International Renewable Energy Agency

RENEWABLE ENERGY AUCTIONS

ANALYSING 2016

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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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DISCLAIMER

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ACRONYMS

ADWEA	Abu Dhabi Water and Electricity Company
ANEEL	Agência Nacional de Energia Elétrica (National Agency for Electricity, Brazil)
BNDES	Brazilian National Development Bank
BOEM	Bureau of Ocean Energy Management (United States of America)
CAMMESA	Compania Administradora del Mercado Mayorista Electrico S.A. (Wholesale Electricity Market Administrator, Argentina)
CEL	Certificadas d'Electrididad Limpia (Clean Energy Certificates, Mexico)
CEM	Clean Energy Ministerial
CENACE	Centro Nacional de Control de Energía (National Energy Control Center, Mexico)
CfD	Contract for Difference
CFE	Comisión Federal de Electricidad (Federal Commission for Electricity, Mexico)
COD	Commercial Operation Date
CSP	Concentrated Solar Power
DEWA	Dubai Energy and Water Authority
DLM	Delattre Levivier Maroc
EEG	Renewable Energy Act (Germany)
EnBW	Energie Baden-Württemberg AG
EPC	Engineering, Procurement and Construction
EU	European Union
FODER	Fondo para el Desarrollo de Energías Renovables (Renewable Energy Development Fund, Argentina)
FRV	Fotowatio Renewable Ventures
GDP	Gross Domestic Product
GW	gigawatts
GWh	gigawatts-hours
GSA	Government Support Agreement
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IDC	Industrial Development Corporation
IFC	International Finance Corporation
IPP	Independent Power Producer
kWh	kilowatt-hour
LCCC	Low Carbon Contracts Company
LCR	Local Content Requirements
MEM	Ministerio de Energía y Minas de Perú (Ministry of Energy and Mines of Peru)
MIGA	Multilateral Investment Guarantee Agency
MINEM	Ministerio de Energía y Minería (Ministry of Energy and Mining, Argentina)
MNRE	Ministry of New and Renewable Energy of India
MW	megawatts
MWh	megawatt-hour
MYNHyF	Ministry of Finance and Treasury (Argentina)
NREL	National Renewable Energy Laboratory
NSM	National Solar Mission (India)
NTPC	National Thermal Power Corporation (India)
ONEE	Office National de l'Electricite et de l'Eau Potable (National Bureau of Electricity, Morocco)
Osinergmin	Organismo Supervisor de la Inversión en Energía y Minería (Supervisory Agency for Investment in Energy and Mining, Peru)
PPA	Power Purchase Agreement
PRG	Partial Risk Guarantee
PV	Photovoltaic
RFP	Request for Proposal
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme (South Africa)
SECI	Solar Energy Corporation of India
SIE	Energy Investment Company (Morocco)
SPV/E	Special Purpose Vehicle/Entity
TSO	Transmission System Operator
TWh	Terawatt-hours
UAE	United Arab Emirates
VAT	Value-Added Tax
VGF	Viability Gap Funding
WTO	World Trade Organisation
ZESCO	Zambia Electricity Supply Company

GLOSSARY

The following definitions reflect the nomenclature used by the International Renewable Energy Agency (IRENA) and are strictly related to the renewable energy industry; definitions used by other organisations and publications may vary.

Auction: Auctions refer to competitive bidding procurement processes for electricity from renewable energy or where renewable energy technologies are eligible. The auctioned product can be either capacity (MW) or energy (MWh).

Auction demand bands: Different categories within the total demand of an auction that require specific qualification requirements for submitting the bid (e.g. demand bands dedicated to specific technologies, project sizes, etc.).

Auctioned volume: The quantity of installed capacity (e.g. MW) or electricity generation (e.g. MWh) that the auctioneer is aiming to contract through the auction.

Auctioneer: The entity that is responsible for setting up the auction, receiving and ranking the bids.

Bid: A bidder's offer for the product awarded in the auction – most usually a power purchase agreement for the renewable energy generation or capacity.

Bidder: A physical or juridical entity that submits its offer in the auction process. Also referred as project developer, seller.

Levelised cost of electricity (LCOE): The constant unit cost of electricity per kWh of a payment stream that has the same present value as the total cost of building and operating a power plant over its useful life, including a return on equity.

Power Purchase Agreement (PPA): A legal contract between an electricity generator (the project developer) and a power purchaser (the government, a distribution company, or any other consumer).

Project developer: The physical or juridical entity that handles all the tasks for moving the project towards a successful completion. Also referred as seller and bidder, since the developer is the one who bids in the auction.

Off-taker: The purchaser of a project's electricity generation.

Overcontracting capacity: Contracting more capacity than the auction volume.

Underbidding: Offering a bid price that is not cost-recovering due to high competition and therefore increasing the risk that the projects will not be implemented.

Underbuilding: Not being able to bring the project to completion due to underbidding.

Undercontracting capacity: Contracting less capacity than the auction volume.

INTRODUCTION

Auctions have spread quickly in developed and developing countries as a means of eliciting supplies of energy from renewable sources, in line with the increasing maturity and rapid decline in the costs of renewable energy technologies (with costs approaching grid parity), the growing share of variable renewable energy in global energy mixes, and the need for grid extension. In the past few years, the rate of adoption of auctions has been growing at a faster rate than administratively set feed-in tariffs (or premiums) and quotas (or renewable portfolio standards), and they are often implemented in combination with other measures. The number of countries that have adopted auctions for renewable energy increased from 6 in 2005 to at least 67 by mid-2016 (REN21, 2016).

