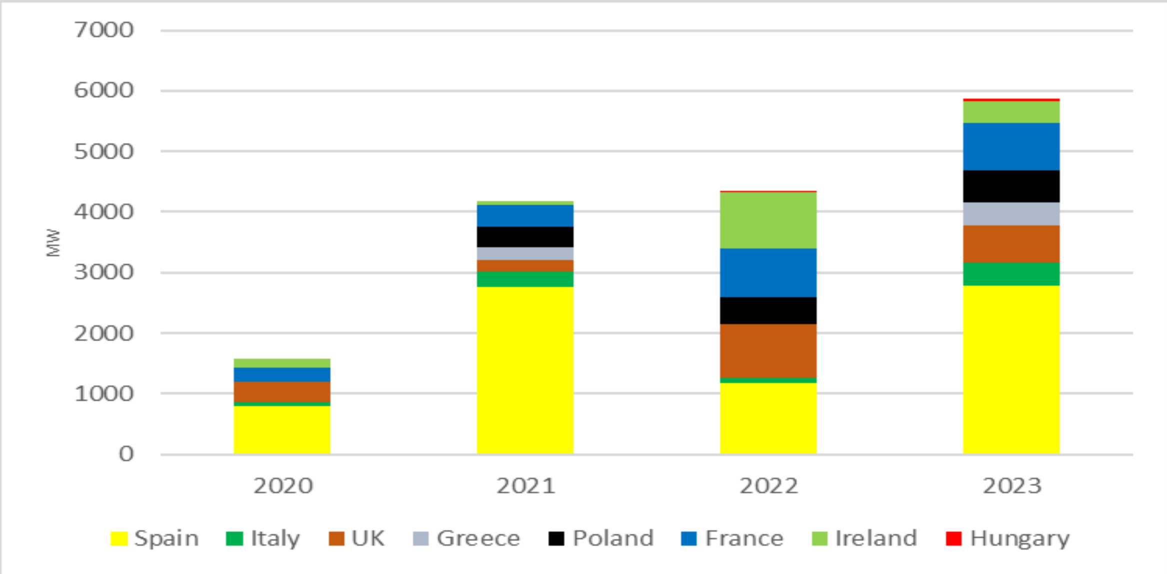
2.3 PPA markets and auctions

PPA markets across Europe are also very heterogeneous in terms of contracted volumes, prices, and maturity. In 2022, Aurora[18] classified Spain and the United Kingdom as mature, Poland and Italy as moderately mature, and the rest of the analysed 8 countries as immature, with respect to their PPA markets.

A general tendency in Europe since 2021 is that contracted PPA capacities are on a constant rise, however the geographical distribution of new contracts is very uneven, with most of these installations concentrated in Western or Northern European markets. The main reason for this phenomenon is that PPAs usually require many financially reliable off-takers, which are more common in these regions, due to their economic development. On top of the general economic situation, the regulatory environment is also a very important factor determining the popularity of PPAs.

Figure 2 summarizes the contracted capacities of the last three years in the 8 markets.

FIGURE 2: CONTRACTED NEW PPA CAPACITES FOR THE 8 COUNTRIES OF INTEREST, 2021-2023[19]



Source:windeurope.org[20] and national sources

The graph shows that Spain is the most mature PPA market in Europe, usually with the highest contracted capacity within a year across the continent. In 2023, the newly contracted capacities

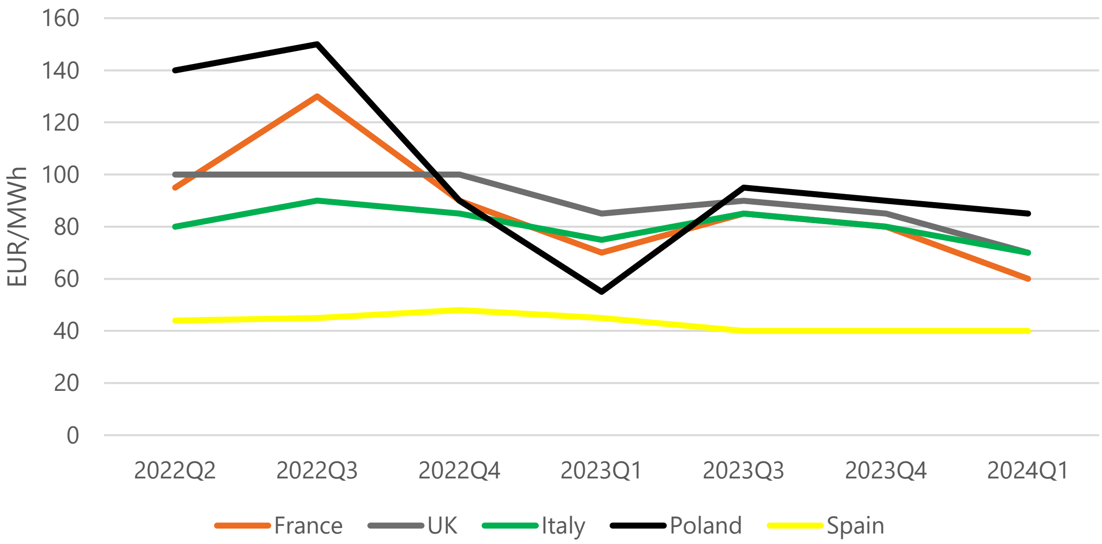
[18] https://auroraer.com/wp-content/uploads/2023/05/Role-of-PPAs-in-the-GB-Power-Market-Redacted-report.pdf

[19] Exact data is not available for Hungary, so volumes were estimated based on publicly available contract data. Also, some discrepancies are present between different PPA databases, so the presented values may slightly differ from the actual ones for all countries.

[20] https://windeurope.org/intelligence-platform/product/the-corporate-ppa-tool/

were significant in 7 of the 8 countries, with Hungary slightly lagging. Figure 3 summarizes the average estimated PPA prices[21] from Q1 2022 to Q1 2024.

FIGURE 3: EVOLUTION OF AVERAGE PPA PRICE IN THE 8 COUNTRIES OF INTEREST 2022Q2-2024Q1



Source: futurenergygo.com[22]

From the graph it can be concluded that price differences are significant across different PPA markets, with Spain being by far the cheapest, while Poland and UK tend to be the most expensive. By comparing PPA values with auction prices, a general conclusion can be drawn that the former tend to be higher. This suggests that producers can typically achieve higher profits relative to government auctions, but at the cost of taking higher risk by signing PPAs.

With the increasing importance of PPAs and considering the recent high prices, there is a highly debated topic regarding whether auctions and PPAs can be considered more as supplements or competitors. The European Commission argues that they are, in general, supplements. However, there is some evidence[23] suggesting that in the short run they can act like competitors. When prices are high, PPAs tend to be more popular, while lower prices tend to favour government auctions.

However, there are also arguments for complementarity. For example, there are several cases where projects participate in government auctions while promoters also sign PPA contracts for the same power plant. Nevertheless, there are significant differences in how the regulatory environment governs the relationship between governmental auctions and private PPAs, which is summarised for the eight countries of interest in Table 3.

---

[21] Data was not available for Ireland, Greece, and Hungary

[22] https://futureenergygo.com/ppa-price-trends-q1-2024/

[23] https://rekk.hu/downloads/events/ENC_auction_recommendation_final_1.pdf

TABLE 3: SPECIAL REGULATIONS IN PLACE IN THE 8 COUNTRIES OF INTEREST CONCERING THE RELATIONSHIP BETWEEN AUCTIONS AND PPA

	Special regulation for PPAs and auctions
France	Projects are not eligible for guarantees of origin (GOs) if they participate in the governmental scheme and sign a PPA in parallel.
Greece	PPA projects have a preferential treatment in the interconnection queue.
Hungary	PPA projects (except for onsite PPAs with no feed-in to the grid) must pay 40%-point higher income tax than projects participating in the governmental auction schemes.
Ireland	No special regulation
Italy	No special regulation
Poland	Projects participating in auctions cannot sell through PPAs.
Spain	Projects participating in auctions cannot sell through PPAs, they can only sell on the wholesale market if the installation is ready e to start production before the realization deadline, but after the realization deadline passed, they must sell within the auction support scheme
United Kingdom	Projects participating in governmental auctions can only sing utility PPAs, but not corporate PPAs

Source: REKK data gathering based on interviews and national sources

The Table shows that many countries do not have special regulation in place for the relation between auctions and PPAs. However, in some instances, regulations introduce restrictions, usually for PPAs. This can be a direct ban (United Kingdom) or financial incentive (France, Hungary). In Greece, however, preferable treatment is provided for PPA projects.

2.4 Market integration of dispatchable RES

Based on the analysed countries, in most of the cases there are none or very few elements present within the auction design which support the market integration of dispatchable renewables. In most of the countries, the main measure to support market integration is to allow for a longer reference period, which was discussed in more detail in Chapter 2.2. There are two countries, the United Kingdom and Ireland, where the reference period is different for dispatchable renewables (half a year/year) and intermittent generation (one hour).

On top of the reference period, Spain implemented an explicit measure to support the integration of dispatchable RES. Instead of considering the bid price as the basis for the reference payment, Spain uses the weighted average of the market price and the bid price. This measure is described in more detail in the Spanish Case study (Chapter 3.2.2). Hungary has implemented another measure by offering a short-term CfD called "brown premium" for biomass projects after their support period ends, to keep them in the market. This solution is also described in more detail in the Hungarian case study (Chapter 3.1.3).

