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Design options for cross-border auctions

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Executive Summary

Current developments on EU energy policy trigger interest in cross-border auctions. In contrast to national auctions, cross-border auctions are characterized by their openness for participation of projects from more than one country. For example, if country A conducts a cross-border auction that is open to projects in country A as well as projects in country B, competition is created between project developers from both countries. Cross-border auctions will typically result in cross-border flow of support payments.

Economic rationales for cross-border auctions: There are several arguments for implementing cross-border auctions:

- Better natural resource potential: By tapping into better natural resource potential of a cooperation country, the amount of energy that can be generated per € invested in a certain technology may be higher.
- Higher market values: Higher market values compared to the values of domestic RES power plants can lead to a significant decrease in support payments.
- Lower cost of capital: Cross-border cooperation can under certain circumstances provide access to lower cost of capital and overall better financing conditions and thus reduce overall investment needs.
- Higher competition: Countries can use cross-border auctions to increase competition in their domestic scheme and decrease the risk of collusion.

Outlook for cross-border auctions: Despite the potential gains of cooperation, most countries have so far been reluctant to make use of cross-border auctions. Only Germany and Denmark implemented pilot cross-border auctions for solar PV in 2016. Nevertheless, an increasing number of cross-border auctions might be triggered in the near and mid-term future, *inter alia,* due to the following developments:

- The new 2030 RES governance: The new governance sets an EU binding target of at least 32% in final energy consumption but does not translate it into national targets. However, the EU target needs to be achieved by Member States' contributions. In this context, the use of cost-efficient RES potential is as important as ever and may result in cross-border RES auctions.
- Voluntary opening of national support schemes under the REDII: According to Art. 5 of the recast renewable energy directive (REDII), EU Member States have indicative shares for a voluntary opening of their support schemes of at least 5% from 2023 to 2026 of the newly-supported capacity in each year and at least 10 % from 2027 to 2030. The European Commission will evaluate the implementation and may even make cross-border auctions obligatory as of 2025.
- The new "Financing Mechanism" may trigger EU wide RES auctions: Article 33 of the Governance regulation states that if the EU is not on track to meet its 2030 RES target, Member States which do not sufficiently contribute to the EU target achievement may provide funds to the "financing mechanism". The EU would use these funds to implement RES auctions across all Member States (voluntarily) participating as potential hosting countries for RES installations.
- Renewables Projects of Common Interest (PCIs): The EU set up a new funding line in the Connecting Europe Facility (CEF) regulation for "cross-border renewables projects" with potentially 1.3 billion € of available funding for the Multiannual Financial Framework (MFF) 2021-2027. This funding may additionally incentivise Member States to implement cross-border auctions.

Cross-border auctions are still perceived to be complex to design and burdensome to implement. This report aims to address this complexity and assesses various design options for cross-border auctions and provides practical guidance for Member States seeking to implement them.

Case: German-Danish cross-border auctions prove that cooperation can achieve efficiency gains: In late 2016, Germany and Denmark mutually conducted pilot cross-border auctions. All winning bids came from Denmark. In the German cross-border auction, all 5 winning bids required a sliding premium of 5.38 ct/kWh, which was much lower than the weighted average of 6.9 ct/kWh for the awarded bids in the German national auction that took place only days after the cross-border auction. Also, during the whole period the awarded PV plants have been in operation since May 2018, Germany did not pay support on top of the market revenues in most months due to the high market values in Denmark. German levy payers are thus saving money.

Three basic models of cross-border auctions: Countries may choose to conduct unilateral -, mutual cross-border auctions, or joint auctions.

Basic models of cross-border auctions:

1. "Unilateral opening" - Only one country opens its support scheme by implementing a cross-border auction that allows for the participation of bidders in a cooperating country.
2. "Mutual opening" - The cooperation countries both implement separate cross-border auctions.
3. Joint auction (with separate/joint funding) - The cooperation countries set up a joint auction, awarded projects are assigned to one country's support scheme or a jointly established fund.

A unilateral cross-border auction is the simplest model, yet it achieves the fundamental benefits of cross-border cooperation, i.e. the reduction of support costs by access to better natural potential and/or market conditions. Under this model, little commitment is required from a host country.

Setting up a joint auction, on the other hand, requires the countries' agreement on all aspects of the auction and remuneration design (i.e. sliding or fixed market premium) and on a rule that determines the attribution of successful bids to the countries' support schemes. Implementing joint auctions increases the transaction cost of preparing the cross-border auction but it has advantages. By increasing the auction volume, the auction is more attractive for potential bidders and economies of scale may be achieved. Also, a joint auction can be more easily expanded for the participation of further countries in the future.

Differing national regulatory and market environments persist in cross-border auctions: The support scheme design must be the same for all participants of a RES auction to allow for comparison of bids and thus effective bid selection. However, the conditions under which project developers can realize RES projects differ between countries due to the national specific regulatory and market conditions. Key aspects impacting the cost of project development apart from resource availability include planning and permitting, grid connection, eligible areas and sites, environmental requirements, financing conditions, taxation, project realization periods and risk of non-realization. These aspects cannot easily be aligned in the context of a cross-border auction, as they reflect a broader regulatory and political context.

The table below illustrates the differentiation between support scheme design and the national specific regulatory framework and market conditions.

	Unilateral and mutual cross-border auctions	Joint auctions	Bidders' perspective
Support scheme (auction and remuneration design) Examples: bid size, pricing rule, market premium	Countries mostly decide on support scheme design of their opened auction individually	Single support scheme design required	Same rules apply
National specific conditions (regulatory and market conditions) Examples: site restrictions, taxation, market values	Rules and conditions of the country apply in which the installation is to be implemented		Different national rules apply

Key options to level regulatory differences are:

1) Adjusting bids by the cost impact of the regulatory framework,
2) Implementing quotas to limit the distributional effects of these differences, and
3) Aligning the regulatory framework.

Our recommendation is to refrain from levelling differences artificially in order to tap into the full efficiency potential of the auction. However, if differences need to be addressed, consider quotas as they are the most straightforward solution to the challenge.

Interactions with national auctions: Cross-border auctions usually run in parallel to national auctions or other national support schemes, which can be considered as outside options or alternative opportunities to receive support for projects. The relative attractiveness of one opportunity to get support depends on the overall availability of alternatives.

When introducing cross-border auctions in parallel to existing national auctions, it is important to synchronise the auction schedules with a view to provide a continuous pipeline and avoid boom and bust cycles in the RES industry. If auction schedules are not coordinated and auctions are conducted with timely proximity, the level of competition could be undermined.

Good practices of cross-border auction design: Auctions can only successfully contribute to achieving effective and efficient RES deployment if they are specifically designed to match the market environment in the area where the auction is conducted. Cross-border auctions add further complexity by combining political preferences and market environments of two or more countries.

Good practices of auction design – which have been identified in the first AURES project –also apply in the cross-border context. In addition, the following principles should be taken into consideration:

1. Bids need to be comparable: Auction and remuneration design must be the same for all participants to allow for comparison of bids and thus effective bid selection.
2. Adapt design to cross-border context: The auction design needs to consider the political goals and market situation of all countries involved. No single perfect cross-border auction design exists.
3. Check cross-border applicability of all design elements: Some requirements put forward in national auctions may not be applicable in cross-border auctions (e.g. material prequalification where different national permitting processes with differing costs and timelines may exist).
4. Keep it simple: Avoid design choices that increase complexity. This is even more important in cross-border auctions where market participants already need to become familiar with a new auction set-up and might have alternative auctions schemes to participate in.
5. Take care to not exacerbate differing conditions of participation for bidders: Against the background of differing national contexts, design elements determining the conditions for participation have the potential to *de facto* discriminate against bidders from one cooperating country. Special attention is required regarding the design of material prequalification, penalties and realization deadlines.
6. Ensure RES deployment while limiting transaction costs: As in national auctions, there is a trade-off between setting design elements to, on the one hand, encourage a high realization rate of winning bids, and, on the other hand, limit the transaction costs for bidders and regulators by avoiding excessive material or financial prequalification criteria
7. Give sufficient consultation and bid preparation time: To attract a large number of market actors, potential auction participants need to be given sufficient time for consultation and bid preparation to become familiar with and adapt to a new auction design and procedure.
8. Reduce the administrative complexity: The bidders and the auctioneer are likely to face additional administrative challenges in cross-border auctions. Reducing administrative complexity reduces transaction costs and increases participation.

Conducting cross-border auctions separately to the national RES auctions, in contrast to simply extending an existing national auction for projects in other countries, facilitates the alignment of rules for the cross-border auctions. The rules for national RES auctions can remain unchanged.

When setting up cross-border auctions, the design elements determining the conditions for participation as well as deadlines and penalties require a closer assessment regarding their applicability, their impact on participants' costs and risks as well as their impact on project realization and thus effectiveness of the cross-border auction. If not tailored to the specific cross-border context, such rules may exacerbate existing differences between bidders from different countries, have a strongly limiting effect on the participation of bidders from one of the cooperating countries or strongly affect the bidding behaviour, all of which may lead to a distorted competition and negative auction results.

Premium design for cross-border auctions: In the context of cross-border auctions, the design of a suitable premium becomes more challenging as two electricity markets with two potentially very different electricity prices are involved. Depending on the specific remuneration design, the various electricity prices can provide significant advantages for bidders from a certain country, posing the question if and how a level-playing can be established.

No design is clearly preferable. A fixed premium is the easiest option regarding the implementation in cross-border and joint auctions. It strongly favours bidders from countries with higher (expected) market values and thus lowers the attractiveness of the cross-border auction for bidders from countries with lower (expected) market values.

A sliding premium based on national market values implies relatively low risks and financing costs. However, the level of support necessary is uncertain. In case of a joint auction, the allocation of plants between countries is also more complex if a sliding premium is chosen. Our recommendation for open auctions is to use the prevailing national premium.

Allocation of costs and benefits: For a cross-border cooperation to be attractive, the benefits must outweigh the costs for each participating Member State to ensure that it is better off with the cooperation than without.

The key elements to be considered are the cost of support payments on the one hand and the benefit of RES target achievement on the other. Generally speaking, the Member State paying support costs should receive the target achievement statistics. However, there is a range of additional cost and benefit elements. Identifying and these additional costs and benefits in detail and distributing them between countries has various challenges. First, the participating countries have to agree on a list of elements to be considered for the detailed consideration of costs and benefits. Second, for various elements it is quite burdensome to quantify and monetize them. This relates foremost to system and grid integration costs, which can only be quantified in a robust manner when using energy market and grid modelling.

Past experience has shown that the level of complexity of the cost-benefit analysis and the subsequent decision on the distribution can become a show stopper. Thus, we recommend that countries try keeping the cost-benefit analysis and the resulting distribution as simple as possible.

Practical implementation of cross-border auctions: Setting up cross-border auctions is more complex than setting-up national auctions, because the design and implementation process includes negotiations between at least two governments and agreements between different regulatory agencies. This requires the mutual understanding of the two (or more) sets of political priorities, regulatory frameworks and market conditions.

The implementation of a cross-border auction requires the conclusion of a cooperation agreement between the countries to avoid legal uncertainty, reduce counter party risks as much as possible, and thereby reduce the risks for investors. Furthermore, the cooperation agreement needs to define the details regarding the exchange of information, responsibilities, and legal liabilities as well as how financial support and the statistical benefits from the renewable sources are to be allocated amongst the participating countries.

Considering the number of aspects that need to be agreed upon, it is even more important to reduce the administrative complexity of cross-border auctions and make use of procedures that are already established at national level. We also recommend refraining from determining principles of cooperation that strongly limit the potential pool of cooperation countries. This is particularly the case for the principle of physical import. Countries should define their principles of cooperation in a way that maintains flexibility in the choice of the most suitable cooperation countries.

Disbursement of funding and data transfer: The cooperation countries need to define rules and responsibilities for the cross-border disbursement of funding. This involves the exchange and monitoring of information to ensure correct support payments to the installation.

Furthermore, processes need to be established for the frequent data exchange of the production volume of each installation, as well as the (technology-specific) market values that are the basis for calculating the support payments. National bodies may have to set up procedures for the exchange of the required information, specifying the format, frequency and timing of the data transfer.

There are numerous aspects to be considered by all involved parties when designing cross-border auctions. The practical guidance provided in this report shows that establishing cross-border auctions is indeed feasible. Experience with cross-border auctions is still limited and the potentially increased number of such auctions being implemented will generate further knowledge on how to tap into the vast potential for RES deployment while keeping the complexity and transaction costs limited.

1 Introduction

Support schemes for renewables in the EU are, in principle, organised nationally. Nonetheless, in recent years the EU has experienced a development resulting in convergence of renewables (RES) support schemes towards auctions and feed-in premiums. At the same time, opening auctions for RES installations located in other Member States has become an increasingly discussed topic – not least because Germany and Denmark have conducted pilot cross-border auctions for PV installations.

This report aims to address the potential complexity of cross-border auctions and to show how they can be designed to be effective and efficient. To do so, it assesses various design options for cross-border auctions and provides practical guidance for countries seeking to implement them. The study builds on the findings on auction design from the first AURES project (http://auresproject.eu/) and incorporates experience from the German-Danish auction.[1]

1.1 Origins of cross-border auctions

Cross-border auctions stem from the broader concept of RES cooperation as enshrined already in the Renewable Energy Directive 2009/28/EC, whereby Member States can finance RES installations located in other Member States. There are several economic arguments for such cooperation, all revolving around increasing the cost-effectiveness of public subsidies for RES deployment: Countries with limited natural potential for RES deployment can use resources in other countries to reach their national RES targets. Indeed, for the current RED one discussed solution was a European-wide support scheme to make best use of the existing RES potential across Europe. However, Member States insisted on their sovereignty in defining their energy mix. Voluntary cross-border cooperation was seen as a way to reconcile the two opposing viewpoints: using each other's RES potential while maintaining Member States' sovereignty on their energy mix. Not only natural resources, but also lower costs of capital and higher market values can result in efficiency gains when deploying RES capacities in one country instead of another (see chapter 2 for a detailed discussion of these elements).

Apart from economic considerations, the legal framework as defined in the current Guidelines on State aid for environmental protection and energy[2] rules has triggered the first implementation of cross-border auctions: When assessing the compliance of support schemes with State Aid rules, the European Commission's Directorate General for Competition (DG COMP) has argued with a view to the Treaty on the Functioning of the European Union (TFEU), especially Articles 30 and 110: A RES producer is initially not able to access a Member State's support scheme but he/she is subject to the related levies when selling electricity in that Member State. This is interpreted as an import tax and thus a breach of the freedom of movement of goods in the EU. As a result, DG COMP has approved RES support schemes in various Member States only under the condition that they would at least be partially open to installations from abroad.

The recent convergence towards RES auctions in the EU has further facilitated the implementation of cross-border cooperation: Member States have so far been reluctant to make use of the Cooperation Mechanism because when applying administratively set feed-in premiums, the selection and control of the volume of projects from abroad eligible for support was a major concern. With the general shift towards auctions – a mechanism that inherently determines the volume of supported capacities – this previous barrier has effectively been removed.

[1] Note that this report focusses on auctions used to allocate support payments, not to procure energy or to provide services related to grid stability or energy security.

[2] Guidelines on State aid for environmental protection and energy 2014-2020, (2014/C 200/01): https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52014XC0628%2801%29

1.2 Outlook for cross-border auctions

In the near and mid-term future various developments may trigger an increasing number of cross-border auctions.

1. Ensuring achievement of national RES targets in 2020: The recent Renewable Energy Progress Report reveals that meeting their RES targets for 2020 will be challenging for several Member States.[3] Implementing cross-border auctions may be one way to address this challenge. By conducting cross-border auctions, Member States may tap into the pipeline of readily available projects in other Member States. However, this is only an option if projects can be until end of 2020.

2. The new 2030 RES governance: Cross-border auctions are likely to play an increasing role in the period from 2021-2030: This framework is defined, among other elements, by the Eu Directive 2018/2001 on the promotion of the use of energy from renewable sources (REDII) and the Governance regulation: it sets an EU binding target of at least 32% in final energy consumption but does not translate it into national targets. The EU target needs to be achieved by individual Member States' contributions. However, back-up benchmarks define the expected contribution of each Member State in case the EU falls behind its overall trajectory for the 2030 target. In this context, the use of cost-efficient RES potential is as important as ever and may result in cross-border RES auctions. Cross-border auctions are legally embedded in the Cooperation Mechanisms of the REDI[4]. These are continued in the REDII and thus can be implemented in the period 2021-2030.

3. Voluntary opening of national support schemes under the REDII: The REDII includes a provision on the opening of support schemes for electricity from renewable sources (Article 5): Member States have the right to decide to which extent they open their support scheme (with indicative shares of at least 5% from 2023 to 2026 of the newly-supported capacity, or of the budget allocated thereto, in each year and at least 10 % from 2027 to 2030, or, where lower, to the level of interconnectivity of the Member State concerned in any given year). In this context, the Commission will evaluate the implementation of cross-border auctions and may even introduce an obligation for Member States to partially open their support schemes (5 % opening by 2025 and 10 % by 2030).