One of the possible reasons for the wide and fast dissemination of auctions is the fact that they are not tied to a specific market arrangement or regulatory-institutional framework. Completely liberalised markets can weave long-term renewable energy auctions into their market design, but so can single-buyer markets and even vertically integrated monopolies, many of which have turned to auctions as a means of attracting private investors. In addition, because the auction winners are typically awarded a legally binding contract, it is more difficult to challenge the outcomes of an auction later, even if the political and institutional scenarios and circumstances change. Investors' positions are thus more secure with auctions than under feed-in tariffs or tradable green certificate mechanisms, unless additional measures are included to prevent retroactive changes.

More importantly, the potential of renewable energy auctions to achieve low prices has been a major motivation for their adoption worldwide. This can be attributed to the competition they create, which allows falling technology costs to be reflected in prices faster than with other support schemes. The price results for solar and wind auctions have shown a decreasing trend over recent years. In 2010, solar energy was contracted at a global average price of almost USD 250/MWh, compared with the average price of USD 50/MWh in 2016. Wind prices have also fallen, albeit at a slower pace, as the technology was already fairly mature in 2010. However, comparing auction outcomes in different countries or across different auctions in the same country can be challenging, as policy objectives, underlying conditions, and remuneration structures in contracts differ. Because auction price comparisons are not always straightforward and can lead to misleading conclusions, the record low prices obtained in different regions throughout 2016 require a closer examination.

Building on IRENA's work on the topic (Box i), this study analyses the results of renewable energy auctions globally. It provides an overview of the most recent renewable energy auctions, analyses trends in auction prices and designs, and provides an in-depth overview of the interesting experiences and results. This analysis is meant to provide policy makers with a thorough understanding of the dynamics of auctions to support their design in particular, and to make informed decisions regarding the choice of policy instruments in general.

Chapter 1 provides an overview of the highlights of the renewable energy auctions held or announced in 2016. Following a summary of the main trends, Chapter 2 analyses the evolution of prices resulting from auctions; and the key determinants of those prices are analysed in Chapter 3. These include: 1) access to finance and country-specific conditions; 2) investors' confidence and the presence of a conducive environment; 3) other policies aimed at supporting renewable energy development; and 4) the design elements of the auction. Chapter 4 presents country case studies to show how the design of the auction should be tailored to a specific context and objectives. Finally, the use of auctions to support the deployment of less mature technologies while delivering socio-economic benefits, such as offshore wind and biomass, is analysed in Chapter 5.

Box i **IRENA's ongoing work on auctions**

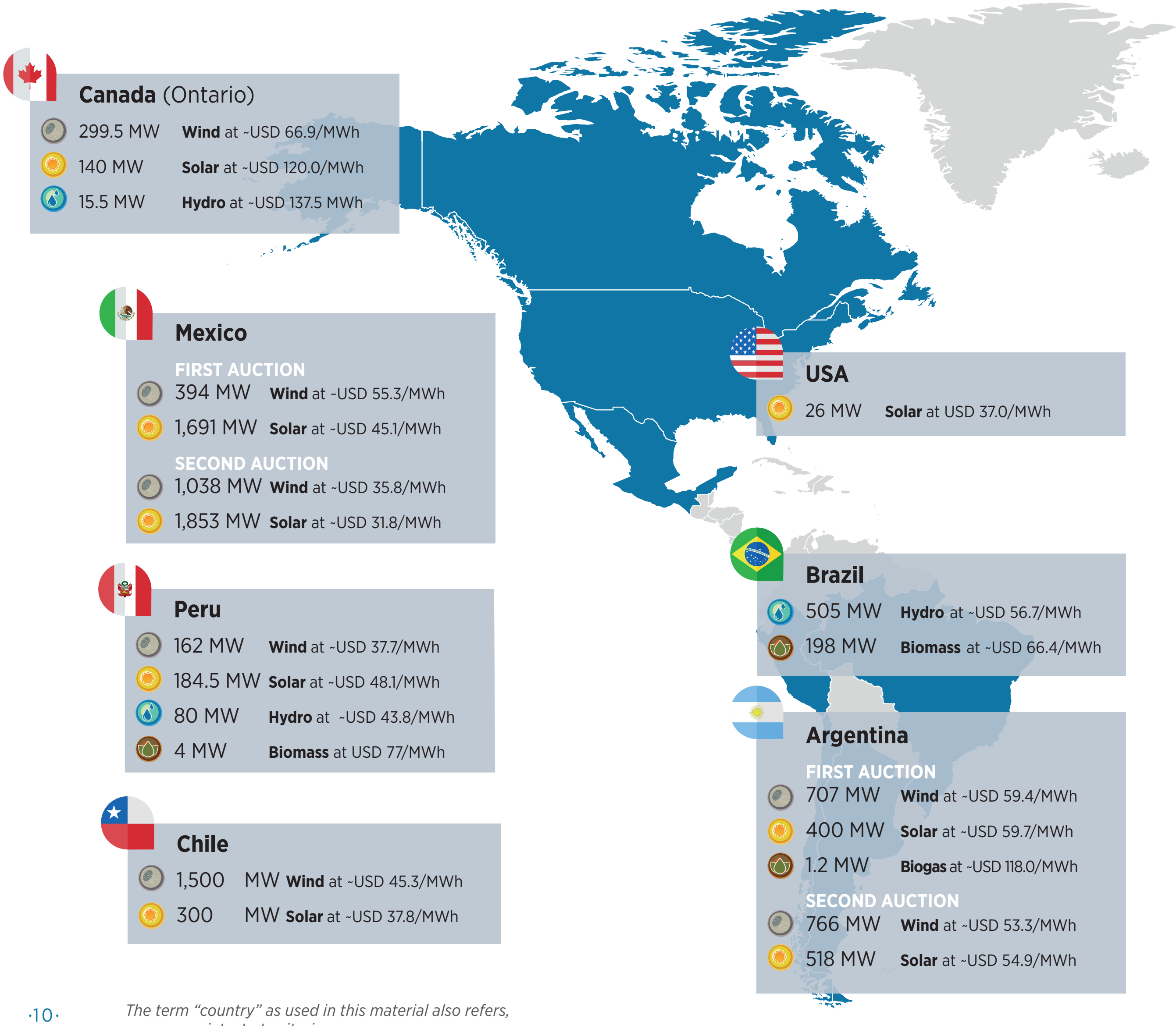
In anticipation of the growing interest in renewable energy auctions globally with the increasing maturity of the renewable energy sector, IRENA started analysing renewable energy auctions in 2013. The report *Renewable Energy Auctions in Developing Countries* highlighted key lessons learnt from countries that have implemented auctions (Brazil, China, Morocco, Peru and South Africa). The report presented an analysis on auction design options, and best practices on the implementation of auctions in the form of recommendations for policy makers.

