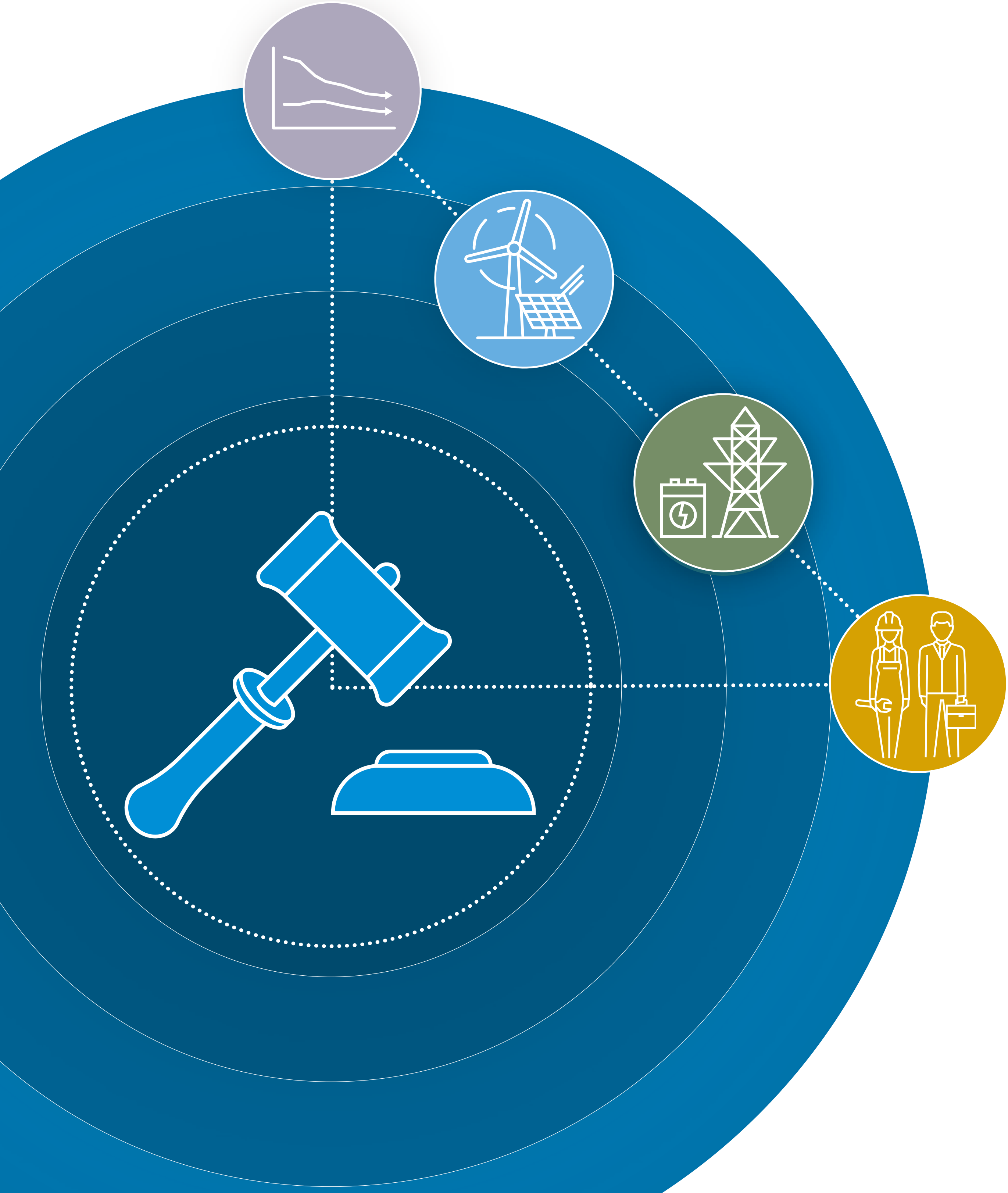
International Renewable Energy Agency

RENEWABLE ENERGY AUCTIONS

STATUS AND TRENDS BEYOND PRICE



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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

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INTRODUCTION

As the renewable energy sector matures, policies must be adapted to reflect changing market conditions, new technical and socio-economic challenges, and the need for an inclusive, just transition well beyond the energy sector. Falling costs for new technologies, the growing prevalence of variable renewables (*i.e.,* solar and wind) in the power system, and greater policy emphasis on economic, social and environmental objectives have altered 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 electricity based on renewables at the lowest possible price, while simultaneously fulfilling other social or economic objectives.

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

Four years after IRENA's first report on the topic, auctions were achieving record-breaking low prices for solar and wind power. **Renewable Energy Auctions: Analysing 2016** (IRENA, 2017a) analysed the factors behind those new price lows, including aspects of auction design. Additionally, at the regional level, **Renewable Energy Auctions: Cases from sub-Saharan Africa** (IRENA, 2018a), analysed recent auctions in South Africa, Uganda and Zambia. Collectively, these studies can serve as a reference for renewable energy auction design around the world.

ABOUT THIS STUDY

The present report focuses on how to design auctions to achieve objectives beyond price discovery. Auctions designed in innovative ways can help to achieve specific national goals, beyond solely procuring electricity at the lowest price. Such goals might include ramping up solar and wind power; integrating higher shares of those sources into the grid; ensuring greater participation by communities, small companies or new market entrants; and maximising the socio-economic benefits of renewables, including job creation. Alongside such diverse aims, ensuring timely project completion remains a paramount objective.

1

RECENT TRENDS IN RENEWABLE ENERGY AUCTIONS

Renewable energy auctions are becoming increasingly popular, owing chiefly to their ability to reveal competitive prices. Moreover, flexibility in their design allows them to be tailored to country-specific conditions and objectives beyond price discovery. In 2017-2018, some 55 countries used auctions to procure renewables-based electricity, raising the number of countries that have held at least one auction for renewables to 106 by the end of 2018 (REN21, 2004-2019; IRENA Database, n.d.).

One-third of the 55 countries had no previous experience with auctions. The decision of these newcomers to adopt auctions was likely driven by the reported success of auctions in other markets in attaining low prices while achieving other goals.

This chapter begins with a global overview of auctions in terms of the total volumes auctioned, classified by technology, along with global average prices for solar photovoltaic (PV) and onshore wind (Section 1.1).

Section 1.2 describes regional trends, while Section 1.3 analyses the factors behind trends in prices.

Section 1.4 provides an updated framework for auction design and discusses trends in design elements of auctions conducted around the world between 2017 and 2018.

When analysing the price results, an important factor to consider is the trade-off between obtaining low prices and achieving other objectives. This is done in this chapter for both solar PV and onshore wind auctions held in 2017-2018. Subsequent chapters in this report analyse design elements that can be used to achieve objectives beyond price reduction. Those objectives include ensuring projects are delivered on time, integrating higher shares of variable renewable energy, and supporting a just and inclusive energy transition.

Unless otherwise stated, the source of the figures in this chapter is a database consisting of information obtained from IRENA, Bloomberg New Energy Finance (BNEF) and PSR Energy Consulting and Analytics.

1.1 GLOBAL OVERVIEW AND PRICE TRENDS

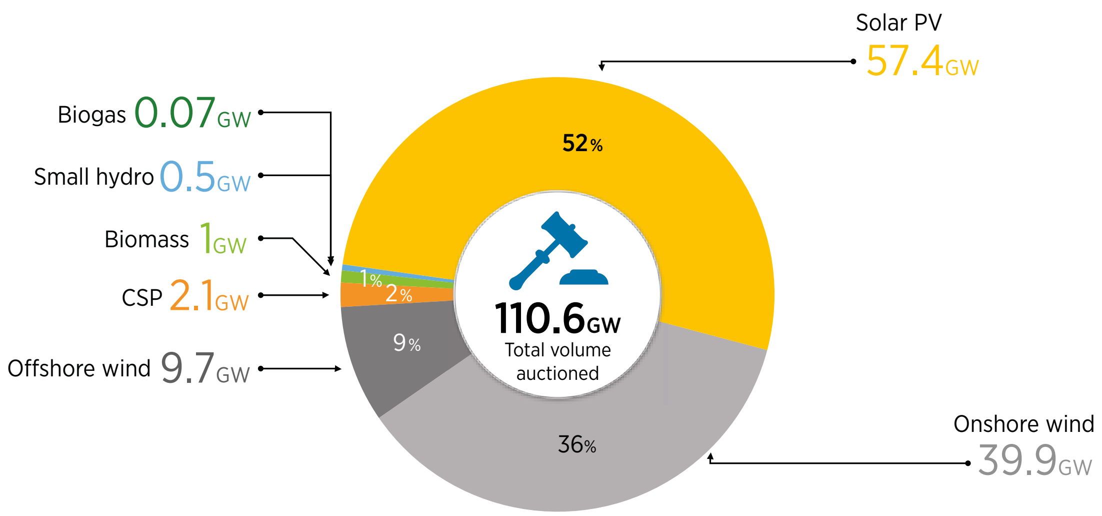
Most renewable energy auctions still focus on mature and cost-competitive power generation technologies. An estimated total volume of 111 gigawatts (GW) of electricity was auctioned (or announced) in 2017-2018, with solar PV and onshore wind accounting, respectively, for more than one-half and more than one-third of the total volume (Figure 1.1). Offshore wind has seen a substantial increase in auctioned volume, and auctions for concentrated solar power (CSP) were held in three countries, two of which were new to the technology.

The potential of auctions to achieve low prices has been a major motivation for their adoption worldwide. As Figure 1.2 illustrates, price results for solar and wind auctions have decreased overall in the past decade. In 2010, solar energy was contracted at a global average price of almost USD 250/MWh, compared with the average price of USD 83/MWh in 2016. Wind prices also fell during that period, albeit at a slower pace (since the technology was more mature in 2010). The average price in 2016 was USD 50/MWh, down from USD 75/MWh in 2010.

Falling technology costs during the period led policy makers around the world to consider auctions as a way of determining the market price of renewables in their specific context and avoiding windfall profits for developers. This downward trend continued in 2017. In 2018, solar PV prices continued to fall, though at a slower pace, reaching USD 56/MWh in 2018. Onshore wind prices rose, reaching USD 48/MWh (up from USD 43/MWh in 2017).

Figure 1.2 illustrates global average price results for solar PV and onshore wind auctions held between January 2010 and December 2018. These yearly weighted averages are obtained by averaging out the auction outcomes of countries with differences in terms of macro-economic context, energy policy and auction design, among many other factors.[1] The mix of countries that make up the sample each year is always changing, particularly as more and more newcomers adopt auctions. Moreover, in analysing trends, it is important to note that an outlier in the sample can potentially influence (weighted) average prices significantly. This is particularly true when the sample is small.

Figure 1.1 Share of the total volume of renewable energy auctioned in 2017-2018, by technology

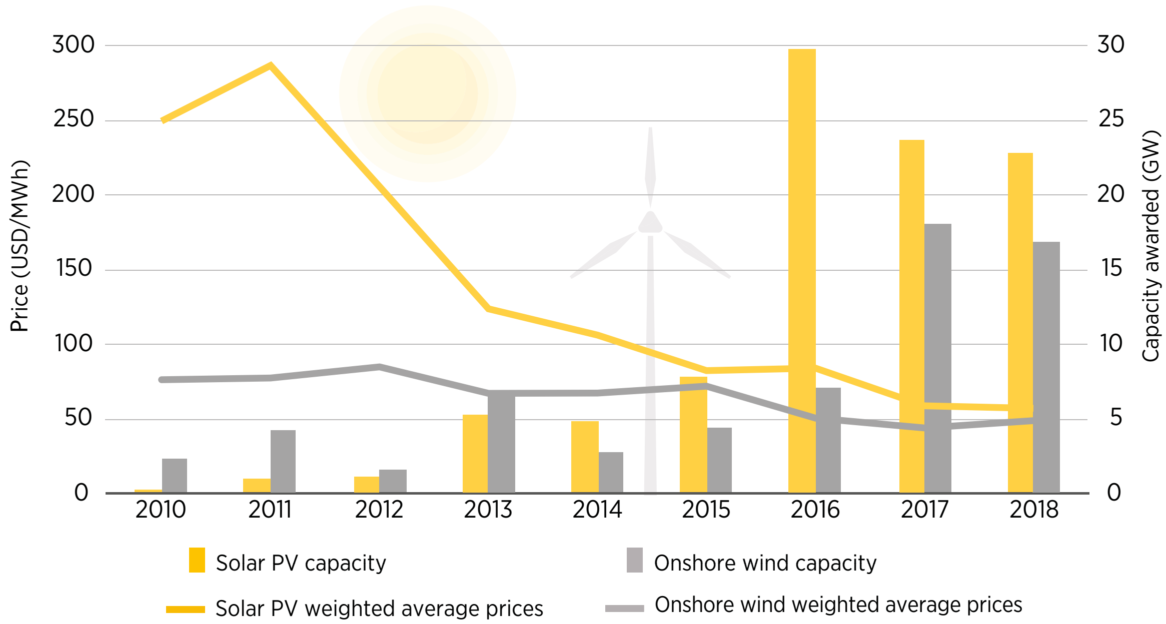


Notes: PV = photovoltaic, CSP = concentrated solar power and solar thermal. Preliminary findings presented by IRENA in June 2019 reported a total volume auctioned of 97.5 GW through June 2018. This report also extends to the end of 2018.

Source: IRENA Database, n.d., based on BNEF, 2019a and PSR, n.d.

[1] *The global weighted averages are calculated by averaging each country's auction prices, adjusted by the volumes (capacity) awarded.*

Figure 1.2 Global weighted average prices resulting from auctions, 2010-2018, and capacity awarded each year



Source: IRENA Database, n.d., based on BNEF, 2019a and PSR, n.d.

Notes: This figure shows awarded volumes, while Figure 1.1 shows auctioned volumes. The graph depicts awarded weighted average global prices from auctions between January 2010 and December 2018, excluding feed-in-premium auctions. The latter are discussed throughout the report, but are not part of these calculations. The same is true of results from 2019 auctions.

In **Brazil**, for example, a remarkable price decrease for onshore wind from USD 28.96/MWh in December 2017 to USD 18.58/MWh in April 2018 can be explained by one aggressive bidder being awarded the entire demand (114 MW). In the subsequent auction (August 2018), with more capacity awarded (1,251 MW) and more firms participating, the average price increased (to USD 24.86/MWh), returning to the trend that previous auctions had followed. Hence, the April 2018 auction can be considered an outlier, which could have had a greater impact on the global trends had the awarded capacity been greater. Thus, the analysis and discussion on average prices provide valuable insights, but they are not perfectly comparable over time or across countries (IRENA, 2017a).

Between 2017 and 2018, nearly half of all solar PV auctions were held in South and East Asia and the Pacific, with almost one-third occurring in Europe (Figure 1.3).

India alone allocated 17 GW of solar PV capacity at an average price of USD 42.3/MWh[2] (BNEF, 2019a). Likewise, **China** awarded 5 GW of solar PV at an average price of CNY 427/MWh (USD 64.6/MWh) in a total of 10 auctions (Climatescope, 2018). The **Philippines** received bids as low as PHP 2,339/MWh (USD 43.9/MWh)[3] in a 50 MW auction (Bellini, 2018a). Indeed, in South and East Asia and the Pacific, solar PV is becoming competitive with traditional energy sources owing to high levels of solar irradiance and the falling cost of the technology.

Onshore wind auctions were most popular in Europe, followed by South and East Asia and the Pacific. **Germany** alone auctioned more than 5 GW in seven rounds over this period at an average price of EUR 51.65/MWh (USD 58.7 MWh).[4] Offshore wind auctions saw considerable uptake in Europe, led by **Germany** and the **United Kingdom**.

[2] *When neither the exchange rate or the date are specified, the USD value is taken from the reference.*
[3] *1 USD = 53.28 PHP in August 2018.*
[4] *1 USD = 0.879995 EUR on average in 2017 and 2018.*

Biomass auctions were mainly concentrated in Europe and the Americas. **Argentina** awarded 143 MW of biomass at an average price of USD 107.5/MWh under the second round of the RenovAr program. CSP was auctioned mainly in Central and Western Asia, specifically in the **United Arab Emirates**, where Dubai awarded 700 MW at a price of USD 73/MWh (DEWA, 2018). The contract was later amended to add 250 MW of solar PV at a price of USD 24/MWh, increasing the total capacity to 950 MW.

1.2 REGIONAL TRENDS

A closer look at regional trends shows a concentration of newcomers in Africa and Asia, while other regions gain more experience in the use of auctions and experiment with innovative designs.[5]

Most **African** countries that held renewable energy auctions in 2017-2018 did so for the first time. Their choice was driven by three characteristics of auctions:

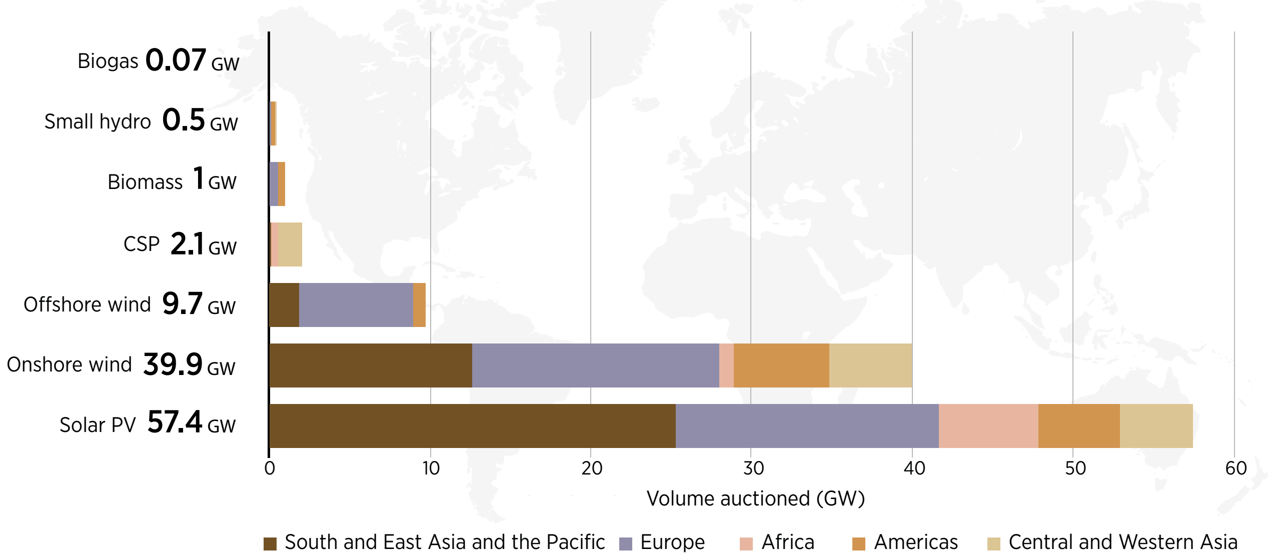
1) their potential for price discovery, especially when there is uncertainty regarding how to price renewable-based generation (*e.g.*, if they were to adopt a feed-in tariff (FiT));
2) the ease with which they can be tailored to a particular context or policy purpose; and
3) their ability to attract private investment, domestic and foreign, through clear and transparent processes.

Along these lines, the positive experience that pioneers such as Morocco and South Africa have had provides many lessons that can be shared (IRENA, 2018a, 2013).

African auctions were dominated by solar PV in 2017-2018 (Figure 1.4), with Algeria, Egypt and Morocco playing the major roles. In addition, the Scaling Solar Program was successful in attracting investments in Ethiopia, Madagascar, Senegal and Zambia (see Box 3.1).

Most of the countries in the **Americas** have considerable experience with auctions. In Latin America, Brazil, Peru and Uruguay were early adopters. More recently, Argentina, Chile and Mexico have joined the trend of innovating with auction designs: Argentina regarding guarantees backing up contracts and mitigating risks; Chile and Mexico regarding system integration. Colombia is the most recent adopter, driven by the success of auctions in neighbouring countries and a conducive market structure.

Figure 1.3 Volume auctioned between January 2017 and December 2018, by technology and region (GW)



Note: PV = photovoltaic, CSP = concentrated solar power and solar thermal.
Source: IRENA Database, n.d., based on BNEF, 2019a and PSR, n.d.

[5] *The regions selected for this analysis are based purely on geographic distribution of countries.*

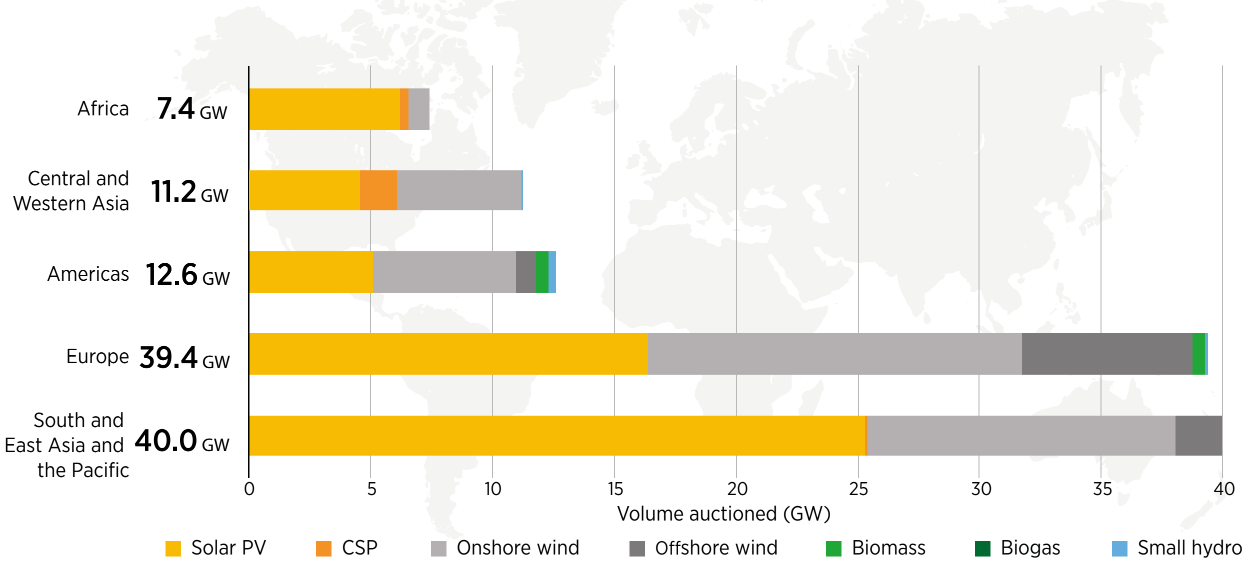
Several countries in Central America (*e.g.*, Honduras and Belize) held auctions before 2010, but some have suspended their programmes in recent years. Canada and the United States continue using auctions at the subnational level with an increasing scope. In the United States, auctions are mainly conducted by public or private utilities. A variety of technologies beyond wind and solar appear in auctions in the Americas, thanks to the availability of biomass (Brazil), hydropower (Brazil) and biogas (Argentina) (Figure 1.4).

Across the **Asian** continent, countries' experience with auctions is varied. Most countries in Central and Western Asia are newcomers, but some countries, such as the United Arab Emirates, have had previous experience. In terms of technology, the focus was on onshore wind, dominated by Turkey, followed by solar PV (Figure 1.4). Solar 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 their potential to yield 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. Growing demand for energy, abundant solar resources and cost-competitive PV technology have led many newcomers in South and East Asia to turn to auctions. Malaysia, the Philippines, Thailand and Viet Nam are good examples (IRENA, 2018b). Japan has switched to auctions from administratively set FiTs to reduce the cost of supporting solar PV. Meanwhile, China and India have been holding at least 10 renewable auctions per year. In terms of technology, the region has mainly focused on solar PV, followed by onshore wind and, recently, a boom in offshore wind (Figure 1.4).

In **Europe**, newcomers included contracting parties to the Energy Community Treaty (*e.g.*, Albania and Montenegro). 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 2014-2020, which establish market-based mechanisms such as auctions as the main instrument of support for renewables.

Figure 1.4 Volume auctioned between January 2017 and December 2018, by region and technology (GW)



Note: PV = photovoltaic, CSP = Concentrated solar power and solar thermal.
Source: IRENA Database, n.d., based on BNEF, 2019a and PSR, n.d.

The guidelines favour competition between renewable technologies but explicitly allow for technology-specific auctions. Countries with extensive experience also conducted auctions in that time period (*e.g.*, Denmark, France, Germany, the Netherlands and Spain). The next section provides a deeper look at price trends observed in the period 2017-2018. Section 1.4 focuses on trends in auction design.

1.3 PRICE TRENDS

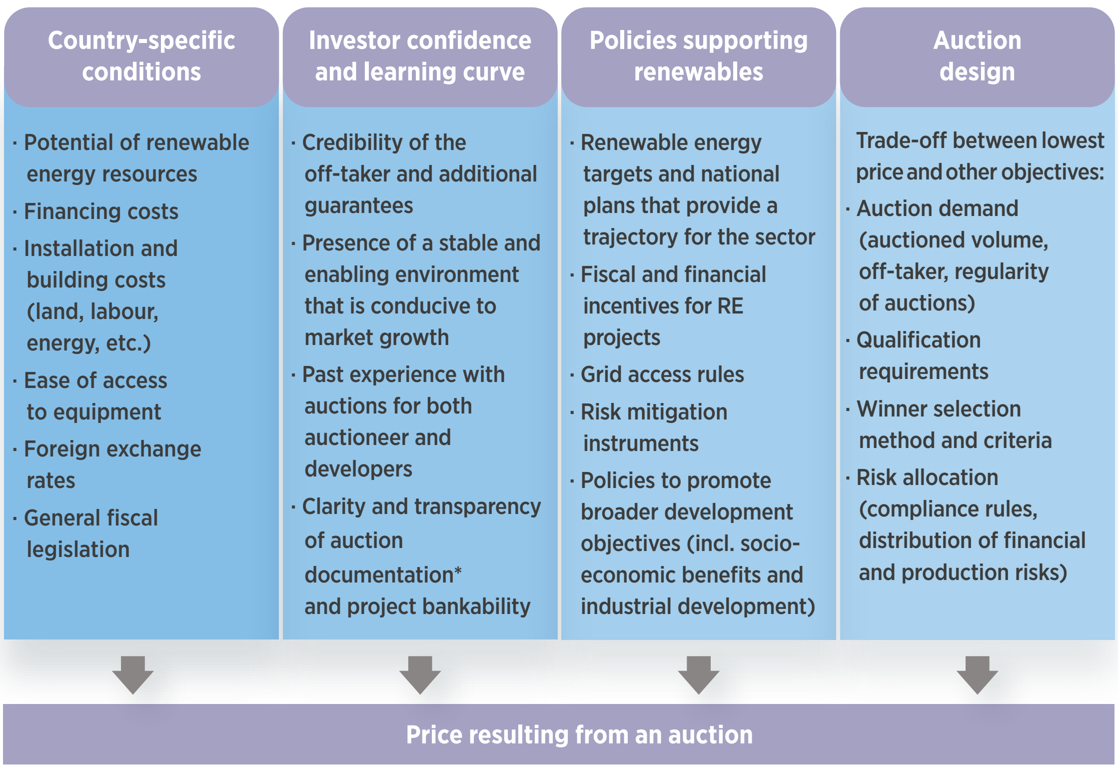
As analysed in IRENA's *Renewable Energy Auctions: Analysing 2016*, many factors shape the prices that emerge from auctions. They can be grouped into four categories: 1) country-specific conditions such as resource availability, power market design and the costs of finance, land and labour; 2) the degree of investor confidence related to, for example, the experience of the bidder and auctioneer, and credibility of the off-taker; 3) other policies related to renewable energy, including clear targets, grid policies, priority dispatch, and 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 1.5).

Price trends for solar PV

As seen in Figure 1.2, global average prices for solar PV decreased sharply between 2010 and 2017, followed by more stable prices afterwards. The steep decrease was driven mainly by a steady decline in the price of solar panels, which fell to a quarter of their initial price over the period (IRENA, 2018c). Increases in investor confidence, developers' experience and competition in auctions also contributed to the decline.

One possible reason for the stability of average global prices during 2017-2018 could be the overall maturity of the sector. In addition, experience with previous auctions, along with the adoption of strict compliance rules, may have led developers to bid less aggressively.

Figure 1.5 Factors that impact the price resulting from auctions



*The Open Solar Contracts by IRENA and Terawatt Initiative provide freely available standardised contract documentation designed to streamline project development and finance processes for solar PV projects (see Box 1.8).

Source: Adapted from IRENA, 2017a.

In some countries, once the most profitable projects have been awarded – *i.e.,* those located in the most favourable sites – it is natural for prices to plateau. The plateau may also reflect a larger share of auctions resulting in higher prices in the overall volume of PV auctioned globally (see Figure 1.5 for factors affecting prices). Nevertheless, there are opportunities for further cost reduction, for example, through economies of scale and increased research and development.

Between 2017 and 2018, **China** (5 GW) and **India** (17 GW) exerted a strong influence on global average prices, as they were responsible together for 39% of the solar PV capacity auctioned (Boxes 1.1 and 1.2).

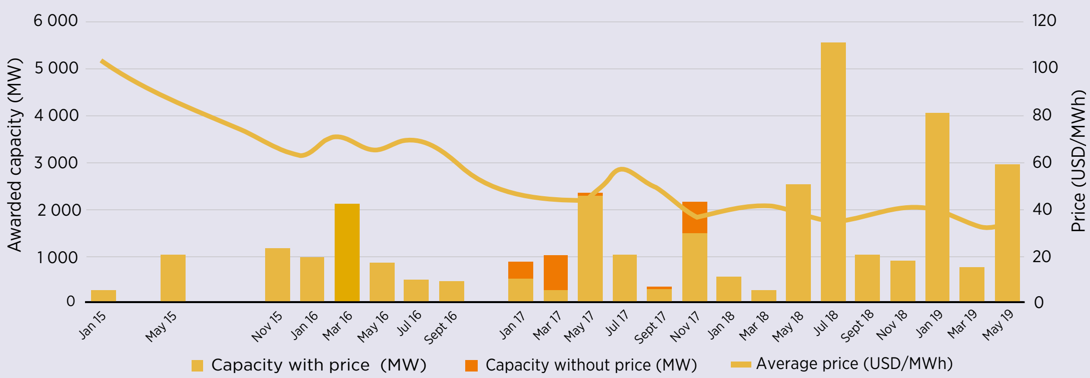
In the rest of the world, auction price outcomes varied greatly over 2017-2018. On the one hand, record low prices continued to be undercut. **Mexico** awarded the equivalent of 3 TWh at USD 20.80/(MWh + Clean Energy Certificates) (BNEF, 2019a; PwC, 2018).[6]

BOX 1.1 PRICES FROM INDIA'S 2017-2018 SOLAR AUCTIONS

In 2018, auctions for solar PV (and wind) rose dramatically from prior years, accompanied by lower bid prices. In July 2018, a price of INR 2.44/kWh (USD 35.42/MWh)[a] was registered in the 600 MW solar auction held by the Solar Energy Corporation of India (MNRE, 2018), but subsequent auctions in 2018 yielded relatively higher prices for a few reasons. First, several were state auctions, which have higher off-take and project development risks as financially stressed distribution companies can delay or cancel payments to developers (Atal *et al.*, 2018) (see Indian case study in IRENA, 2017a). Second, the imposition of a 25% safeguard duty that took effect on 31 July 2018, coupled with volatility in the Indian rupee in 2018, deepened developers' uncertainty. These factors largely offset the steep reduction in module prices (from USD 0.33/kW to USD 0.21/kW) over the course of 2018 (Singhvi, 2019).

Tender issuance remained strong through the second quarter of 2019, accounting for over 24 GW (Nandamuri, 2019). However, many recent tenders have been cancelled or undersubscribed (see Section 2.1 for definition). High tariffs and wide tariff gaps between winning bids are the reasons for cancelling auctions. Meanwhile, the low tariff caps set for several auctions – together with land and transmission bottlenecks, payment delays by distribution companies, and steps by some state governments to renegotiate existing power purchase agreements – are all contributing to reduced participation in auction rounds.

Figure 1.6 Auctioned capacities and resulting prices from solar auctions in India, 2015-2019



[a] 1 USD = 68.7 INR in July 2018.

Source: BNEF, 2019a.

[6] *Mexican auction prices are typically comprised of bundles of two products: energy and Clean Energy Certificates (CEC). For instance, one of the wind bids in the third auction can be broken down as following: USD 17.7/(MWh+CEC) = USD 11.8/MWh + USD 5.9/CEC (PwC, 2018).*

BOX 1.2 ENABLING ENVIRONMENT DRIVING SOLAR PV PRICES DOWN IN CHINA'S AUCTIONS

Under the Top Runner programme, China held a total of 10 auctions in 2018, awarding 5 GW in solar PV contracts at an average price of CNY 427/MWh (USD 64.6/MWh) (Climatescope, 2018) – a 48% decrease from the average price in the 17 auctions conducted in 2016 (USD 123.65/MWh). The main drivers for the decrease in price were 1) conducive land-use policies for renewables, 2) competitive interest rates on loans and 3) government commitments to low curtailment.

