Master Thesis

An analysis of lessons learned with bidding/tender for the promotion of Renewable Energy Technologies in selected countries worldwide

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Abbreviations

APAMSI	Indonesian Solar Panel Manufacturing Association
IPP	Independent Power Producer
kWh	Kilowatt-hour
MC	Marginal production costs
MWh	Megawatt-hour
MEMR	Ministry of Energy and Mineral Resources Indonesia
P	Price
Q	Quantity
PPA	Power Purchase Agreement
PV	Photovoltaic
RE	Renewable Energy
RES-E	Electricity from Renewable Energy Sources

Abstract

Renewable energy generation systems gained international popularity in the last decade, due to the increasing demand for energy. On top the pressing climate change issue and the related urgency and awareness for the need of clean energy production systems further enhanced the requirement. The Paris Agreement, which was signed in 2015 by 196 countries, set a common ground for the implementation of new energy policy strategies and led to a renaissance of RES-E within a broad international community (UNFCCC, 2016).

The main question, which has to be answered in the context of renewable energy promotion, is related to acceptance and efficiency of different policy instruments. This paper is taking a closer look on quantity-driven bidding and tender systems, which were often neglected in policy discussions and literature, but recently experienced popularity. This is demonstrated by technology reviews of renewable energy auctions worldwide. The theory is then illustrated with selected country analyses to derive lessons and policy implications at the global level.

1 Introduction

After decades of ignorance and stagnation in environmental concerns the Paris Agreement finally brought the global community on track with the pressing issue of climate change. To meet the Paris Agreement long-term temperature limit of up to 2 degrees Celsius, there is still a long way to go. One reason is that the extent of the agreement varies from country to country and some partner countries have not put it into force at all (UNFCCC, 2016).

One crucial step to contain climate change, is decarbonization of global energy systems and therefore reduce carbon emissions by supporting environmentally friendly energy production. This can only be successful if we analyse existing policy measures that promote sustainable energy sources. The goal is to support those which fit the geographical, economic and social environment best (Chen et al., 2008).

An example of well-intended policy, that was also capable but suffered from insufficient calibration to the economic dynamic, are CO2 certificates. Instead of the expected slow increase of costs for emitting CO2 that would have allowed businesses to adapt, prices for CO2 dropped. Thus, the dominant trigger for price changes was not the increasingly higher demand for certificates but rather the poor economic performance of industries during the financial crisis (Chen et al., 2008).

Since the majority of renewable energy production was triggered through fixed payment schemes, whereas quantity-driven support did not find its way to popularity (Lucas et al., 2013), this paper aims to examine the importance of bidding and tender schemes in the promotion process of renewable energy systems. Auction schemes have been broadly dismissed in academics as well as in policy practice for decades (del Ŕio & Linares, 2014). While authoring this paper, more research has been done in this area (IRENA, 2019; Anatolitis et al., 2021), and auction schemes have been rising rapidly over the last few years (Anatolitis et al., 2021). Growing global experience with multiple rounds of auctions in different countries, provide a learning opportunity to policymakers. This knowhow can help optimizing future auction designs to efficiently adapt to local conditions and requirements (Dobrotkova et al., 2018). The core objective of this work is therefore to analyse which tender programmes exist worldwide for RE and to connect country specific lessons learned effecting RES in electricity generation. Therefore, the effectiveness and efficiency of renewable energy auctions is analysed. Thus, this work takes a closer look on existing literature and link it to learnings from accomplishments and challenges of renewable energy auctions worldwide.

First this paper will give a theoretical overview of renewable energy support schemes, to understand different promotion strategies. Then a deep dive into most common price and quantity driven support schemes will follow, whereby a focus is put on advantages and disadvantages of quantity driven tender policies. Onwards, this work further concentrates on renewable energy auctions, looking at their mechanisms and design elements. In chapter 4 global trends of renewable energy tenders are assessed, looking at technology and price tendencies. Chapter 5 highlights selected country case studies illustrating accomplishments and challenges on a more specific level. Finally, the practical learnings are contextualized with advantages and disadvantages, to get a holistic view on the promotion of renewables through quantity driven tender schemes.

2 Renewable Energy support schemes

This chapter is intended to provide the basis for understanding various renewable energy support policies. To get a feeling for how the supporting mechanisms behind these price and quantity driven policy instruments work, section 2.1 and 2.2 will outline the theoretical background on it. Since this paper is further focusing on quantity driven RE auctions, it will additionally give an overview of benefits and drawbacks of quantity driven instruments.

One of the reasons for a relatively slow dissemination of renewable energy technologies is insufficient renewable energy subsidy (Atalay et al., 2017). A study of Zhao et al. (2013), which compares different renewable electricity policies in a panel data set of 122 countries, shows that investment incentives are positively correlated with renewable energy production and therefore play a key role in boosting the diffusion of renewable energy technologies.

Nevertheless, the promotion of renewable energy based electricity generation is connected to several barriers originating from economical as well as non-economic backgrounds. When non-economic barriers like grid access, network capacities and authorization procedures are overcome, economic barriers like high costs of capital and low electricity prices can still embody severe entry restrictions. Furthermore, barriers are divergent and dependent on country specific conditions, market maturity as well as general technological progress of renewable energy systems (Lucas et al., 2013). This will become more tangible in chapter 5, where country specific analyses exhibit some of the mentioned obstacles.

Countries have a variety of different incentives and supporting tools for renewable energy generation (Carley, 2009). In Table 1 you see an overview of possible policy measures clustered by different supporting channels promoting clean forms of energy production. In order to achieve an effective multiplication of the use of renewable technologies, the variants can also be combined to stimulate different channels simultaneously (IRENA, 2017).

Table 1: Overview of policies promoting RE

NATIONAL POLICY	REGULATORY INSTRUMENTS	FISCAL INCENTIVES	GRID ACCESS	ACCESS TO FINANCE	SOCIO-ECONOMIC BENEFITS
• Renewable energy target • Renewable energy law/ strategy • Technology-specific law/ programme	• Feed-in tariff • Feed-in premium • Auction • Quota • Certificate system • Net metering • Mandate (*e.g.*, blending mandate) • Registry	• VAT/fuel tax/ income tax exemption • Import/export fiscal benefit • National exemption of local taxes • Carbon tax • Accelerated depreciation • Other fiscal benefits	• Transmission discount/ exemption • Priority/ dedicated transmission • Grid access • Preferential dispatch • Other grid benefits	• Currency hedging • Dedicated fund • Eligible fund • Guarantees • Pre-investment support • Direct funding	• Renewable energy in rural access/cook stove programmes • Local content requirements • Special environmental regulations • Food and water nexus policy • Social requirements

Source: (IRENA, 2017)

Looking at the row of regulatory instruments, many different methods are listed. In literature an overwhelming focus was put on Feed-in-tariffs, quotas and certificate systems, as the effects of this specific policies on the renewable energy market have been studied most extensively (Baldwin et al., 2017). To get a deeper insight on the different approaches, see Haas et al. (2011a) or IRENA (2018a), who give an overview and Zhao et al. (2013), Haas et al. (2011b), Kitzing et al (2016), Baldwin et al. (2017), Mihaylov et al. (2019) or Polzin et al (2019), who are comparing different instruments and their effectiveness.

In general, regulatory instruments can be clustered in price and quantity driven strategies, seen in Table 2 by Haas et al. (2004). On the one hand there are price driven policies like feed-in schemes, on the other hand quantity driven policy instruments like public tendering schemes (Lucas et al., 2013). To get a feeling for how the supporting mechanisms behind these price and quantity driven policy instruments work, section 2.1 and 2.2 will outline the theoretical background on it.

Table 2 Fundamental types of regulatory strategies

Fundamental types of regulatory strategies

	Price-driven	Capacity-driven
Investment focused	Rebates Tax incentives	Bidding
Generation based	Feed-in-tariffs Rate-based incentives	Quotas/TGC

Source: Haas et al., 2004

2.1 Price driven

The most common price driven policy instruments are tariff-based support mechanisms. These provide electricity generators with subsidies per kW of installed capacity or per kWh of produced energy. Financial support strategies, to push renewable energy generation, can be granted through feed-in tariffs or feed-in premiums. If policy makers decide to provide feed-in-tariffs, generators obtain fixed payments per generated kWh independent from generation costs or electricity prices. Whereas in premium schemes, generators receive a fixed amount additional to the electricity price. As a result of volatile electricity prices, feed-in premiums bear more insecurity compared to feed-in-tariffs being independent from the market prices (Haas et al., 2011a).

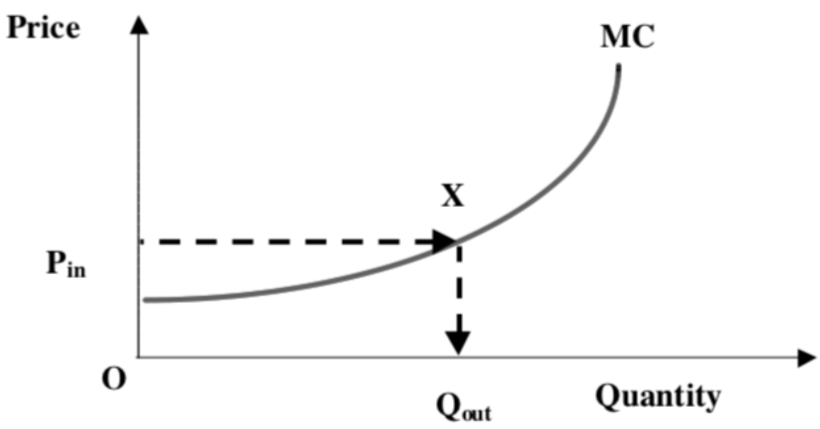

Figure 1: price driven support mechanism

Source: (Menanteau et al., 2003)

Figure 1 shows the Feed-in-tariff scheme, where the quantity produced is determined by the tariff which is guaranteed for a specified period of time.

Renewable energy producers are incentivized to generate energy until the marginal costs (MC) equal the guaranteed feed-in-tariff P_{in}. The electricity output varies between the different projects, as the marginal cost curve is not the same for every renewable technology or generator (Menanteau et al., 2003).

One of the main downsides of price-driven support schemes is the hardship of predicting the total amount of remuneration of RES-E projects, since prices or premiums for RES-E are usually guaranteed without a restriction on total support costs (del Río, 2017). This makes budget control for authorities quite difficult, which is not the case for quantity driven schemes (IRENA & CEM, 2015), which we will look at in the following section 2.2. Further discussion on this benefit is then picked up in section 3.3 where advantages and disadvantages of the methods are outlined.

2.2 Quantity driven

In terms of financial predictability quantity driven approaches can be a more assessable support choice. In comparison to its price driven opposite, the focus of quantity driven policies lays on a preferred quantity of generated electricity. Thereby the amount of generated electricity is set by the regulators, to stimulate or encourage market penetration. The final price within this support system is not determined by individual generators, but through the competition process from energy producers (Haas et al., 2011b). This competition amongst energy generators is created by the regulating authority, which organizes a bidding procedure that is specified by a restricted market for electricity of renewable energy due to the appointed quantity (Menanteau et al., 2003). Typical examples for quantity-driven instruments are public tendering schemes as auctions (Haas et al., 2011a). In chapter 3 the process of auctions will be described in more detail.

To first master the mechanism behind this policy method, you can see in Figure 2 , that the price is determined by the quantity. The quantity (Q_{in}) of the demanded renewable energy electricity is predefined by the regulator, and the output price (P_{out}) depends on the offers of the participating parties as well as on the selection criteria of the regulators. The final subsidy assigned to each generator depends on the design of the tender scheme. But in most cases, it equals the difference between the bid price and the wholesale market price (Menanteau et al., 2003). Both selection criteria and auction design, will be elaborated on in chapter 3.

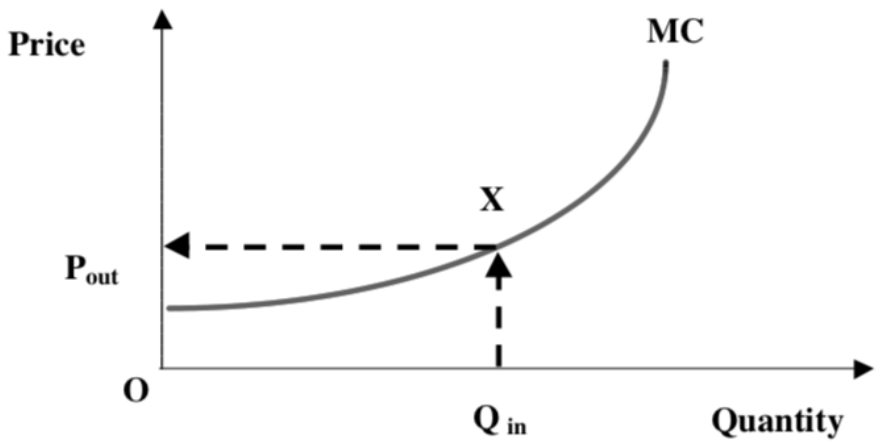

Figure 2: Quantity driven support mechanism

Source: (Menanteau et al., 2003)

The idea of this system, in comparison to price driven mechanisms, is to expose the marginal production costs (MC) during the tender process, as generators offer low bids to get awarded. These bids should ideally correspond to the marginal costs, to be profitable. Unfortunately, the exact trend of the marginal cost curve is often unknown, whereby the overall costs to reach the aim get frequently underrated (Kitzing et al., 2016).

