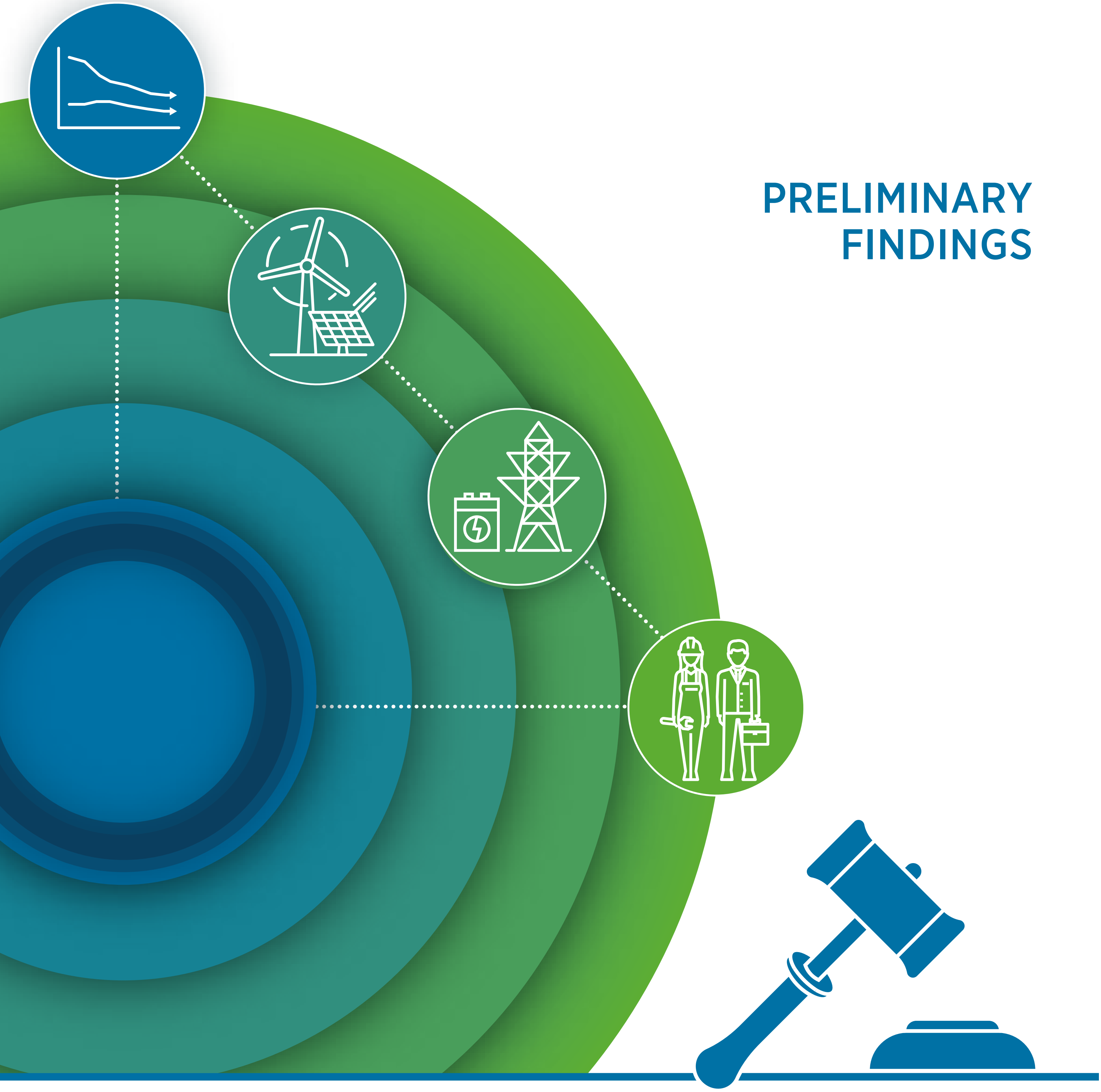
IRENA
International Renewable Energy Agency

PRELIMINARY FINDINGS



RENEWABLE ENERGY AUCTIONS

STATUS AND TRENDS BEYOND PRICE

CONTENTS

1. INTRODUCTION

As the renewable energy sector matures, policies must be adapted to reflect changing market conditions. The falling cost of new technologies, the growing prevalence of variable renewables in the power system, and greater emphasis in policy toward economic, social and environmental objectives alter the conditions for new market entrants and new power generation projects. One important trend has been the increasing use of auctions, as policy makers seek to procure renewables-based electricity at the lowest price while fulfilling other objectives.

The International Renewable Energy Agency (IRENA) produced its first study on auctions in 2012. *Renewable Energy Auctions in Developing Countries* highlighted key lessons from countries that had implemented auctions, namely Brazil, China, Morocco, Peru and South Africa (IRENA, 2013). *Renewable Energy Auctions: A Guide to Design,* published in 2015, advised policy makers on the implications of various approaches to designing auctions (IRENA, 2015) and has served as a basis for auction guidelines issued by development banks and related organisations, such as the European Bank for Reconstruction and Development and the Energy Community Secretariat (EBRD and EnCS, 2018).

Four years after its first report on the topic – and amid record-breaking low prices for solar and wind power resulting from auctions – IRENA published *Renewable Energy Auctions: Analysing 2016*, which analysed the factors behind the low prices, including aspects of auction design (IRENA, 2017a). In 2018, IRENA analysed auctions in South Africa, Uganda and Zambia in *Renewable Energy Auctions: Cases from sub-Saharan Africa* (IRENA, 2018a). Collectively, IRENA's studies have provided an invaluable reference for renewable energy auction design around the world.

ABOUT THE ONGOING STUDY AND THE PRESENT BRIEF

This brief – produced for IRENA's 17th Council in June 2019 – outlines preliminary findings from IRENA's next major study of auctions, provisionally entitled *Renewable Energy Auctions: Status and Trends Beyond Price*. A focus of the study will be how to design auctions to achieve objectives beyond price discovery. Auctions designed in innovative ways can help to achieve specific country goals, beyond solely procuring electricity at the lowest price. These goals might include integrating higher shares of variable renewable energy into the grid; ramping up solar and wind power, in particular; ensuring greater participation of communities or other new and small players; and maximising the socio-economic benefits of renewables. Alongside such diverse aims, ensuring timely project completion remains a paramount objective.

The findings are presented here with several aims: to highlight key elements of design needed to achieve specific objectives beyond price; to stimulate discussion among experts and policy makers on successful practices in auction design and implementation, particularly practices that could be replicated more widely; and to invite IRENA's worldwide membership to provide information on the types of support they may require in the design and implementation of their future renewable energy auctions.

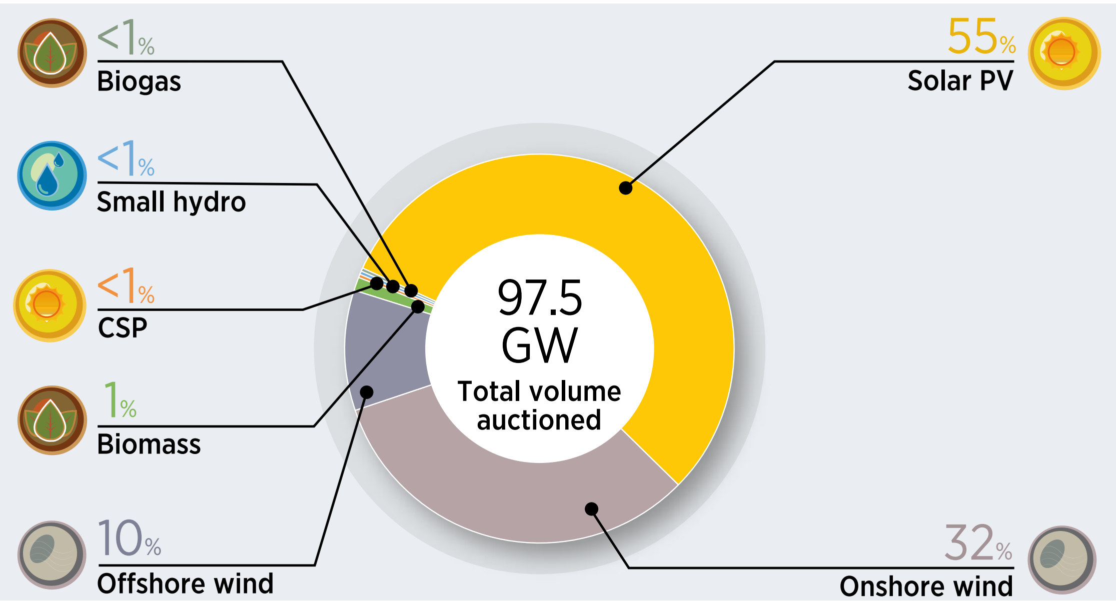
2. RECENT TRENDS IN RENEWABLE ENERGY AUCTIONS

2.1 GLOBAL OVERVIEW AND TRENDS

In the 2017-2018 period, around 50 countries used auctions to procure renewables-based electricity, raising the number of countries that have ever held an auction for renewables to 100 by 2019 (REN21, 2004 - 2019). Almost half of the 50 countries had no previous experience with auctions (herein referred to as newcomers); they were likely driven by the reported success of auctions in other markets in attaining low prices. The use of auctions continues to rise, owing chiefly to their ability to reveal competitive prices and the flexibility in their design and their susceptibility to be tailored to fit country-specific conditions and objectives.

Most renewable energy auctions still focus on mature power-generation technologies. An estimated total volume of 97.5 gigawatts (GW) of electricity was auctioned in 2017-2018, with solar photovoltaic (PV) and onshore wind accounting for more than half and almost a third, respectively, of the total volume (Figure 1). Offshore wind has seen a substantial increase in volume, and auctions for concentrated solar power (CSP) have recently been held in new countries.