4. The new "Financing Mechanism" may trigger EU wide RES auctions: Article 33 of the Governance regulation states that if the EU is not on track to meet its 2030 RES target, Member States which do not sufficiently contribute to the EU target achievement may provide funds to the "financing mechanism". The EU would use these funds to implement RES auctions across all Member States (voluntarily) participating as potential hosting countries for RES installations.

5. Renewables Projects of Common Interest (PCIs): The EU set up a new funding line in the Connecting Europe Facility (CEF) regulation for "cross-border renewables projects" with potentially 1.3 billion € of available funding for the Multiannual Financial Framework (MFF) 2021-2027. This funding may additionally incentivize Member States to implement cross-border auctions.

6. Revision of State Aid guidelines: The upcoming review of the State Aid guidelines for the period 2021-2030 may include provisions on the opening of support schemes (given the numerous interventions by DG COMP to urge Member States to open their support schemes).

Despite the recent changes, the only two examples of cross-border auctions are the mutually opened auctions between Germany and Denmark based on an agreement between both Member States signed in 2016. Cross-border auctions are still (perceived to be) complex to design and burdensome to implement.

[3] See Ecofys, eclareon, Fraunhofer ISI, TU Wien (2019): Technical assistance in realization of the 4th report on progress of renewable energy in the EU, available at: https://ec.europa.eu/energy/sites/ener/files/documents/technical_assistance_in_realisation_of_the_4th_report_on_progress_of_renewable_energy_in_the_eu-final_report.pdf.

[4] Cooperation Mechanismsm are introduced in Articles 6 to 11 of the Renewable Energy Directive (2009/28/EC).

1.3 Structure of the report

In assessing the design options and providing guidance, the study explores:

- The economic rationale of countries to implement cross-border auctions. Understanding the specific motivation of MS to implement cross-border auctions is important as it has implications for the design of the auction and its practical implementation (chapter 2).
- The experience with the German-Danish auction in depth, including the auction design, a discussion of the results and lessons learnt (chapter 3).
- The various types of cross-border auctions that may be applied to meet the countries' preferences (chapter 4). The types of cross-border auctions (unilateral and mutual cross-border auctions, joint auctions and joint auctions with joint funding) represent incremental steps towards intensified support scheme cooperation between countries.
- The local regulatory and market conditions in MS, which can impact the competitiveness of projects participating in the cross-border auction and options on how to deal with such conditions (chapter 5).
- The support scheme design, including the auction design options, (building on the work previously done in the AURES project, specifically applied to the context of cross-border auctions), as well as the remuneration design (chapter 6).
- The allocation of costs and benefits between countries, implemented in a way that it addresses the countries' preferences (their rationale to participate) (chapter 7), first and foremost improved cost-effectiveness of their target achievement.
- Issues around the practical implementation of cross-border auctions (chapter 8). These can become quite burdensome and thus using existing experience on practicalities may reduce transaction costs for countries.

The report closes with conclusions (chapter 9).

2 Economic rationales for cross-border auctions

Besides the legal provisions outlined in the previous chapter, the main economic rationale for countries to implement cross-border auctions is an increase in the cost-effectiveness of RES support.

Although the costs for electricity generation from RES have decreased significantly over the last years, substantial investment is still necessary to reach the 2030 target. The level of investment (as the costs of renewable electricity generation) and the needed support can be decreased by access to:

- better natural potential
- higher market values
- lower cost of capital
- increased competition

In the following, these different aspects are briefly explained and put into perspective.

2.1 Natural resource potential

The resource quality, i.e. the amount of energy that can be generated per € invested in a certain technology, differs heavily within countries and even more so between EU Member States.

Figure 1 and Figure 2 show the resource quality for photovoltaics and wind plants across the EU. As expected, solar resources are much better in Southern Europe when compared to Northern Europe while wind resources are distributed more evenly across the continent with particularly good resources along the coastlines, in the UK and Ireland, as well as in parts of Greece, Spain, France and Sweden. This uneven distribution across the EU is one of the reasons for potential benefits from cooperation between the EU MS when it comes to investing in RES plants. The maps also show opportunities for cooperation with third countries - solar resources are for example even better in Northern Africa, while Norway has very good wind resources.

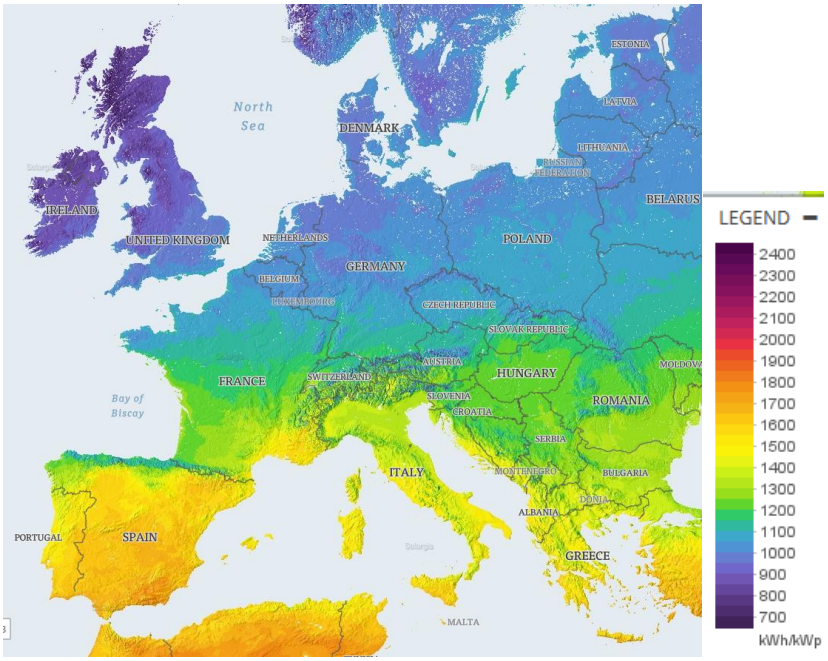

Figure 1 - PV Full load hours in Europe (Northern parts excluded due to low degree of irradiation, Source: Global Solar Atlas)

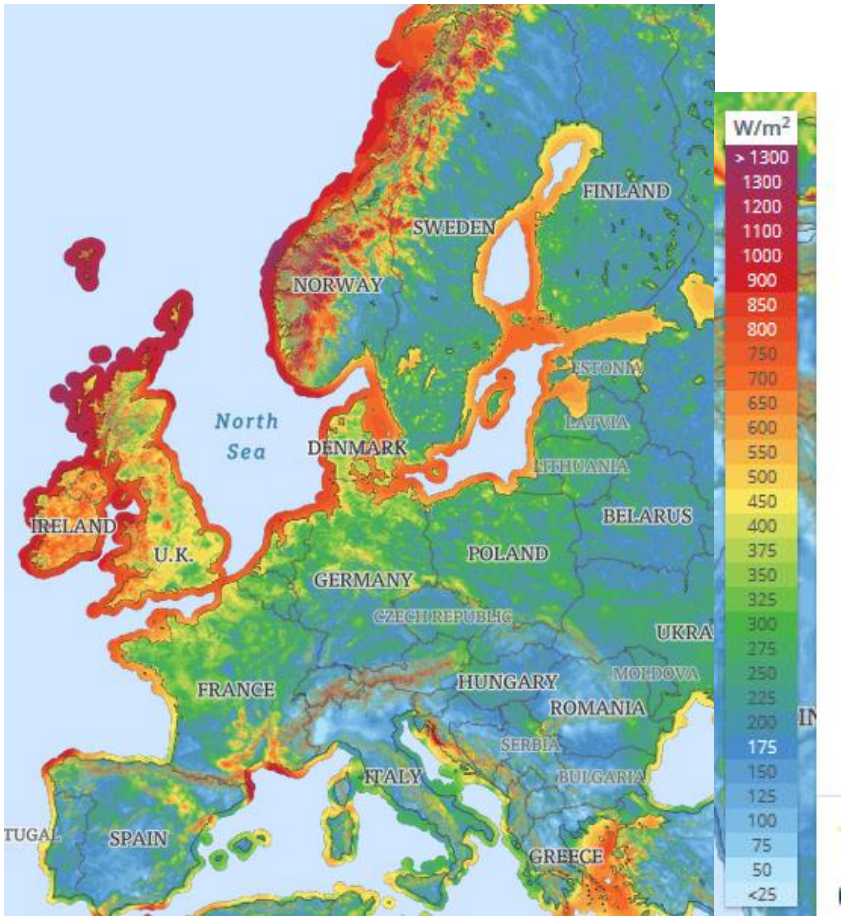

Figure 2 - Wind energy resources across Europe (W/m2) 100m above ground (Source: Worldbank Global Wind Atlas)

2.2 Market value

Renewable power plants, especially wind and solar power plants, are weather-dependent and not fully dispatchable. More precisely, they can be curtailed but cannot freely ramp-up generation depending on demand or electricity prices.

As a consequence, the income that renewable energy power plants can generate from the regular electricity market is determined to a large degree by their variable feed-in profile which depends on the weather. The income, which renewable energy power plants can generate from the regular electricity market under these conditions, is called the "market value". The absolute market value represents the average price the renewable energy plant receives for selling electricity at the electricity market and the relative market value represents the income of a renewable plant compared to the average electricity price.

Market values differ between countries or bidding zones depending among others on the generation mix, the existing capacities of both renewable and conventional electricity generation plants and the level of interconnection. Figure 3 shows the development of average electricity prices in selected EU Member States. While these do not represent exactly the market values of RES, the differences can give a first indication for the differences in market values. In 2017, the lowest price in the selected countries was 32.41 €/MWh in the Nordic and Baltic region, the highest price was 53.15 €/MWh in Italy. Such a range can of course influence the competitiveness of RES in different Member States.

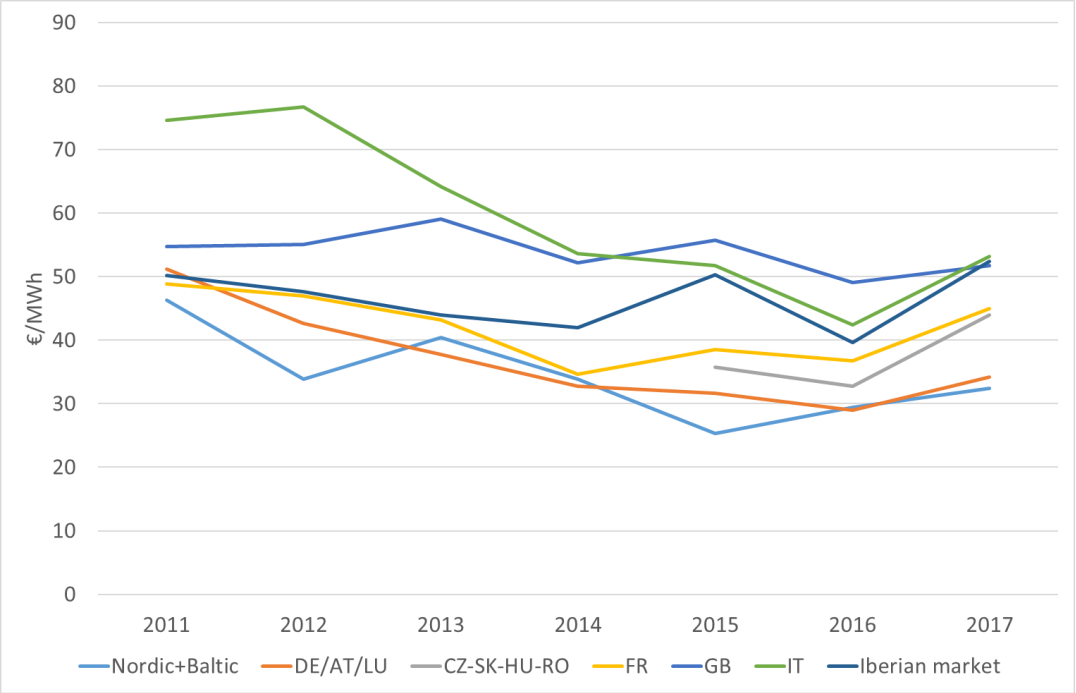

Figure 3 - Development of average day-ahead electricity prices in selected EU Member States (Source: ACER 2018)

By implementing cross-border auctions, countries can gain access to projects with higher market values compared to the domestic RES power plants, which can lead to a significant decrease in support payments. The Danish-German case (see chapter 3 for more details) can be considered a practical example: due to the generally higher electricity market prices and the lower PV penetration, Danish PV plants are expected to have a higher market value compared to PV plants in Germany. Danish projects that were awarded in the opened German auction receive their support in form of a sliding feed-in premium, the difference between the awarded price and the national market value. Thus, German levy payers save money in form of support payments due to the higher Danish market values. So far, since the awarded PV plants are in operation, Germany did not pay any support on top of the market revenues in most months (see chapter 3).

2.3 Cost of capital

The costs of financing of RES installations also differ substantially between the EU Member States. The costs of financing (usually measured as the weighted average costs of capital "WACC") are partially influenced by the kind of support system for renewables in place in a certain country. For example, a sliding feed-in premium over a long period (e.g. 20 years) implies a very low revenue risk for the plant operator, while a quota system with a market for green certificates or a fixed premium paid on top of the electricity wholesale price implies a higher revenue risk. However, a part of the investment risk also depends on the political risk associated to the respective country. An indicative study by the RE-FRAME project (http://re-frame.eu/) found that WACC for onshore wind power in EU Member States varies significantly with values between 2.5 and 3.5% in Germany on one end and up to 12% in Latvia and 13.7% in Greece at the other end of the spectrum.

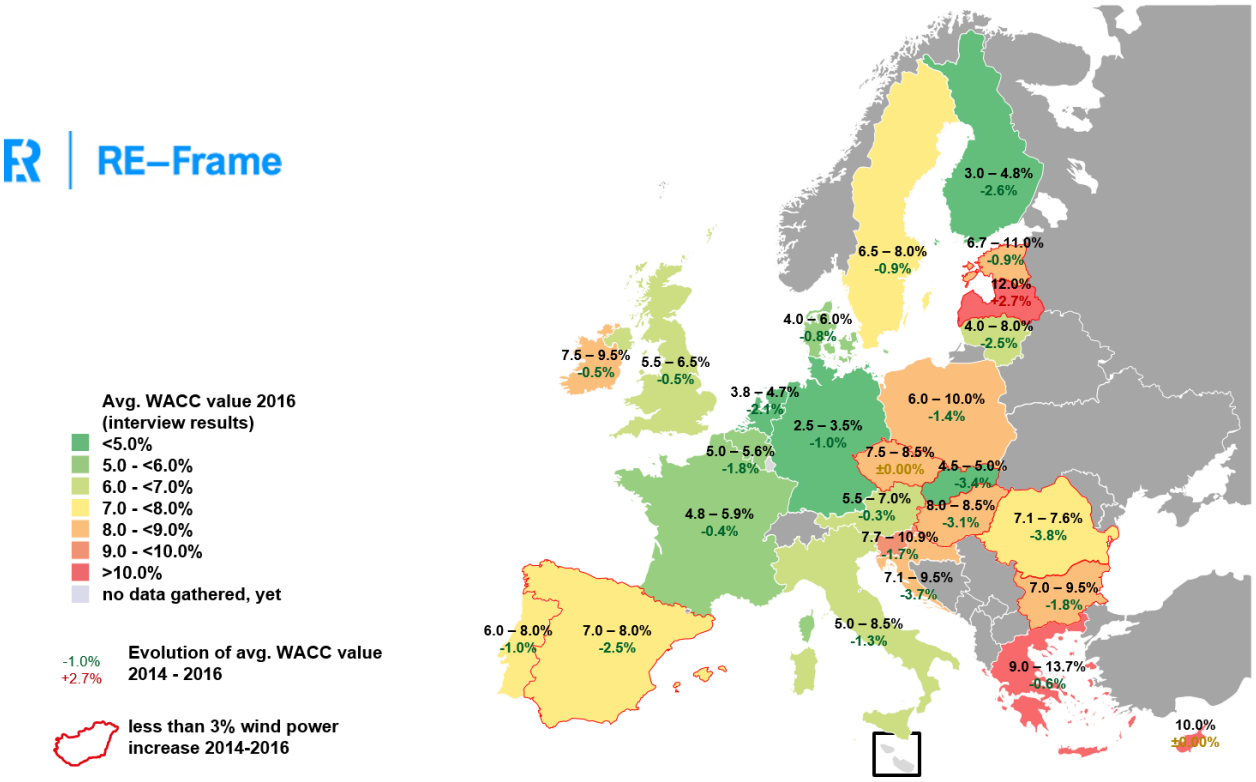

Figure 4 - WACC for onshore wind across the EU in 2016 (Source: RE-FRAME)

Besides a long-term effect of harmonization, cross-border cooperation can under certain circumstances provide access to lower cost of capital and overall better financing conditions and thus reduce overall investment needs if, for example, the German financing conditions apply for investment in wind parks in Greece. In this case, if Greek projects could participate in a German cross-border auction, their WACC could be significantly lowered, since they would be supported through the more stable German remuneration scheme. Similarly, if Greece opens its national auction scheme, German projects with a relatively low WACC could help Greece achieve its RES goals in a cost-efficient manner.