First, regarding land-use policies, some local governments have fixed the land rental price for 20 years in pre-determined areas for auctioned projects. The land rental costs are 80% to 90% cheaper than in other locations, particularly in and around cities in eastern China. Yet, demand for electricity is largely focused on those cities, requiring new transmission infrastructure, the cost of which is borne by the state-owned transmission system operator.

Second, loans at reduced interest rates have also helped to reduce auction prices. In 2017, the National Energy Administration (NEA) asked financial authorities for a 10% reduction in loan rates (from around 4.9% to 4.4%) for renewable energy projects. It also requested a reduction in some local taxes. Consequently, local governments exempted renewable projects from urban land-use taxes or expenses, which can account for up to 5% of the total investment cost of solar PV plants.

Third, the NEA addressed curtailment concerns, bolstering investors' confidence and further reducing prices. In the wake of a national average curtailment rate of 10% for solar PV in 2016 (BNEF, 2019b), NEA required local authorities and system operators to commit to less than 5% curtailment for all auctioned projects.

Source: National Energy Administration, 2017.

Saudi Arabia (USD 23.4/MWh), **Egypt** (USD 27.50/MWh) and **Jordan** (USD 28.00/MWh) achieved similarly competitive prices. Near the end of 2019, further reductions were recorded in **Dubai**'s 900 MW auction (USD 16.9/MWh). In **Portugal**'s 1.15 GW auction, more than half of the volume was awarded at around USD 16.54/MWh (EUR 14.76/MWh)[7] (PV Magazine, 2019a, 2019b).

On the other hand, some newcomers to auctions started out with relatively high prices. **Greece** recently switched from a fixed feed-in tariff scheme to auctions. Three rounds have been carried out so far (in addition to the 2016 pilot auctions), and average prices dropped from EUR 77.95/MWh (USD 92/MWh) for 53 MW to EUR 62.78/MWh (USD 70.6/MWh) for 143 MW within two years (Tsagas, 2019a).

The experience from the initial auctions has helped increase the confidence of international project developers and financiers in further rounds, driving prices downward.

The novelty of auctions as an instrument for procuring renewable energy is not the only element shaping risk perception. Risk is an important element. The risks, real or perceived, attached to the institutional, economic and political framework of a country plays an important role. Linked to the perception of risk is also the readiness and maturity of the renewable energy sector itself, which is reflected in auction prices. The Scaling Solar Program is designed to mitigate these kinds of risk, by offering packages of technical support, document templates, preapproved financing, insurance products and guarantees (see Box 3.1).

Price trends for onshore wind

As seen in Figure 1.2, average global onshore wind prices have experienced a less regular trend. Following a spike in 2015, prices decreased between 2015 and 2017, followed by an increase in 2017-2018. Most of that increase reflects the fact that high-price countries constituted a larger share of the wind volume auctioned globally (see Figure 1.5 for factors affecting prices).

[7] 1 USD = EUR 0.892 in August 2019.

As with solar PV, the participating countries include some newcomers, for which prices typically start out higher than in markets with established auctions, as well as countries with generally higher perceived risks in addition to the factors described in Figure 1.5.

In **Germany**, where 13% of the global onshore wind capacity was awarded, average prices rose from EUR 38/MWh (USD 42/MWh) in May 2017 to EUR 62.6/MWh (USD 71.95/MWh) in October 2018, before stabilising at EUR 61/MWh (USD 68.32/MWh) in February and May 2019 (see Figure 2.2).[8] The price increase may be a result of changes in permitting procedures and suitability of sites related to, for instance, public opposition, radar issues and bird protection (Wehrmann, 2019). In addition, changes in auction design, particularly relating to the removal of preferential rules previously granted to community projects, may have led to undersubscription and reduced competition (see Box 4.3).

Despite the increase in average prices, onshore wind also chalked up some record-breaking low prices between 2017 and 2018. **Mexico** awarded the equivalent of 2.5 TWh at an average price of USD 18.62/(MWh + CEC) in the third round in late 2017 (BNEF, 2019a; PwC, 2018). This represented a decrease of 48% from the previous auction, held the year before (USD 35.77/(MWh + CEC)). The first auction (2016) awarded bids at an average of USD 55.33/(MWh + CEC) (IRENA, 2017a; Garcia and Pinzon, 2016). Nonetheless, the new administration decided not to stage a fourth round in 2018 (Box 1.3). This case demonstrates the importance of a stable policy framework backed by strong political commitment for ensuring the long-term success of a chosen policy instrument.

1.4 IDENTIFYING TRENDS IN AUCTION DESIGN ELEMENTS: AN UPDATED FRAMEWORK

IRENA's 2015 report, *Renewable Energy Auctions: A Guide to Design*, presented a framework for designing auctions that classified design elements into four main categories: auction demand, qualification requirements, winner selection process and sellers' liabilities (IRENA and CEM, 2015). An updated framework reflecting developments and lessons learned since 2015 in the fast-changing renewable energy sector is presented in Figure 1.7 and explored in the following sections.

[8] 1 USD = 0.904 EUR on average in May 2017; 1 USD = 0.870 EUR on average in October 2018; 1 USD = 0.893 EUR on average in February and May 2019.

BOX 1.3 UNCERTAINTIES SURROUNDING MEXICO'S ELECTRICITY MARKET

The first three long-term auctions held in Mexico in 2016 and 2017 attracted over USD 8 billion in investments and contracted over 7.4 GW of mostly solar and wind projects. However, by late 2018, the momentum had slowed, as the new federal administration cancelled the fourth auction, which had already been announced, along with tenders for two transmission lines. In 2019, medium-term auctions for capacity, transmission rights, and clean energy certificates (CECs) were also cancelled. All had been pillars of a redesigned and liberalised wholesale electricity market.

The cancellation of these auctions aligns with the new National Electricity Plan, which aims for self-sufficiency from non-privatised energy assets. The only renewable energy technology included in the budget for 2019 was hydropower, with funds allocated to increase the capacity of the state-owned Federal Electricity Commission's (CFE) plants. Beyond hydropower, renewables played a negligible role in the government's plan. The 2019 budget mainly included investments in combined cycle thermal plants, coal-fired plants, conventional steam power stations and diesel power plants.

Private clean energy developers may now have less incentive to deploy new capacity. Initially, only new clean energy plants were entitled to receive and sell CECs. However, if the Secretariat of Energy's proposal to change regulation of CECs is accepted,[a] existing clean energy plants would become eligible to receive them. This would allow CFE generation subsidiaries to obtain CECs for its current hydro, geothermal and nuclear plants. While clean energy generators that were awarded contracts in the first three long-term auctions have secured a price for CECs for 20 years, the increased supply of CECs would decrease their market value for other players. Retailers, particularly the CFE subsidiary that dominates the market, would find it easier to comply with the renewable portfolio standard, set at 5% in 2018 (and set to increase in subsequent years). However, lower CEC prices would weaken the instrument's effectiveness in attracting new generation investments.

These decisions intensified uncertainty regarding the continuation of Mexico's clean energy programme. In June 2019, a private-sector renewable energy auction was announced. It is expected to attract the same developers that expressed interest in the government's cancelled auction. The products to be auctioned will be energy, capacity, energy balancing and CECs, for 5, 10 or 15 years. To address cpncerns about credit-worthiness, an administrator was appointed to manage payments and guarantees. Later in 2019, a second private-sector auction platform was launched, opening registration to potential participants. The private auctions rely on corporate power purchase agreements (PPAs) to allow direct contracting between energy generators and firms under the corporate sourcing model (IRENA, 2018d). This procurement model was available in Mexico before the 2013-2014 structural reforms that mandated centralised renewable energy auctions.

[a] The proposal was still under review by the time of publication.
Sources: BNEF, 2019c; CENACE, 2019; CONAMER, 2019; Mirec, 2019.

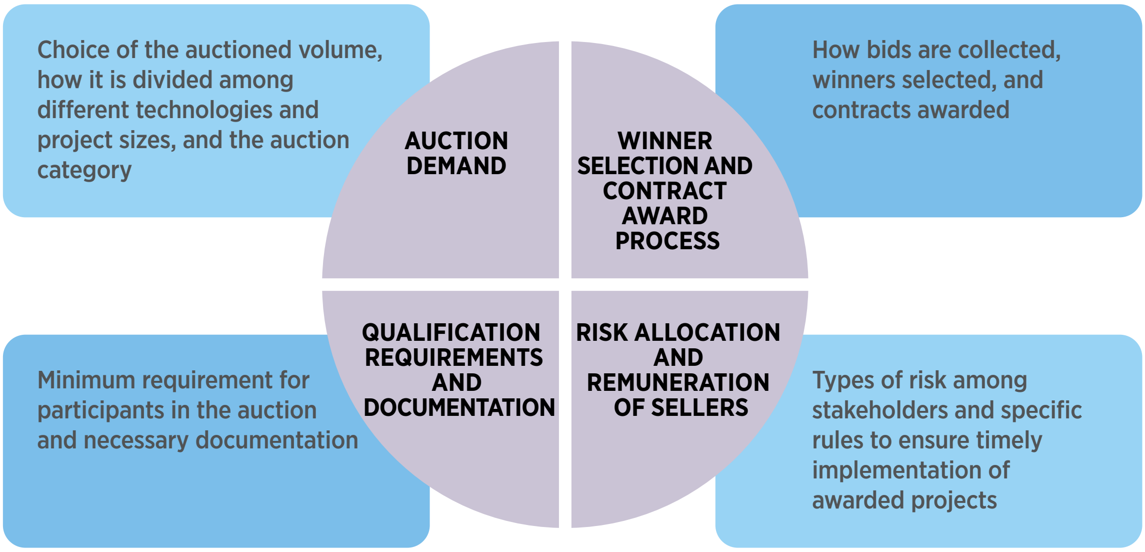
1.4.1 Auction demand

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 (*e.g.*, energy, capacity, green certificates, ancillary services or a mix);
2) whether and how the total demand is to be split among different bands (technologies, zones, sites or generation profiles);
3) the volume of product to be auctioned and the lower and upper limits on project size;
4) whether a pre-set auction schedule will be adopted and, if so, the schedule of future auctions; and
5) responsibility for demand-side commitments, including the selection of the contract off-taker.

IRENA and CEM (2015) provides details on each design element.

Figure 1.7 Updated framework of auction design



Source: Updated from IRENA and CEM, 2015.

Areas where new trends in auction design have been observed are discussed below. Those trends are in how the demand can be split (demand bands) and the product to be auctioned.

Technology specificity

In deciding how to split products and volumes, auctioneers must choose between technology-neutral or technology-specific auctions. The two strategies serve different deployment purposes. Technology-neutral auctions allow multiple technologies – including conventional sources – to compete, with the aim of identifying which will yield electricity at the lowest price. Technological neutrality has been especially popular in Latin America, but some countries have begun to shift towards technology-specific auctions to support the introduction of renewable energy into the mix. In **Brazil**, where technology-neutral auctions were meant to ensure capacity additions at competitive costs, sharper lines are now being drawn between renewable and conventional technologies (IRENA, 2017a). A variant of technology-neutral auctions that includes only renewable technologies is designed to identify the most cost-competitive among them. After many years of technology-neutral capacity auctions, **Colombia** conducted its first renewable-exclusive auction in February 2019, which was quickly followed by another round in the same year (Box 1.4).

Auctions exclusively for renewable energy are common in Europe. They are motivated by EU guidelines on state aid for environmental protection and energy, which explicitly encourage competition between renewable technologies. Denmark, Finland, Germany and Spain, for example, have already adopted renewable-exclusive auctions, sometimes in parallel with technology-specific ones. Technology-specific auctions are a tool for introducing (or further deploying) a technology into a country's energy mix, enabling (or enhancing) diversification and complementarity among technologies. An example is the complementarity between hydropower and other technologies in Latin America.

Technology-specific auctions can also support the development of a local industry for a given technology and strengthen domestic supply chains. More than one technology can be introduced in a single auction, as in **South Africa** and **Ukraine**, where separate demand bands for each technology translate technology-specific targets into concrete projects. Project-specific auctions are more defined types of technology-specific auctions. They are discussed in detail in Section 3.2.

BOX 1.4 DRIVERS AND RESULTS OF RENEWABLE ENERGY AUCTIONS IN COLOMBIA

Colombia began implementing technology-neutral capacity auctions in 2006. Unlike neighbouring countries such as Brazil, Chile, Peru or, more recently, Argentina and even Mexico, Colombia did not adopt a centralised process for contracting energy over the long run until 2019.

Several factors pushed Colombia toward a renewable energy auction. First, there was the significant drop in the cost of renewable technologies, as signalled by attractive auction prices in neighbouring countries. Second was the potential of auctions to bring new players into a market with a heavy concentration of dominant players. A third factor was the energy security attained by diversifying a hydro-based system vulnerable to droughts.

In this context, Colombia's first renewable auction was held in February 2019. Because the minimum competition requirements were not met, no capacity was awarded (see Box 1.7). A second round, launched in August, awarded almost 1.3 GW of solar and wind in October at a weighted average price of COP 95.65/kWh (USD 28/MWh) (Djunisic, 2019).

Location specificity

Auctions are increasingly designed to specify zones and locations where projects can be developed. This is done for two reasons: First, to support the integration of variable renewable energy, as in Mexico, Kazakhstan, Turkey, and the planned fifth round in South Africa (see Chapter 3) and second, to promote the socio-economic development of underserved regions (see Chapter 4). A potential downside of this design choice is the risk that the specified zone or region may not receive enough bids, leaving the auction undersubscribed. This risk is further increased in the case where a rule specifies a minimum number of bids or a minimum volume to go forward with the auction. This was the case in Kazakhstan's 2018 auction (Box 1.5).

Products auctioned

Traditionally, renewable energy auctions have focused on procuring new capacity. However, in a fast-changing electricity sector with increasingly complex system needs, a trend of auctioning multiple products, including energy, system services and capacity, has emerged. In Mexico, in addition to energy, renewable operators may sell clean energy certificates (see Boxes 1.3 and 3.10) and/or capacity products. In Denmark and the United Kingdom, auctions for ancillary services have also been opened to generators of variable renewable energy. A more detailed discussion on this topic is found in Chapter 3.

Auctions are increasingly specifying the time of day when energy is procured. This is the case of Chile and Thailand (see Sections 3.3 and 3.6).

1.4.2 Qualification requirements and documentation

Qualification requirements and documentation determine which suppliers will be eligible to participate in a given auction, including the conditions that participants must meet and the documentation they must provide before bidding. IRENA and CEM (2015) provides details on each design element. Such requirements commonly relate to:

1) documentation supporting the bidder's technical and financial capacity to develop the project;
2) project-related documentation pertaining, for example, to grid access or environmental and social impact assessments;
3) the project's technical specifications; and
4) commitment to local socio-economic development, as more countries become aware of the potential benefits that a domestic renewable energy sector can bring.

The last class of requirements are discussed at length in Chapter 4. Areas where new trends in qualification requirements have been observed are discussed below.

BOX 1.5 ZONE-SPECIFIC AUCTIONS IN KAZAKHSTAN

After several efforts to introduce a feed-in tariff in Kazakhstan, two rounds of auctions were implemented in 2018 to help meet a target of 1.7 GW of installed renewable capacity by 2020 (933 MW of wind, 467 MW of solar PV, 290 MW of hydro and 10 MW of biogas) and a 50% share of renewables in the electricity mix by 2050. The 2018 auctions were divided into tranches dedicated to individual renewable technologies, zones and plant sizes. Wind tranches, for example, were split among zones in the north, south, and west, and between small- and large-scale installations.

In the first round in May 2018, ten demand tranches were auctioned almost simultaneously, two of which were not awarded due to insufficient competition. In October 2018, a second auction round of 10 demand tranches took place, but only six projects were awarded. The Kazakh auctioning mechanism requires that at least three bids be received for each demand tranche before the capacity can be awarded. In addition, the total volume of bids received should amount to at least 150% of the total volume auctioned. Some tranches may not have met those criteria and thus were not awarded.

Source: USAID, 2018.

Bidder-related documentation: experience requirements

To ensure that projects are delivered as bid, auctions increasingly require proof of experience as a condition for bidding. This has been possible as more and more developers around the world have gained the requisite experience in a maturing sector.

Experience requirements include proof of the bidder's competence through similar projects successfully completed. In **Saudi Arabia**, the developer must own or hire an engineering, procurement and construction (EPC) company having at least 200 MW of capacity in operation (composed of projects of at least 10 MW and at least one high-voltage project of 50 MW or more and international experience with projects of the same type and technology). In **Bangladesh**, the requirements are more lenient, considering the smaller volumes auctioned. At least one previous project using the same technology is required. It must generate at least 5 MW and have been in operation for at least two years.

Qualification requirements focused on previous experience work best in markets with a developed renewable energy sector or in cases where the auction is open to international developers. It should be noted that a trade-off exists between establishing experience requirements and limiting the pool of participants, thereby potentially reducing competition.

Project-related documentation: permits and grid access

Another type of requirement increasingly being considered relates to site-specific documentation such as land permits, environmental and social impact assessments, and grid access. Requirements regarding grid access, for example, can take the following forms, starting with the most lenient:

1) no access permit is required to qualify, allowing auction winners to obtain needed permits only after the auction;
2) an access permit is required before the auction, but projects that necessitate grid expansion or grid enforcements are allowed to participate; and
3) an access permit must be obtained before the auction, and only projects that do not necessitate grid expansion or strengthening are allowed to participate.

Many auctions have faced delays in project commissioning owing to delays in obtaining such documentation (see Chapter 2), which has prompted policymakers to include them as prerequisites. At the same time, some auctions, notably those designed to encourage the participation of community projects, have opted to relax the requirements for certain players, as in **Germany** (see Chapter 4).

A balance must be struck between imposing overly harsh requirements that may limit the pool of potential bidders (thus excluding

small and new players or increasing the risk of undersubscription) and relaxed requirements that may lead to underbuilding and delays.

Additional project specifications

Other project-related requirements are being adopted to increase the reliability of the power system. In **Colombia**'s first renewable energy auction, qualification requirements included criteria relating to the system's resilience, security, emissions reduction and complementarity. To qualify, bidders had to accumulate at least 50 points out of a possible 100; each of the four reliability-related criteria was worth a maximum of 25 points (Table 1.1).

1.4.3 Winner selection and contract award process

In the winner-selection process, bidding and clearing rules are applied and contracts are awarded. Aspects of the process 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.

IRENA and CEM (2015) provides details on each design element. Two aspects of the winner-selection process where new trends have emerged are discussed below.

Winner-selection criteria

An element of rising importance in numerous winner-selection processes is concern over transmission capacity limits (as further discussed in Chapter 3). Some countries have dealt with this issue as part of the auction demand, while others, such as Brazil, Germany and Mexico, consider it as part of the winner-selection process (Box 1.6). Price is not the only criterion for the selection of winners.

A project's technical performance or its socio-economic impacts are also considered in many cases through a variety of weighting systems. In **Chinese Taipei**, a construction criterion represents 25% of the score; engineering design, 20%; and operations and maintenance planning, 15%. All in all, technical capabilities represent 60% of the score, with the remaining 40% weight accorded to price. In **Uganda**, a multi-criteria auction has been implemented, in which technical, financial, environmental, and social parameters account for 70% of the weight (IRENA, 2018a).

Table 1.1 Criteria to qualify for the first round of Colombia's 2019 renewable energy auctions

RESILIENCE (25 POINTS)	Enhancement of the resilience and adaptability of the energy system through diversification of the energy mix
COMPLEMENTARITY (25 POINTS)	Complementarity of project's seasonal profiles with historical flows in the main hydropower basin
EMISSIONS REDUCTIONS (25 POINTS)	Contribution of the project to the reduction of CO_2 emissions
REGIONAL ENERGY SECURITY (25 POINTS)	Impact on the supply-demand balance and reduction of operational restrictions

Source: MINMINAS, 2018.

BOX 1.6 GERMANY'S NETWORK EXPANSION AREAS FOR THE DISTRIBUTION AND TRANSMISSION GRIDS

The north of Germany produces more wind power than it can consume, driven by resource endowments and attractive local policy instruments. The transmission infrastructure is not able to transport all this power to industrial centres in the south, causing congestion for both Germany and its neighbours. In 2017, the bottlenecks required grid-stabilisation efforts costing EUR 1.4 billion and forced grid operators to shut down wind plants during periods of high wind in northern and eastern Germany. The new power grid plan includes, among other measures, new transmission infrastructure.

So-called transmission network expansion areas have now been established for wind projects. The auctioneer defines a maximum quantity of power to be met by wind projects located in the north, even if the limit means turning away financially attractive projects. This measure is meant to align the capacity additions from renewable power auctions to Germany's transmission grid development plans.

Furthermore, renewable energy projects are not evenly distributed within northern or southern districts and adding renewable capacity to the distribution grid in congested districts may increase distribution costs. The joint wind and solar technology-neutral auctions have been designed to address this issue by factoring the location of projects into the selection of winners. Districts in which an additional renewable energy plant is likely to require expansion of the distribution grid are determined prior to the auction. Wind and solar bids for projects located in one of those overloaded districts are penalised by adding a virtual premium to their bid prices.

Sources: EEG, 2017; Bundesnetzagentur, 2018; Appunn, 2018.

Finally, there is the possibility of combining post-qualification requirements with winner-selection criteria. In **Colombia**'s first round in February 2019, if the auction did not yield a diversified pool of players (diversity in the electricity market being one of main drivers of adopting a renewable energy auction, as explained in Box 1.4), no one would have won, and the auction would not move forward (Box 1.7).

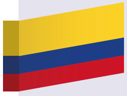
Clearing mechanism: combinatorial auctions

The clearing mechanism sets rules for allocating contracts in cases where the volume offered by the winning projects does not exactly meet the auctioned demand (IRENA and CEM, 2015). Intuitively, one could expect a simple algorithm to yield the most optimal allocation: ordering the bids from the highest to the lowest score received and accepting them in descending order of score until the auction demand is met. However, if bids are "bulky" (that is, if the quantity bid must be accepted or rejected in full), this algorithm will not necessarily yield the optimal allocation. To deal with such cases, alternative winner-selection and clearing mechanisms may be implemented.

For example, bids may be required to be of a certain size (a specific fraction of the total demanded quantity), or the marginal bidder may be required to accept a certain percentage reduction in the project size to better match auction demand. For example, in **Japan's** third solar PV round, one bidder was awarded 1 MW that remained after the lower bids were accepted and ultimately did not proceed to sign the contract (Solar Journal, 2018) (see Figure 2.3).

Auction designs are becoming more sophisticated, with the possibility of awarding multiple contracts at the same time or considering various constraints and aspects of the demand-side preferences (see Chapter 3). Under such circumstances, combinatorial auctions may become a more attractive solution. Offering many possible permutations for choosing the winning projects, typically through an optimisation program, combinatorial auctions mix winner selection with a clearing mechanism to determine the optimal selection (of one or more bids) that satisfies the criteria considered while also coming the closest to the volume needed.

BOX 1.7 COLOMBIA'S FEBRUARY 2019 POST-QUALIFICATION PHASE: ENSURING SUFFICIENT COMPETITION



Colombia's February 2019 auction introduced three quantitative indices to be analysed after provisional winners are identified. Minimum thresholds had to be met for a reasonably competitive auction, and if they were not met, the entire auction was to be called off. The selected metrics included: 1) a participation index to limit the share of players owning both generation and distribution companies and bidding on both sides; 2) a concentration index used to detect high concentrations of bids from a limited number of players; and 3) a dominance index establishing a market-share limit for a winning bid.

The first round of the auction awarded no capacity, as the concentration and dominance indices were not met. In the second round, the criteria were relaxed: the only criterion was that one bidder could not win more than 40% of the awarded volume.

Source: UPME, 2019.

Mexico is perhaps the most prominent example of their use, though countries such as Chile and Panama have adopted them in the past. **Mexico** uses an optimisation program to choose which set of bulky bids will best meet the system's demand and buyer's surplus for three separate products: energy, capacity and clean energy certificates. Unfortunately, although the clearing mechanism was published by the system operator, it was perceived as unclear by some participants (PwC, 2017). Auctioneers and policymakers must consider the trade-off between the benefits of combinatorial auctions and their complexity, at least in the minds of bidders.

1.4.4 Risk allocation and remuneration of sellers

The category of risk allocation and remuneration of sellers defines how risks (financial, production and other) are allocated among stakeholders (bidders, auctioneers, off-takers, financial institutions, consumers). These risks, responsibilities and obligations should be spelled out in auction documents. These critical design elements involve:

1) payment to the winner;
2) commitment bonds (typically a bid bond and a completion bond) and a schedule for contract signature and commencement of commercial operations;
3) production and financial risks (associated with inflation, currency fluctuations, market prices and production hazards);
4) quantity-based liabilities, including settlement rules and penalties for underperformance; and
5) penalties for delays and underbuilding.

Details on each design element can be found in IRENA and CEM (2015).

For the most part, auction documents, such as the power purchase agreement (PPA), have been inherited from predominantly conventional, large-scale and technically complex power projects. Owing to their highly intricate transaction structures, these projects required customised and complex legal solutions, which have been passed on to renewables. This has resulted in high transaction costs and prolonged project timelines, hindering further capacity growth. Therefore, reforming the overly complicated contractual framework for renewables has emerged as a pressing need. In response, IRENA and the Terawatt Initiative (TWI) undertook a joint effort to simplify and streamline the contractual framework for solar power (Box 1.8).

Payment to the winner

The most common method of determining the payment to the winning bidder continues to be the pay-as-bid method based on a sealed-bid offer. This scheme entails less risk to both the developers and off-takers, as the remuneration is set before the contract is signed.

However, some countries have opted for uniform pricing mechanisms, which can affect risk allocation differently. **Germany** adopted marginal pricing for citizen wind parks as part of their preferential rules, whereby winners are granted a price equal to the highest awarded bid (see Section 4.1), while regular bidders are paid as bid. In this case, a uniform price set by the highest bid encourages community projects to participate in the auction by offering a higher remuneration than what was bid. However, there is a risk that communities relying on this design scheme will submit overaggressive bids just to be selected. In **India**, by contrast, contracts can be re-negotiated with bidders after the auction to match the lowest bid. In this case, the auctioneers' aggressive strategy to reach low prices may expose bidders to additional risks; some of those bidders may not be able to develop their projects for such a low payment (see Box 1.1 and Section 2.2 on underperformance in the awarding and contracting stage).

Risks associated with production and curtailment

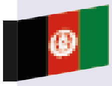
The type of product auctioned (installed capacity or energy produced) strongly affects production risks. Typically, the product offered is some type of long-term energy contract – a PPA – that ties the developer to operating the power plant. When PPAs do not attract investors, alternative models such as EPC can be contemplated in auction design, where the developer's responsibilities end with the construction of the project, as in **Afghanistan** (Box 1.9). Under a turnkey model, the developer delivers the project for a fixed price by a

BOX 1.8 THE OPEN SOLAR CONTRACTS INITIATIVE

Backed by several top-tier law firms, the Open Solar Contracts initiative provides standardised and simplified contract templates that are freely available and designed to be universally applicable. The following templates have been drafted in consultation with the global solar power community and made available on https://opensolarcontracts.org as a comprehensive legal documentation solution: 1) Power Purchase Agreement, 2) Implementation Agreement, 3) Supply Agreement, 4) Installation Agreement, 5) Operation and Maintenance Agreement and 6) Financing Facility Term Sheet.

The initiative aims not only to decrease transaction costs and expedite project timelines, but also to achieve a balanced risk allocation among public and private parties. To this end, Open Solar Contracts systematically allocate risks to the parties that are best positioned to manage those risks in a cost-effective manner. The purpose is to avoid overpricing risk (*i.e.,* pricing risks as if they were more probable or severe than they really are), which would lead to a higher cost of capital and hence higher power prices. More information on the initiative's approach to risk allocation can be found in the "*Guide to Open Solar Contracts*" which is also available on the initiative's website.

BOX 1.9 AFGHANISTAN ENGINEERING, PROCUREMENT AND CONSTRUCTION CONTRACTS



Afghanistan had its first experience with renewable energy auctions in 2016, when a total 14 project-specific auctions were held between March and May, accounting for 48 MW of solar power and 14 MW of wind power. These were part of a plan launched in January 2016 to develop 100 MW grid-connected renewable energy projects.

Whereas the 2016 auctions specified that bidders were to design, finance, build, own, commission, and operate the projects under a long-term power purchase agreement, the Ministry of Energy and Water recently shifted to tendering only the engineering, design, procurement, and construction (EPC) of renewable plants. The project developer's liability ends once these functions have been completed.

Under the EPC model, the winner's remuneration is a lump-sum payment rather than a long-term contract based on the quantity of electricity produced. Between September 2017 and December 2018, seven project-specific auctions of this type were held and three projects were awarded: one 10 MW solar hybrid project to the WAAREE Energies, an Indian company, and two other similar projects totalling 45 MW to the Chinese Shuangdeng group. All three projects included, besides the stated nominal capacity of solar PV, diesel-fired generators and/or batteries as backup.

Source: DLA Piper, n.d.

guaranteed date. In reducing bidders' risks, it shifts them to the plant operator, who then assumes the risks associated with quality, construction, energy production, etc.

Regarding curtailment, risk allocation models vary, ranging from those where the generator takes full responsibility, to shared responsibility, or models where the off-taker is fully liable. In recent years, there has been a tendency away from take-or-pay models towards remuneration mechanisms with higher risk allocation to the generators which are typically factored in the price. This topic is discussed at length in Chapter 3.

Risks associated with inflation and currency exchange

A key component in designing a contract's remuneration profile is the risk allocation between buyers and producers. One important risk is inflation, especially in emerging and developing economies. As inflation increases, and in the absence of long-term hedging markets, project developers' revenues may become insufficient to recover costs.

Another concern for developers is the exchange rate risk that arises when project costs are largely denominated in a foreign currency, but auction contract revenues are denominated in the local currency. In this case, the generator is exposed to the currency risk, and exchange rate movements can have a strong impact on a project's viability.

To shield developers from inflation risks, contracts can be indexed to inflation, meaning that the contract remuneration escalates in nominal terms during the project's lifetime. This is particularly relevant for countries such as Egypt and Turkey, where inflation reached 30% in 2017 and 16% in 2018, respectively (World Bank, 2019). In India and Zambia, contracts are not adjusted for inflation, and developers must factor in this risk into their bids. In India, the same applies to currency exchange risks when contracts are denominated in Indian rupees.

Currency exchange risks are spreading as growing numbers of countries move to auctions involving dependence on imported equipment and financing in hard currency (usually U.S. dollars). The auction design determines how those risks are allocated among players (developer, off-taker, financier or guarantor, etc.).

In **Brazil**, contracts are not adjusted for foreign exchange risk, but most financing comes in reals from publicly owned Brazilian banks and at attractive interest rates. Brazil has also managed to develop a local wind industry. Consequently, the currency risk in Brazilian wind auctions is relatively low, as most of the project developers' costs and revenues are in the same (local) currency. However, for solar auctions, the case is different. Solar panels are imported and paid for in foreign currency.

In **Namibia**, contracts are also denominated in local currency, but a guarantee provided by PROPARCO, a subsidiary of the Agence Française de Développement that focuses on private sector development, has increased the attractiveness of the projects.

In **South Africa**, the difference between the exchange rate at the date of bidding and the date of financial close is factored into the tariff – up to a maximum percentage commensurate with the level of local content required.

In **Mexico**, developers can select their level of exposure to foreign exchange. They can choose whether to index their offers to Mexican pesos or to U.S. dollars. Regardless of the option chosen, the bidder is (partially) shielded from inflation. While offers indexed to the U.S. dollar shield the generator from currency risk, developers who can find financing denominated in Mexican pesos obtain a small advantage, as the winner-selection criteria apply a minor penalty on dollar-indexed offers.

Germany, India and Italy do not offer any indexing of prices, leaving sellers unprotected against inflation risks while the plant is being built. Neither do they offer any hedge against currency risk. Those economies have well-developed local lending and wind-component markets, but the same cannot necessarily be said for PV components, where currency fluctuation may have stronger effects.

Risks associated with market price

Market price risk, in liberalised markets, is related to how spot prices can affect developers' remuneration over the life of the PPA. There are several ways to allocate this risk. The most common design is to award a fixed price specified in the bid per kilowatt hour produced (following a scheme resembling a FIT), and to apply the contractually defined price to the entire production, allowing nothing to be remunerated at spot-market prices.

The generators incur some quantity risk associated with the aggregate amount of electricity they produce, but no market risk associated with spot-price movements. In contrast, the design that allocates the most risk to generators involves remuneration dependent on the electricity spot price, either directly, as in Chile, Denmark and Finland (Box 1.10), or indirectly, as in Mexico and Brazil (see Chapter 3).