Figure 1: Share of the total volume auctioned in 2017-2018, by technology



Note: PV = photovoltaic, CSP = concentrated solar power

Figure 2 shows the breakdown by region and technology of auctions carried out between January 2017 and December 2018.

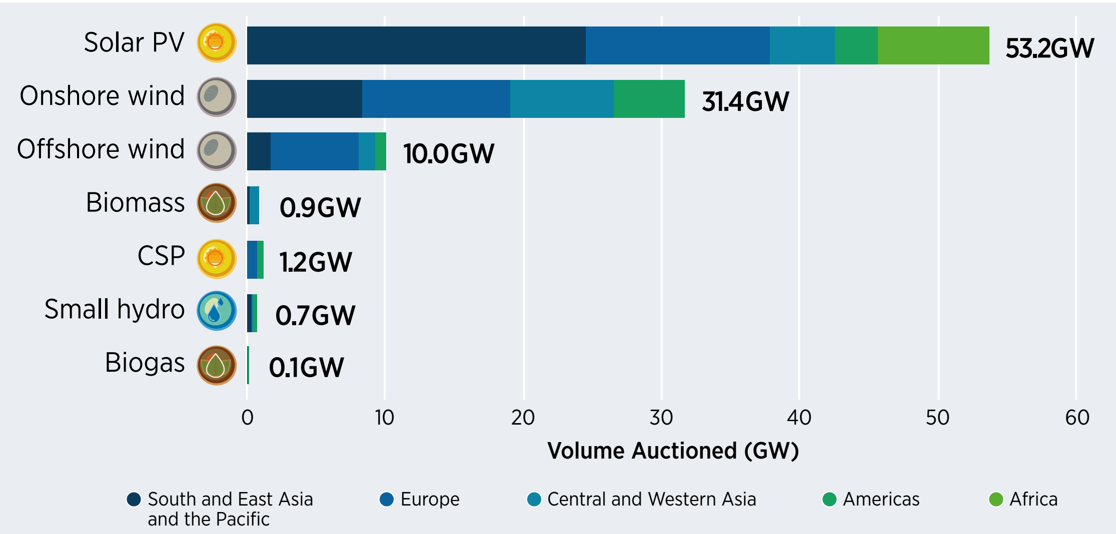
Solar PV was the most widely auctioned technology. Nearly half of all solar PV auctions took place in South and East Asia and the Pacific, with most of the balance occurring in Europe. Solar PV is becoming competitive with traditional energy sources in these regions owing to large endowments of solar resources and the falling cost of technology. China awarded 5 GW of solar PV at an average price of USD 67.8/MWh[1] in a total of 10 auctions (Climatescope, 2018). The Philippines received the lowest bid of USD 43.9/MWh[2] for a 50 MW auction (Billini, 2018).

Onshore wind was auctioned primarily in Europe, followed by South and East Asia and the Pacific, driven by the richness of wind resources in these regions. Germany alone auctioned more than 6 GW in seven rounds during the period at an average price of USD 57.17 MWh.[3] **Offshore wind** auctions saw considerable uptake in Central and Western Asia, led by the announcement of a 1.2 GW auctions in Turkey (Tisheva, 2018)[4].

Biomass auctions were concentrated in Europe and the Americas. Argentina, for example, awarded 143 MW of biomass at an average price of USD 106.7/MWh under Round 2 of Argentina's RenovAr program (Yaneva et al. 2018).

CSP was auctioned mainly in Central and Western Asia, specifically in the United Arab Emirates (UAE). Dubai awarded 700 MW at a price of USD 73/MWh (DEWA, 2018).

Figure 2: Breakdown of auctions carried out between January 2017 and December 2018, by region and technology (GW)



Note: PV = photovoltaic, CSP = concentrated solar power

A closer look at regional trends indicates a concentration of newcomers in Africa and Western and Central Asia, while other regions are gaining experience in the use of auctions and experimenting with innovative designs to meet objectives such as integrating growing shares of variable renewable energy and maximising the socio-economic benefits of projects.

1 1 USD = 6.3 RMB on average in 2018
2 1 USD = 53.28 PHP in August 2018
3 1 USD = 0.879995 EUR on average in 2017 and 2018
4 The 1.2 GW offshore wind auction in Turkey was later cancelled

2.2 REGIONAL TRENDS

Additional countries in Africa, Asia, and the Pacific adopted auctions in 2017-2018, with a focus on solar PV and onshore wind. Europe remains focused on technology-specific auctions for large-scale projects, while Latin America continues to pioneer and innovate in auction designs, with a continued preference for technology neutrality.

Most of the **African** countries that held auctions in 2017-2018 are newcomers. Their selection of auctions to support their energy transition is driven principally by two characteristics of auctions: 1) their potential for price discovery; and 2) the ease with which they can be tailored to a particular context or policy purpose. Along these lines, the positive experience that pioneers such as Morocco, South Africa and Zambia have had, provide many lessons that can be shared (IRENA, 2013 and 2018). Auctions in Africa were dominated by solar PV (Figure 3), with Algeria, Egypt, Morocco and Zambia playing the major roles.

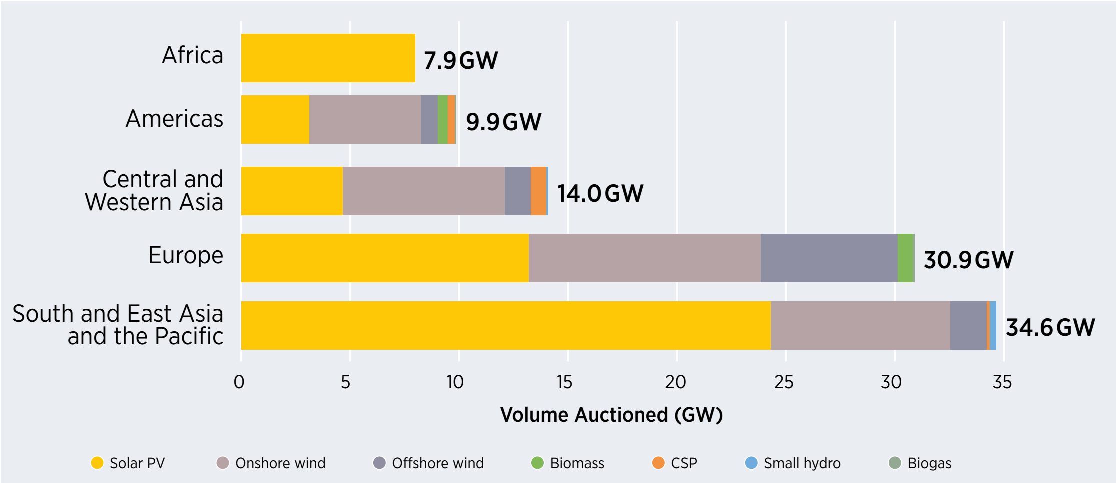
Most countries in the **Americas** have considerable experience with auctions. In Latin America, Brazil and Peru were early adopters; more recently, Argentina, Chile and Mexico have joined the trend of innovating with auction designs. Driven by the success of auctions in neighbouring countries and the conducive structure of its power market, Colombia is the latest country to adopt this instrument. Canada and the United States of America continue using auctions, with increased scope at the subnational level. In terms of technology, the availability of biomass (Brazil), hydro (Brazil) and biogas (Argentina) allows for a variety of technologies in auctions in the Americas (Figure 3).

Across the **Asian** continent, countries' experience with auctions is varied. In terms of technology, the focus is on onshore and offshore wind, dominated by Turkey's 1 GW auction, followed by solar PV (Figure 3). Most countries in Central and Western Asia are newcomers, but Jordan, Kazakhstan and the UAE have significant experience. Auctions in the Emirates of Abu Dhabi and Dubai are setting the pace for replication in the countries of the Gulf Cooperation Council, notably for CSP (IRENA, 2019a). The increased adoption of renewable energy auctions in a region with abundant fossil fuel resources demonstrates the potential of the instrument to result in competitive prices when designed properly.

South and East Asia and the Pacific also contain dynamic and heterogeneous markets with a diverse mix of newcomers and countries with established auction experience. Efforts to fuel economic growth have encouraged many newcomers in South and East Asia seeking to take advantage of abundant solar resources and cost competitive PV technology. Malaysia, Philippines, Thailand and Viet Nam are good examples (IRENA, 2018b). Japan has also adopted auctions in an effort to reduce the cost of support for solar PV. Meanwhile, China and India, the region's renewable giants, have been holding at least ten renewable auctions per year. In terms of technology, the region is mainly focused on solar PV, followed by onshore wind and, recently, a boom in offshore wind (Figure 3).

In **Europe**, auctions were adopted by a large number of newcomers in 2017-2018, including Contracting Parties of the Energy Community (*e.g*. Albania and Montenegro), as well as by countries with extensive experience with auctions (*e.g*. Denmark, France, Germany, the Netherlands, and Spain). Contracting Parties to the Energy Community, like the Member states of the European Union, are required to follow the European Commission's Guidelines on State Aid for Environmental Protection and Energy for 2014-20, which establish auctions as the main instrument of support. The Guidelines are characterised by competition between renewable technologies (Figure 3) and assignment to bidders of a larger share of project risks.