In 2015, IRENA published the six-volume guidebook *Renewable Energy Auctions: A Guide to Design.* The report contextualises auctions within the larger realm of renewable energy support policies. It analyses the strengths and weaknesses of auctions based on a host of design elements, supported by specific country experiences in different contexts, and provides recommendations on the key considerations in the design of an auction. The guidebook has become the reference for countries adopting auctions.

1 HIGHLIGHTS OF RENEWABLE ENERGY AUCTIONS IN 2016

Renewable energy auctions have seen important developments in 2016. Countries such as Argentina, Canada, Mexico and Zambia kicked off auction-based programmes for promoting renewable power. In countries such as Chile and Mexico, mature renewable technologies such as onshore wind and solar photovoltaic (PV) proved to be competitive at the same level as conventional energy technologies and won a large share of contracts at record-breaking prices. Even auctions for less mature renewable technologies have attracted interest from policy makers and investors. Examples of this trend are the offshore wind auctions in Denmark, Germany and the Netherlands, bioenergy capacity auctions in Argentina and Peru, and the announcement of an auction for solar thermal power in Dubai. Figure 1.1 details the results of each of the selected 2016 auctions for 17 countries, illustrating the technology contracted, the quantity auctioned and the average price.

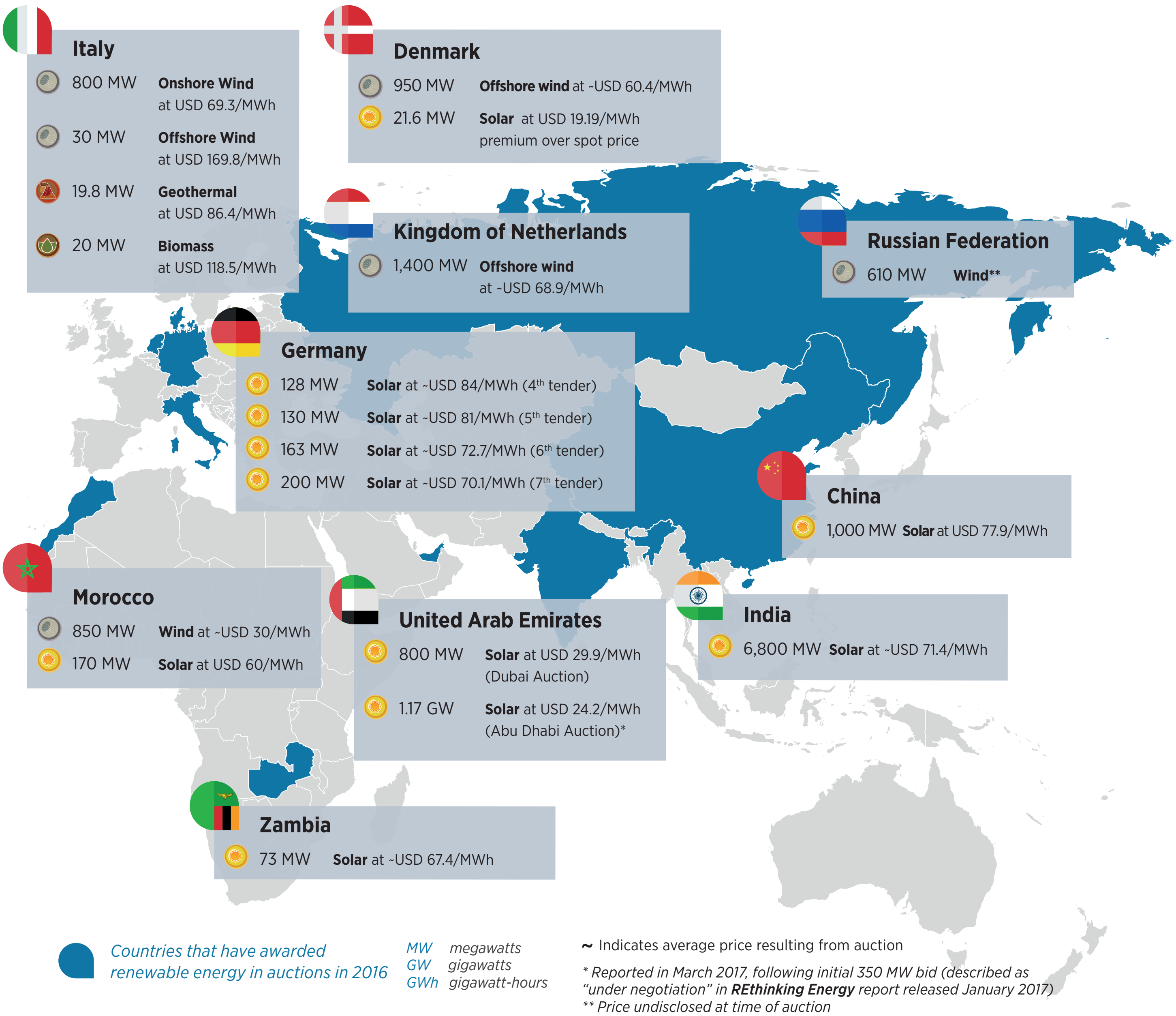
Figure 1.1 Countries that have awarded renewables in auctions in 2016: technology, quantity and price



The term "country" as used in this material also refers, as appropriate, to territories or areas.