Risks associated with contract duration

The duration of the contract also influences the allocation of risk. As a rule, offering shorter contracts (10 to 15 years' duration) requires generators to assume some risk at the end of the contracts. In countries with liberalised markets, generators can continue selling electricity to the market after the contract expires. However, this is not guaranteed in non-liberalised market contexts. Thus, countries with a developed and mature renewable sector tend to adopt auction designs that assign a higher level of risk to the seller.

BOX 1.10 SUPPORT SCHEME FOR RENEWABLES IN FINLAND

In June 2018, Finland introduced a technology-neutral auction to support its target to source half of its electricity from renewables by 2020. The new scheme applies to wind, solar, wave, wood fuel and biogas power plants (hydropower is excluded), and only new projects are allowed to participate. Participants bid for a premium (capped at EUR 53.5/MWh[a] (USD 62.5/MWh)) on top of the market price, and the winning bidders are remunerated as bid, up to a maximum of EUR 83.5/MWh (USD 97.5/MWh), including both the premium and the market price (together known as the target price).

The premium-based scheme consists of a combination of a sliding premium and a fixed premium. The project developer bids a single premium in EUR/MWh and, if it wins the contract, its revenue streams are as follows:

- If the market price is below the floor price (EUR 30/MWh or lower), the standard feed-in premium applies. The bidder receives the market price plus the awarded premium.
- If the market price is above the floor price but below the target price, the reduced feed-in premium applies. The premium is calculated dynamically based on the market price in such a way that the bidder receives EUR 30/MWh (USD 35/MWh), plus the awarded premium (the target price).
- If the market price is higher than the target price, no feed-in premium applies. The premium falls to zero and the generator seeks its profit in the spot market.

In all cases, the market price is defined as the average Nordpool area price for the relevant calendar quarter.

[a] 1 USD = 0.856 EUR in June 2018.

Source: HPP Attorneys, 2018.

That said, contract duration has varied greatly among auctions, and a common strategy has been to calibrate the duration to match the plant's likely useful life. In this case, the project developer can avoid the burden of estimating the plant's residual value once the contract terminates – which would otherwise be an important component of the developer's remuneration – and post-contract provisions become less important to consider.

Similarly, the typical duration of the financing maturity given by banks must be considered in setting the contract duration to ensure the projects' bankability. Latin American countries, such as Brazil and Peru, follow this rule when setting the contract duration.

In **Uruguay**, the contract length, which should be between 10 and 20 years, is proposed by bidders and included in the bidding documents. In the end, and given the financial market, developers tend to submit proposals for a 20-year PPA.

Compliance rules and penalties

A common concern of auctions is the extent to which the developer's bid is a binding commitment, given that most liabilities are not enforced until after the auction is complete and the winners are announced. Requiring commitment bonds, in the form of bid or completion bonds, typically offers greater assurance that the contracts will be signed and the projects built. Chapter 2 discusses bid and completion bonds in detail.

1.5 CONCLUSIONS ON RECENT TRENDS

Dynamic developments have marked the last few years of auctions, in terms of prices, geographical coverage and design elements. As the renewable market matures and stakeholders gain experience, auctions are becoming increasingly sophisticated to address the evolving needs of the electricity sector, economy and society.

Notably, a total of 55 countries conducted renewable energy auctions in 2017-2018 to support the deployment of renewable-based power at competitive prices.

From 2010 to 2018, the auctions' solar PV global average prices decreased by 77% and onshore wind prices by 36%. Yet beyond their potential to achieve low prices, renewable energy auctions are increasingly used to achieve broader development and socio-economic aims.

In any case, for either price or wider objectives to materialise, the awarded renewable energy projects need to start operations in the first place. Sound auction design elements can provide an effective way for countries to ensure timely project completion.

2 ENSURING TIMELY PROJECT COMPLETION

While 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. When a project committed in an auction is delayed, cancelled or fails to produce (or install) the quantities of energy (or capacity) promised in the bid, the energy transition and ultimately the reliable supply of electricity in the country concerned may be compromised. At the same time, an awarded project that does not deliver in accordance with the bid may be blocking the deployment of other projects that could have delivered, but were not awarded.

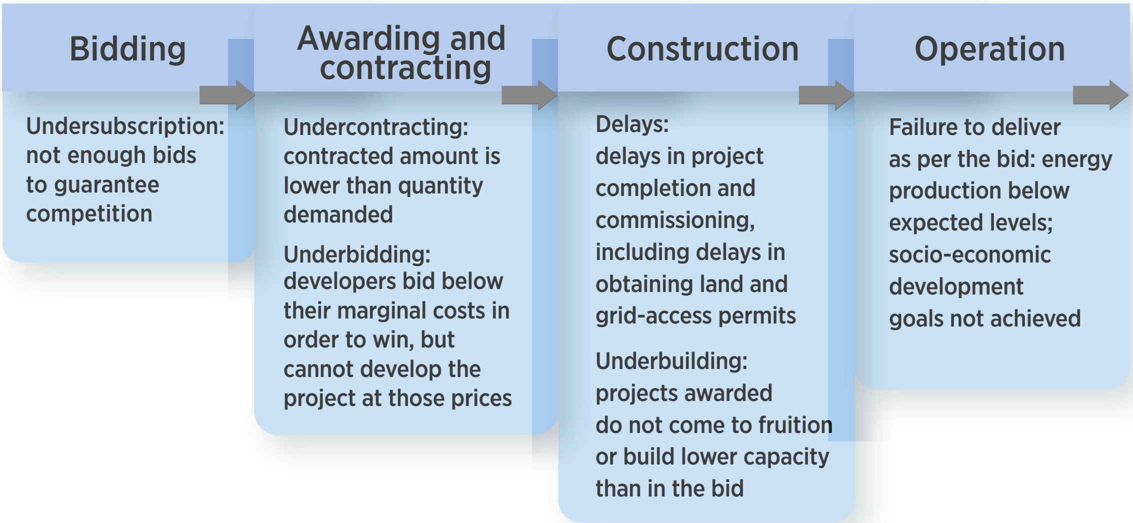
In fact, negative experiences with pioneer auctions delayed the global adoption of the scheme by several years. In the United Kingdom, for example, only 391 MW of the 2,659 MW awarded in the 1989 onshore wind auctions was built (Azuela, *et al.*, 2014; Pollitt, 2010).

Following such failures, other mechanisms came to be regarded as more effective instruments to foster the development of the renewable energy sector.

As markets developed, a gradual move from administratively to competitively set tariffs took place, generally enabling price discovery and capturing the falling cost of technology. As the understanding of auction design has matured, experiences with auction performance have improved accordingly. Three of the key lessons are 1) the importance of compliance rules to ensure that awarded projects are completed on time and delivered as bid (IRENA and CEM, 2015), 2) an auction design that accounts for the limitations of the sector, and 3) the need for an enabling environment capable of supporting project development (IRENA, IEA and REN21, 2018).

This chapter analyses the performance of projects awarded through auctions in selected countries and explores the factors that have contributed to the timely completion or delay of those projects. The analysis covers the stages of an auction during which underperformance can occur, starting with the announcement of the auction and extending through the processes of bidding, awarding and contracting, constructing and operating the assets specified in the power purchase agreement (Figure 2.1).

Figure 2.1 Risks of underperformance at each stage of the auction process



2.1 BIDDING STAGE

Well before any contracts are signed, underperformance can begin in the form of undersubscription, which occurs when the auction does not receive enough bids to meet the demanded volume. Possible reasons for a failure to attract enough bidders include low investor confidence in the market, an insufficient pool of eligible projects, the lack of an enabling environment (*e.g.*, permitting procedures that are lengthy and burdensome, or targets that are unclear, not binding or not ambitious) or unfavourable auction design (*e.g.*, overly strict compliance rules and requirements, unattractive disclosed ceiling price, or too large a volume auctioned at once).

Enabling environment for attracting bids

Although falling costs, increasing sector maturity, and successful auctions worldwide have significantly boosted the attractiveness of renewable energy investments, perceived risks still constitute a major barrier in many parts of the world. They include political and regulatory; counterparty, grid and transmission; and currency, liquidity and refinancing risks. In this context, risk perception reduces the participation of bidders in the auction. Measures to mitigate such risks and attract bidders have been explored in previous work (IRENA, 2016). In addition, some of the risks can be accounted for in the auction design (Section 1.4.4). The enabling environment for inducing bidders to participate in an auction also encompasses land-use policies, permitting procedures and licencing provisions, especially when project documentation is a prerequisite to participate in the auction.

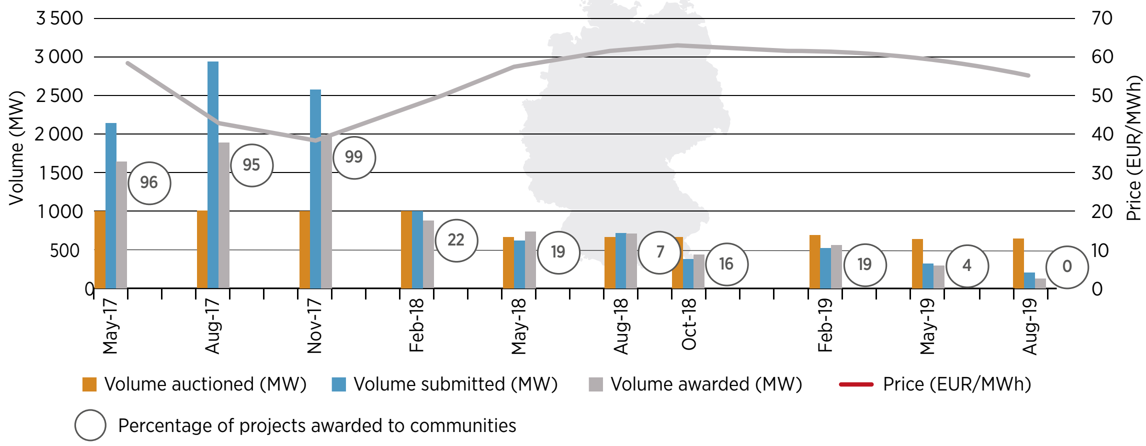
Qualification requirements

As discussed in Section 1.4.2, overly harsh requirements for participation, whether bidder-related (*e.g.*, technical or financial experience) or project-related (*e.g.*, required documentation), may limit the pool of potential bidders, and exclude small and new players.

Germany's wind auctions since 2018 are an example where compliance rules, in an environment not conducive to obtaining permits for wind projects, have resulted in undersubscribed auctions. First, the auction required all projects to obtain permits prior to the bidding stage.[1] Second, the permitting process became more complicated and lengthy, increasing from 300 days in 2016 to 700 days in 2018 (WindEurope, 2018); several permitting procedures were put on hold because of legal disputes about the underlying regional siting plans.

[1] *Chapter 4 describes the previous rounds' preferential rules for community projects that pushed their permit requirements to the contracting phase.*

Figure 2.2 Undersubscription in German onshore wind auctions leading to increased prices, May 2017-May 2019



Source: WWEA, 2019.

By 2019, at least 750 MW of wind-farm projects were mired in legal proceedings (WindEurope, 2019). Third, public opposition and local barriers, such as Bavaria's minimum-distance rules, also increased. Consequently, and fearing penalties for non-delivery, developers have become reluctant to bid. Bids received in May 2019, for example, amounted to just 45% of the volume up for auction (295 MW out of a demanded 650 MW) (Figure 2.2).

Undersubscription can affect prices, as an auction that fails to attract enough competition does not fulfil its potential for price discovery. The average prices resulting from wind auctions in Germany rose from EUR 38/MWh (USD 42/MWh)[2] in May 2017 to EUR 62.6/MWh (USD 71.9/MWh)[3] in October 2018 (+65%), before stabilising at EUR 61/MWh (USD 69/MWh)[4] in February and (USD 68.3/MWh)[5] May 2019, close to the ceiling price (Figure 2.2).

In the **South African** Renewable Energy Independent Power Producers Procurement Programme, bidding requirements included contributions to socio-economic development (see Chapter 4); securing land, including for transmission lines; obtaining all needed permits; gathering at least 12 months of wind monitoring data, as well as 12 months of bird and bat monitoring data; and ensuring that projects reached financial closure by the time of bidding.

As a result of the challenging requirements, especially for foreign developers, and the short bid timelines (three months), many proposals were not ready for the first round. Moreover, of the 53 bids received, only 28 were accepted.

Disclosed ceiling price

A ceiling price that is disclosed at the time of the launch of the auction, if perceived as low, could deter the participation of bidders. In the first auction round in **Mexico**, the disclosed capacity ceiling price of MXN 10,000 (USD 567.37/MW)[6] proved to be unattractive for developers and no bids were submitted for the 500 MW of firm capacity auctioned. In the subsequent round, a significant increase in the ceiling price – to MXN 1,723,992 (almost USD 90 000/MW)[7] - proved more effective, yielding 102 firm capacity bids. Out of those, 20 were accepted, resulting in the award of 80% of the auctioned volume (Garcia and Pinzon, 2016; CENACE, 2018).

Commitment bonds

Compliance rules that include commitment bonds may also dissuade some participants from participating in the bid, although such bonds may be crucial to ensuring timely completion of projects.

Japan's solar PV auctions were undersubscribed as a result of strict compliance rules, coupled with difficulties in securing land and grid access.

[2] 1 USD = EUR 0.904 in May 2017. [3] 1 USD = EUR 0.870 in October 2018. [4] 1 USD = EUR 0.880 in February 2019.
[5] 1 USD = EUR 0.893 in May 2019. [6] 1 USD = 17.65 MXN in March 2016. [7] 1 USD = 19.2 MXN in September 2016.

A total volume of almost 1 GW of solar PV capacity was planned in 2017-18 through three auctions, and a fourth round was held in 2019. All four rounds attracted a large number of participants, with 29, 19, 38 and 146 bids registered, respectively, with corresponding capacities mostly meeting or exceeding the volume auctioned. As shown in Figure 2.3, the majority of those bids were qualified. In the first round, qualified bids corresponded to almost 80% of auctioned volume; in the second, third and fourth rounds, capacities of qualified bids exceeded the volumes auctioned (corresponding to 23, 15, 32 and 107 bids for each round). However, the challenge was in retaining bidders beyond that point because, once qualified, many bidders dropped out and did not place bids. As shown in Figure 2.3, only 9, 9, 16 and 71 bids were placed after qualifying. As a result, the first, second and fourth rounds were undersubscribed (participating capacity below auctioned capacity). Less than 30% of the volume bid in the first round elicited interest from participants.

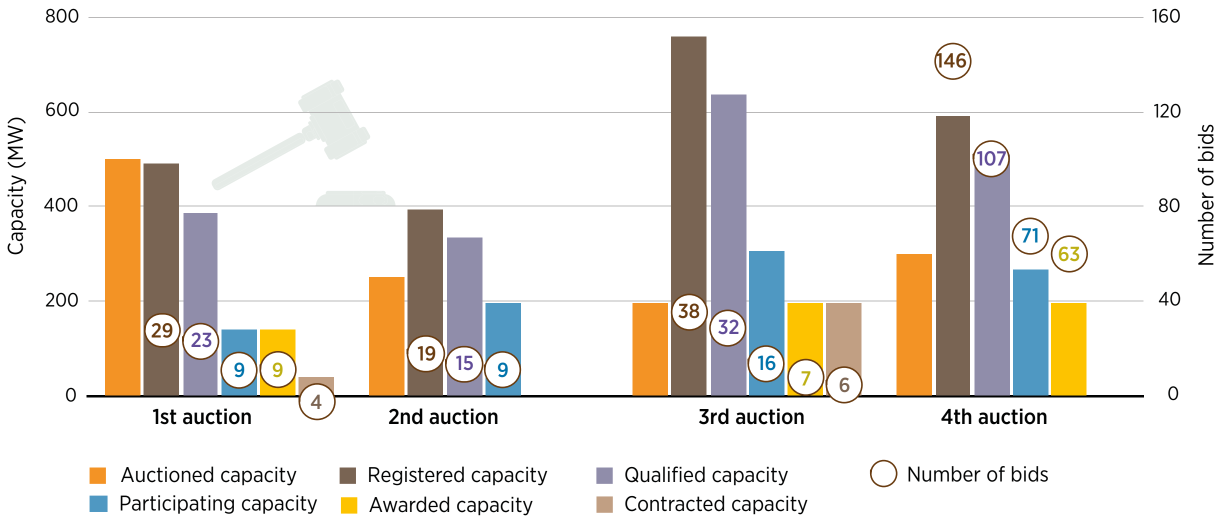
In a survey conducted after the first round, developers indicated that the main reasons for not participating in the auction were difficulties in securing land; limited system capacity and the associated hard capacity limits; and strict compliance rules, specifically related to commitment bonds (Kageyama, 2017a).

In fact, difficulties in procuring land and grid connection rights are recurring issues in the Japanese solar PV sector and may explain the diminished role of economies of scale in the country (BNEF, 2019d). Completion bonds may also have affected participation (see Box 2.2 for the steps taken after the first round to increase participation). Decreasing project size requirements in the fourth round further increased participation, mainly from small and new players (see Box 4.2).

Pool of bidders

Participation can be boosted by opening the auction to bidders from another country. Cross-border auctions also typically result in cross-border flows of support payments and renewable energy certificates, which are crucial for target accounting. In addition, cross-border auctions can improve the cost-effectiveness of support for renewables through, for example, access to sites with better resource potential and the potential to benefit from higher market prices and lower costs of capital. In the European Union, regulatory and market developments may trigger the implementation of cross-border auctions in the near and mid-term future. The first experiences with cross-border renewables auctions in Europe occurred in late 2016 (Box 2.1).

Figure 2.3 Underbidding in Japan's solar PV auctions



Source: Bellini, 2019a; 2019b; Publicover, 2018; 2017.

BOX 2.1 THE CROSS-BORDER SOLAR AUCTION HELD BY GERMANY AND DENMARK

In late 2016, **Germany** and **Denmark** each launched a solar photovoltaic auction open to bidders from the other country. In the German auction, the volume of bids received (297 MW) exceeded the volume auctioned (50 MW) by almost six-fold. Bids from Denmark were more competitive, resulting in Danish projects being awarded at EUR 53.8/MWh (USD 48.63/MWh)[a] as a sliding premium, well below the EUR 69/MWh (USD 62.38/MWh) awarded in German national auctions at around the same time. All the awarded PV plants have now been installed. Support payments to the Danish projects that won in the German auction have been marginal or zero, owing to high market prices in Denmark. The cross-border auction has therefore resulted in savings in support costs for Germany. By contrast, no German project participated in the Danish open auction, in which only 2.4 MW of the total auctioned volume of 20 MW were open to the participation of German bidders.

It should be noted that cross-border auctions could bring additional complexity by combining the political preferences and market environments of two or more countries. The optimal auction design for a cross-border auction may therefore be different from the optimal auction design in a single national market. The following principles for setting up cross-border auctions have been identified in the EU's Horizon 2020 project, AURES II (Auctions for Renewable Energy Support):

- **Bids need to be comparable.** Auction and remuneration design should be the same for all participants to allow for comparison of bids and effective bid selection.
- **The design should be adapted** to the cross-border context. The auction design must consider the political goals and market situation of all countries involved. Some requirements put forward in national auctions may not be applicable in cross-border auctions – notably permitting processes and prequalification requirements (with varying costs and timelines).
- **The auction should be kept simple**. Design choices and administrative procedures that increase complexity should be avoided. This is even more important in cross-border auctions where market participants are not familiar with the auction structure. Moreover, reducing administrative complexity can minimise transaction costs and increase bidder participation.
- **Sufficient time must be allotted for consultation and bid preparation.** To attract a large number of bidders, market players should be given sufficient time to become familiar with and adapt to a new auction design and procedure.

[a] 1 USD = 0.904 EUR in December 2016.
Source: AURES II, 2019.

2.2 AWARDING AND CONTRACTING STAGE

Undercontracting is another form of underperformance. It occurs when, after the bidding process is complete and winners selected, the contracted amount is lower than the quantity demanded. The implications are that volumes of capacity are not contracted and renewable energy targets may not be met. Undercontracting can take several forms:

1) undersubscription contributing to undercontracting, when the total of the bids received is lower than the auction demand, as in the German wind auctions in 2018 and 2019;
2) bids not meeting the criteria for minimum competition, such as undisclosed ceiling price or rules to avoid market concentration, and
3) selected bidders choosing to opt out, especially as a result of speculative bidding (underbidding).

This section focuses on the second and third cases, using several country examples.

Undisclosed ceiling price and volume auctioned

Depending on the design of the auction, pre-qualified bids may go through an additional screening that can lead to undercontracting, even with high participation from bidders. One example is undisclosed ceiling prices.

In the second round in **Japan**, the auctioned volume of 250 MW was met with much interest, with almost 400 MW registered, out of which more than 330 MW were qualified. Almost 200 MW proceeded to participate, but no awards were made (Figure 2.3), as the bids were above the undisclosed ceiling price of JPY 15.5/kWh (USD 138.3/MWh).[8] In the first round, the ceiling price of JPY 21/kWh (USD 186.2/MWh) was disclosed to bidders. There is a trade-off to consider when deciding whether to disclose a ceiling price. Disclosing ceiling prices, especially in markets with limited competition, can limit price reduction. Indeed, two of the 10 awarded bids in the first round were at the ceiling price; the average of the 10 bids was only slightly below JPY 19.5/kWh (USD 172.9/MWh)[9] (Kageyama, 2017b).

In **South Africa**'s first round, a volume of 3,626 MW was auctioned all at once, which may have been too large for the market. Participants bid right below the disclosed ceiling price. The circumstances led to significant undercontracting, with only 1,425 MW contracted (IRENA, 2018a). Although this may be considered a sizable volume for a first round, it was less than 40% of the volume offered (IRENA, 2013).

Table 2.1 Commitment bonds for solar and wind auctions in selected countries

COUNTRY	COMMITMENT BONDS FOR SOLAR PV		COMMITMENT BONDS FOR ONSHORE WIND	
	Bid bond	Completion bond	Bid bond	Completion bond
Brazil	1% of CAPEX	5% of CAPEX	1% of CAPEX 5% of CAPEX	
Germany	EUR 5/kW (USD 5,750/MW), assuming an exchange rate of EUR 1 = USD 1.15	EUR 25/kW with permits and up to EUR 50/kW with preliminary permits (USD 28,750/MW – USD 57,500/MW)	EUR 30/kW (USD 34,500/MW)	
India	USD 13,500/MW	USD 27,100/MW	USD 13,500/MW	USD 27,100/MW
Italy	NA	NA	EUR 61.25/kW (USD 78.5/kW) in 2012	EUR 122.5/kW (USD 157/kW) in 2012
Japan	JPY 500/kW (USD 4,500/MW)	JPY 5,000/kW (USD 45,300/MW)	NA	NA
Mexico	Technology-neutral auction with no differentiation between the bid bond and the completion bond. The guarantees required depend on the amount of each type of product committed in the bid. The bonds are denominated in Mexican investment units (UDI); an exchange rate of 3 UDI/USD can be assumed			
South Africa	USD 8,000/MW in round 4	USD 16,000/MW in round 4	USD 8,000/MW in round 4	USD 16,000/MW in round 4

Sources: GIO, 2019b; CENACE, 2018; IRENA, 2018a; Bundesministeriums fuer Umwelt, Naturschutz und Reaktorsicherheit, 2017; AURES, 2016; IRENA, 2013.

[8] 1 USD = 112 JPY in September 2018.
[9] 1 USD = 115.4 JPY in November 2017.

Compliance rules

Bidders selected after the auction is conducted may choose to opt out before signing a contract. Compliance rules, specifically commitment bonds, can be introduced to minimise the incidence of undercontracting and underbidding. They include bid bonds and project completion bonds (also called performance bonds). The trade-off to consider when setting commitment bonds is that they may discourage possible bidders, mostly small and new players (see Chapter 4) and thus limit competition. Table 2.1 presents some of the commitment bonds that have figured in solar and wind auctions in some of the countries analysed in this chapter.

The bid bond is a deposit or similar guarantee required from the developer as a condition for participating in the auction. It is usually returned to losing bidders. The bid bond is forfeited if a winning bidder fails to sign the contract or to submit the completion bond in a timely fashion.

The project completion bond is typically required of winning bidders before they can sign a contract. It serves as a guarantee against issues that may be encountered in project implementation. Most auctions impose partial confiscation of the completion bond if the project is delayed. It is forfeited if the bidder does not build the project or live up to contractual commitments. Completion bonds range from security deposits to actual bonds issued by a guarantor (bank or insurance company). The amount of the bond (lump sum, percentage of the contract remuneration, or other formula) is generally calibrated to constitute sufficient disincentive for delay or failure to complete, without being so high that it imposes barriers to entry on too many potential players. In **Africa**, the completion bond is usually two to three times the bid bond. In **Japan**, it was 10 times higher in the most recent auction, which led to a high incidence of undercontracting. Winning bidders had only two weeks to submit the bond and the conditions and deadlines related to forfeiture were strict (Box 2.2). As a result, five awarded developers in the first round, accounting for 100 MW, chose not to present the completion bond owing to uncertainty about the deadlines. Only 41 MW out of the 141 MW that were awarded signed the contract (Kageyama, 2018).

BOX 2.2 COMMITMENT BONDS IN JAPANESE SOLAR PV AUCTIONS

After being selected in the first round of the solar auction, developers were given only two weeks to secure completion bonds, and failure to meet this deadline would result in forfeiting the bid. Moreover, if a developer failed to obtain certification from the Ministry of Economy, Trade and Industry (METI) within three months of award, and then to settle the grid connection agreement a month later, the contract would also be void and the bond confiscated. Such strict provisions meant that generators could be penalised for events not within their control, increasing their risk perception. The completion bond was relatively high (JPY 5,000/kW; USD 45.3/kW) – 10 times higher than the bid bond.

Taking into account the feedback received from developers, the government relaxed the confiscation rules for subsequent rounds. If METI's certification could not be procured within the deadline, the completion bond could be carried forward to the next auction.[a] Furthermore, the deposit would not be confiscated if the developer failed to deliver owing to external factors. Japan also enforced long-term planning and systematic auctions to increase investors' confidence and tackle the problem of undersubscription. Two solar auctions and one biomass auction are scheduled each year until the solar PV targets are met.

Looking ahead, future auctions could ease the task of developers in securing land and grid connection. Section 3.2 describes project-based strategies to reduce those risks and costs to bidders.

[a] As long as the project capacity and location did not change and the bid price in the later auction was lower.

Sources: GIO, 2019a and 2019b; BNET, 2019d; Kageyama, 2018; Matsuda *et al.*, 2018.

Payment to the winner

India has seen several cases of undercontracting in recent years, sometimes resulting from negotiations after the auction. In some instances, when the auctioneer has not been satisfied with the outcomes, in terms of the lowest tariffs obtained and the tariff spread, it has chosen to cancel the auction altogether or to request bidders to match the lowest tariff (see Box 1.1). In 2018, nearly 5 GW of solar auctions were cancelled (Kabeer, 2019). Where bidders have been asked to match the lowest bid, often only a few developers agree. In the case of the 1 GW wind auction conducted by Gujarat Urja Vikas Nigam Limited (GUVNL), the difference between the lowest bid (L1) and that of the last winner (L8) was INR 0.15 (USD 0.002) per kWh, which GUVNL deemed inconsistent with industry norms. It then invited all bidders to match the lowest bid. Only two of the eight developers did so, leaving over 500 MW to be contracted through a future auction (Ranganath, 2019). The same approach has been followed several times since 2010 and has discouraged various winners from signing a contract because their projects would not be economically feasible at the lowest price (Azuela *et al*., 2014). This issue arises in India's solar auctions particularly, as policymakers have pursued ever-more-competitive solar power contracts, seeking prices incommensurate with developers' costs and the risks assumed.

2.3 CONSTRUCTION STAGE

Underperformance during construction, referred to as underbuilding, can be associated with delays in project completion, installation of less capacity than committed or project cancellation. The most common occasion for underbuilding is when awarded projects encounter obstacles during construction, but issues with grid connection can also have an impact.

Lead times

Typically, the auctioneer sets a lead time, which is the period from contract award to the date of entry into operation (see IRENA and CEM, 2015 for more details). If the lead time is too short, the probability of project delay increases. If the lead time is too long, bidders may underbid, speculating that costs may fall and more advanced components may be on the market by the date commercial operation is to begin. Long lead times may also expose developers to inflation and currency risks, depending on how the contract prices are indexed and denominated (see Section 1.4.4). Box 2.3 discusses the implications of lead times and currency exchange on the performance of wind and solar auctions in **Brazil**.

Lead times are not comparable, as they are generally set according to the auction objectives and specific conditions. The lead time of an auction designed to supply additional capacity

BOX 2.3 LEAD TIMES AND CURRENCY EXCHANGE RISKS IN BRAZIL

Brazil typically conducts two types of auctions: one for delivery in three years (A-3) and the second for delivery in five (A-5) (IRENA, 2013). The five-year lead time allows more flexibility for planning construction and commissioning the project, while also minimising the likelihood of delays and the attendant penalties. It also gives project developers the opportunity to profit from falling costs of components. The A-5 auctions, therefore, should be expected to yield lower prices. For example, the December 2013 A-5 auction yielded a price 6% lower than the A-3 price of the November 2013 auction carried out just a month earlier. A similar price difference was observed between the November 2014 A-5 and the October 2014 A-3 auctions (IRENA, 2017a). The choice of the lead time therefore can impact the performance of the auction when it comes to resulting price.

As for the risks of currency exchange, solar developers that import technology won contracts to sell power in 2014 at an average price of BRL 215.12/MWh (about USD 87/MWh at the time). The exchange rate by the time the projects had to be delivered put the value of that power at about USD 68/MWh. At the same time, Brazil's economic downturn limited the growth of electricity, a decline of 0.9 percent in 2016. The auction was then cancelled, which was a win-win result for for investors and the government alike (IRENA, 2017a).

on an urgent basis, for example, is generally shorter than that of an auction designed to support the development of a local industry, which should allow more time for domestic businesses to seize the opportunity presented. Specific conditions to consider include the level of development of the sector, technological maturity, and the complexity of project pre-development requirements (*e.g.*, permits).

In the case of technology-specific auctions, lead times are generally shorter in solar PV than in wind auctions. For example, in their solar auctions, **India** and **Germany** adopted 13- and 18-month lead times, respectively, although the exact target varies for each individual auction. For wind, **Italy**'s auctions involved 28- and 31-month lead times in 2012 and 2016. In some cases, lead times are the same for both technologies. In **Brazil**, 36- or 60-month lead times apply to solar and wind, depending on the category (A3 or A5, see IRENA, 2013). In **Mexico** and **South Africa**, project developers may suggest their own commercial operation date up to a maximum of 30 and 24 months, respectively. In **Japan**, the first solar auction allowed project developers to set their lead time. Less than half of the bidders set it to less than 36 months – equivalent to the lead time in the feed-in tariff scheme. In fact, 13.8% of the projects even had a lead time between eight and ten years (Kageyama, 2018).

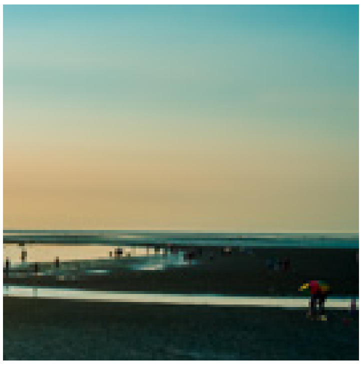
Most auction designs also include a maximum permissible construction time (or delay) beyond which the contract is written off and another project selected. In cases where the asset is partly developed by the time the deadline is reached, the contract may be written off, but provisions are made for the asset. IRENA's Open Solar Contracts provides options for the partially completed asset (see Box 1.8).

Compliance rules

Penalties can minimise the risk of project delays and completion failures during construction. Three types of penalty are commonly applied in the event of delay:

1) confiscation of a fraction of the project's completion bond in proportion to the delay observed, or charging a pre-defined penalty for each unit of time the project is delayed (a one-time cost);
2) reduction of the project's contractual remuneration (a recurring cost) or duration; and
3) cancellation of the contract, if the delay extends beyond a defined deadline.

Beyond those penalties, it is crucial to establish whether the project developer retains contractual obligations during the delay period. If that is the case, the developer is typically required to purchase compensatory products (in the spot market, when applicable) in lieu of the electricity not delivered. In **Brazil** and **Mexico**, the developer retains this responsibility during delays. This can put a significant strain on the company's cash flow during the delay, as it must meet financial obligations without receiving contract income. In **Germany**, **India** and **Italy**, there is no such obligation during the delay period. But whereas generators in these countries have less exposure to market risk, the delay penalties affecting contract remuneration tend to be harsher. These apply not only during the delay but during the entirety of the project's remaining useful life.