Figure 3: Renewable energy auctions: Capacity auctioned by region and technology, 2017-2018 (GW)

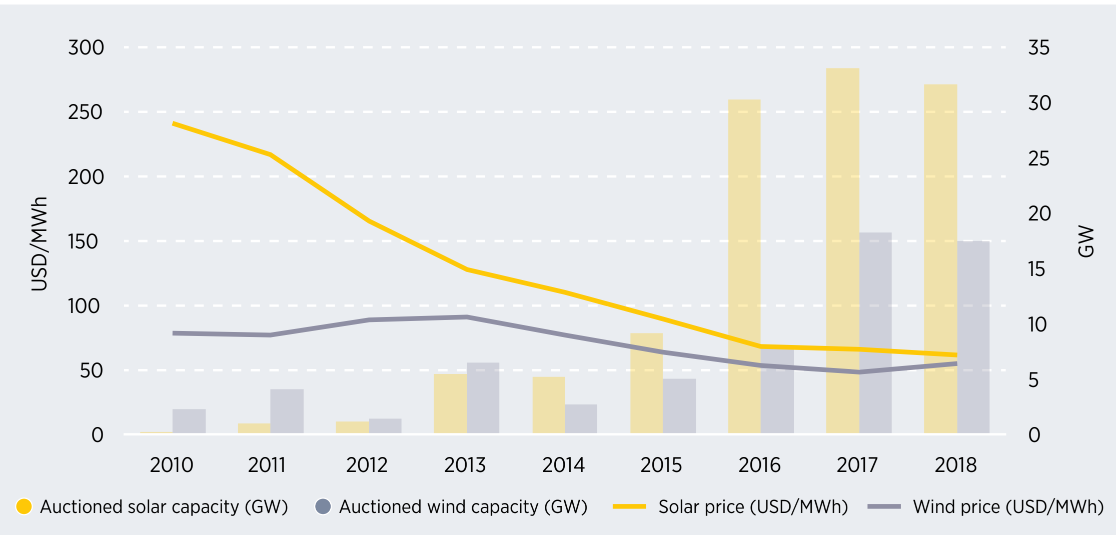


Note: PV = photovoltaic, CSP = concentrated solar power

2.3 PRICE TRENDS

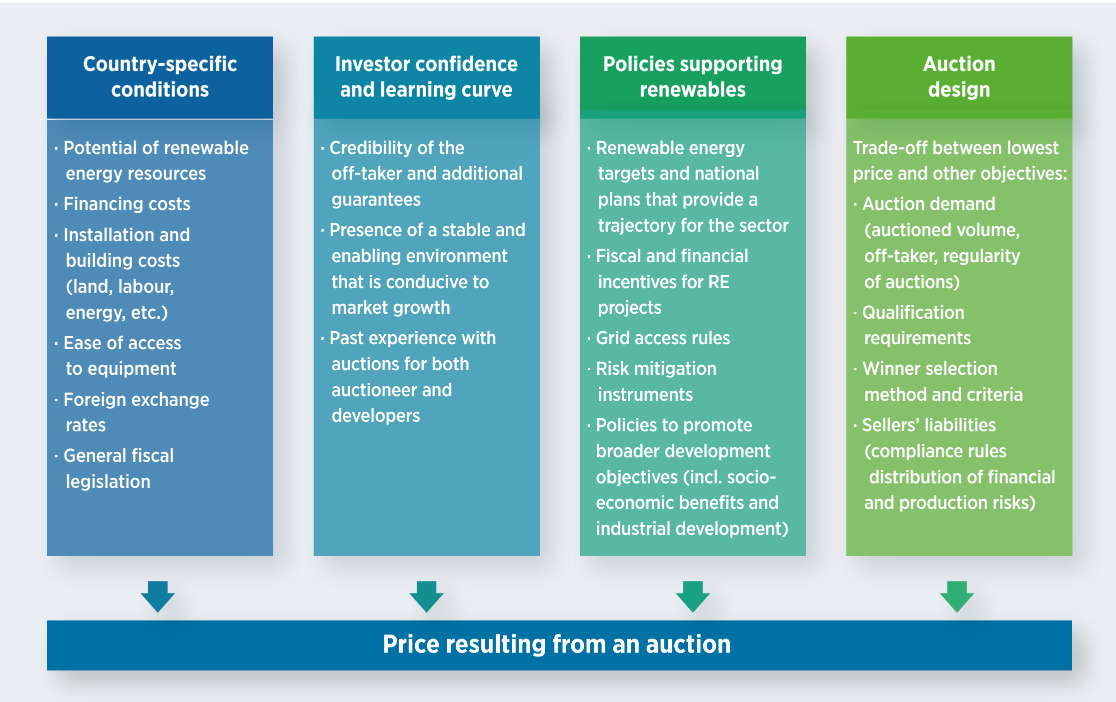
While prices for solar PV continued to fall in 2018, onshore wind took an interesting turn. Both technologies showed a downward price trend from 2010 to 2017, but the price decrease for solar PV was more marked, reflecting the greater maturity of onshore wind technology at the start of the period. The global average prices dropped from around USD 241 to USD 66/MWh for solar PV (-73%), while onshore wind prices dropped from around USD 79 to USD 46/MWh (-36%). Between 2017 and 2018, solar PV prices continued to fall, albeit at a slower pace, reaching USD 62/MWh in 2018. Onshore wind prices edged slightly upward, reaching USD 55/MWh. Figure 4 illustrates global average price results for solar PV and onshore wind auctions carried out between January 2010 and December 2018.

Figure 4: Global average prices resulting from auctions, 2010-18



As analysed in IRENA's *Renewable Energy Auctions: Analysing 2016*, many factors shape the prices that emerge from auctions. They can be grouped into four categories: 1) country-specific conditions such as resource availability and the costs of finance, land and labour; 2) the degree of investor confidence (clear targets, credible off-taker); 3) other policies related to renewable energy (grid policies, priority dispatch, local content rules); and 4) the design of the auction itself, taking into consideration the trade-offs between obtaining the lowest price and achieving other objectives (Figure 5). Box 1 presents IRENA's updated framework of auction design and summarises the various design elements in each category.

Figure 5: Factors that affect the price resulting from auctions



Source: Adapted from IRENA, 2017.

Solar PV prices. A sharp decrease in global average prices for solar PV was observed between 2010 and 2017, followed by more stable price trends in 2017-2018. One possible reason for the stability of prices could be the maturity of the sector and consolidation among its players. The decrease in prices between 2010 and 2017 was driven mainly by a steady decline in the price of solar panels, which fell to a quarter of their opening price over the period (IRENA, 2018c). Increases in investor confidence, developers' experience, and competition in auctions also contributed to the decline. That said, once the most profitable projects, such as those at the best sites, have been awarded, prices naturally tend to plateau. Nevertheless, some opportunities for further cost reduction may be found – for example, through economies of scale.

Another reason global average prices stabilised in 2017-2018 is that newcomers (allowing for differences in macro-economic context, energy policy, and auction design, among others) constituted a considerable share of the solar PV volume auctioned, and the resulting prices were higher than in countries with established markets. Examples include Greece and Poland. As many of the newcomers are countries with lower levels of sector development, bidders and financiers may require a higher rate of return. In this context, the risks of investing in countries that may not yet have a fully robust institutional, economic and political framework are reflected in auction prices.

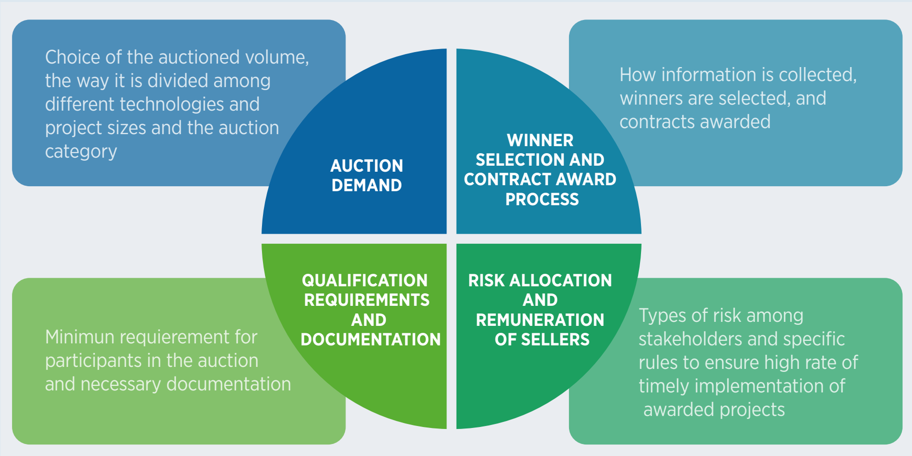
Onshore wind prices. Figure 4 shows a sharp decrease in average global prices between 2013 and 2017, followed by a slight increase in 2017-2018. The increase is due chiefly to the fact that countries with higher prices constituted a larger share of the wind volume auctioned globally in 2017-2018, and the prices resulting from those auctions lifted average prices globally. The countries in question include some newcomers, for which prices typically start out higher than in markets with established auctions, as well as countries with generally higher prices (see Figure 5 for factors affecting prices). Moreover, the period has seen an increase in prices in some countries including Brazil and Germany.

When analysing the price results for both solar PV and onshore wind auctions carried out in 2017-2018, one important factor is the trade-off that has been considered by policy makers between obtaining low prices and achieving other objectives. Auction designs may have prioritised other criteria (specific benefits). The remaining sections of this report discuss design elements that can be used to achieve objectives beyond price discovery. Those objectives include ensuring projects are delivered on time, integrating higher shares of variable renewable energy, and supporting a just and inclusive energy transition.

Box 1: Updated framework of auction design with overview of design elements

IRENA's 2015 report *Renewable Energy Auctions: A Guide to Design* presented a framework for analysing auctions. The framework classified design elements into four main categories: auction demand, qualification requirements, winner selection and sellers' liabilities (IRENA, 2015). An updated framework reflecting developments and lessons learned in the dynamic renewable energy sector in the intervening years is presented in Figure 6 and the accompanying text.