Note: Calculated average prices resulting from renewable energy auctions presented in this report may differ from the data published by other sources due to the different aggregation and/or price correction methodologies used. In particular, when there are multiple winners, it is possible to obtain an average price for the auction using various means. Besides a simple average, it is possible to weigh the bids according to capacity awarded, yearly committed generation quantities, or even a total energy delivered amount (which differentiates products with different durations), for example. The exchange rate used to convert prices quoted in local currency into US dollars can be another cause for the differences, as throughout this report, the exchange rate at the date of the auction is used. In addition, certain official sources already report average prices incorporating certain correction factors that depend on the contract's duration and price escalation.

Sources: Argentina: MINEM (2016a, b); Brazil: ANEEL (2016), Morais (2016); Canada (Ontario): Bailey (2016), Kenning (2016); Chile: Coordinador Eléctrico Nacional (2016); China: Mahapatra (2016a); Denmark: Roselund (2016), Vattenfall (2016); Germany: BNEF (2016a), BNetzA (2017a); India: Bridge to India (2017a); Italy: GSE (2016); Mexico: Santiago and Sinclair (2017a, b); Morocco: Enel (2016), Ola (2016); Netherlands: Escritt (2016), Weston (2016a); Russia: Newbase (2016); United Arab Emirates: Abu Dhabi BNEF (2016c), Dubai Mahapatra (2016b); United States of America: Ayre (2016); Zambia: IFC (2016)



1. The sources listed were used in the rest of Chapter 1.

Throughout 2016, several state-level and national-level auctions were organised in **India** for a total capacity of more than 6,800 MW (BNEF, 2016a). In total, 16 auctions were held, of which two were conducted by states (Bridge to India, 2017a). Between July 2016 and December 2016, over 12.6 GW of solar projects were tendered. The large number of auctions being conducted are linked to the revised target of reaching 100 GW of solar energy by 2022. The year 2016 ended with the lowest tariffs hovering around the INR 4/kWh (USD 70/MWh)[2] mark. Since then, the bids have progressively fallen to around INR 3.3/kWh (USD 49.27/ MWh) for the 750 MW Rewa Solar Park and INR 2.44/kWh (USD 38/MWh) for the Bhadla Solar Park. In March 2017, India awarded 1 GW of wind capacity in the first-ever wind auction. Four projects of 250 MW capacity were awarded each at INR 3.46/kWh (USD 51.9/MWh). A second round of wind auction for 1 GW has recently been announced (Mahapatra, 2017). (See more on Indian auctions in Section 2.2 and Section 4.5).

In January **Morocco** contracted 850 MW of wind power at the record-breaking average price of USD 30/MWh (Enel, 2016). The winning bid was submitted by a consortium composed of Enel Green Power (Italy), Nareva Holding (Morocco) and Siemens Wind Power (Germany). The country also organised its first solar PV auction in May, which will result in the addition of 170 MW to the Noor-Ouarzazate solar power complex. The Saudi-based companies ACWA Power, Fotowatio, and Alfanar placed the lowest bids in the range of USD 60/MWh. At this same site, 510 MW of solar thermal capacity has already been awarded from past auctions. (See more on the Moroccan wind auction in Section 2.3).

In February, **Peru** held its fourth renewable energy auction since 2010, resulting in the lowest wind and solar energy prices in Latin America at the time. Grenergy (Spain) offered a bid of USD 36.8/MWh for wind,[3] and Enel Green Power (Italy) a bid of USD 47.9/MWh for solar PV (BNEF, 2016a; BNEF, 2016b). (See more on the Peruvian auctions in Section 4.7).

Mexico's two 2016 energy auctions, carried out in March and September, are tied to the country's newly reformed electricity market, operational since January 2016. Although the auctions allow the participation of different technologies and several products are auctioned (electricity, firm capacity and clean energy certificates), wind and solar power proved to be extremely competitive. USD 42.8/MWh was offered for wind by Acciona (Spain) in March; in the second auction seven months later, the wind record for the Latin American region was broken with the submission of a USD 32/MWh bid by Enel Green Power (Italy). Meanwhile, for solar PV, USD 34.8/MWh[4] was registered in the first round in March, only weeks after the auction in Peru, confirming that those may be viable prices for renewable energy in Latin America. Solar prices fell even further in Mexico's second round, establishing a Latin American record for solar energy of USD 27/MWh, offered by FRV (Spain/ Saudi Arabia) (BNEF, 2016a). (See more on the Mexican auctions in Sections 2.3 and 4.6).

In April, **Canada**'s province of Ontario organised its first renewable energy auction, which was meant to replace its feed-in tariff scheme for large-scale projects (above 500 kW). The auction resulted in the lowest price for solar power seen in Ontario to date: an average of CAD 156.67/MWh (USD 120/MWh)[5] for the seven solar projects contracted in the auction, with the lowest at CAD 141.5/MWh (USD 109/MWh) (PV Tech, 2016a).

In April, August, and December, **Germany** continued the auctioning programme initiated in 2015, with the fourth, fifth and sixth solar auction rounds. These auctions represent the country's pilot scheme for replacing solar feed-in

2. Exchange rate considered: 1 INR = 0.015 USD in 2016.

3. The auction also comprised another project of 18 MW which elicited a bid of USD 37.7/MWh, resulting in an average of USD 37.25/MWh.