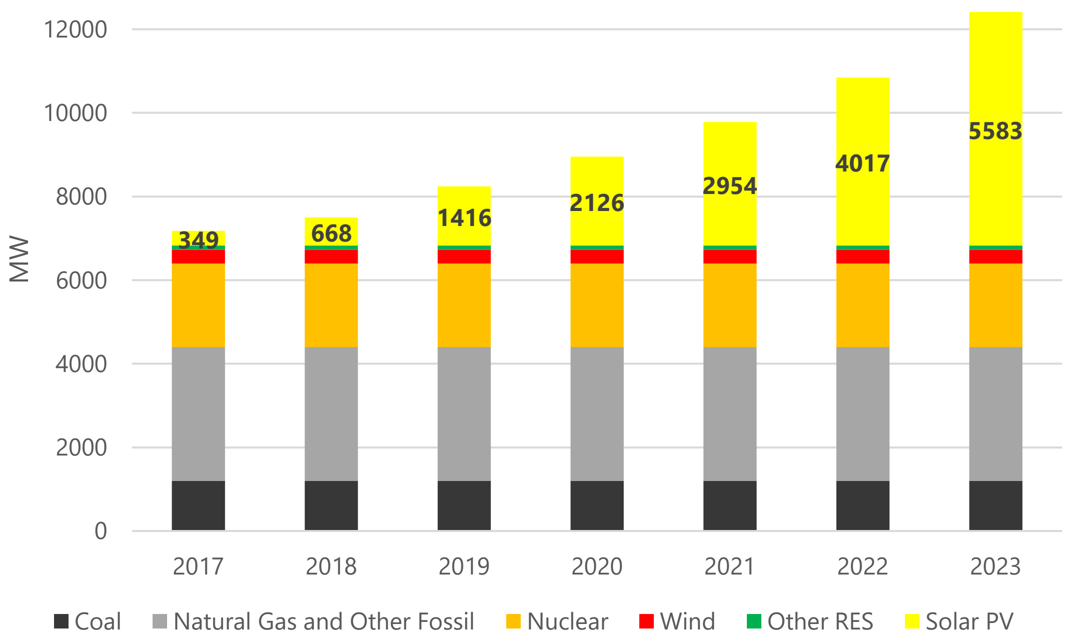
3 Country case studies

After comparing eight countries which apply CfD schemes, three of them were selected to describe them in more detail in a case study. The three case study countries are Hungary, with a special element of avoiding paybacks in CfDs, and very punishing PPA regulations for investors. United Kingdom, where CfDs originate from, and which country applies a special multi-technology auction involving many different technologies. And thirdly Spain, where there is a booming PPA market along with government auctions and special pricing measure is in place to facilitate the market integration of renewables.

3.1 Hungary

Hungary does not have a long history of renewable based electricity generation. The country's electricity generation is historically a balanced mix of coal, natural gas, and nuclear energy, supplemented by 330 MW of wind energy since the beginning of 2010s. Since the mid-2010s however, the country has seen a rapid expansion of solar PV capacities, mostly as a result of household solar PV installations and the feed-in tariff-based incentive mechanism. Feed-in premiums were introduced in 2017, in the so-called 'METÁR' scheme, with the first auction being organised in 2019. The total PV capacity installations of the country have reached 6 GW in 2024.

FIGURE 4: EVOLUTION OF THE CAPACITY MIX OF HUNGARY 2017-2023



Source: Beyondfossilfuels.org[24]

[24] https://beyondfossilfuels.org/data/

3.1.1 Description of auction design and history

Hungary operated a feed-in tariff system (called 'KÁT') until the end of 2016. Since then, no new power plants were allowed to benefit from it. The KÁT system provided a stable cash flow for solar PV investors. Therefore, when the termination of the support scheme was announced, approximately 2-3 GWs of new support request were handed in to the Hungarian regulatory authority within the old system.

After a couple of years of interregnum period, the new support system called METÁR was announced. In its original form, the METÁR system, provided feed-in tariff for new power plants with capacity less than 0.5 MW, administrative two-sided CfDs between 0.5 and 1 MW (in case of wind, 3 MW), and auction based CfDs for power plants with a capacity of at least 1 MW. The system also incorporates a "brown premium" for existing biomass capacities. The main aim of the brown premium (a 5-year-long CfDs) is to provide incentives for biomass power plants to continue operating once their old feed-in tariff (FIT) contracts' support periods end.

The original system was changed in 2020, as since then the administrative feed-in tariff and the administrative CfDs have not been available for new power plants[25]. Instead, those power plants need to participate in auctions, too.

The first auction in the METÁR framework was organised in 2019, followed by four consecutive rounds. Since March 2022, no METÁR tender has been organised in Hungary, because the rapid capacity expansion has made the grid integration of new solar PV capacities more and more difficult.

The main characteristics of the METÁR auctions are summarised in Table 4. Both energy and budget are auctioned in the tenders (the energy constraint was effective in all rounds), in two size categories, projects below and above 1 MW. The support period is in line with the EU average of 15 years.

TABLE 4: MAIN CHARACHTERISTICS OF THE HUNGARIAN AUCTION SCHEME

Technology focus	Multi-technology (except onshore wind)[26]
Auctioned product	Energy[27] & Budget
Size limitations	Two size categories (A: 0.3 MW – 1 MW; B: 1 MW – 20/50 MW[28]
Support period	15 years
Allowed realisation time for projects	36 months + 12 months (after first deadline: losing bond, after second deadline losing the right for support)

[25] https://www.mekh.hu/download/0/64/61000/METAR_osszegzo_jelentes_20240318.xlsx

[26] Until 2024 it was not allowed in Hungary to deploy new onshore wind capacities in 12 km proximity of inhabited are, which made the deployment of new onshore wind capacities impossible.

[27] The total energy which has to be supplied to system is prescribed per year.

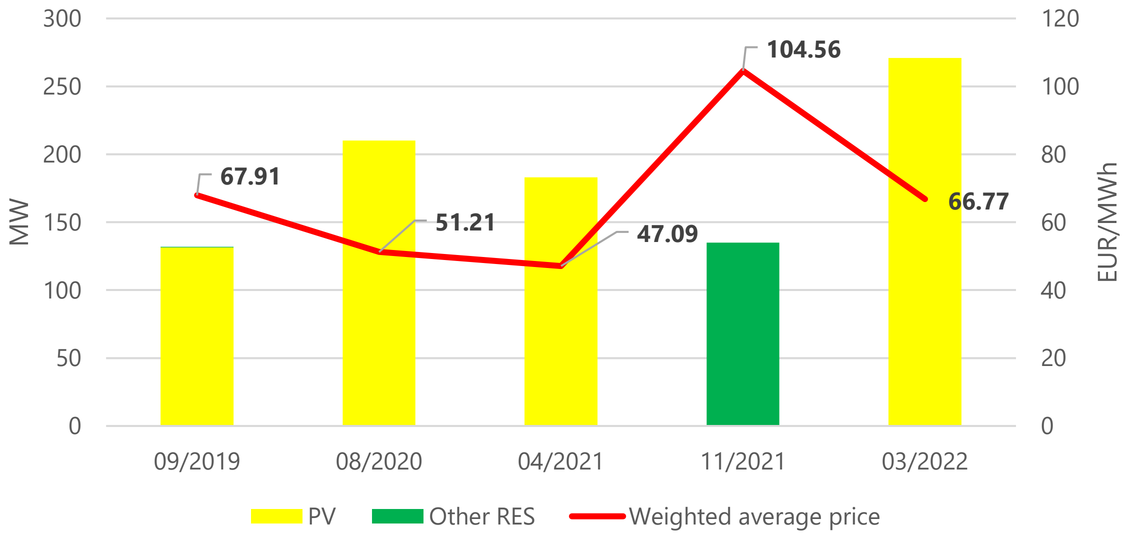
[28] These were different for the last auction for RES + storage, small: 5-20 MW, large 20-50 MW.

Prequalification criteria	Operation licence (above 0.5 MW), grid connection agreement, building permit, 2-stage financial bonds (1.5% and 5% of the investment cost)

Source: Webpage of regulatory authority of Hungary (MEKH)[29]

Most of the auction rounds were considered successful, at the time of the tenders, as the tenders produced competitive prices in both size-based baskets, most of the auctions were oversubscribed. The main results (winning capacities and prices) of the tenders are summarised in Figure 5.

FIGURE 5: RESULTS OF THE HUNGARIAN AUCTIONS



Source: Webpage of regulatory authority of Hungary (MEKH)[30]

The first three auction rounds were organised within a similar framework. The auction was fully dominated by solar PV projects, as wind technology could not participate because of regulatory reasons. The only exception was the first auction where a 0.5 MW landfill gas project was also able to win in the small-scale category. All these rounds were oversubscribed, and prices decreased from round to round.

The 4th auction was special, as only power plants operating for at least 20 years were able to participate for refurbishment, with a very short (couple of days) auction deadline, technically excluding solar PVs. This round was also oversubscribed with 3 biomass and 1 hydro project winning the tender, of course at significantly higher prices, compared to the previous rounds. The 5th round is also not fully comparable with the first three, as for this round an additional requirement was introduced, namely that the project had to involve a storage system, with a capacity of at least 10% of the total project's annual generation capacity. This was the only

[29] https://www.mekh.hu/megujulo-tamogatasi-rendszer-metar
[30] https://www.mekh.hu/megujulo-tamogatasi-rendszer-metar

METÁR round that was undersubscribed, only approximately 50% of the total targeted energy were contracted. Altogether, the Hungarian auction rounds resulted in competitive prices.

By looking at the project realisation rates however, there are several problematic elements present, with respect to the Hungarian scheme.

TABLE 5: REALISATION OF PROJECTS WON AT HUNGARIAN AUCTIONS

	09/2019 round	08/2020 round	04/2021 round	11/2021 round	03/2022 round
Total awarded capacity (MW)	133	210	183	135	271
Total completed capacity (MW)	62	51.4	6	0	0
Current realisation rate (%)	47%	24%	3%	0%	0%
Original maximum allowed realisation time (with penalties)[31]	03/2024	02/2025	11/2025	12/2025	06/2026

Source: Webpage of regulatory authority of Hungary (MEKH)[32]

It is difficult to assess the realisation of Hungarian METÁR projects, as according to Governmental Decree 526/2022. (XII. 16.)[33], project promoters were allowed to extend the realisation time of their projects upon request, with the period they indicated in their requests. These requests were dealt on a case-by-case basis. Therefore, the original realisation times are no longer valid, as there are projects expected to be completed even in 2028 or after. But based on the available data, it can be concluded that the realisation of the projects is generally poor, less than half of the projects were completed, even from the round which was concluded almost 5 years ago. Additionally, there is a total of 170 MW installed capacities, which have already declared that they won't be realised within the METÁR framework[34], most of which were awarded in the 03/2022 round, meaning that these are PV+ storage projects. Probably they shifted toward market-based alternatives or alternatively they cancelled their projects.

3.1.2 CfD specification

Hungary operates a classic type of CfD, where there is no cap or floor price, thus the bid price (later adjusted with inflation) is compared to the reference price. The main elements are summarised in Table 6.

[31] The original deadline of completion without paying penalties is one year earlier, than the value shown in the Table.
[32] https://www.mekh.hu/megujulo-tamogatasi-rendszer-metar
[33] https://net.jogtar.hu/jogszabaly?docid=a2200526.kor
[34] https://www.mekh.hu/download/fix/METAR_tender_elorehaladas

TABLE 6: CFD SPECIFICATION OF HUNGARY

Reference price method	Production-weighted average monthly DAM price for solar PV and onshore wind, unweighted average price for all other RES technologies (including brown premium)
Reference period	monthly
Bid price modification	Bid price is adjusted yearly upward, with inflation minus 1% point (efficiency factor)
Cap or floor	No
Contract entry/exit	It is possible to delay entry into the remuneration payment system. Once entered, exit is not allowed.