In **Germany**, when the solar project fails to meet the target commercial operation date, normally 18 months from the time the project is awarded, penalties are pro-rated to the absent capacity. In addition, for solar PV, the contract is reduced by EUR 3/MWh for the entirety of the plant's useful life if operation begins more than 18 months late or if the installation deviates from the specifications in the bidding documents. Considering a typical contract price of EUR 60/MWh for solar auctions in Germany, this penalty represents a loss of 5% of the contract value over a 20-year period (Bundesnetzagentur, n.d.). Box 2.4 presents the results of the performance of early solar auctions in Germany. For onshore wind, commercial operation must begin no later than 24 months from the public announcement of winning bids (except for citizen wind parks, which are given the benefit of two additional years; see Box 4.3). Thereafter, penalties must be paid to the grid operator for shortfalls in capacity exceeding 5%, with the bid bond standing as guarantee in case of non-payment. The penalty increases with time: EUR 10/kW if operation begins between months 24 and 26; EUR 20/kW between months 26 and 28; and EUR 30/kW after month 28. The contract is terminated if operation does not begin by month 30, unless an extension is granted (*e.g.*, by court order) (Bundesnetzagentur, n.d.).

Likewise, in **Italy**, if the developer fails to meet the deadline, its contract price is reduced by 0.5% for each month of delay (for a maximum of 24 months). This translates to a 3% reduction in value for a six-month delay. Box 2.5 discusses the performance of the wind projects awarded through the 2012 and 2016 auctions in Italy.

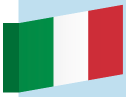
In **Japan** and **South Africa**, rather than penalising the contract price, the contract is shortened commensurate with the delay. In **Japan**, the procurement period is shortened by one month for each month of delay: given a six-month delay, the contract will only be valid for 19.5 years instead of 20. Moreover, the completion bond is forfeited in its entirety if the project does not meet the deadline for commencement of commercial operations.. In **South Africa**, for every delayed day, the contract is reduced by an additional day: one day of delay results in two days of lost revenue.

BOX 2.4 PERFORMANCE OF EARLY SOLAR AUCTIONS IN GERMANY

An analysis of solar auctions in Germany conducted in 2015-2016 covered six auctions that awarded 174 solar projects with a total of 963 MW of installed capacity. The analysis showed high rates of timely completion. More than 65% of the capacity awarded was built on time, and only around 23% was delayed. At the time of publication, data was still missing for around 11% of the capacity awarded. Among the countries analysed, Germany has one of the highest rates of timely completion for solar PV. As commitment bonds in Germany are not much higher than in the other countries analysed (see Table 2.1), the success may be due to strict compliance rules related to penalties for delays, and most importantly, to an enabling environment that supports timely completion. This includes the ease of obtaining permits and licenses, in addition to the availability of a developed domestic PV sector.

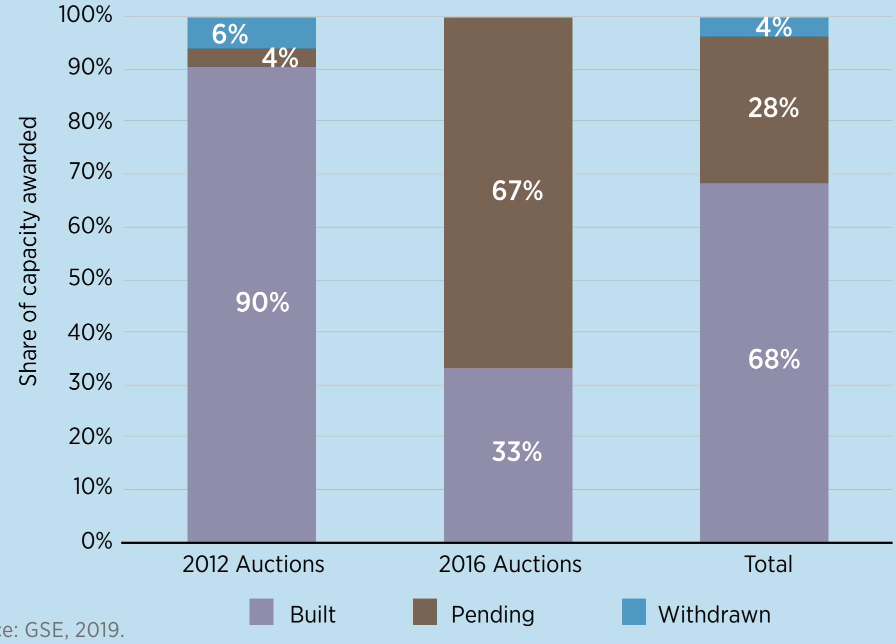
Source: Bundesnetzagentur, n.d

BOX 2.5 PERFORMANCE OF WIND PROJECTS AWARDED THROUGH THE 2012 AND 2016 AUCTIONS IN ITALY



Almost 90% of the wind capacity awarded in Italy's first auction round in 2012 has been built (corresponding to 47 out of 49 projects) (Figure 2.4). One project was withdrawn, while the other is still pending (corresponding to 6% and 4% of total capacity awarded, respectively). The system for monitoring projects does not account for delays but some assumptions can be made regarding the second round in 2016. Considering a lead time of 28 months, two-thirds of the projects awarded were already delayed by the time this report went to publication and one project of 1 MW capacity had withdrawn. Delays may be related to grid connection problems as well as financial prequalification criteria that were deemed unreliable (AURES, 2016).

Figure 2.4 Status of projects resulting from wind auctions in Italy



Source: GSE, 2019.

Thus, a delay of six months in the scheduled commissioning date would shorten a typical 20-year contract by a year, or 5% of its term. The performance of projects awarded through the different rounds of the Renewable Energy Independent Power Producers Procurement Programme (REIPPPP) is described in Box 2.6.

In **India**, if the project is delayed for more than three months, the contract price is reduced by INR 0.005/kWh for each additional day of delay. For a six-month delay and an average contract price of INR 3/kWh, the contract would lose 30% of its value. Particularly in India, a six-month delay is not implausible, given India's shorter target construction times and possible delays in permitting.

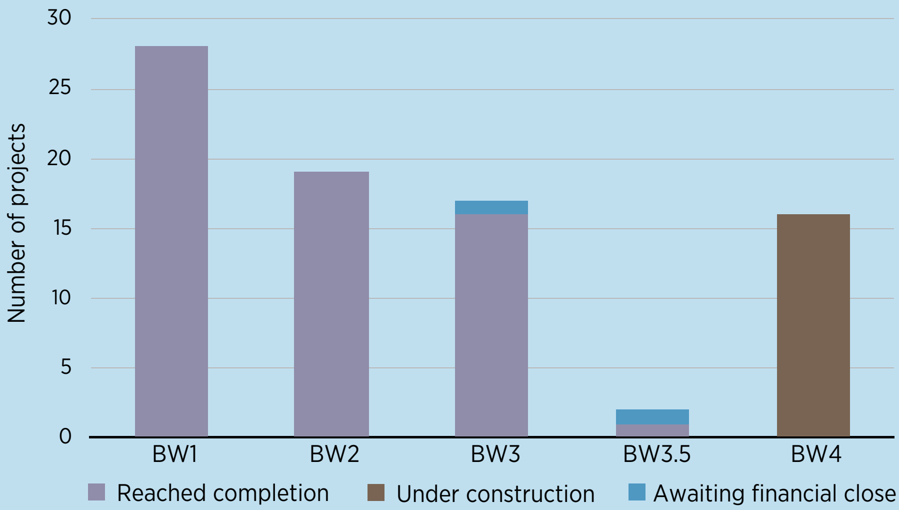
Enabling and integrating measures

Delays in project completion can pertain to issues that are not related to auction design, or even the choice of the auction as a policy instrument. In the initial stages of development of the **Brazilian** wind industry in 2002, the sector was driven by a feed-in tariff (PROINFA) that contracted a total capacity of 1.4 GW by 2004. The awarded projects were subject to years of delay and the last wind power plants commenced commercial operation toward the end of 2011. The total capacity built amounted to 1.3 GW, indicating that some projects were cancelled. Delays and cancellations at the time were due to factors unrelated to the policy instrument chosen to support deployment; most were related to the level of development of the sector (Bayer *et al.*, 2018).

BOX 2.6 PERFORMANCE OF AUCTIONS IN SOUTH AFRICA

Of the 90 projects awarded in the five rounds (BW1, 2, 3, 3.5 and 4) that have started construction, 64 had been successfully completed by March 2019[a] with an average completion time of 702 days (a bit less than 2 years). Based on scheduled commissioning dates and progress to date, it is projected that all 90 projects will be operational by 29 October 2021. Figure 2.5 illustrates the status of projects awarded as of March 2019.

Figure 2.5 Status of projects awarded in South African auctions as of March 2019



For most of the projects built, only 1% encountered underperformance related to delays or underbuilding, peaking at 350 MW capacity in June 2014. The majority of this capacity was delayed, with only 23 MW shortfall of capacity built. The average delay period for all 64 projects that have reached their commercial operation date (COD) was 64 days. Those were mostly focused in BW1 projects, followed by BW2, with average delays of 89 and 79 days respectively. Those delays were mainly attributed to grid connection issues and to extended industrial action in the metals and mining industries in early 2014, particularly impactful given the shares of local content in South Africa. The average delay dropped to 7 days by BW3, indicating that the learning curve and experience gained contributed greatly to reducing delays. In addition, cross-cutting issues such as grid connection delays were addressed with priority. Projects that reach COD but are not able to connect to the grid due to network unavailability are paid for deemed energy. Payments reached ZAR 325 million by March 2019 (approximately USD 22 million) which may have incentivised action from the government to address the issue.[b]

[a] The operational capacity of 3,976 MW consists of solar PV (1,474 MW), onshore wind (1, 980 MW), concentrated solar power (500 MW), hydropower (14 MW) and landfill (8 MW).

[b] 1 USD = 14.33 ZAR as of 31 March 2019.

Source: Republic of South Africa, 2019

Delays and underbuilding can be caused by factors that lie outside the developer's control. In particular, the processes of obtaining environmental and social permits and securing grid access are significant causes of underperformance in the construction phase. It is therefore essential to allocate those responsibilities fairly between the bidder and auctioneer. Alternatively, permits may be included as a qualification requirement, but this may limit the pool of participants in the auction (as discussed in Chapter 3). In any case, in many jurisdictions, permitting processes can and should be made more transparent and streamlined.

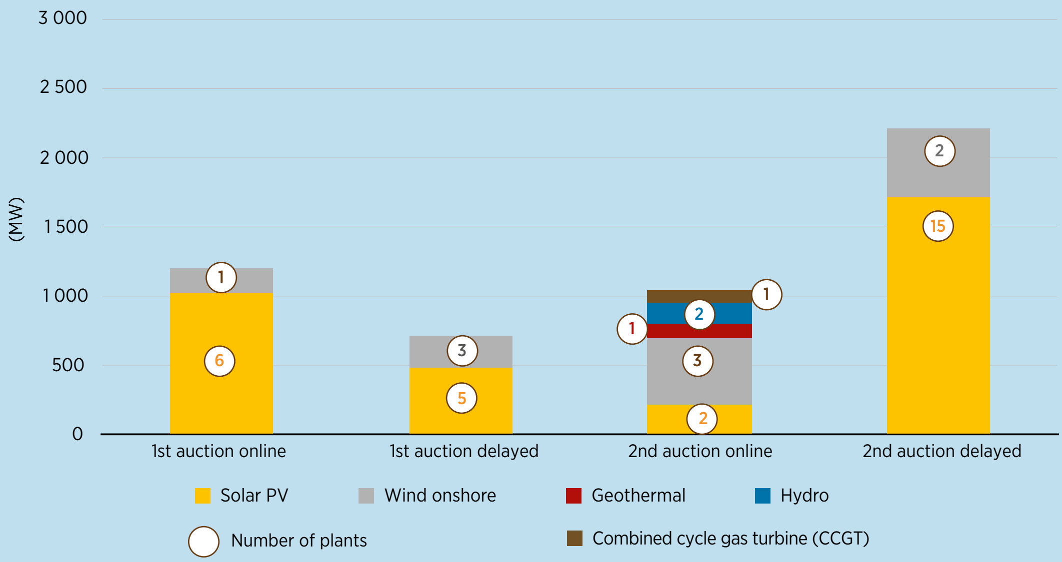
In **Mexico**, administrative burdens and bureaucracy in obtaining documentation and construction permits were among the main causes of underperformance in the construction stage, especially in the second round (Box 2.7). In the state of Sonora, for instance, a developer had to request 16 construction permits from 13 different agencies at the federal, state and municipal levels, and most of those permits were duplicated. For example, an environmental permit had to be obtained at the federal level and then again from the municipality. Other permits that were duplicated across government levels related to urban development and land use, civil protection, and road-impact studies. The permitting process took more than a year to complete, half of the two-year project lead time. Project developers in other regions face similar challenges, with even more permits required in some cases, resulting in even longer waits (Guadarrama, 2018).

BOX 2.7 CONSTRUCTION DELAYS IN MEXICAN AUCTIONS

As of September 2019, only 16 of the 42 awarded projects in the first two rounds had started their power purchase agreements (PPAs), although they were all past their commercial operation date (Figure 2.6). Of the 15 projects resulting from the first auction in March 2016 (11 solar PV and 4 wind) that committed to begin operation between March and September 2018, only five were on time. Two additional projects came online in 2019, but eight projects totalling 715 MW were still delayed as of September 2019, representing 37% of the planned capacity from the first round. Of the eight projects delayed, six are located in the state of Yucatan, one of the locations favoured in the winner selection criteria (see Box 3.10). These outcomes suggest that broader challenges beyond system integration must be considered when adopting an adjustment-based strategy (see Section 3.4) in auction design. Obtaining permits in Yucatan is difficult, given that it is a hurricane zone, has complex topography, and is home to many Mayan archaeological sites (Guadarrama, 2018).

The second auction awarded 28 projects: 17 solar, 6 wind, 2 hydropower plants built in the early 1900s (existing plants seeking a PPA may participate in the auction), a geothermal plant built in 2006 and 2 combined cycle gas turbine plants (CCGT) one built in 2018 (and one under construction in Texas, U.S.).[a] Solar PV and wind plants had to be built after the auction, in most cases. and they committed to start operation between July 2018 and June 2019. Among, the 22 solar and wind plants awarded, only five (three wind and two solar), were in operation by September 2019. Sixty-two percent of the second auction's plants' capacity is delayed.

Figure 2.6. Status and technology of awarded plants in Mexican auctions



[a] One wind plant, that was also awarded in the first round, and the CCGT plant in Texas are not depicted.

In **Brazil**, of all the projects resulting from the first ten rounds of wind auctions that had reached their implementation deadline in 2017, only 17% were completed on time, and some projects took up to four additional years to be implemented. Grid connection was stated as the principal reason for the delays in early rounds, with little coordination between the expansion of renewable energy and that of transmission grids. Until 2013, delays in extending the transmission grid was not the responsibility of the project developer, but as of round LEN 11/2013, the auction design changed.

Even when project delays were due to the extension of the transmission grid, the generators had to fulfill their contractual obligation to supply energy. Following this change, the timely completion rate of the LEN 11/2013 and LEN 06/2014 auctions improved considerably, with 46% and 69% of capacity delivered on time, respectively. However, the additional risk allocated to the developer was factored in the price bid, which increased by 9% in LEN 11/2013.

Another reason for the delay in early projects was the nascent domestic wind industry that was not yet capable of supplying the equipment needed for developers to fulfil their local content quota of 60% —and so benefit from concessional finance from the national development bank, *Banco Nacional de Desenvolvimento Econômico e Social* (BNDES). For some components, there was only one supplier, compared to ten for the same components in Europe (Bayer *et al*, 2018).

Requests for a deadline extension to postpone obligations and avoid penalties are common in Brazil. The regulator, Brazil Agência Nacional de Energia Elétrica (ANEEL) has recognised cases where delays are not the responsibility of developers: delays in processing licenses (project, environmental, etc.) caused by public authorities, and delays in the transmission grid extension.

A deadline extension request can also be approved if it is in the public interest (Bayer *et al*, 2018). The performance of wind projects awarded through the different rounds of the Brazilian auction is described in Box 2.8. Project delay or cancellation in Brazil can have three main legal consequences for developers: 1) reimbursement of the energy that was not delivered, 2) execution of financial guarantees, and 3) other penalties such as contract termination, a ban from auctions, or administrative fines as high as 10% of the investment (Bayer *et al*, 2018).

Contract termination

Most PPAs include a provision to terminate the contract that may be invoked once the maximum allowable construction time is reached. India, Italy and Germany set a 24-month maximum construction time (counted from the announcement of auction winners) after which the contract can be terminated. **Brazil** and **South Africa** may cancel the contract after a delay of 18 months (with some exceptions). **Mexico** sets a 12-month limit.

BOX 2.8 PERFORMANCE OF WIND PROJECTS RESULTING FROM AUCTIONS IN BRAZIL

The first wind power plant was awarded in 2009. Of the 16 auction rounds auctioned by 2017 (contracting a total 14.6 GW), ten rounds (with a total awarded capacity of 10 GW) had achieved the implementation deadline (Brazilian Power Trade Chamber, 2017a): 77% of the capacity awarded had reached commercial operation, 7% were under construction, 4% were in the planning phase, and 12% were either cancelled or had very low likelihood to be implemented (Bayer *et al.*, 2018).

Projects awarded in new energy auctions are subject to significant penalties for delays and underproduction. Developers must purchase firm energy certificates in the market to meet their contractual obligations if they are not connected to the grid by the time set for project completion. But in the reserve auctions, settlement rules are more relaxed and generators do not have the financial obligation to provide the contracted quantity as these auctions aim to provide surplus energy to guarantee system reliability. Projects awarded in reserve auctions are also protected against transmission delays that are beyond the control of the developer.

Even though cancelling a project may seem like an extreme penalty, it may be preferable for a developer facing significant cost overruns. This scenario is more plausible in the models adopted by Brazil and Mexico, where the developer retains market liabilities during the delay period.

Incentives for early project completion

Beyond penalising projects for delays or setting thresholds for cancellation, auction design can encourage developers to implement faster and more efficient construction processes. For instance, projects that are completed earlier than scheduled may be allowed to sell their energy into the market until the specified start date of their PPA. Providing an incentive for early completion can shorten average construction time.

Such a policy is in place in **Brazil**, **Italy** and **Mexico**, which allow agents to sell their electricity (and other energy products) in the wholesale market until the scheduled commercial operation date. This feature tends to be particularly attractive for developers in **Brazil**, who have a lead time of up to five years and where spot prices have been high compared to auction prices, partly because of recent hydropower trends. In **Italy**, almost all projects that were not delayed were operational more than a year before the target date.

In Germany and South Africa, the remuneration begins earlier and at the awarded contract price if projects are completed early. However, in **Germany**, this shift automatically also changes the contract's end date, while in **South Africa** the end date remains fixed. **India**, in contrast, has adopted a fixed tariff of INR 3/kWh to be paid during the early-completion period. The tariff is then revised upon the commercial operation date.

2.4 OPERATIONAL STAGE

Delays aside, failures to deliver in accordance with the bid can occur at other levels, including the quantities delivered in terms of energy, and the socio-economic goals achieved.

Quantities of energy

Owing to the uncertainties implicit in generating variable renewable energy, underperformance during the operational stage is hard to measure. Several years of monitored output are typically needed to assess whether underdelivery is systematic or simply attributable to variable production cycles. On the technical level, the generation load may be predetermined (*e.g.*, in Mexico), and actual production from the generators may deviate from the required generation profile.

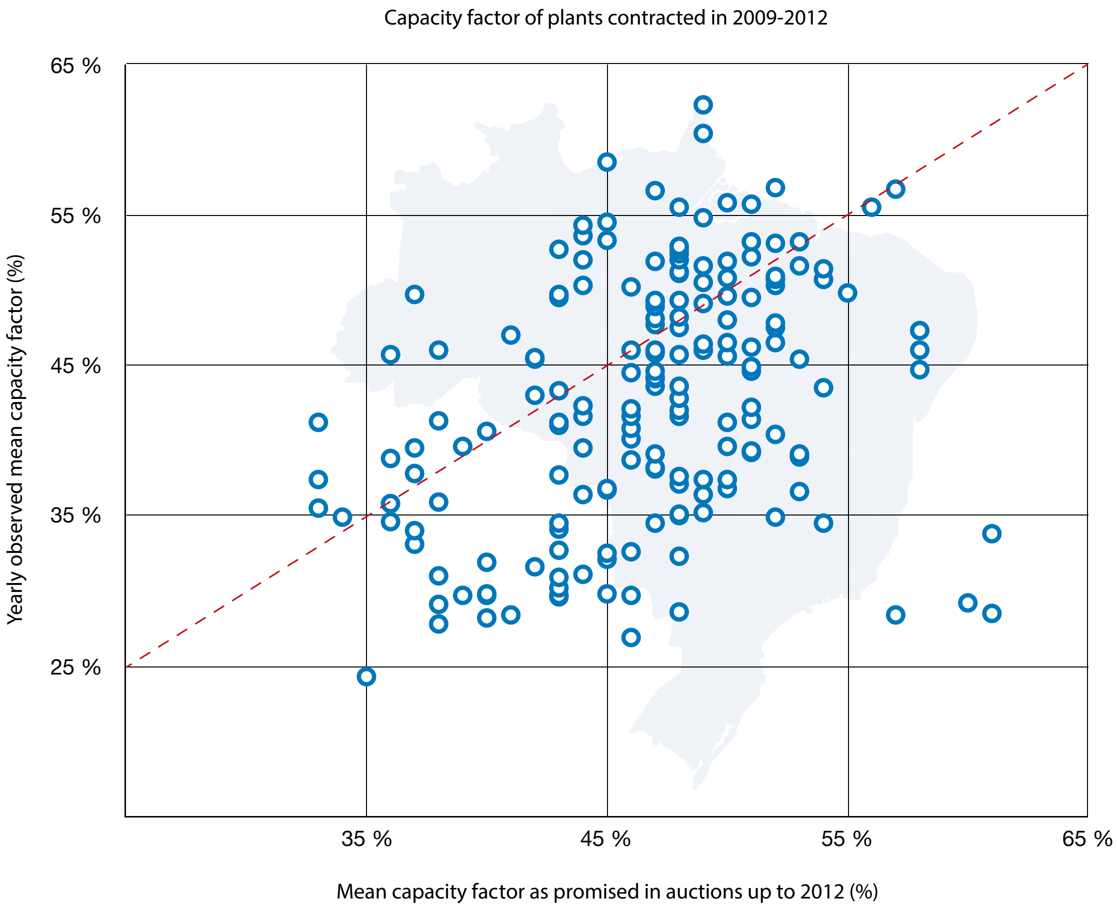
In Brazil, underdelivery was twice as common as overdelivery from wind auctions between 2009 and 2012. Underdelivery relates to the explicit commitment made by developers at the time of the auction to a given quantity to be delivered.

In Figure 2.7, the diagonal dotted line represents a match between the awarded and delivered capacity factors. Many points lie far from the line, and more than half are below it.

Underdelivery can be addressed through by clearly defining the auction's quantity-related liabilities (see IRENA and CEM, 2015) between 1) capacity-oriented agreements, 2) energy-oriented agreements and 3) financial agreements, accompanied by provisions on how to handle delivery deviations. Settlement rules can vary from case to case, but the general rule is to implement strict penalties for obvious underperformance (and in some cases for overperformance), exercising leniency where doubt exists.

IRENA and CEM (2015) provides a more detailed analysis on the various options for temporal aggregation, provisions for over- and underperformance, and grounds for revision of contracted quantities.

Figure 2.7 Underdelivery from Brazilian wind auctions: delivering less than the committed capacity



Source: PSR, n.d.

Socio-economic development goals

Failure to deliver as bid may also entail a failure to meet promised socio-economic objectives. Projects awarded in Morocco and South Africa have been reporting on the benefits achieved. In **Morocco**, the inclusion of local labour and materials was encouraged in the four rounds of the Noor-Ouarzazate complex. Remarkably, commitments presented in bids for each of the phases were higher than the thresholds specified in the auction. In the fourth phase, the commitments doubled the threshold (Table 2.2).

Early results have matched, if not exceeded, expectations. Noor I indeed sourced 30-35% of the project costs in local components and services (ESMAP, 2018). Throughout the four phases, 6,430 Moroccans have been employed (70% of the total) and a third of the jobs were sourced locally from the region of Ouarzazate (Table 2.3).

These outcomes can be attributed to *L'Agence Marocaine pour l'Energie Durable* (MASEN) assuming an active role in promoting education, training, and research and development. For the Noor complex, MASEN partnered with the *Agence nationale de promotion de l'emploi et des compétences* (ANAPEC) to ease local recruitment for developers and to provide the needed training to a young workforce in the region. For example, for Noor II and III, 96 students were trained to become electrical and mechanical technicians, solar field operators or mirror cleaning operators, among other fields. Ultimately, 50 candidates were recruited through this programme for operation and maintenance activities (Stitou, 2019).

Table 2.2 Share of local content commitments in Noor-Ouarzazate, Morocco

	Noor I	Noor II	Noor III	Noor IV
Committed share	34.7%	40.5%	42%	24%
Threshold share	30%	35%	35%	11.7%

Source: Stitou, 2019.

Table 2.3 Employment at Morocco's Nour Ouarzazate facility

Employees on site						
	Local share commitment	Total	Moroccan employees		Local area employees	
	(percent)	*(number)*	*(number)*	*(percent of total)*	*(number)*	*(percent of total)*
Noor I	35	1 906	1 471	77	659	35
Noor II	40	4 063	2 723	67	927	23
Noor III	40	2 524	1 695	67	797	32
Noor IV	24	656	541	82	386	59
Combined	**-**	**9 149**	**6 430**	**70**	**2769**	**30**

Source: Stitou, 2019.

In **South Africa**, the seven rounds conducted so far have attracted significant investment, reaching ZAR 209.7 billion (USD 14.64 billion) by March 2019, including ZAR 41.8 billion (USD 2.92 billion) foreign investment and financing. The capital expenditure incurred on the design, construction, development, installation and/or commissioning of projects, has created many opportunities for local value at each segment of the value chain. By March 2019, ZAR 63.1 billion (USD 4.44 billion) was spent on construction and operation of projects, and the total spending planned is ZAR 149.9 billion (USD 10.54 billion). The share of procurement from Broad Based Black Economic Empowered (BBBEE) suppliers, Qualifying Small Enterprises (QSE), Exempted Micro Enterprises (EME) and women-owned vendors are tracked against committed and targeted shares. While shares of procurement from BBBEE, QSE and EME suppliers as of March 2019 has exceeded commitments, the involvement of women-owned businesses is still lagging, especially in construction (Republic of South Africa, 2019). The performance of projects awarded through the REIPPP as of March 2019 are presented in Table 2.4.

When it comes to local content, ZAR 46.5 billion, billion (USD 3.27 billion) has been spent locally, out of a total spending of ZAR 90.3 billion, (USD 6.35 billion). However, for the projects already completed, local spending was 0.4% below planned.

In terms of job creation, the REIPPP has created a total of 40,134 job-years (equivalent of a full-time employment for one year) for South African citizens, of which 33,019 were in construction (101% above planned) and 7,115 in operations. The 64 projects that were completed by March 2019 created 31,633job-years, 53% higher than the committed to 20,689 job-years.

Employment thresholds for South African citizen employment were exceeded, with 89% for construction (BW1 – BW4) and 95% for operation (BW1 – BW3) respectively. The procurement conditions required at least 40% of each project to be owned by South African entities. This was surpassed with local equity shareholding across all rounds reaching 52%.

The REIPPPP contributes to Broad Based Black Economic Empowerment and the creation of black industrialists. Black South Africans own, on average, 33% of projects that have reached financial close, 3% higher than the 30% target. This includes black people in local communities that have ownership in the IPP projects that operate in or nearby their vicinities. On average, black local communities own 9% of projects that have reached financial close. This is well above the 5% target. Shareholding by black South Africans has also been secured across the value chain.

Table 2.4 The performance of projects awarded in South Africa in terms of socio-economic development, as of March 2019

Element (weighting)	Description	Threshold	Target	Achievement as of March 2019
Job creation (25%)	RSA-based employees who are citizens	50%	80%	89% in construction and 95% in operation
	RSA-based employees who are black people	30%	50%	79% in construction and 83% in operation
	Skilled employees who are black people	18%	30%	67% in construction and 79% in operation
	RSA-based employees who are citizens and from local communities	12%	20%	67% in construction and 83% in operation
Local content (25%)	Value of local content spending	40-45% [a]	65%	52%
Ownership (15%)	Shareholding by black people in the seller	12%	30%	33%
	Shareholding by local communities in the seller	2.5%	5%	9%
Preferential procurement (10%)	BBBEE procurement [b]	-	60%	86% for construction and operations combined [c]
	QSE and SME Procurement [b]	-	10%	31% of total procurement as of March 2019 [d]
	Women-owned vendor procurement [b]	-	5%	3% of construction and 6% of operations
Socio-economic development (15%)	Socio-economic development contributions [e]	1%	1.5%	2.2%

Notes: RSA = Republic of South Africa; BBBEE = Broad based black economic empowerment (BBBEE); QSE = qualifying small enterprises; EME = Exempted micro enterprises; SED = socio-economic development.

[a] Depending on technology; 45% for solar PV, 40% for all other technologies.
[b] As percentage of total procurement spend.
[c] The reported procurement numbers do not represent the final procurement spend and the data has not been verified by the IPPPP Office. Therefore, this achievement is reported with caution.
[d] 32% of total procurement for construction and 23% for operation.
[e] As a percentage of revenue.

Source: Republic of South Africa, 2019.

2.5 CONCLUSIONS ON ENSURING TIMELY PROJECT COMPLETION

Although the countries analysed in this chapter are quite heterogeneous in their auction design and other respects, underperformance was prevalent and frequent at different stages, especially during construction. This suggests that despite innovations in auction design over the past decade, there is still room for improvement when it comes to licences and permits, facilitating grid connection, and aligning project timelines with socio-economic development goals.

Sound auction design elements, such as establishing a regular schedule for auction rounds, auctioning adequate volumes, defining clear off-taker commitments and setting reasonable ceiling prices (where applicable) can mitigate undersubscription by attracting sufficient competition (IRENA and CEM, 2015). Likewise, clear, transparent and technically sound criteria for selecting winners can minimise undercontracting.

In setting qualification requirements, a balance must be struck between imposing overly stringent requirements that may limit the pool of potential bidders (and thus increase the risk of undersubscription) and lax requirements that may lead to underperformance at later stages.

The same reasoning applies to compliance rules related to the allocation of risk and the remuneration of sellers. Stringent compliance rules are meant to ensure that, once 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 may lead to undersubscribed auctions that could result in lower competition and higher prices.

Experience with auctions suggests that shielding investors from permitting risk – by centralising these procedures in a site-specific auction, for example – can have a positive impact on performance in the bidding, contracting and construction stages (see Section 3.2). Nonetheless, centralising responsibilities in this manner is not feasible in all contexts. Auctions should be tailored to each country's technical, administrative and political capabilities. Smooth coordination between various institutions involved in approving renewable energy construction projects is critical. The lack of robust institutions and permitting processes frequently raises concerns among project developers and increases the likelihood of delays and underbuilding. Increasing the predictability of these processes may be the most efficient way of combatting underperformance.

Finally, monitoring project performance related to socio-economic development objectives can be complicated. For instance, when reporting on local jobs created, one may encounter ambiguity in the definition 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 of the employment and its significance for individuals (see Chapter 4).

3

SUPPORTING THE INTEGRATION OF VARIABLE RENEWABLE ENERGY

Solar PV and wind are the most commonly auctioned renewable energy technologies, accounting for 97% of auction volume in 2017-2018 (see Figure 1.1). This is consistent with global trends in the last decade. Solar PV and wind are also the most widely deployed renewable energy technologies by a large margin, driven by their growing maturity and falling costs. Variable renewable energy (VRE) technologies, however, have characteristics that distinguish them from conventional and other generation sources. This chapter explores auction design elements that can support the deployment of VRE plants in a more appropriate system, one that considers their specific characteristics. As the transition progresses, it becomes increasingly important to update operational and market patterns that were originally designed for the fossil fuel era.

3.1 VRE CHARACTERISTICS RELEVANT TO AUCTION DESIGN

VRE is limited in dispatchability (the ability to control its output). It exhibits variable hourly, daily and seasonal generation patterns and may not always be available at times of peak demand. This variability calls for additional system flexibility.[1]

VRE generation can be predicted based on weather forecasts, but some uncertainty in projections always remains, with implications for system reliability. Strategies that can mitigate the adverse effects of variability and uncertainty include forming portfolios of various technologies or widening the geographic distribution of projects, adopting the most accurate forecasting systems and moving closer to real-time electricity markets and operations.