2.4 Increased competition

Cross-border cooperation can be used to increase competition in domestic support schemes. Especially smaller countries that face the issues of a limited amount of domestic resource potential, or a limited amount of competition/market actors, can make use of cross-border auctions to reach their RES targets cost-effectively.

In case of low domestic RES potential in terms of available sites or natural resources, small countries could for example unilaterally open their support scheme to foreign projects. Like that, the opening country can attract foreign projects which will decrease the support costs solely due to lower LCOE.

In case of a high market concentration or undersubscription in a country's auction – the lack of actor diversity can lead to insufficient competition and even collusion in the auction and thus to higher prices – opening the support scheme to foreign projects can increase the competitive pressure in the national auction scheme and thus decrease support costs and realize efficiency gains.

This argument counts for larger countries as well: more competition in form of foreign projects can also decrease the risk of collusion.

3 Experience from the German-Danish cross-border auctions

In late 2016 the first cross-border auctions for renewable subsidies where held. These cross-border auctions for solar photovoltaic (PV) were a pilot project between Germany and Denmark. Specifically, the German auction permitted installations located in Denmark, reciprocally the Danish auction was partially open for installations located in Germany.

As a result of state aid approval procedures in 2014, Germany and Denmark agreed to conduct two cross-border auctions, one implemented by Germany and one by Denmark. Both countries emphasized the pilot character of the auctions, yet especially Germany had the ambition to use this pilot to develop and test various design options and procedures for the implementation of future cross-border auctions. Denmark, on the other hand, had no intention to conduct further cross-border auctions (Kitzing & Wendring, 2016[5]).

3.1 Cross-border cooperation agreement

A bilaterally negotiated cooperation agreement was signed in July 2016 (Germany & Denmark, 2016[6]). As stipulated in the agreement, each country maintains discretion in terms of the design of their auction and their support scheme. The following table provides an overview of the most important design features:

	German cross-border auction	Danish cross-border auction
Auction volume	50 MW	20 MW (only 2.4 MW open to installations in Germany)
Maxi. bid size	Projects in the range of 0.1–10 MW in size were eligible.	2.4 MW
Remuneration method	Uniform pricing No premiums are paid if negative prices persist for more than 6 consecutive hours.	Pay-as-bid Premiums are paid only when (local) market prices are positive.
Ceiling price	The maximum accepted bid is 11.09 ct/kWh.	No ceiling price.
Premium design	sliding feed-in premium based on the local market prices	fixed feed-in premium paid on top of the local market prices
Material prequalification	Proof of land ownership or permission from the land owner of the site. No further material prequalification was required, which is less compared to the national auction.	No material prequalification criteria apply. Permits and licenses to be provided ahead of construction.
Financial prequalification	Bid bond of €70 per kW To balance lower material prequalification, the financial prequalification was raised compared to the national auction.	180 DKK per kW (approx. €24.12)
Realization deadline and penalty	After 18 months the premium is reduced by 0.3 ct/kWh. After 24 months the contract is revoked and a penalty of the size of the bid bond is levied.	If the project is not connected to the grid within 2 years, the contract is terminated, and the energy agency claims the amount guaranteed.

Table 1 – Overview of most important design features of German-Danish cross-border auctions

[5] Kitzing & Wendring (2016). Cross-border auctions for solar PV - the first of a kind.

[6] Germany & Denmark (2016). Agreement between the Government of the Federal Republic of Germany and the Government of the Kingdom of Denmark on the Establishment of a Framework for the Partial Opening of National Support Schemes to Support the Generation of Energy from Solar Photovoltaic Projects and for the Cross- border Administration of such Projects in the Context of a Single Pilot Run in 2016.

Furthermore, the cooperation agreement regulates the following issues, *inter alia*:

Local site restrictions: German zoning and planning laws prohibit the use of farmland (among other things) for PV installations, which installations located in Germany have to comply with. No site restrictions apply for installations located in Denmark.

Data exchange: National administrative entities will exchange data on the supported projects, hourly production and hourly market prices from the relevant bidding zones.

Energy targets: Installations located in Denmark, but supported by Germany, will count towards the European renewable energy target of Germany and vice versa.

For the German auction, the deadline for submitting bids was 23 November 2016, and winning projects where announced on 28 November 2016 (Bundesnetzagentur 2016[7]). For the Danish auction, the deadline for submitting bids was 8 December 2016, and winning projects where announced 4 days later.

3.2 Results

Figure 5 shows the location of all projects that were awarded in both cross-border auctions.

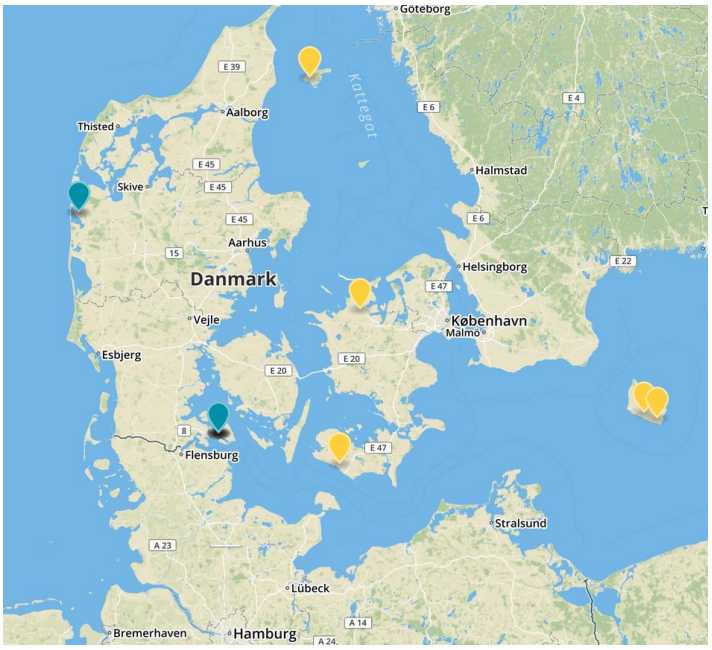

Figure 5 – Location of the 5 awarded projects in the German auction (yellow markers) and of the 9 awarded projects in the Danish auction (green markers); Sources: Bundesnetzagentur (2016); Mail correspondence with Energistyrelsen

3.2.1 Result of the German cross-border auction

The German auction attracted 43 bids totalling 297 MW (Bundesnetzagentur 2016[8]). Of these, 26 bids totalling 143 MW were for projects located in Germany, while 17 bids totalling 154 MW were for projects in Denmark. The average German project size was 5.5 MW, which is significantly smaller than the average Danish project size at 9.1 MW.

The five winning bids were all given for projects located in Denmark and were submitted by the same parent

[7] Bundesnetzagentur, (2016, October). General information cross-border auctions.
[8] Bundesnetzagentur, (2016, October). General information cross-border auctions.

company *European Energy*. The winning projects all locate installations on farmland, notably Germany prohibits this type of land from being used for ground-mounted PV installations. All the five winning bids required a sliding premium of 5.38 ct/kWh, and the size of each project was 10 MW (i.e. the capacity limit). This was almost 2 ct/kWh below the previous German national auction, when awarded bids had a weighted average bid level 7.25 ct/kWh. A national German auction that took place only days later resulted in a weighted average bid level of 6.9 ct/kWh. Additional seven months passed before the bid levels in the German national auction reached a similar bid level to that achieved in the cross-border auction.

The average quantity-weighted price of all bids was 7.02 ct/kWh. While it was 7.65 ct/kWh for the 26 projects located in Germany, it was 6.44 ct/kWh for the 17 projects located in Denmark.

As of May 2018, all five winning projects have been constructed.

3.2.2 Result of the Danish cross-border auction

The Danish auction attracted 36 bids totalling 79.45 MW, thus the average project size was 2.2 MW (Energistyrelsen, 2016[9]). Although the auction was partially open, no bids were submitted for installations located in Germany. The 9 winning bids were submitted by three companies, all subsidiaries of the parent company *Pure and Better Energy*[10]. All the 9 winning bids required a fixed premium of 12.89 øre/kWh (approx. 1.73 ct/kWh), and the size of each of the 9 projects was 2.4 MW (i.e. the capacity limit), thus totalling 21.6 MW. The annual expected expenditure on subsidies for the nine winning projects is 2.8 million DKK (approx. 0.38 million €), notably less than the 8 million DKK estimated in the preceding legislative process.

As of January 2019, all nine winning projects have been constructed or are under construction.

Several factors have made the Danish cross-border auction unattractive for German project developers. First, the volume that was open to installations in Germany – only 2,4 MW – was extraordinarily small, which significantly reduced the chances of being awarded for German bidders. Second, due to the German national auctions with a volume of 160 MW that took place only days later, German developers had an immediate and possibly more attractive alternative to secure support. Third, transaction costs were associated with becoming familiar with the Danish support scheme and auction design. Against the background of the relatively small Danish auction and with no plans for future cross-border auctions, German bidders may have found that the transaction cost of participating in the Danish auction outweighed the benefits of potentially winning the auction. And fourth, PV projects that are funded through the Danish auction are exposed to fluctuating spot market price due to the fixed market premium. This exposure to market prices and risk may have deterred German developers.

3.3 Reasons for more competitive Danish bids

Determining the exact reasons of a specific auction result is a challenging task as auction outcomes are always impacted by an interplay of many factors of which most are difficult to observe (e.g. LCOE of bidders, bidding strategies, etc.). Nevertheless, we aim to offer possible explanations for the one-sided outcome of these first cross-border auctions by identifying aspects that may have impacted the competition – and thus bid-levels – between German and Danish bidders.

The most decisive factors that, according to our analysis, led to more competitive bids from Danish project developers, are discussed below.

[9] Energistyrelsen. (2016). Pilot tender of price premium for electricity from solar PV.

[10] Around the time of the auction, this Danish company had a PV portfolio totalling 78.3 MW. Its installations are primarily located in Germany, with an average size of 2.4 MW per installation.

3.3.1 Resources – solar potential

To analyse whether solar potential was a decisive factor in the German cross-border auction outcome, we compared the general solar potential in both Denmark and Germany. As shown in Figure 6, besides the locations with very high solar potential in the South of Germany, Denmark has on average better sites available in terms of full-load hours (FLH) than Germany. This finding can be explained by two observations: less cloud formation over the coast, i.e. high solar irradiation, and lower temperatures, which increase the PV modules' efficiency and thus the capacity factor.

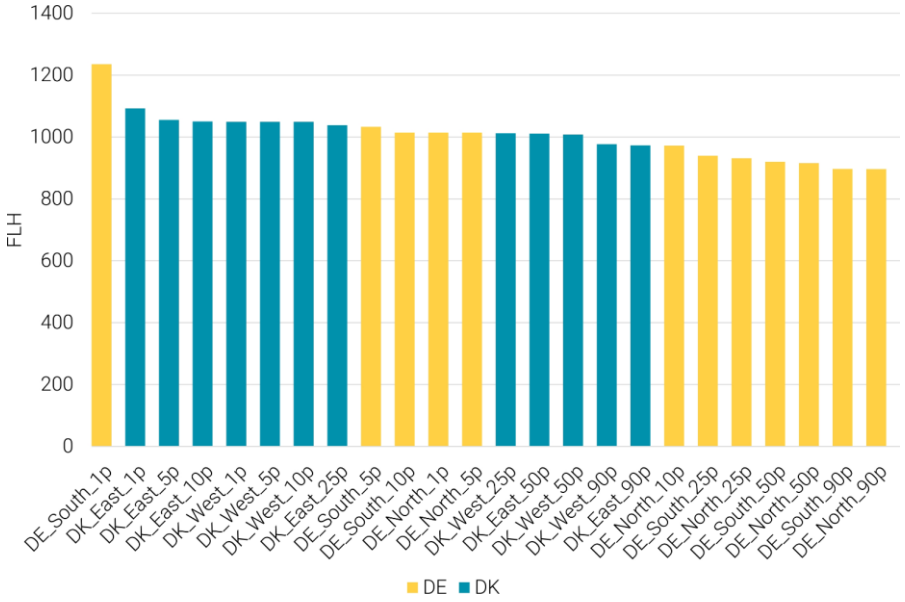

Figure 6 – Solar potential in terms of full-load hours for Danish and German sites (Source: Fraunhofer ISI / Navigant)

Note: In the figure, the last part of the column's name shows the share of sites that achieve at least a certain amount of FLH, which is indicated by the column's height. For example, the column DE_South_1p specifies that 1% of all sites in Southern Germany have 1220 FLH or more, while DK_West_25p means that 25% of all sites in Eastern Denmark have full-load hours of at least 1020 h. This means e.g. that only 1% of all sites in Southern Germany could compete with 25% of the East-Danish sites in terms of natural potential.

The figure gives an indication on the role of the solar potential. Nevertheless, Germany and Denmark differ in terms of available capacity due to the difference in land size, i.e. it would be theoretically possible that the superior 1% of German sites has a higher potential capacity than most of its Danish counterparts. Therefore, we need to take into account the potential of the actual projects that participated in the auction.

We evaluated the sites and FLH of all (awarded and non-awarded) bids below 7 ct/kWh. For the five awarded bids we estimated around 1050 FLH on average, while the five lowest, i.e. most competitive, bids from Germany were estimated to have around 920 FLH on average. Thus, in terms of LCOE, the Danish projects had an advantage of around 0.6 - 0.8 ct/kWh, solely due to a higher solar potential.

Given the very low average of 920 FLH for the locations of the five lowest German bids, we assume that projects at German locations with good solar potential, which would have been able to compete with the Danish projects awarded in the cross-border auction, did not participate in the auction. Instead, however, only German projects with lower solar potential entered the cross-border auction.

3.3.2 Site availability

In contrast to Denmark, where fewer site restrictions exist, Germany did not allow solar PV installations on farmland, but only on so-called conversion areas. This significantly reduced the availability of sites. If

available sites or sites with high solar potential are scarce, this might increase site procurement costs for PV developers and hence the premium they would require. In the context of the German national auctions, scenario calculations that compare the costs of solar PV deployment under the current site restrictions with a scenario that allows solar PV on farmland estimate a decrease in LCOE of around 0.3 ct/kWh in case solar PV can be built on farmland (Kelm et al., 2019[11]). Without having taken into account the exact land lease costs on Germany and Denmark – this type of information is not readily available –, it can be assumed that bidders in Denmark had lower site procurement costs than their German competitors.

3.3.3 Alternative options

At the time of the German-Danish cross-border auctions, Danish project developers had no alternative option to apply for support. On 10th of May 2016, the Danish government had stopped its main solar PV support programme with immediate effect. The open volume of applications at the time exceeded the national deployment targets significantly. Subsequently, no support scheme for PV installations larger than 0.5 MW was in place or had been announced. Due to the lack of alternatives for Danish bidders and a significant pipeline of planned projects, there was a strong interest by Danish developers in the cross-border auctions and it can be assumed that Danish project developers placed aggressive (i.e. low) bids to secure support.

German project developers, on the other hand, faced a regular schedule of frequent national auctions (three auctions per year) for ground-mounted PV systems (Bundesnetzagentur, 2019[12]). Specifically, a national auction with a volume of 160 MW took place on the 1st of December 2016, just one week after the German cross-border auction and one week before the Danish cross-border auction. Due to the national auction, the incentives for participation in the cross-border auction decreased. Moreover, it can be assumed that German bidders did not bid aggressively. From their perspective, there was no reason to bid below the bid level they could expect from a national German auction. The most recent national auction at the time took place in August 2016 and resulted in a weighted average level of awarded bids being 7.25 ct/kWh (awarded bids ranging from 6.89 – 7.77 ct/kWh).

3.4 Lessons learnt

The German-Danish cross-border auctions proved that cooperation can achieve efficiency gains. In the German cross-border auction, all five winning bids required a sliding premium of 5.38 ct/kWh, which was much lower than the weighted average of 6.9 ct/kWh for the awarded bids in the German national auction that took place only days after the cross-border auction. Also, during the whole period the awarded PV plants have been in operation since May 2018, Germany did not pay support on top of the market revenues in most months due to the high market values in Denmark. German levy payers are thus saving money in form of support payments as compared to if the installations had been located in Germany.

Our analysis shows that Danish bidders had a competitive edge over their German competitors mostly due a higher solar potential, but also due to site restriction rules in Germany. Furthermore, at the time of the German-Danish cross-border auctions, Danish project developers had no alternative options to apply for support. Therefore, it can be assumed that Danish developers placed aggressive (low) bids to secure support.

The German-Danish experience emphasizes the importance of resource potential, market environment, but also the regulatory conditions in cross-border auctions. It also emphasizes, that before implementing cross-border auctions, cooperating countries should aim to reach a good understanding of their respective country-specific starting points in terms of renewables policies and market condition. Furthermore, the pilot auctions have shown the importance of aligning the timing of cross-border auctions with schedule of national auctions to avoid overlapping auctions. Parallelism of auctions could undermine the level of competition in the auctions or lead to unwanted bidding behaviour, potentially even collusion.