Figure 6: IRENA's updated auction design framework



Decisions made in the **auction demand** category determine what is to be procured, and under what conditions. Crucial demand-side considerations include: 1) which product is to be auctioned (energy, capacity, green certificates, transmission lines, financial transmission rights, ancillary services or a mix); 2) whether and how the total demand is to be split among different products (technologies, zones or other breakdowns); 3) the volume of product to be auctioned and the lower and upper limits on the project size; 4) whether a pre-set auction schedule will be adopted and, if so, the schedule of committed future auctions; and 5) responsibility for demand-side commitments, which includes evaluating the factors that assure project developers of the off-taker's creditworthiness.

The category of **qualification requirements and documentation** determines which suppliers will be eligible to participate in an auction, including the conditions participants must meet and the documentation they must provide prior to the bidding stage. Such requirements commonly relate to: 1) documentation to confirm that the firm has the capacity to develop the project; 2) site-specific documentation; 3) technical requirements for the project; and 4) instruments to promote socio-economic development.

In the **winner selection and contract award process**, bidding and clearing rules are applied and contracts are awarded to the winner(s). The subcategories include: 1) the formal bidding procedures, which set forth how supply-side information is collected; 2) minimum competition requirements, including provisions to ensure participation by multiple, competing bidders; 3) winner selection criteria, dictating how bids will be ranked and winners selected; and 4) the clearing mechanism, which defines rules for allocating contracts based on accepted bids; and 5) payment to the winner.

Procedures in the category of **risk allocation and remuneration of sellers** define how risks (financial, production and other) are allocated among stakeholders (bidders, auctioneer, off-taker, financial institutions, consumers, etc.). These risks, responsibilities and obligations should be spelled out in auction documents. This critical design element involves 1) commitment bonds (typically a bid bond and a construction bond) and a schedule for contract signature and commencement of commercial operations; 2) production and financial risks (associated with inflation, currency fluctuations, market prices and production hazards); 3) quantity-based liabilities, including settlement rules and penalties for underperformance; and 4) penalties for delays and underbuilding.

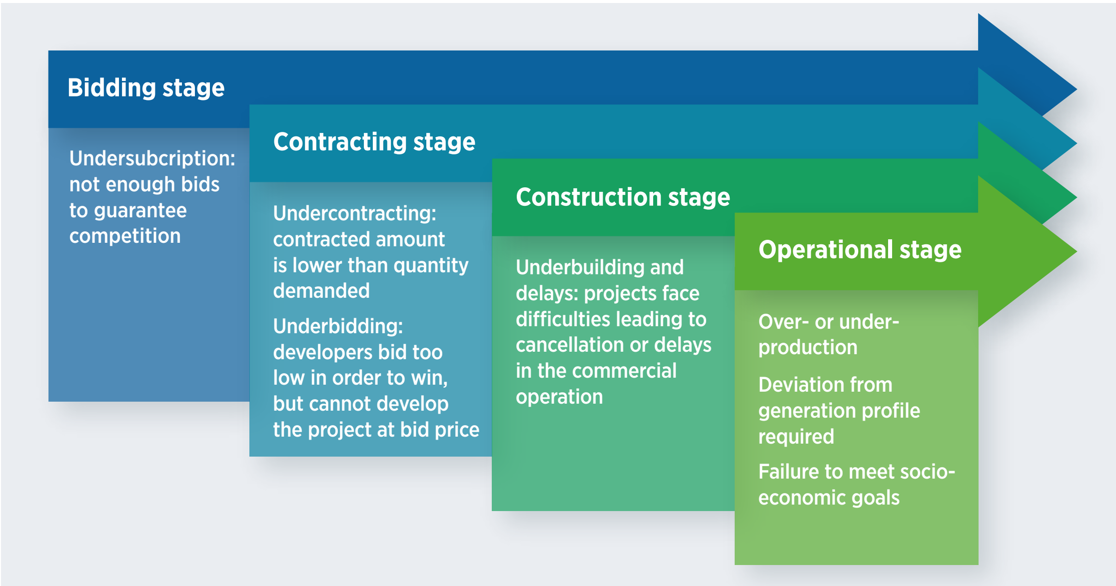
See IRENA (2015) for details on each of the design elements.

3. ENSURING TIMELY PROJECT COMPLETION

Although auctions are recognised for their potential for price discovery and their ability to achieve objectives beyond decreasing prices, they are also associated with the risk that projects may be delayed or never come to fruition. IRENA's *Renewable Energy Auctions: A Guide to Design* stressed the importance of compliance rules to ensure that awarded projects are completed on time and delivered as bid. The likelihood of timely project completion can be raised through the use of appropriate auction design of the auction, but this requires the presence of an enabling environment capable of supporting project development (IRENA, IEA and REN21, 2018).

This section looks at the status of project completion in various contexts and countries – among them Brazil, Germany, India, Italy, Mexico and South Africa. It investigates cases of underperformance resulting from auctions for solar PV, CSP and onshore wind. Underperformance occurs when an auction's objectives are not met at any of the various stages, starting with the announcement of the auction and extending through the processes of bidding, contracting, constructing and operating the assets specified in the power purchase agreement (Figure 7).

Figure 7: Risks of underperformance at each stage of the auction process

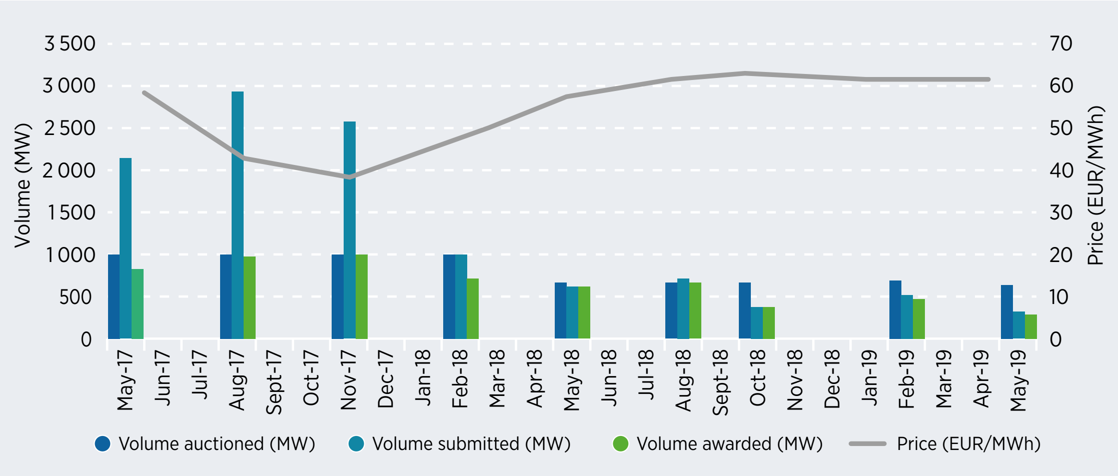


3.1 BIDDING STAGE

Starting from the day the auction is announced until the contracts are signed, underperformance can occur in the form of undersubscription which occurs when the auction does not receive enough bids to meet the volume of the demand. This can be an indication that the auction was not able to attract enough bidders, possibly owing to low investor confidence in the market, lack of an enabling environment, or unfavourable auction design (*e.g.* strict compliance rules, low ceiling price, permitting requirements). Onshore wind auctions in Germany, for example, have been undersubscribed since 2018, when the design of the auction was changed to require projects to obtain permits in order to bid. At the same time, the permitting process became harder and lengthier, taking 700 days in 2018, up from 300 days in 2016 (WindEurope, 2018). Developers have also become more reluctant to bid, since, even after obtaining a permit, they could be exposed to legal challenges owing to shortcomings in the regional siting plans that determine the location of wind farms. By 2019, at least 750 MW of wind farm projects were mired in legal proceedings (WindEurope, 2019).

Undersubscription can have implications for prices, as an auction that fails to attract enough competition does not fulfil its full potential for price reduction. The average prices resulting from the German wind auctions rose from EUR 38/MWh in May 2017 to EUR 62.6/MWh in October 2018 before stabilising at EUR 61/MWh in February and May 2019 (Figure 8). Notably, onshore wind has competed with solar PV in three auctions to date – all three have been won by solar, with a drastic difference in the prices offered.

Figure 8: Undersubscription in German onshore wind auctions leading to increased prices, May 2017-May 2019

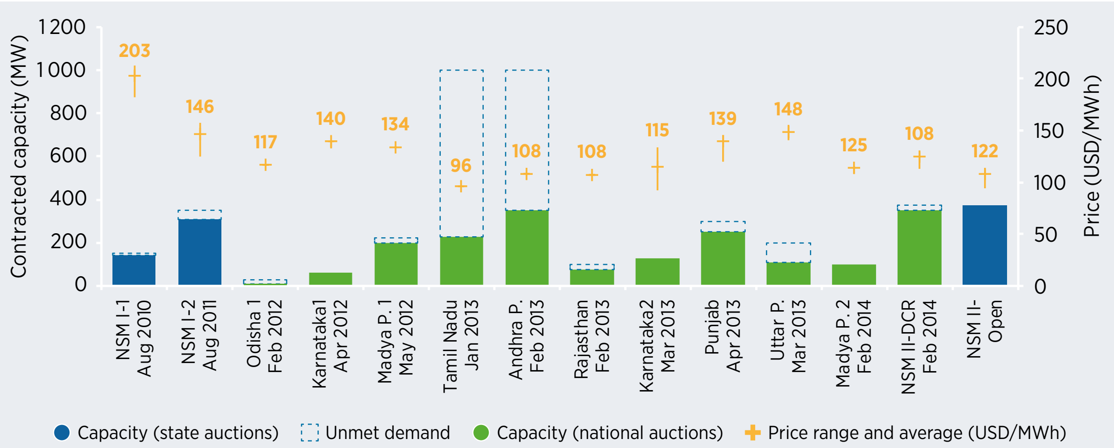


3.2 CONTRACTING STAGE

Undercontracting occurs when, after the bidding process is completed and the winners selected, the contracted amount is lower than quantity demanded. This can be an indication that some of the bidders were bidding speculatively, a practice known as underbidding, and were not serious about closing the contract if selected. The implications of undercontracting are directly linked to volumes not being contracted and renewable energy targets not being met.