In general, uncertainty about marginal costs plays an important role in the choice of price or quantity driven instruments as inaccurate price or quota signals can affect the outcome. Quantity driven schemes often have a relatively flat marginal cost curve in comparison to price schemes and therefore are to favour (Kitzing et al., 2016).

Summarizing price as well as quantity driven RES support mechanisms share some benefits, as both ensure a reliable long-term income for RE generators and clarity of support levels for regulators. Regarding the certainty of support levels, auctions give the regulator not only certainty about prices but also about quantity, which makes them even more predictable (del Ŕio, 2017).

To get a deeper understanding of the benefits and drawbacks of quantity driven schemes, the following chapter 3 outlines the procedure, design options as well as giving an overview of advantages and disadvantages related to auctions.

3 Tendering systems for the promotion of RE sources

To get a deeper understanding of quantitative driven policies, the following sections outline the procedure as well as auction design possibilities. In part 3.1, the mechanism of bidding schemas to further RE sources within the energy mix of a country will be explained. Followed by part 3.2, which describes different characteristics of bidding schemes and their effect on the resulting RE provision. As the previous section 2.2 touched on, characteristics and design elements have different effects on effectiveness and efficiency of the RES-E tenders and therefore result in advantages and disadvantages (del Ŕio, 2017). Finally in part 3.3 these benefits and drawbacks of quantity driven policy instruments like tender schemes are summarized. This chapter is going to build the core for the following evaluations and analyses in chapter 4, 5 and 6.

3.1 Mechanism

Like introduced, this part will emphasize on the process of renewable energy tenders to explain the functions of the auction mechanism. Figure 3 shows the main features of an auction scheme. In general, the government calls for tenders referring to the installation of a certain capacity of electricity generated by renewable energy sources under predetermined conditions. To successfully participate in the auction process, project developers must fulfil specific requirements defined by the government. Possible criteria are the used technology, proof of financial security, environmental license, local production approaches, etc. (more details on design elements are described in the section 3.2). Energy companies then enter the auction by submitting a bit with a per unit price of electricity, which they should ideally be able to implement the project with. After a submitting deadline, the government assesses the offers under consideration of the specific requirements and signs a "Power Purchasing Agreement" (PPA). With this contract the winning bidders are provided with a fixed price over a specified period as well as a guarantee for the purchase of generated electricity (Atalay et al., 2017; Lucas et al., 2013).

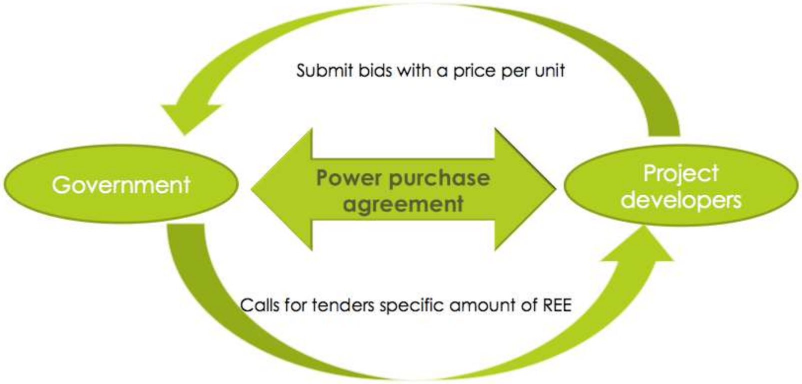

Figure 3: Auction scheme mechanism

Source: Own illustration, based on (Lucas et al., 2013; Atalay et al., 2017; IRENA, 2018b)

According to Maurer & Barroso (2011) there are certain elements that are necessary for an auction to be successful:

- **Ensuring competition**
  Competition must be ensured through a regulatory environment that attracts competition and opposes collusive behaviour, to obtain real price discovery.

- **Solid institutions and independent regulators**
  In order to facilitate and implement successful auctions, it is important to have reliable institutions bidders can trust in. Therefore, a country should also have a trustworthy rule of law and judicial system.

- **Framework for tariffs**
  A legal or policy framework should ensure cost-reflective tariffs, to attract efficient and sufficient investments of buyers.

- **Creditworthiness**
  Buyers should be creditworthy, or the government should have guarantees in place for insolvency.

- **Good design**
  The auction must be well designed, so bidders are aware of the conditions and offer distinct propositions.

- **Clear rules of bidding process**
  Explicit rules for the auction and bidding process should be specified and made transparent. So, auctioneer and bidders are on the same page regarding timelines, revealed information, the code of conduct, selection process and penalties for violating rules.

- **Publication of auction**
  The auction should be published through several channels to attract sufficient interest from participants including target bidding groups.

If regulators do not consider these elements, it is very likely that auctions are not leading to the aimed effect and turn out to be trivial or ineffective (Maurer & Barroso, 2011), going to be described in section 3.3.2.

Depending on the country and the bidding process, auctions can vary referring to the technology focus, the auction format, pricing rules, pre-qualifications criteria and other design elements (Mora et al., 2017). These are now discussed in section 3.2 and illustrated with example in chapter 4 and 5.

3.2 Auction Designs

Design elements are aspects of the auction that the regulator can design by choice when introducing a tender. The success of bidding systems, like for almost every policy instrument, depends on the ability of its design elements to understand and tackle shortcomings of the market. To accomplish a sustainable and fitting promotion of renewable energy electricity production, auction schemes must be designed to capture specific market conditions (Mora et al., 2017).

Besides capturing market condition, auction design elements can also affect the size of the impact, whereby current literature is evaluating the trade-off between efficiency and effectiveness from different designing elements (Matthäus, 2020).

The following subsections are going to look at specific design options, influencing the effectiveness.

3.2.1 Organisational pattern

There are different formats of auction procedures regarding the awarding structure and pricing rules. Figure 4 shows the different organisational pattern options, whereby the most common types are sealed-bid and descending clock auctions (Lucas et al., 2013).

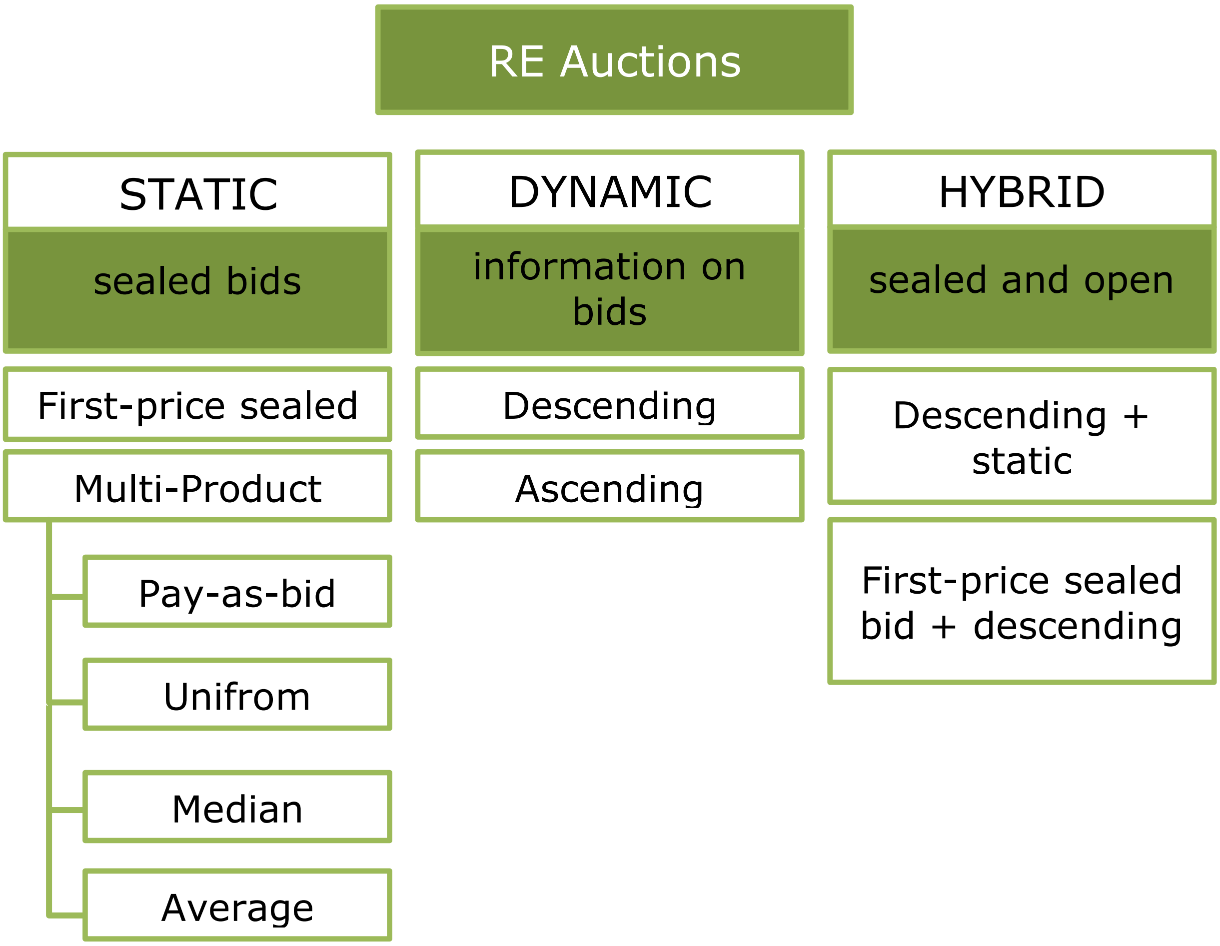

Figure 4: RE auctions organisational pattern options

Source: Own illustration (Lucas, et al. 2013; Atalay, et al., 2017; Mora, et al., 2017; del Ŕio & Linares, 2014; Matthäus, 2020)

Static Auction design

The **sealed-bid auction** is a static form, where the bidders submit their bids simultaneously and therefore do not know the prices offered by their competitors. Offers that meet the determined requirements are ranked and get awarded until the auctioned volume is met. Within this auction design there is also differentiation between the units of the allocated products, whereas a **first-price sealed bid**

auction is allocating the volume of one product to one project developer and a **pay-as-bid auction** is allocating multiple units of the same product with different prices to several project developers (Lucas et al., 2013; Atalay et al., 2017; Mora et al., 2017). Particularly in the praxis most countries use pay-as-bid auctions, as the structure allows to spread the risk of not producing enough energy to meet the demand, if single projects get delayed or are not able to deliver the submitted tender (Lucas et al., 2013).

The prices awarded often vary in the different designs. Some countries choose **uniform pricing**, where all winning projects receive a clearing price, based on the last bid accepted to fulfil the quota (del Río & Linares, 2014; Matthäus, 2020). Moreover, relevant system operators also call for **median or average price bids**, where the awarding price refers to the median price of all price bids submitted, or successful tenders receive an average weighted price of successful bids (del Río & Linares, 2014). In China there were also auctions held where the closest offer to the average bid price were awarded (Mora et al., 2017).

In Table 3 the different pricing models are summarized to get an overview. Literature is on strife when it comes to effectiveness and impact of the two most popular pricing rules, pay-as-bid and uniform pricing. Matthäus (2020) outlined the different perspectives, whereby some researchers like Anatolitis & Welisch (2017) find on average higher profits for developers by uniform pricing, which leads to more viable projects and therefore an increase in effectiveness. While other researchers like Kreiss et al. (2017) or Mora et al. (2017) argue that higher award prices under a pay-as-bid pricing rule favours realization and therefore effectiveness. Looking at the empirical evidence provided by Matthäus (2020), auctions with a pay-as bid pricing rule have a higher realization rate and seems to be more effective.

Overview Pricing

Table 3: Overview on pricing models

Pricing Model	Description
Pay-as-bid pricing	Discriminatory pricing, where several winning projects receive payments according to their submitted bid.
Uniform pricing	All winning projects receive same price based on e.g. last accepted offer.
Median pricing	The awarding price refers to the median price of all bids submitted.
Average pricing	Winning tenders receive an average weighted price of all successful bids.