4. Prices are approximate, as the Mexican auctions do not reveal the bidder's price per form of energy, but rather per package of products (a lump-sum yearly amount to be received for the offered quantity of capacity, energy and green certificates). Exchange rate considered: 1 MXN = 0.057 and 0.052 USD in March and September 2016 respectively.

5. Exchange rate considered: 1 CAD = 0.77 USD in April 2016.

tariffs, and they have consistently attracted a high number of participants. In just one year, Germany's auction has led to a price drop of more than 20% from the first round. Despite the country's low irradiation levels and land-use constraints, average prices of EUR 74.1/MWh, EUR 72.3/MWh and EUR 69/MWh (USD 84/MWh, USD 81/MWh and USD 72.7/MWh)[6] were obtained. In addition, the last auction in February 2017 was awarded at EUR 65.8/MWh (USD 70.1/MWh) (BNEF, 2016a; PV Magazine, 2016). (See more on the German auctions in Sections 2.2 and 4.4).

In April, **Brazil** contracted 198 MW of biomass and 263 MW of small hydro at an average price of BRL 198.59/MWh (USD 57.4/MWh)[7]. In September, more than 180 MW of small hydro was awarded at BRL 227.02/MWh (USD 68.16) (ANEEL, 2016). A third auction exclusive to wind and solar projects had been scheduled for December but was cancelled, mainly due to the power oversupply caused by the country's economic recession of the last few years, which significantly affected electricity demand. The country has a lengthy experience with both technology-neutral and technology-exclusive renewable energy auctions. (See more on Brazilian renewable energy auctions in Sections 2.3 and 4.2.)

In May, **Zambia** became the first country to organise solar auctions under the *Scaling Solar* programme in Sub-Saharan Africa, designed and implemented by the International Finance Corporation and the World Bank. The auction's results set a new price record for utility-scale solar in Africa, with a minimum contracted price of USD 60.2/MWh by First Solar (United States) and Neoen (France). The second-lowest bid received was USD 78.4/MWh by Enel Green Power (BNEF, 2016a). Senegal, Ethiopia and Madagascar have also subscribed to the Scaling Solar programme. (See more on the Zambian auction in Section 4.9).

In June, in the **United Arab Emirates**, **Dubai** announced the results of its second solar PV auction, which represented the lowest solar price worldwide at that time. The winning price of USD 29.9/MWh, offered by Masdar (UAE) and FRV (Spain/Saudi Arabia), was the lowest solar price worldwide at the time (Hirtenstein, 2016). This bid was 19% lower than the second-lowest bid and 50% lower than the result of the first phase of the Dubai auction in 2015. In September, in **Abu Dhabi**, a bid of USD 24.2/MWh was submitted by Jinko Solar (China) and Marubeni (Japan), for 1.17 GW of capacity. (See more on the UAE auctions in Section 4.8).

Also announced in June was **Russia**'s fourth renewables auction, which, despite ambitious targets for wind, hydropower, and solar capacity, attracted only one bidder for a 610 MW wind power facility. Rosatom, the Russian state-controlled nuclear energy company, won the bid to install the three projects (150 MW by 2018, 200 MW by 2019, and 260 MW by 2020) with a total investment of RUB 83 billion (USD 1.3 billion).[8] The country's sharp economic downturn, stringent domestic content requirements and a reduction in the project's subsidy payment all contributed to this poor response from potential investors.

In July, the **Kingdom of the Netherlands** organised its first offshore wind auction for a large-scale 700 MW project, which yielded an average price of EUR 72.6/MWh (USD 80.43/MWh)[9] by DONG Energy. In December, another 700 MW auction was awarded at EUR 54.5/MWh (USD 57.43/MWh) to a consortium led by oil and gas giant Shell (Weston, 2016a). The Dutch auctions draw significantly from Denmark's similar auctioning programme and have benefited from Denmark's extensive experience. (See more on the Dutch offshore auctions in Section 5.1).

6. Exchange rates considered: 1 EUR = 1.13, 1.12, and 1.05 USD for April, September and December, respectively.

7. Exchange rate considered: 1 BRL = 0.289 and 0.3 USD for April and September, respectively.

8. Exchange rate considered: 1 RUB = 0.015 in June 2016.

9. Exchange rates considered: 1 EUR = 1.106 and 1.054 USD for the months of July and December, respectively.

In August, **Chile** organised one of its largest energy auctions to date, contracting 23% of the country's projected energy demand for the next decade. USD 29.1/MWh was the lowest bid registered, submitted by Solarpack (Spain) for a 120 MW solar project; a bid of USD 39.7/MWh was received for a 270 MW onshore wind project. The average prices for solar and wind were USD 37.8 MWh and USD 45.3/MWh respectively, proving the competitiveness of renewable energy technologies (BNEF, 2016a). (See more on the Chilean auctions in Section 4.3).

In September, **China** organized its largest solar auction, contracting 1 GW of new capacity with the lowest price at CNY 520/MWh (USD 77.88/MWh)[10] (PV Tech, 2016b). (See more on the Chinese solar auction in Section 2.2).

Also in September, **Argentina** organised its first renewable energy auction under the RenovAr programme, leading to the contracting of wind, solar, and biogas capacity at average prices of USD 59.4, 59.7 and 118/MWh, respectively (MINEM, 2016a).[11] The success of the experience led to the scheduling of a second round in November. That auction awarded 765.4 MW of wind at an average price of USD 53/MWh and 518 MW of solar at USD 55/MWh (MINEM, 2016b). (See more on the Argentinean auctions in Section 4.1).