India has seen several cases of undercontracting, which were partly due to holding negotiations with bidders after the auction in an effort to further reduce prices (Figure 9). The L1 awarding mechanism, for example, whereby bidders could advance only if they were willing to match the lowest bidder, discouraged several winners, who decided not to build their projects because they were not economically feasible at the lowest price (Azuela et al., 2014). This issue continues to be a problem in India, as policy makers have sought ever-more-competitive solar power contracts, leading them to set excessively low prices incommensurate with developers' costs and the risks assumed.

Figure 9: Undercontracting and underbidding in India's L1 award mechanism since 2010



Note: Due to the very different nature of the auctioned products (such as the shorter 10-year power purchase agreement in Uttar Pradesh and the very different schedule of payments implied by the VGF mechanism from NSM Phase II), several assumptions had to be made to obtain reasonably comparable values for this figure. For this reason, the auctioned prices listed here should be interpreted as rough estimates rather than exact values. The exchange rate used was 60 INR/USD.

Source: IRENA, 2015

In South Africa, of the 53 bids received in the three rounds of the Renewable Energy Independent Power Producers Procurement Programme (REIPPPP), only 28 were accepted, which led to significant undercontracting: only 649 MW of the 1850 MW of wind capacity and 627 MW of the 1450 MW of solar capacity demanded were ultimately awarded. This result can be attributed partly to requirements for socio-economic development that some developers, mostly foreign, found problematic.

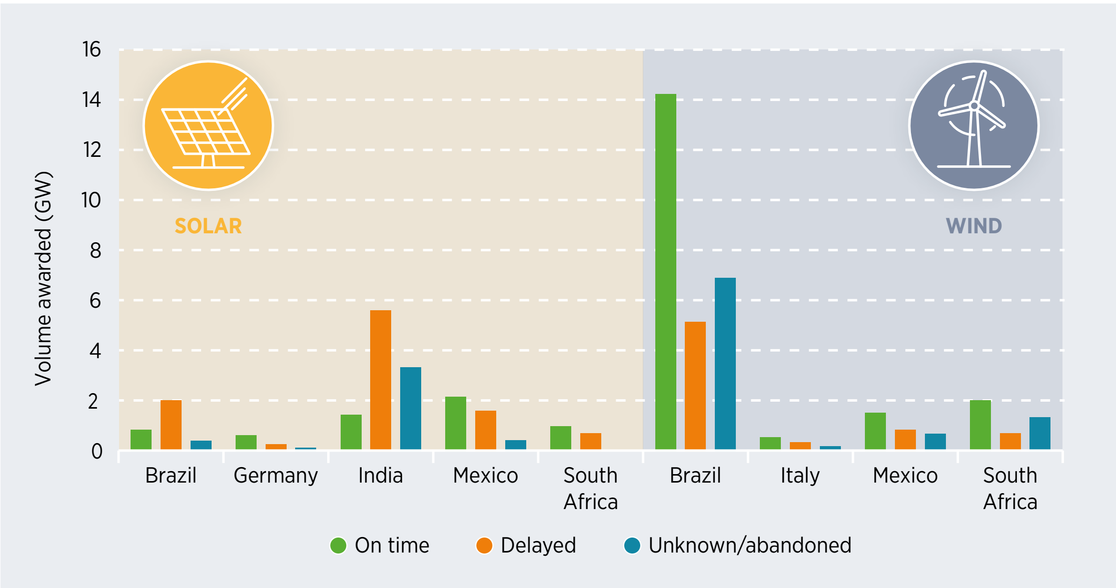
3.3 CONSTRUCTION STAGE

During construction, underperformance can be associated with delays in project completion or cancelation of projects, also known as underbuilding. Underbuilding often occurs when awarded projects encounter obstacles in construction or grid connection, leading to delays. The extreme case is when the project never comes online. In general, the maximum delay that can occur before the project is written off and another project selected is specified in the auction documents.

Looking at some of the projects awarded through auctions for solar PV, Germany has had the highest share of timely completion (*i.e.* not delayed and not cancelled), at almost 65% of the capacity awarded, followed by South Africa (60%), Mexico (53%), Brazil (26%) and India (14%) (Figure 10).The high rate of timely completion in Germany can be attributed to the compliance rules in place, in addition to flexibility in site location for projects up to 10 MW (Hannen, 2017).

Delays occurred in Brazil (63% of projects awarded), India (54%), South Africa (40%), Mexico (37%) and Germany (23%). With respect to projects being cancelled (or where the project status is unknown), India has the highest rate (32%), followed by Brazil and Germany (11%) and Mexico (10%). Part of the capacity listed as abandoned in Brazil was voluntarily uncontracted by the government in an effort to reduce system oversupply: the country launched a "decontracting auction" in 2017 to undo some of the commitments it had previously assumed in the wake of a Brazilian economic crisis (IRENA, 2017).

Figure 10: Underbuilding and delays for solar PV and wind auctions in selected countries



Notes: The analysis for **Brazil** is based on 19 auctions awarded from 2009 to 2015, during which 662 solar and wind projects were awarded for a total of 17 501 MW of installed capacity. The data for **Germany** is based on six auctions in 2015 and 2016, from which 174 solar projects were awarded totalling 963 MW of installed capacity. That for **India** is based on 19 auctions from 2012 to 2017, from which 329 solar projects were awarded totalling 10 353 MW of installed capacity. For **Italy**, the data are drawn from two auctions in 2012 to 2013, during which 23 wind projects were awarded totalling 562 MW of installed capacity. The figures for **Mexico** are based on two auction rounds in 2016, which led to 39 wind and solar projects being awarded for a total of 5 617 MW in installed capacity. The **South African** data are based on three auctions from 2011 to 2013, from which 55 wind and solar projects were awarded totalling 3 673 MW of installed capacity.

3.4 OPERATIONAL STAGE

Aside from delays, failure to deliver the quantities promised in the bid can occur at many levels. On the technical level, in instances when the generation load is predetermined (*e.g.* in Mexico), the actual production from the generators can deviate from the generation profile required.

Failure to deliver as bid may also entail a failure to meet the socio-economic objectives promised. In such cases, the monitoring of project performance can be complicated. For instance, when reporting on local jobs created, one may encounter ambiguity in the delineation of the sector, in what is considered a newly created job, and in assessments of the quality of the jobs created. Moreover, monitoring the jobs created should consider qualitative dimensions such as the duration and meaningfulness of employment for individuals.

3.5 AUCTION DESIGN ELEMENTS TO ENSURE TIMELY PROJECT DELIVERY

As part of the **qualification requirements**, a balance must be struck between imposing overly harsh requirements that may limit the pool of potential bidders (and thus increase the risk of undersubscription) and relaxed requirements for qualification and documentation that may lead to underbuilding and delays.

This is also the case for compliance rules related to the **allocation of risk and the remuneration of sellers**. Stringent compliance rules are meant to ensure that, once the winners are selected, contracts will be signed, projects will be completed on time, and the risks of under- or overperformance will be reduced. However, overly strict rules may deter small and new players and even lead to undersubscribed auctions.

4. INTEGRATING SOLAR AND WIND POWER

As shown in Figure 4, the global average prices resulting from solar PV and onshore wind auctions have stabilised since 2016, with a slight increase in wind prices in 2017-2018. One of the factors contributing to this trend could be that growing numbers of auctions are being designed to achieve additional objectives other than price. One of those objectives is supporting the integration of variable renewable energy (VRE). Solar PV and wind are the most commonly auctioned renewable energy technologies, accounting for 97% of auction volume in 2017-2018. This reflects a global trend over the past decade: Solar PV and onshore wind are also the most widely deployed renewable energy technologies by a large margin, driven by their growing maturity and falling costs.

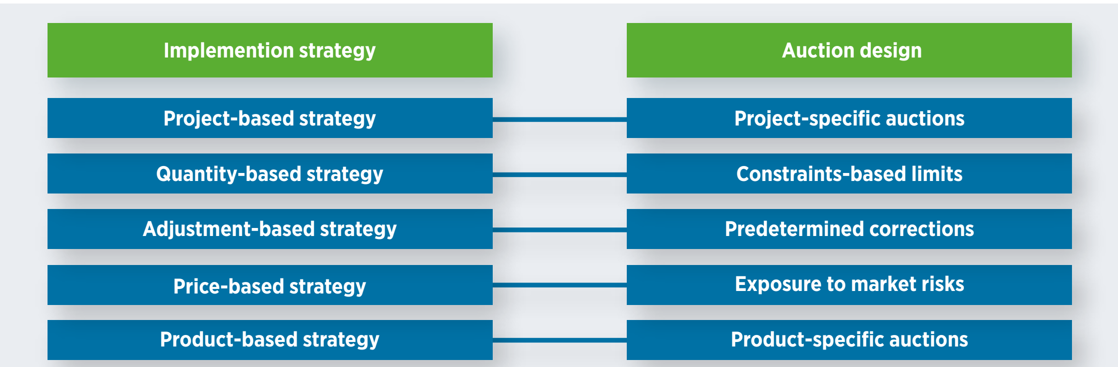
VRE, however, has characteristics that distinguish it from other generation sources, related to its dependency on the weather. VRE technologies are relatively more limited in the degree to which their output (and consequently their dispatchability) can be controlled, and they exhibit seasonal and diurnal (*i.e.* within-day) **variability** in its patterns of production. VRE generation can be forecast, but not without some **uncertainty**. Variability and uncertainty call for increased system flexibility – that is, the ability of the power system to match generation with demand on any timescale. VRE technologies are also **location-constrained**, meaning that they operate predominantly in areas where energy production is feasible and convenient (*e.g.* sunny or windy areas), which may require additional infrastructure for transmission and distribution.