Source: own illustration (Lucas et al., 2013; del Ŕio & Linares, 2014 ; Atalay et al., 2017; Kreiss et al., 2017; Mora et al., 2017; Matthäus 2020)

Dynamic auction design

In comparison a **descending clock auction** is a more dynamic approach in which the price is determined throughout multi-round bids in the auction process. Within this system the bidders discover the prices and quantities offered by all participants, throughout the bidding rounds (Maurer & Barroso, 2011). Figure 5 shows the price adaption process in a descending auction. The government starts to auction at a high price to reach an excess supply of produced electricity from renewable energy generators. To meet the aimed supply the auctioneer lowers the price in following rounds and tenders adapt to this price reduction with lower quantities. This process continues until the supply meets demand and the offered quantity matches the quantity that can be produced by the electricity generators. Within this design model there is no ranking of the bids as the auction result is determined by the price and the adjusted quantities (Maurer & Barroso, 2011; Lucas et al., 2013). An **ascending clock auction** is the equivalent, where the price increases throughout the auction and the auctioneer sells the product (Maurer & Barroso, 2011).

A very common tool within dynamic auction designs is the **simultaneous** approach. Here the products that are procured are not identical, e.g. baseload and peak-load contracts, but the bidding starts at the same time. The different price reduction, whereby only prices for products with excess supply are reduced, allows bidders to shift the supply between the products (Maurer & Barroso, 2011).

Descending Auction Dynamic

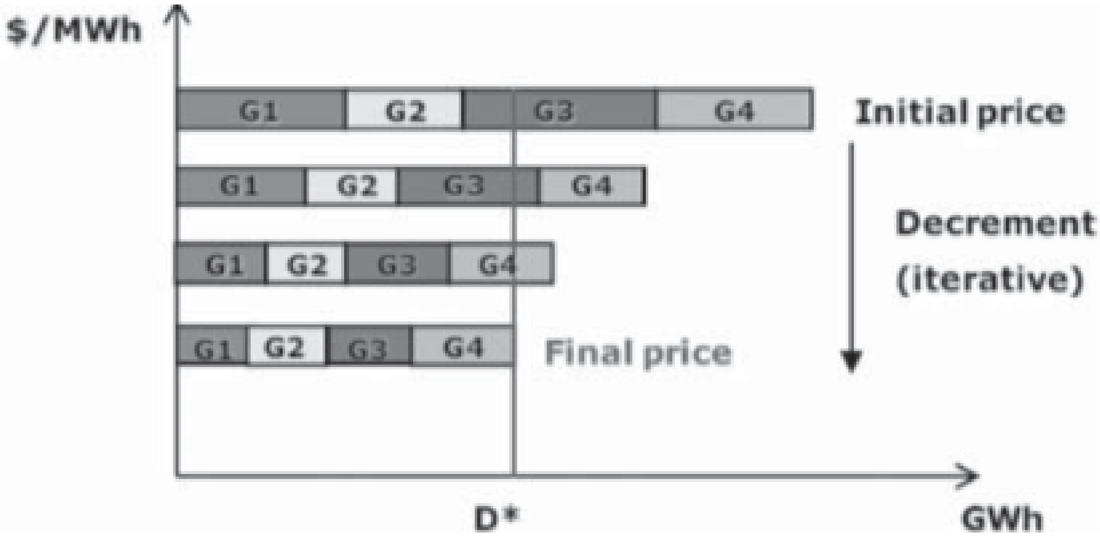

Figure 5: Price adaption process descending auction

Source: (Maurer & Barroso, 2011)

Hybrid auction model

Very occasionally, countries use a **hybrid auction** structure, which combines the benefits of the described static and dynamic auction designs. It can be split in two stages, where the first stage can be a dynamic descending clock auction with multiple offers and the second stage is a static auction where the winners from the first stage make a single offer. With this approach governments try to discover real prices in the first round and try to avoid collusion in the second one (Lucas et al., 2013; Mora et al., 2017). But there is also the possibility of first holding a sealed-bid auction with undisclosed bids and then secondly a multi-round descending clock auction to progressively lower the offered prices (Atalay et al., 2017).

Table 4 gives a well-structured overview of the different key auction designs, including advantages and disadvantages of the options. It is based on a World Bank Study by Maurer & Barroso (2011).

Table 4: Overview of different organizational patterns

Auction Design	**Advantage**	**Disadvantage**
First price sealed bid (single product)	• simplicity • easy to implement • handles weak competition	• no price discovery
Pay-as-bid auction (multiple units of same product)	• simplicity • easy to implement • handles weak competition	• no price discovery
Uniform price auction (multiple units of same product)	• simplicity • easy to implement • handles weak competition • viewed as fair • attracts small bidders	• no price discovery • possibly high political costs
Descending clock auction (single or simultaneous auctions)	• easy to implement • good price discovery • suitable for multiple products • less vulnerable to corruption • viewed as fair • attracts small bidders	• possibility of collusion • higher complexity
Ascending clock auction (single or simultaneous auctions)	• easy to implement • good price discovery • suitable for multiple products • less vulnerable to corruption	• possibility of collusion • higher complexity

	• viewed as fair • attracts small bidders	
Hybrid auctions (mix of descending clock phase followed by a static design phase)	• speeds auction convergence • handles weak competition • good price discovery	With multiple products: • difficult to implement • exposure problem

Source: own illustration (Maurer & Barroso, 2011) and author´s findings

The main advantages of the static approaches are the simplicity of the model and the easy implementation. The big advantage of the dynamic auction model is that the adjustment of the bidders, through more information, improves the efficiency. If policy makers choose this auction design, they should also be aware that a lack of competition can lead to a coordination of bidding (collusion), which increases the final price (Maurer & Barroso, 2011).

Below in Table 5 you can see examples for countries, which implemented different forms of awarding strategies in their auction design. The vast majority of countries is using static pay-as-bid auction formats as mentioned above, whereby especially European countries tend to have uniform pricing. Moreover, there are some countries that try to diversify their auction programmes by offering different awarding strategies like China, France, Uruguay etc. The visible outliers are the Netherlands and Brazil, which are not using the typical energy auction mechanisms. The Netherlands use dynamic auction structures and Brazil the above explained hybrid version.

Table 5: Auction awarding structures by country

Static		Dynamic		Hybrid	
Pay-as-bid	Ireland	**Descending clock auction**	Netherlands	Hybrid	Brazil
	United Kingdom		Spain		
	France		Columbia		
	Denmark		USA		
	Lithuania	**Ascending clock auction**	France		
	Netherlands		Spain		
	India		USA		
	USA		Canada		
	Canada				
	Argentina				
	Peru				
	South Africa				
	Kazakhstan				
	Germany				
	Ethiopia				
	El Salvador				
	Israel				
	Poland				
	Mexico				
	Egypt				
	Uruguay				
	Indonesia				
	Russia				
	Panama				
	Belize				
	Japan				
	Guatemala				
	Brazil				
	Costa Rica				
First price sealed bid	Morocco				
	China				
	Uruguay				
	Iraq				
	Indonesia				
	Zambia				
	Vietnam				
	Peru				
Uniform Pricing	France				
	United Kingdom				
	Spain				
	Lithuania				
	USA				
Average pricing	Uruguay				
	China				

Source: Own illustration (Maurer & Barroso, 2011; IEA, n.d.; RES Legal, 2018)

According to Polzin et al. (2019) variable conceptional options of tenders like the bidding process, the contract duration, the technological alignment or the different pricing should be uniformed throughout the auctions to favour industry learning and therefore increase the effectiveness of the policy. This conceptional options depend on the various characteristics of bidding systems, which will be further described in the next section.

3.2.2 Conceptional options

Regulators have to consider various characteristics concerning their renewable energy auction, which can influence competition, technology, bid range or winner selection (Matthäus, 2020). Therefore, they can choose from a variety of conceptional options like price ceilings, entry barriers, local requirements, penalties and incentive mechanisms, which will be explored in this section.

Ceiling price

If several companies join forces and offer extraordinarily high prices, a maximum price can protect against market-distorting agreements. An introduced price ceiling should maintain the prices below the set limit and gives energy policymakers certainty about expenditures (IRENA & CEM, 2015; USAID, 2019). The auctioneer needs to decide upfront publishing the auction, if the ceiling price should be disclosed. Even though the publication of the ceiling price increases the transparency, policy makers must be aware that filed bids will be close to the limit. In this case the intended goals of low prices as well as price discovery will not be achieved (IRENA & CEM, 2015; IRENA, 2017). Undisclosed ceiling prices on the other hand can disqualify participants offering slightly higher prices than the maximum price and result in not contracting the desired auction volume (IRENA & CEM, 2015). This was the case in Peru, where authorities failed to communicate maximum prices and disqualified submittals for anticipated power requirements (see section 5.2.6).

Project size and duration

Another factor, which greatly affects an auction is the contract duration of PPAs, which influence the profitability of investors depending on the timespan. It is a common practice to reconcile the duration to a renewable energy plants useful lifespan. Thereby regulators can try to reduce the inflation risk. Additionally, the defined project size is an organisational benchmark for bidders to know what minimum or maximum project size is required. This helps bidders to submit suitable projects, that are more likely to be rewarded in the end. An upper limit can also help smaller players to take part, as generation levels can be met easier, which promotes competition and hamper the default rates. Furthermore, the limit can also be a useful tool to spread risks in dealing with grid constraints or diversifying the geographic project distribution (del Ŕio & Linares, 2014; IRENA, 2017). In Guatemala, the flexible duration was a useful tool to react on volatile energy demand, as well as attracting different project sizes, see section 5.1.3.

Technology banding

Another design element that affects the market is the decidedly support of specific technologies. With technology banding regulators try to promote certain RE technologies to diversify energy sources. They can therefore publish an auction that requires one or more determined technologies, they want to further (del Ŕio & Linares, 2014). Chapter 4 will pick on this element and show, what technology banding means for the market maturity and prices on a global scale.

Local content requirement

There is no consistent design of renewable energy auctions, as every country constructs it differently according to their desired policy target. Governments often use auctions to not only follow the original support purpose of promoting renewable energy production, but also to target other development benefits related to it, e.g., economic growth, increasing regional employment or supporting local ownership. It therefore serves as multiple use instrument, which can be conceptualized with a set of characteristics that trigger diverse socio-economic benefits (IRENA, 2019). Listing one design element that affects other policy areas than mainly the renewable energy supply, is the inclusion of local content requirements in a RE auction.

Local content requirements are a design element, which obliges bidders to use domestically manufactured products, equipment and services, depending on the applied rule (Atalay, et al., 2017). The implementation of this kind of qualification criteria can develop local industries, boost domestic job creation or enhance community benefits (IRENA, 2019). Nevertheless, according to Hansen et al. (2020) it is hard to assess the true impact of local content requirements as other legal, economic and technological factors also may be affecting the aimed output. Furthermore, the promised benefits have to be balanced with the exclusion of potential international bidders, who usually have less access to local resources and thus, are either excluded or have to consider additional costs including local suppliers, which results in higher prices (IRENA, 2017). These higher prices may be driven by longer project duration, project risks or coordination effort as foreign generators face language gaps, or are not familiar to domestic supply chain process providing the equipment. To advance the effectiveness of local content requirements it is recommendable for regulators to ensure a stable market (Hansen et al., 2020). Also, penalties can help to assure the achievement of the use of local services or requirements (Atalay, et al., 2017).

Penalties

Penalties are a belated financial punishment, if the electricity generation is not implemented to the advertised deadline. Penalties can be either modulated by the delay or also be a fixed amount like the pre-qualification deposit, whereby penalties are harder to collect than pre-qualification payments e.g., when the bidder goes bankrupt. But they both have the same incentive structure to realize the submitted offer (del Ŕio & Linares, 2014; Matthäus, 2020).

In general, penalties can be set for all defined requirements and are a leading instrument to ensure the accomplishment of the project. It can encourage a detailed analysis forehand to align the priorities of the regulators with the bidders. For example, if there is a penalty on the contracted production amount, the investors will pay more attention to accurate production possibilities. Therefore, aggressive bidding and underbuilding can be avoided (Atalay et al., 2017; Matthäus, 2020). Examples of implementing penalties are illustrated in section 5.1.4, by Russia and Turkey.

Entry barriers

Criteria regarding the participants can also be set in advance, in form of an entry barrier to take part in the bidding process, or as selection criterion for the winning bid (IRENA, 2017). The design trait entry barriers can be clustered into physical and financial pre-qualification. **Physical pre-qualifications** are non-financial criteria that enable a participation and can e.g. be premises regarding the construction like building permits, land property, conduction or feasibility studies etc., which indicate the capability and determination of seriously deliver the offered bid. **Financial pre-qualifications** require upfront payments from the bidder to the auctioneer, to generate a liability of realization, as the deposit is not refunded if the offered outcome is not delivered (Matthäus, 2020; del Río & Linares, 2014).

Additional financial and technical support

Other supporting mechanisms or complementary policy measurements can be additional financial support for auction participants like soft loans, where bidders are granted a loan to fulfil their project. Especially in developing countries international organizations and financial institutions like the World Bank play a significant role in financing costs or providing technical support, to reduce participation risks and increase the competition level (del Río, 2017). This is going to be exemplified in section 5.1.7, by international organizations supporting countries like Ethiopia, Egypt or Nigeria.

With the presentation of the functional process and the possible design elements, the following section 3.3 will summarize the benefits and drawbacks of auction schemes.