In September and November, **Denmark** carried out two offshore wind auctions as part of a long-running programme in which four large-scale projects had already been contracted. The new contracts were awarded for the Vesterhav (350 MW at DKK 475/kWh or USD 71.5/MWh)[12] and Kriegers Flak projects (600 MW at DKK 372/kWh or USD 53.9/MWh).[13] These prices represent reductions of 39% and 53%, respectively, from the prices attained in the 2015 auction. Denmark also carried out a pilot auction for solar power in 2016, involving a premium over the wholesale price of electricity. Solpark Denmark secured the auctioned capacity of 21.6 MW at a premium of DKK 128.9/MWh (USD 19.19/MWh). This outcome is tied to estimations regarding future wholesale prices (to which the bid fixed premium will be added).

In December, **Italy** awarded 869.8 MW of renewable capacity. Potential developers bid for the maximum percentage discount from the reference price that they are willing to offer (between 2 – 40%). 800 MW onshore wind was awarded at (40% discount on the reference price) EUR 66/MWh (USD 69.3/MWh)[14], 30 MW offshore wind at (2% discount) USD 169.8/MWh, 20 MW biomass at (5.15% discount) USD 118.5/MWh and 19.8 MW geothermal at (2% discount) USD 86.4/MWh

In conclusion, several price records were set during 2016: in Chile and the United Arab Emirates for solar PV, in Morocco for onshore wind, and in Denmark for offshore wind. These outcomes have set universal expectations for future renewable energy auctions, as very low prices have been attained even in countries with a less mature renewable energy sector. Evaluating the factors that have led to those prices is important for at least two reasons—first, to support policy makers confronted with the task of designing auctions in a way that meets specified objectives (not necessarily achieving the lowest prices) and second, to set reasonable expectations for future auction outcomes.

10. Exchange rate considered: 1 CNY = 0.15 USD in September 2016.

11. With the minimum prices received for wind, solar PV and biomass being USD 49.1, 59 and 118/MWh, respectively.

12. Exchange rate considered: 1 DKK = 0.150 USD in September 2016.

13. Exchange rate considered: 1 DKK = 0.145 USD in November 2016.

14. Exchange rates considered: 1 EUR = 1.05 USD in December 2016.

2 TRENDS IN RENEWABLE ENERGY AUCTIONS

Factors that influence policy making in the renewable energy realm have shifted dramatically in the past decade. Chief among those factors are the rapid decline in the costs of renewable energy technologies and the growing share of variable renewable energy entering the grid. The new circumstances call for tailored policies informed by-past experiences and lessons learnt, therefore policies need to adapt to changing market conditions (IRENA, 2014a).

Auctions for renewable energy development, often implemented in combination with other measures, have become increasingly popular in developed and developing countries. The number of countries that have adopted renewable energy auctions grew from 6 in 2005 to at least 67 by mid-2016 (REN21, 2016).

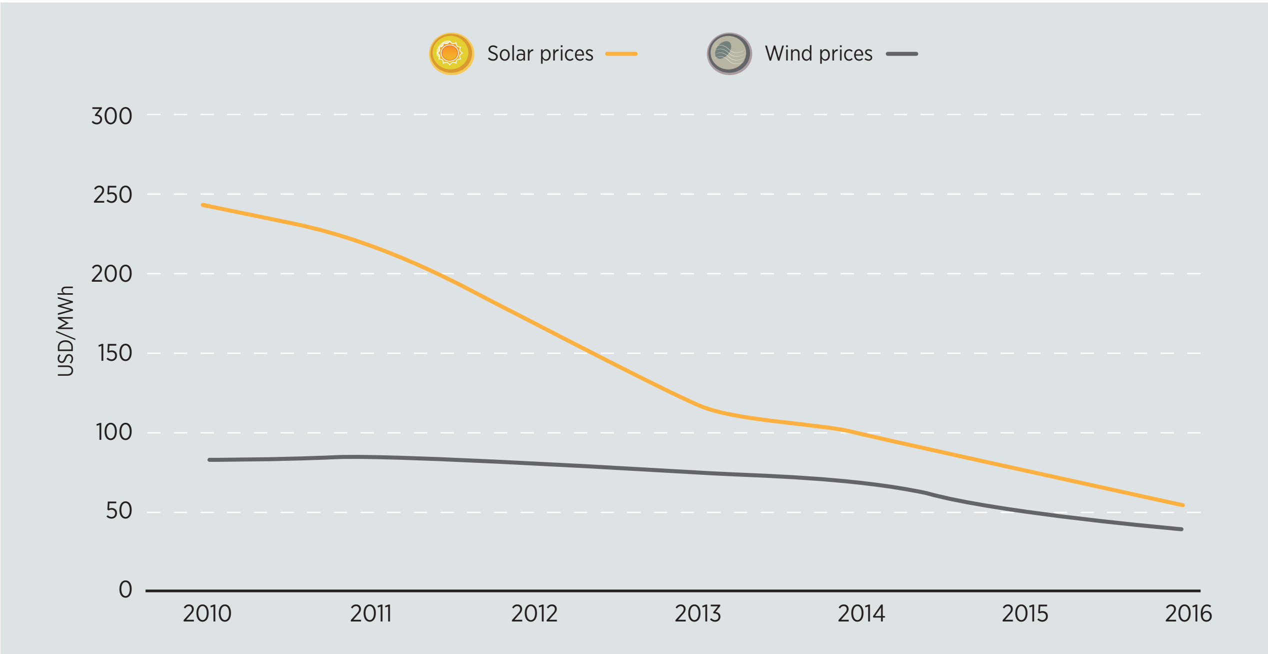
2.1. THE STRENGTHS AND WEAKNESSES OF AUCTIONS

Auctions have gained popularity in different contexts, owing to their flexibility of design, the increased certainty they lend to prices and quantities, the degree of commitment and transparency they create, and most important, their potential for real price discovery (see Box 2.1).