To continue integrating VRE smoothly into power systems, the auctions that support its deployment should be designed to accommodate for its characteristics. Auction design can support the integration of renewables through the selection of system-friendly projects, that is, projects most easily accommodated by the power system.

This section explores auction design elements that can help reduce some of the consequences of increased shares of VRE in power systems. The discussion is structured around five implementation strategies that may be chosen by system planners to meet the needs and circumstances they they face depending on context (Figure 11). The optimal auction design will vary with the strategy chosen.

The strategies are ordered according to the degree of central planning required, from the highest to the lowest. For example, under the project-based strategy, developers have little flexibility in the design of their power plants, whereas the product-based strategy allows them the maximum degree of flexibility: they need only to guarantee the availability of a predetermined quantity of a given product (capacity, energy, system services, etc.). While this framework may hide nuances, it attempts to classify design options according to a predetermined approach to system integration that reflects country conditions (resources, power market structure, objectives, etc.).

Figure 11: Implementing strategies and related auction designs



4.1 PROJECT-BASED STRATEGY

Where this strategy is being applied, outcomes are highly predictable, as central planners maintain tight control. Parameters such as the size and location of projects, as well as the technology involved, are determined before the auction. Strict planning allows the central planner to estimate how much additional stress a given quantity of new renewable capacity is likely to impose on the system, making it possible, for example, to design auctions to yield projects that minimise investment in infrastructure or to identify the potential need for new assets.

In most cases, a project-based strategy can be implemented using design elements falling within the **auction demand** category described in Box 1. In other words, planners need only determine the characteristics of the projects that need to be procured and specify them in the auction design.

Site- and project-specific auctions have been adopted in a number of countries with lower levels of renewable energy development as a way to support deployment of renewables by reducing costs and risks to bidders. Some of those costs and risks are related to building the infrastructure needed, including roads and grid connections, as well as land permits. Some site- and project-specific auctions have brought record-low prices, such as auctions for solar power in the UAE and Morocco. The sites of those projects were selected as part of a plan that accounted for the investments needed in grid infrastructure. Moreover, the mix of technologies chosen –CSP and PV – was part of a plan to introduce CSP plants to exploit their storage capabilities.

4.2 QUANTITY-BASED STRATEGY

Quantity-based strategy imposes less strict limitations for projects, compared to the previous examples, but maintains a significant degree of control in the hands of the central planner. Under this kind of strategy, the more important system limitations are identified and used to apply limits in the auctions. For example, shortage in the transmission capacity to evacuate generation from a resource-rich area toward the main consumption centres may call for limitation on the volume that can be awarded in that area. More sophisticated planning methodologies may consider several system characteristics, such as the amount or flexible reserves or the amount of inertia, in order to identify more specific constraints.

The options for a quantity-based strategy are quite diverse, but various design elements are available to enforce the constraints identified by the system planner.

Under the category of **auction demand**, the volume to be auctioned can be determined based on the maximum capacity that the existing system can accommodate. Zone-specific volumes can even be set for each technology, such as Kazakhstan's distribution of the volumes of solar and wind auctioned in various regions. Technological limitations specified in order to procure only system-friendly power plants are another design element falling within the auction demand category.

Qualification requirements can also be useful under this strategy, as they shortlist projects that are able to integrate power into the system. One common requirement (used in South Africa and elsewhere) is an official document from the grid operator declaring the availability of the infrastructure needed to accommodate the proposed project.

4.3 ADJUSTMENT-BASED STRATEGY

The adjustment-based strategy relies strongly on a central planner's ability to forecast how system needs will evolve, in order to yield the most socially desirable outcome for the electricity sector. But instead of imposing hard constraints or limitations on projects, as in the project- and quantity-based strategies, the adjustment-based strategy relies on the application of adjustments dictated by the project location or time of generation. This allows developers to anticipate where and when, according to the system operator, energy production will be most valuable, so they can shape their bids accordingly.

The strategy accounts for the trade-offs involved in system planning by penalising market agents who provide services that are less valuable to the system and incentivising others to provide the services that are most valuable. Whereas a price-based strategy (see next section) relies on market prices to incentivise market agents to make choices that are most valuable to the system, an adjustment-strategy adopts predetermined penalties and incentives that serve to align the outcomes of the projects selected with so-called emulated markets (simulations of the future market based on an estimated system evolution). Adjustment-based strategies can be achieved through design elements that fall within the categories of **winner selection** and **risk allocation and remuneration of sellers** (see Box 1).

Grid integration could be made one of the criteria for **selecting winners**, for example, by assigning a weight to their proximity to the grid, or by awarding projects nominal bonuses or penalties according to their technical characteristics and the stress they impose on the system. As such, projects with less favourable locations are penalised in the winner selection process, as in Mexico. Including grid integration in the selection process tends to be more flexible than project- or site-specific auctions or auctions with zonal constraints (quantity-based strategy), as it allows for a share of the volume auctioned to be assigned to different zones, as long as the competitive advantage gained from the availability of resources outweighs the costs imposed on the system. One example is the Brazilian design in which the expected future value of the electricity is incorporated in a cost-benefit index that permits a holistic and fair comparison of generators having different seasonal and hourly production profiles (and, in some auctions, production from different technologies) in order to select those that are considered most valuable for the system.

In addition to winner selection, Mexico also provides an example of design elements related to **risk allocation**. Before the auction, the auctioneer discloses a long-term set of hourly adjustment factors, which does not affect the winner selection process but rather the remuneration of the project once it begins operations. In addition to the contract payment, the seller receives an adjustment, which may be positive or negative. Plants that have a generation profile in line with system needs (according to expectations at the time of the auction) receive additional remuneration, while plants that have the opposite production profile receive a penalty. This way, investors are shielded from actual market risks, but they are still incentivised to produce at times or in locations of higher demand (according to expectations at the time of the auction). This is crucial in countries that lack a market track record (or even a market), where perceived risks in the power purchase agreement can greatly affect the availability of financing.

4.4 PRICE-BASED STRATEGY

Under this strategy, the auction is designed in a way that relies on the market price to signal the best VRE production profile. Under the previous strategy, adjustments are calculated by the system operator by emulating future system needs (as in the Mexican case). Under the price-based strategy, by contrast, the responsibility of matching generation to system needs is left to the developers.

This strategy relies on the presence of a market capable of providing time-based price signals depending on demand and supply curves. This strategy draws most heavily on the **risk allocation and sellers' remuneration** category of design elements. VRE plant operators participate in the market like the operators of other power plant. The value of energy delivered to the grid is identified at points in the network and at given time intervals (*e.g*. hourly or sub-hourly), based on a supply-demand balance.

A straightforward method to introduce ex post market signals into the auction design is a remuneration of the type known as the **feed-in-premium**, whereby operators receive a premium determined by the auction on top of their market revenue. Denmark, Finland and the Netherlands are examples of countries that have adopted this type of mechanism, in which agents bid for a surplus on top of the wholesale market revenue to which the renewable power plant is entitled. Such a design can ensure that renewable generators receive, through spot electricity prices, the correct signals to deliver electricity at times and locations where it is most valuable.

Contracts with financial obligations are another way to introduce market signals, in which the generator must either 1) meet the total quantity committed in the auctioned contract at each point in time with its own physical production or 2) purchase the difference between committed and delivered quantities in the spot market. If the generator produces more than was committed in the contract, it may also be allowed to sell the surplus in the spot market. Chile is one country that has adopted this design.

Subjecting renewable generators to spot price signals may give them the opportunity to **curtail** their production when the price of energy is below zero. **Curtailment** of VRE is usually a signal of system inflexibility, and it can take different forms, from the need to observe minimum operating levels on thermal generators at times of low demand, to transmission or operational constraints in renewable energy hotspots that may lack necessary infrastructure. Policy makers are increasingly aware that curtailing renewable energy generation may be inevitable, but attempting to allocate this risk to generators is not desirable, particularly in jurisdictions where financiers are very sensitive to perceived risk. Yet introducing price-based strategies to address VRE curtailment typically involves allocating some portion of the curtailment risk to the generators. In the auction designs of Finland, Namibia and Sri Lanka, for example, generation not delivered due to curtailment is not accounted for when determining generators' remuneration. Curtailment may also be encouraged by suspending the premium during hours when the local price falls below a certain threshold.

4.5 PRODUCT-BASED STRATEGY

A fifth potential strategy for supporting system integration through auction design involves fundamentally changing the way renewable energy is procured, by focusing on products rather than on the technologies used to produce them. This strategy relies on standardising system needs in terms of electricity market products such as energy, capacity, certificates and ancillary services, leaving the door open for renewables to supply the needed products, potentially with the support of other flexible resources (*e.g*. demand-side management and storage). Product-based strategies are mainly associated with the design category of **auction demand**, but they also involve r**isk allocation**, since renewable generators will typically participate in ex post financial settlements for the products to which they commit.

Ultimately, this approach can enable producers generating from renewables to be treated just like any other producer, competing for the same products and with the same risks and obligations as those assumed by producers using other technologies. Whenever a VRE generator requires support from the system because of one of the characteristics described earlier in this section, or whenever an agent provides additional flexibility or reliability support to the system, these services can be properly valued in a systemic manner in the form of one of the products defined in the market.