VRE is location-constrained and may be concentrated in areas with abundant resources. This may lead to so-called hotspots (*e.g.*, areas with higher concentration of solar PV or wind farms). Hotspots are usually far from centres of demand, which may require additional infrastructure to avoid transmission congestion and losses. Moreover, hotspots can increase system vulnerability to weather events.

VRE generators are also characterised by low operating costs and they can produce electricity at a short-run marginal cost that is close to zero. When generation is remunerated based on the marginal cost of the most expensive active generator, cheaper VRE generation can decrease wholesale market prices.

This reduces the attractiveness of merchant (*i.e.,* non-subsidised) investments in the power sector, for both renewable and conventional generation.[2] The former, however, has high initial capital costs; in a system with potential low electricity prices, renewables deployment calls for long-term and certain payments.

To that end, power purchase agreements provided through auctions can help in keeping finance costs low and in turn, minimising the cost of procuring renewable power. Indeed, sound auction design can find a balance between long-term revenue certainty for renewable energy developers and the competitive procurement of renewable technologies that have higher value for the system (IRENA, forthcoming-a).

This chapter 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 have been adopted around the world (Figure 3.1). These strategies can be implemented separately or as a mix, as shown in Section 3.7. An in-focus discussion on different approaches to curtailment risk in auction design can be found at the end of the chapter.

Figure 3.1 Implementation strategies for auction design to support increasing shares of VRE

Implemention strategy	Auction design
Project-based strategy	Project-specific auctions
Quantity-based strategy	Constraints-based limits
Adjustment-based strategy	Predetermined corrections
Price-based strategy	Exposure to market risks
Product-based strategy	Product-specific auctions

[1] *Defined as the ability of the power system to bring demand and supply into balance at any given time-scale.*

[2] *Although this discussion mostly applies to the wholesale market, similar effects can also be observed in some regulated power systems, since the rules are designed to maximise the economic efficiency of the power system.*

The strategies are sorted according to the degree of central planning, from highest to 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.).

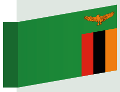
Importantly, the choice regarding the strategy to adopt (and associated auction design elements) is context-specific and depends on the structure of the power market and the level of development of the sector. In any case, the structure of the power system needs to be redesigned such that it becomes more appropriate for a renewables-based system. Within it, long term procurement strategies (such as auctions) will be one of the pillars. Indeed, sound auction design can help to overcome the unsuitability of the current power system structures to accommodate renewable-based power systems. The report "*Power System Organisational Structures for the Renewable Energy Era*" (IRENA, forthcoming-a) analyses this aspect and future IRENA work on auctions will provide strategies that can support this approach.

3.2 PROJECT-BASED STRATEGY

A project-based strategy aims for a highly predictable outcome, as the auctioneer maintains tight control of the results through pre-determined parameters such as project size, technology, location and technological characteristics. A strategy built on such strict planning can be implemented through a project-specific auction, typically in power systems based on the single-buyer model.

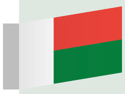
BOX 3.1 PROJECT-SPECIFIC AUCTIONS UNDER THE SCALING SOLAR PROGRAM

The Scaling Solar Program brings together several World Bank Group services under a single engagement. It includes a comprehensive package of technical support, document templates, pre-approved financing, insurance products and guarantees to enable the development of large-scale solar plants via project-specific auctions and private financing. It has supported solar PV deployment in various countries in Central Asia and Sub-Saharan Africa, including:

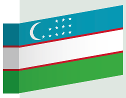


Zambia was the first African country to join Scaling Solar. In 2015, the country's Industrial Development Corporation (IDC) signed an agreement with the International Finance Corporation (IFC) that resulted in awarding two solar projects with a total capacity of 88 MW in the Lusaka South Multi Facility Economic Zone. The 34 MW Ngonye plant was awarded to Enel Green Power at USD 78.4/MWh and was brought online in April 2019 (Enel Green Power, 2019), and the 54 MW Bangweulu plant was awarded to the Neoen-First Solar consortium at USD 60.2/MWh and brought online in March 2019 (Takouleu, 2019).

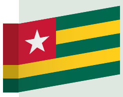
Senegal was the second African country to join Scaling Solar to develop 60 MW of solar PV. Two projects have been awarded. The partnership between ENGIE, investor Meridiam and Senegal's sovereign wealth fund FONSIS can start construction at sites by the West Senegal towns of Kael and Kahone. The two 30 MW projects will sell electricity to Senegal's power regulator (CRSE) at EUR 38/MWh (USD 42/MWh) and EUR 40/MWh (USD 44/MWh) (IFC, 2019; Martin, 2019).



Madagascar was the third country to join the programme. One year after the launch of the first auction in 2018, six bidders have been shortlisted to compete for a 25 MW project located near the capital, Antananarivo (Scaling Solar, 2018).



Beyond the African continent, **Uzbekistan** was the first country to join Scaling Solar to develop a 100 MW plant in the Navoi region. The project was awarded to the UAE developer Masdar Clean Energy at USD 27/MWh (Keating, 2019).



Togo was the latest country to join the programme in July 2019 to develop up to 90 MW of solar PV power. So far, a 30 MW project was approved on a selected site in Blitta, in the center of the country (Bellini, 2019 c).

In such cases the design elements all pertain to auction demand. Project-specific auctions can advantage both parties, the developer and system operator.

Project-specific auctions benefits to the developer

Bidders for project-specific auctions bear the minimum level of risk. Project-specific auctions can minimise costs and risks related to assessing resources, securing permits, and gaining access to the needed infrastructure (*e.g.*, grid connections and roads). As such, they are generally favoured by newcomers, including in Central Asia and Sub-Saharan Africa, where some countries adopted project-based auctions as part of the Scaling Solar Program (Box 3.1).

Project-specific auctions benefits to the system operator

Project-specific auctions can also be favourable for specific technologies such as offshore wind (see Chapter 5 in IRENA, 2017a) or Concentred Solar Power (CSP), for which dedicated infrastructure must be established. Project-specific auctions for CSP have brought record-low prices in **Morocco** and the **United Arab Emirates** (project-specific PV auctions also resulted in record-low prices on many occasions in the emirates of Abu Dhabi and Dubai). Both the emirate of Dubai in the United Arab Emirates and Morocco have auctioned CSP and PV specific projects separately, to form hybrid solar complexes and benefit from the storage capabilities of CSP.

In 2019, Morocco conducted a hybrid project-specific auction, the 800 MW CSP-PV Noor Midelt. Results of the hybrid solar complexes in the United Arab Emirates and Morocco are presented in Box 3.2.

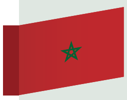
Depending on permitting procedures, a utility-scale PV system can be built typically in six to nine months; a wind farm can be commissioned in a year or two (IRENA, IEA and REN21, 2018; Lazard, 2018). A new transmission line, on the other hand, can take up to a decade from approval to construction. Aligning generation and transmission planning can help ensure that projects connect to transmission lines that are not congested and that they start feeding power the day they are commissioned.

Project-based auctions can be used to synchronise the development of new generation assets with grid infrastructure, thereby reducing curtailment risks and other avoidable costs. They allow the system operator to ensure that newly installed renewable capacity does not impose too much stress on the system, minimising economic and environmental losses that could occur, if projects had to be curtailed, for instance (see in focus discussion).

In project-based auctions, the cost related to the development of the needed infrastructure (*e.g.*, roads and grid works) is normally borne by the auctioneer.

BOX 3.2 HYBRID SOLAR COMPLEXES IN THE UNITED ARAB EMIRATES AND MOROCCO

The Mohammed bin Rashid Al Maktoum Solar Park auction in Dubai (United Arab Emirates) is planned to reach a total capacity of 5 GW. The fourth phase, a 700 MW concentrated solar power (CSP) project consisting of 600 MW from a parabolic basin complex and 100 MW from a concentrated solar tower, with thermal storage capacity of 15 hours, was awarded at USD 73/MWh. The project was amended to add 250 MW of solar PV awarded at 24 USD/MWh, increasing the total capacity to 950 MW.



In Morocco, the Noor Power Station in Ouarzazate was auctioned in four rounds: the first three rounds for CSP totalled 510 MW: The 160 MW Noor I and 200 MW Noor II projects use parabolic-through technology with storage capacity of three and seven hours respectively and Noor III, a 150 MW solar tower has seven hours of storage capacity. They were followed by a fourth round for PV of 72 MW.

In May 2019, Morocco auctioned the world's first advanced hybrid of CSP and PV. The 800 MW CSP-PV Noor Midelt is designed to provide dispatchable solar energy during the day and until five hours after sunset for a record-low tariff at peak hours of MAD 0.68/kWh (71 USD/MWh).

Sources: DEWA, 2019; Kraemer, 2019; Power-technology, n.d.

BOX 3.3 INDIA'S SOLAR PARKS

In India, Solar Parks have been established for the concentrated development of large-scale solar PV projects. The Solar Parks are primarily intended to address two critical elements: land and power evacuation infrastructure. The project-based strategy can support planning while enabling cost reductions by allowing project developers to benefit from economies of scale for the necessary infrastructure (procurement of land, road connectivity, communications network, water and other utilities) while also reducing the number of approvals required.

Source: MNRE, 2019a.

Bundling multiple projects into one site, or complex, as in the Mohammed bin Rashid Al Maktoum Solar Park or the Noor Power Station in Ouarzazate, could minimise those costs for the auctioneer. In India, specific solar projects are auctioned in one area to minimise connection costs and associated risks in so-called Solar Parks (Box 3.3).

Finally, project-specific strategies may entail the auctioning of a renewable energy project together with other technologies. Project-specific auctions for solar PV and battery storage, for example, have taken place in India, Jordan, and Lebanon. It should be noted that auctions for storage may be tied to a specific VRE generation asset as part of a project-specific strategy, as in South Australia (Box 3.4) or may be carried out separately as part of a product-specific strategy (see Section 3.6).

3.3 QUANTITY-BASED STRATEGY

The quantity-based strategy for system integration of VRE is more flexible than the project-based one discussed in Section 3.2. Nevertheless, the auctioneer still maintains a significant degree of control over the auction results.

Under this strategy, the most important system constraints are identified and applied as limits in the auction (*e.g.*, location or technology) to ensure smooth system operation. For example, a shortage in the transmission capacity needed to evacuate generation from a resource-rich area toward consumption centres may call for limiting the volume that can be awarded in that area.

BOX 3.4 AUCTIONS FOR STORAGE IN SOUTH AUSTRALIA

An auction was held for a 100 MW storage facility adjacent to a large wind farm in the state of South Australia. Tesla and Neoen won the contract for USD 50 million and deployed the Hornsdale Power Reserve (HPR), a 100 MW/129 MWh battery energy storage system.

The HPR system, which came online in November 2018, has had a positive impact on the local network. Depending on system circumstances, it provides grid services such as frequency control and load management. It has proved that batteries reduce the need for network upgrades and additional capacity at a low price. The HPR system can also operate in the market with a share of its capacity (30 MW), arbitraging energy in VRE-rich South Australia.

Following the success of the project, two more battery storage plants came online in 2019 in Victoria. In one, a 25 MW/50 MWh battery is co-located and integrated with the 60 MW Gannawarra solar farm, near Kerang. The other involves a 30 MW/30 MWh grid-connected battery operating at a terminal station in Warrenheip, Ballarat.

Source: Wahlquist, 2018.

More sophisticated planning methodologies may consider several system characteristics, such as the amount of flexible reserves or inertia, to identify more specific constraints. The options for a quantity-based strategy are diverse, but various design elements are available to enforce the constraints identified by the system planner. They are mostly focused in the categories related to auction demand and qualification requirements.

Auction demand

The auctioned volume can be determined based on the maximum capacity that the existing system can accommodate. Zone-specific capacity limits, based on transmission constraints, have been implemented in many auctions, including in Germany, Mexico and Peru. Zone-specific capacity limits can even be set for each technology, as in Kazakhstan where solar and wind are distributed among regions (see Box 1.5).

Another design element to consider is the demand band that defines what exactly is to be procured and under which conditions. Under competitive demand bands, bids can compete according to defined generation profiles, such as a contract that involves energy delivery obligations concentrated in defined hours, catered to periods of high demand (see IRENA and CEM, 2015).

The auction demand specifications may also call for generation bound to a particular profile of production, as Thailand's hybrid auction (Box 3.5).

System constraints may call for innovative solutions to guarantee smoother generation profiles. To that end, combining different technologies with different generation profiles in one installation can ensure a more balanced generation curve. Moreover, renewable energy hybrid projects have higher capacity utilisation factors and make fuller use of the grid, thereby reducing grid integration costs (USAID and MNRE, 2017). In 2018, India released guidelines for hybrid wind-solar auctions, with the possibility to include storage (Box 3.6).

BOX 3.5 AUCTION FOR DISPATCHABLE GENERATION IN THAILAND

Thailand's 300 MW auction in 2017 was renewable-exclusive, but the power purchase agreements (PPA) required a continuous baseline level of production to ensure a fixed output at specific hours, due to system constraints. In particular, the PPAs required the power producer to deliver between 98% and 102% of the specified capacity during peak periods (between 9 am and 10 pm on weekdays) and limit power output at other times to 66.3% of the capacity.

Project sizes had to be between 10 and 50 MW. Two-thirds (65%) of the baseline requirements were expected to be achieved through biomass, biogas and waste-derived fuel, while solar, wind and small hydro combined with storage batteries could bring generation up to 100% during the peak daytime periods.

The 300 MW were allocated by region, but unfulfilled capacity demand in one region could be transferred to another as long as bidding prices were lower and grid capacity remained available. Projects competed according to a percentage discount rate on the fixed portion of the feed-in tariff, with a ceiling price of USD 110.9/MWh.

Such mechanisms generally favour dispatchable power plants, which can more easily deliver electricity at peak hours. Indeed, 14 of the 17 winning projects, totalling almost 260 MW, used biomass, with prices ranging from USD 60 to 110/MWh. The lowest bid prices were from biomass projects located inside sugar mills. The remaining three projects were hybrid solar power plants: one coupled with biogas, one with biomass, and one with backup batteries.

Source: Energy Storage, 2017.

BOX 3.6 WIND-SOLAR HYBRIDS IN INDIA

In 2018, India's Ministry of New and Renewable Energy (MNRE) issued a National Wind-Solar Hybrid Policy that sought to optimise the utilisation of infrastructure and better match the generation of variable renewable energy (VRE) with the demand profile.

At the end of 2018, the Solar Energy Corporation of India (SECI) introduced wind-solar hybrid auctions, requiring bidders to present co-located projects with a capacity factor of at least 30%. The nation-wide auction achieved prices as low as 2.69 INR/kWh (USD 38.7/MWh) for wind-solar hybrids in 2019. As resource potential and seasonal generation varies between regions, but the required capacity factor and ceiling prices did not differentiate between regions, wind-solar hybrids were predominantly awarded in resource-rich states that already had high shares of renewable energy generation (Prateek, 2018).

In 2019, SECI advanced its hybrid auctions further. It announced that in its hybrid auctions with an "assured peak power supply", all projects would be remunerated with a fixed off-peak tariff of 2.70 INR/kWh, but would have to bid the tariff they would require during peak hours (morning and evening) (SECI, 2019). Their capacity factor requirement has been set at 35% and can be achieved with any renewable energy combination with or without storage. This way SECI seeks to procure renewable energy hybrids that further contribute to its demand-supply match.

Source: USAID, 2019.

Qualification requirements

Qualification requirements are another design element used in quantity-based strategies. The bidding documents may require developers to obtain a statement from the grid operator to the effect that sufficient infrastructure exists to accommodate the proposed project. The case of **South Africa** (see Box 3.7) is one example of this type of requirement. Because documentation submitted during the qualification process cannot take into account the interactions between various potential winners, this approach is often supported by other strategies.

Similar to project-based strategies, quantity-based strategies are effective only if the information upon which the system planner relies when setting the constraints of the auction is accurate. However, quantity-based planning differs from project-based approaches in offering bidders greater flexibility on power plant design. It does this by presenting a range of possible choices of projects, sites and potentially even technologies. Although a variety of design elements can figure in such strategies, a common characteristic of those elements is the system limits set at the time of the auction.

As the system ages and evolves, its characteristics and limits change, which may lead to sub-optimal outcomes if auction parameters are not kept up to date. Quantity-based strategies do not allow for potential cost-benefit trade-offs, unlike the strategies described in the following sections, for which these considerations are key.

3.4 ADJUSTMENT-BASED STRATEGIES

The chief difference between quantity-based and adjustment-based strategies is that the former imposes hard constraints (strict limits) on auction outcomes, whereas the latter imposes soft ones (penalties or incentives). They rely on the application of adjustments dictated by factors such as the project location or time of generation. This difference allows developers to anticipate how, where and when energy production will be most valuable to the system so they can shape their bids accordingly. Adjustment-based strategies, therefore, rely strongly on a system operator's ability to forecast how system needs will evolve in order to yield the most desirable outcome.

BOX 3.7 RENEWABLE ENERGY DEVELOPMENT ZONES IN SOUTH AFRICA

Beginning with round five of South Africa's Renewable Energy Independent Power Procurement Programme, which has not yet been launched, new rules will improve coordination between generation and transmission planning and environmental licensing in eight Renewable Energy Development Zones (REDZs) and five Power Corridors. The REDZs seek to concentrate wind and solar PV developments in specific geographical areas where investments to strengthen the transmission grid will be concentrated. Strategic environmental assessments will also be undertaken in these zones, simplifying environmental impact assessments for projects in those areas.

Developers bidding on wind or PV projects in one of the REDZs, or on grid expansion within the Power Corridors, must obtain the required documents prior to site selection and the auction. These include a confirmation from the grid operator regarding sufficient capacity in designated substations and in distribution and transmission lines. Failure to obtain this confirmation may result in disqualification.

Source: IRENA, 2018a.

Adjustment-based strategies allow the potential costs of different technological alternatives to be factored into an *ex ante* signal. Trade-offs involved in system planning are accounted for by penalising market agents who would provide services considered less valuable to the system. Conversely, services that are considered more valuable are incentivised. Whereas a price-based strategy (see Section 3.5) relies on market prices to incentivise power plant operators to provide services most valuable to the system, an adjustment-based strategy adopts predetermined penalties and incentives. Those are designed by the auctioneer to align the outcomes of selected projects with future system needs. A system used to predict such needs may be the so-called emulated markets (simulations of the future market based on an estimation of system evolution). Adjustment-based strategies can be achieved through design elements that fall into the categories of winner selection and risk allocation and remuneration of sellers.

Winner selection

Grid integration could be made one of the criteria for selecting winners, for example, by assigning a weight to proximity to the grid or by awarding projects bonuses or penalties according to their technical characteristics and the stress they impose on the system. Projects in less favourable locations are thus penalised in the winner-selection process, as in **Mexico**. It is important to note that bonuses and penalties in Mexico are only considered for ranking projects as part of the winner-selection, but ultimately they are not factored into the price. Including grid integration in the selection process allows for the distribution of the volume auctioned across different zones, as long as the availability of resources makes up for the costs imposed on the system. One example is the **Brazilian** design, in which the expected value of electricity generated is incorporated into a cost-benefit index that allows for a comparison of generators with different seasonal and hourly production profiles. This helps select projects that are deemed most valuable to the system (see Box 3.8).

Remuneration of sellers

Adjustment factors can also be applied during the operational phase of the power plants through risk allocation and remuneration of sellers. Before the auction, the auctioneer discloses some adjustment factors, which do not affect the selection of winners but rather the remuneration of the project once it begins operations.

Payments are then subject to the adjustment, which may be positive or negative. For example, plants that have a generation profile matching system needs (according to expectations at the time of the auction)[3] may receive additional remuneration (see the Mexican case in Section 3.7). Power plants are incentivised to produce at times or in locations of higher demand (according to expectations at the time of the auction).

[3] *The profile that must be matched in order to benefit from additional remuneration is the one anticipated when the auction was launched. It is not determined by demand in the system at the time the electricity is sold.*

BOX 3.8 INCORPORATING AN EMULATED MARKET CALCULATION INTO BRAZIL'S WINNER-SELECTION PROCESS

For certain technologies in Brazilian energy auctions, winners are selected on the basis of a cost-benefit index and not on the basis of price alone. The reasoning behind the index is to incorporate, for bid comparison purposes, an expected value of the renewable electricity based on its geographical location, hourly profile and seasonal profile.

The second-most important item (after price) in determining the index ranking of a renewable power plant is its expected cost of net energy purchases, known as the CEC (*custo esperado de compra*). The CEC is defined as the expected value of spot-market settlements over the plant's useful life, taking into account the difference between the plant's production profile and the contract's demand profile. It is determined through a simulation in which the system planner attempts to differentiate renewable generators at different locations and with different production profiles.

The CEC is calculated for each plant based on its certified production profile. Here, complementarity plays an important role. For instance, wind generators located in Brazil's northeast region complement the country's abundant hydropower, as their output typically increases during the dry season. As such, plants with more-pronounced complementarity receive a greater bonus.

Since adjustments are set *ex ante* in adjustment-based strategies, the system operator's ability to forecast how system needs will evolve is central to their success. When this strategy is applied to technology-neutral auctions, comparing technologies with very different production profiles could become a concern as systems evolve. A system that already has high solar penetration, for example, may value an additional unit of solar power less than an additional unit of wind power and much less than an additional unit of hydropower with storage (Hirth, 2013). In this sense, the auction design should always allow room for correction between rounds, as the system evolves.

3.5 PRICE-BASED STRATEGIES

Under a price-based strategy, the auction is designed to rely on market prices to signal the best VRE production profile. Unlike adjustment-based strategies, in which adjustments are set *ex ante* by the system operator on the basis of an estimate of future system needs, price-based strategies assign the responsibility to developers of matching generation to system needs.

This strategy leaves power plant operators exposed to market prices and risks, obliging them to rely on their own market knowledge to develop plants capable of meeting system needs while maximising their own revenues. Price-based strategies rely on the existence of a mature market capable of providing time- and location-based price signals, such that price formation is cost-reflective and non-distortive, and renewable energy producers bear low market access risk.

This strategy draws most heavily on design elements related to risk allocation and sellers' remuneration.

A straightforward method to adopt the price-based strategy into the auction design is the use of fixed and sliding feed-in premiums (FiP)[4], whereby operators receive a premium determined by the auction on top of their market revenue. Many European countrieshave adopted this type of mechanism, following the European Commission's Guidelines on State Aid for Environmental Protection and Energy for 2014-2020. One such example is Finland (see Box 1.10).

[4] *While sometimes grouped under the Feed in premium definition, contracts for difference (e.g., in the United Kingdom) are not considered in this publication. CfDs do not offer incentives to shift production to hours of higher demand or to do any activity toward system integration. The buyer pays the generator when the market price is below the strike price, and the generator refunds the difference when the market price exceeds the strike price. As a result, the generator always receives a fixed payment (as with a feed-in tariff), regardless of the time of production.*

For both the fixed and sliding feed-in premiums, the reference market price can be calculated following one of these methods:

- As an average of wholesale market prices over a certain time period (*e.g.*, hourly or monthly)
- As a weighted market value representing the average wholesale market price over a certain time period, weighted by the total production of a given renewable technology. **France** and **Germany** adopted the market value price for their FiP scheme.

The main difference between the two methods is that, for the weighted market value, power plants are incentivised to produce in a more system-friendly manner than other producers from the same technology. As a result, auction outcomes can differ substantially, given the country's specific conditions.

3.6 PRODUCT-BASED STRATEGIES

Another strategy for auctioning system-friendly VRE involves focusing on power market products (energy, capacity, system services, etc.) rather than on the technologies used to produce them. The product-based strategy could in time allow renewables themselves to supply all the system needs. Ultimately, this approach can enable the treatment of renewables as any other generator, competing for the same products, potentially in combination with measures to support flexibility such as demand-side management.

Product-based strategies are mainly associated with the design category of auction demand, but they also involve risk allocation, since renewable generators will typically participate in *ex post* financial settlements for the products to which they commit.

Auction demand

The main decision pertaining to auction demand is to determine the product being auctioned. Energy products commit the generator to provide a defined quantity of electricity throughout the contract's duration and over a certain timeframe (*e.g.*, year, month, day/night). Remuneration is proportional to the total electricity generated and any positive or negative deviations from the agreed quantity must be settled within the scope of the contract itself (see Chapter 2 and the example of Brazil in IRENA and CEM, 2015). Financial agreements may force producers to deliver a certain amount of electricity during the contract's duration. In this type of agreement, any deviations between actual plant generation and the quantity committed in the contract must be settled at the electricity spot price in real time. **Chile** is one country that has adopted this design (IRENA, 2017a).

Capacity products contribute to a power system's security of supply. Suppliers are required to ensure that generation facilities meet minimum availability standards (*e.g.*, number of operational hours per year, excluding failures and maintenance stops), and penalised in case of failure. Owing to their variability, VRE technologies have generally been overlooked as potential contributors to adequate capacity. However, depending on their characteristics and on the system's needs, these technologies can in fact contribute to security of supply – especially when considered as a portfolio. Capacity products in **Mexican** auctions are open to VRE technologies. Plants must meet a minimum average generation during the 100 most critical hours of the year.[5]

Other power sector-related products, such as clean energy certificates, can also be auctioned and they can mitigate production and price risks with increasing shares of VRE. This is only effective in the presence of a conducive legal framework and a market for certificates. In Mexico, Clean Energy Certificates could be bundled together with energy and capacity products. Auctions for certificates in such a context can guarantee long-term certainty concerning production and prices, mitigating risk for generators and obliged parties.

Auctions for ancillary services are common and open usually only to conventional generators. They may be, however, designed to allow renewables to provide adequate supplies of services such as frequency response, voltage support, system reserves and fast response for ramping.

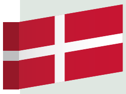
[5] *The hours when the difference between available capacity and electricity demand is the smallest.*

Denmark, for example, has adopted this approach, and as a result, ancillary services are being supplied by wind turbines (Box 3.9). Although these ancillary service auctions are quite different from classic renewable energy auctions, they allow for a portfolio of renewables (potentially including flexible resources like storage) to be used to supply ancillary services. It should be noted that ancillary services provide renewable energy operators with an additional stream of revenues, while reducing the system's need for fossil fuel generators. They usually do not cover the total cost of a VRE plant (nor of a conventional plant).

3.7 BLENDED STRATEGIES

An auction design may combine more than one implementation strategy, with design elements bundled to facilitate the accommodation of renewable resources and ensure particular system needs. 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 blended strategies described in Box 3.10.

BOX 3.9 AUCTION FOR ANCILLARY SERVICES IN DENMARK



In Denmark, the system operator Energinet procures ancillary services through auctions to ensure stable and reliable system operation. The services, provided by generators, are divided into two groups, depending on whether they are supplied in Western Denmark (DK1 group) or Eastern Denmark (DK2 group).

- DK1 group ancillary services include primary reserve, secondary reserve, manual reserves and properties required to maintain power system stability.
- DK2 group ancillary services include frequency-controlled disturbance reserve, frequency-controlled normal operation reserve, secondary reserve, manual reserves and services required to maintain power system stability.

Wind power plants, which provide the bulk of ancillary services in Denmark, may participate in the auction along with another production technology that can guarantee supply if the wind turbines are unable to deliver the required amount.

Source: Energinet, 2017.

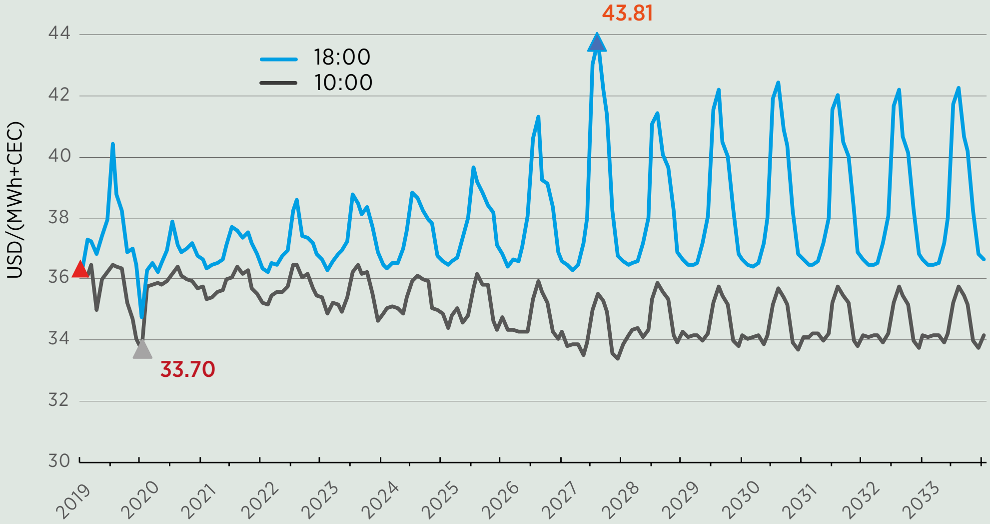
BOX 3.10 BLENDED STRATEGIES IN MEXICO'S AUCTIONS

Mexico's auctions are among the most complex in the world. They have design elements linked to strategies based on products, quantities, adjustments and prices. Starting in 2013, Mexico underwent a market reform. One of the reform's main goals was to foster private sector investment in clean energy, while minimising the associated cost. Auctions were among the main instruments of choice to that end. The auction demand for energy, capacity and Clean Energy Certificates (CEC) is the main element of the product-based strategy. Energy and capacity products are part of the technology-neutral mid-term auctions under three-year contracts. Energy, capacity and CECs can be procured in the long-term as part of 15-year contracts for energy and capacity and 20-year contracts for CECs. Winners are selected based on geographic limits as part of a quantity-based strategy. The long-term auctions limit the capacity that may be contracted in defined zones. The limits are determined by the system operator according to transmission grid constraints.

Winners are also selected based on geographic signals and are remunerated according to geographical and temporal signals as part of an adjustment-based strategy. This helps reflect the need for electricity at a given location and time (hourly):

- The geographical signals in the winner-selection criteria entail adjusted offers: the submitted bids are adjusted by a locational premium or penalty. These premiums or penalties serve only for bid comparison purposes, but once the project is awarded, the locational factor does not affect developers' remuneration (see Mexico case study in IRENA, 2017a).
- Regarding sellers' remuneration, the auctioneer discloses a long-term set of hourly and locational adjustment factors prior to the auction. The adjustments are calculated based on an estimation of system needs and projected spot prices (up to 2030). When generators produce in line with system needs, they receive a surplus remuneration, while production at a less opportune time is penalised. For instance, an awarded 36.3 USD/(MWh+CEC) bid in Sonora state can bring the remuneration up to 43.8 USD/(MWh+CEC), if the generator produces electricity at 6 pm on a summer day. The same bid can reduce remuneration to USD 33.7/(MWh + CEC) if the generator produces electricity when it is less needed (Figure 3.2).

Figure 3.2 Adjustment factors in Mexico's first auction



Sources: CENACE, 2018; Guadarrama, 2018.

Electricity generated when market prices are negative is not considered toward the amount that a generator is required to deliver, as part of the price-based strategy. Subjecting project developers to a spot-price risks, incentivises them to perform in line with system needs.

3.8 CONCLUSIONS ON VARIABLE RENEWABLE ENERGY SUPPORT

Many strategies can be incorporated into an auction's design to support the integration of VRE. The choice of strategy and design elements should be tailored to specific circumstances such as the structure of the power market and the level of development of the sector, among other factors. While auctions without any form of temporal, locational or technology price signals, among others, do not pose significant challenges to the integration of VRE at low shares, a failure to adapt the auction design to future system needs may lead to additional long-term costs and systematic integration challenges. As a final note, auction design alone cannot provide a complete solution to the challenge of integrating high shares of VRE. That will require structural changes in the configuration of the power system (IRENA, forthcoming-a).

IN FOCUS: CURTAILMENT OF VARIABLE RENEWABLE ENERGY

A VRE-rich power system needs to be highly flexible. It must be able to match demand and supply on any timescale, both in periods of high and low VRE production. A prime indicator of insufficient system flexibility is the curtailment of VRE, a reduction of the output of a generator from what could otherwise have been produced given available resources. Curtailment may be imposed by the system operator to address an oversupply of generation during low load periods, but it may also result from congestion, lack of access to transmission lines, voltage conflicts or interconnection problems (Bird *et al*., 2014).

While some low level of curtailment of renewables becomes inevitable when VRE accounts for a high share of the energy in the system, large scale curtailment has severe consequences owing to the reduction of the share of renewable-based electricity consumed and potentially discouraging further investment in renewables. For generators, curtailment represents a significant loss in economic value, and the risk of curtailment, a component of the volume risk faced by bidders, should be avoided when possible.

Auction design may aim to minimise curtailment risks, pending a broader transformation of the power system, through the selection of system-friendly projects that can be easily accommodated by the power system. Models for the allocation of curtailment risks vary, ranging from those where the off-taker assumes full responsibility, to those where the generator is fully liable – with shared responsibility falling between these two extremes. In both cases, strategies targeted at minimising the risk of congestion or lack of infrastructure needed include prohibiting building new capacity in congested areas, through quantity-based strategies, for example, or incentivising developers toward non-congested areas, through an adjustment-based strategy.