Real price discovery in auctions

The potential of auctions to achieve low prices has been a major motivation for their adoption worldwide. As Figure 2.1 illustrates, price results for solar and wind auctions have been decreasing in recent years. In 2010, solar energy was contracted at a global average price of almost USD 250/MWh, compared with the average price of USD 50/MWh in 2016. Wind prices have also fallen, albeit

Figure 2.1 Average prices resulting from auctions, 2010-2016



Note: The countries considered in this graph are the ones detailed in Figures 2.3 and 2.9, for solar and wind respectively. The average price for each year was calculated by weighing average prices in individual auctions by the awarded capacities, and then adding a dampening effect to smooth the curve.

Sources: Based on data from BNEF (2016 a, b,c), ANEEL (2016), BnetzA (2017a), Bridge to India (2017a), Coordinador Eléctrico Nacional (2016), Eberhard and Kåberger (2016), EGP (2016), Elizondo-Azuela, Barroso et al. (2014), IFC (2016), Mahapatra (2016 a,b), MINEM (2016a, b), MNRE (2010), MNRE (2012), Osinergmin (2016), Santiago and Sinclair (2017a, b), Shahan (2016).

at a slower pace (since the technology was more mature in 2010). The average price in 2016 was USD 40/MWh, down from USD 80/MWh in 2010.

The falling cost of technology has led policy makers across 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. Indeed, data show that the competition in the market that is created by a properly designed auction can bring down the price of renewable energy projects more efficiently than other support mechanisms.

This is illustrated in Figure 2.2, which shows the estimated cost of developing utility-scale PV projects (blue line), between 2010 and 2016, compared to those resulting from auctions (yellow line). The yellow line takes into account only projects awarded from auctions and for which estimated investment costs could be obtained. A comparison of the two curves indicates that average installation costs for auctioned projects is consistently lower than average global installation costs. This corroborates with the notion that by promoting competition, auctions are able to award contracts to the most competitive alternatives, thus driving prices down.

Moreover, auctions can play a role in guiding the evolution of the price trends, as the results from past auctions tend to set expectations for future results within a given country but also globally. Project developers, for example, are likely to expect competing bids to be close to results of past auctions and to adjust their bids according to those expectations. This is why the prices resulting from past auctions are not only an outcome but also an influencer or input for future auctions and even for other support mechanisms (such as feed-in tariffs).

There is, however, a risk associated with the fierce competition in the market and it is important to consider whether the drop in prices is sustainable from an industry point of view. A sustainable price decrease indicates that prices are falling owing to increasing market maturity while businesses remain profitable, whereas an unsustainable price decrease could lead to bankruptcies. This is due to the pres-

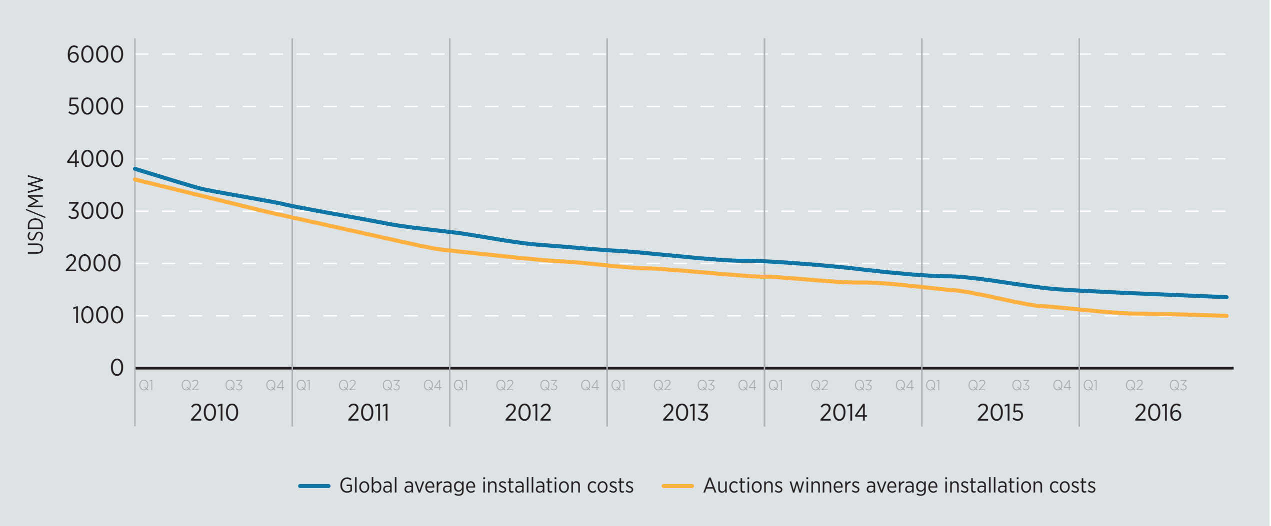
Box 2.1 Strengths of renewable energy auctions

The growing interest in auctions reflects their ability to achieve deployment of renewable electricity in a well-planned, cost-efficient and transparent manner while also meeting other development objectives, such as job creation and domestic value creation and ownership. Specific features include the following:

- **Flexibility of design**, which makes it possible to combine and tailor different elements to meet deployment and development objectives and cater to a country's economic situation, the structure of its energy sector, the maturity of its power market and its level of renewable energy deployment.
- **Certainty regarding prices and quantities**, which enables policy makers to control both the price (in the presence of a ceiling price) and quantity of renewable energy purchased by providing stable revenue guarantees for project developers (similar to the administratively set feed-in tariff) while also ensuring that the renewable generation target is met more precisely (as with quotas and tradable green certificates).
- **Degree of commitment and transparency**, reflecting the fact that auctions result in contracts that 1) clearly state the commitments and liabilities of each party, thus offering regulatory certainty to investors and minimising the likelihood that their remuneration will be challenged in the future if the market and policy landscapes change, and 2) specify clear penalties for underbuilding and delays, thus ensuring that projects are delivered as per the bid.
- **Potential for real price discovery**, reducing information asymmetry between project developers and the entity responsible for determining purchase prices and support levels (usually the regulator). This feature has been of particular relevance given recent market developments, such as the significant technology costs decreases, the development of local supply chains, and the maturity of the market.