Source: Webpage of regulatory authority of Hungary (MEKH)[35]

The reference price is calculated on a monthly basis, meaning that power plants are able to deviate from the expected market outcome positively or negatively, by producing in hours within the month associated with higher/lower prices. For most of the technologies, the average exchange price (HUPX day-ahead price) is considered, but for solar PV it is weighted with PV production, meaning that PV own price is calculated. This creates a more favourable condition for PV, as by using own price as reference price, the cost associated with expected market value loss in the future due to the new PV capacity installations are not borne by the producers. The resulting market value loss is simply compensated by the increasing premium payment in this case.

Additionally, there is one very special element in the Hungarian auction scheme: The system allows for delayed entry into the CfD compensation payment scheme. It means, that when the project is commissioned, the support period starts, but producers have the option not to enter into the CfD contract. In this case the project does not receive support till it does sign the CfD contract, but it does not need to pay compensation if prices are high. There is an option to enter the contract at a later date, but once entered, it is not possible to leave it. Thus, producers in the early years may treat the CfD contract as an option. The system applied in Hungary is very generous compared to the others presented in Section 2.2. A general practice is to limit late entry into the payment scheme to 18-24 months. In Hungary, however, while the support period starts with the completion of the power plant, producers can avoid pay-backs for indefinite time, if market conditions are advantageous.

This design has important consequences, as according to an interview conducted with the regulatory authority of Hungary, many producers delayed the entry into the scheme from the second part of 2021, due to the high wholesale electricity prices, and they entered into short-

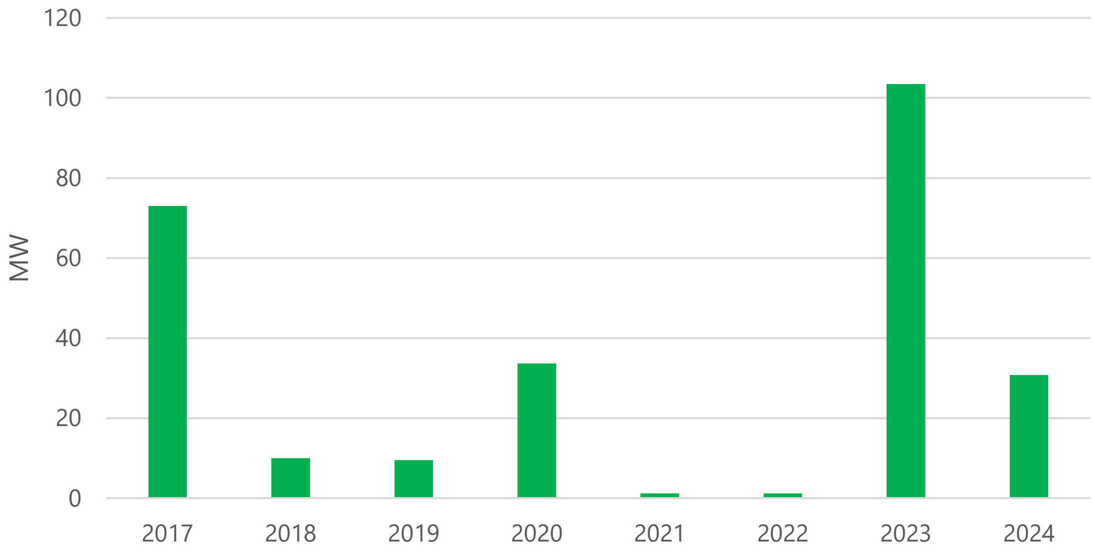
[35] https://www.mekh.hu/megujulo-tamogatasi-rendszer-metar

term PPAs (or other market-oriented solutions) at a significantly higher price level. The exact ratio of the capacities which exercised this option is not known publicly.

3.1.3 Market integration of dispatchable RES capacities

Very low dispatchable RES capacities are part of the Hungarian auction based CfD scheme. In the 4th METÁR auction, such projects won for retrofit, but none of these capacities finished the refurbishment until January 2024. On top of that, the only participant of an auction-based scheme is the 0.5 MW landfill gas power plant which won at the 1st auction[36]. On the other hand, significant capacities were awarded through the administratively set brown premium system between 2017 and 2024, which is presented in Figure 6.

FIGURE 6: AWARDED "BROWN PREMIUM" CAPACITES IN HUNGARY 2017-2024



Source: Webpage of regulatory authority of Hungary (MEKH)[37]

It is impossible to tell whether these power plants would continue to operate without the additional incentive, but it is evident that the mechanism is popular among existing biomass power plants. In the brown premium system, the administrative price is determined on a case-by-case basis by the regulatory authority, upon the producer's request considering its operational costs[38].

As brown premium is a CfD, the market integration of these power plants is a serious question to tackle as CfDs basically provides a fix revenue, discouraging biomass power plants to consider price signals throughout their operation. One design element to counter this incentive is a monthly reference period, which allows for the power plants to slightly overperform the average monthly price and earn extra revenues. Additionally, these power plants are able to participate in the upward reserve markets, where they can realise additional revenues. As a final

36 There is no publicly available information about the status of this project.
37 https://www.mekh.hu/megujulo-tamogatasi-rendszer-metar
38 https://rekk.hu/downloads/events/REKK_GP_0608_v2.pdf

point, in case the power plant can cut its operational cost within a year, its profit would also increase.

3.1.4 Auctions and PPAs

The PPA market in Hungary is currently in a very early stage, only a few MW of capacities are contracted[39], but the contracts' actual structure, and length are not publicly known. Also, there is no public data available on the exact value of contracted PPA capacities and prices within the country. The first corporate PPA contract in Hungary was signed in early 2022, for 26 MW of PV capacity, as an on-site PPA[40].

Generally, the PPA market is less developed in Central and Eastern Europe, mainly because of the lack of financially robust buyers. However, in Hungary, PPA contracts are in a disadvantaged position relative to government auctions because of the regulation. Since 2008, energy producers must pay a special, additional income tax (often called as Robin Hood tax),[41] which was 31% of the profit in the recent years but was increased to 41% at the end of 2022. Considering the 9% corporate tax this means a 50% tax burden on the profit of energy producers. However, those power plants which receive feed-in tariff or feed-in premium in the METÁR system, are excluded from the payment of Robin Hood tax, which is a significant competitive advantage for them.

In the Hungarian auction system, there is no special provision regarding the coexistence of governmental support and PPAs, which means that a governmental contract can be and in some instances is supplemented with a short-term PPA. On the other hand, PPAs are heavily disincentivized outside the governmental scheme because of the taxation rules (Robin Hood tax). However, since 2022, the METÁR tenders have not been organised due to the lack of sufficient grid connection capacities, which put investors in Hungary in a difficult position to implement new RES power plants.

Despite the large tax burden, some PPA contracts emerged in the Hungarian market, due to the high wholesale electricity prices. The regulatory environment also slightly changed in early 2024, as a new regulation[42] exempts power plants from the payment of Robin Hood tax in case their capacity is over 5 MW and they are implemented through an on-site PPA contract, and do not feed into the electricity network. However, the other forms of PPAs remain under the heavy income tax obligation.

3.1.5 Summary of good and bad practices

Analysing the Hungarian auction design, it can be concluded that while Hungary has implemented some good practices, there are some elements which Austria should avoid in their auction design.

[39] Based on energy related news about Hungary, long-term PPA contracts can be estimated between 30 and 100 MWs.

[40] https://www.idenergy.group/en/id-energy-group-and-lafarge-sign-the-first-ground-mounted-corporate-ppa-of-26-mwp-solar-pv-capacity-in-hungary/

[41] https://net.jogtar.hu/jogszabaly?docid=a0800067.tv

[42] https://mkogy.jogtar.hu/jogszabaly?docid=A2300099.TV

In terms of efficiency, the Hungarian auction design can be considered well performing, because of the intense competition and cost-reflective bids made in the auctions. The main reasons behind the system's efficiency probably lies in the fact, that the Hungarian auctions were simple and relatively small, but frequent rounds were organised until 2022. The system also successfully integrated small projects into the tendering scheme by creating a separate category for them. The auction for the small-sized power plants did not result in significantly higher prices and the competition was strong in that category. Additionally, the tender design helped the market integration of renewables, as for the CfD contract a monthly reference period is applied, encouraging power plants to outperform the average market performance.

By analysing its effectiveness, at first glance, one could conclude that the Hungarian auction was also a success, because, except for the last round, all auctioned energy was contracted. However, the most important conclusion of the Hungarian case study is that when evaluating effectiveness, it is not sufficient to analyse auctions until the point when the auction results are announced, but the aspects associated with realisation are equally important.

On the project realisation side Hungary performs poorly, which hinders the effectiveness of the scheme. Less than 50% of the projects which won 5 years ago are commissioned and connected to the grid, and further delays are expected. Additionally, a large amount of capacities fully exited the remuneration system before commissioning. The main reason for the underperformance in terms of realisation mainly lies in the ad-hoc extension of the completion deadlines, allowed by the regulatory framework, a practice that Austria should avoid.

Another important aspect associated with the Hungarian CfD scheme is the special provision allowing market operation for an indefinite time before entering into the payment scheme. This is very beneficial for energy producers as they can basically treat the CfD as an option, however it contradicts the main idea of the mechanism. A CfD is designed to provide incentives for renewable energy producers when revenues are low, but in case of high prices there is a pay-back obligation to avoid over subsidisation. However, with this measure in place, in case of high prices it is possible for power plants to avoid this obligation in the beginning of the support period and later in a low-price environment they can receive support. Also, as strike prices for the projects are based on the bids of the promoters, these extra revenues can be considered as extra profit, which could have been used for grid development. A CfD system would be more in line with its theoretical goals, if no such late entry into the scheme would be allowed.

Another important aspect of the Hungarian auction regulatory framework is that it provides examples for implicit support of different technologies or forms of implementation. For example, the Hungarian auction is theoretically technology neutral, however, only solar PV and onshore wind can be considered as competitive technologies. As the new installation of onshore wind was banned by regulation until early 2024, Hungary operated practically a technology-specific PV tender.

Another similar example is related to PPAs. There is no explicit legislation which regulates the role of PPAs or the coexistence of auctions and PPAs in the country. However, as PPA projects face a significantly higher income tax than projects which participate in the governmental support schemes, the regulation implicitly favours tenders over market-based solutions. In a well operated system, such implicit incentives should be avoided, as they can considerably hinder transparency and predictability.