Shielding generators from curtailment risks is especially relevant to developing markets where risk perception is already relatively high, or where information on power dispatch and grid quality is not complete enough for bidders to incorporate curtailment risk into the bid price. The off-taker can take on these risks by, for example, committing to paying for electricity generated even when it is curtailed, similar to a take-or-pay model. This is the case in Afghanistan, Bangladesh and Saudi Arabia, among many other countries. The take-or-pay model features in most project-based strategies, as the developer has no say in the selection of the project location or technology. In auctions that are not project-specific, the take-or-pay model may incentivise inefficient investments – for example, if bidders focus more on the theoretical potential than on supplying energy to the grid. The curtailment costs of the take-or-pay model may be passed on to the consumers in their electricity bills or they could be borne by the system operator.

In the latter case, the cost of take-or-pay payments to generators should be weighed against the cost of ensuring the grid infrastructure needed to accommodate the full potential of renewable energy assets. The solution is context-specific and depends on the long-term planning of the system.

Recent years have seen a shift toward remuneration mechanisms that allocate greater risk to generators, including curtailment risk. Assigning the curtailment risks to generators may encourage the selection of less congested sites, although forecasted curtailment is typically factored in financial models, potentially resulting in higher bid prices. Price-based strategies can expose developers to the risk of very low (or negative) prices thereby penalising them for excessive generation in periods of low demand.

Subjecting renewable generators to spot prices may encourage them to curtail their production when the price of energy is below zero. In Finland, Namibia and Sri Lanka, for example, generation not delivered due to curtailment is not accounted for in the remuneration of generators. Assigning the curtailment risk to generators may deter financiers that are sensitive to perceived risks.

One approach that minimises the impact of risk of curtailment in price-based strategies is through the adoption of a feed-in premium, whereby the premium offered on top of the market price could be suspended during hours when the price falls below a certain threshold, signalling that additional power is not needed.

Another option to allocate curtailment risk is through a product-based strategy. The auctioneer specifies the time periods during which electricity must be delivered. Given this information, developers can find innovative solutions to avoid curtailment that may happen in the periods when energy is not requested. Developers may choose, for example, to couple the generating technology together with storage.

When assigning curtailment risks to the generators, a common feature is to set an annual curtailment threshold above which the generator is compensated for curtailed energy. In **Portugal**, where the flexibility of the power system is guaranteed by hydropower plants and interconnectors, legislation restricts curtailment of renewable energy generation except in the case of technical problems. In those cases, wind producers take on the risk of the initial 50 hours and are compensated for losses that exceed 50 hours at full capacity (USAID, 2015; WindEurope, 2016). In **Japan**, in contrast, utilities can curtail wind and solar generation for 30 days without compensation or even for an unlimited time if the capacity newly added to the grid exceeds a centrally defined limit (Kimura, 2017).

Developers' concern of unlimited curtailment risk can slow renewables deployment down.

4

SUPPORTING A JUST AND INCLUSIVE ENERGY TRANSITION

The energy transition has the potential to positively impact the global economy and welfare, and create new employment opportunities which may affect communities, households and an estimated 58 million workers employed – directly or indirectly – in the global energy sector in the year 2050 (IRENA forthcoming-b). Policies favouring rapid deployment of renewable energy have at times side-stepped the social dimensions, which should figure alongside technical, economic and political factors in determining how the energy transition unfolds. The notion of a just and inclusive transition implies an equitable allocation of opportunities to raise the chances that positive outcomes are broadly shared (*e.g.*, new employment, domestic industries), that adverse implications are limited (*i.e.,* the loss of jobs in disappearing sectors), and that any misalignments between positive and negative dynamics are proactively addressed. If the transition to a renewable energy based system is to fulfil its potential, policies must take into account that an evolving energy sector is part of the broader socio-economic system (IRENA forthcoming-b).

From a competitive perspective, auctions can yield an economically efficient allocation of resources, but their outcomes may be less than optimal from other perspectives, depending on country-specific policies and objectives.[1] For example, they may not produce a diversified landscape of actors or generate the shared benefits envisioned for a just and inclusive transition (Fell, 2017). Such outcomes are particularly likely when the pursuit of such benefits is not integrated into auction design. Indeed, auctions focused purely on price may result in geographical clustering, the crowding out of small and medium-sized project developers, the centralisation of market power, and the potential exclusion of communities from decision-making processes (Fell, 2017; del Río and Linares, 2014). Fortunately, many design options are available to policymakers seeking to reconcile transition-related objectives with broader development goals.

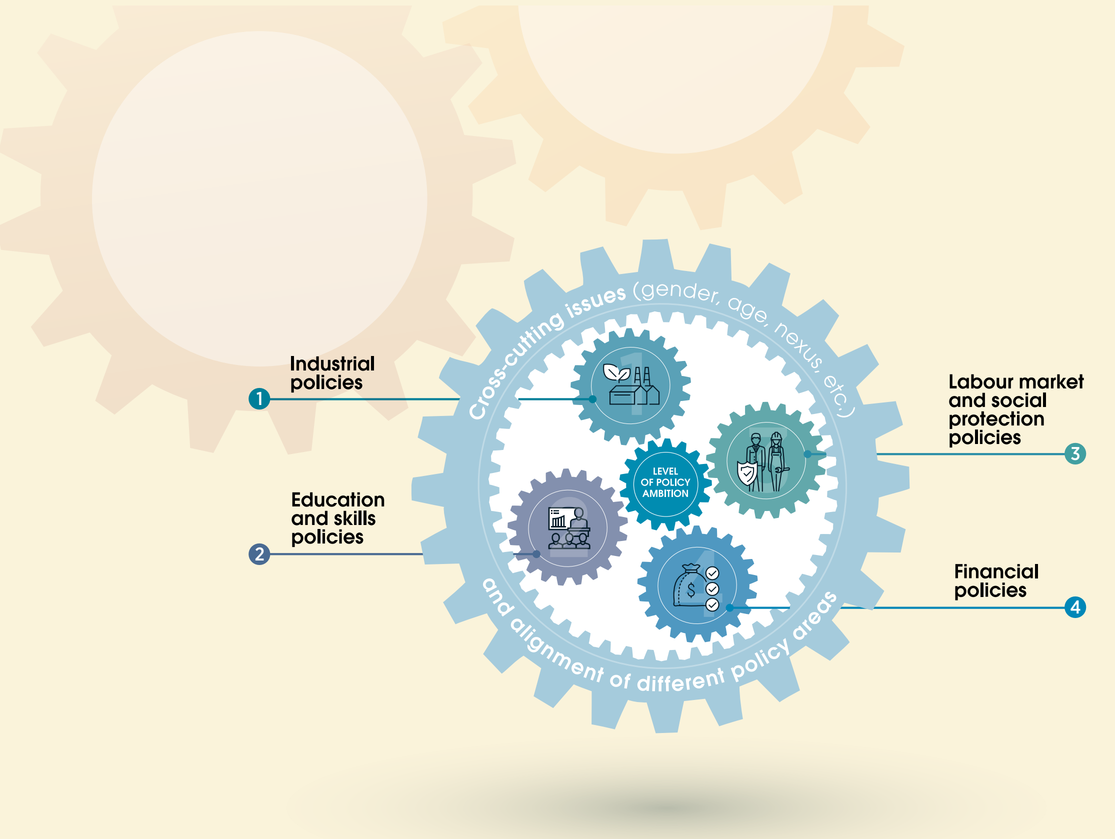
This chapter analyses how auctions can adapt to address issues around a just and inclusive energy transition. It evaluates design elements intended to include small and new players, foster the development of local industries, create local jobs, contribute to subnational development and engage communities. These design elements, effective as they may be, are only part of a broader policy framework to ensure a more just and inclusive energy transition. This framework promotes renewables deployment as a catalyst of economic, inclusive and sustainable growth and it rests on three transformative sets of policies: deployment, enabling and integrating policies (Box 4.1).

[1] *IRENA recognises the role of competitive prices in the fair and inclusive transition – for example, in their effect on the affordability of electricity. However, this chapter focuses on the broader benefits to be gained through the development of a renewable energy sector domestically.*

BOX 4.1 A BROAD POLICY FRAMEWORK FOR A JUST AND INCLUSIVE ENERGY TRANSITION

Auctions designed to contribute to a just and inclusive energy transition are only effective if they are introduced in co-ordination with the following enabling policies (Figure 4.1): 1) **industrial policies** that aim to leverage and enhance domestic capabilities (*e.g.*, through requiring business incubation initiatives, support for research and development, supplier development programmes, support for small and medium enterprises, and promotion of key industry clusters); 2) **education and skills policies** that help build/augment technical capacity and technological learning (*i.e.*,, a focus on the science, technology, engineering and mathematics (STEM) fields) and build know-how in several non-technical professions critical to renewable energy; 3) **labour market and social protection policies** including those that promote employment services (*e.g.*, matching jobs with qualified applicants, facilitating on- and off-job training), measures to facilitate labour mobility, and social protection measures where needed; and 4) **financial policies** aimed at mobilising revenue streams through carbon pricing and other measures, including green bonds, and devising revenue recycling schemes to ensure a just transition. These enabling policies are part of a broader framework that includes integrating measures targeted at integrating renewables in daily lives. Prime examples are behavioural policies or measures to enhance system flexibility (IRENA, IEA and REN21, 2018; IRENA, forthcoming-b).

Figure 4.1 Enabling policy components of the just transition framework



Source: IRENA, forthcoming-b.

4.1 INCLUSION OF SMALL/NEW PLAYERS

Renewable energy auctions remain an efficient and effective pathway to attract large-scale investors and achieve low prices. At the same time, high transaction costs associated with the administrative procedures required to take part in an auction (*e.g.*, qualification requirements) can raise barriers for small and new players and could lead to growing market concentration.

In fact, among the weaknesses of auctions is their tendency to favour large players that have greater capacity – financial and reputational (*i.e.,* related to experience) – to compete. In general, even when small or new players manage to overcome the administrative burdens to enter the auction, they are disadvantaged compared to larger players that can bid lower prices by leveraging larger portfolios or broader financing options. Consequently, small-scale actors are likely to perceive and experience auction frameworks as discriminatory and restrictive (Fell, 2017). Although it is recognised that large multinational players bring benefits such as technology transfer and higher project completion rates, the engagement of small-scale actors in the energy transition is an important way to maximise inclusiveness and socio-economic benefits. Smaller actors are likely to be more attentive to opportunities for localised hiring and sourcing of inputs than players who serve markets worldwide from a limited number of production or service hubs. In emerging economies, small and medium-sized enterprises (SMEs) are responsible for up to 45% of employment and 33% of GDP, respectively (IFC, 2010). To that end, some countries are making efforts to promote the participation in auctions of small companies and so-called energy communities, which are discussed below.

Renewable energy auctions are flexible in design and can accommodate elements to encourage the participation of new and small players. This section begins with a definition of the players that are considered small and new. It then analyses the design elements that can support their participation in auctions, pertaining to the categories of auction demand, qualification requirements, winner selection in addition to risk allocation and sellers' remuneration.

Definition of small and new players

New players are defined as recent entrants to the market, while the definition of small players varies from country to country.[2] Small companies are usually categorised by the number of employees. In the **United States**, firms with less than 500 workers can be categorised as small businesses (depending on the industry, the number can be as high as 1,500). The Organisation for Economic Co-operation and Development categorises SMEs as firms with fewer than 250 workers and breaks its definition down further into micro enterprises (fewer than 10 workers), small enterprises (10 to 49 workers) and medium-sized enterprises (50 to 249 workers). Other indicators used to categorise companies by size include sales, annual revenues and profits, and assets, among others. In **Mexico**, micro-enterprises are those with fewer than 10 employees and annual sales below MXN 4 million (~USD 210,500); small companies have less than 30 employees and annual sales of MXN 100 million (~USD 5.3 million), at the most (SE, 2019). The small enterprises' definition in **China** includes firms with ten times more employees than in Mexico, but half of the annual sales (CNY 20 million; ~USD 2.8 million) (MIIT, 2012).

Community ownership (CO) structures allow small-scale actors such as households, individuals and businesses to unite in investing, developing and operating energy assets. By sharing costs, CO models enable participants to own assets with lower levels of investment. CO projects tend to be small: around 50 kW to 10 MW. While energy generation is their most common purpose, CO initiatives can also deploy energy storage, energy efficiency, and distribution, as well as district heating and cooling systems.

More generally, a CO project is characterised by local stakeholders owning most of the project, voting rights and control resting with a community-based organisation, or most of the project's socio-economic benefits being distributed locally (IRENA Coalition for Action, 2018).

[2] *This report does not aim to establish a small player criterion for auctions. It does, however, recognise the edge that large players have over small companies and communities.*

There are presently over 4,000 CO initiatives globally, primarily in Australia, Denmark, Germany, the Netherlands, the United Kingdom and the United States (REN21, 2016; Interreg Europe, 2018). The legal models vary depending on each country context, but the most popular are cooperatives, partnerships and associations (Table 4.1).

An inclusive auction focuses on providing a level playing field for all participants. This may be done for example, by offering exceptions to small players to reduce the up-front costs of preparing for the auction or by compensating their projects beyond their pricing offers as in **Germany** (see Box 4.3). Loosening pre-qualification requirements may have negative consequences, however, such as increasing the risk that a project may not be built. Taking this trade-off into account, design elements that can support the participation of newly established or small companies and communities may take various forms, as discussed below.

Auction demand

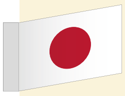
In the design category of auction demand, a share of the total volume auctioned can be set aside for small and new players. Limiting project size may also increase their chances, in cases where they do not have the capacity to develop large projects. The **Japanese** solar PV auction is one case in point (Box 4.2). Large developers are generally not keen on competing for small projects, leaving the way open for small actors, as demonstrated by **South Africa**'s Small Projects IPP Procurement Programme, introduced in 2013 (IRENA, 2018a). The solar auctions in the **Indian** state of Punjab have used both: a share of the total volume auctioned dedicated to small/new players and an upper limit on project size. A 2011 auction had an upper limit of 20 MW, which was later increased to 100 MW for the 2014 auction. In 2013, a portion of the demand (50 MW) was reserved for relatively small-scale projects (<5MW) for which only newly established companies could compete. The remaining 250 MW was reserved for well-established companies with project sizes between 5 and 30 MW (IRENA and CEM, 2015).

TABLE 4.1 COMMUNITY OWNERSHIP LEGAL MODELS

COMMUNITY OWNERSHIP MODELS	DESCRIPTION
CO-OPERATIVES	Co-operatives are jointly owned by their members to achieve common economic, social or cultural goals based on the democratic principle of "one member, one vote".
PARTNERSHIPS	Individual partners own shares in the partnership. The key objective of the partnership firm is to generate profits for the partners, in addition to any other benefits of the project. Unlike co-operatives, partnerships may not operate on the basis of "one member, one vote". Nor do partnership firms rely solely on volunteers, as co-operatives do. They may employ full-time staff to provide expertise needed for specific projects.
NON-PROFIT ORGANISATIONS	A non-profit is formed by investments from its members, who are responsible for financing the organisation but receive no profits. Profits are re-invested in projects focused on community development.
COMMUNITY TRUSTS/ FOUNDATIONS	Trusts and foundations use the returns from investments in community projects for specific local purposes. These benefits are also shared with people who are not able to invest directly in the projects.
HOUSING ASSOCIATIONS	A form of non-profit, associations offer housing to low-income families and individuals.

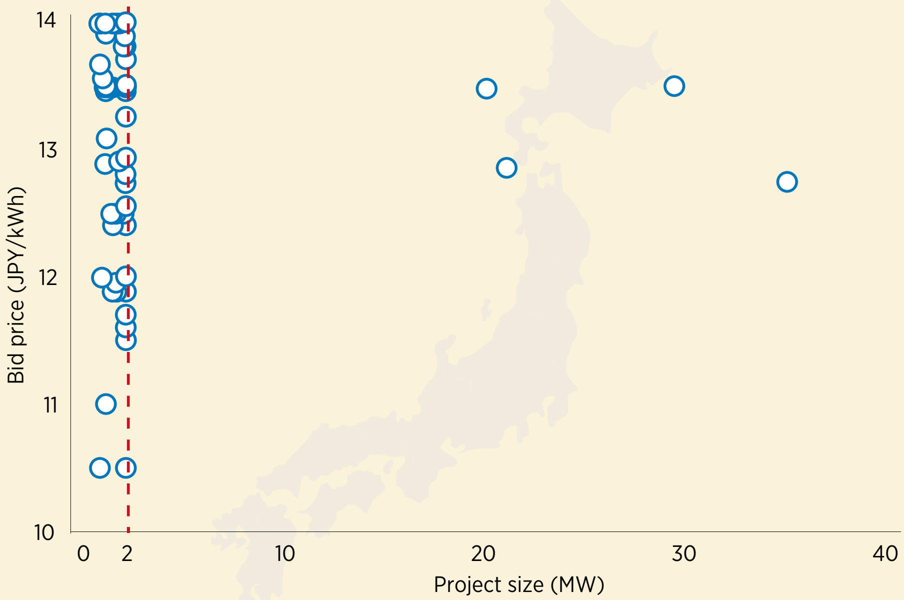
Source: IRENA, forthcoming-c.

BOX 4.2 INCREASED PARTICIPATION OF SMALL PLAYERS IN THE 2019 SOLAR AUCTION IN JAPAN



Japan had four rounds of solar PV auctions by 2019. In the last round, changes were made related to minimum project size and the ceiling price. The first three solar PV auctions had a minimum project size requirement of 2 MW, which was reduced to 500 kW in 2019, with plans for a further reduction to 250 kW in the future (Kageyama, 2018). The (undisclosed) ceiling price of JPY 14/kWh (USD 132/MWh)[a] was higher than expected at JPY 13 and 13.5/kWh (BNEF, 2019a). Between the third and fourth rounds, the auction saw a three-fold increase in the number of bids registered, indicating an increased interest from market players, and a nine-fold increase in the number of bids awarded (Bellini, 2019b, 2019c and BNEF, 2019a). As shown in Figure 4.2, the majority of projects awarded are below the previous 2 MW size limit.

Figure 4.2 Project size and bid price of awarded projects in the fourth solar auction in Japan



Sources: GIO, 2019 and BNEF, 2019a.

Interestingly, the increased participation of small and new players did not prevent prices from falling between rounds three and four. The average price decreased from JPY 15.2/kWh (USD 135/MWh)[b] in the third auction to just below JPY 13/kWh (USD 122/MWh) in the fourth. In fact, as Figure 4.2 shows, the majority of the projects below 2 MW bid lower than the four projects above 2 MW, implying that economies of scale do not seem to play a major role in the Japanese context: the lowest bids – as low as JPY 10.5/kWh (USD 99/MWh) – were all for projects below 2 MW. Similarly, many winners are not established market players, suggesting that experience is not a determining factor in winning an auction. It should be noted that undersubscription persisted in the fourth round from previous rounds. This outcome may be attributed to difficulties in securing land and obtaining grid-connection permits, mostly impacting large-scale projects. Moreover, solar PV projects above 40 MW are subject to stricter environmental assessment rules. This could be one of the reasons large-scale projects do not benefit from economies of scale when it comes to bid prices in Japan.

[a] 1 USD = 106 JPY in September 2019. [b] 1 USD = 112 JPY in December 2018.

The arrangement of the auction can also incentivise or discourage the participation of small-scale actors. Generally, developers face a higher degree of competition in technology-neutral auctions, given the large pool of projects that are eligible and the fierce price competition introduced by some technologies (IRENA and CEM, 2015). Therefore, technology-specific auctions, which limit the pool of eligible projects and can be tailored to address technology-specific challenges, can encourage the participation of small-scale actors.

Germany's wind auctions are a case in point; they were more successful at attracting small wind firms (Box 4.3) than were the technology-neutral auctions (referred to as joint auctions) that were not able to attract any wind projects. More specifically, site- and project-specific auctions may be more attractive to small players because they require less documentation as part of their qualification requirements.

BOX 4.3 CHALLENGES IN DESIGNING INCENTIVES FOR COMMUNITY ENGAGEMENT IN GERMANY'S WIND AUCTIONS

In Germany, community ownership (CO) projects proliferated as a result of preferential rules in wind auctions following the country's renewable energy law. Under these preferential rules, citizen wind projects had up to two years after winning a bid to obtain a building permit, unlike other bidders, which had to present the permit at the moment of bid submission. It also split their bid bond into two payments: EUR 15/kW (USD 16.95/kW)[a] at bid submission and EUR 15/kW after obtaining the building permit; extended the project implementation period by two years (to a four-year implementation period); and awarded bids based on uniform pricing as per the highest offer, instead of pay-as-bid.

As a result of the more favourable conditions, the first three rounds until November 2017 awarded over 90% of the total auction volume of 2,890 MW to CO projects. In fact, most of the COs participating in the auctions were formed just before the 30 June deadline set in the Renewable Energy Resource Act, and with a small number of members. Notwithstanding, Germany's experience with exceptions for CO wind projects prove that designing incentives for community engagement can be challenging.

First, as of June 2019, only 167 MW of the 2,688 MW that were awarded to citizen wind parks had obtained a building permit, reflecting the general permitting challenges faced. Second, the requirements for a project to qualify as community-owned[b] were perceived as vague, at times allowing stakeholders that would otherwise not be eligible to take advantage of the preferential rules. In particular, the requirement referring to 51% voting rights in the hands of residents allowed for external capital contributions and thus for the involvement of established developers in the auctions.

Ultimately, most of the projects presented as community-owned were developed by just three players, one of which participated in as many as 60 awarded projects with a total volume of 1 GW. The preferential treatment thus came to be perceived as distorting the auctions, to an extent that the lenient bidding requirements were abolished after three rounds. Thereafter, the share of CO projects in auctions declined dramatically from more than 90% in 2017 to less than 16% at the end of 2018. The diversity of bidders also decreased in the 2018 auctions.

While having only a handful of developers involved in energy communities may not be conducive to market decentralisation, such an arrangement can be beneficial for both COs and developers. Although CO projects can be initiated by citizens, they are typically planned and implemented by developers who have the required expertise. A survey of the German experience showed that 75% of COs chose voluntarily to partner with a developer. In turn, the developers indicated that their incentive in partnering with COs lay mainly in reduced administrative burdens.

The building permit exemption for citizen wind parks is suspended until June 2020. This could open the discussion of whether alternative means to promote community engagement might be more successful. Alas, the suspension is expected to be extended.

[a] 1 USD = 0.884 EUR in May 2016.

[b] The requirements included: 1) having at least 10 persons as voting shareholders, 2) residents in the project district holding a minimum of 51% of the voting rights, and 3) no single shareholder holding more than 10% of the voting rights.

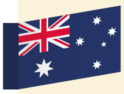
Sources: Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit, 2017; Bundesnetzagentur, 2017; Erneuerbare Energien, 2017; GWEA, 2017; Klessmann and Tiedemann, 2017; Tenk, 2018; Clearingstelle EEG-KWKG, 2019; Fachagentur Windenergie an Land, 2019; Grashof *et al.*, 2019 and WWEA, 2019.

Qualification requirements

Qualification requirements are introduced to ensure a higher degree of commitment (IRENA and CEM, 2015). At the same time, overly strict requirements (whether material or financial) may bar small and new actors from participating (Fell, 2017). Site-specific documentation such as building and environmental permits may represent an obstacle for small and new actors, which are more prone to participate in auctions in which these requirements are relaxed. The first three rounds of **Germany**'s wind auctions are one example (Box 4.3). Some auctions have included community engagement as a bidding requirement but without encouraging community-owned projects to bid. The **Australian** state of Victoria is one example of this approach (Box 4.4).

Requirements to submit evidence of past experience and the financial capability to shoulder the project, reasonable as they may be, also put small and new actors at a disadvantage. In some contexts, it may be enough to require bidders to submit evidence of their current technical capacity to execute a given project to allow them to compete in the auction. In other words, a shift from bidder-centric criteria, based purely on experience or financial capacity, to project-centric pre-qualification criteria can facilitate the participation of small and new players. In this case, quality control requirements based on the offered project (for example, proofs of building consent, grid access, or land acquisition) would be prioritised over bidders' past experience.

BOX 4.4 COMMUNITY ENGAGEMENT IN VICTORIA, AUSTRALIA



Proof of community engagement was part of the qualification requirements for the state of Victoria's 2017 renewable energy auction scheme. The requirement was designed to encourage initiatives that empower communities. Qualifying evidence could include social risk analysis, community engagement strategies, benefit sharing programs, reporting, monitoring and evaluation plans, or letters of support. Yet at the end of the auction, none of the six awarded project developers were small enterprises or community power initiatives. Because community initiatives were only starting to take off at the time of the auction, and because the auction was technology-neutral, community projects were not in a position to compete against larger and more established players. In fact, high up-front costs for proposal preparation, along with the inability to exploit economies of scale, hindered the participation of communities and other small-scale actors.

Thus, the state government of Victoria had to employ other support schemes, such as grant funding (Renewable Communities Program), to promote and support community energy power initiatives. Alternatively, pairing Victoria's original objectives with some of the auction demand elements discussed in this chapter could also foster community energy projects deployment.

Source: Victoria State Government, 2019.

Winner selection

Among the design elements falling under the category of winner selection, criteria that go beyond price may help attract smaller players, as they are usually not capable of engaging in bidding wars with larger 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. Furthermore, projects may earn points for contributions to a community benefit fund, efforts to strengthen local education and awareness raising, among others. In the **South African** Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), qualified bids are evaluated based on price (70%) and contributions to economic development (30%). The economic development criteria consider black and local shareholders in the company, in addition to procurement from small, medium and micro enterprises (IRENA, 2018a).

The inclusion of small and 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 first auction in 2019 used a measure of market concentration to detect high concentrations of bids from a limited number of players (see Box 1.7). The measured value was almost three times higher than the *ex ante* criterion to be met, implying that just one bidder represented 88% of the market share, and a second bidder the remaining 12%. No award was made (UPME, 2019).

Ceiling prices above which bids are not considered may exclude small and new players by preventing them from participating in the auction, even if, once other design elements are considered, they might have a chance of prevailing. In **Mexico**, disclosed ceiling prices for the first, second and third auctions were as low as USD 76.68/(MWh+clean energy certificate (CEC)) and USD 60.01/(MWh+CEC)[3] (IRENA, 2017a). The low ceiling price may have discouraged small players from participating, which may be one of the reasons why the auctions were dominated by large and international players better able to compete, such as Acciona, Électricité de France (EDF), Enel, Engie, Jinko Solar, SunPower and X-Elio Energy.

Risk allocation and sellers' remuneration.

Under the category of risk allocation and sellers' remuneration, 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, particularly since financial guarantees are often financed through equity.[4] Given the limited financial capacity of small companies and community power initiatives, it may be necessary to reduce the amount of the deposits necessary to secure such bonds, or to develop ways in which less-solvent actors can manage this burden. In **Germany**, the bid bond at the initial bidding stage was reduced from EUR 30/kW (USD 33.9/kW) to EUR 15/kW (USD 16.95/kW) for communities – the other EUR 15/kW coming due once the building permit was obtained. Regarding project completion time, the German wind auctions also allow communities a longer project implementation period (see Box 4.3). However, such a choice can have negative impacts on completion rates if no alternative penalty system is in place.

Small and new players also tend to have smaller profit margins than their larger counterparts and rely greatly on transparent and fair remuneration schemes. To that end, preferential rule schemes could benefit small-scale projects, particularly when marginal pricing is introduced. In those, bidders could receive remuneration higher than their bid price. For example, the community wind projects in **Germany** are granted a price equal to the highest awarded bid in the auction in

[3] USD 51.14/MWh and USD 25.64/CEC in the first auction; USD 40.01 and USD 20.00/CEC in the second. The USD/(MWh+CEC) ceiling was kept constant for the third auction. There were slight changes in the USD/MWh and USD/CEC amounts that balanced out in the end.

[4] A more detailed discussion of the effect of auctions and project finance can be found in AURES II (2019).

which they participate (the uniform-pricing-principle), in contrast to other players who (if successful) receive only their own bid price (pay-as-bid) (see Box 4.3).

Uniform pricing enabled citizen wind parks to offer lower bids in the expectation that ordinary bidders with higher bid levels would set the clearing price level. Moreover, citizen wind projects have also been allowed to base their bids on future wind turbines with better yields, while other bidders had to base their bids on current models (the turbine model must be stated in the building permit).

In sum, auction design elements are flexible and can enhance the participation of small and new actors. While the actors may not be able to exploit economies of scale, they are drivers of growth, employment and development in many economies. Facilitating the participation of local communities and small and new players in auctions can foster the development of local supply chains and industries, as discussed below.

4.2 DEVELOPMENT OF LOCAL INDUSTRIES

Auctions can be designed to serve broader socio-economic development objectives in addition to the deployment of renewable energy capacity. The secondary objective most commonly sought is that of fostering local development through new industries and supply chains. This is perceived as especially important at a time when structural changes, such as those promised by the energy transition, are disrupting traditional sectors, with implications for the economy and communities (Box 4.5). In addition to policies discussed in Box 4.1, nascent industries can be supported by stimulating demand for locally sourced equipment and services. To that end, developers of large projects are often required or encouraged (through incentives) to use a minimum threshold of local goods and services (UNCTAD, 2014).

Local content requirements (LCRs) can be introduced as qualification requirements to participate in the auction or as one of the criteria for the selection of winners. But LCRs often raise a legal concern.

BOX 4.5 REORIENTING ECONOMIES DEPENDENT UPON FOSSIL FUELS

A just transition can address the positive and negative aspects of structural change by:

- Pursuing pro-active planning and investments to drive economic diversification in support of the energy transition;
- Identifying local economic capacities and seeking ways to leverage them in support of renewable energy development;
- Foreseeing evolving skills needs in the renewable energy sector and matching them with available skills in the local economy;
- Aligning, to the extent feasible, relevant expertise and skills from the fossil fuel sector (*e.g.*, using offshore oil and gas industry expertise in offshore wind development) and re-training and re-skilling existing labour in the fossil fuel sector (*e.g.*, coal miners) to integrate them into the renewable energy sector;
- Developing active labour market policies to help individuals who lose their jobs find new livelihoods;
- Introducing adequate measures to manage the transition for fossil-fuel-dependent communities, including social protection measures.

Past economic adjustment processes suggest that re-orienting fossil-fuel-dependent regions is likely to take time and is not always certain to succeed. Acquiring new skills can be a resource-intensive process. Further, new job creation in the renewable energy sector will not necessarily be neatly aligned, temporally or geographically, with fossil fuel job loss – hence the need for appropriate social protection measures for affected communities. Governments also may choose to develop public work programmes to bridge the period required for revitalising local and regional economies.

Sources: IRENA,forthcoming-b; World Bank, 2018; World Bank, ESMAP, and SERIS, 2019.

Qualification requirements

LCRs can be introduced in auction qualification requirements, by restricting participation to developers who comply to a predefined minimum threshold of local content (Steinhilber and Rosenlund, 2016). Such requirements have been seen in Brazil, South Africa, Turkey, and the United Kingdom, among many others. They have had a mixed outcome, depending on policy design, local context and implementation (Box 4.6).

Winner selection

Auctions can 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. **China**'s LCR in onshore wind auctions began at 50% in 2003, before being raised to 70% in 2005. It was abolished in 2009, but grants under the "*Special Fund for Wind Power Manufacturing*" that were contingent on LCRs continued until 2011. The LCR – coupled with favourable market conditions, such as large volumes auctioned and substantial public financial support – helped to develop the wind turbine manufacturing industry. Few foreign companies were able to compete in wind auctions, given the price competitiveness of local equipment (IRENA, 2013). The subsequent removal of LCRs enabled the importation of products of higher quality and increased foreign investment and technology transfer (OECD, 2015).

As previously mentioned, **South Africa**'s REIPPPP is a multi-criteria auction, using both price (70% of the score) and economic development (30% of the score) to determine the winning bid. The auction's economic development criteria reflect specific national and governmental priorities. These include, for instance, broad-based black economic empowerment codes as measurable criteria for the selection of winners (see Table 2.4).

Auction demand

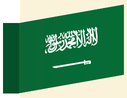
Finally, local products can be supported by reserving a specific volume of auction demand for projects with certain levels of local content. In **India**, separate auctions were conducted in 2013 for projects that committed to meet a given level of local content (see IRENA and CEM, 2015).