[11] Kelm et al. (2019): Untersuchung zur Wirkung veränderter Flächenrestriktionen für PV-Freiflächenanlagen.
[12] Bundesnetzagentur. (2019). Beendete Ausschreibungen.

4 Types of cross-border auctions

In contrast to national auctions, cross-border auctions are characterized by their openness for participation of bidders from more than one country. For example, if country A conducts a cross-border auction that is open to projects in country A as well as projects in country B, competition is created between projects (i.e. project developers) from both countries. Cross-border auctions will typically, subject to the distribution of awarded bids, result in a cross-border flow of support payments.

This section presents three basic models for the implementation of cross-border RES auctions: 1) unilateral cross-border auction, 2) mutual cross-border auctions and 3) joint auction. These options come with different involvement by the participating countries and with increased complexity. In all three models, auctions can be extended to more than two countries.

Figure 7 – Basic models of cross-border auctions

In model 1 (unilateral cross-border auction) support is typically only paid by the country implementing the cross-border auction (contributing country). The cooperating country (host country) makes available its natural potential and project pipeline. However, the host country may also contribute to the support payments. On the contrary, models 2 and 3 foresee an opening of the support scheme and thus support payments from all cooperating countries in any case. Notwithstanding the distribution of installations and the countries' respective shares in the support payments, the cooperating countries can flexibly define the details of the cost-benefit distribution and the level of alignment of national rules.

Countries will generally take their national auction design as the starting point for designing the cross-border auction (see chapter 6 for details on support scheme design). The need for the cooperating countries' coordination on the auction design depends on the model of cross-border auction. Also, the level of integration of national support schemes varies between the models. The model of unilateral cross-border auctions requires the least alignment of national rules, whereas joint auctions imply a stronger integration of national support schemes and hence require more alignment.

Countries may open an existing national auction for cross-border participation or decide to conduct a separate cross-border auction. Conducting a separate auction in addition to the existing national auctions facilitates the tailoring of the auction and support scheme design to the cross-border context.

The decision about which installation will be awarded should in principle be determined by the price of each bid, not by the location of the project. Nevertheless, cooperating countries may want to establish additional criteria. This may be the case if cooperating countries aim to ensure a balanced distribution, where each country ends up hosting some of the installations (e.g. by using a minimum or maximum quota). A cooperation agreement specifies the details regarding the scope of the cooperation (e.g. auction volume that is open to bidders in host country, eligible technologies), the cost-benefit allocation, the payment procedure (and cross-border flow of funds) and the transfer of production data (see chapter 8 for allocation of costs and benefits). The statistical attribution of RES benefits should in principle correspond with each country's share in the payments.

4.1 Unilateral cross-border auction

Under the unilateral cross-border auction model, only one country conducts a cross-border auction. Unilateral cross-border auctions require the lowest degree of coordination among the cooperating countries.

The cooperating countries agree on the scope of their cooperation, the cost-benefit sharing and transfer of payments and information. However, the country conducting the auction will largely determine the auction design. This includes the general design elements such as the pricing rule and maximum bid size, but also the auction procedure, the conditions for participation, as well as the penalties and realization deadlines. Deviations from the national auction design will be necessary to account for specific conditions of the host country, for example for material prequalification which are often aligned with national planning and permitting procedures. No harmonisation of auction designs between the cooperating countries is necessary and, all in all, the number of aspects that cooperating countries need to agree upon is limited.

A unilateral cross-border auction is the simplest model, yet it achieves the fundamental benefits of cross-border cooperation, i.e. the reduction of support costs by access to better natural potential and/or market conditions. Under this model, the contributing country's chances of finding a fitting cooperation country are high, as relatively little commitment is required from the host country. Likewise, more countries will be willing to become a host country and thereby getting the benefits of hosting RES installations at zero support costs (e.g. creation of jobs, reduced dependency from energy imports, etc. see chapter 7), if they do not have to commit to a cross-border opening/payments themselves. However, the – by default – unilateral payment of support can reduce the public acceptance of the cooperation in the country that pays the support.

In derogation of the basic operation of this model, it is also possible that the host country contributes to the support payments in return for part of the statistical RES benefits. The size of the financial contributions as well as the attribution of the statistical benefits is subject to negotiation in the cooperation agreement between the two countries.

4.2 Mutual cross-border auctions

In mutual cross-border auctions, all cooperating countries conduct auctions that are open to installations on the territory of the partner country. However, each country conducts its own cross-border auction.

The process of setting up the auctions, as well as the number of aspects that cooperating countries need to agree upon is similar to the unilateral cross-border auction model. The cooperating countries agree on the scope, cost-benefit sharing and transfer of payments and information, but each country largely determines the design of its cross-border auction.

Each country uses its national support scheme to pay the funding to installations that have been successful in its cross-border auction regardless of whether the installation will be located on its own territory or abroad.

Countries may opt for mutual cross-border auctions if each country wants to conduct a cross-border auction, for example to fulfil a commitment made in the course of the state aid approval. The reciprocal nature of the cooperation may also increase the public acceptance of the cooperation in all cooperating countries. Another motivation for cooperating countries to conduct mutual cross-border auctions instead of a joint auction, is to maintain more control over the design of the auction and remuneration scheme. Not having to agree on a single joint auction design, may also simplify setting up the cross-border auctions.

4.3 Joint auction

Countries can also cooperate more intensively by carrying out a joint auction that is open to installations in all partner countries. The model of joint auction will also be implemented under the renewable energy financing mechanism that will be established according to the Article 33 of the Governance Regulation[13] and that foresees EU wide RES auctions.

Setting up a joint auction requires the agreement on all aspects of the auction design. In contrast to unilateral and mutual cross-border auctions, cooperating countries also need to agree on a remuneration design, i.e. sliding or fixed market premium, to guarantee equal funding conditions for all bidders, irrespective of their future attribution to either of the countries' support schemes.

In addition, the cooperating countries also need to agree on a rule that determines the attribution of successful bids to the countries' support schemes, i.e. from which country the installation will eventually receive the support payments. The rule of attribution needs to reflect the fact that support payments per kWh usually vary between installations, unless a fixed premium is combined with a pay as clear pricing rule. Alternatively, cooperating countries may set up a joint fund, or a jointly established levy to provide the funding. This second option, entailing a joint handling of budgets, is an even more intense form of cooperation and requires additional coordination and agreement among the cooperating countries.

Agreeing on these additional aspects increases the complexity and transaction costs of preparing the cross-border auction. However, the administrative burden of implementing one joint auction is lower compared to conducting several mutual cross-border auctions. Joint auctions have further advantages. By increasing the auction volume (compared to separate unilateral/mutual cross-border auctions), the auction is more attractive for potential bidders and economies of scale may be achieved. Also, a joint auction can be more easily expanded for the participation of further countries in the future. Cooperating countries may also aim to send a strong political signal for cooperation by choosing this more integrating model.

For countries that have little administrative capacities and/or little experience with auctions, setting up a joint auction is a chance to make use of the administrative capacities of a cooperation country and to learn from best practice of a more experienced cooperation country.

[13] Regulation on the Governance of the Energy Union and Climate Action ((EU) 2018/1999): https://eur-lex.europa.eu/legal-content/de/TXT/?uri=CELEX%3A32018R1999

5 Differing national regulatory and market environments

Chapter 2 described economic rationales for cross-border auctions. Ultimately, cross-border auctions identify cost-reduction potential, tapping into natural potential, market value and low cost of capital. These elements also play out from a bidders / project developer's perspective who is developing specific projects within local contexts. These local regulatory and market environments have a significant impact on the competitiveness of his / her projects and thus the chance to be selected in the auction.

From a bidder's perspective the most relevant aspects apart from the resource availability are the national market conditions (i.e. market value and cost of capital), the regulatory framework, and the support scheme design. Especially with a view to the local regulatory environment the question has been discussed on whether and how to address such differences in the auction design.

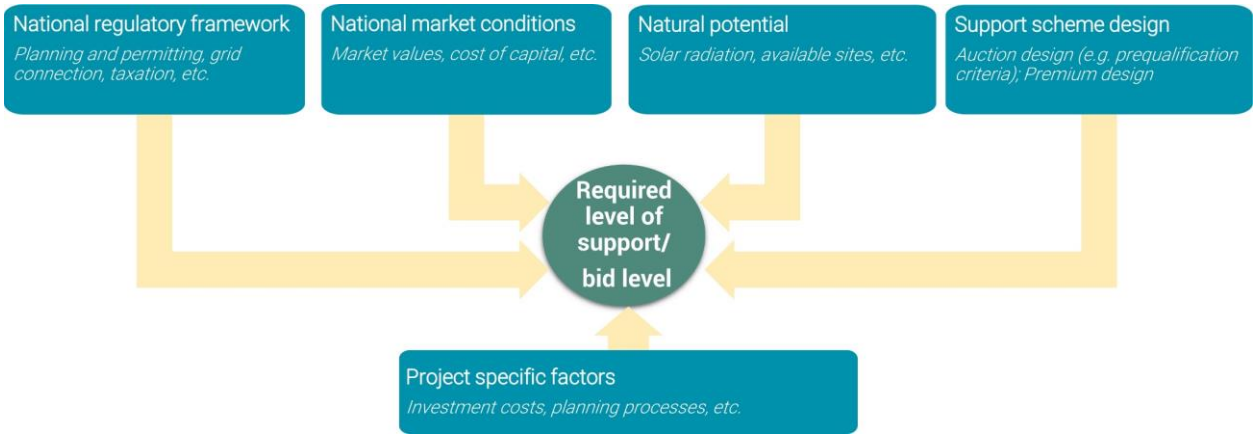

Figure 8 – Overview of factors influencing the required level of support (Source: Navigant)

5.1 National regulatory framework

In theory, cross-border RES auctions allow countries to access better renewable resources, higher market values and/or lower costs of capital, thus reducing RES support costs. Cross-border auctions create competition between auction participants across the involved countries. While the auction rules applied for the participants will in principle be the same, the conditions under which project developers can realize RES projects differ between countries. These wider regulatory conditions include corporate taxation, planning and permitting rules, conditions for grid connection, eligible areas and sites, and environmental requirements. These aspects cannot easily be aligned, as they reflect a broader regulatory and political context (e.g. corporate taxation). Therefore, the conditions that prevail in the country where the installation is to be located will usually apply.

Differences in national regulatory frameworks have direct effects on the auction outcome[14] and thus on the geographic distribution of selected projects. The effects of differing regulatory conditions can be very strong, as has been demonstrated in previous studies that, for example, analyse the cost of financing renewables in Europe[15]. Next to resource availability and competitive pressure, regulatory differences (most notably site restrictions in Germany) were also a factor in the German-Danish auctions as discussed in chapter 3.

[14] This chapter largely builds on study conducted by Ecofys and eclareon in 2018, which compares the impact of national policies and regulation on the cost of onshore wind across the PENTA countries (Austria, Belgium, France, Germany, Luxembourg, Netherlands, Switzerland). Ecofys and eclareon (2018): Cross-border renewables cooperation. Study on behalf of Agora Energiewende, available at: https://www.agora-energiewende.de/fileadmin2/Projekte/2017/RES-Policy/144_cross-border_RES_cooperation_WEB.pdf

[15] See DiaCore (2016): "The impact of risks in renewable energy investments and the role of smart policies": http://diacore.eu/images/files2/WP3-Final%20Report/diacore-2016-impact-of-risk-in-res-investments.pdf

5.1.1 Relevant regulatory conditions and their effects

Key aspects impacting the cost of project development apart from resource availability are:

- Planning and permitting
- Site restrictions and requirements
- Grid connection
- Taxation
- Financing conditions (debt interest rate, share and term)
- Taxation
- Project realization periods
- Risk of non-realization

Planning and permitting: Planning and permitting includes a wide range of internal and external costs borne by the project developer related to the procedures of planning and permitting (such as preliminary site assessments, securing of land, all types of assessments and permits). This aspect is important as costs, time requirements and risks related to procedures of planning and permitting vary significantly between Countries and are to a large extent driven by regulatory conditions.

In a study for Agora Energiewende, which compared regulatory costs for the development of an onshore wind project[16] between the countries of the Pentalateral region (Austria, Belgium, France, Germany, Luxembourg, Netherlands, Switzerland), the differences in the impact of planning and permitting on LCOE ranged from 0.25 ct/kWh in France to 0.54 ct/kWh in Switzerland[17]. It is important to note that project specific planning and permitting costs can deviate significantly from these average costs, with cost ranges being particularly large in Germany (0.18–0.44 ct/kWh) and in the Netherlands (0.27–0.63 ct/kWh) (Ecofys and eclareon, 2018).

Typical issues around planning and permitting include a lack of standardisation in permitting requirements and procedures, a lack of coordination between different levels of administration, the duration of planning and permitting procedures, and court appeals. These challenges already impact projects' competitiveness at the regional and national but even more at cross-national levels as differences between countries are larger.

Site restrictions and requirements: Site restrictions can have significant impacts on the costs of RES deployment. Most countries have various regulations that restrict the availability of land that is suitable for the development of RES projects, including minimum distance requirements from urban zones, radar towers and environmentally protected areas. Depending on the extent of these limitations and the remaining availability of land with favourable conditions, these restrictions can increase the competition for available land and thus lead to higher land leasing costs (as seen in the German-Danish cross-border auctions for solar PV).

Grid connection: Grid connection costs includes all costs borne by the project developer that are related to the connection of the plant to the grid and, if applicable, grid reinforcement. Costs related to grid connection vary considerably between countries depending on the grid connection regime, which can be "shallow" or "deep". A "shallow" grid connection policy means that generators only pay the cost of connection assets. All costs related to the reinforcement of the grid are either paid by the TSO or shared among network users. Under a "deep" connection policy, generators are obliged to pay all the connection costs plus the costs related to the expansion and strengthening of the grid. The "deep" connection approach is therefore cost-reflective and provides a locational signal. Some countries chose hybrid "shallow-deep" approaches, obliging generators to pay some of the reinforcement costs.

In addition to the grid connection costs, generators are charged for grid usage in some countries (and increase operational expenditures and thus the LCOE).

[16] The cost impacts were calculated using a base case onshore wind project consisting of six 3 MW wind turbines, each 140 meters high. The generation potential was fixed at 3,000 kWh per Kilowatt per year. Furthermore, the base case assumed values for all relevant capital and operational expenditures, the fiscal regime and financing costs. See Ecofys and eclareon (2018).

[17] Excluding costs related to preparing the site or planning/implementing construction activities, etc.

Ecofys and eclareon found that in the Pentalateral region, the impact of grid connection costs on the LCOE of an onshore wind project varies significantly, ranging from 0.24 ct/kWh in Belgium to 0.71 ct/kWh in Switzerland (Ecofys and eclareon, 2018). Again, there are also large cost ranges within countries (e.g. in France, the Netherlands and Switzerland, project developers face strong variations in grid connection costs). Project-specific costs depend to a large extent on the project's size, its distance to the next network connection point and the voltage level to which it is connected. The length of the cable is usually the most important cost factor. However, for countries with a "shallow-deep" or "deep" grid connection regime, grid reinforcement requirements can also vary according to the project location.

Also, the coordination of grid planning and spatial planning is a recurring area for improvement: better coordination between local authorities and grid operators in jointly preselecting potential areas for RES installations could streamline procedures, ease permitting and reduce the costs of grid connection and reinforcement.

Taxes: Costs related to corporate taxation reflect a much broader area of regulation and of political priorities compared to the specific field of RES deployment. Accordingly, harmonising corporate taxation in the context of cross-border RES cooperation can imply unreasonable transaction costs. Nevertheless, differences in taxation are an obvious source of distortion to cross-border competition and have stimulated public debate in the German-Danish cross-border auctions for solar PV held in December 2016 (see section 3). The impact of different corporate taxation rules on LCOE identified in the study for Agora Energiewende ranged from 0.19 ct/kWh in Switzerland to 0.46 ct/kWh in Belgium (Ecofys and eclareon, 2018).

Financing conditions: As outlined in chapter 2.3, the cost of capital has a major impact on the cost of RES deployment. Financing conditions – specifically, interest rates on debt financing, debt/equity ratios and debt terms – are determined by market factors and are also influenced by regulatory conditions. However, they are an important indication of the perceived regulatory risks in investment conditions. Among others, they are influenced by risks related to the support scheme design (exposure to market price and other revenue risks), planning and permitting (potential of non-realization or changes in project configuration and operation) and political stability (potential of retro-active changes in support schemes).

Previous studies (e.g. Diacore (2016), Ecofys and eclareon (2018)) have surveyed developers for onshore wind projects and found that even in the quite homogeneous Penta-Region there are remarkable differences in financing conditions. Compared to a "theoretic financing case" that provides very favourable conditions (debt interest rate of 2%, debt term of 17 years and a debt/equity of 85/15), the additional financing costs ranged from 0.19 ct/kWh in Germany to 1.28 ct/kWh in Belgium. The large differences between countries are a clear indication of the strong influence financing conditions can have on the outcome of competitive cross-border auctions.[18]

Project realization periods: The project realisation period encompasses all activities from the initiation of project planning to the retrieval of necessary permits, connection to the grid and the start of RES plant operation. The number of years required to realise a RES project provides an indication of the complexity of the processes involved. While regulatory requirements related to planning, permitting and grid connection reflect broader policy goals (related to, for example, environmental protection and ensuring public acceptance), they can complicate the expansion of renewables and may impact the cost of deployment. Long project realisation periods increase the costs of project development as well as the risk of non-realisation. The longer it takes to acquire the necessary final permits for construction, the higher the probability that the initial planned configuration of the project will no longer be feasible, forcing the development to be terminated or reconfigured (e.g. by changing the overall size of the project, exact location, turbine specifications, etc.), which induces additional costs. Average planning periods for an onshore wind project vary largely between countries (e.g. from 6 years in Austria and Germany to 9 years in Switzerland). The key issue here are legal challenges to projects during the development phase (e.g. appeal options).