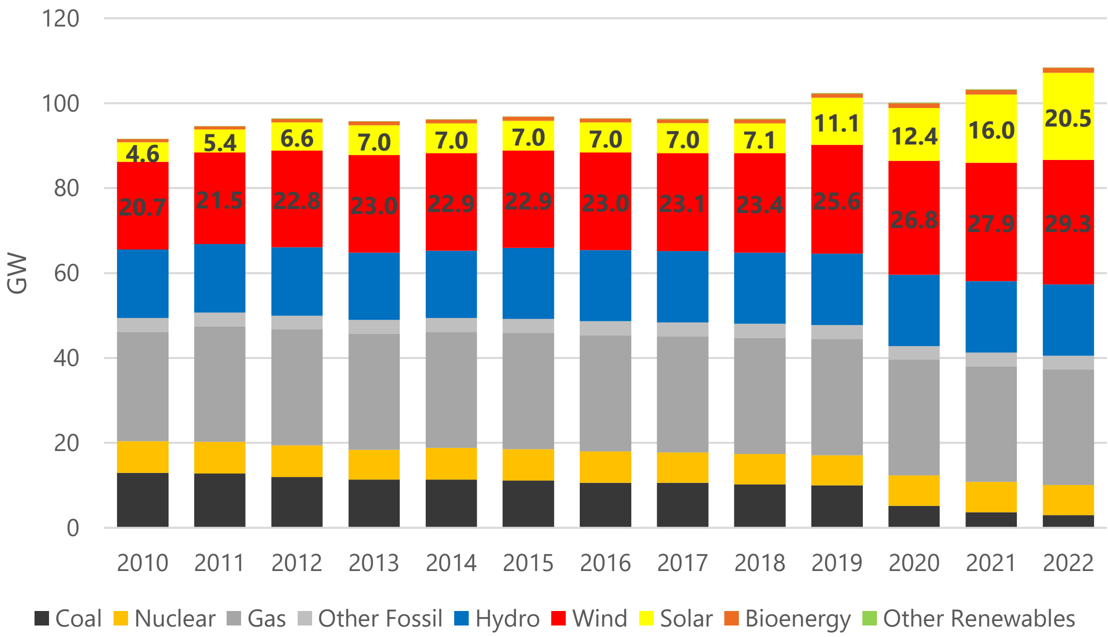
As a final point, it seems a good practice to support biomass power plants through CfDs towards the end of their lifetimes to keep them in the system. In Hungary, the brown premium system is used for their support.

3.2 Spain

In terms of electricity generation capacity, Spain has been operating with a relatively high proportion of renewable energy for a long time. Approximately 16 GW of hydropower plants have been in continuous operation in the last two decades, while wind power plants also appeared in the 2000s and approached 30 GW of capacity by 2022. Solar power plants appeared at the end of the 2000s and reached today's capacity level of more than 20 GW in two major expansion phases, between 2008-2012 and since 2018.

The continuous phase-out of approximately 12 GW of coal-fired capacity takes place intensively, the capacity of still operating coal-fired plants has already fallen below 3 GW by 2022. Significant gas-fired capacity appeared in the system between 2001 and 2010 and is still operating.

FIGURE 7: CAPACITY MIX OF SPAIN 2010-2022



Source: Ember Database

3.2.1 Description of auction design and history

Spain's first solar boom was a result of a generous FIT scheme operating between 2007-2013. At the time of introduction, the fixed feed in tariff was planned to be valid for 30 years and was adjusted by CPI every year. As the scheme was very effective and resulted in massive capacity uptake, it quickly became very costly. From 2010, different charges (generation and grid access charges) were introduced, also the tariff updating method was changed, leading to gradually reduced support, which resulted in a moratorium of support from 2012 and eventually the 2013 reform which affected the already existing plants retroactively[43].

The 2013/2014 regulatory package brought significant changes, which were not welcomed by the investors. The reformed remuneration had two parts, both for investment (payment per kW) and for operation (payment per kWh). These payments were provided to reach a "reasonable profitability level" which was 7.5% in the first regulatory period (determined by the return of 10-year Spanish government bonds) and were adjusted by the productivity of the plants. The reform resulted in lower payments in the country.[44]

For new RES-E plants (installed after 2013), the above-mentioned support was distributed on competitive auctions, offering auction-based investment support. As this scheme had its first round in 2016, new plants were unable to get support for 4 consecutive years after the 2012 support moratorium. As the capacity mix figure shows, there were no new PV installations during this period between 2012-2018, as first plants were connected in 2018 after winning the 2016 auction.

The three concluded rounds offered support for 25 years, in the first round in a multi-technology set-up, while the others were technology specific. Overall, the three rounds awarded 8.7 GW capacity, mostly solar PV, onshore wind, and biomass. The huge, awarded volumes brought Spain very close to the 2020 targets, therefore the government decided not to organize further rounds after 2017.

In 2020, Spain set its decarbonization targets until 2030, which significantly increased the projected annual RES-E capacity expansion. This led to reforms in RES-E regulation, including– the REER auction scheme.

The REER auctions introduced in 2020 offered CfDs to RES-E producers in a hybrid design, which is basically technology neutral with minimum quotas for specific technologies. In the case a minimum quota of a specific technology is not covered, the remaining part is added to the "neutral" part of the overall volume. The auction design does not define size limits, while it emphasizes the importance of actor diversity, for example the involvement of smaller actors, e.g. energy communities.

43 https://www.sciencedirect.com/science/article/pii/S0957178722001400
44 https://www.sciencedirect.com/science/article/pii/S0957178722001400

TABLE 7. MAIN CHARACHTERISTICS OF THE SPANISH AUCTION SCHEME

Technology focus	Hybrid design: technology neutral with technology specific minimum caps
Auctioned product	Capacity
Size limitations	Not defined
Support period	12 years (for biomass, CSP and biogas projects it is 20 years), but if a project reaches the maximum supported quantity sooner, it must exit the support scheme
Allowed realisation time for project	Differs per technology and can differ from one auction round to another
Prequalification criteria	Bid bond: 60 EUR/kW (refunded after successful registry) Performance bond (2nd stage bid bond): 60 EUR/kW (refunded in parts: 18 EUR/kW after the initial steps of the implementation, 12 EUR/kW after having construction permit, 30 EUR/kW after completion of the project)

The auctioned product is capacity, but legislation allows to choose energy in future auctions. The REER auctions define a minimum level of produced energy, meaning that there is a minimum quantity requirement for the generated electricity by a given deadline by each awarded plant.[45] Thus, winners on the auctions need to deliver this required amount before the end of the 12-year long support period, otherwise they need to pay a penalty. Once the minimum quantity requirement is met, the producer can decide whether to stay in the scheme or to leave it. A maximum quantity is also determined, which means that every winner can benefit from the REER scheme up to that specific limit, after which they must exit the scheme.[46] As support is not provided for a fixed period of time, but it is limited in quantity, it provides extra incentive for market participants to produce in high-priced hours (as the remuneration formula allows in Spain for small extra revenues, see 3.2.2 for details), thus this design element enhances the market integration of RES.

The financial qualification criteria are quite unique in the Spanish scheme, as the release of a performance bond (2nd stage bid bond) guarantee is linked to specific milestones of the development phases.

The REER scheme has a few specificities. First, a minimum level of competition is defined, according to which the sum of the prequalified submitted project capacity must be at least 20%

[45] When capacity is the auctioned product, the following formula is applied: Minimum energy=capacity*minimum number of annual full-load hours*maximum delivery periods (year) where the minimum number of full-load hours is defined in the respective resolution

[46] Maximum energy=capacity*maximum number of annual full-load hours*maximum delivery period (year)

higher than the announced capacity. Second, one single firm cannot win more than half of the volume announced on the specific round. And finally, several detailed factors are defined individually for each auction round, such as technology quotas or realisation deadlines.

Four auction rounds were organized in 2021 and 2022 within the REER scheme. The eligible technologies and the main outcomes of the auctions are summarized in Table 8. The realization deadlines for the 2021 rounds have passed for PV installations, but actual realisation data is not yet known.

TABLE 8. SUMMARY OF THE SECOND SPANISH AUCTION SCHEME RESULTS

	Average price EUR/MWh	Technology	Announced volume & minimum quota (MW)	Awarded volume (MW)	Subscription rate %
January 2021	24.4	Solar PV	1000 (minimum quota)	998	100%
	25.3	Onshore wind	100 (minimum quota)	2036	
	24.7	TOTAL	3000+6%	3034	
October 2021	31.65	Solar PV	700	866	94.6%
	30.18	Onshore wind	1500	2258	
	36.34	Local PV[47]	300	5.75	
	33.54	Fast-track installations (PV and wind)	600	21.95	
	30.5	TOTAL	3300	3124	
October 2022	93	Biomass	140	146	34%
	-	CSP	220	0	
	-	Other technologies	20	0	
	53.8	Local PV	140	31	
	-	TOTAL	520	177	
November 2022	42.7	Onshore wind	1800	45.5	1.3%
	-	Solar PV	1500	0	

[47] Distributed solar PV for installations smaller than 5 MW for local use.

	42.7	TOTAL	3300	45.4	

Source: del Rio-Kiefer (2023)

The first auction round lead to high level of competition and low prices. In the second-round, minimum quotas were introduced for local PV and fast-track PV, but none of these limits were effective. One explanation for the slightly lower participation in these cases was the too tightly set deadlines and lengthy permission processes.

The third round was mainly focusing on dispatchable technologies, which naturally resulted in higher prices. The announced volumes were also lower. The aim of this round was to support actor diversity and grid flexibility (CSP with storage requirement), but two of the eligible technologies (CSP and the 'other' category) were not awarded at all, so this round cannot be considered as a success. The case of CSP can only be explained by the outstanding complexity of constructing such plants and the relatively big project sizes which are typical for this technology. Auction rules and deadlines were not adjusted to these specifications.

The fourth round was organized in a very high price environment, when Spanish PPAs were already a very popular option as a result of high prices. The round was a victim of the ceiling price, which was defined at such a low level that deterred participation. But when market prices are that high as were in 2022-2023, higher support prices are also not justifiable as projects would be built anyway. As market prices have remained relatively high and PPAs have become very popular, no new renewable auction rounds have been announced in Spain since 2022.

3.2.2 CfD specification

The main elements of the REER scheme are summarised in Table 9 and detailed below.