Lessons learned for supporting local industries through auction design

If well designed, LCRs can be an important industrial policy tool to provide a conducive environment for the development of a nascent domestic renewable energy industry, albeit often at a higher price, at least at initial stages. Their anticipated positive effects are more likely to manifest in cases where they are coupled with sufficiently large and stable market volumes, where industrial sectors are already established, and when accompanied by long-term planning. They are most effective when included as part of a broad mix of policies related to trade, labour and strengthening of local industries

BOX 4.6 LOCAL CONTENT REQUIREMENTS IN SELECTED COUNTRIES

In **Brazil**, a local content requirement (LCR) for wind projects – one involving eligibility for subsidised loans; not for the right to bid – led to the successful development of local wind supply chains. But a cancellation of wind auctions in 2016, followed by a change in turbine size requirement (to 3 MW from 2 MW in previous rounds), posed challenges for local manufacturers (Spatuzza, 2018).

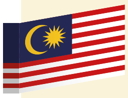


In **Saudi Arabia**, the solar PV auction in 2017 had a moderate LCR of 30%. Upon its completion in 2019, the Sakaka PV independent power producer (IPP) registered over 30% of contractual local content during the construction and development phases. It has also committed to a 100% local employment rate within the first year of operation, 90% of the workforce comprised by the youth of Al Jouf region where the project is located (Bellini, 2019d).

In **South Africa**, the Renewable Energy Independent Power Producer Procurement Programme had LCR thresholds that started at 45% for solar PV and 40% for other technologies, with targets reaching 65% over the rounds (IRENA, 2018a). Commitments for local content for all procured projects were approximated at USD 4.7 billion (ZAR 67.1 billion)[a], amounting to 45% of total project value. This boosted local manufacturing: imports of solar PV and wind turbine components declined and a small export industry started to develop (IRENA, forthcoming-c). However, an unrelated and unexpected development —a three-year delay in signing power purchase agreements from past rounds— resulted in most of those factories either closing down or reducing operations (SAWEA, 2019).

Turkey has established a 65% LCR criterion for the auctions in its Renewable Energy Resource Areas (YEKA). In addition, the winning bidder for solar PV is required to build a solar panel manufacturing facility in Turkey with a capacity of at least 500 MW within two years after contract date and must establish a research and development (R&D) facility and employ a minimum of 100 permanent technical personnel. For onshore wind, the winning bidder must commit to the establishment of an R&D facility (Sarı *et al.*, 2018).

In the **United Kingdom**'s contract for difference (CfD) support scheme, offshore wind projects with a capacity of 300 MW or more are required to provide a supply chain plan that specifies mechanisms for the promotion of local innovation, competition and skill development. Currently, only about a third of the supply chain is localised, but the government seeks to increase this share to 60% (Pantry, 2019). This scheme is not an LCR, but rather an assessment of the local impact of the project.



In **Malaysia**'s Large-Scale Solar auction, foreign ownership cannot exceed 49%. The bidder must be a local company with Malaysian equity of at least 51%, or a consortium of legal entities including a minimum of one local company. The Malaysian equity in the consortium must also be at least 51% (Suruhanjaya Tenaga Energy Commission, 2019a).

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.

[a] 1 USD= 14.08 ZAR in mid-2020

(IRENA, 2014). In the absence of measures to support building local capacities, LCRs may result in reduced competition, bottlenecks, more expensive and less efficient inputs, higher prices for end users, and an increased number of incomplete projects (IRENA, 2019b; del Río, 2017; Leigland and Eberhard, 2018).

Local industries thrive best in areas where there is more than one developer, a situation that helps to produce diversification and specialisation of labour. In short, LCRs for a single round of auctions are not ideal to support the development of local industries. Support for local industry needs to be strategically integrated into a large and continuous vision for the implementation of renewable energy projects (IRENA, forthcoming-d).

Increasing the depth, length and diversity of renewable energy supply chains is also crucial for maximising the benefits of the energy transition (IRENA, forthcoming-b). It is generally believed that the first step is to assess the readiness of the local market for the implementation of LCRs. Before they are established, the needs for material and human resources presented by various renewable energy technologies must be well understood.[5]

A sound assessment of existing domestic resources and capabilities will allow maximising domestic value creation by leveraging and enhancing local industries (see Box 4.7). This assessment can look into all segments of the value chain, since local job creation in project development, installation and, especially, operations and maintenance (O&M) can be more sustainable than in other segments and less vulnerable to variations in annual market size (OECD, 2015).

Finally, where renewable energy is publicly misperceived as expensive or expected to crowd out competing industries, visibly widening opportunities for local economic development, including employment, may increase the social acceptance of the auction scheme.

4.3 LOCAL JOB CREATION

Job creation is a key policy objective of a just and inclusive energy transformation. As more and more countries manufacture, trade and install renewable energy technologies, the sector has grown to employ 11 million people worldwide. This number could exceed 40 million by 2050 under the IRENA transformation pathway to scale up renewables (IRENA, forthcoming-b). Maximising employment creation is closely linked to the concept of local content, in that the localisation of segments of the value chain generates employment. O&M of production facilities is the segment most readily localised, and construction and installation activities also lend themselves for local job creation. By comparison, manufacturing of equipment and complex services require much greater effort –and can be successful. If the low-carbon transition is to be just and inclusive, emerging employment opportunities should be accessible to all, including those affected by the transition.

Potential and distribution of jobs created along with the skills needed

Renewable energy auctions, among other deployment policies, can bring new employment opportunities. In **Brazil**, the awarded projects from auctions have generated an estimated 1.3 million jobs over the last 15 years (Viana, 2019). In **Argentina**, the *RenovAr* programme (a total volume of 2.5 GW onshore wind, 1.7 GW solar PV, and 268 MW of hydro, biomass and biogas awarded) led to the employment of 9,614 people in the sector as of March 2019. Wind energy accounted for over 50% of the total, with 5,343 jobs, while solar energy accounted for 2,555 (Ministerio de Energía, 2019).

The distribution of jobs created depends on the segments of the value chain being localised. Because a solar PV or onshore wind plant normally operates for 20 years, the O&M phase provides more long-term opportunities for employment than the construction or manufacturing phase. Box 4.8 examines the distribution of jobs by segment of the value chain for solar PV, onshore wind and offshore wind.

[5] It should be noted, however, that a country may choose a longer-term development objective and devote resources to build an industry even if the benefits that accrue to the economy are not immediate. Historically, this was the case of most current industrialized nations (see for example Ha Joon Chang, 2009).

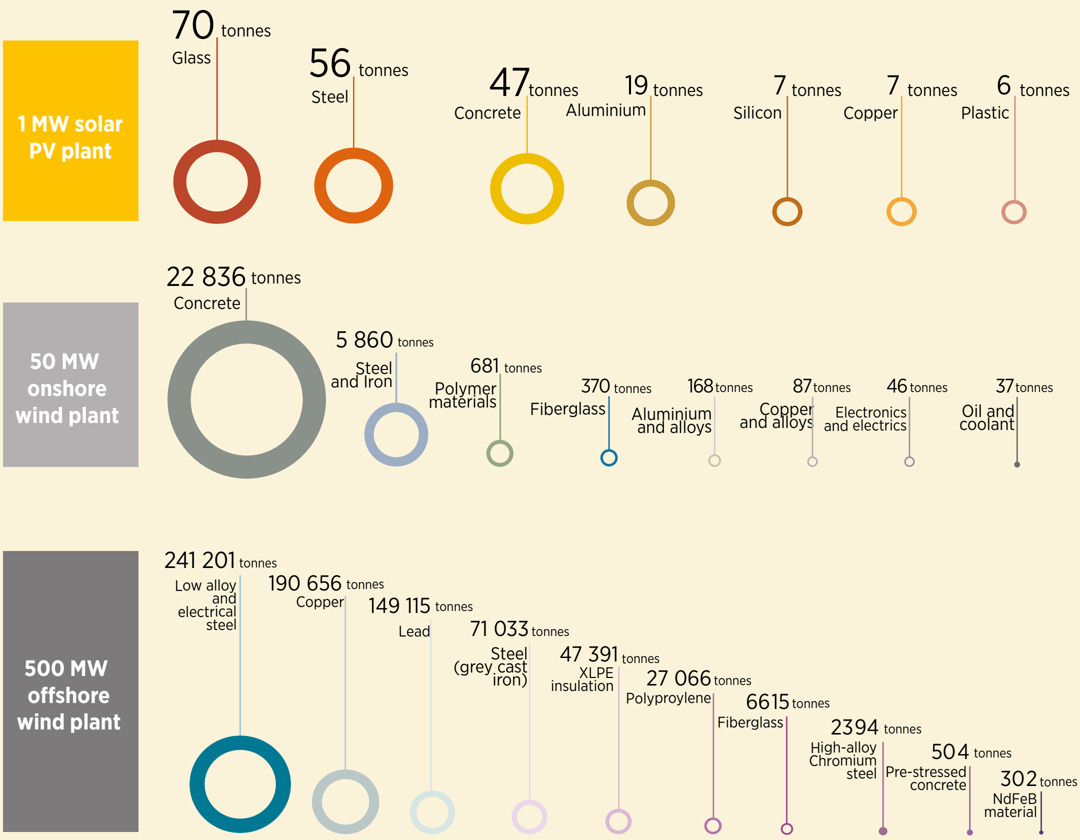
BOX 4.7 IRENA'S LEVERAGING LOCAL CAPACITY REPORT SERIES

IRENA's series of reports on *Leveraging Local Capacity* examines the material and human resource requirements for developing robust industries in solar PV, onshore wind and offshore wind (IRENA, 2017b, 2017c, 2018e). The main materials required by each of these renewable energy technologies are shown in Figure 4.3. The labour requirements are described in Box 4.8.

To maximise value creation from a domestic wind industry, for example, capacities in industries such as concrete, steel, polymers and fiberglass need to be leveraged. This includes providing expertise, as well as the raw materials and intermediary products needed to manufacture wind components such as blades and towers. For a typical 50 MW onshore wind facility, almost 23,000 tonnes of concrete are needed for the foundations, and nearly 6,000 tonnes of steel and iron for the turbines and foundations. The requirements for offshore wind are similar.

Manufacturing the main components of a wind turbine requires specialised equipment, as well as the welding, lifting and painting machines used in other industries, such as construction and aeronautics. The foundations also require the use of specialised equipment including rolling, drilling and welding machinery. Special vessels and cranes are used to move these big structures. Examining these and further requirements provides insights on the industrial capabilities that can be leveraged and enables policymakers to set appropriate country-specific local content requirements.

Figure 4.3 Materials required for a 1 MW solar PV plant, a 50 MW onshore wind plant and a 500 MW offshore wind plant



Source: IRENA, 2017b, 2017c, 2018e.

The work force needs certain skills to allow for sustainable growth (Lucas, Pinnington and Cabeza, 2018). The skills required to build, operate and maintain a renewable energy project are varied; O&M requires mostly highly skilled workers. Box 4.9 presents an overview of the types of jobs required in each segment of the value chain, along with the qualifications needed.

To ensure that the low-carbon transition is as just and inclusive as possible, the positive effects of emerging employment opportunities must be spread equitably among those affected by the transition. Auctions can be designed to strengthen the social and economic value of renewables.

This includes measures to ensure benefits for specific disadvantaged stakeholders, social groups or minorities, through job creation or other means. Some of the options are reviewed below, by category of auction design.

Qualification requirements.
An auction's qualification requirements can be configured to require that project proposals meet quotas or minimum thresholds keyed to the demographic or ethnic characteristics of the work force. In the **Turkish** YEKA auctions, for example, 80% of the engineers employed by the awarded onshore and offshore wind projects must be Turkish (Sarı *et al.*, 2018).

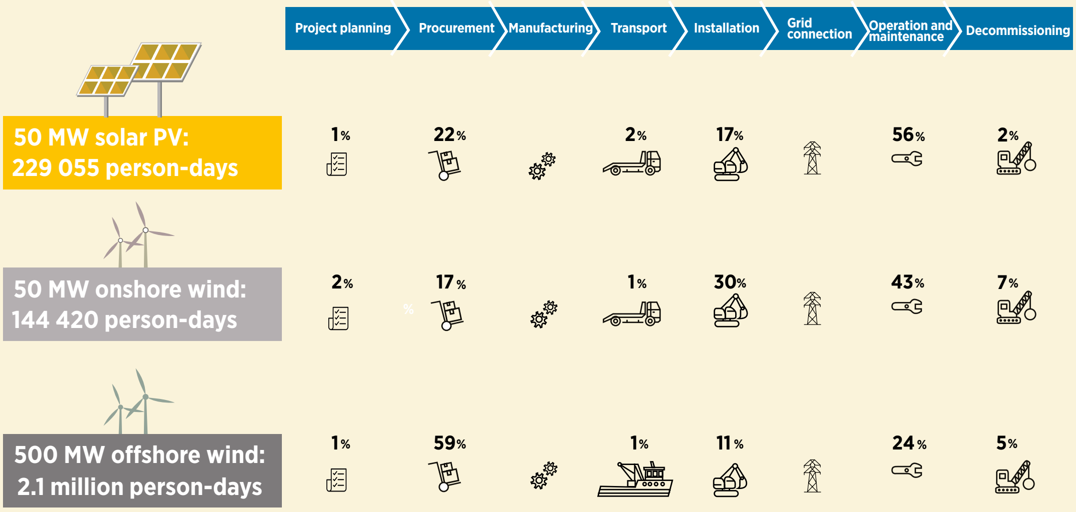
BOX 4.8 DISTRIBUTION OF HUMAN RESOURCES ALONG THE VALUE CHAIN FOR SOLAR PHOTOVOLTAIC, ONSHORE AND OFFSHORE WIND PROJECTS

A typical 50 MW solar PV project requires some 230,000 person-days to plan, manufacture, install, operate, maintain and decommission. The greatest labour requirements are in O&M (56%), followed by procurement and manufacturing (22%) and construction and installation (17%).

Similarly, for the development of a 50 MW onshore wind project, a total of 144,000 person-days is needed. Here again, labour requirements are highest in O&M (43% of the total), followed by construction and installation (30%) and manufacturing (17%).

For offshore wind, the bulk of the labour requirements (totalling 2.1 million person-days for a 500 MW farm) are in manufacturing and procurement.

Figure 4.4 Distribution of human resources along the value chain for 50 MW PV project, 50 MW onshore wind and 500 MW offshore wind



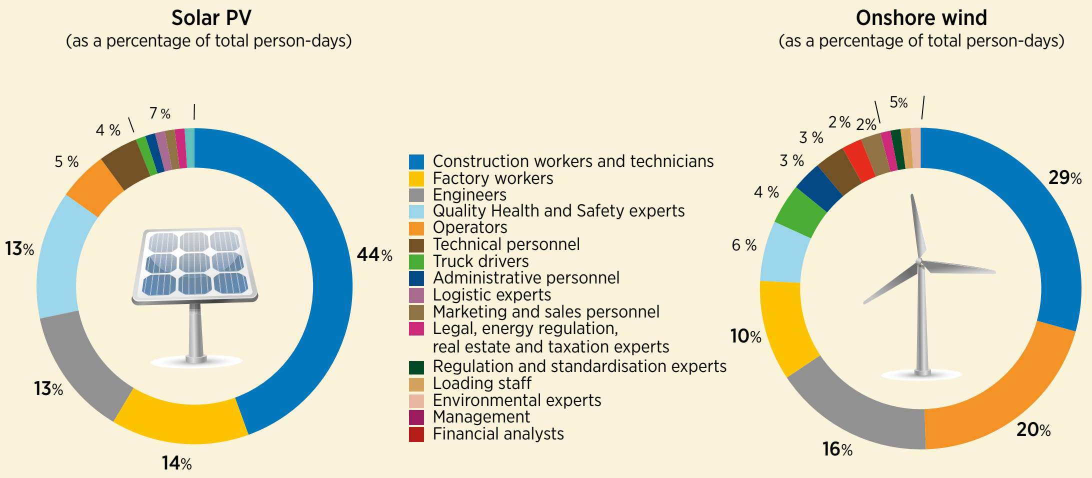
Source: IRENA, 2017b, 2017c, 2018e.

BOX 4.9 TYPES OF JOBS CREATED AND SKILLS REQUIRED ALONG THE RENEWABLE ENERGY VALUE CHAIN

Renewable energy technologies offer employment opportunities along all segments of the value chain. The occupations involved require a wide range of skills, training and experience.

Of the total labour requirements for a 50 MW solar PV plant, the single largest category of occupations is construction workers and technicians (44%), followed by factory workers (14%) and engineers (13%). For a 50 MW onshore wind project, the share for construction workers and technicians is lower than in solar (29%); those categories are followed by operators (20%) and engineers (16%). For both technologies, more than half of the occupations offered are low- to medium-skilled, especially in the construction and installation phases, making them easy to source locally. Within renewable energy technologies, occupational shares also vary by segment of the value chain. Reports in IRENA's Leveraging Local Capacity series provide details (IRENA, 2017b, 2017c, 2018e).

Figure 4.5 Distribution of total labour requirements for a 50 MW solar and wind project



In **South Africa**, these requirements entail thresholds for employees holding South African citizenship, for skilled and unskilled black citizens, and for residents of local communities (see Table 2.4). It is estimated that, through four auction rounds, more than 100,000 job-years would have been created for local citizens: almost 85,000 for black citizens and almost 58,000 job-years for members of local communities, with some overlap (Eberhard and Naude, 2017). As for the job-years created so far for South African citizens, the number increased from around 17,800 at the end of 2014 to around 36,500 by early 2019. The construction phase accounted for 85% of the employment created, while O&M was responsible for the remaining 15%. A total of 27 signed projects in 2019 are expected to provide an additional 54,362 job-years (IRENA, forthcoming-d).

Women have yet to benefit from this programme, as they only represent 8% of total employment created to date (Republic of South Africa, 2019). Women in general remain underrepresented in the renewable energy sector, particularly in the construction and O&M segments of the value chain (IRENA, 2019c).

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).

Auction demand

A systematic scheme can promote longer-term job opportunities. The communication of reliable long-term auction schedules and volumes signals market opportunities and can induce longer term job creation through a pipeline of projects. In **Uganda**, staggering the development of projects instead of deploying them simultaneously, as originally intended, extended the length of employment. Having overcome a learning curve, costs (both in terms of time and resources) were reduced for contractors on later projects, who were able to rely on workers who had gained experience on earlier projects. Even though the outcome was a less diverse workforce, the opportunities for more productive and meaningful work increased, providing a chance for workers to further develop their skills (IRENA, forthcoming-d).

Winner selection

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 receive a bonus in the winner selection (see Table 2.4).

Lessons learned for maximising job creation through auction design

Quantitative employment targets in auctions should be accompanied by qualitative dimensions, such as the sustainability of the newly created jobs, accessibility for all genders and social groups, and the significance of the jobs for those employed. **South Africa**'s Department of Energy has reported that job creation targets were not only achieved, but surpassed, with national skills levels exceeding developers' expectations (DOE, 2018). However, most of the unskilled labour provided by black citizens was short-term, and training, education and development needs may not have been prioritised (McDaid, 2016).

Ultimately, short-term, low-paid, unskilled jobs are not a lasting solution to poverty nor a path to sustainable development. Particularly in Africa, local labour predominates in unskilled positions. In **Senegal** and **Uganda**, skilled construction activities for renewable energy projects were largely carried out by expatriates, while the local community held mostly unskilled positions (IRENA, forthcoming-d). While this model may be ubiquitous and possibly unavoidable in the early stages of the sector development, policies and measures are needed to build local capacities as the sector evolves.

The challenge of job creation thus goes far beyond identifying the competencies needed by renewable energy project developers (Baker and Wlokas, 2015). Foreign project developers may find themselves lacking the on-the-ground networks or community liaisons they need to build a stable workforce (WWF South Africa, 2015). Ultimately, sustainable employment opportunities can be created only when a growing industry is able to absorb and retain the newly created and evolving workforce. This requires a broader set of policies, including measures for education and skills development (see Figure 4.1).

Skills development requires long-term planning. Bottom-up education and training programmes that address fundamental skills gaps can take up to 10 years or more to yield results. Alternatively, transferable skills in other industries can be identified, and workers with such skills retrained according to the needs of the renewable energy sector. Even in that case, however, it can be difficult to attract and retain skilled workers in rural areas where large renewable energy projects are often developed. Indeed, employees often prefer temporary contracts that allow them to travel back and forth between work and home (IRENA, forthcoming-d). Nevertheless, rural and remote areas can benefit greatly from economic activities related to renewable energy deployment.

4.4 SUBNATIONAL DEVELOPMENT AND COMMUNITY BENEFITS

Renewable energy deployment can be a strong driver for job creation and other positive socio-economic outcomes, but the geographical distribution of renewable capacity is to a large extent determined by the location of the underlying resources, clustering in regions rich in them. Although the macro-economic effects of low-carbon transitions are almost universally seen as positive, the regional concentration of projects can leave some less-endowed stakeholders heavily disadvantaged.

Benefits of the geographical distribution of renewable energy projects

Influencing the geographical distribution of renewable energy projects can bring value to disadvantaged regions and maximise transition benefits for communities. But renewable energy projects may struggle to obtain public acceptance where they are perceived to entail high costs – including disruptions from construction and noisy operation – and the main benefactors live outside the community (Wustenhagen, Wolsink and Burer, 2007).

Moreover, the use of land for large-scale renewable energy projects may displace pre-existing economic activities and force the resettlement of local citizens, leading to negative social and economic impacts (Yenneti, Day and Golubchikov, 2016; Mathur, 2011). In addition, renewable energy projects may be located near rural communities that lack access to modern energy services.

Such regions, which will generally have high rates of poverty and inequality, usually expect more from a project than it can deliver. This is why engaging communities and maximising benefits on the local level are crucial for project sustainability and can contribute to a just and inclusive transition.

Also, renewable energy projects that ensure community participation 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 acceptance of renewable energy projects while also yielding economic and social benefits for the community (Box 4.10).

BOX 4.10 ENHANCING SOCIAL ACCEPTANCE THROUGH COMMUNITY PARTICIPATION

Inadequate community involvement can slow or halt the implementation of renewable energy projects, as was the case, for example, with wind projects that were terminated in **Mexico** and **Kenya** (Business and Human Rights Resource Centre, 2018). But community involvement can also increase social acceptance and minimise a not-in-my-back-yard effect.

Under the community engagement modality, generators engage with local communities through consultation and dialogue before developing their projects (DELWP, 2017). Dialogue, inclusive planning and the collaborative policy development are all necessary for a just low-carbon energy transition, even when projects are not developed by the community itself (Smith, 2017).

Communities may also take an equity stake in projects, for example, in response to policies designed to maximise socio-economic benefits or requirements for a social license to operate (IRENA, 2019d). This is the case in **Denmark**, for example, where neighbours of near-shore wind projects must be given the opportunity to invest in the project. Alternatively, when citizens entirely take over control and ownership of a project to independently develop renewable energy, the engagement of citizens takes the form of community ownership initiatives (see Box 4.2).

Community power initiatives have proven their significance in settings as varied as **Germany** (Musall and Kuik, 2011) and **Japan** (Maruyama, Nishikido and Iida, 2007). On-site participatory planning with indigenous communities in **Mexico** (Huesca-Pérez, Sheinbaum-Pardo and Köppel, 2016) and in the Latin America and the Caribbean region generally (REN21, 2017) has also shown promise. More commonly, assessment of local stakeholder engagement is a requirement for environmental and social-impact approval of projects (see Box 4.12).

As detailed in the paragraphs that follow, elements of auction design can facilitate the development of renewable energy projects in regions with sub-optimal resource endowments. It can also encourage the participation of host communities so as to maximise benefits, improve regional development, and increase social acceptance – combining to enhance the equity and inclusiveness of the low-carbon energy transition.

Auction demand

Regional development can be pursued through design elements falling within the auction demand category. By limiting the participant pool and selecting technologies in which a given region has a comparative advantage, technology-specific auctions can increase the chances that projects will be awarded in regions that would otherwise not be able to compete. Likewise, by conducting zone-, site-, or project-specific auctions, the auctioneer can pre-select the sites and regions that best suit policy objectives.

The Noor solar complex in **Morocco** is a case in point, presenting opportunities for job creation and regional development in the remote area of Ouarzazate (Box 4.11).

Qualification requirements

Site-specific qualification requirements, particularly proof of land-use rights, can promote community benefits when grounded in solid documentation that is binding on auction participants. Indeed, land access and acquisition processes offer local communities leverage to participate in and benefit from renewable energy projects. Communities may be concerned about conflicts between energy production and other economic activities. However, this can be mitigated through location constraints that focus on land use (IRENA and CEM, 2015).

Requirements that projects yield socio-economic benefits where they are built can also support regional and community development. In such cases, developers must demonstrate that their projects will have beneficial spillovers in a given region. In **Australia**, project developers are required to submit evidence to support community engagement and benefit sharing. For this purpose, the Victoria state government has developed a community engagement and benefit sharing guideline that includes a social risk analysis, a community engagement strategy, a benefit sharing program, and letters of support, as well as reporting, monitoring and evaluation plans (see Box 4.4).

BOX 4.11 NOOR-OUARZAZATE SOLAR COMPLEX IN MOROCCO PROVIDES BENEFITS TO THE REGION

The auction for the Noor-Ouarzazate solar complex was designed to generate electricity from concentrated solar power (CSP) while contributing to the development of a domestic industry and creating economic opportunities for local communities. Populations in neighbouring villages are among the main beneficiaries of the project. The local communities made choices that benefited everyone, including women and children.

For example, instead of cash compensation for the land lost, which would benefit only male landowners, the community opted for investments in basic amenities and social services for all, such as drainage and irrigation channels, drinking water facilities, community centres, and mobile health caravans. Some projects, such as a dormitory for female students and sport and camp programs for children, directly benefit women. The complex has also offered employment opportunities to women in Morocco, whose participation in the labour force is among the lowest in the world.

However, women still face challenges in finding jobs because of adverse gender norms in rural areas and inadequate qualifications. Indeed, they represent only 4% of the workforce at the CSP facility. Provisions for a safe and positive work environment for women made it possible for them to work in a range of positions within the complex, from traditional activities such as catering, cleaning, and administration to technical roles in quality control and health and safety, and even highly skilled positions such as topographer and welder. Without the provisions, their participation in the workforce would have been lower.

Source: ESMAP, 2018.

In **South Africa**, REIPPPP projects have been required to have either a community trust or a company that represents local communities.[6] As project shareholders, communities earn dividends which are expected to be invested in community development initiatives. To date, REIPPPP has committed USD 3.6 billion to local shareholding, representing a net income for community organisations of about USD 1.5 billion (IRENA, forthcoming-d). In **El Salvador**, 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).

In **Namibia**, the national utility, NamPower, has focused on including "previously disadvantaged Namibians" in auctions. The Equitable Economic Empowerment Policy includes as a condition for obtaining a generation license, 30% ownership and shareholding by the disadvantaged, with special emphasis on women and disabled individuals. Other criteria required included management positions for disadvantaged Namibians; spending on skills development, entrepreneurship development, and community investments; and local hiring from communal and underdeveloped regions (IRENA, forthcoming-d).

In **Mexico**, developers must obtain a social impact permit before building their plants. This permit has become a bottleneck in deployment of awarded projects (Box 4.12).

Winner selection

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 **Malaysia**'s Large-Scale Solar PV auction, plans to use land for economic activities in addition to solar generation (*e.g.*, agricultural activities) can yield merit points to the bidder (Suruhanjaya Tenaga Energy Commission, 2019b). In **Germany**'s solar PV auction, ground-mounted projects were incentivised to deploy in industrial zones rather than to use land with alternative or potential agricultural uses. This was done by capping the number of sites that could be built on arable land. Once the cap is met, the construction of ground-mounted systems is supported only on brownfield sites, along train tracks and highways, or in non-arable areas.

BOX 4.12 MEXICO'S SOCIAL IMPACT PERMIT

Mexico's structural energy reform (2013-2014) requires every new energy project to conduct a social impact assessment. The assessment must include measures to mitigate negative impacts and to maximise positive ones (Chacón, 2016). The national Secretariat of Energy (SENER) is responsible for approving and issuing the permit, which takes around one year, chiefly because the resources dedicated to the process are limited.

Because of this delay, the permit has become a bottleneck to timely development of projects (Guadarrama, 2018). The lack of clarity around the framework for social impact permits has also had negative repercussions. For instance, consultations with indigenous communities for wind projects in the state of Oaxaca have been neglected. The development of renewable energy projects in other regions has been accompanied by socio-economic tensions, as most of the project sites lie within indigenous territories (del Río, 2017). SENER will have to establish clearer criteria for sound and binding social impact assessments.

The social impact permit was considered as a qualification requirement in the fourth auction round, instead of a post award requirement (Guadarrama, 2018), but the auction was ultimately cancelled (see Box 2.3).

[6] *While corporate project developers comply with the policy requirement to involve communities, they often form the entities that represent local communities on their behalf (WWF South Africa, 2015). The requirement is being phased out in future rounds, as it has been found not to be representative of the communities and has in some cases led to community conflicts.*

Sellers' remuneration and risk allocation

Concerning sellers' remuneration, regions with lower levels of resource endowments can be compensated through higher adjusted payments based on a pre-established reference. This is known as a "reference yield model". Project developers bid the price at which they estimate they can compete; however, for locations with higher resource endowments (*i.e.,* above the reference yield), a lower price is paid, and vice versa. **Germany** has facilitated the development of wind projects in regions with lower wind resource endowments by implementing this strategy. The objective is not to build projects with sub-optimal resources, but to level the playing field for sites with lower wind speeds to compete with those with higher speeds, while also compensating for the transmission constraints between north and south.

Germany's experience shows that the reference yield model does not limit supply and can potentially reduce grid and congestion costs. That said, the effectiveness of the approach depends on the diligent setting of parameters, such that good projects remain competitive and contracts are not awarded solely on the basis of location-specific adjustments (Steinhilber and Rosenlund, 2016). In sum, the move to renewables does not automatically ensure that marginalised regions and communities will benefit from the energy transition without dedicated policy action (IRENA, forthcoming-d). The design of renewable energy auctions can encourage the participation of communities to maximise benefits, improve regional development and enhance the equity and inclusiveness of the low-carbon energy transition. In addition, it can facilitate the development of renewable energy projects in regions with lower resource endowments.

4.5 CONCLUSIONS ON ENSURING A JUST TRANSITION

The deployment of renewable energy presents ample opportunities to achieve broader economic and social objectives. To date, however, deployments have too often side-stepped such questions. Fortunately, auctions offer the potential to foster the development of local industries, create jobs, include small and new players, engage communities, and contribute to subnational development.

Small-scale actors, including communities, are drivers of growth, employment and development in many countries, and the energy sector can and should encourage their participation. Auction design can do so by reducing transaction and up-front costs or by compensating small developers' projects beyond their pricing offers. Mobilising them through auctions contributes to the development of local supply chains and industries.

Local content requirements are often adopted to support nascent and domestic renewable energy industries and to maximise local value creation by stimulating demand for locally sourced equipment and services. Developers of large projects can be required or encouraged to employ a minimum threshold of local goods and services. Increasing the depth, length and diversity of renewable energy supply chains is one of the crucial factors for maximising the benefits from the energy transition. An initial step is to understand the material and human resource requirements of different renewable technologies, to assess those requirements in the context of existing domestic resources and capabilities, and to identify ways to maximise domestic value creation by leveraging and enhancing local industries.

New employment opportunities are among the benefits that renewable energy projects and auctions can promote.

Incentives for local employment requires that the workforce itself possesses the skills and knowledge needed to support the sector's development. Related education and training policies must, therefore, prepare the enabling conditions. In addition, the newly created jobs must be equitably distributed within the population –in terms of gender, ethnic minorities and marginalised groups– and must be sustainable and significant for those employed. Opportunities for employment can also benefit populations living in underdeveloped and remote areas.

A concentration of projects in resource-rich regions can disadvantage other regions and stakeholders. A more even regional distribution can help spread the socio-economic benefits of renewable energy projects, while also facilitating grid integration (see Chapter 3). A variety of auction design elements can promote community participation and social acceptance, improve regional development, and enhance the equity and inclusiveness of the low-carbon energy transition. Yet these design elements, effective as they may be, must figure within a broader policy framework designed to ensure a just and inclusive energy transition.

Finally, the trade-off between achieving socio-economic objectives and procuring electricity at low prices cannot be avoided. In the pursuit of socio-economic development, a main challenge for policymakers is to align deployment policies with enabling and integrating polices (see Figure 4.1).

Failure to exploit synergies between the energy sector and the broader economy can result in a lost opportunity to maximise the benefits of the energy transition (IRENA, forthcoming-b).

THE WAY FORWARD

As renewable energy becomes more mainstream, the policies driving its deployment and integration are evolving rapidly. This reflects multiple factors, including changing market conditions, new technical and socio-economic challenges, and the need to ensure a just transition. Through the increasing use of auctions, policy makers have sought to procure renewable electricity cost-effectively while also fulfilling other, often country-specific, social and economic aims.

Remarkable progress has occurred in the field of renewable energy auctions in recent years.