[18] These results need to be interpreted with caution: the LCOE impact of the financing conditions is highly sensitive to debt interest rate, debt term and the debt/equity ratio and thus varying any of these elements changes the picture slightly. In addition it is likely that financing conditions will to some degree align between countries if they introduce a common support scheme design when implementing cross-border auctions.

Risk of non-realization: There are various reasons for the non-realisation of projects, including, for example, failing to receive the required permits, successful legal appeals, and regulatory requirements or other factors that would limit the operation of the project or make it uneconomic (e.g. changing financing conditions). The average percentage of projects at the beginning of the planning stage that go unrealized is a result of the uncertainties of project development, influenced by the transparency and efficiency of administrative procedures and likelihood of legal appeal. The higher the share of planned projects that go unrealised and the later the decision to terminate a project, the higher the sunk costs that developers need to recover through successfully completed projects. In this context also the specific local context in which a project is planned is important (related to the very specific location of the project, the project developer's strategy in project planning, the technical configuration of the project and support by local stakeholders).

The impacts (sunk costs) of non-realisation depend mostly on the timing of project abandonment. The later the decision to terminate a project, the higher the sunk costs. The study by Ecofys and eclareon shows that here are structural differences between countries as to when the termination of an onshore wind project is typically decided on: In Austria and Netherlands termination is decided early in the project development, in Belgium and Switzerland very often the decision not to realize a project comes at a late stage in project development.

5.1.2 How to handle differing regulatory conditions in cross-border auctions?

Before identifying options to address these differences and their effects on cross-border auctions the question needs to be raised whether levelling them is necessary in the first place. Ultimately, cross-border auctions simply create competition between projects developers facing a wide range of context factors. Analysing the factors impacting the competitiveness of projects in cross-border auctions simply makes cost components transparent which in national auction are usually not analysed in such detail.

The cost-effectiveness of support allocated through auctions may be better if the auction participants are fully exposed to these regulatory conditions and their cost impacts. However, political acceptance of cross-border auctions may be undermined if not only natural resources, but also regulatory conditions impact the outcome of the auctions: they may be perceived as unfair and countries may have preference to provide at least a partial level-playing field in cross-border auctions, i.e. by intervening in some of the elements impacting the competitiveness of projects in the auction.

The urge for countries to effectively address (and potentially align in the mid-term) regulatory and investment conditions depends on a combination of the following elements:

- Extent of existing distortions: The larger the distortions stemming from regulatory conditions, the more important the need to address them.
- Share of cross-border cooperation in total new RES capacities: The share of the cross-border cooperation in overall new RES capacity auctioned will determine the extent to which local project developers are confronted with the varying regulatory conditions of the other member state.
- Geographic scope (number of involved countries): While the impacts that will result from differing regulatory conditions in two countries might be more or less straightforward, if the number of countries participating in a cross-border cooperation increases, assessing the impacts of regulatory conditions and potentially aligning them becomes more complex.

There are various basic options to deal with these differences in national regulatory frameworks: 1) adjusting bids by the cost impact of the regulatory framework, 2) implementing quotas to limit the distributional effects of these distortions and 3) aligning the regulatory framework.

Adjusting bids by the cost impact of the regulatory framework: The bids of auction participants may be adjusted by the amount of cost impacts. The advantage of this option is that the distortions would be reduced without having to actually align all regulatory conditions. The key disadvantage is that exactly estimating the impacts of each factor is very difficult (due to methodological restrictions and lack of data) and that there are also large variations within countries that would need to be accounted for. Another disadvantage is that

this approach would undermine efficient outcomes of the auction: depending on the aim of the auction (e.g. identifying the lowest LCOE or identifying the lowest support costs) levelling certain cost factors would result in comparably cost-effective projects to be excluded from the awarded ones.

Implementing quotas to limit the distributional effects of these distortions: An option which is much easier to implement would be to establish quotas of bids accepted in each country (e.g. minimum of 20% of installations/capacities in country A). This would limit the distributional effect of regulatory conditions and may address political acceptance issues, if due to regulatory and market conditions all projects are located in one country only. However, the extent to which the quotas become effective, they decrease the efficiency of the auction.

Aligning the regulatory framework: The most desirable and yet most unlikely option is to align the regulatory framework in the cooperating countries towards good practices. This would mean that cross-border auctions result in more coordination and alignment of national policies and regulations.

Apart from these options, the auction may be designed in a way that the differences have the least possible impact. Obvious issues are to implement project realization deadlines that can be met by projects in all countries. A more detailed discussion on how to reflect the differences in the auction design can be found in chapter 6.1.The following recommendations result from the discussion:

	Observation	Recommendation
General impact of context factors	Cross-border auctions identify cost-reduction potential, covering resource potential, market conditions and regulatory frameworks.	Be aware of the basic influencing of factors and identify whether any of them will have major effects on the auction outcome.
Regulatory conditions	Regulatory conditions impact risks and costs related to, *inter alia*, planning and permitting, grid connection, financing conditions (debt interest rate, share and term), taxation, project realization periods, risk of non-realization and site restrictions and requirements.	If necessary, assess any of these key impact factors in detail to know about the effect in detail.
Addressing differences?	Cross-border auctions simply create competition between projects developers facing a wide range of context factors.	Define whether levelling any of the differences is necessary at all. Preferably do not level such differences artificially in order to tap into the full efficiency potential of the auction.
Options to level regulatory differences	Key options are: - Adjusting bids by the cost impact of the regulatory framework - Implementing quotas to limit the distributional effects of these distortions - Aligning the regulatory framework	If differences need to be addressed, consider quotas as they are the most straightforward solution to the challenge.

Table 2 – Observations and recommendations regarding differing regulatory conditions

5.2 National market conditions

Besides the regulatory conditions, specific market conditions differ between countries. Chapter 2 outlines how these differences bear the potential to reduce support costs and are thus a main argument for conducting cross-border auctions. However, it is also important to understand their effects from a bidder's point of view, i.e. effects on the bidder's behaviour and thus auction outcomes, which is the focus of this chapter. These market conditions comprise the national market value of the projects' generated electricity,

the role of the national support schemes as alternative options to gain support payments, as well as the cost of capital. Additionally, the long-term effects between cross-border and national schemes are analysed.

5.2.1 Market value

The auction design and especially the premium design can favour projects with a higher national market value. This is for example the case when a fixed premium on top of the national electricity price is auctioned. Under the assumption of equal LCOE, bidders realizing a higher market value with their generated electricity need lower additional support payments and can consequently submit a lower bid. For further information on the remuneration design, please refer to chapter 6.2.

5.2.2 National schemes as alternative options

Cross-border auctions usually run in addition to national auctions or other national support schemes, which can be considered as outside options or alternative opportunities to receive support for projects. The relative attractiveness of one opportunity to get support – e.g. a cross-border auction – and thus also the bidder's behaviour in that auction depends on the overall availability of alternatives and the overall level of demand and supply for RES installations in the entire market.

The existence of a higher-valued outside option leads to less aggressive bidding behaviour, i.e. in the RES context to higher bid prices (Kirchkamp et al., 2008)[19]. This might have been one reason for the lower bids from Danish plants in the Danish-German cross-border auctions: In Denmark, a support scheme was neither in place, nor foreseen in the near future. Therefore, Danish bidders had to participate in both cross-border auctions aggressively in order to secure any kind of support. In contrast, the German bidders, who had regular national auctions taking place, had a much lower incentive to bid aggressively in the cross-border auction, i.e. to submit a bid that is below the level that bidders could expect to receive in the national auctions, or even to participate.

Often, the cooperating countries will have a national support scheme in place and thus bidders are facing two different options in which they can participate with their project. The resulting effect on their bidding behaviour can be described two-fold: competition- and price-driven. Although both concepts are intertwined, it is worth analysing their effects separately.

5.2.2.1 Domestic competition

Competition in an auction can be characterized by a sufficient number of different bidders (market concentration) as well as enough bids/projects. A high level of competition in an auction is desirable for the auctioneer, since it increases the chances of a cost-effective allocation and decreases awarded prices. On the contrary, bidders prefer a lower competition level, since it increases their chances to be awarded with a comparatively higher bid price.

Since bidders usually opt for the more attractive scheme, the level of competition in the national auction plays an important role for the cross-border auction. The following table summarizes the effects of the competition in the domestic auctions on the cross-border auction outcome. It should be noted that the analysis is based on the assumption that the two national, as well as the cross-border scheme, do not differ significantly in terms of the auction design, as well as the attractiveness and the risk of the remuneration design.

[19] Kirchkamp, O., Poen, E., Reiß, J.P. (2008): Outside options: Another reason to choose the first-price auction.

		Level of competition in Country B	
		High	Low
Level of competition in Country A	High	• Aggressive bidding by participants from both countries • High level of competition • Projects from both countries should be awarded (if general conditions are similar)	• Aggressive bidding by participants from country A • High/medium level of competition (depending on auctioned volume) • Mostly projects from country A are awarded (if general conditions are similar)
	Low	• Aggressive bidding by participants from country B • High/medium level of competition (depending on auctioned volume) • Mostly projects from country B are awarded (if general conditions are similar)	• No aggressive bidding • Low level of competition • Projects from both countries should be awarded (if general conditions are similar) • Undersubscription possible

Table 3 – Effects of the competition in the domestic auctions on the cross-border auction outcome

As mentioned above, opening national auctions can increase the level of competition. An example could be the case of high market concentration or undersubscription in a national auction: a limited number of actors can lead to collusion in the auction and thus to high prices. Opening the support scheme to foreign projects can increase the competitive pressure in the national auction scheme and thus decrease support costs and realize efficiency gains.

5.2.2.2 Domestic support levels

As mentioned above, the national support scheme can be regarded as an outside option to the cross-border auction. Bidders will thus incorporate the prices in the domestic schemes into their strategy. The effect depends on the design of the domestic scheme.

- Administratively-set FIT/FIP scheme: Due to the current EU legislation and the ongoing implementation of auction-based support schemes, this combination is increasingly rare. Nevertheless, it is worthwhile analysing this setting to understand the implications of an outside option. Bidders from the country with an administratively set FIT/FIP scheme will in general be rather hesitant to participate in the cross-border auction, since the national scheme provides a more risk-free outside option. Should they decide to submit a bid, the level of the national FIT/FIP will function as a floor price for the respective group of bidders in the cross-border auction. Since they can secure this level of support in their domestic scheme, they will only participate if they have the opportunity to realize a higher remuneration.
- National auction-based scheme: The interaction between two auction-based support schemes is more complicated. Regarding the bid prices, the level of the highest awarded bids in the national auction might be regarded as a floor price as well. If potential bidders assume to be able to secure that level of remuneration in the domestic auctions, the only incentive they have to participate in the cross-border auction is to be able to realize a higher price.

The above findings highlight the importance for policymakers to set the ceiling price of the cross-border auction cautiously. A ceiling price lower than the highest awarded bid in one or both of the national auction schemes might decrease the competition in the cross-border auction.

5.2.3 Long-term effects of interaction

The introduction of cross-border auction in addition to national auctions is likely to cause interactions between the parallel systems and with potentially long-term effects on the national auctions. The most important interactions relate to the:

- Availability of sites: In case the foreign/cross-border scheme is more attractive, domestic project developers might opt for this option, reducing the availability of sites for RES installations under the national support schemes. In the long-term, this can increase support costs of domestic support schemes due to less sites with good potential and it may negatively impact the level of competition in the national support schemes. However, the extent of these effects also depend on whether or not cross-border auction volumes come in addition or replace national auction volumes.
- Auction schedule: When introducing cross-border auctions in addition to existing national auctions, it is important to synchronise the auction schedules with a view to provide a continuous pipeline and avoid boom and bust cycles in the RES industry. If, however, auction schedules overlap and run in parallel, it is crucial to ensure that bidders are not allowed to participate with the same project in national and cross-border auctions at the same time, as this could severely undermine the functioning of the auctions. Even if project developers are not allowed to bid the same project in parallel auctions, the parallelism of auctions could undermine the level of competition in the auctions or lead to unwanted bidding behaviour, such as collusion.
- Benefits and learning effects for countries and project developers: Should the cross-border auctions consist of additional capacities compared to the domestic auction volumes, the total benefits are likely to outweigh the costs for the participating countries (see chapter 7 for benefits regarding participating countries). Furthermore, cooperating countries can use cross-border auctions to test different auction designs without needing to change the national auctioning system. Project developers may also benefit from learning effects and additional market insights created through cross-border auctions.
- Smaller bidders: If the national auctions are usually oversubscribed and show a high level of competition, cross-border auctions can provide an opportunity for smaller bidders to secure support. This can be the case if in the cross-border auction the auctioned volume is small in terms of capacity (e.g. the opened 2.4 MW in the Danish auction) or the maximum installation size is rather restrictive, making the scheme unattractive for bigger participants.

6 Support scheme design

The support scheme entails the auction and remuneration design. In order to allow for a comparison of bids – and thus effective bid selection – the support scheme design must be equal for the participants of a RES auction. The support scheme design features are defined in the context of the RES auction and can be adjusted for cross-border auctions.

In contrast to support scheme design, the rules of the national regulatory framework as well as the national market conditions (see chapter 5 for more details) can remain unchanged in the context of cross-border auctions. In terms of the regulatory framework as well as the market conditions, the circumstances of the country where the installation is built apply. In general, they stem from a broader regulatory and political context and thus extend into multiple regulatory areas, including those that are not energy related. Taxes are one example for location specific conditions. As a result, in cross-border auctions, bidders from different countries inevitably face differing circumstances even though they are competing on the basis of a common support scheme design.

The table below illustrates the differentiation between support scheme design and the national specific regulatory framework and market conditions.

	Unilateral and mutual cross-border auctions	Joint auctions	Bidders' perspective
Support scheme (auction and remuneration design) Examples: bid size, pricing rule, market premium	Countries mostly decide on support scheme design of their opened auction individually	Single support scheme design required	Same rules apply
National specific conditions (regulatory and market conditions) Examples: site restrictions, taxation, market values	Rules and conditions of the country apply in which the installation is to be implemented		Different national rules apply

Table 4 – Overview of applicable rules in cross-border auctions

The support scheme design consists of two parts: first the design of the auction and second the design of the remuneration. Auction design includes a set of elements that, depending on the type of cross-border auction, may need to be agreed upon by the cooperating countries. As a general rule, cooperating countries shall aim for an agreement on common rules where possible. For unilateral and mutual cross-border auctions, every country will generally design its auction according to its own priorities and – possibly – in alignment to an existing national auction design. Deviations from the national auction design will be required to tailor the auction to the specific cross-border context and the principles of the cooperation agreed between the participating countries. In case of joint auctions, the cooperating countries need to agree on a common auction design.

The following sub-chapters elaborate the options for tailoring the auction design elements (chapter 6.1) and the remuneration design (chapter 6.2) to the specific requirements of cross-border auctions.

6.1 Auction design options

Auctions can only successfully contribute to achieving effective and efficient RES deployment if they are specifically designed to match the market environment in the area where the auction is conducted. This requires taking into account specific policy goals, project pipelines in comparison to deployment targets, the potential bidder structure, the competitive positioning of bidders, the risk of collusion, the experience of bidders and/or auctioneer, the level of market and cost information, financing conditions and more.

Cross-border auctions add further complexity by combining political preferences and market environments of two or more countries. The optimal auction design for a specific cross-border auction between two or more countries may therefore be very different from the optimal auction design implementation in each single national market.

The following sub-chapters identify several principles and design options that should be taken into consideration when designing cross-border auctions for renewable support.