3.3 Advantages and disadvantages

Given the choice between the fundamental different approaches, introduced in section 2, there are some trade-offs that need to be considered when choosing a support scheme. A few aims of an auction are for example transparency, low prices or the strengthening of regional energy markets. Whereas underbuilding, underbidding and delays can lead to ineffectiveness (IRENA, 2017). The following section will give an overview of the main advantages and disadvantages of quantity driven auction schemes, clustered by stakeholders.

3.3.1 Advantages

As already mentioned in section 2, the main advantage of quantity driven support systems is the certainty regarding the quantity that is supported (del Ŕio & Linares, 2014). This benefits the regulator, who has direct control over the volume of energy as well as the costs that are subject to support by the auctions. Additionally, penalties for not fulfilling a power purchase agreement, can further help to increase the certainty of supply (IRENA & CEM, 2015). But the volume control is not only crucial for energy security, but also for creating a competitive market, which is not overcompensated as it can occur in price-driven schemes (del Ŕio & Linares, 2014).

Furthermore, tenders can create transparency in a field that is dominated by asymmetrical information, as real costs and prices can be discovered through the bids (del Ŕio & Linares, 2014). The flexible design helps reducing the information gap between project developer and regulator, which helps adapting in such a dynamic market driven by technology cost decreases and a maturing industry (IRENA & CEM, 2015). Due to the price competition among the participants, cost efficiency can be improved as industry costs will become visible. Nevertheless, bidders may also take advantage of a competitive position and add an extra charge on the price which is still competitive but does not represent the real development costs (IRENA, 2017). Anyhow here regulators are taking the role of a public information source, that provides data on the auction and the market. This input can help improve the sector, as asymmetric information is reduced (del Ŕio & Linares, 2014).

The described benefits were mainly concentrated on the regulator and the market, but also renewable energy producers profit from the instrument. The regulated framework of auctions offers, with PPAs, guaranteed revenues over a certain time for renewable energy producers. This reduces the financial risks for the investors and gives them certainty regarding prices independent form changing market conditions or policy landscapes (IRENA & CEM, 2015). Through the specific design elements and rules of an auction, it is a very secure support mechanism as renewable energy producers know the conditions for the defined contract duration (Dobrotkova et al., 2018).

3.3.2 Disadvantages

As every policy mechanism, which facilitates renewable energy development, auction schemes also bare disadvantages and require a competitive market and well-developed RES technology with enough resources to be effective (Kitzing et al., 2016).

As regulator there is an incentive that not only the tender process is successful, but also the implementation of the renewable energy production. Therefore, it is necessary to prevent negative effects of the bidding process to prevent falling short on the aim of producing renewable energy. Researchers like Barroso, Kreiss et al, del Rio and Linares and Matthäus found a variety of reasons that cause ineffectiveness of auctions. Main reasons for not achieving the desired objectives are complex auction processes, negligible participation, aggressive market entry strategies and unreliable bids (Maurer & Barroso, 2011; del Ŕio & Linares, 2014; Kreiss et al., 2017; Matthäus, 2020). Especially unreliable bids and underbidding affect the desired goal of real price discovery, causing significant delays or underbuilding of projects (IRENA, 2017). Underbidding occurs when an auction participant submits very low bids, which do not allow a realization of the project. This lack of realization is also named underbuilding, as the financial resources granted through the auction are not sufficient for the completion (Shrimali et al., 2016; Ocker et al., 2018).

Another argument against auctions from a regulators point of view, is that RE producers are not getting the right market signals as operational efficiency is not addressed through this policy mechanism. For example, producing more RE energy in peak times or maintaining machines in lower demand seasons are not covered in a direct manner within auctions (del Ŕio & Linares, 2014).

If we look at the energy producers, the main complaint about auctions is the high level of bureaucracy. The complexity of the tender procedure and the bureaucratic requirements induce higher transaction costs, which can detain possible bidders from participating. Especially smaller companies, which do not have experience in this field, are hesitant to take part. This could hamper the competition and is also giving a small number of participants a high opportunity for market power (del Ŕio & Linares, 2014). Moreover, long-term power purchase agreements are criticised for the long duration between tenders as well as the high competition level, which does not provide market stability or economic viability (Lewis & Wiser, 2007).

Table 6 summarizes the addressed advantages and disadvantages, clustered by stakeholders. As the table shows, there are more benefits for the regulator, who represents society and especially consumers. Del Rio & Linares (2014) argue that other industrial market players like developers, investors or producers are not necessarily better off with this policy measure and are therefore not in favour of it. Since these groups have a better lobby with a higher bargaining power to prevent the implementation of auction schemes, this could be a reason why it was not that common over the years (del Ŕio & Linares, 2014).

Table 6: Overview on advantages and disadvantages for stakeholders

Stakeholder	**Advantages**	**Disadvantages**
Regulator	• Secure energy supply • Budget control • Real price discovery • Adaption to market development • Active shaping of the power market	• Higher transaction costs • Market power in case of few participants • Low efficiency of RE production and maintenance

RE energy producer	• Price certainty over a fixed time period • Market information • Investment risk reduction	• Low profitability through low prices • Complex and bureaucratic mechanisms

Source: own illustration (Lewis & Wiser, 2007; Maurer & Barroso, 2011; del Río & Linares, 2014; IRENA & CEM, 2015; Kreiss et al., 2017; Matthäus, 2020)

Summarized it can be said that quantity driven support schemes help make the volatile electricity supply from renewable energy resources more predictable and provide a certain budget control through a regulated setting and uncovered market information (IRENA & CEM, 2015). But it can also miss the policy goal, through complex processes and low competition (del Río & Linares, 2014).

Concluding this chapter, it can be seen that policy makers have a vast toolbox on creating an auction, that fits the local market. The difficult task here is to find the right level of design elements. If the requirements are too high or too complicated, one protects oneself against many eventualities, but also reduces the number of participants; if the requirements are too low or too lax, it leads to high competition and low prices, but carries the risk of underbuilding and delays. Regulators have the challenging task of assembling regulatory options in a way that adapts to domestic conditions and optimally stimulates the market. To investigate global trends of renewable energy auctions worldwide, the next chapter 4 is providing a market review to look at the development of the support scheme on a global scale. Chapter 5 will than outline specific country cases contextualizing addressed design elements and global trends on a granular level.

4 Technology trends worldwide

There are different types of auctions, depending on the aims of the support mechanism as well as on the design elements of the tender. The most common differentiation between auctions is made through a focus on a certain type of technology (technology-specific) or a particular generation area (site-specific) from renewable energy sources (Atalay et al., 2017). The previous chapter 3 already outlined technology banding as an auction element, concentrating on supporting specific renewable energy systems (del Ŕıo & Linares, 2014). Now the focus will be on the praxis, analysing global trends regarding to technology.

4.1 Supported technologies

On a global scale, most countries have implemented technology specific auctions, as they can provide room for the parallel development of various technologies (Mora et al., 2017). Haas et al. (2004), go even further and argue that technology specific designs are crucial for the success of the policy, as market realities and technological life cycles are addressed. Nevertheless, some countries are also opening the tender for multiple sources in one tender, to foster competition among different renewable resource technologies (Mora et al., 2017). Following scholar Matthäus (2020), in auctions open to all sources mature technologies can outperform others and receive most of the auctioned volume. This was one of the reasons why in Italy from auctioned 500 MW only 5 MW were awarded to solar power (Bellini, 2020b), see also section 5.2.2.

Having a look on various policy databases (IEA, n.d.; RES Legal, 2018) and published papers (del Ŕıo, 2017; Kruger et al., 2018), Table 7 gives an overview on countries worldwide, that employed auctions, which are specific to various RE sources. The last column additionally shows countries having experience in holding auctions for more than one specific RE source and technology in one tender. Overall, the table shows, that solar technologies are supported most frequently by auctions, whereas there is yet no prominent focus set on geothermal technologies.

Table 7: Technology specific support in different countries

SOLAR	WIND	GEOTHERMAL	BIOMASS	HYDRO	MULTIPLE RE SOURCES
Albania	Albania	El Salvador	Argentina	Brazil	Argentina
Argentina	Argentina	Indonesia	Brazil	El Salvador	Belize
Belize	Belize	Japan	El Salvador	Finland	Brazil
Denmark	Brazil	Poland	Finland	France	Costa Rica
Egypt	Denmark	Turkey	France	Guatemala	Egypt
El Salvador	Egypt		Germany	Japan	El Salvador
Finland	El Salvador		Guatemala	Lithuania	Estonia
France	Finland		Japan	Panama	France
Germany	France		Lithuania	Peru	Germany
Greece	Germany		Moldova	Poland	Guatemala
Guatemala	Greece		Panama	South Africa	Honduras
India	Guatemala		Poland	United Kingdom	India
Indonesia	India		South Africa	Uruguay	Italy
Iraq	Japan		Spain		Lithuania
Israel	Kazakhstan		United Kingdom		Mexico
Italy	Lithuania				Netherlands
Japan	Malta				Panama
Kazakhstan	Morocco				Peru
Lithuania	Netherlands				Poland
Luxembourg	Panama				Russia
Malta	Peru				Slovenia
Morocco	Poland				South Africa
Nigeria	South Africa				Spain
Panama	Spain				Turkey
Peru	Turkey				United Kingdom
Poland	Uruguay				Uruguay
South Africa					
Turkey					
Uruguay					
Zambia					

Source: Own illustration referring to (IEA, n.d.; RES Legal, 2018; del Ŕıo, 2017; Kruger et al., 2018)

Interestingly, there is only a small number of countries worldwide that offer technology neutral renewable energy auctions (see Table 8), and are therefore open to all renewable, and sometimes even non-renewable, energy producers. The most interesting finding thereby is, that all of these countries are located in Europe.

Table 8: Countries with technology neutral bidding regimes

technology neutral
Estonia
Finland
Lithuania
Moldova
Poland
Slovenia
Greece
Malta

Source: Own illustration referring to (IEA, n.d.; RES Legal, 2018; del Ŕıo, 2017; Kruger et al., 2018)

Kitzing et al. (2016) relate the rare practice to the different market as well as natural conditions of RES technologies within a country. They argue that supply costs vary substantially between the technologies, and therefore do not back technology neutral support systems (Kitzing et al., 2016).

In comparison Mora et al. (2017) also highlight the attractiveness of the technology-neutral auctions for a higher number of participating bidders, which increases the competition not only within one technology but across all RES-E production. But they also state, that the related disadvantage to this kind of auction method is, that only the most competitive or even mature technology will win the bid. Taking this argumentation one step further, could also give less mature technologies the incentive to advance and ultimately compete with others.

Nevertheless, this method is seen to be a future outlook in supporting mechanisms, since Lithuania reached a zero bid (EUR 0/MWh) due to this approach and is already planning on another similar auction (see also section 5.1.2).

To further derive geographical trends, Table 7 is categorized by continents, seen in Figure 6. It illustrates the most popular technologies supported are solar and wind energy. Wind is very popular in Europe, whereas Asian and African countries have a clear focus on solar energy. Additionally, especially European countries put an emphasis on the support of Biomass. According to IRENA (2017) the interest on contracting bioelectricity capacity stems from its potential to contribute to base-load electricity generation, rural economic development and waste management. Moreover, it is also interesting that in comparison to other regions, countries in Asia are also focusing on supporting geothermal technology systems with renewable energy auctions, which could be a result of the natural resources (e.g., volcanic landscape in Japan and Indonesia). In terms of diversity and promoting different kinds of renewable energy technologies America is a front runner as a diverse set of technologies is supported simultaneously (IEA, n.d.; RES Legal, 2018; del Ŕio, 2017; Kruger et al., 2018).