TABLE 9. CFD SPECIFICATION IN SPAIN

Reference price method	Hourly DAM price is considered for all technologies
Reference period	Hourly
Bid price modification	For payments, the weighted average price of the bid price and the market price is compared with the reference price
Cap or floor	No
Contract entry/exit	Entry: It is possible to sell electricity on the market if the project is constructed faster than the allowed realisation time. After that it is mandatory to enter the CfD scheme. Exit: Possible after minimum quantity requirement is met, compulsory when maximum quantity limit is reached

A distinctive feature of the scheme is, that not the strike price directly, but a modified price is compared to the reference price. The exact price the producer receives builds up as follows:

PR=AP+AF*(MP-AP), where

PR: price received by the producer

AP: awarded price (winning bid price/strike price)

AF: adjustment factor (weight), 25% for dispatchable producers, 5% otherwise

MP: day-ahead hourly market price (reference price)

This method encourages the producers to produce more in hours when the market prices are high, which can eventually lead to lower prices. This is reflected in the formulas which apply after arranging the equation. Revenues of dispatchable producers are more affected by the current market price:

Dispatchable: PR= 75%*AP+25%*MP

Non-dispatchable: PR=95%*AP+5%*MP

Of course, in case when PR is higher than the market price, the producers receive the excess revenue, while when the market price is higher, producers are obliged to pay back the difference.

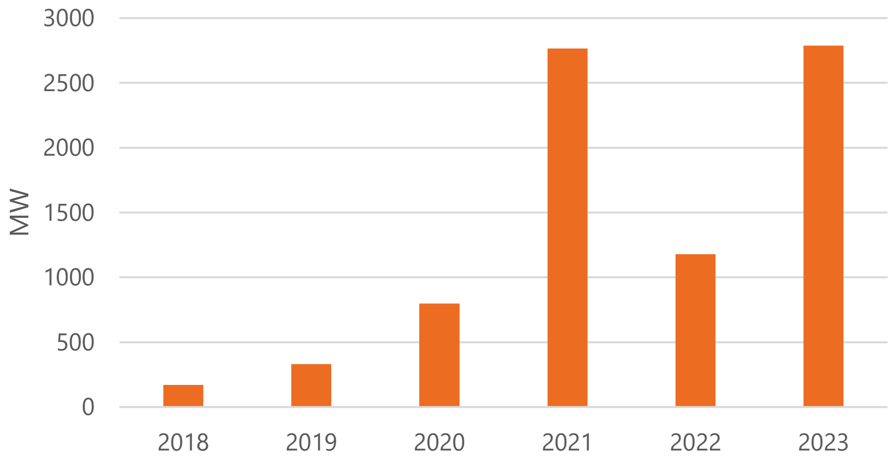
This pricing is applied in Spain because the country uses hourly reference periods even for dispatchable RES. As a result, these power plants are not incentivised to follow market price signals, and intermittent generators have no incentives to install storages. A more common solution in Europe is to apply longer reference periods (as Poland, Hungary) or separate reference period for dispatchable power plants (such as Ireland, UK).

The entry/exit rules are quite specific in the REER scheme, as discussed in the previous subchapter: bidders can calculate at the time of defining their bid prices the minimum energy volume they have to produce to stay in the scheme and receive the supported price. Until producers reach their maximum quantities, they are incentivised to produce more electricity in high market price hours. Unlike in other European countries, it is not possible in Spain to delay entry to the remuneration scheme.

3.2.3 Auctions and PPAs

Spain is the leading PPA market in Europe (second worldwide) providing a clearly competitive alternative to traditional auction-based support.

FIGURE 8. ANNUAL CONTRACTED PPA VOLUMES IN SPAIN



Source: WindEurope.org[48]

Of the 8035 MW already contracted capacity, 921 MW is wind + solar hybrid installations, 1714 MW is wind, 4954 MW is solar, and 446 MW is other renewables.

Spanish PPAs started to appear from 2018 but became extremely popular after the above-mentioned regulatory reform package in 2020, which introduced some significant changes. A decree incentivises large electricity intensive companies (using more than 1 GWh energy per year in at least 2 of the previous 3 years and at least half of this consumption takes pace during off-peak hours) to stabilize the variability of their energy costs through PPAs. If these companies contract 10% of their yearly consumption with signing renewable PPA contracts (for at least 5 years), they accessed a reserve fund (Fondo Espanol de Reserva para Garantias de Entidades Electrointensivas – FERGEI) which helped them out if the off-taker was not able to provide the contracted energy quantity. A decree in 2019 eliminated some taxes and tolls for on-site PPAs, while in 2020, Royal Decree-Law 36/2020 allowed to widen the timeframe of power supply contracts by public procurement regulations from 4 to 10 years, meaning that public bodies can enter into long-term supply contracts.[49]

At time of the first REER round, auction prices were already significantly lower (24.7 EUR/MWh on average) compared to PPA prices which were above 30 EUR/MWh (or 33 EUR in case of pay-as-produced PV contracts or 39 EUR/MWh in case of baseload contracts both for PV and onshore wind). This difference became much bigger in 2022 and made PPAs a lot more attractive option than auctions.

Regulation related to auctions does not allow auction winners to sell energy within PPA contracts at the same time, but if the power plant is able to start generation sometime before the realization deadline, they can sell electricity on the wholesale market in that short period. After the realization period, if power plants want to sign PPA contracts before they delivered the minimum required quantity, they must pay penalty and leave the auction scheme.

[48] https://windeurope.org/intelligence-platform/product/the-corporate-ppa-tool
[49] https://www.fieldfisher.com/en/insights/corporate-ppas-in-spain

3.2.4 Summary of good and bad practices

On the one hand, the reform of the RES-E regulation in 2020 reflected the problems of the previous FIT and auction scheme, as it tried to stick to a well-planned schedule, to support RES-E installations more consistently, more cost-efficiently and made room for dispatchable but more expensive technologies. On the other hand, it opened the opportunities for less regulated channels like PPAs, which eventually became the main form of RES-E deployment.

The REER auction scheme had a few specificities. Firstly, the minimum and maximum quantity requirements seem a bit unusual but calculating them is not very difficult for the developers. The maximum requirement is an effective upper limit on the overall cost of support, while also helps the market integration of RES as it incentivises producers to produce in high priced hours if able, so this can be more beneficial in system point of view relative to a support which is defined for a specific period

The second specificity is the treatment of dispatchable producers, and the different price formulas applied to them. It is hard to evaluate this aspect of the design, as there was only one round open specifically for dispatchable technologies (biomass and CSP with storage) and, in case of the latter technology, some rules (deadlines and processes) were not aligned to the complexity of the technology, so finally no project applied for support.

The Spanish CfD-based support scheme was very effective and efficient in its first year of operation, as produced heavily oversubscribed tenders, with the second most competitive prices in Europe and a large amount of contracted capacities. However, the 2022 auction was more of a failure, mostly due to the auction design (especially in terms of dispatchable capacity), but also because of market developments, meaning the outstanding popularity of PPAs.

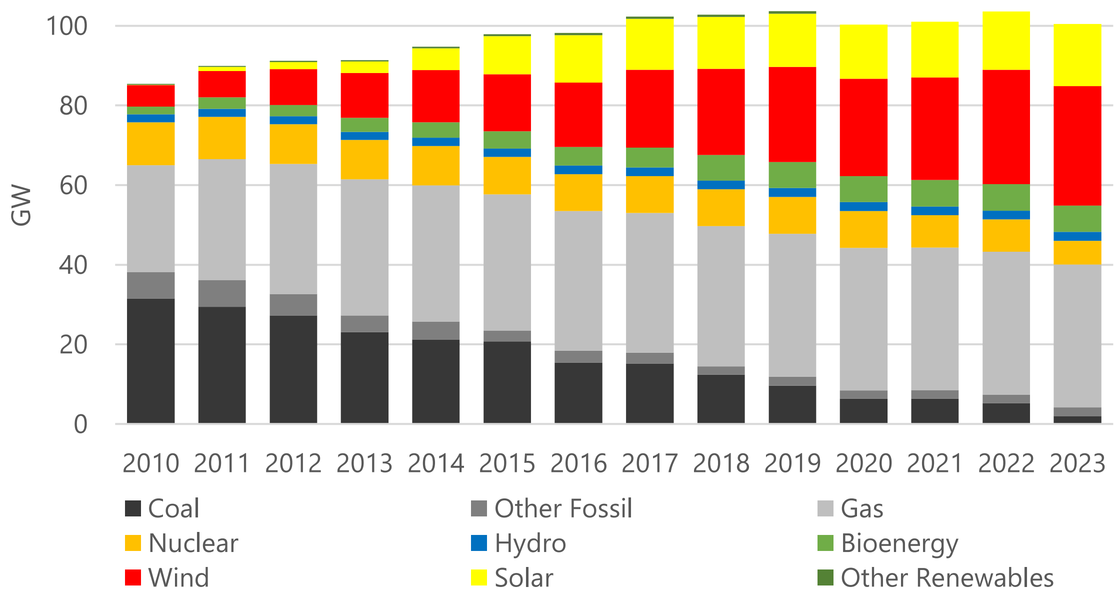
Spain's solar and wind abilities are one of the best in Europe, meaning that the projects can be profitable without market-based support even in a lower price environment. As a result, the case study of Spain provides an example for a situation where auctions and PPA projects are more like competitors rather than supplements. The main reason for this is that for government auctions to be competitive with PPAs, the ceiling prices of the tenders should have been increased. However, from another point of view, they should not be increased as projects do not need support in this high price environment. This means that in the current market environment, government auctions are only alternatives to PPAs if projects are over subsidized or if the expectation is that prices will significantly fall. As a result, Spain has not organised any more auctions since 2022. It is important to highlight that if the market environment changes drastically, there may be room for Spanish auctions in the future in addition to PPAs. Also, the Spanish renewable targets are so ambitious, that it is possible that the market cannot provide enough growth, and certain regulated channels will also be necessary.

Finally, it is important to highlight that Spain has put high emphasis on establishing a design that allows the country to support dispatchable RES generation. Although the dispatchable round of 2022 was not successful, this should not discourage Spain from continuing with such types of tenders, as the LCOE of these technologies is significantly higher than PV and wind, thus PPAs are less likely an option.

3.3 United Kingdom

United Kingdom's electricity mix was traditionally dominated by coal and natural gas power plants. Due to the decommissioning of coal capacities and the emerging of renewable technologies, currently natural gas (35.8 GW) and wind (30 GW) are the two main technologies with solar PV (15.6 GW) being the third. Public policy has supported renewable electricity expansion since 1990 through the Non-Fossil Fuel Obligation.[50] The scheme (auction) ran until 1998, replaced by the Renewables Obligation[51] (RO) scheme in 2002. Due to public opposition and rapid solar PV growth, certain technologies were excluded from RO support starting in 2015 (>5MW solar) and 2016 (onshore wind), and the RO system was closed to new projects in 2017.