A total of 106 countries had adopted competitive procurement for renewable-based electricity by the end of 2018, up from 8 in 2005. In 2017 and 2018 alone, 55 countries adopted auctions, a third of those for the first time. Competitive cost reduction and record-low prices were achieved in countries that prioritised deployment at the lowest price, mainly for solar PV and wind (both onshore and offshore) power supply.

The global price average for solar PV fell 77% between 2010 and 2018, reaching USD 58.7/MWh, while onshore wind declined 36% to USD 47/MWh.

Other countries focused their auction designs on other goals, such as integrating solar and wind power (*i.e.,* VRE), ensuring timely project completion, and ensuring a just and inclusive energy transition.

Many auction strategies can support VRE integration, based on varying degrees of central planning.

Under the project-based strategy, the desired technological characteristics, project size, location and other parameters are pre-determined to fit system needs. Quantity and adjustment-based strategies identify system constraints and set limits (*e.g.*, on size or location) or apply penalties and incentives to maintain smooth system operation.

A price-based strategy typically relies on price signals to identify the best VRE production profile, while a product-based strategy focuses on auctioning system-friendly energy, capacity, services, and other power-market products.

The choice of auction strategy and design elements in each case needs to reflect specific circumstances, such as the existing market structure, level of sector development and other factors.

Projects must come online on time and perform as planned. Successful delivery in terms of capacity, energy, and socio-economic benefits, are prerequisites to meet renewable energy targets, as well as to achieve wider sustainable development goals.

This can be done through auction design elements such as qualification requirements and compliance rules but careful consideration needs to go into how these impact the different auction stages. For example, while elaborate qualification requirements can minimise underperformance at the construction and operation stages, they may deter participants at the bidding stage and impact competition.

Responsibilities and risks must be allocated among multiple stakeholders depending on the context. Balanced risk mitigation through auction design could be explored further in future studies. This topic becomes increasingly relevant with more newcomers to auctions, and higher levels of risks that can be political and regulatory and/or related to off-take, transmission, currency, etc.

Beyond auction design, project performance also depends on the subsequent enabling environment for renewables, from robust institutions and ease of issuing licences and permits, to facilitating grid connection and aligning project timelines with socio-economic development goals.

Renewable energy auctions can foster local industries, create jobs, encourage small and new participants, engage communities and contribute to sub-national as well as national development.

Reduced up-front costs and additional compensation can encourage the participation of small and new players, which are drivers of growth, employment and development in many countries. Mobilising such players through auctions enables wider competition and strengthens local supply chains and industries. Those can also be supported through local content requirements and the selection of developers with higher shares of local spending.

Local job creation is another objective, but one that requires the availability of skills and knowledge among the local workforce. Education and training policies must create the conditions for renewable energy uptake. To ensure a durable transition, newly created jobs must be fairly distributed, in terms of gender and ethnic minorities and marginalised groups – and must be sustainable and significant for those employed.

Opportunities for employment can also benefit populations living in underdeveloped and remote areas and a more even regional distribution can help spread the socio-economic benefits of renewable energy projects. Auction design can promote community participation and social acceptance, improve regional development, and enhance the equity and inclusiveness of the low-carbon energy transition. Yet these design elements, effective as they may be, must figure within a broader policy framework designed to ensure a just and inclusive energy transition.

The trade-off between achieving socio-economic objectives and procuring electricity at low prices cannot be avoided. A major challenge for policy makers is to align renewable energy deployment with other policies and socio-economic goals. Failure to exploit synergies between the energy sector and the broader economy, meanwhile, can mean a lost opportunity to maximise the benefits of the energy transition.

To ensure success, auctions can be tailored to each country's technical, administrative and political capabilities and deployment and development objectives. Smooth co-ordination among all stakeholders is vital throughout the process.

Long-term electricity procurement, including through auctions, forms a key pillar of this transition to a sustainable energy future.

Auction design alone cannot overcome all the challenges involved in large-scale renewable energy integration. Each power system requires comprehensive structural changes to maximise the value, and optimise the use of solar, wind and other renewables.

Yet sound auction design can help to adjust current power system structures, introduce higher shares of renewables and lay the groundwork for the sustainable, renewable-based power systems of the future. Further IRENA work on auctions will provide strategies to support such systemic evolution.

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ANNEX: HIGHLIGHTS OF RENEWABLE ENERGY AUCTIONS, 2017-2019

Afghanistan: Since September 2017, Afghanistan has been organising auctions following the engineering, design, procurement, and construction of renewable plants (EPC). Between September 2017 and December 2018, seven project-specific auctions of this type were held, and three projects were awarded: one 10 MW solar hybrid project and two other similar projects totalling 45 MW (Bellini, 2017c). By the end of 2018, a call for expression of interest was launched for a total 2 GW of grid-connected solar parks across the country (400 MW in each of five selected provinces) (Petrova, 2018b).

Albania: In August 2018, an auction was called to build a 50 MW solar photovoltaic (PV) plant under a project-specific scheme. The winning offer involved a price of EUR 59.9/MWh (USD 68/MWh)[1] and a commitment to build an additional 50 MW of capacity that will sell electricity at market prices (Jovanović, 2018b).

Algeria: In May 2017, the Algerian Ministry of Energy announced the country's first renewable energy auction with the goal of contracting 4 GW of solar capacity (Climatescope, 2018f). In November 2018, the Algerian government issued a tender for the deployment of 150 MW of solar capacity (Bellini, 2018b).

Argentina: In 2017, the Argentine government awarded 2,042 MW of projects under Round 2 of the RenovAr program. The awards included 993 MW of wind capacity at an average price of USD 41/MWh and 816 MW of solar at an average price of USD 43/MWh, as well as 143 MW of biomass at an average price of USD 107.5/MWh, 69 MW of biogas at an average price of USD 153/MWh, and 21 MW of small hydro at an average price of USD 98.9/MWh (Yaneva, Tisheva and Tsanova, 2018).

Armenia: In May 2017, the government published a tender to contract a 55 MW solar park under the project-specific scheme. Five bidders were shortlisted for the final phase. The winning bid was awarded at USD 41.9/MWh in May 2018 (Petrova, 2018c).

Australia: The state of Victoria first renewable energy auction was held in 2018. In it, 673 MW of onshore wind and 255 MW of solar PV capacity were contracted (928 MW in total) (Maisch, 2018). The state of South Australia held an auction for concentrated solar power (CSP) in 2017 in which 150 MW was awarded at a price of AUD 78/MWh (USD 61/MWh)[2] (Kraemer, 2017). Later in 2018, an auction was held for a 100 MW storage facility adjacent to a large wind farm. Tesla and Neoen won the contract for USD 50 million and deployed the Hornsdale Power Reserve's 100MW/129MWh battery energy storage system (Wahlquist, 2018).

Bahrain: In February 2019, Bahrain awarded 100 MW of solar PV at an average price of BHD 14.7/MWh (USD 38.9/MWh)[3] (BNEF, 2019).

Bangladesh: Bangladesh launched an auction in March 2017 that awarded 258 MW of PV projects at an average price of BDT 10,880/MWh (USD 136/MWh[4]) (Shumkov, 2017). In August 2018, another auction was launched for 200 MW of PV projects to be developed in four locations; that auction is still underway (Petrova, 2018a).

Bolivia: In early 2018, Bolivia awarded Spain's TSK a contract to build (but not operate) the 50 MW Oruro Solar Park (TSK, 2018).

Botswana: Botswana launched its first auction in May 2017 to contract 100 MW of solar capacity consisting of two 50 MW facilities. The auction was originally planned for joint ventures between the government and the selected private investors, but the model adopted was redefined to the independent power producer (IPP), with investors fully owning and operating the plants (Bellini, 2019b).

Brazil: In four auctions held between 2017 and 2018, Brazil awarded 2,828 MW of wind capacity, 1,823 MW of solar, 650 MW of small hydro, and 292 MW of biomass (BNEF, 2019). The A4 technology-neutral auction in 2017 was dominated by solar PV (791 MW out of the total of capacity assigned, 64 MW to wind, 25 MW to biomass and 12 MW to hydro). In the A6 technology-neutral auction in October 2019, only 530 MW of the 2.98 GW of capacity contracted was awarded to solar, at an average price of USD 20.52/MWh, more than 1 GW was awarded to wind, 734 MW went to gas-fired power, 445 MW to hydro and 229 MW to biomass (Molina and Bellini, 2019).

Canada: In the first round of the province of Alberta's auctioning program, 600 MW of wind capacity were contracted at an average price of CAD 37/MWh (USD 29/MWh)[5] in December 2017. In December 2018, during the second and third rounds, a total of 763 MW of wind generation (363 MW in the second round and 400 MW in the third) were awarded with an average price of CAD 38.69/MWh (USD 28.76/MWh)[6] and CAD 40.14/MWh (USD 29.84/MWh), respectively (AESO, n.d.).

Chile: Chile's latest technology-neutral auction, held in November 2017, awarded 2,200 GWh - equivalent to approximately 600 MW of renewable capacity (equivalent to the estimated annual energy demand). The final award price was USD 32.5/MWh (Bellini, 2017a).

China: China held a total 10 auctions under its Top Runner program in 2017 and 2018, awarding contracts to 5 GW of solar projects at an average price of CNY 427/MWh (USD 64.6/MWh) (Climatescope, 2018a). In December 2018, an onshore wind auction in Ningxia region awarded 1.9 GW of wind projects at an average price of CNY 451.5/MWh (USD 65.5/MWh)[7]. In July 2019, China awarded 22.8 GW of solar PV at an average price of CNY 446.4/MWh (USD 64.9/MWh)[8] (BNEF, 2019).

[1] *Note: 1 USD = 0.879906 EUR in November 2018.*

[2] *When neither the exchange rate nor the date are specified, these can be found in the cited reference.*

[3] *Note: 1 USD = 0.378 BHD in February 2019.*

[4] *Note: 1 USD = 80 BDT in March 2017.*

[5] *Note: 1 USD = 1.275719 CAD in December 2017.*

[6] *Note: 1 USD = 1.345234 CAD in December 2018.*

[7] *Note: 1 USD = 6.892 CNY in December 2018.*

[8] *Note: 1 USD = 6.879 in July, 2019.*

Chinese Taipei: In June 2018, Chinese Taipei launched an auction in which 1,664 MW of offshore wind capacity were contracted at an average price of TWD 2386.3/MWh (USD 79.1/MWh) (BNEF, 2019; Tisheva, 2018).

Colombia: In October 2019, Colombia awarded 1.3 GW of solar and wind energy, following the cancellation of the first renewable energy auction in February that year. The average price for the 8 signed contracts (5 wind and 3 solar) was COP 95,650/MWh (USD 28/MWh) (Kenning, 2019c).

Denmark: The country's first solar-wind auction was launched in September 2018. The results, announced in December 2018, were the contracting of a total of 269 MW: 165 MW of wind and 104 MW of solar PV capacity at a weighted average feed-in premium (FiP) (fixed on top of the market price) of DKK 22.8/MWh (USD 3.47/MWh)[9] (Bellini, 2018c). A second round was held in 2019 where solar and wind competed. A ceiling on the FiP to be paid to successful bidders was set at DKK 60/MWh, more than halving the previous round's ceiling price of DKK 130/MWh. In mid-November 2018, Denmark also awarded 19 MW of solar PV capacity at an average price of DKK 129.7/MWh (USD 20.4/MWh) (BNEF, 2019) in the technology-specific small-scale PV auction. In late 2019, the country was preparing to auction an 800 MW offshore wind project (Kleist, 2019).

Egypt: In 2017, a first auction for the development of solar parks was held. It took the form of a technology-exclusive bidding round designed to award 600 MW of solar capacity (Climatescope, 2018g). In August 2018, an additional project-specific auction was launched to contract the 200 MW Kom Ombo solar PV project. The winning bid was awarded at USD 27.5/MWh (Enterprise, 2019).

El Salvador: In January 2017, El Salvador awarded 50 MW of wind at an average price of USD 98.78/MWh and 120 MW of solar capacity at an average price of USD 49.55/MWh (Climatescope, 2018j).

Ethiopia: In June 2017, Ethiopia awarded 100 MW of solar PV. In October 2017, a site-specific auction was launched to contract two 125 MW solar plants with a combined capacity of 250 MW (Climatescope, 2018h).

Finland: Finland held a technology-neutral renewable energy auction in November 2018 allowing competition among various renewable energy sources. In total, 26 proposals were submitted, all of which were for wind power production. Only seven projects were awarded, with an average price of EUR 2.49/MWh (USD 2.81/MWh)[10]. Under the auction terms, winners were awarded the tariff plus a feed-in premium, the exact amount of which will depend on whether the average three-month market price of electricity is equal to, lower than, or higher than EUR 30/MWh (Mäkitalo, 2019).

9 Note: 1 USD = 6.562453 DKK in December 2018
10 Note: 1 USD = 0.885152 EUR in March 2019

France: France launched its ground-mounted solar PV programme in August 2016, with plans to auction 3 GW in six 500 MW phases in 2017, 2018 and 2019. The first auction results were disclosed in March 2017, with 535 MW awarded at an average price of EUR 62.5/MWh (USD 66.8/MWh)[11] (Kenning, 2017b). The results of the second auction were published in July 2017, with 508 MW awarded at an average price of EUR 63.9/MWh (USD 73.65/MWh)[12] (Kenning, 2017c). The third auction, the results of which were revealed in February 2018, awarded 508 MW at an average price of EUR 61.6/MWh (USD 76/MWh)[13] (Shumkov, 2018). The fourth auction awarded 720 MW in August 2018 at an average price of EUR 58.2/MWh (USD 67.15/MWh)[14] (Bellini, 2018d). The fifth awarded 855 MW in March 2019 at an average price of EUR 62.7/MWh (USD 70.83/MWh)[15] (Martín, 2019b). In March 2018, France awarded 22 onshore wind projects totalling 508.4 MW in its first onshore wind auction, with an average price of EUR 65.40/MWh (USD 80.63/MWh)[16] (Dodd, 2018). In September 2018, the country awarded 118 MW in a second onshore wind auction, with an average price of EUR 68.7/MWh (USD 79.9/MWh). After a third onshore wind auction in April 2019, 516 MW were awarded at an average price of EUR 63/MWh (USD 73.3/MWh) (BNEF, 2019). In June 2019, the country awarded 500 MW in the first offshore wind auction in Dunkirk at an average price of EUR 44/MWh (USD 49.7/MWh) (BNEF, 2019; Brnic, 2018).

Germany: In November 2018, the Federal Network Agency (Bundesnetzagentur) awarded 201 MW of solar PV to 36 projects at an average price of EUR 57.2/MWh (USD 65/MWh)[17] (Hill, 2018). This was followed by three solar auctions: In February 2019, 80 contracts totalling 465 MW were awarded at an average price of EUR 48/MWh (USD 54.5/MWh)18 (Hill, 2019a). In March 2019, 121 contracts totalling 505 MW were awarded at an average price of EUR 65/MWh (USD 73.4/MWh)[19] (Hill, 2019b). In April 2019, 210 MW were awarded at an average price of EUR 56.6/MWh (USD 63.6/MWh)[20] (Hill, 2019c). For onshore wind, more than 6 GW were auctioned in 2017 and 2018, out of which more than 5 GW were awarded at an average price of EUR 52.4/MWh. In 2019, five rounds were held. In February, 67 contracts totalling 476 MW were awarded at an average of EUR 61/MWh (USD 69.2/MWh). In May, 270 MW were awarded at an average of EUR 61.5/MWh (USD 68.9/MWh)[21]. In August, 208 MW were awarded at an average of EUR 62.3/MWh (USD 69.5/MWh)[22]. In September, 176 MW were awarded at an average of EUR 62.1/MWh (USD 68.5/MWh)[23]. And in October, 204 MW were awarded at an average of EUR 62.2/MWH (USD 68.9/MWh)[24] (BNEF, 2019).

11 Note: 1 USD = 0.9351 EUR in March 2017
12 Note: 1 USD = 0.867527 EUR in July 2017
13 Note: 1 USD = 0.810022 EUR in February 2018
14 Note: 1 USD = 0.866686 EUR in August 2018
15 Note: 1 USD = 0.885152 EUR in March 2019
16 Note: 1 USD = 0.811046 EUR in March 2018
17 Note: 1 USD = 0.879906 EUR in November 2018
18 Note: 1 USD = 0.880959 EUR in February 2019
19 Note: 1 USD = 0.885152 EUR in March 2019
20 Note: 1 USD = 0.890132 EUR in April 2019
21 Note: 1 USD = 0.893524 EUR in May 2019
22 Note: 1 USD = 0.897508 EUR in August 2019
23 Note: 1 USD = 0.907199 EUR in September 2019
24 Note: 1 USD = 0.903815 EUR in October 2019

Greece: In July 2018, Greece launched its first auction for renewable capacity, organised into three rounds. The first round, solar-specific, was for plants of less than 1 MW; it resulted in awards of 53.5 MW at an average price of USD 92/MWh (EUR 77.95/MWh). The second round, also solar-specific for plants between 1 MW and 20 MW, awarded 53 MW at an average price of EUR 67/MWh (USD 79/MWh). The third round, specific to wind plants between 3 MW and 50 MW, awarded 171 MW at an average price of EUR 70/MWh (USD 82.6/MWh) (BNEF, 2019; Tsagas, 2018). In December 2018, Greece awarded 62 MW of solar PV at an average price of EUR 66.6/MWh (USD 78.6/MWh) and 222 MW of onshore wind at an average price of EUR 58.6/MWh (USD 69.15/MWh). In May 2019, the country held its first technology-neutral auction, which resulted in the award of 370 MW of renewables at an average price of EUR 57/MWh (USD 64.4/MWh) (BNEF, 2019). In its latest auction in July 2019, Greece awarded 143 MW of solar PV at an average price of EUR 62.8/MWh (USD 70.6/MWh)[25] and 180 MW of wind at an average price of EUR 67.3/MWh (USD 75.7/MWh) (Tsagas, 2019a).

India: In 2018, auctions for solar PV (and wind) rose dramatically from prior years, accompanied by lower bid prices. In July 2018, a price of INR 2.44/kWh (USD 35.42/MWh) was registered in the 600 MW solar auction held by the Solar Energy Corporation of India (MNRE, 2018), but subsequent auctions in 2018 yielded relatively higher prices.

Indonesia: In June 2017, Indonesia held an auction to contract 168 MW of solar capacity in the Sumatra region. The auction attracted 116 bids from interested companies (Petrova, 2017).

Israel: Israel's first and second renewable energy auctions under the country's renewable plan were held in March and July 2017. Both were technology-exclusive. The first awarded 235 MW of solar PV at an average price of ILS 199.00/MWh (USD 55.34/MWh); the second, 105 MW of solar PV at an average price of ILS 197.80/MWh (USD 54.9/MWh) (BNEF, 2019).

Japan: In October 2017, the first tender for solar projects (2 MW or greater) was held, contracting only 141 MW (out of 500 MW targeted) at an average price of JPY 18,628/MWh (USD 165/MWh)[26] (Solarplaza, 2018). The country's second solar auction in September 2018 contracted no projects, because no bid came in below the ceiling price set in advance (Argus Media, 2019). A third solar auction held in December 2018 contracted 196.6 MW at an average price of JPY 15,024/MWh (USD 134/MWh)[27] (Bellini, 2019a). In parallel, auctions for offshore wind have been gaining traction in the country, with 229 MW (Japan's largest offshore wind project to date) contracted in January 2017 (IPP Journal, 2017). In December 2018, Japan held its first biomass auction; it resulted in the award of 35 MW of biomass projects at an average price of USD 174/MWh (BNEF, 2019).

Jordan: In September 2018, Jordan awarded 150 MW of solar PV at an average price of USD 28/MWh (BNEF, 2019). Prior to that, 50 MW of wind capacity were auctioned in the third round of Jordan's renewable auction held in December 2016; the results have yet to be announced (PV Magazine, 2018).

Kazakhstan: Twenty auctions held by the government in 2018 aimed to award 1 GW of installed capacity in tranches keyed to renewable energy technologies, zones and size categories. The auctions that took place awarded 858 MW of capacity, consisting of 270 MW of solar, 500 MW of wind, 82 MW of hydropower and 5 MW of biomass-fired generation split among 36 projects proposed by 30 companies. The lowest tariff submitted for solar projects was KZT18/kWh (USD 48.5/MWh); the lowest for wind and hydropower projects were KZT 17.39/kWh (USD 46.9/MWh) and KZT 12.8/kWh (USD 34.5/MWh). The lowest tariff submitted for a biomass-fired generation project was KZT 32.15/kWh (USD 86.7/MWh) (IPP Journal, 2018).

Kuwait: In June 2018, the Kuwait National Petroleum Company launched a site-specific auction to build the 1.2 GW Dibdibah solar-power plant. A total of 17 companies were prequalified in the first stage of the auction, but no results have been announced (Gupta, 2018).

Lebanon: Lebanon held one solar auction early this year for a capacity of 180 MW divided among 12 plants (each 15 MW). Of this, only 45 MW has been awarded; the rest are under negotiation (Tsagas, 2019b). Lebanon also held two auctions for wind projects in July 2017 and April 2018. The July auction has been awarded; the contracted price, after several rounds of negotiations, dropped from more than USD 140/MWh to USD 104.5/MWh for the first three years and USD 96/MWh for the remaining 17 years of the contract. The second April 2018 auction, launched through an expression of interest, received 42 offers.

Luxembourg: The country's first auction, held in February 2018, called for solar projects with capacity exceeding 500 kW (Seeger, 2018).

Madagascar: The third African country to join the World Bank's Scaling Solar program held its first renewable energy tender in January 2018 to contract a 25 MW solar plant. Six companies qualified to submit commercial bids (Scaling Solar, 2018).

Malaysia: Malaysia's February 2017 auction awarded a total 563 MW of solar projects at an average price of RM 429/MWh (USD 96.6/MWh)[28]. The government revised the original demand of 460 MW in response to the high number of bids received (Climatescope, 2018b; Kenning, 2017a).

Malta: The country's first tender, held in October 2017, contracted 12.9 MW of solar capacity at an average price of USD 153.25/MWh. The second, held in August, contracted 18 MW of solar capacity at an average price of USD 159.6/MWh. A third tender is expected in 2020 to meet the government target of 50 MW of solar capacity through 2021 (BNEF, 2019).

[25] *Note: 1 USD = 0.888913 EUR in July 2019*
[26] *Note: 1 USD = 112.9 JPY in October 2017.*
[27] *Note: 1 USD = 112.12 JPY in December 2018.*
[28] *Note: 1 USD = 4.44 RM in February 2017.*

Mexico: In Mexico's third long-term clean energy auction, held in November 2017, a total of 2.5 TWh of onshore wind was contracted at an average price of USD 18.6/(MWh+Clean Energy Certificates) and 3 TWh of solar PV at an average price of USD 20.8/(MWh+CEC) (BNEF, 2019; PwC, 2018; Mora, 2017). Another auction, planned for 2018, was indefinitely delayed by the regulator (Bellini and Zarco, 2018).

In **Montenegro**, a tender was launched for the construction of a 250 MW solar power plant in the southernmost part of the country. The winning consortium offered the best terms for newly created jobs, technical capacity, financing and participation of domestic companies (Jovanović, 2018a).

Morocco: In Morocco, the Noor Power Station in Ouarzazate was auctioned in four rounds. The first three rounds, for CSP, totalled 510 MW. The 160 MW Noor I and 200 MW Noor II projects use parabolic-trough technology with storage capacity of three and seven hours, respectively. Noor III, a 150 MW solar tower, has seven hours of storage capacity. These were followed by a fourth round for 72 MW of solar PV. In May 2019, Morocco auctioned the world's first advanced hybrid of CSP and PV. The 800 MW CSP-PV Noor Midelt is designed to provide dispatchable solar energy during the day and until five hours after sunset for a record-low peak-hour tariff of MAD 0.68/kWh (71 USD/MWh) (Kraemer, 2019).

Namibia: In early 2017, a site-specific auction for a 37 MW solar PV power plant was awarded at a price of USD 63.2/MWh (Climatescope, 2018i).

Netherlands: In March 2017, October 2017 and April 2018, the Netherlands's SDE+ scheme awarded a total 1,780 MW of wind capacity, 5,963 MW of solar capacity, 243.8 MW of biomass projects, and 200 MW of geothermal plants (Bellini, 2017b; 2018e; 2018f). In March 2018, the Dutch authorities awarded to the Swedish power company Vattenfall a contract to build two 350 MW offshore wind farms in the Netherlands which, upon completion in 2022, will be the first offshore wind farms to be built without subsidies (Weston, 2018).

Oman: In March 2018, Oman Power and Water Procurement Company (OPWP) awarded the Ibri II solar power project (500 MWp) to a group consisting of ACWA Power and Kuwait's Gulf Investment Corporation and Alternative Energy Projects Company ((Shumkov, 2019). The winning price had not been disclosed at the time of publication.

Pakistan: In a solar PV auction held in 2018, 50 MW of solar PV capacity was tendered; contracts have yet to be awarded (BNEF, 2019).

Philippines: In February 2018, the Philippines held a technology-specific auction and awarded 150 MW of onshore wind at an average price of PHP 3,500/MWh (USD 67.5/MWh)[29] (Lectura, 2018). In its first solar auction, 50 MW of solar PV were awarded at a price of PHP 2,339/MWh (USD 43.9/MWh)[30] (Bellini, 2018a).

[29] Note: 1 USD = 51.875 PHP in February 2018.
[30] Note: 1 USD = 53.28 PHP in August 2018.

Poland: In January 2017, Poland awarded 70 MW of solar PV and 8 MW of onshore wind at an average price of USD 86/MWh in its first renewable energy auction (BNEF, 2019). In November 2018, an auction was held for both solar PV and onshore wind projects in excess of 1 MW capacity; 31 bids have been awarded at an average price of PLN 195.16/MWh (USD 51.57/MWh)[31] (Murphy, 2018).

Qatar: In May 2018, an auction was launched for a 500 MW solar power plant to be developed near Al Kharsaah. In October 2018, Qatar announced that it had prequalified 16 bidders for the tender (Bellini, 2018g).

Russia: Russia's technology-neutral auctions of 2017 and 2018 yielded contracts for more than 2.5 GW of wind capacity, 669 MW of solar PV, and 90 MW of hydropower (Tisheva, 2017; Climatescope, 2018k).

Saudi Arabia: Saudi Arabia's first renewable energy auction in February 2017 awarded a 300 MW solar project at a price of SAR 87.81/MWh (USD 23.4/MWh)[32] (ACWA Power, 2019). In April 2017, a second tender for a 400 MW wind project was awarded at a price of SAR 79.85/MWh (USD 21.3/MWh)[33] (Masdar, 2019). In 2019, Saudi Arabia launched a 1.5 GW solar PV auction and invited developers to submit expressions of interest for seven PV projects under the second round of the kingdom's National Renewable Energy Programme (NREP) (Roscoe, 2019).

Senegal: Senegal awarded two projects under the Scaling Solar Program. The two 30 MW projects will sell electricity to Senegal's power regulator (CRSE) at EUR 38/MWh (USD 42/MWh) and EUR 40/MWh (USD 44/MWh) (IFC, 2018; Martín, 2019a).

Singapore: Singapore has carried out three auctions under the SolarNova program, which aims to achieve 350 MW of rooftop solar capacity in government buildings. A total of 76 MW was awarded in December 2015, 40 MW in June 2017, and an additional 50 MW at the end of 2017 (Beetz, 2015) (Photon, 2016) (Bhambhani, 2018).

Sri Lanka: Since 2017, Sri Lanka has held several renewable energy auctions, culminating in the contracting of 100 MW of wind capacity and 90 MW of solar PV capacity that have been tendered and awaiting award. An additional 10 MW of solar PV capacity was tendered and awarded at an average price of LKR 124.9/MWh (USD 76.8/MWh) (BNEF, 2019; Climatescope, 2018c; Climatescope, 2018d).

Slovenia is now the auction frontrunner in the Western Balkans. In accordance with the European State Aid Guidelines, the country adopted competitive auctions in 2016. The three auction rounds held since then have attracted close to 300 MW worth of renewable energy and Combined Heat and Power (CHP) projects. The 2018 auction round awarded 129 MW to 41 projects, including 109 MW for 13 wind projects. The average price of winning bids fell from USD 86.36/MWh to USD 75/MWh in three years.

[31] Note: 1 USD = 3.784039 PLN in November 2018
[32] Note: 1 USD = 3.750321 SAR in February 2018
[33] Note: 1 USD = 3.74905 SAR in January 2019

Spain: In two auction rounds in May and July 2017, Spain awarded a total 3,910 MW of solar power and 4,107 MW of wind power at an average price of EUR 43/MWh (USD 49.6/MWh) and EUR 25.4/MWh (USD 29.3/MWh), respectively (BNEF, 2019; Climate Action, 2017).

Thailand: In October 2017, Thailand held its first technology-neutral hybrid auction, which encourages the use of energy storage to supplement renewable energy generation. A total capacity of 300 MW of renewable energy (biomass, biogas, and refuse-derived fuel, in addition to solar, wind, and small hydro combined with storage batteries) were awarded. Of the 17 winning projects, 14 used biomass, totalling almost 260 MW, with prices ranging from USD 60 to 110/MWh (Climatescope, 2018e; Leds, 2018).

Tunisia: The country's first auction, awarded in May 2018, resulted in the contracting of 64 MW of solar PV capacity. Two more auctions, awarded in 2019, resulted in the contracting of 60 MW of solar PV and 120 MW of wind (Dodd, 2019; Kenning, 2019a).

Turkey: Since 2017, the government has conducted five major auctions. The first, in March 2017, awarded 1 GW of solar capacity at an average price of USD 69.9/MWh (Hürriyet Daily News, 2017). The second, held in June 2017, was a pre-license auction in which 710 MW of onshore wind was awarded at an average price of USD 11.5/MWh (BNEF, 2019; Balkan Green Energy News, 2017). The third, in August 2017, awarded 1 GW of onshore capacity at an average price of USD 34.8/MWh (Daily Sabah, 2019). The fourth, in December 2017, was a pre-license auction in which 2,110 MW of onshore wind was awarded at an average price of USD 50.8/MWh (BNEF, 2019; Balkan Green Energy News, 2018). A fifth auction in June 2019 awarded 1 GW of onshore wind at an average price of USD 39.4/MWh (BNEF, 2019).

United Arab Emirates: The fourth phase of the Mohammed bin Rashid Al Maktoum Solar Park auction in Dubai was originally for 700 MW concentrated solar power (CSP) consisting of 600 MW from a parabolic basin complex and 100 MW from a concentrated solar tower, with thermal storage capacity of 15 hours. It was awarded at 73 USD/MWh. The project was later amended to add 250 MW of solar PV awarded at USD 24/MWh, increasing the total capacity to 950 MW. In 2019, DEWA launched a 900 MW solar PV auction, issuing a request for qualification for developers under the fifth phase of the same initiative (DEWA, 2019).

United Kingdom: The United Kingdom launched its second auction for Contracts for Difference in September 2017, allowing for competition between renewable technologies. The auction culminated in the contracting of 3.196 GW of offshore wind (860 MW to be delivered in 2020/2021 and 2336 MW to be delivered in 2022/2023) at average prices of GBP 74.7/MWh (USD 98/MWh)[34] for the 2020/2021 delivery and GBP 57.5/MWh (USD 75.4/MWh) for the 2022/2023 delivery. In addition, 86 MW of biomass (waste to energy, to be delivered in 2020/2021) and 64 MW of biomass (advanced conversion technologies, of which 32 MW is to be delivered in 2020/2021 and 32 MW in 2022/2023) were also awarded at average prices of GBP 74.7/MWh (USD 98/MWh) for the 2020/2021 delivery and GBP 40/MWh (USD 52.4/MWh) for the 2022/2023 delivery (BNEF, 2019; Hill, 2017).

United States: In November 2017, a site-specific auction in the state of Georgia awarded 510 MW at an average price of USD 36/MWh of solar capacity (Roselund, 2017). In December 2017, another site-specific auction was held for a 100 MW solar PV project in the state of Massachusetts (JD Supra, 2017). In May 2018, Massachusetts also launched a technology-specific offshore wind auction which culminated in the award of an 800 MW project under a power purchase agreement at a price of USD 74/MWh for the first phase (400 MW) and USD 65/MWh for the second phase (400 MW) (BNEF,2019).

Zambia: Under the first round of the Solar Scale Programme, Zambia awarded 88 MW of solar PV capacity (Kenning, 2019b). The country also awarded 120 MW of solar PV capacity under the GET FiT Zambia programme in April 2019, setting a record-low price for Sub-Saharan Africa. The lowest bid of 3.999 US cents per kWh is the first under the four-cent mark. The six winning bids were awarded in pairs to three successful bidders (20 MW each, for a total of 120 MW) at an average price of USD 44.1/MWh (Parnell, 2019).

[34] *Note: 1 USD = 0.75113 GBP in September 2017*

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