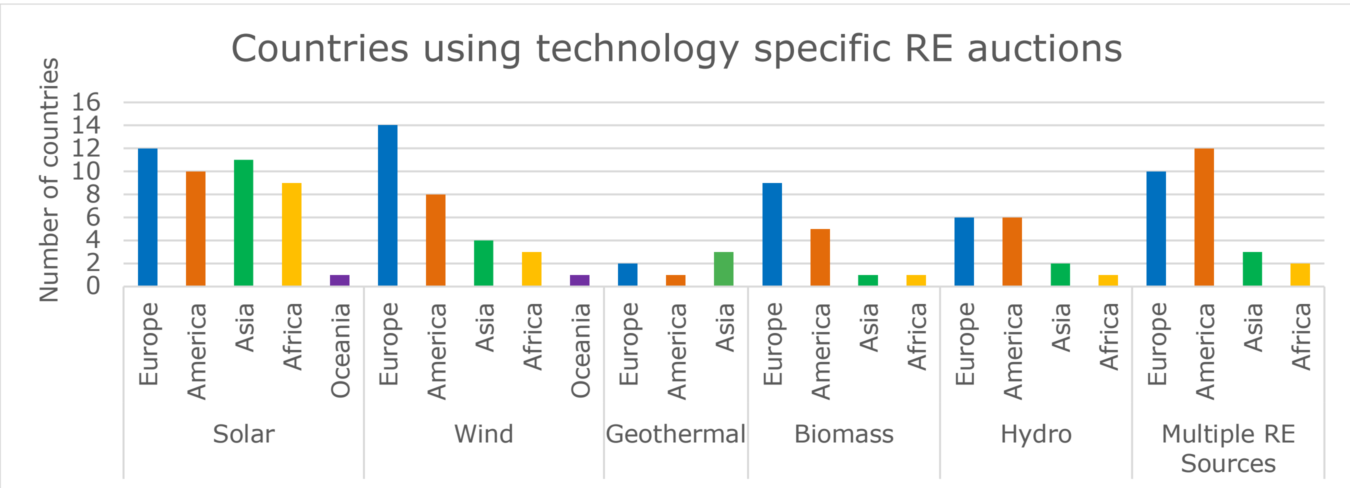

Figure 6: Countries using technology specific renewable energy auctions

Source: Own illustration referring to (IEA, n.d.; RES Legal, 2018; del Ŕio, 2017; Kruger et al., 2018)

IRENA (2019) looks in Figure 7 at the global volume of 110,6 GW auctioned between January 2017 and December 2018 and finds similar technology preferences within these years. There is a clear global focus on the support of solar PV (57,4 GW) and wind energy (49,6 GW), whereby solar PV and onshore wind are promoted throughout all regions. The support of Biomass technologies is only common in Europe and America, which can be linked to the complexity of the underlying technology route and the used feedstock (IRENA, 2017). Interesting to see is that the RE support by competitive auctions for electricity generation through water seems only to be attractive to America, since no other region auctioned small hydro technologies.

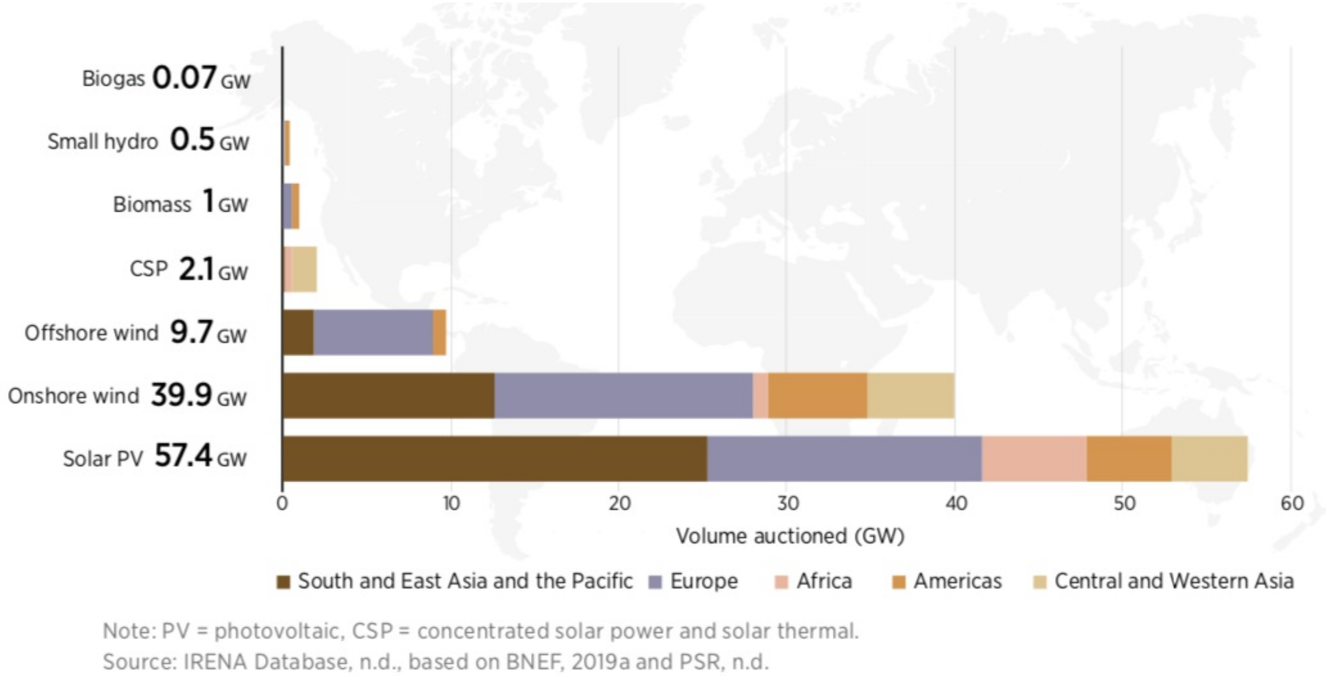

Figure 7: Global volume auctioned by technology (2017-2018)

Source: (IRENA, 2019)

Summarized it can be said, that solar and wind technologies are the most popular, supporting targets of renewable energy auctions. In the next section 4.2 we are looking at price developments with a special focus on these two technologies.

4.2 Technology driven price development

Chapter 3 stated, that the competitive environment created through renewable energy auction, can reduce prices. This is possible through a transparent process discovering real costs. Thereby prices can be reduced according to the bidding process. In only eight years (from 2010-2018) the auctions global average prices for solar PV decreased by 77 %. A similar trend is seen for onshore wind auctions, where the global average prices decreased by 36 %. The difference in the price reduction of solar PV and onshore wind can be explained due to the maturity of the technology, since onshore wind technologies were already advanced in the chosen index year 2010 (IRENA, 2019).

If we take a closer look at it, by breaking it down to technology and country, we see in Figure 8, that the price reduction for solar PV is steeper in those countries where auctions were held quite early. With photovoltaic systems maturing, more and more countries adopted energy auctions for Solar PV. The average auction prices in Mexico, Germany, Chile, Brazil or the United Arab Emirates (Dubai) decreased on a smaller base, since photovoltaic systems were already advanced at the time of adoption and therefore only experienced a smaller decrease in prices in comparison to Peru, India, South Africa and France, which already held auctions quite early (IRENA, 2017).

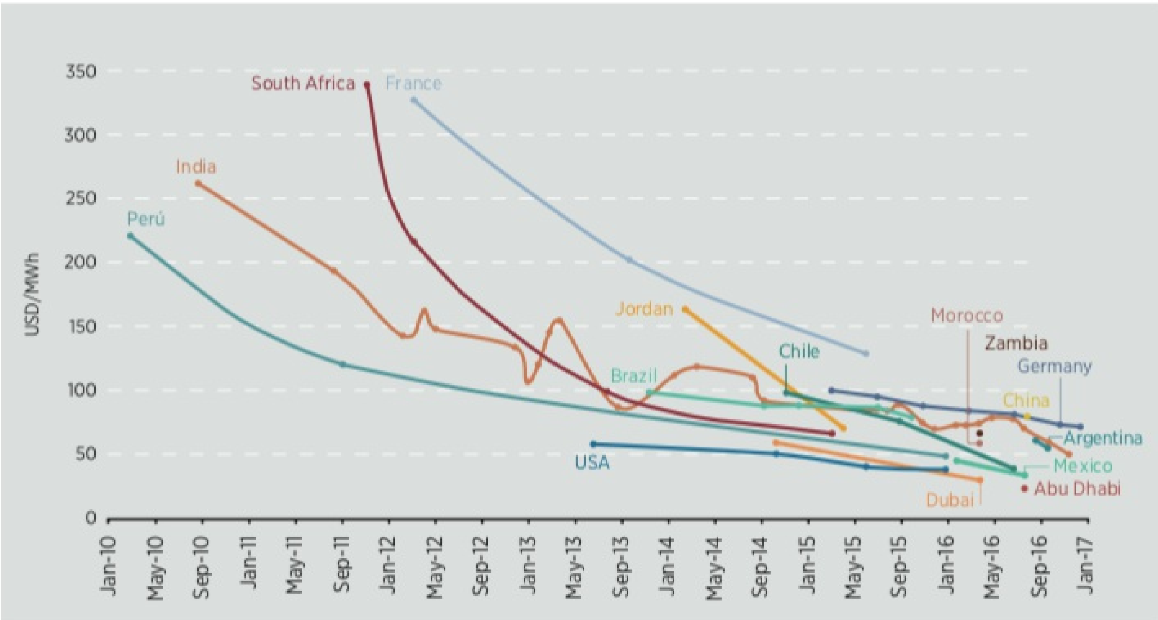

Figure 8: Solar PV evolution of average auction prices (2010-2017)

Source: (IRENA, 2017)

Looking at auctions for onshore wind (Figure 9), we see a similar trend, but with flatter price curves. Morocco and Peru for example already held auctions in 2010/11, whereby the average auction prices declined steady over time.

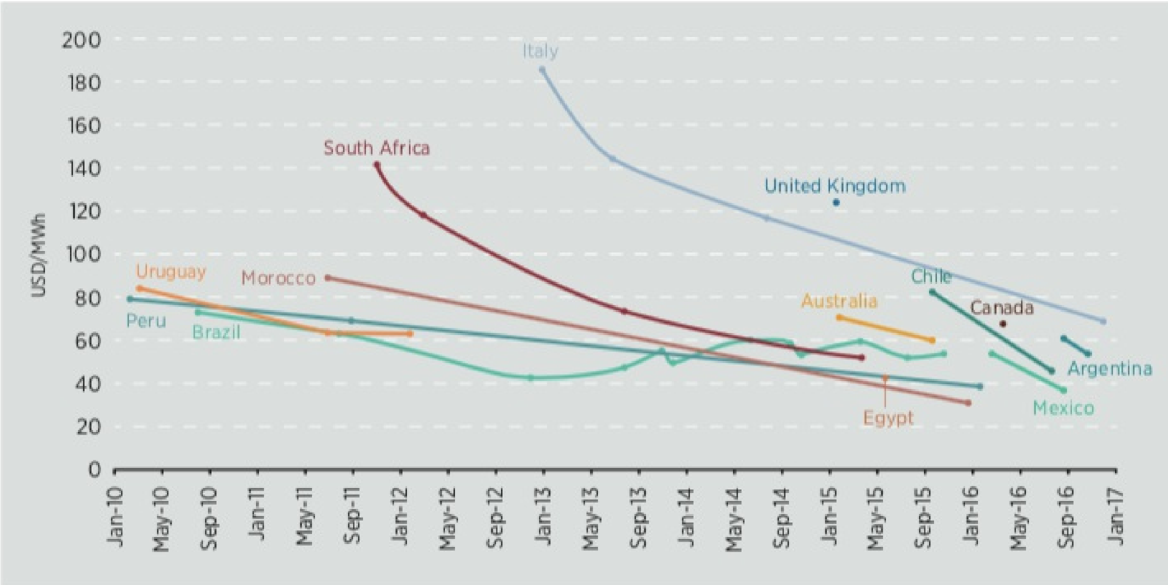

Figure 9: Onshore wind evolution of average auction prices (2010-2017)

Source: (IRENA, 2017)

Figure 10 shows that over the time two positive effects regarding global energy auctions for solar PV and onshore wind become visible. On one hand we see the above-described price decline of global weighted average prices resulting from auctions. On the other hand, we see that regarding to more countries adopting, renewable energy auctions awarded capacity increased worldwide. This effect can be explained by low costs and technology maturity. Apart from the price reduction due to tenders, the technological advancement progress of renewable technologies for electricity production is developing. By putting more research effort into it, new materials and methods are used, whereby technologies become more efficient decreasing prices (IRENA, 2019).

Some countries even try to foster the technological development in this sector by introducing auction requirements targeting the recency of the technology. In Moldova for example, the technology used for electricity generation is not allowed to be older than 48 months by the day of activation (Blajin, 2019).