FIGURE 9: CAPACITY MIX OF POWER PLANTS IN THE UK



REKK figure based on EMBER data and own data collection

3.3.1 Description of auction design and history[52]

The Energy Act (2013)[53] implemented regulations to enable the CfD scheme to meet a range of the country's Electricity Market Reform (EMR)[54] programme objectives: (1) ensuring a secure electricity supply by providing a diverse range of energy sources (including renewables, nuclear, CCS equipped plant, unabated gas and demand side approaches); (2) ensuring sufficient

---

[50] The Non-Fossil Fuel Obligation (NFFO) mandated electricity distribution networks in England and Wales to buy power from nuclear and renewable sources. Scotland and Northern Ireland had similar systems.
[51] The RO requires licensed electricity suppliers in the UK to source an increasing amount of electricity from renewable sources.
[52] The presented support scheme is applied in England, Wales, and Scotland.
[53] https://publications.parliament.uk/pa/bills/cbill/2012-2013/0135/2013135.pdf
[54] This EMR is not identical to a recent EU EMD reform.

investment in sustainable low-carbon technologies; and (3) maximising benefits and minimising costs to the economy as a whole and to taxpayers and consumers.

Contracts for Difference in the UK are 15-year private law contracts between low-carbon electricity generators and the Low Carbon Contracts Company (LCCC), a government-owned company that is operationally independent, manages CfDs and makes payments. National Grid ESO is responsible for running the CfD allocation process. The contracts are for output (MWh), but the number and size of the contracts allocated are restricted by a budget cap, not by the generated electricity. The budget caps are set for total spending in each year, rather than for spending on projects which start generating in a particular year. In addition, minimum and maximum capacity and budget constraints are applied occasionally for specific technologies which vary across allocation rounds.

In general, the CfD scheme is designed for projects with capacity above 5 MW. For smaller projects, a feed-in tariff system was operational until 2019, replaced by the Smart Export Guarantee (SEG) system in 2020. In SEG, electricity suppliers with at least 150k customers must make offers to small scale renewable producers (<5 MW), but the tariff is not regulated.

The first CfD Allocation Round (AR) was opened in 2015, and five ARs were completed altogether (2015, 2017, 2019, 2021 and 2023). This 2-years cycle is accelerated as the sixth round will take place in 2024, and the seventh in 2025. Prior to this, CfD-based 'investment contracts' were awarded for nuclear generation (Hinkley Point C) and eight renewable electricity projects through bilateral negotiation in the Final Investment Decision Enabling for Renewables (FIDER) process. (These contracts are referred to as 'pre-AR1'.)

TABLE 10: MAIN DESIGN ELEMENTS OF THE CFD SCHEME IN THE UK

Technology focus	Multi-technology
Auctioned product	Budget
Size limitations	For solar PV, wind, onshore wind, anaerobic digestion: min. 5MW For Hydro: between 5 and 50 MW (It can vary between Allocation Rounds)
Support period	15 years (If the delivery of the project delays, the effective support period is shortened.)
Allowed realisation time for project	Contracts are awarded for delivery in a particular year, generally 2-3 years from the date of the auction.
Prequalification criteria	Grid connection agreement, planning decision notice, relevant planning consents (project-specific), for floating offshore wind projects and all projects beyond 300MW: Supply Chain Statement. No financial prequalification.

A specificity of the system is the pricing rule, as uniform pricing (pay-as-clear) is applied.[55] If a minimum volume (capacity/energy) has been set for a technology, a separate price can be determined for this technology, unless the general clearing price for that year is higher than the clearing price for the protected technology. In this case, the protected technology receives the general price. The system employs technology-specific ceiling prices known as 'administrative strike prices' intended to represent similar investor returns to the previous support mechanism.

It is also a special feature of the system that contracts are awarded for different delivery years, and developers are free to choose any of the delivery years listed in the Budgetary Notice of the given round. For example, in AR1 (2015), developers could submit bids for six different delivery years (from the financial year 2015/16 to 2020/21), while AR5 (2023) contracts were awarded for delivery in 2025/26, 2026/2027 and 2027/28. If the project is delayed, there is an additional period of 12 – 24 months beyond the original target start date known as the Long Stop. A specified proportion of the project must be commissioned by the end of the Long Stop period, or the contract could be terminated. In sum, the delivery deadlines are project-specific, and can be much longer in the UK's CfD system than in other countries.

Technologies are divided into 'Pots' according to their technological maturity. The sixth Allocation Round (AR6) will apply the following technology groups, where a new pot (Pot 3 for offshore wind) will be created[56]:

- Pot 1 (established technologies): Energy from Waste with CHP, Hydro (>5MW and <50MW), Landfill Gas, Onshore Wind (>5MW), Remote Island Wind (>5MW), Sewage Gas, and Solar Photovoltaic (PV) (>5MW).
- Pot 2 (less established technologies): Advanced Conversion Technologies (ACT), Anaerobic Digestion (AD) (>5MW), Dedicated Biomass with CHP, Floating Offshore Wind, Geothermal, Tidal Stream, Wave.
- Pot 3: Offshore Wind. (Offshore wind was part of the Pot 2 in AR1-3, Pot 1 in AR5, and Pot 3 in AR4)

The second Allocation Round (AR2) was opened for Pot 2 technologies only. AR3 was only opened to Pot 2 technologies, plus onshore wind projects on remote islands.

Information on the participation rate is not publicly available for any of the allocation rounds[57], but the procedures are considered to have been sufficiently competitive, with the exception of the last round. The tight budget constraints and the low frequency of allocation rounds have ensured that participation has generally been well above the allocated budget and

---

[55] In theory, uniform pricing can be more efficient than a pay-as-bid system because it incentivises developers to bid the lowest price they are willing to accept (to maximise the chance of winning), whereas in the latter, firms include a margin in their bid based on their expectation of the final strike price (to maximise the margin multiplied by the chance of winning). However, this presupposes intense competition in the auctions. Nevertheless, the use of pay-as-bid is more common in auction systems as it is more predictable from both the auctioneer's and the developer's point of view. There are also historical reasons, as each country uses the pricing scheme it used when it launched its first auction.

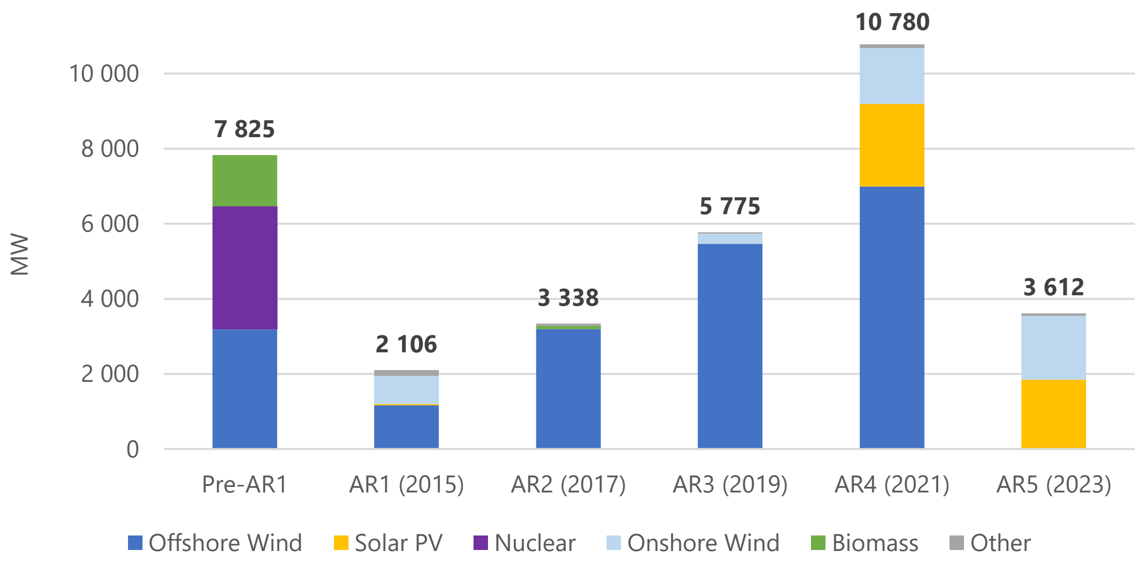
[56] Before AR6 offshore wind was part of POT 2.

[57] For budget-based support it is not even evident how to theoretically calculate oversubscription.

capacity/energy. On the other hand, the low frequency of allocation rounds is seen as a disadvantage, as it has limited both capacity additions and market predictability. This is the reason for increasing the frequency from this year to organise an allocation round every year in the coming years, instead of 2 years.

Overall, two thirds of the awarded capacities were allocated to offshore wind projects in AR1-5, but the composition was highly influenced by the changes regarding the eligible technologies, the varying classification of offshore wind projects, and the changes in the ceiling prices. For example, solar PV was not eligible in AR2 and AR3, which led to high allocations to offshore wind projects, AR4 brought a more balanced technology mix, while AR5 failed to attract any bids from eligible offshore wind projects because of the low ceiling prices.[58]

FIGURE 10: AWARDED CAPACITIES IN THE CFD SCHEME (UK)



REKK figure based on LCCC data[59]

Although the applied pricing rule is pay-as-clear, there isn't a uniform strike price for all awarded projects, due to the pots (which function as separate auctions), the different delivery years, the technology-specific ceiling prices, and the technology-specific capacity/budget caps. As a result, the strike prices are often different for the different technologies.

Downward moving price trend can be observed until 2019 (AR3), while AR4 and 5 resulted in higher prices. This is related mainly to technological changes (increasing deployment costs) but also to a specific auction design element: the above-mentioned case of too low ceiling price for offshore wind has led to less efficient technologies being supported with higher ceiling prices (geothermal, tidal stream).

[58] For the upcoming AR6 auction, the ceiling price has been increased by 66% for offshore wind projects, from £44/MWh to £73/MWh, and by 52% for floating offshore wind projects, from £116/MWh to £176/MWh (in 2012 reference prices).

[59] https://cfd.lowcarboncontracts.uk/

TABLE 11: STRIKE PRICES IN THE CFD SCHEME (UK) (EUR/MWH)

	AR1 (2015)	AR2 (2017)	AR3 (2019)	AR4 (2021)	AR5 (2023)
Offshore Wind	170.02	77.86	52.13	50.49	
Floating Offshore Wind				118.00	
Onshore Wind	117.56			57.41	80.49
Remote Island Wind			51.34	62.70	80.49
Solar PV	113.66			62.16	72.34
Advanced Conversion Technology	169.36	92.02	51.97		
Dedicated Biomass with CHP		92.02			
Energy from Waste with CHP	114.77			62.16	
Tidal Stream				241.33	304.77
Geothermal					183.17
Weighted average	**147.83**	**78.46**	**52.09**	**55.07**	**79.97**

REKK calculations based on LCCC data[60]

Only 9% of the awarded capacity has been realised already, but the majority of the contracts were awarded in later years and the commissioning deadlines have not yet expired. As regards the first two allocation rounds, the realisation of the awarded projects is subject to significant delays (5+ years in some cases), and no projects have been commissioned from AR3 that have already passed their deadline. On the other hand, the share of terminated contracts is low, so the system allows (*de facto*) such a high delay in the deployment. The main reasons behind the delays (and terminations) are the lower-than-expected strike prices, and the almost non-existent sanctions in relation to delays. Currently, if a project is delaying, the support period can be shortened, but it seems that this penalty is not strong enough to incentivise timely delivery.