6.1.1 General principles

In general, countries entering a cooperation will take their national auction designs, each tailored to the specific national policy goals and market conditions, as the starting point for the design of the cross-border auction. To account for the national contexts of all involved cooperation countries, some parts of the auction design require adaptation (in case of unilateral or mutual cross-border auctions) or aligning (in case of joint auctions). The multinational context adds complexity. Good practices of auction design – which have been identified in the first AURES project[20] – however also apply in the cross-border context. In addition, the following general principles should be taken into consideration:

1. Bids need to be comparable: Auction and remuneration design have to be the same for all participants to allow for comparison of bids and thus effective bid selection.
2. Adapt design to cross-border context: The auction design needs to consider the political goals and market situation of all countries involved. No single perfect auction design exists for cross-border auctions.
3. Check cross-border applicability of all design elements: Some requirements put forward in national auctions may not be applicable in cross-border auctions (e.g. material prequalification where different national permitting processes with differing costs and timelines may exist).
4. Keep it simple: Avoid design choices that increase complexity. This is even more important in cross-border auctions where market participants already need to become familiar with a new auction set-up and might have alternative auctions schemes to participate in.
5. Take care to not exacerbate differing conditions of participation for bidders: Against the background of differing national contexts, design elements determining the conditions for participation have the potential to *de facto* discriminate against bidders from one cooperating country. Special attention is required regarding the design of material prequalification, penalties and realization deadlines.
6. Ensure RES deployment while limiting transaction costs: As in national auctions, there is a trade-off between setting design elements to, on the one hand, encourage a high realization rate of winning bids, and on the other hand limit the transaction costs for bidders and regulators by avoiding excessive material or financial prequalification criteria
7. Give sufficient consultation and bid preparation time: To attract a large number of market actors, potential auction participants need to be given sufficient time for consultation and bid preparation to become familiar with and adapt to a new auction design and procedure, ideally also with information in all languages of the participating countries.
8. Reduce the administrative complexity: The bidders and the auctioneer are likely to face additional administrative challenges in cross-border auctions. For instance, it may be difficult to assess the pre-qualification documentation and monitoring the project implementation in another country. Reducing administrative complexity reduces transaction costs and increases participation.

[20] The final report of the AURES I Project provides an overview of the most important design questions and best practice options. See Mora et al., 2017: Auctions for renewable energy support – Taming the beast of competitive bidding: http://auresproject.eu/sites/aures.eu/files/media/documents/aures-finalreport.pdf

Conducting cross-border auctions separately to the national RES auctions, in contrast to simply extending an existing national auction for projects in other countries, facilitates the alignment of rules for the cross-border auctions. The rules for national RES auctions can remain unchanged, but interdependencies between the different auctions and the resulting incentives for bidders need to be considered. If certain auctions are considered as having a higher or lower competition level than others it may affect bid strategies and result in comparably less efficient or less effective auctions.

6.1.2 Design elements

In the context of renewables auctions, design elements can be categorized as follows:

1. General design elements provide control over scope of the auction and the group of bidders participating. They include technology type, auctioned item (kWh, KW, budget), the size of the installations, multi vs. single item auctions.
2. Auction procedure include the type of auction (static vs. dynamic auction), price caps, selection criteria (price based only or multi-criteria), pricing rule (pay as bid vs. pay as clear) and the number of rounds.
3. Conditions for participation include the timing of the auction, technical requirements, material prequalification and financial prequalification (bid bond).
4. Deadlines and penalties

Other elements are also part of the RES policy design but are not necessarily defined in the tender specifications, for example remuneration design which is discussed in chapter 6.2.

6.1.2.1 Which aspects require special attention?

In any case, cooperating countries need to agree on basic scope of the cooperation, including aspects such as the technology, volume, maximum size of installations and the timing of the auctions, which are mostly determined by the design elements pertaining to the categories of the general design and the auction procedure. However, the general design and the auction procedure are not *per se* impacted by the cross-border nature of an auction. If suitable, some of the rules can remain the same as for national auctions.

However, when setting up cross-border auctions, the design elements determining the conditions for participation as well as deadlines and penalties, require a closer assessment regarding their applicability, their impact on participants' costs and risks as well as their impact on project realization and thus effectiveness of the cross-border auction. If not tailored to the specific cross-border context, such rules may exacerbate existing differences between bidders from different countries, have a strongly limiting effect on the participation of bidders from one of the cooperating countries or strongly affect the bidding behaviour, all of which may lead to a distorted competition and bad auction results.

In cross-border auctions, the conditions for participation (material and financial prequalification requirements) in combination with the deadlines and penalties can have different effects on the auction participation and bidding behaviour of bidders from different countries. Especially those design elements that are more sensitive to local conditions and therefore affect bidders from different countries in a different way, should be determined with care. For the following design elements, an equal treatment *de jure* may *de facto* cause unequal treatment or even discriminatory effects between bidders:

- Material prequalification
- Financial prequalification
- Penalties
- Realization deadlines
- Ceiling prices

For instance, obtaining a particular permit may pose a significant administrative burden in country A, but a relatively small burden in country B. Likewise, this permit may serve as reliable safeguard for the advanced progress and thus high likeliness of project realization in country A, but in country B, a comparable likeliness

of project realization is not achieved with the same permit, but, for instance, only upon the grid operator's consent to connect the installation to the grid. This example illustrates that different practical barriers exist in relation to fulfilling certain material prequalification requirements and highlights the necessity to take into account the existing differences in the participating countries, particularly regarding:

- Planning and permitting procedures in the cooperation countries
- Average realization periods
- Risks of non-realization, both in terms of ratio of projects that are aborted as well as the timing of abortion (late in some countries)
- Access to financing
- Financing conditions

Alternatively, cooperating countries could also explicitly define different rules applying to participants (e.g. differing material or financial prequalification), aiming for a more level playing field. This, however, raises the questions for which design elements differences should be defined and which level of differentiation is reasonable. Our recommendation is to refrain from such differentiation as it is difficult to strike the right balance.

6.1.2.2 Individual design elements

Recommendations on the implementation of individual design elements are kept rather general in this chapter, as the use of design elements always needs to be tailored to the countries involved in the cooperation, taking into account the differences in national contexts and the objectives of the cross-border auction. Nevertheless, the following discussions will provide guidance on applicable options to set the right conditions for participation.

Material prequalification requires a certain project development status upon entering an auction, e.g. obtained environmental or building permits or grid concession agreements. They aim at ensuring high project realization and reducing the Winner's curse, as they force bidders to know their projects and its costs well when submitting the project. However, they increase sunk costs for the project developers and cause additional risks. In national auctions, they have proven to be an important safeguard for project realisation.

Material prequalification requirements are based on national planning and permitting procedures and therefore vary between the countries. In cross-border auctions, the inconsistent practices regarding the individual steps of project planning and permitting lead to an incomparability of specific permits in terms of 1) their significance for the probability of project realization when holding the permit, 2) the point of time at which the project developer must obtain the permit in the national processes and thus the indication of the expected remaining time required until the project is complete and in operation, and 3) the costs incurred by the project developer to obtain the permit and develop the project to this level. As a result, it is very difficult to identify a comparable level of material prequalification in cross border auctions. On the contrary, material prequalification criteria are likely to result in an unequal treatment of bidders. In some cases, however (e.g. if similar permits exist for the development of RES projects) one could consider adapting auction rules to the specific conditions in the participating countries.

The authority assessing the correctness of the material prequalification – usually a national regulator – is most likely not familiar with the licensing and permitting procedures in the cooperation countries. Familiarizing with the context of the cooperation country would induce additional transaction costs. Instead, bidders can be asked to simply provide a statement that they have the permit in question.

Recommendation for material prequalification
Limit or even avoid the use of material prequalification criteria in cross-border auctions. If you use material prequalification (e.g. similar permits) bidders should provide a statement that they have the permit in question to avoid extensive work for the administration. Asking bidders to provide proof for the securing of the site, for example through a lease contract with the land owner, should also not pose a problem. Implementing stronger financial prequalification requirements is an alternative to material prequalification.

Financial prequalification are financial guarantees to secure the completion of the project. They are usually connected to the **penalties**, e.g. bid bonds that need to be placed as financial prequalification at the bidding to guarantee the payments of penalties. Financial prequalification help to secure the seriousness of bids, as they reduce the incentive for underbidding. However, penalties increase the risk of bidders and can potentially lead to higher bid-levels. In addition, if penalties are too high and financial guarantees difficult to obtain, they may deter project developers from participating. In national auctions, financial prequalification and penalties are often implemented to safeguard project realisation.

However, financial prequalification impact actors differently. For example, large project developers usually pay the bid bond from their balance sheet, whereas small (single) project developers could have more difficulty to raise the needed equity and some might require financing from a bank. As a result, financing prequalification tends to favour larger players, or project developers operating in more established markets with good access to financing. On the other hand, markets that are characterized by small, less established players or with limited access to financing, can be disadvantaged in cross-border auctions. Therefore, the higher the financing prequalification, the higher the likeliness of causing discrimination in favour of larger players and more established markets with good access to financing.

Compared to the potentially distortive effects of material prequalification, financial prequalification are, however, less likely to cause strong distortions between countries and thus change the allocation of installations between cooperating countries.

Recommendation for financial prequalification
Make use of financial prequalification in combination with penalties to secure a high project realization rate. The level of financial prequalification should, however, not be so high as to disadvantage bidders from markets with less favourable access to financing.

Setting the **realization deadline** is connected to the question at which stage in the project development process the auction takes place. Auctions can take place at an early stage of project development. In such a case, typically lower material qualification are balanced by penalties and developers have a rather long time before their realization deadline is passed (e.g. more than two years after the auction). Alternatively, in late auctions, bidders are required to advance the project development to a certain level, for example by obtaining all necessary building permits, before they participate in an auction. Late auctions are typically characterized by lower penalties balanced by higher material prequalification. But, late auctions can also be implemented implicitly via (short) realization periods to be complied with by a successful bidder.

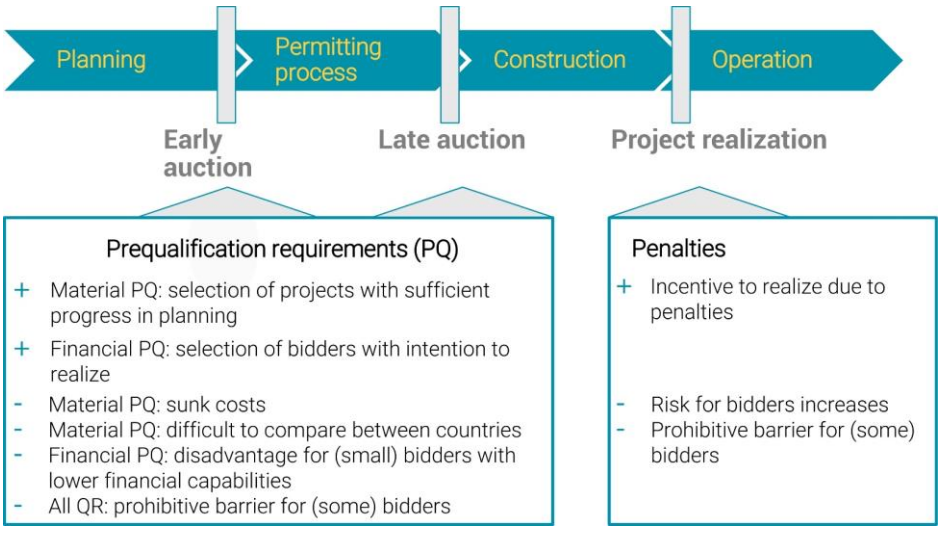

Figure 9 – Stylized representation of timing of auctions and effects of prequalification requirements (Source: Navigant)

The timing of the auction has implications on the costs, the risk level and also on the actor composition. Determining a realization deadline bears the risk of discriminating against bidders from one or more of the cooperating countries. The general realization periods as well as the risks of non-realization vary substantially across countries, subject to differences in planning and permitting, as well as legal appeals and procedures. As a result, the set deadline may be challenging for bidders from one or more of the cooperating countries while in other countries project developers might be faced with significant risks of non-realization also in the final stages of project development.

In other words, a project developer intending to participate in the a cross-border auction in a country with longer national permitting procedures may need to begin the pre-development of his project (i.e. obtaining the explicitly or implicitly required permits) significantly earlier than project developers with projects located in countries with faster and less burdensome approval processes. The affected project promoter will typically incur higher risks and costs and may thus be systematically disadvantaged in the auction compared to other bidders with more favourable national framework conditions. A late auction for a project located in one country might well turn out to be an early auction for projects in another country with faster planning and approval processes.

In any case, when setting realization deadlines, this potential discrepancy should be thoroughly assessed to ensure that realization deadlines are reasonable and consider typical project development cycles in all cooperating countries.

Early auctions may lower the barrier of entry to auction, but providing long realization deadlines, bears greater uncertainty regarding the overall realization rate. Short realization deadlines (late auction), even though potentially more discriminating and incurring higher costs of pre-development that are potentially sunk, increase the likeliness of realization and thus brings bids on a more equal level with regard to the target achievement perspective.

Recommendation for timing of auction
In cross-border auctions, it is important to set realization rates that consider the local planning and permitting processes. Overall late auctions can be preferable where projects bid with already pre-developed projects as they increase realization rates.

Another aspect that is connected to the realization deadlines is the suspensory effect of legal proceedings and administrative appeals. Differences can be observed between countries regarding the timing, extent and duration of legal proceedings and administrative appeals, as well as regarding the practice of dealing with these types of risks in terms of granting extra time for the project realization. As a consequence, defining rules that are equally applicable for bidders from different countries may be challenging. Our recommendation is therefore to align with the rules that are defined within national auction systems. These rules should, however, be checked in advance to avoid overly distortive effects, i.e. avoiding very lenient rules in country A versus very strict rules in country B.

Ceiling prices: The main purpose of ceiling prices is to protect against the risk of inadvertently awarding projects to very high-priced bidders. If less bids are offered than there is auction volume, ceiling prices can ‘save’ the auction by providing an objective award price. They also set a cap on total support costs and thus increase budget certainty, which may create higher acceptance for contributing countries.

Setting adequate price caps is recommendable, if appropriately calibrated to reflect the respective market conditions of cooperating countries. With regard to the exact determination of the applicable level of price caps, we recommend a LCOE-based approach rather than an opportunity cost approach. Compared to the latter, a LCOE-based approach provides a realistic production cost assessment and thereby increases the chance of reliable RES deployment while reducing the risk of windfall profits. When applying the LCOE-based approach, the ceiling price should be calculated from the perspective of a typical investor.

Against the background of various national contexts in the cross-border auction, we recommend that the methodology should take the broader regulatory framework and transaction costs into account (taxes and tax exemption, market risk premiums, financing conditions etc.) or at least leave room for projects under different regulatory settings rather than defining different ceiling prices for projects from different countries.

6.1.2.3 Recommendations

The design of a cross-border auction needs to be tailored to the specific context, yet it should be kept as simple and non-distorting as possible. Our general recommendation is to opt for a combination of a late auctions (shorter realization deadline) and a higher financial prequalification instead of a material prequalification, if it is difficult to identify similar permits for the development of RES projects. A similar approach was chosen in the German-Danish cross-border auctions for solar PV, where material prequalification was renounced, and financial prequalification was raised to 70€/kW. However, if similar permits for the development of RES projects in terms of progress of project development and likeliness of project realization can be identified, material prequalification could be used in combination with lower financial prequalification.

The approach of a late auction should increase the realisation rate. However, it also increases sunk costs, reduce overall participation and may favour the participation of larger project developers that can balance risks in a portfolio more easily.

The following recommendations result from the discussion:

	Observation	Recommendation
Auction design elements to focus on in cross-border auctions	The general auction design (technology type, auctioned item, etc.) and procedure is not per se impacted by the cross-border nature of an auction. Here, the same rules as for national auctions may apply.	Focus on design elements determining the conditions for participation (prequalification requirements) as well as deadlines and penalties. If not tailored to the specific cross-border context, such rules may have a strongly limiting effect on the participation of bidders from one of the cooperating countries.
Material Prequalification	Material prequalification requirements are based on national planning and permitting procedures and therefore vary between the countries. Inconsistent practices of project planning and permitting lead to an incomparability of specific permits.	Limit or even avoid the use of material prequalification criteria in cross-border auctions. Implementing stronger financial prequalification requirements is an alternative to material prequalification.
Financial Prequalification	Financial prequalification impact actors differently, favouring larger players. Compared to material prequalification, financial prequalification are less likely to cause distortions between countries and thus change the allocation of installations between cooperating countries.	Make use of financial prequalification in combination with penalties to secure a high project realization rate. The level of financial prequalification should reflect a good balance between project realization on the one hand and actor diversity on the other hand.
Timing of the auction	In cross-border auctions, it is important to set realization rates that consider the local planning and permitting processes.	Overall, late auctions can be preferable where projects bid with already pre-developed projects as they increase realization rates.

Table 5 – Observations and recommendation on individual auction design elements

6.2 Remuneration design

Just as in national auctions, the remuneration design determines the allocation of market risks between plant owners and the society. While under a feed-in tariff, plant owners do not bear any market price risk but only have to deal with the quantity risk (i.e. the risk of unexpected weather regimes or plant defaults), the society bears the market price risk by paying the same amount for every unit of energy produced irrespective of market prices.

In feed-in premium schemes, which now prevail in EU Member States, and are encouraged by European regulation with limited exemptions, plant operators assume parts of the market price risks. The concrete design of the feed-in premium determines to which degree the plant operators assume these market price risks. In general, higher market price risks for the plant operators imply higher financing costs for renewable plants (and hence higher support costs). They also increase the stability of support payments for the society and in certain cases might lead to alternative market-based measures for risk insurance.

In the context of cross-border auctions, the design of a suitable premium becomes more challenging as two electricity markets with two different electricity prices are involved. Depending on the specific remuneration design, the various electricity prices can provide significant advantages for bidders from a certain country, posing the question if and how a level-playing can be established. In practical terms, different electricity markets can complicate the calculation of support payments for the regulator and thus increase administrative and transaction costs. The same challenges apply if a country has more than one price zone. In the future, the challenge might be reduced as European market coupling further evolves and grid extensions contribute to a higher convergence of market prices between European countries.