Energy is one type of product. Chile held technology-neutral auctions in 2017 for the energy to be produced during certain time periods (yearly, quarterly, day, night); auction winners had to sign a financial obligation guaranteeing supply of the committed products. Capacity is another product, one that contributes to a power system's security of supply. Owing to their variability, VREs have generally been overlooked as contributors to adequate capacity. However, depending on their characteristics and on the system's needs, renewable energy technologies can contribute to security of supply – especially when considered as a portfolio. In its new auction mechanism, Mexico encourages (to a certain extent) the use of renewable technologies in long-term capacity contracts. The capacity product ascribed to each plant is measured for a given year by its average generation during the hundred most critical hours of the system – that is, the hours when the difference between available capacity and electricity demand is lowest. Mexico also auctions clean energy certificates as one of its products.

Auctions for **ancillary services** may allow a portfolio of renewables to be committed to provide adequate supplies of various services, such as frequency response, voltage support, system reserves and fast response for ramping. Denmark, for example, has adopted this approach; large volumes of ancillary services have recently been supplied by wind turbines.

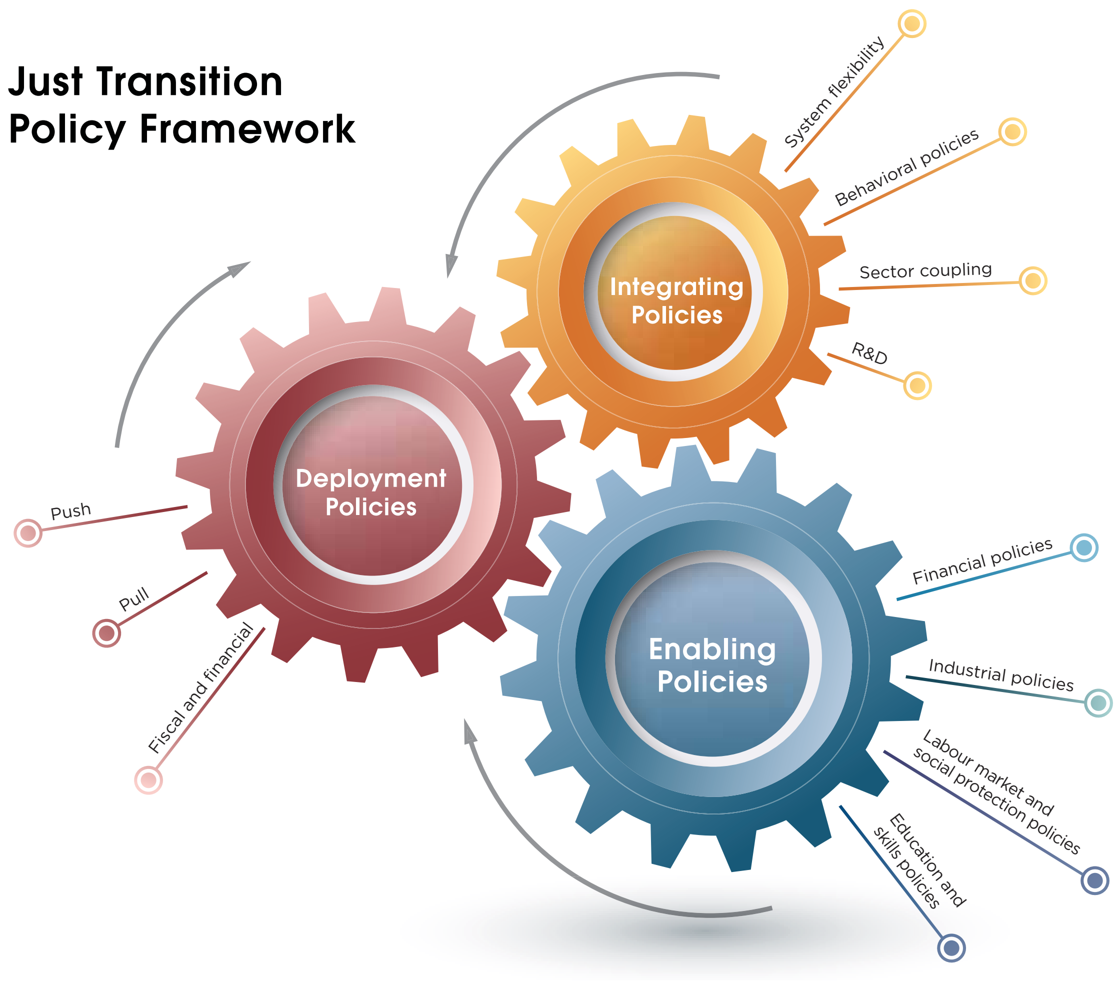
Finally, policymakers may decide to select more than one implementation strategy. For example, an offshore wind auction that is limited to selected sites (constraint-based strategy) may offer a premium on top of the market price (price-based strategy) as in Germany. Mexico's auction design incorporates elements of adjustment, price and product-based strategies.

5. SUPPORTING A JUST AND INCLUSIVE ENERGY TRANSITION

Although auctions can yield an economically efficient allocation of resources from a competitive market perspective, their outcomes can be less than optimal from other perspectives. For example, they may not produce a diversified landscape of actors or generate the shared benefits envisioned for a just and inclusive transition (Fell, 2019) - when such objectives are not integrated in their design. Indeed, purely price-centric auctions may lead to geographical clustering, crowding out small and medium project developers, centralising market power, and excluding communities from decision making processes (Fell, 2019; del Río and Linares, 2014). While auctions evidently have limitations, multiple design options are available to policy makers to reconcile deployment objectives with broader development goals.

This section analyses auctions as one way of pursuing a just and inclusive energy transition. It evaluates design elements intended to foster the development of local industries, create jobs, include small and new players, engage communities, and contribute to subnational development. These design elements, effective as they may be, are only part of a broader policy framework to ensure a more just and inclusive transition (IRENA, forthcoming) (Figure 12).

Figure 12: Broadening the policy framework to ensure a just and inclusive energy transition



5.1 INCLUSION OF SMALL AND NEW PLAYERS

Among the weaknesses of auctions is their tendency to favour large players that have the capacity –financial and reputational (*i.e*. related to past experience) – to compete, leaving out small and new players. Design elements can support the participation of such players, including newly established or small companies, communities, and co-operatives[5].

Under the **auction demand** category of design elements (see Box 1), a share of the total volume auctioned can be set aside for small/new players. An upper limit on project size may also increase their chances, in cases where they do not have the capacity to develop large projects. In the Indian state of Punjab's 2013 solar auction, for example, a portion of the demand (50 MW) was reserved for relatively small-scale projects (1-4 MW) for which only newly established companies could compete. The remaining 250 MW was reserved for well-established companies with project sizes of 5 to 30 MW (IRENA, 2015).

Under the same category, technology-focused auctions, which limit the pool of eligible projects, can encourage the participation of small-scale actors. In Germany's technology-neutral auctions, in which solar PV and onshore wind went head to head, solar PV projects were the winners, with price results of USD 46.7/MWh in April and USD 52.7/MWh in November 2018. At that time, wind contracts were being awarded in wind-specific auctions at prices in excess of USD 60/MWh. Wind was disadvantaged in this context, but the situation was even worse for small players, which stood no chance of competing with solar at such low prices. Another reason why site- and project-specific auctions may be more attractive to small players is that they require less documentation.

In terms of **qualification requirements**, site-specific documentation such as building permits may represent an obstacle for small-scale actors, which are more to participate in auctions where these requirements are relaxed. Part of the success of Germany's 2017-2018 wind auctions in attracting the participation of communities can be attributed to a relaxation of permitting procedures such that bidders could participate in the auctions before obtaining permits (Bundesministeriums für Umwelt Naturschutz und Reaktorsicherheit, 2017). Requirements to submit evidence of past experience and financial capability, reasonable as they are, also put small and new actors at a disadvantage. In some contexts, it may be enough to require bidders to submit evidence of their technical capacity to execute a given project as a condition for allowing them to compete in the auction.

5 *The size of the company can be determined by its revenues or number of employees.*

Among the design elements falling under the category of **winner selection**, selection criteria that go beyond price may crowd in smaller players. Small-scale developers may obtain higher scores for high percentages of community control and co-operation, diversity in the project development consortium, and partnerships with local organisations. In the South African REIPPPP, qualified bids are evaluated based on price (70%) and an economic development (30%) criteria. The economic development criteria establish thresholds of 30% and 5% for black and local community shareholders in the company, respectively. Moreover, a threshold of 10% for small, medium and micro enterprise procurement expenditure, among other criteria, is also established (IRENA, 2018a).

Inclusion of small/new players can also be promoted by limits on the number of projects or total volume that can be awarded to a single player. Colombia's auction used a Herfindahl-Hirschman Index (HHI) – a common measure of market concentration – to detect high concentrations of bids from a small number of players. In addition, small players and communities can be encouraged to participate by a preferential price rule for payment. In the German onshore wind auction, community projects are awarded a clearing price equivalent to the highest successful bid (while other bidders receive the price they bid). Ceiling prices above which bids are not considered may exclude small and new players by not offering them the chance to participate in the bid, even if, once all design elements are considered, they might have a chance of prevailing.

Under the category of **risk allocation and the remuneration of sellers**, a requirement of (excessive) financial guarantees (*i.e.* commitment bonds) may be only a minor barrier for large and established developers, but a very challenging one for smaller actors without financial track records. In Germany, the bid bond at the initial bidding stage was reduced for communities from EUR 30/kW to EUR 15/kW. With regard to project completion time, the German wind auctions also allow communities a longer project realisation period (Klessmann & Tiedemann, 2017).