[60] https://cfd.lowcarboncontracts.uk/. Original price data is provided in GBP/MWh, 2012 prices.

TABLE 12: STATUS OF REALISATON (UK)

	AR1 (2015)	AR2 (2017)	AR3 (2019)	AR4 (2021)	AR5 (2023)	Total
Allocated (MW)	2 106	3 338	5 775	10 780	3 612	25 611
Delivery years	2015/16-2020/21	2021/22-2022/23	2023/24-2024/25	2025/26-2026/27	2025/26-2027/28	-
Terminated (MW)	99	142	33	150	0	424
Realised (MW)	1523	860	0	0	0	2 382
In delay (MW)	486	2 336	755	40	0	3 616
On track (MW)	0	0	4 986	10 591	3 612	19 189
Terminated (%)	4.7%	4.3%	0.6%	1.4%	0.0%	1.7%
Realised (%)	72.3%	25.8%	0.0%	0.0%	0.0%	9.3%
In delay (%)	23.1%	70.0%	13.1%	0.4%	0.0%	14.1%
On track (%)	0.0%	0.0%	86.3%	98.2%	100.0%	74.9%

REKK calculations based on LCCC data[61]

3.3.2 CfD specification

In the CfDs, additional payments per MWh are calculated as the difference between the contract or 'strike price' (determined through the auction) and a bespoke index of the wholesale market price known as the 'reference price.'

Strike prices

In general, the strike price is the clearing price of the given technology pot for a specific delivery year. However, as different technologies have different ceiling prices, it is often the case that the clearing price of the pot is higher than the ceiling price of some winning projects. In this case, the project owners will be contracted for the ceiling price, and not the clearing price.[62]Thus, strike prices are specific to pots, technologies, and delivery years, but are uniform within one pot, technology, and delivery year combination.

Reference price calculations

The auction documentations contain ex ante reference prices, which are used for estimating the subsidy needs in order to keep the budget caps in the allocation process. During the

[61]https://cfd.lowcarboncontracts.uk/

[62] For example, if the clearing price for a given pot and year is £100, but the ceiling price for offshore wind was £90, then the strike price for the offshore wind will be £90, while other technologies with higher ceiling price will have the strike price of £100.

support period, however, the actual support payments are determined based on ex post calculated reference prices. The calculation of the reference price is different for baseload (dispatchable) and for intermittent technologies:[63]

- The Baseload Market Reference Price (BMRP) is calculated using a traded volume weighted average based on forward season data received from LEBA (London Energy Brokers' Association). The BMRP is published in April and October of each year. (A BMRP covers a half year period, called Summer and Winter.)
- The Intermittent Market Reference Price (IMRP) is calculated using day-ahead data received from EPEX SPOT and N2EX. An IMRP is calculated for every hour of the day.

Both BMRP and IMRP are calculated by EMRS, which is the Settlement Service Provider for CfD scheme on behalf of LCCC. EMRS calculates every day the daily support amount for each generator.

In cases where the wholesale electricity price is higher than the strike price, the contract requires the generator to make payments to the counterparty.

Adjustments of the strike price

The budgets and strike prices for each AR are published in 2012 prices, allowing direct comparison between each auction round. The actual strike prices are calculated based on annual CPI Indexation of the Strike Price in 2012 prices.

Previously (in AR1 and AR2) two additional adjustments were used in several contracts (but not in all contracts): the Balancing System Charges (BSC) Strike Price Adjustment and the Transmission Loss Multiplier (TLM) Adjustment. These adjustments aimed to reduce financial risks by offsetting the changes in relation to the balancing system charges and the Transmission Loss Multiplier.[64] Starting from the AR3 (2019), these adjustments are not used.

TABLE 13. CFD SPECIFICATION IN THE UK

Reference price method	For dispatchable (baseload) technologies: Traded volume weighted average based on forward season data. For intermittent technology: DA exchange prices (technology-neutral)
Reference period	For dispatchable (baseload) technologies: Seasonal (half year, Winter, and Summer) For intermittent technology: Hourly
Bid price modification	CPI indexation (in AR1 and AR2: BSC and TLM adjustments in some contracts)
Cap or floor	No

[63] https://www.emrsettlement.co.uk/document/guidance/g24-cfd-generator-payments/

[64] Losses on the transmission system are allocated across Balancing and Settlement Code (BSC) Parties through the use of Transmission Loss Multipliers (TLMs).

3.3.3 Auctions and PPAs

Great Britain is one of the largest and most mature PPA markets with 14 GW of contracted capacity (as of end of 2022).[65] The term 'PPA' covers many types of Power Purchase Agreements in terms of volume delivery (as-produced, baseload, etc.), off-taker (end-customer or supplier), location (on-site or off-site), contract length (3-20 years), pricing scheme and risk hedging.

Generators with a CfD must also sell their electricity on the market, and a PPA with a licensed electricity supplier is one way of doing this. If a generator opts for a CfD PPA with a licensed supplier, this will complement the structure of the CfD by ensuring that the generator receives an electricity price that is as close as possible to the CfD reference price. This minimises the price risk for the generator. To achieve this price certainty, the generator must ensure that the PPA it enters into with a supplier complements the terms of the CfD.

Despite the option for CfD PPA contracts, these two financing solutions can also compete against each other. One reason for this is that CfD PPA contracts are allowed only for producer-supplier agreements (utility PPAs), but not for producer-customer relationships (corporate PPAs). Moreover, from an investor's point of view, a CfD is a low-risk low-yield opportunity, with also low level of flexibility in contract terms. Thus, developers which target end-customers, or are less risk averse, or simply prefer a higher level of flexibility, would choose non-CfD PPA contracts.

Currently, the bargaining power lies with the power generators in the PPA market, as there are fewer renewable projects compared to corporate demand. Companies are responding to high energy prices by increasing the use of PPAs, but limited access to projects, especially grid access, is hampering the emergence of new renewable projects and intensifying competition for available projects. Additionally, as more onshore wind projects than expected were successful during AR5, CfDs can be seen as an appealing alternative to PPAs, corporate buyers may experience a reduced volume of projects available in the PPA market. Recent changes to the allocation framework that favours offshore wind against PV and onshore wind[66] may incentivise investors of these technologies to turn again to the PPA market. This can ensure that PPAs and the CfD auction process can co-exist in the future.

Based on the growing demand for corporate PPAs, and the possibility that mature technologies will not be eligible for CfDs, it is expected that CfD will have a smaller share in PV and onshore wind investments in the longer term, and corporate PPAs will have a much greater role in financing such developments.

3.3.4 Summary of good and bad practices

The UK CfD scheme can be considered effective in driving down the cost of capital by providing a very low risk investment environment for developers of low carbon electricity technologies.

---

65 https://auroraer.com/wp-content/uploads/2023/05/Role-of-PPAs-in-the-GB-Power-Market-Redacted-report.pdf

66 Smaller budget and moderately increased ceiling prices for PV and onshore wind, large budget and significantly increased ceiling prices for PV and offshore wind.

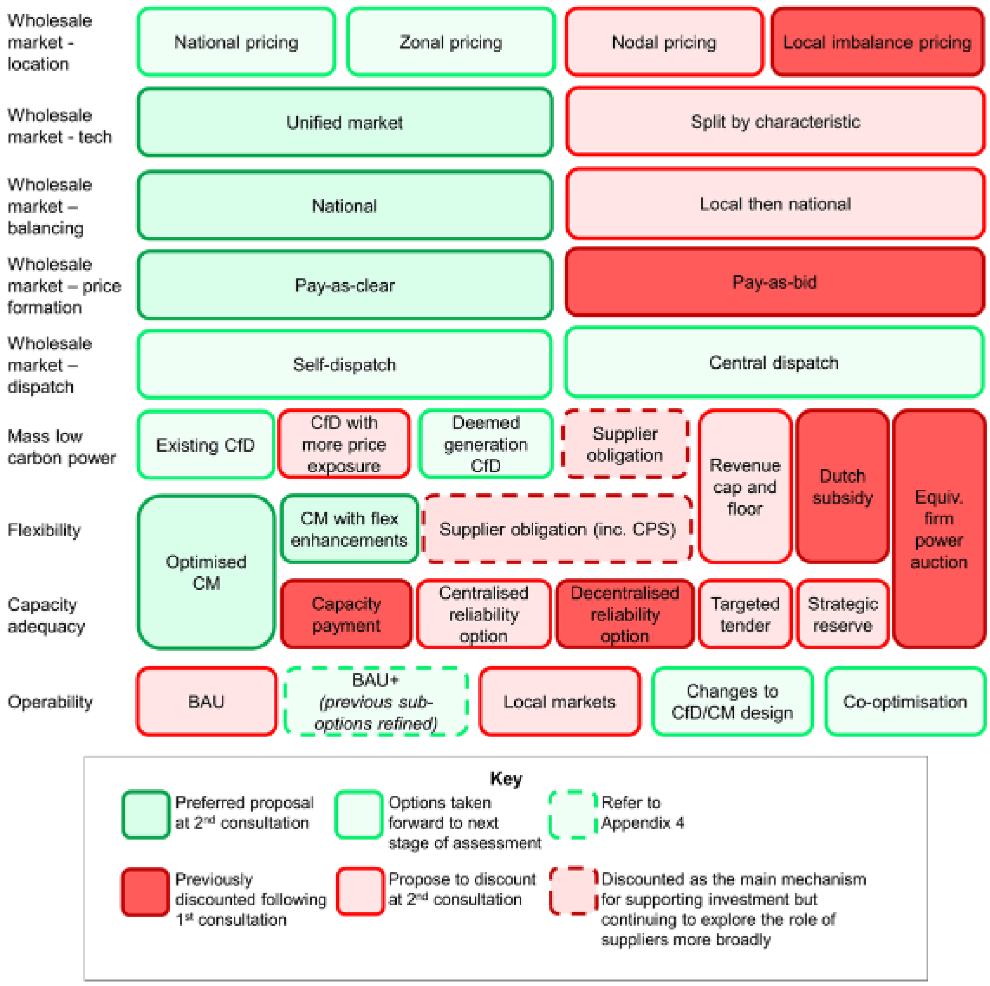
In addition, this has been achieved through a simple financial model that has been available and attractive to medium sized developers (mainly above 5MW).