In the following, different options for feed-in premium design are elaborated and evaluated regarding their usage in cross-border auctions.

6.2.1 Support payment mechanisms (premium design)

6.2.1.1 General issues

In EU Member States, fixed and sliding premiums are used to support renewable energy power plants. Figure 10 shows the income generated by the renewable power plants under the two premium models.[21]

Under the fixed premium scheme, renewable energy plants receive a fixed payment on top of the market value they generate from the regular electricity market. In the Figure, an increasing market value is assumed in the long term. Under the assumption of perfect information and perfect competition, the power plants participating in an auction for the fixed premium anticipate this increase in the market value over time and bid a premium that covers their levelized costs of electricity generation (LCOE) over the plant's lifetime. Therefore, in the example given here, the plant makes a loss in the first years of operation whereas profits are generated towards the end of the plant's lifetime. As in reality, the future development of market values is not known in advance, when bidding into the auction, the plant operator runs a high risk of over- or underestimating its income over the plant's lifetime which depends to a high degree on the development of long-term market values. Due to these high risks born be the plant operator, the share of debt is typically lower for plants under fixed premium schemes compared to sliding premium schemes, which increases the total costs of financing (WACC) and therefore might lead to higher support costs. However, once the premium payments are defined, the support payments to be borne by the society are clear and stable over time. The long-term market price risk is mostly borne by plant operators.

In the same situation with increasing market values, perfect information and competition, a plant which receives a sliding premium will also make a loss in the first years and profits in the later years of operation. However, both are less pronounced as the sliding premium partly balances the income. Under the sliding premium, the plants bid a value that is very close to their LCOE, reduced only by future additional profits they expect to generate from periods where the market value exceeds the guaranteed price. As a consequence, the risk of over- or underestimating the necessary support levels is lower. Also, the possibility to access debt is higher and thus financing costs (and therefore LCOE and support costs) are typically lower under sliding

[21] Depending on the support scheme design, negative electricity market prices can be treated differently, which can impact the participants' bids. For example, in Germany no support is paid (for the entire period) if 6 or more consecutive hours of negative electricity market prices occur, while e.g. Denmark and UK don't pay support in any hour with negative prices. Since bidders are pricing in this loss of income when calculating their bids, we might see lower bids from German developers (all else equal), since cutrailment due to negative prices will happen less often. This can impact the auction's outcome if an increasing number of negative prices are expected to occur in the future.

premium schemes[22]. The development of support expenditures that need to be paid by final consumers or the society depends however on the long-term developments of market values. Under this premium design, the long-term market price risk is thus mainly borne by society.

Different mechanisms exist to adapt both support schemes. A floor price in combination with a fixed premium can increase the share of secure income streams for plant operators and thus facilitate access to capital. A cap can reduce the risk of very high incomes for plant operators and at the same time reduce the uncertainties for calculating the bid for the fixed premium. A sliding premium can be combined with a pay-back mechanism whenever the electricity market price is higher than the bid price. This avoids overcompensation and decreases the risks for plant operators. However, all additional design elements make the support system more complex and imply regulatory risks (e.g. when setting the floor and cap or designing the pay-back mechanism).

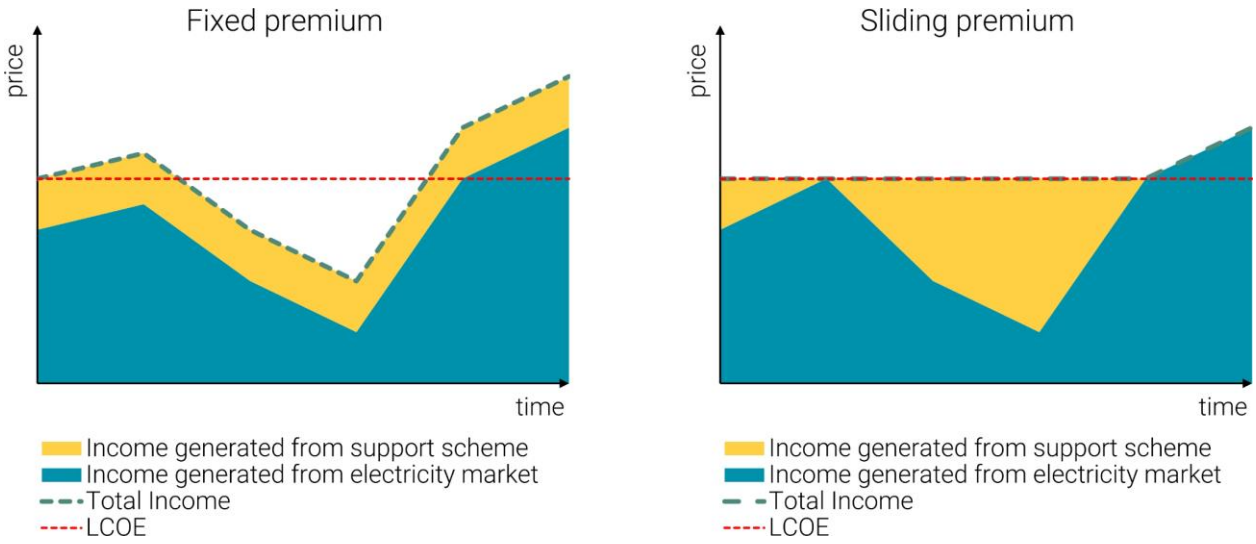

Figure 10 - Income streams for renewable energy plants under fixed and sliding premium schemes (Source: Fraunhofer ISI)

6.2.2 Premium design in cross-border auctions

In cross-border auctions, the difference in market values between different countries needs to be considered for identifying a premium option. While in the case of Denmark and Germany, each country kept its own support scheme for the cross-border auction, the involved countries could also decide for a specific premium design for the cross-border auction. In a joint auction, defining one scheme is even necessary. In the following, effects of different market values and possible adaptations of the premium schemes are assessed for fixed and sliding premiums.

Fixed premium in cross-border auctions

If two or more countries engaging in a cross-border auction choose to use a fixed premium, in addition to the general effects described above, the location of the winning plants is affected.

[22] Please see also AURES II report 5.1 on the effect of auctions on financing conditions for renewable energy

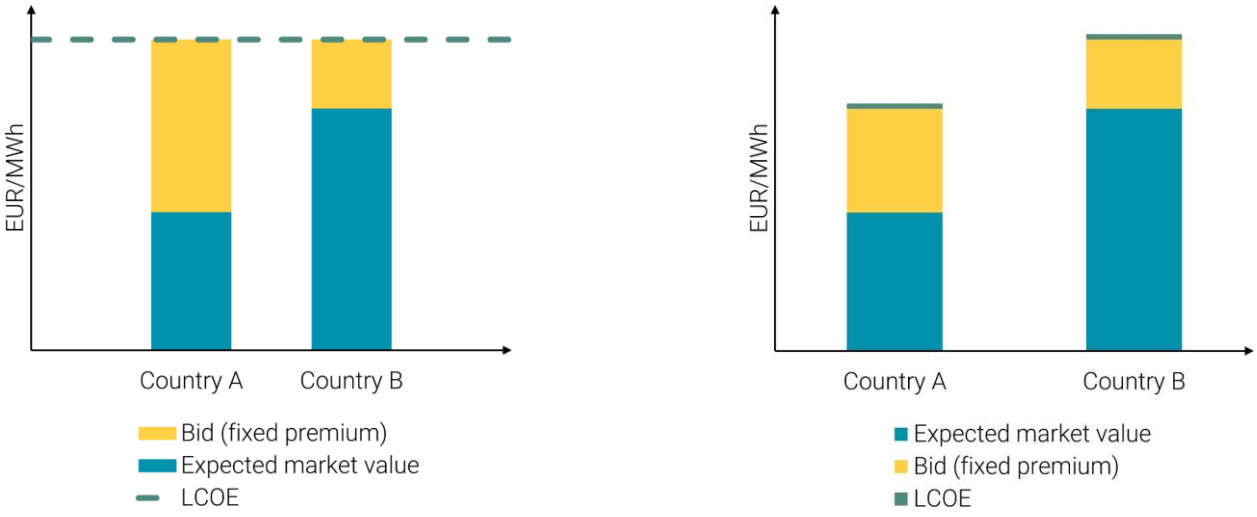

Figure 11 - Effects of fixed premia in cross-border auctions (Source: Fraunhofer ISI)

As shown in chapter 5.2.1, plants that are located in a country with a higher expected market value have an advantage in the auction - under the assumption that in the auction the bids with the lowest prices are awarded. As shown in Figure 11 (left), if two projects have the same levelized costs of electricity generation but the one located in Country A can expect higher revenues from its national electricity markets, this plant can reduce the bid level for the fixed premium accordingly. All else equal, plants in the country with higher market values are preferred due to their lower bid prices.

In an extreme case this can lead to a decrease in allocative efficiency, i.e. that the projects with the lowest costs (LCOE) should be awarded. Although the plant in Country A (Figure 11 - right) has lower LCOE compared to the project in Country B, it won't be awarded in the cross-border auction, solely due to the higher market value in Country B. This project needs a smaller support in form of a mixed premium and thus the bidder can submit a lower bid price than the project in Country A.

Nevertheless, this implies that support costs for the overall auction are minimized, at least if negative effects on financing costs of the fixed premium are not considered. Another advantage of a fixed premium in cross-border auctions is the easy comparability of bids from the different countries. If differences in market values are high, the bias towards one country might be politically problematic even though it reduces overall support expenditures.

Sliding premium in cross-border auctions

The implementation of a sliding premium in a cross-border auction is a bit more complicated as there are several options to consider the differences in market value between the two countries. In the following two alternatives, namely a sliding premium based on the individual national market value and a sliding premium based on the average of the market values reached in the involved countries are explained and analysed.

Sliding premium based on national market values

If the sliding premium is calculated based on national market values, it has the same effect for investors as the sliding premium described above for a national auction, i.e. investment risks and thus financing costs are very low. In terms of plant selection, the differences in market values play a very minor role. As shown in Figure 10, the impact of the market value on the bid is much lower in comparison to the fixed premium. If expected differences are significant, the country with higher market values is preferred but in most cases uncertainties regarding market developments will have a bigger effect on plant selection than differences between countries' market values. As in the national case, the sliding premium implies the possibility of increasing support costs if market values are below expectations in the future. The plant operator only needs to consider national prices both in her bid and her dispatch.

One disadvantage of a sliding premium based on national market values is the fact that plant selection is mainly based on LCOE and only to a limited extent on support costs (or minimizing the difference between LCOE and market values).

Another drawback is the necessity of a payment mechanism between the involved countries in a joint auction. As support expenditures can differ substantially even between plants that have placed similar bids (if they are located in different countries and market values differ), it is necessary to implement a mechanism to share the support payments and thus to clearly allocate the installations to the respective national support scheme. This problem does not arise in unilateral or mutual cross-border auctions though.

Sliding premium based on average market values

An alternative is to calculate the sliding premium based on the average market value achieved in the involved countries. In this case, projects will still generate income from the local electricity market, but in contrast to the sliding premium based on national market values, the premium depends on both countries' market values.

This design option can be seen as a compromise between a fixed premium and the sliding premium based on national market values. A sliding premium based on the average market value has the following effects:

- the advantage of plants located in the country with higher market values is more pronounced than in the case of a sliding premium based on national market values but less than in the case of the fixed premium.
- the plants still generate a relatively high share of stable income and have therefore access to comparatively cheap financing. However, the uncertainties are higher as the income depends not only on the market value in the country where the plant is located but also on the development of market values in the other country (or countries). This creates additional complexity, since bidders have to make assumptions on the future development of two (or more) market values to calculate their bid prices.
- the effect on total support costs is unclear - on the one hand, market values and the support needs are partly integrated in the bid levels and on the other hand financing costs are lower compared to a fixed premium but higher compared to a sliding premium based on national market values.
- the support costs do not depend on the national market values but on the average market values and are therefore more similar between the plants. Thus, the cost allocation between countries can be implemented by simply allocating specific plants to each country (as in the case of the fixed premium).

Comparison of premium design options for cross-border auction:

	Fixed premium	Sliding premium based on national market values	Sliding premium based on average market values
Plant selection criterion	Difference between LCOE and national market value	Mainly LCOE (and national market value)	Mainly LCOE (and difference between domestic and average market values)
Support cost efficiency	• consideration of market value and LCOE minimizes support costs • higher financing costs can outweigh the above advantage	• low financing costs (and thus low LCOE) due to low market risk exposure • no consideration of market value	• medium financing costs (and thus medium LCOE) due to low market risk exposure (but influence of foreign market value) • partial consideration of market value
Certainty of support costs	High • fixed premium is determined for the duration of support	Low • premium depends on development of market values	Low • premium depends on development of market values
Generation cost efficiency	Medium	High	Medium

Risk of overcompensation	High	Medium	Medium
Investor risk and financing costs	High • high financing costs (and thus high LCOE) due to high market risk exposure	Low • low financing costs (and thus low LCOE) due to low market risk exposure	Medium • medium financing costs (and thus medium LCOE) due to medium market risk exposure
Bid calculation	Medium • LCOE and future development of national market values needs to be considered	Simple • LCOE play main role • in addition, future development of national market values needs to be considered if market values are expected to increase above LCOE	Medium • LCOE play main role • In addition, future development of national and average market values needs to be considered
Cost allocation between countries (in case of joint auction)	Easy (plants can be allocated to countries at start of operation)	More complex (total support expenditures need to be calculated annually and allocated between countries)	Easy (plants can be allocated to countries at start of operation)
Complexity of premium calculation	Easy • premium payments independent of market values	Medium • calculation of reference market values and measurement need to be agreed upon between countries	Medium • calculation of reference market values and measurement need to be agreed upon between countries • calculation of average market value (simple or weighted average) needs to be defined

Table 6 - Overview of effects of different options for premium design in cross-border auctions

Table 6 gives an overview of the effects of the three models described for premium design. As in the national case, caps and floors as well as pay-back mechanisms are also possible in the international context but increase the complexity of the design. The table shows that no design is clearly preferable.

When deciding for a premium design, one option is therefore to start from the existing premium designs in the countries involved due to a potentially easier implementation. Otherwise, the decision for an alternative premium design depends on the political preferences and objectives of the countries involved.

A fixed premium is the easiest option regarding the implementation in cross-border and joint auctions. However, it has several drawbacks regarding support costs certainty, the risk of overcompensation and higher financing costs for plant operators. A fix MP also strongly favours bidders from countries with higher (expected) market values and thus lowers the attractiveness of the cross-border auction for bidders from countries with lower (expected) market values.

A sliding premium based on national market values implies relatively low risks and financing costs. However, the level of support necessary is uncertain. In case of a joint auction, the allocation of plants between countries is also more complex if a sliding premium is chosen. Furthermore, if one country's sliding premium scheme is used for plants in another country, the necessary measurements and calculations need to be implemented in the second country or alternative ways of defining reference market values need to be agreed upon. The sliding premium based on average market values increases the complexity of calculating premiums and bids compared to the sliding premium based on national market values. This might also increase the complexity of implementation.

7 Allocation of costs and benefits

A cross-border auction creates costs and benefits for the cooperating countries. For a cross-border cooperation to be attractive, the benefits must outweigh the costs for each participating Member State to ensure that it is better off with the cooperation than without.

The key elements to be considered are the cost of support payments on the one hand and the benefit of RES target achievement. Generally speaking, the Member State paying support costs should receive the target achievement statistics. If a joint support scheme is set up and the support scheme payments are distributed equally between the participating countries, their share of target achievement should be equal, regardless of where the installations are located.

However, there is a range of additional cost and benefit elements. Depending on the significance of these elements, countries may decide to consider them explicitly and to include them into a more comprehensive distribution. In that case, the basic exercise is to identify the relevant categories, monetize them as much as possible and identify the net cost or benefit for the two countries.

An overview of the potential costs (orange) and benefits (green) beyond support costs and target achievement is presented in the following table.

Impact	Host MS	Paying MS
Economic impacts		
Cost-effectiveness of RES support in cross-border auction: Cost at which a certain target can be achieved / capacity can be deployed.		
Creation of jobs alongside the value chains: Net job effects of building RES capacities and replacing conventional capacities.		
Innovation effects: Effects on the technology learning curve.		
Transition of economic structures towards decarbonization: Effects on the structure of market players, the development of new business models, etc.		
Environmental impacts		
Landscape and environment		
Air quality		
Energy system impact		
Energy system costs for RES integration: Impacts on redispatch and grid reinforcement.		
Security of supply: Impacts on generation adequacy and import dependency.		
Transition of national energy system towards decarbonization: Aggregated technical effects of additional RES capacities on the decarbonized energy system.		
Wholesale price impact: impact of RES capacities on wholesale market prices, incl. RES market values, technology-specific market values, overall levy payments, etc.		
Other impacts (political / societal / regulatory)		
Acceptance of RES deployment		
Changes to national legislation/regulation		
Fostering political cooperation between countries		

Table 7 – Overview of costs (orange) and benefits (green) of cooperation

The monetization of costs and benefits happens by defining a counterfactual, i.e. by defining the situation of non-cooperation, for instance with a view to how much support scheme payments would be necessary in the case of non-cooperation compared to implementing the cross-border auction.