Facilitating the participation of communities and small/new players in auctions is crucial for the development of local supply chains and industries.

5.2 DEVELOPMENT OF LOCAL INDUSTRIES

Among the main strengths of auctions is their potential to serve broader socio-economic development objectives in addition to the deployment of renewable energy capacity. The secondary objective most commonly sought is to foster local development through new industries and supply chains. This is perceived as especially important in a time when structural changes such as those promised by the energy transition disrupt traditional sectors, with implications for the economy and communities. To support nascent industries and to maximise local value creation by stimulating demand for locally sourced equipment and services, developers of large projects are often required or encouraged (through incentives) to employ a minimum threshold of local goods and services (UNCTAD, 2014).

Local content requirements (LCRs) have been introduced as part of the auction's **qualification requirements** to restrict participation to developers who comply to a predefined minimum threshold of local content (Steinhilber & Rosenlund, 2016).This has been the case in Brazil (as a requirement to receive development loans), Morocco, South Africa, Turkey, and the United Kingdom, among many others, and they have had a mixed outcome depending on policy design, potential, implementation and context. South Africa, for example, has had success in the wind tower segment, but has faced more challenges with turbine manufacturing, which is more technically demanding (IRENA, 2017). Morocco has created much of the local content in the form of construction jobs. LCR measures can be designed to be more or less flexible. In Argentina, foreign technology imports are permitted only where no local alternatives exist. For projects in which at least 60% of the materials are sourced locally, tax certificate regimes exist. LCR measures are most effective when included as part of a broader mix of policies related to trade, labour and strengthening of local industries (IRENA, 2014).

Auctions can also support local industries through their criteria for **winner selection**. Multi-criteria auctions can attribute higher scores to participants willing to draw on local value chains (Steinhilber & Rosenlund, 2016), as in China and South Africa.

Finally, local products can be supported by reserving a specific volume of **auction demand** for projects with high levels of local content. In the 2014 National Solar Mission auction in India, projects that used nationally manufactured equipment were auctioned separately.

Increasing the depth, length and diversity of renewable energy (and transition-related) supply chains is one of the crucial factors for maximising the benefits from the energy transition (IRENA, forthcoming). Where renewable energy is publicly misperceived as expensive or expected to crowd out competing industries, expanding opportunities for local economic development may increase the social acceptance of the auction scheme (del Río, 2017a). An initial step is to understand the material and human resource requirements of different technologies, to assess them in the context of existing domestic resources and capabilities, and to identify ways to maximise domestic value creation by leveraging and enhancing local industries (IRENA, 2017b).

5.3 LOCAL JOB CREATION

Job creation has emerged as one of the key indicators in the world's accelerating energy transformation. As more and more countries manufacture, trade and install renewable energy technologies, the sector has grown to employ 11 million people worldwide (IRENA, 2019b). This number could reach 40 million by 2050 under the IRENA roadmap to scale up renewables. Yet to ensure that the low-carbon transition is maximally just and inclusive, the positive effects of emerging employment opportunities have to be spread equitably among those affected by the transition. Renewable energy auctions can be designed to incorporate measures to strengthen their social and economic value for specific disadvantaged stakeholders, social groups or minorities, through job creation or other means.

An auction's **qualification requirements** can be configured to require that project proposals meet quotas or minimum thresholds related to the demographic or ethnic characteristics of the employment structure. In South Africa, these requirements entail thresholds for employees with South African citizenship, skilled and unskilled black citizens, and residents of local communities. In the auction conducted for the Turkish Renewable Energy Resource Areas (Yenilenebilir Enerji Kaynak Alanları, or YEKA), the winning bidder must employ local technical personnel for research and development, and 80% of the engineers employed on onshore and offshore wind projects must be of Turkish nationality.

Local employment quotas cannot be effective unless the workforce itself has the skills and knowledge needed to support the development of the sector. Among the examples of auction design elements that incorporate a focus on training and education is Denmark's auction for the Horns Rev 3 offshore wind farm, which required bidders to provide a certain number of traineeships in the construction of the farm (Wendering et al., 2015).

Auctions can also be designed such that the degree of job creation and levels of demographic or ethnic consideration can be evaluated and ranked together with bid prices as part of the **selection of winners**. In South Africa's REIPPPP auctions, projects exceeding target values for employment (stipulated as qualification requirements) are valued higher. Quantitative employment targets in auctions should be accompanied by qualitative dimensions, such as the duration of the newly created jobs and their significance for those employed. For instance, in the South African case, most of the unskilled labour provided by black citizens was short-term, while training, education and development needs were neglected (McDaid, 2016).

Governments may wish to review auction design elements to ensure that they do more than create short-term employment that does not bring sustained benefits, especially in the communities where projects are developed.

5.4 SUBNATIONAL DEVELOPMENT AND COMMUNITY BENEFITS

The geographical distribution of renewable energy capacity is to a large extent determined by the location and abundance of the underlying resources. Consequently, clusters or hotspots in regions rich in these resources tend to form. Although the overall macro-economic effects of low-carbon transitions are almost universally seen as positive, the regional concentration of projects can leave some stakeholders heavily disadvantaged. Auction design can facilitate the development of renewable energy projects in regions with sub-optimal resource endowments. In addition, auction design can encourage the participation of communities so as to maximise benefits, improve regional development and enhance the equity and inclusiveness of the low-carbon energy transition.

Regional development and community participation should go hand in hand. Proof of that is the Mexican case, where the development of renewable energy projects in some regions was accompanied by socio-economic tensions, as most of the project sites lay within indigenous territories (del Río, 2017b). Renewable energy projects accompanied by processes to ensure community participation in planning convey procedural fairness and result in planning processes that are perceived as more transparent (Firestone et al., 2018). Steps like these can enhance the social acceptability of renewable energy projects while also yielding economic and social benefits for the community.

Regional development can be pursued through design elements falling within the **auction demand** category. By conducting zone-, site- or project-specific auctions, the auctioneer can pre-select the sites and regions that best suit policy objectives. Likewise, by limiting the participant pool and selecting technologies in which a given region has a comparative advantage, technology-focused auctions can increase the chances that projects will be awarded in regions that would otherwise not be able to compete. Establishing socio-economic benefits as **qualification requirements** can also support regional and community development. In such cases, developers must demonstrate that their projects will have socio-economic spillovers for a given region. In El Salvador, for example, the 2014 tender for 100 MW of solar and wind power required developers to invest 3% of their revenue in social projects in the adjacent communities (REN21, 2017).

Winner selection criteria can also be adjusted to enhance regional development and community benefits. Through a multi-criteria evaluation, projects in desired locations can be awarded additional points and thus have a higher chance of winning. In Mexico's 2017 auction, bids from projects in preferred regions were adjusted using a correction factor. In the first auction, bids in favoured regions could be evaluated as if they were cheaper (by USD 34.3/MWh), while less preferred regions where penalised (by USD 8.4/MWh. In Germany's 2015 solar PV auction, large-scale projects were incentivised to deploy projects in industrial zones rather than to use land with alternative or potential agricultural uses.

6. CONCLUSIONS

Renewable energy auctions continue to support the deployment of renewable-based power, revealing competitive prices in many regions of the world. Solar PV and wind are the most widely auctioned technologies, accounting for 97% of the total volume of auctions in more than 50 countries in 2017 and 2018. Almost half of those were newcomers to auctions, mainly African countries driven by an abundance of solar resources and falling technology costs, or West and Central Asian countries rich in solar and wind resources. Global prices for solar PV power continued their downward trend, albeit at a slower rate, while onshore wind power showed a slightly higher average global auction price in 2018 compared to the year before.

Beyond their potential to achieve low prices, renewable energy auctions are increasingly used to achieve objectives beyond price. Indeed, auction design elements can provide an effective way for countries to integrate other practical or policy objectives. Such objectives can include ensuring timely project completion, integrating solar and wind power, and supporting a just and inclusive energy transition.

Underperformance at key stages of an auction – bidding, contracting, construction or operational – can hinder project timely completion. While certain design elements ensure higher rates of completion, policy makers must find a balance between inclusive, flexible participation requirements, with some risk of delay or underbuilding, and overly strict ones that may discourage potential bidders, reducing competition. In Germany, for example, onshore wind auctions have been undersubscribed following a re-design requiring projects to obtain permits before bidding. Likewise, strict compliance rules can deter small or new players, reducing inclusiveness.

Auctions can be designed to include small and new players, nurture domestic industries, create jobs, engage communities and contribute to subnational development. Key design elements in this regard include qualification requirements (*e.g*. setting a minimum local content threshold) and winner selection (*e.g*. giving higher scores for community benefits or enhancing regional development), as in Morocco and South Africa.

A just and fair energy transition requires a different approach to technical and economic design of energy and power systems. Also, integrating large shares of variable renewable energy (VRE) – namely wind and solar PV power – calls for specific measures.

Specific characteristics of VRE technologies affect power system operation. Auctions, however, can strengthen VRE integration by ensuring procurement of the system-friendliest power plants. Every auction design type offers options to support different strategies, depending on the degree of central planning in the power market. Winner selection, for example, can be designed to prioritise the lowest system-integration cost, as in Brazil. Risk allocation and seller remuneration rules can guarantee higher revenues to the operators able to produce energy when and where it is more needed, like in most European auctions.

Renewable energy deployment – along with transition-related investments – opens the possibility to achieve broader development and socio-economic aims. Auctions design elements can further accommodate such aims, particularly when combined with other enabling measures, such as financial, industrial, labour and education policies.

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RENEWABLE ENERGY AUCTIONS
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