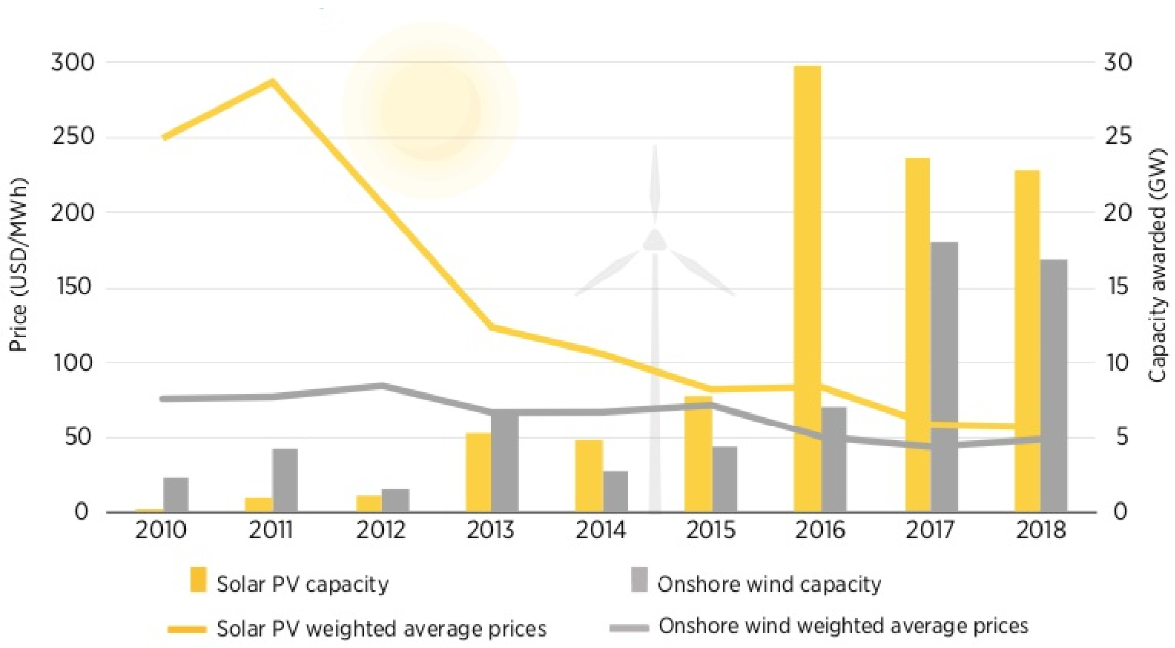

Figure 10: Global weighted average prices resulting from auctions & capacity awarded each year (2010-2018)

Source: (IRENA, 2019)

Furthermore, the analyses on price reduction must be contextualized, since varying auction designs as well as country specific factors (e.g. labour costs) also have an impact on the price development (IRENA, 2019).

Considering the overall political aim of making renewable energy production more attractive than the conventional one, the low prices are a positive sign for the electricity sector. In several countries (e.g. Brazil, Chile, Ethiopia, India) record breaking prices for energy production by solar PV and onshore wind, can compete with conventional energy technologies and are sometimes even more cost-effective (IRENA, 2017). The increase of competitiveness from renewable energies can also be seen in Danish tenders. "We have contracted far more renewable energy for far less money than expected," said Minister of Climate and Energy Dan Jørgensen. As a result the Danish government said, that this indicates that an increasing amount of renewable energy projects can be realised with zero / decreasing subsidies (Bellini, 2019a).

To further research these trends, the next step is to examine auctions on a granular level. This is done by connecting the described global trends from this chapter 4 with the design possibilities including the advantages and disadvantages from the previous chapter 3.

5 Country specific analysis

This part will focus on the illustration of implemented renewable energy auctions around the world, picking up on the design elements introduced in chapter 3 and the identified global trends in chapter 4. The over proportional support of solar PV and onshore wind will also be seen in the country specific analysis, as well as the advantages and disadvantages discussed earlier. The examples were chosen because of their suitable characteristics in relation to mentioned auction components. This section is therefore going to shed light on the implications of previous sections, containing specific design elements or practices that result in advantages and disadvantages. Some country specific examples will go even further and demonstrate the effects of insufficient or well-planned auction designs, supporting global trends. To make it more comprehensible, the case studies are clustered in accomplishments and challenges.

5.1 Accomplishments

5.1.1 Low auction prices through international participation (INDIA)

In the previous chapter 4 we discussed the trending price fall, in renewable energy auctions, which can also be related to deregulated design and current market conditions, as seen in the following case study of India.

Over the last few years, India has become the global leader in renewable energy auctions and ranks second in attracting clean energy investments. Applying different support schemes of renewable energy, the Ministry of New and Renewable Energy (MNRE) defined an energy target of 100 GW from Solar PV, 60 GW Wind, 10 GW Biomass and 5 GW Small Hydropower by 2020 (ETEnergyWorld, 2018).

India has the largest market for auctions of renewable energy generation projects worldwide. In 2017 the auctioned capacity has increased by 68 %, which led to a rise of solar energy installations by 90 % (ETEnergyWorld, 2018). Experimenting with different mechanisms and implementation approaches, led to adaptions of auction designs, which are now the key driver for solar energy production (IRENA, 2017). High volume auctions, were reversing the trend from usually undersubscribed tenders to oversubscription that led to high competition, attracting many participants from around the world (Prasad, 2020a).

In November 2020, the Solar Energy Corporation of India (SECI) discovered a new record low of Rs 2/unit for 1,070 MW of solar projects (Chatterjee, 2020), which is 15,3 % lower than the previous low of Rs 2.36/unit, which was reached in June earlier that year. Little regulation helped reducing project costs and attracted foreign project developers (Gupta, 2020). There were almost no restrictions on the bids, so developers did not face local production requirements and were able to import equipment and modules from anywhere in the world (Hill, 2020).

These low country specific requirements are also seen in the participation of foreign developers. The winning competitors were mainly international bidders from Saudi-Arabia and Singapore, whereby also in the previous auction international participants dominated the field (Prasad, 2020a). The following Table 9 exemplifies the auction result of the bidding in June 2020, where bidders originate from seven different countries and won the auction with bids around 0.0313 $/kWh. The Indian generator (ReNew Power) offered 1,200 MW, but was only awarded with one third of its capacity (Prasad, 2020a).

Table 9: Auction results India June 2020

SECI 2 GW ISTS Tranche IX Solar Tender: Auction Results

MERCOM INDIA RESEARCH

Bidder/Developer	Country	Capacity	Quoted Bids/Tariff		% Over Winning Bid
		MW	(₹/kWh)	($/kWh)	
Solarpack	Spain	300	2.36	0.0313	-
Avikiran Surya (ENEL Green Power)	Italy	300	2.37	0.0314	0.42%
Amp Energy Green	Canada	100	2.37	0.0314	0.42%
Eden Renewables	France	300	2.37	0.0314	0.42%
ib vogt Singapore	Germany	300	2.37	0.0314	0.42%
Ayana Renewable (CDC Group)	UK	300	2.38	0.0316	0.85%
ReNew Power	India	400 (1,200)*	2.38	0.0316	0.85%

*ReNew Power bid for 1,200 MW but won only 400 MW — Note: $1 = ₹75.37

Source: Mercom India Research

Source: (Prasad, 2020a)

However, several circumstances may explain the low bids in these auctions: Firstly, SECI already assured buyers, whereas in other auctions, it took several months for the power sale agreements to be signed (Prasad, 2020b). Furthermore, the pandemic also facilitated the process as branches worldwide are profiting from low interest rates and falling module prices (Prasad, 2020b). Lastly, due to good conditions on capital markets and the related access to low-cost financing (Evans, 2019) those aggressive bids were possible to submit.

Learning:

Guaranteed buys of high electricity volumes can attract international competition, whereby little regulation and beneficial capital market conditions as well as low interest rates help reducing prices.

5.1.2 Win of subsidy-free bid (LITHUANIA)

As described in section 4.1 there are different perspectives on the effects of technology-neutral tenders. Due to recent developments in Lithuania, expectations on a technology-neutral auction design are high, since it led to a unique tender where a developer won with a zero subsidy bid. The auction was held technology-free, whereby UAB Windfarm Akmene One won for an annual power output of 300 gigawatt hours. "To our knowledge, this is the first case in Europe in an onshore renewable energy auction for a developer to win with a zero bid. […] At the same time, however, it is important to note that this trend will not necessarily persist in subsequent auctions.", said Aistis Radavicius, chief executive at the Lithuanian wind power association (Radowitz, 2020a).

Radavicius added that the limited grid capacity was a main reason for the zero-bid, since companies are competing for grid access rather than short-term profits. Three companies took part in the tender with zero bids. At the end the offered capacity was decisive for winning the bid, therefore UAB won, as they offered the highest annual production of electricity (Petrova, 2020).

Meanwhile there are several examples for subsidy-free onshore wind projects, e.g., in Finland (Radowitz, 2020b), UK (BBC, 2020), Poland (Franke & Easton, 2019) or Germany (Tranninger,2021; Jacobsen, 2021).

The increase of subsidy-free bids clearly shows the competitiveness of renewable energies. Nevertheless, as shown in the examples above, all subsidy-free bids are onshore wind parks. The Lithuanian tender was technology neutral, but there is no proof, that this is the reason for the first zero bid in a renewable auction. As Santana (2016) points out in his research on the paradox of technology-neutral policies, it could happen that a technology-neutral approach locks out emerging technologies and avoid a long-term LCC reduction. Therefore, a mix of technology-neutral and technology-specific policies is suggested in the paper (de Mello Santana, 2016).

Learning:
Renewable energy auctions are discovering subsidy-free bids. Especially trending onshore wind, is proofing with zero subsidy bids in technology-specific as well as technology neutral RE auctions its competitiveness with conventional energy sources. Crucial for this phenomenon is the limited grid access, which producers are fighting for.

5.1.3 Flexible PPA-contract duration (GUATEMALA)

Attracting different market players to diversify the energy mix, can be targeted through renewable energy auctions, since quantity driven mechanisms are adaptable to energy demand. To get a recap see section 2.2 and chapter 3, especially section 3.2.2 elaborating on contract duration.

In Guatemala all energy supply must be procured through energy auctions, whereby the regulator is trying to diversify the technology neutral energy auctions towards more renewables. On one hand they implemented minimum quotas for specific renewable technologies, on the other hand they are providing different short-, medium- or long-term contract duration options. Depending on capacity different PPAs are offered, whereby a minimum quota for certain renewable energy technologies is required. Long term auctions offer 15-year PPAs, whereby short-term auctions result in 1–5-year contracts. And in some cases, defined distributed generators (<5 MW) can be awarded with 10-year contracts (IAE & IRENA, 2017). The flexibility of different contract duration from PPA can achieve a precise governance that can adapt to energy demand and attracts small, mid-sized as well as large scale projects. With this method a variety of power producers can be supported (Worldbank, 2021).

In general, PPAs are a sufficient tool of auctions to provide certainty to energy producers and regulators, as it guarantees a regulated framework with defined revenues over a fixed time as described in chapter 3. In this special case it might be argued that a short contract duration may not give certainty to utilities, whereby it must be considered that auctions are compulsory in Guatemala and therefore certainty is given even through short-term contracts.

Learning:
In an environment dominated by energy procurement through auction schemes, flexibility in contract durations can be a useful tool to react on volatile energy demand, as well as attracting different project sizes.

5.1.4 Penalties (RUSSIA)

Section 3.2 describes different design elements, that effect the participation in energy auctions and help regulators influence the actual renewable energy production. To understand the mechanism of penalties within the special capacity auction system in the Russian Federation, this case study will be discussed in more detail.

In Russia a capacity market for renewable electricity was implemented. The main difference is that payments are based on the available capacity (MV) and not on the energy output (MWh). The prime objective of a capacity market is a long-term security of supply. It should create a clear signal for long-term investments, reduce monetary risks for investors and simultaneously ensure that the electricity supply meets the demand, especially for more volatile and unpredictable renewable energy sources (ENGIE, n.d.).

There were several reforms to increase the share of renewable energy sources in Russia: In 2009 the Russian Energy Strategy was adopted, it set a target of 4,5 % of renewable energy sources by 2020 (excluding large hydropower plants of more than 25MW). Capacity payments are implemented for 15 years, on annual basis the capacity remuneration contracts are auctioned. Therefore, only wind, solar PV and small hydropower plants are eligible to participate at the auctions. The threshold for hydropower plants is 25 MW, plants with higher capacity cannot take part. To be eligible at the auctions the bidder must proof a high local content (localisation), e.g., for small hydro power plants over 5 MW the minimum local content requirement is 20 % in 2014 and increases to 65 % for 2018-2020. Contracts are awarded based on the lowest capital costs; the prices are usually several times higher than the price for conventional capacity.

To control the yearly increase of renewable generation capacities, an annual limit was established by the Russian government, shown in Table 10 and expressed in MW (IEA, 2015a).

Table 10: Annual limit of RE generation capacity in MW in Russia

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Sum**
Wind	100	250	250	500	750	750	1.000	3.600
Solar	120	140	200	250	270	270	270	1.520
Small hydro	18	28	124	124	141	159	159	751
Sum	238	416	574	874	1.161	1.179	1.429	5.871

Source: IEA, 2015a

The governmental decree in 2009 set the target of 4,5 % of renewable energy sources (equals 5,9 GW) by 2020, later this percentage was postponed to 2024. In 2019 the total installed renewable energy source was 52,7 GW, the main part came from large hydropower plants, representing 51,5 GW (Tissot & Bogdanov, 2020).

The auctions can be described as very successful, since in 2019 95 % of the 5,9 GW targeted for 2024 were already assigned, mostly in wind and solar projects. The main participants were Enel, Rosatom and Fortum (together with Rusnano). This shows, that also state-owned and mainly on nuclear power focused companies like Rosatom or Rusnan are shifting their focus on renewable energies. Rosatom stated the total investments in wind projects may exceed 1,3 billion USD (Powertechnology, 2018).

Besides these successes there are nevertheless limitations: Only power plants over 5 MW are eligible, decentralized small energy plants are not taken into account. Also, the regulation doesn't allow the promotion of renewable energy sources in very isolated regions, where renewables would be economically sensible.