The table shows that most elements create a benefit in one country and at the same time a cost in the other country. For instance, the cost-effectiveness of support within the cross-border auction is clearly improved for the contributing Member State. The Member State hosting these installations may experience a decreasing cost effectiveness for the remaining national deployment, as good sites may be used for the cross-border auction. Other factors are more ambivalent: for instance, low or high wholesale market prices are not per se good or bad but have complex distributional effects on the entire energy system, the energy market, consumers and levy payers (lower wholesale market prices can reduce consumer prices but increase the levies).

There are various challenges related to identifying costs and benefits in detail and to distributing them. First, the participating countries have to agree on a list of elements to be considered for the detailed consideration of costs and benefits. Second, for various elements it is quite burdensome to quantify and monetize them. This relates foremost to system and grid integration costs, which can only be quantified in a robust manner when using energy market and grid modelling. This exercise in itself can be costly and will in any case be related to major uncertainties, especially since such cost elements would have to be quantified over a period of at least 15 years (i.e. a common support payment time frame). In addition, some elements would have to be considered in a semi-quantitative or only qualitative manner, making it difficult to include them into an "objective" cost-benefit distribution.

The complexity of the negotiations surrounding the cross-border auctions will increase with each element that needs to be considered in the cost-benefit distribution. Past experience around the Cooperation Mechanisms has shown that the level of complexity of the cost-benefit analysis and the subsequent decision on the distribution can become a show stopper. As a result of the discussed challenges and based on past experience, we recommend that countries try keeping the cost-benefit analysis and the resulting distribution as simple as possible.

It appears that the general will to cooperate, i.e. to provide on the one side support payments in exchange with target achievement statistics and to provide on the other side sites and grid use for RES projects, should be the starting point and main guiding principle when distributing costs and benefits.

Even if such a pragmatic and simplified approach is chosen, there are possible situations requiring decisions on the distribution:

Large-scale complex projects: For instance, a cross-border auction involving major grid-costs, a larger number of countries and support payment contributions from various countries will require a more detailed assessment of the costs and benefits. The most obvious example is the one of a cross-border auction for a large-scale offshore wind park, which is connected to various countries. For such situations, the RED II foresees in Article 5 assistance by the European Commission by "providing information and analysis, including quantitative and qualitative data on the direct and indirect costs and benefits of cooperation."

Low support costs: In some cases, the availability of good sites will result in very low bids (e.g. in the case of fixed premiums). In this situation the costs for grid integration in the host country can become more relevant as they become more significant in comparison to the support scheme payments. In case a sliding premium is applied, increasing market values (going structurally above the strike price) may result in no support payment at all after a certain period. In this situation the question is whether the "contributing" country should still receive all target achievement statistics. If two countries anticipate that the results in the auctions may lead to very low or even no support scheme payments (which is generally favourable), they may agree up-front on a certain distribution, e.g. a 50/50 split, of the target achievement statistics.

End of support: Another question is what happens with target achievement statistics after the end of the support period? One option is to continue transferring the target achievement to the contributing country for the entire technical lifetime of the installation. The reason would be that the contributing country triggered the investment through its support payments in the first place. The alternative is to let the respective installation contribute to the hosting country's target achievement after the support period, given that the host country provides the site and the grid integration.

A specific case arises if upfront investment aid is allocated in the auction, as there is no "support scheme duration". In this case both countries need to agree on a certain time period for the transfer of target achievement statistics, which can be 15 years (to reference typical support scheme durations) or the technical lifetime of the plant.

The following recommendations result from the discussion:

	Observation	Recommendation
Main cost and benefit elements	A cross-border auction creates a wide range of different costs and benefits for the cooperating countries. The key elements are support cost payments and target achievement.	When discussing costs and benefits, focus on these key issues to determine the basic distribution principle.
Additional elements	Additional cost-benefit elements include: local job creation, innovation effects, environmental effects, RES integration costs, security of supply impacts, and wholesale market impacts.	If necessary, identify the impact of any of these elements. Keep the elements as limited as possible as to reduce complexity and transaction costs of the cooperation.
Specific situations	More nuanced cost-benefit distribution might be required in the context of large-scale complex projects, low support costs (or even 0-bids) and the end of the support period.	Still keep distribution rules simple and consider 50/50 approaches.

Table 8 – Observations and recommendations on allocation of costs and benefits

8 Practical guidance for implementing cross-border auctions

Setting up cross-border auctions is more complex than setting-up national auctions, because the design and implementation process includes negotiations between at least two governments and agreements between different regulatory agencies. This requires the mutual understanding of the two (or more) sets of political priorities, regulatory frameworks and market conditions.

The following sub-chapters provide guidance on the practical aspects that should be taken into account in the preparation as well as the practical issues of implementation of cross-border auctions. A more detailed check-list for cooperating countries will be developed in the remainder of the AURESII-project to provide even more comprehensive practical guidance on how to implement cross-border auctions.

8.1 Preparation of cross-border auction

Before implementing cross-border auctions, cooperating countries should aim to reach an understanding of their respective policy objectives of the cooperation as well as the country-specific starting points in terms of renewables policies and market condition. Such a mutual understanding will facilitate the process or preparing the cooperation and help to avoid unintended consequences in the auction.

The following table provides an overview of aspects that countries should or may investigate. Aspects related to the goals and principles of the cooperation, the basic concept and scope of the cross-border auctions and the potential gains and distributional effects of cooperation should in any case be discussed by the cooperating countries. The extent to which a mutual understanding of the other items listed is required, depends on the goals and the scope of cooperation.

Aspects to investigate	Details
National RES policy	- General energy policy goals of the cooperation country - Political priorities of the current RES framework - Details of current support scheme for RES (e.g. auction and remuneration design; volume of newly supported installations per year; technological focus; level of remuneration)
Goals of cooperation	Goals and priorities of the cooperation can be, for example: - Reduction of support costs - Improving RES-integration - Maximising available RES potential - Best practice exchange - Technology advancement
Principles of cooperation	Cooperating countries may define basic requirements regarding the implementation of a cross-border auction. Such basic requirements are, for example: - Proof of physical import of electricity - Reciprocity of cooperation (e.g. both countries need to open their support scheme or provide funding) - Consideration of balanced geographical distribution of installations, taking into account, for example, network congestion issues - Other requirements (e.g. installations in hosting country need to fulfil the same requirements as projects located in contributing country)
Basic concept of specific cooperation case (tbd in cooperation agreement)	- Model of cross-border auction - Scope of cooperation (volume, timing, technological focus)
Natural potential	- Resource quality, e.g. wind speeds or full load hours for solar PV - Availability of sites and site restrictions

National regulatory frameworks	- Similarities and differences of current support frameworks - Potential impact of regulatory/permitting frameworks on cross-border auctions
Current market situation	- Competitive situation (e.g. relation of pipeline of projects vs. yearly auction volumes, no. of players in national auctions) - Current level of support / auction results - Market values - Access to financing - Cost of capital - Structure of market participants (e.g. large or small project developers) - Potential impact of market conditions on cross—border auctions
Potential gains and distributional effects of cooperation	- RES production - Impact on support cost expenditures - Geographical distribution of installations - Distribution of other costs & benefits
Administrative processes and responsibilities in national RES schemes	- Administrative processes of national auction and support payment procedures - Established procedures of transfer of production data - Responsible bodies involved

Table 9 – Aspects to investigate in the preparation of a cross-border auction

Cooperating countries may put forward basic requirements that need to be met by any cross-border RES auction. By determining such requirements, or principles of cooperation, countries intend to maintain effective control over the scope and thus cost and benefit distribution of cross-border auctions. This shall ensure that cross-border auctions have public acceptance. In the context of state-aid-induced openings of national support schemes, Member States have put forward such basic principles for cross-border auctions. Note that these principles do not have to be adopted by Member States.

Principles that were put forward by Member States so far can be classified as follows:

- Physical import: Countries may require proof that the electricity produced by an installation in another (host) country is either imported or has a similar impact on the power market of the (contributing) country, compared to a RES installation located in the contributing country.
- Reciprocity: A country may require that its cooperation partner also opens its support scheme by conducting a cross-border auction. Alternatively, a country may only determine that the cooperation must be mutually beneficial and have a genuine impact on the energy transition in both countries.
- Cooperation Agreement: A country may demand that the principles of allocation of RES installations that are subject to cross-border support as well as the details of the cooperation are covered by a cooperation agreement.

The first two principles can restrict the applicability of cross-border auctions significantly, even to the extent that the general goals of cross-border auctions (e.g. reducing support cost expenditures) cannot be achieved. For example, depending on its interpretation, the principle of "physical import" can become a show-stopper, as the electricity flows cannot be traced. In that context, Art. 5 II of the RED II specifies, that "Member States may limit participation in their support schemes to producers located in Member States with which there is a direct connection via interconnectors". Despite this lenient interpretation of physical import, it can be difficult to find a neighbouring country for the implementation of a cross-border auction. Also, even in case of an actual physical interconnection between the contributing and the hosting country, there is no certainty on the physical import or impact of an installation on the power system of the contributing country.

Recommendation on basic principles for cross-border auctions

Our recommendation is to refrain from determining principles of cooperation that strongly limit the potential pool of cooperation countries. This is particularly the case for the principle of physical import. Countries should define their principles of cooperation in a way that maintains flexibility in the choice of the most suitable cooperation countries.

8.2 Implementation of cross-border auctions

The implementation of a cross-border auction requires the conclusion of a cooperation agreement between the governments of the involved countries. In the cooperation agreement, the countries determine the scope of the cooperation and the distribution of costs and benefits. The cooperation agreement is important to avoid legal uncertainty, reduce counter party risks as much as possible, and thereby reduce the risks for investors.

In determining the scope of the cooperation, countries control the volume of RES capacity installed under cross-border auctions, which is important for public acceptance. Furthermore, the cooperation agreement needs to define the details regarding the exchange of information, responsibilities, and legal liabilities as well as how financial support and the statistical benefits from the renewable sources are to be allocated amongst the participating countries.

Before a cooperation agreement can be signed, cooperating countries must agree on a range of aspects. The table below lists the most important cornerstones of such an agreement.

Aspects to agree upon	Details
Cooperation model	- Unilateral/mutual cross-border auctions or joint auction
Scope and extent of the auctions	- Technology: Single or multi-technology auctions, which technologies - Volume: Determining overall volume of cross-border auctions and share of each country - Timing: Timing, number and frequency of auctions, ideally aligned with the schedule of national auctions to provide a continuous auction pipeline. - Maximum/minimum size of installations (bid size)
Support scheme design	Unilateral/mutual cross-border auctions: - Cooperating countries mostly draft support scheme design of their cross-border auction individually Joint auctions: - Common agreement on auction design
Differing regulatory and market conditions	- Whether or not to establish rules for handling/balancing differing conditions
Allocation of costs and benefits	- Rules regarding the assigning of successful installations to cooperating countries (in case of joint auction) - Allocation of RES statistics during and after support period - Whether or not to determine and allocate other costs and benefits
Administrative procedures (e.g. distribution of responsibilities, timing and transfer of information)	*Pre-auction*: - Procedure of publication of call for bids - Tendering authority *During auction or prequalification phase*: - Assessing technical and material prequalification (if applicable) - Assessing compliance with national regulation, e.g. site restriction - Exclusion of bids - Which is the awarding authority? Can regulator in country A award installations in country B? - Which authority administers the financial guarantees (bid bonds)? - Allocation of successful bids to cooperation countries (in joint auction) *Post auction*: - Monitoring of project implementation - Which authority issues the funding approval?

	Project operation (related to disbursement of support payments): - What production and technical data is needed? - How will this data be transferred? (involved parties, frequency, format, etc.) - Transfer of information on (technology specific) market prices in the relevant price zone (depending on premium design) - Process of payment of support
Contractual arrangements and legal liabilities	- Contracts with bid winners: What will be the exact legal relationship between bid winners and the funding country? - How to avoid any retroactive changes to the support schemes and the rights and obligations determined in the cooperation agreement and the contracts with bid winners? - What is the place of jurisdiction? - What happens if projects do not realize? - How to reduce the offtake risk as much as possible?

Table 10 – Key aspects to specify in cooperation agreement

Considering the number of aspects that need to be agreed upon, it is even more important to reduce the administrative complexity of cross-border auctions and make use of procedures that are already established at national level. For instance, it may be difficult to assess the pre-qualification documentation and monitoring the project implementation in another country. Instead, it is recommended to involve the authorities assigned with these tasks in the national schemes and agree on cross-border mechanisms to ensure the close cooperation between these national authorities.

The perceived complexity may deter countries from setting up cross-border auctions. To facilitate the implementation of cross-border auctions, the European Commission offers in Art. 5 IV of the RED II to assist Member States throughout the negotiation process "by providing information and analysis, including quantitative and qualitative data on the direct and indirect costs and benefits of cooperation, as well as with guidance and technical expertise". Furthermore, the Commission may develop templates for cooperation agreements.

Given the effort and commitment of policy makers involved in setting up cross-border auctions, parties may be less likely to re-open negotiations for adjustments, once they have reached agreement on the cross-border support scheme. This may result in increased stability and predictability for market players.

In the context of cross-border auctions, a number of issues arise regarding the distribution of responsibilities and legal liabilities. The following sub-chapters highlight the most important administrative procedures pre, during and post auction.

Invitation and evaluation of bids: For inviting, evaluating and awarding of the bids, a place of jurisdiction needs to be assigned by the cooperation countries. This can either be done by one or several authorities. For unilateral and mutual cross-border auctions this is typically a national regulatory body or agency. In the cases of joint auctions, this can be the respective national agencies, or, alternatively, the cooperating countries establish a new joint body for that purpose.

Disbursement of funding and data transfer: The cooperation countries need to define rules and responsibilities for the cross-border disbursement of funding. This involves the exchange and monitoring of information to ensure correct support payments to the installation. A dedicated body has to be assigned with the disbursement of funding. For unilateral and mutual cross-border auctions this can be the body responsible in the national support scheme. For joint auctions a common body may be established.

Furthermore, processes need to be established for the frequent data exchange of the production volume of each installation, as well as the (technology specific) market values that are the basis for calculating the support payments. National bodies may have to set up procedures for the exchange of the required information, specifying the format, frequency and timing of the data transfer. In addition, on-site checks of whether installations are installed according to the technical requirements specified in the auction may have to be conducted to ensure that all pre-conditions for the payment of cross-border funding are fulfilled.

9 Conclusions

This report explores the basic rationale for cross-border auctions, which is twofold: legal-political and economic. The key benefit of cross-border auctions is to increase the efficiency of RES auctions by means of using better natural potential, higher market values, lower cost of capital and increased competition compared to national auctions.

Experience from the German-Danish auction has shown that cross-border auctions can indeed be successfully implemented: in this case it meant lower costs for levy-payers in Germany with all winning projects being in Denmark. It showed as well that the national context of all cooperating countries needs to be assessed carefully to at least anticipate – and potentially to accept – a full shift of awarded projects from one country to another (with a view to the volumes of the cross-border auctions). It also showed the importance of aligning schedules of cross-border auctions with those of national auctions to support a continuous pipeline, avoid boom and bust cycles in the RES industry and avoid that auctions undermine each other's level of competition.

The report identifies three types of cross-border auctions (unilateral cross-border auction, mutual cross-border auctions and joint auction) and shows that while they vary in intensity of the cooperation, moving from the former to the latter options is not a necessarily implemented progression.

Triggered by the experience of the German-Danish auction, the report discusses the impact of differing national regulatory and market environments on the outcome of cross-border auctions. It further discusses whether to balance distorting effects of differing regulatory and market environments and presents three options how to address them.

Auction design can build on good practice for nationally organized auctions, but several elements need to be reconsidered when implementing cross-border auctions, such as the role of financial and material prequalification criteria. The design of the premium scheme – e.g. fixed or floating premium – may have implications on the allocation of awarded projects. Countries may consider deviating from the prevailing national premium design, depending on their political preferences and objectives with the cross-border auctions. In a joint auction premium design is interlinked with additional considerations, related to the attribution of awarded projects to the support schemes of the cooperating countries.

The allocation of cost and benefits mainly revolves around support costs and target achievement statistics. In practice, additional costs and benefits of cross-border auctions will be manifold, but complex to quantify. To avoid political barriers to agreeing on a cost-benefit distribution, the number of additional cost-benefit elements to be considered (such as grid costs) should as limited as possible.

While there are numerous aspects to be assessed and considered by all involved countries when designing and implementing cross-border auctions, the practical guidance provided in this report shows that it is indeed feasible. A more detailed check-list for countries will be developed in the remainder of the AURESII-project to provide even more comprehensive practical guidance on how to implement cross-border auctions.

Experience with cross-border auctions is still limited and the potentially increased number of such auctions being implemented will generate further knowledge on how to tap into the vast potential for RES deployment while keeping the complexity and transaction costs limited.

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

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

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