The other important feature of the scheme is that it is open to many technologies since the beginning, but not in a technology-neutral way. The design elements are tailored to the specifics of the technologies and the policy objectives. In the UK, there was a clear policy preference for offshore wind. Placing offshore wind in the Pot 2 to compete against immature technologies, and opening only this pot in several allocation rounds, is a clear implicit promotion of that technology without explicitly prohibiting other (immature) technologies.

A major criticism of CfDs in general is that they limit generators' exposure to the market, meaning that renewable assets (particularly intermittent technologies) are not exposed to price signals. Related to this, the current design of CfDs is not suited to technologies that increase flexibility in the electricity market, such as low-carbon flexible generation or storage. The current CfD scheme is also not designed to send market signals about where infrastructure should be located in the UK.

A comprehensive review of the electricity market design (Review of Electricity Market Arrangements – REMA) is ongoing, which also addresses issues that are relevant for the future of the CfDs. Figure 11 summarises the policy options that were considered during the consultation, as well as the status of each option (rejected, proposed to reject, taken forward, preferred).

FIGURE 11: STATUS OF REMA CONSULTATION (UK)



Source: Review of Electricity Market Arrangements, Second Consultation Document[67], Figure 2

Following the First REMA Consultation, the Government opted to reform the existing CfD scheme instead of a complete overhaul. This decision came after abandoning two proposed options due to their associated risks and flaws: a strike price range (known also as 'cap and floor CfD') which was deemed to introduce significant developer risk with limited system benefits, and the 'revenue cap and floor', which had design flaws posing gaming risks and potentially distorting incentives for efficient generator operation.

Several alternative options are now under consideration:

- Deeming CfD Payments: This option involves estimating a renewable asset's potential generation under live conditions and replacing the actual metered output with deemed output. However, challenges arise regarding the creation and maintenance of an accurate deeming methodology, especially given recent concerns about gaming risk and overcompensation.
- Capacity-based CfD: This proposal suggests providing fixed payments to generators based on installed capacity, irrespective of market activity. It would allow generators to operate on merchant terms, optimizing trading and operational strategies across markets.
- Partial CfD Payments: Under this option, only a portion of a renewable asset's capacity would be covered by a CfD, while the remainder operates on a merchant basis. This approach seeks to balance the benefits of guaranteed revenue with the flexibility of merchant trading.
- CfD Reference Price Reform: This option explores ways to increase the price exposure of intermittent renewable CfD assets, encouraging generators to be more responsive to market needs. However, potential interactions with factors such as the cost of capital need careful consideration to avoid unintended consequences.

The upcoming phase of REMA will involve conducting a thorough evaluation of the remaining CfD reform options, aiming to determine a preferred option by mid-2025. Keeping the existing CfD design is also possible, due to its advantages. As mentioned above, the main aim and benefit of the CfD scheme comes from its risk-minimising design, and any change that seeks to increase the price exposure of generators goes against that. Moreover, any increase in developer risk is priced into the bids and reflected in the strike prices. It can therefore be argued that for technologies that require a low-risk environment, the existing CfD design is optimal, while for more mature and efficient technologies it is not clear that any kind of support mechanism is needed.

There is an in-built support for dispatchable technologies, as in their case, the reference price is calculated on a seasonal (6 months) average, not on hourly basis as in the case of intermittent producers. For dispatchable generators, the profit-maximizing strategy is to produce in the high-priced hours regardless of the reference price setting methodology, but the achievable

[67] https://assets.publishing.service.gov.uk/media/65ef6694133c220011cd37cd/review-electricity-market-arrangements-second-consultation-document.pdf

profit level is higher if the reference price is calculated as a seasonal average, since this will lead to a reference price that is almost certainly below their real market revenues. This makes dispatchable technologies more competitive as the same strike generates higher revenues for them. However, this advantage cannot be observed in the allocation of CfDs, as only 1.5% of the awarded capacities belong to dispatchable technologies.

As for bad practices, the low frequency of the allocation rounds (2-years) must be highlighted at first place, as it limited both the capacities that are supported and realised, and also created a less predictable and stable environment. Second, there are insufficient sanctions for late delivery, leading to low realisation rates and significant delays. In the first allocation rounds, the pay-as-clear pricing rule also contributed to low realisation rates, as many companies overestimated the resulting strike price and submitted unrealistic bids to ensure a win. Once the low strike price was announced, these developers refused to proceed with the investments. While the lack of sanctions is still a problem, investors seem to have learned the pay-as-clear pricing rule and unrealistic bids are no longer a concern. Besides these, the allocation procedure is also very complex and leads to hardly predicable outcomes, due to the different pots, minima and maxima constraints, but especially to the different delivery years, which are combined with yearly budget caps.

4 Conclusions and recommendations

The eight high-level country analyses and the 3 case studies provided many good and bad practices, which Austria should consider when enhancing its premium design. With respect to CfDs, several conclusions can be drawn. It is important to note that CfDs provide a stable cash flow for producers and therefore are generally preferred by investors as a remuneration scheme. However, the country examples also show that there are many ways to implement CfDs, which can have a serious impact on the auction outcomes.

This report identifies the following main challenges associated with the operation of CfDs:

- The system itself does not really incentivize the market integration of renewables (neither intermittent nor dispatchable generators), because the scheme mainly provides stable revenues.
- The payback obligation (in case of high prices) can create a situation where more beneficial solutions are available to producers, usually PPAs, which can create competition for the governmental scheme or, in extreme cases, can empty the governmental tenders.
- CfDs may carry a higher risk of non-completion of projects if the market environment changes significantly between the time of the auction and the completion of the power plant. Thus, it is advised to operate CfDs with not very long realisation periods.

For market integration, the most common measure applied by countries is the optimization of the reference period. As the high-level analysis showed, most countries in Europe apply a monthly reference period for all technologies, but there are some examples where separate reference periods are applied for dispatchable and intermittent generators, and cases where an hourly reference period is applied for all technologies. This report argues that in order to better facilitate market integration, at least a monthly reference period should be applied for all technologies. It is also important to facilitate the market integration of intermittent generators, as if these power plants experience an environment where market signals matter, they will have more incentive to adopt solutions that allow them to influence their production patterns, such as installing battery storages.

A related and important measure is the calculation of the reference price. For those countries that apply longer reference periods, the general tendency in Europe is that the reference price is the production-weighted average of the exchange (DAM) price. This weighting price is beneficial for the producers, as intermittent generators often experience market value loss over time due to their production profile. If weighted prices are used as a reference price, then the market value loss should not be considered in the bids, as it becomes an external factor for the power plant. On the other hand, this report argues against production-weighted reference prices, especially if a country organizes multi-technology auctions. The main reason is that price cannibalization is significantly stronger for solar PV relative to onshore wind, which means that such a measure neutralises the main disadvantage of PV over wind. As a result, it is easy to have a situation where wind requires lower support, but PV becomes the dominant winner of the auction, which phenomenon is called technology bias.[68] An alternative pricing where the reference price is the unweighted price for all technologies can lead to more efficient allocation of support.

Besides the reference technology, there are many additional design elements that are worth considering in order to facilitate the market integration of RES, thus allowing the efficient operation of CfDs. Spain provides two potentially good examples: First, the support period is not only measured in years, but there is also a produced energy constraint, which incentivizes power plants to produce only in higher price hours. The second is the modification of a strike price by weighting it with the market price when calculating the support. A similar result can be achieved by using cap and floor CfD; however, this solution has not yet been widely adopted in Europe.

The second challenge with CfDs mainly originates from the fact that CfDs are always associated with a payback obligation. This creates an environment where producers may want to receive stable revenues but avoid payback. One such solution for them is to sign PPA contracts, which are often also fixed-price contracts, but the revenues (and risk) tend to be higher than at government auctions. There are many markets where auctions and CfDs coexist, such as France, Italy, Greece, and Poland. In these systems, PPAs and CfDs may act as competitors in the short term but supplement each other in the long run to reach the country's renewable energy targets. Of course, it is important to determine how the country regulates the relation of CfDs and PPAs, as the high-level analysis and the case studies showed. The most extreme case is Hungary, where PPAs are subject to very unfavourable taxing conditions, so that government auctions were strongly prioritized by the policymakers.

Interesting conclusions can be drawn from the case studies of the UK and Spain, the two most mature PPA markets in Europe. In both cases, solar PV and onshore wind have become very mature technologies that can basically operate without any additional support. As a result, government auctions face a challenging situation, as they cannot offer sufficiently high prices to attract project promoters, or they over-subsidize the RES power plants by allowing high price levels. Because of the described discrepancy, Spain has stopped tendering in 2022, and it is also expected in the UK that new solar PV and onshore wind power plants will be mainly built through PPAs. It is questionable however, that purely PPA-based installations will be sufficient for countries to reach their very ambitious renewable goals on the long run. This difficulty is more pronounced in CfDs than in one-sided FIPs (which have other drawbacks not described in this report), as one-sided FIPs do not have a revenue cap, so producers have significantly more incentive to participate in tenders than in a CfD. This report argues that non-favourable auction conditions for producers will be a significant problem across Europe in the long run, thus in Austria as well.

The analysis also showed that in many cases the auctions create an environment in which generators can avoid paybacks in the CfD. Many of the investigated countries allow late entry into the remuneration scheme after project completion, in order to allow higher revenues for the producers. This practice, however, goes against the main idea of a CfD, which is that power plants pay into the system when prices are high and receive support when prices are lower.

[68] https://sciencedirect.com/science/article/pii/S0301421523004494

This setup allows for high revenues if the prices are high after completion, while still receiving support in later periods. This report argues that such measures should not be included in the tendering scheme; many countries that allowed later entry into the contract have already phased out this opportunity.

As a third and final point, the case studies of Hungary and the United Kingdom showed that while auctions were efficient and usually oversubscribed, it can easily happen that the realization rates of the projects are poor. It is important to highlight that these delays and project cancellations are not the direct consequence of the application of CfDs but are also strongly influenced by the auction design of the country. In Hungary, the case-by-case deadline extensions, while in the UK, the very mild penalties and no financial securities may be the main contributing factors. However, it is also important to note that because of the payback obligation at some point during the implementation or operation, it might be beneficial for the power plant to leave the CfD scheme or not complete the project within the original contract framework. Therefore, it is advisable to apply such a scheme with more severe penalties and no option for producers to exit the support scheme once they have entered, only if they fulfil the contractual obligations.