Two main types of penalties were implemented in the regulatory frameworks: Firstly, when the selected bidders are not able to meet the agreed availability requirements, their capacity renumeration will be reduced accordingly. This is extremely important, since capacity markets can lead to the risk of "steel-in-the - ground". Meaning this market regulation leads to less efficiency of the plants, since investors are focussing more on the installed capacity ("steel-in-the-ground") rather than on the output. Therefore, penalties are implemented, if plants fail to produce a certain amount of energy per year, which are quantified with a capacity factor. This factor differs for every type of renewable energy source (solar energy 0,14; wind 0,27; hydropower 0,38) (International-Finance-Corporation, 2013). Secondly, for projects without the required percentage of localisation a reduction factor is applied to the agreed tariffs (Powertechnology, 2018).

Other penalties can be contract annulation and confiscation of deposited guarantees, like in Turkey, where project delays exceeding 18 months are facing harsh reactions (Sternkopf, 2019).

<u>Learning:</u>

The pattern of Russia implies, that if auction design elements like capacity entry barriers, local content requirements and penalties are combined and linked on various levels, auctions can be very effective and successful in fostering renewable energy production. Whereby even conventional power producers are shifting to renewable sources.

5.1.5 Multiple local requirements (URUGUAY)

Local content requirements function as precious design element adding domestic value and targeting a broad set of policies, seen in section 3.2.2.

A pioneer playing with this approach, concentrating on the local development of a country, is Uruguay. Already in 2009, Uruguay held a wind power auction, that qualified wind parks between 30-50 MW ought to have a minimum of 20 % local content. One of the multiple requirements of this edict included a control center of the investor based in Uruguay. Furthermore, the maintenance after the first year must be performed by 80 % local employees. Since only one project could be awarded per generator, the regulators pushed its effect on local economy even further, by awarding three different developers with a joint capacity of 150 MW (IEA, 2016).

Learning:
Including local content requirements with a wide range of different conditions, can stimulate the local employment and therefore add economic value. By also restricting the awarding system to only one project per developer can help broaden the effect.

5.1.6 Different weights of criteria (BELIZE & SOUTH AFRICA)

As mentioned in the previous example of Uruguay, as well as in section 3.2.2, governments often use auctions to not only follow the original support purpose of promoting renewable energy production, but also to target diverse socio-economic and environmental benefits (IRENA, 2019).

In its 2013 auction for the right to supply the country's national electricity system with renewable energy until 2028, Belize was one of the first countries that chose an approach which favours bidders with high social and environmental standards. They gave different criteria different weights in the auction process, price still being by far the most important characteristic with 60 out of a hundred achievable points. Aside from "bidder managerial, financial and technical competence" (20 points), this process also allowed the administration to specifically name and rate socio-economic and environmental aspects as important factors in their decision making with another 20 points, equalling 20 % (IEA, 2017). Unfortunately, the auction announcement does not mention any specifics on what is understood by the social and economic aspects used to rate the contenders in the auction (The Belize Public Utilities Commission, 2013). But the Public Procurement Procedures Handbook of Belize captures environmental sustainability as their guiding principles. Procuring entities are obliged to consider maximum energy efficiency, minimum use of pollutants or unnecessary packaging, as well as maximum use of recycled materials (MFED, 2013). With this selection system Belize gives energy generators an incentive to use environmentally friendly materials and foster socio-economic benefits.

Other countries like South Africa followed its example and also introduced a weighting emphasis on socio economic benefits in their renewable energy auctions. There are projects with high employment rates of black workforce, community shareholding or procurement of women owned vendors, to name a few factors that had been considered, were awarded (IRENA, 2019).

Learning:
The weighting of the requirement criteria can promote sustainable social, economic and environmental objectives.

5.1.7 Involvement of international organizations (EGYPT, ETHIOPIA & NIGERIA)

Additional financial and technical support from international organizations is a common practice in developing countries to reduce risks and increase the probability of successful auctions, like pointed out in section 3.2.2.

The European Bank for Reconstruction and Development (EBRD) and World Bank´s International Finance Corporation (IFC) are consulting as well as financially supporting the Egyptian Electricity Transmission Company (EETC) with the transition from FITs to auction. Thereby, advices are given on structure and development of a competitive tender system implementation to increase procurement of large-scale renewable energy projects, like PV (Clover, 2017).

Similarly, Ethiopia, which is plagued by ethnic tensions and thus an insecure investment environment, was able to receive record low bids in an African solar energy tender ($0.02526/kWh) due to international support (Tsagas, 2019a). The IFC is maintaining an initiative there to increase solar energy production. By organizing auctions and providing financing as well as guarantees for project developers, they try to reduce funding risks and empower investors to participate (Bellini, 2019b).

In Nigeria for instance, the African Development Bank (AfDB) and the World Bank are willing to offer partial risk guarantees for auction winners, since the government cannot afford the agreed prices of the PPA. The authorities in Nigeria are even asking the 14 project developers for reduced payments as none of the project was set up. With the risk guarantees of international institutions, they insure investments against termination of government payments, regulatory law changes and currency transferability risks (Tsagas, 2019b).

Learning:

It seems, that there is a higher probability of an auction success when international organisations are involved. With their support cancellations, currency transferability and sustainable financing risks of governments can be reduced as well as investors' confidence pushed.

5.2 Challenges

5.2.1 Low number of participants (KAZAKHSTAN)

In section 3.3.2, we discovered the disadvantages of renewable energy auctions, where a low number of participants was mentioned as obstacle for aimed energy production.

The government of Kazakhstan is very ambitious by shifting its electricity production to alternative green energy sources. The share of renewables in this sector should increase from not below 3 % by 2017 to 50 % by 2050 (Office of the President of the Republic of Kazakhstan, 2013).

This renewable energy target is tried to be supported through tenders, which aimed to secure 1 GW of green power. Over the course 2018, 30 local and foreign companies offered 3,204 MW. Nevertheless, only 858 MW green power supply contracts have been awarded, which is 142 MW less than initially planned. Table 11 below shows that especially in the area of wind energy, the desired capacity could not be reached, whereas hydropower slightly exceeded the benchmark (Morais, 2018). The additional capacity of hydro energy is partially explained by the lowest price of 30 EUR/MWh. A reason for the missing 119.15 MW of wind capacity, can maybe be linked to the high volume of 620 MW requested.

Table 11: Kazakhstan: contracts of renewables in 2018 auctions

Source	contracted capacity in MW	planned capacity in MW	capacity difference in MW	lowest price per MWh	lowest price per MWh
Solar	270	290	-20	18,000 KZT	43 EUR
Wind	500.85	620	-119.15	17,390 KZT	41 EUR
Hydro	82.08	75	7.08	12,800 KZT	30 EUR
Bio	5	15	-10	32,150 KZT	76 EUR
Total	**857.93**	**1000**	**-142.07**		

Source: own illustration (Morais 2018)

Since the minimum required volume of installed capacity could not be reached due to a low number of participants and therefore lacking competition, the Kazakh government only held 13 instead of 20 auctions (Morais, 2018).

Analysing the results of the wind auctions illustrates the issue of not reaching the target, due to a decreasing number of participants throughout the auction rounds. In the first round of the wind auction, the regulator received nine bids totalling 40.7 MW. In the second auction round, the ministry received four application totalling 127 MW. In the third and fourth round, there were only three applications with a total capacity of 20 MW each (Richard, 2018).

In comparison, the solar auction was quite successful as the regulator received 28 applications from 20 companies, with project capacities ranging from 10.2 MW to 100 MW with a total offered capacity of 1.27 GW in the first round (Bellini, 2018).

Learning:

Competition can decrease over auction rounds, when producers are not rewarded and lose bidding incentive, leading to lower capacity offered and therefore not achieving the desired volume of an energy source.

5.2.2 Resource restrictions and grid constraints (JORDAN, JAPAN & ITALY)

Not achieving the desired electricity volume can also be a result of grid constraints or restricted land availability as seen in the following case studies of Jordan, Japan and Italy.

In Jordan, lacking upfront preparation led to delays of winner announcements and suspension of future auctions, as the capability of the power network is not sufficient for the requested volume (Khashman, 2018; Bellini, 2019c).

Similarly, Japan faces grid constraints. But there, the main issue is receiving bids in solar auctions that meet the high procurement volume. This is linked to the limited land availability, as the use of agricultural sites is restricted (Bellini, 2020a).

A comparable restriction on agricultural land led to underrepresentation of solar projects in comparison to wind projects in an Italian renewable energy auction. From auctioned 500 MW, only 5 MW of solar power were awarded. With this kind of restriction, the regulator forces investors to plan their production sites in urban or industrial areas, but make some technologies uncompetitive (Bellini, 2020b). A follow up auction was also highly undersubscribed awarding only 329.9 MW of capacity instead of attended 936.1 MW. Awarding only 35 % of desired capacity is caused by a very limited number of submissions close to the ceiling price, that leads to an uncompetitive system (Bellini, 2020b).

Learning:

The examples of Jordan, Japan and Italy show that reaching a high volume of renewable energy production is difficult when grid and resource restrictions are in place. The regulators are therefore asked to assess grid constraints and resource restrictions upfront planning an auction to avoid undersubscription or cancellation.

5.2.3 Auction manipulation (GREECE)

Instable participation rates resulting in over- and undersubscription are common problems within auction schemes, also seen in the previous described country case study of Kazakhstan (section 5.2.1).

In scenarios with low competition, it is hard to balance high volume and low prices. Regulators react with awarding lower volumes to the same guarantee price, as in previous auctions with higher volumes. This adaptation, due the lack of competition then endogenously determines the auction (AURES, 2020). This natural adaptation method can lead to biased outcomes of auctions, as bidders respond to their benefit.

In the Greek Solar PV pilot auction in 2016, one bidder admitted after the auction that they registered multiple projects without the intention to realize the projects, just so that the threshold level, under which the auction would not have taken place, would be met (Kreiss et al., 2017). This strategic behavior was repeated in December 2018, when the auction was cancelled due to excessive registrations of dummy projects (Anatolitis, 2020). Cancelling auctions conclude in high economic costs, since auction implementation is connected to public expenditures, but the aim of promoting RES is failed (IRENA & CEM 2015).

Endogenous adaption mechanisms cannot secure competition and will harm the market in the long-term by weakening the supply side through additional uncertainties for bidders (as well as the auctioneer). Though lower prices could be seen at first, the mid- and long-term effects outweigh this (possible) positive tendency. Instead of generating incentives for market entry, the mechanisms generate incentives for manipulation (AURES, 2020).

Learning:

This example shows that the reliability of the auction can be hampered through endogenous rationing, which is supposed to create competition, but rather leads to untruthful bids.

5.2.4 Contract execution and delays (PANAMA)

Critics often fault the effectiveness of renewable energy auctions as projects are not completed or delayed (see chapter 3).

A country, which has a long track record of renewable energy tenders and their pitfalls is Panama. Project delays or drawbacks from awarded contracts are quite common obstacles. Table 12 illustrates that all different technologies tend to be delayed, but especially solar auctions are likely to get cancelled. In some technology specific auctions (Solar and Hydro) awarded project developers did not sign the agreed energy contracts which lead to the execution of their bid bonds (Lucas & Gomez, 2017).

Table 12: Effectiveness of RE Auctions in Panama

Technology	Year	Contracted energy (MWh)	Success rate (%)	Number of projects	Average price of contracts (US$/MWh)	Price ceiling (US$ / kWh)	On time (n°)	With delay (n°)	Canceled (n°)
Wind	2011	975,476	100	4 (268.0 MW)	90.58	0.11	1	3	0
	2013	1,181,950	129	4 (340.5 MW)	96.69	0.11	*	-	-
Solar	2014	660,166	102	5 (95.4 MW)	87.25	0.14	1	2	2
Hydro run of river	2012	6,491,853	73	8	114.12	NA	4	4	0
Hydro with dam	2014	6,279,791	82	9	140.93	NA	**	-	-

* Come into operation in 2019.
** Start operations in July 1, 2020.

Source: (Lucas & Gomez, 2017)

Looking at delays, which are the norm throughout all auctions, reasons are multifarious. Low prequalification requirements, regarding financial guarantees or reputation of developers allowed arbitrary participation. On the one hand, adherence to the schedule depends on the project in question. On the other hand, there is also a lack of access to adequate financing, when investors do not meet the standards for granting credits of financial institutions. Under these circumstances it is hard for regulators to proof the seriousness of bids and guarantee a timely execution (Lucas & Gomez, 2017).

In addition, it is also worth mentioning that delays are not only linked to the auction and auctioneer, but also appear due to external effects. Challenges due to bad weather, resistance from local people, or difficulties in obtaining construction permits and other rights, cannot be influenced by the contracting parties, but are also shifting the start-up (Lucas & Gomez, 2017).

Learning:
In all renewable energy auctions of Panama, in which technologies differed, delays were detected. Lacking prequalification criteria of investors enhanced unqualified investors not able to secure sufficient funding causing contract execution and delayed projects.

5.2.5 Underbuilding (BRAZIL)

In section 3.2 and 3.3 we discussed the issue of underbuilding which will be illustrated by the example of Brazil.

In 2017 a decontracting auction was held in Brazil, where the government of Brazil agreed to cancel contracts worth a total of 576MW of wind and solar power capacity. This phenomenon can be described as underbuilding: In 2007 renewable energy auctions were held, the depreciation of the Brazilian currency and increased financing costs led to underbidding. Developers agreed on a price that did not cover the real costs (Patel, 2018).

The winners of the decontracting auction are relived from their contractual agreed obligations to implement the energy capacities or pay high penalties instead. Bidders who were not able or willing to fulfil the contracted capacity participated at the tender. The original penalty for cancelling one MWh of wind power was over 70USD. The winners of the decontracting auction were allowed to cancel one MWh for 22,9 USD. The average price for cancelling one MWh of PV power was 57,84USD, the winners were able to reduce it to 15,6 per one MWh (Molina & Scharen-Guivel & Hyman, 2018).

The decontracting auction resulted in a reimbursement of 34m USD to the national Energy Account in Brazil (Kenning, 2017). There are several theories why the auction failed in Brazil. USAID sees the main problem in Brazil awarding PPAs for too much capacity in a too short time frame (Molina & Scharen-Guivel & Hyman, 2018). Another explanation is the change of Brazil's macroeconomic condition: A significant decrease in industrial activities led to an increase of unemployment, a lower electricity consumption and therefore slowdown of industrial and infrastructural modernization. The bad economic situation and the energy surplus led to a massive non-implementation of the tendered capacity (Couto, 2017).

Another example for underbuilding occurred in the renewable energy auctions in Peru. The Peruvian government implemented another solution for the problem, that many of the awarded projects were not realized: Planned renewable energy auctions were postponed. Big developers such as Enel Green Power Peru or Enersur, which were awarded before, therefore had no chance to win new projects, since none were awarded (NewEnergy, 2017).

According to IRENA (2016) underbuilding can be avoided "if the auctioning mechanism and awarded contract are solid, penalties are credible and enforceable, and the country has a reasonable degree of legal and regulatory stability".

Learning:

If projects are not realized, as in Brazil or Peru, consequences must follow for bidders. Either in cancelling awarded volume or excluding unsuccessful project developers form future RE auctions.

5.2.6 Non-disclosed price caps (PERU)

In section 3.2.2 price ceilings were elaborated, and publications (IRENA & CEM 2015; IRENA 2017) show that releasing caps can have advantages but also drawbacks. The following case study shows a shift of choice in connection to designing auctions over time.

Since 2009 Peru used non-disclosed price caps for their renewable-energy auctions. The amount of electricity required was calculated for each auction based on the expected demand. This includes the national 5 % target and contracted renewable energy types, not including hydropower. Separate auctions were held for each technology type of wind, solar and biomass. The price cap per technology was not specified in the auctions so bids above were immediately excluded (IEA, 2017c). Because too many submitted projects exceeded the ceiling and therefore not meeting the electricity demand, Peru switched its strategy to a more transparent approach. In its most recent auctions Peru transformed the design and disclosed the price ceiling, to qualify more submissions (Viscidi & Yépez, 2019). The Peruvian electricity market, including auction mechanisms, has transformed, and adopted according to experience and gained knowhow (Wolak, 2021).

Learning:
Failure to provide maximum prices will disqualify submittals for anticipated power requirements.

5.2.7 Coherence with national law (INDONESIA)

Preparation of a well planned auction can be key to a successful support (see section 3), which is illustrated in the following example of Indonesia.

In 2013, Indonesia tried to push solar energy Production with a solar auction programme. This programme included two different price benchmarks: a maximum price for the regular solar power purchase of USD 0.25/kWh, as well as a higher price level of USD 0.30/kWh for projects using at least 40 % local content. Furthermore, there was a penalty like design element included, since the solar projects needed to be commissioned within 18 months period after signing the PPA, otherwise there would be an according reduction from the agreed PPA price with an extension by maximum 12 months (IEA, 2015b).

This solar auction programme has been declared unconstitutional in 2015 by the Supreme Court of Indonesia, since the Indonesian Solar Panel Manufacturing Association (APAMSI) has taken legal action against the local content requirement. APAMSI requested to ban foreign bidders, by demanding 100 % locally produced solar panels. The Ministry of Energy and Mineral Resources (MEMR) therefore cancelled all plans for procurement of solar power from IPPs, besides the awarded winner who were allowed to continue their projects (IEA, 2017a).

In 2016 the government launched a new RE auction, now concentrating on geothermal resources. The auction design mainly focuses on viability of funding, technical aspects and the offered price and excluded any local requirements (IEA, 2017b).

Learning:

The case of Indonesia shows, that if auction design elements are not in line with local feasibilities or law, the aimed support of RE technologies is ineffective.

It is therefore recommendable for governments to coordinated with major stakeholder groups, before launching auction programmes, to avoid cancelations.

5.3 Summary of findings

In summary, the challenges and accomplishments presented in chapter 5 show that renewable energy auctions are highly dependent on the components used. Design elements are crucial for influencing adequate participation, whereby market maturity and external economic factors are also important players for success. A sensible conclusion of this review is that auction results are very context dependent. The following chapter will now combine the country findings with advantages and disadvantages shown in chapter 3.

6 Learnings

This chapter will pick up on the case studies in chapter 5. It contextualizes the lessons learned from accomplishments as well as from challenges that were observed in selected countries using renewable energy auctions for promoting electricity production of renewable energy sources. Therefore, design elements likewise advantages and disadvantages, from section 3.3 will be regarded.

Table 6: Overview on advantages and disadvantages for stakeholders

Stakeholder	Advantages	Disadvantages
Regulator	• Secure energy supply • Budget control • Real price discovery • Adaption to market development • Active shaping of the power market	• Higher transaction costs • Market power in case of few participants • Low efficiency of RE production and maintenance
RE energy producer	• Price certainty over a fixed time period • Market information • Investment risk reduction	• Low profitability through low prices • Complex and beaurocratic mechanisms

Source: own illustration (del Ŕio & Linares, 2014; IRENA & CEM, 2015; Lewis & Wiser, 2007)

If we take a second look at the summarized advantages and disadvantages in Table 6: Overview on advantages and disadvantages for stakeholders of section 3.3, one of the main advantages connected to renewable energy auctions is the competitive system, leading to secure energy supply and low-price discovery. In the case study of India (section 5.1.1) low auction prices followed from aggressive international bidding. The foreign project developers were attracted by the high volume of guaranteed buys from the Indian regulation authority. Also, little regulation and beneficial financial market conditions build an optimal environment for record low bids from powerful market players.

Securing high volumes to low prices is a difficult undertaking, as effectiveness of desired capacity production can be compromised. In Kazakhstan (section 5.2.1), decreasing competition, through lost bidding incentives were accompanied by lower capacity offered, not achieving the desired electricity volume. Furthermore, challenges like unreliable bidders, underbuilding, auction manipulation and delays, seen in the selected cases of Greece, Panama and Brazil (section 5.2.3, 5.2.4, 5.2.5), compound sufficient energy production from different technologies. The example of Greece (section 5.2.3) shows that reliability of auctions can be hampered through untruthful bids, trying to reduce prices but not intending to implement the project. In renewable energy auctions of Panama (section 5.2.4), lacking prequalification criteria enhanced unqualified investors, who are not able to secure sufficient funding, causing contract execution and delayed projects. If projects are not realized, as in Brazil or Peru (section 5.2.5), consequences must follow for bidders. Either in cancelling awarded volume or excluding unsuccessful project developers form future RE auctions.

By discussing volume provision and effective energy production, it is also necessary to look at the benefits for RE energy producers. The price certainty over a fixed time period, reduction of investment risk and transparency are listed as advantages, which are not always fulfilled. Awarded prices over a fixed time period through the PPA, are giving certainty to governments. With budget control as well as reacting to volatile energy demand, seen in Guatemala (section 5.1.3), market information and investment risk reduction is not always given, as in Peru, Nigeria or Egypt (section 5.2.6, 5.1.7). If countries have maximum price caps in place, but do not publicly announce them, appropriate submittals of energy producers close to the cap will be excluded, as they are not reaching aimed targets, seen in the case of Peru (section 5.2.6). Here, market information and transparency is not achieved for project developers. Regarding investment risk, examples of Nigeria, Egypt and Ethiopia (section 5.1.7) demonstrate, that there is a higher probability of an auction success, if international organizations are involved. With their support cancellations, currency transferability and sustainable financing risks of governments can be reduced.

With design elements, national authorities can actively shape the market and therefore try to prevent drawbacks as well as adapting the policy measure according to public, socio-economic and environmental needs. Including local content requirements with a wide range of different conditions, can stimulate the local employment and therefore add economic value, exemplified in Uruguay (section 5.1.5). By also restricting the awarding system to only one project per developer the effect can be broadened, as different investors need to fulfil the beneficial premises. With additionally weighting the requirement criteria, sustainable social, economic and environmental objectives can be additionally promoted on a specific base as seen in Belize and South Africa (section 5.1.6). Nevertheless, the showcase of Indonesia (section 5.2.7) illustrated, that if auction design elements are not in line with local feasibilities or law, the aimed support of RE technologies is ineffective. Therefore, it is recommendable for governments to coordinated with major stakeholder groups, before launching auction programmes, to avoid cancelations. The pattern of Russia (section 5.1.4) implies, that if auction design elements like capacity entry barriers, local content requirements and penalties are combined and linked on various levels, auctions can be very effective and successful in fostering renewable energy production. Whereby even conventional power producers are shifting to renewable sources.

The competitiveness of renewables can also be seen in many European countries, as shown in section 4.1. E.g., Lithuania or Denmark (section 4.1, 5.1.2), where renewable energy auctions are discovering subsidy-free bids. Especially energy production form wind technology, is proofing with zero subsidy bids its competitiveness with conventional energy sources. Crucial for these auction results was the limited grid access, which producers were fighting for. Opposing to this Jordan, Japan and Italy (section 5.2.2) show that reaching a high volume of renewable energy production is difficult when grid and resource restrictions are in place. The regulators are therefore asked to assess grid constraints and resource restrictions upfront planning an auction to avoid undersubscription or cancellation.

7 Conclusion

This thesis is set out to give an overview of the global political landscape, using renewable energy auctions as preferred policy instrument promoting renewable electricity production. By setting the stage in introducing the various policy mechanisms, quantitative support systems with its regulatory specifics as well as their advantages and disadvantages were literature reviewed.

This work is providing analysis on worldwide trends regarding supported technologies and price reductions in connection to tenders, by clustering policy information on a global scale. An empirical assessment of international technology trends supported by renewable energy auctions showed that favored technology tendencies vary between continents. Nevertheless, solar and wind technologies are the most popular supporting targets worldwide, with both registering a steep price fall in technology specific auctions held over the years. Furthermore, successful renewable energy awards in technology neutral auctions, as well as subsidy-free bids illustrate the increasing competitiveness of renewable energy, especially wind, in comparison to conventional energy sources.

In specific country case studies, auction components as well as identified global trends were contextualized to get a comprehensive view on the promotion of renewables through quantity driven tender schemes. Thereby accomplishments and challenges of renewable energy auctions were demonstrated on a granular level. Main findings of this thesis include that design elements are crucial for influencing adequate participation, whereby market maturity and external economic factors are also important players for effectiveness. Low regulation and high purchasing guarantees attract powerful foreign bidders, decreasing bidding prices. The effectiveness of auctions can be compromised by missing pre-qualification criteria, which can lead to fraud, lost bidding incentives, project delays and low realization rates. These side effects are causing insufficient energy production. It is therefore recommended to introduce entry barriers like financial securities, as well as exclude unsuccessful project developers from future RE auctions. When designing auctions it is important to also consider securing benefits for the project developers, like transparency and investment security, to not hamper the credibility of this policy instrument. Furthermore the regulators are well advised to assess grid constraints and resource restrictions upfront planning an auction to avoid undersubscription or cancellation.

With renewable energy auctions, a wide range of policy aims can be achieved. The focus can therefore not only be low energy prices, but with specifically designed qualification criteria, positive side effects like local value creation, increasing employment rates and the use of environmentally friendly materials are boosted.

However, learnings from the given examples showcase that auction results are very context dependent and therefore need a sound preparation for balancing trade-offs of auction features as well as considering local infrastructure conditions.

When starting this paper, only little literature existed on this topic. While writing this thesis over several years, work on the topic of renewable energy auctions has multiplied, with researchers examining more sub-aspects of tenders and international research organizations increasingly publishing country studies. This implies the increasing importance of this policy instrument. Nevertheless, much work is still needed to be done on an empirical level. While investigating this topic it became clear, that due to the various designing possibilities often changing by auction round, as well as the different implementation strategies used from governmental authorities, a comprehensive comparison of policies is likely to be insufficient. For future research extensive data availability would be needed, to make significant policy recommendations that fit a diverse set of countries.

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