Source: IRENA and CEM (2015).

Figure 2.2 Estimated installation costs of utility-scale PV projects: global versus auction winners, 2010-2016



Sources: Based on (IRENA 2014b), BNEF (2016a), BNEF (2016b), Eberhard and Kåberger (2016).

sure that can be exerted on developers to stretch their input assumptions too far. Therefore, auctions can be associated with weaknesses that pertain to the "winner's curse"[15] and to underbidding that can result in projects coming online late or not at all.

The risk of the winner's curse and underbidding

As much as a decrease in prices is a desired outcome of an auction, there is a major concern among policy makers and industry players that the true costs of renewable energy can be underestimated in auctions. In a situation where prices are dropping fast (as is the case currently with solar PV and onshore wind), developers may be tempted to keep up with the trend, adjusting their estimates based on past auction results and other players' bids. This can result in the winner of the auction facing very low or even negative profits. Although the winner's curse tends to manifest itself mostly in a transitory stage when bidders are still learning about the technical, economic, and regulatory aspects of a market, it could still come into play in a more mature auction climate owing to overly aggressive bidding.

Overly aggressive bidding (or underbidding) poses a significant risk of underbuilding and delays, with more serious repercussions in the long run. It can be traced to several factors, from excessive optimism about the evolution of technology costs to the underestimation of the financial consequences of possible project delays. Project developers sometimes bid based on an anticipated investment cost, expecting the cost of technology to drop by the time construction begins. This is typically the case for projects with high lead times or low penalties for delay. Unreasonably aggressive bids may also be offered as part of a developer's strategy to enter a promising market or to build a portfolio in order to qualify for future bids. Underbidding may also reflect a developer's intention either to negotiate additional remuneration after winning the auction or to evade obligations in the absence of strict compliance rules (such as penalties for non-compliance).

Intensified competition in some markets undergoing specific economic conditions, such as the depreciation of the Brazilian real, has led to underbidding and defaults by developers. As a result, innovation in auction design has come to encompass more than just the initial bidding to offer relief to developers that have bid aggressively, especially in situations where the depreciation of the local currency is the main reason for default, as was the case in Brazil (see Box 2.2).

15. The winner's curse refers to a phenomenon according to which the winner of an auction faces losses after underestimating the cost of the project. The winner's curse tends to be more prevalent where uncertainty about a project's valuation is great. As the market matures, agents typically learn to adjust their bids to correct for this effect.

Having acknowledged the risks of underbidding and delays, it should be noted that the price outcomes of auctions in 2016 were more or less consistent in several countries that used different auction designs. With each auction, it becomes increasingly safe to assume that the low prices obtained reflect the current level of development of the renewable energy market. However, since the winning projects have not yet been built, it remains to be seen whether current prices are high enough to sustain investments in renewable energy for the foreseeable future.

Another well-known weakness of auctions is their high transaction costs, both for policy makers and for bidders. The administrative procedures necessary to take part in the auction (*e.g.,* feasibility studies and qualification arrangements) may constitute potential barriers to participation, especially for small and/or new players, knowing that only a few of the bidders participating in the auction will ultimately be contracted (see IRENA and CEM, 2015, vol. 2).

The extent to which each of the above-mentioned strengths and weaknesses will affect the results of an auction depends largely on choices regarding its design elements and how well adapted they are to the specific country context in terms of economic situation, the structure of its energy sector, the maturity of its power market, and the level of renewable energy deployment.

2.2. PRICE TRENDS: SOLAR PV

Solar PV modules have been deployed at a fast rate and with a steep learning curve. The total global installed capacity grew from less than 9 GW in 2007 to more than 290 GW in 2016 (IRENA, 2017a). Driven by technological improvements and manufacturing advances, and with the overcapacities in the market peaking in 2011, PV module prices fell by around 80% between 2009 and 2015. Owing to economies of scale and reductions in soft costs, the levelised cost of electricity (LCOE) from solar PV fell 58% between 2010 and 2015 (IRENA, 2016a). The decreasing costs of installing solar PV projects were reflected in the falling prices of auctions.

Figure 2.3 illustrates the downward trend in auctioned solar prices in selected countries, many of which have been organising solar power auctions on a regular basis for years. The values illustrated indicate the average price outcomes for auctions

Box 2.2 **Dealing with underbidding in economic downturn in Brazil: auction to "de-contract" renewables**

Brazil is one of the pioneers in the design of renewable energy auctions, but its most recent innovation may be an auction mechanism to allow the release of contracts. Policy makers in Brazil are considering a so-called *decontracting auction* to relieve developers that are contractually obligated to deliver new generation projects but are not able to do so, mainly owing to the devaluation of the local currency and the increase in financing costs.

In the proposed legal mechanism, the decontracting auction would enable developers to return projects by bidding the amount of the fine they are willing to pay to cancel their contracts. Companies' bids would include an exit payment that would be lower than equivalent fines and the winners would not be able to participate in the next couple of similar auctions. This would be a one-time event to adapt to the current economic circumstances of the country. The auction is scheduled to take place until August 2017.

This innovative measure is aimed chiefly at solar developers that import technology and that won contracts to sell power in 2014 at an average price of BRL 215.12/MWh (about USD 87/MWh at the time). The current exchange rate puts the value of that power at about USD 68/MWh today.

At the same time, Brazil's economic downturn is also limiting the growth of electricity demand. Power consumption declined 0.9 percent in 2016, mostly owing to a slump in industrial demand of almost 2.9 percent (which also led to the cancellation of the wind and solar auction planned for December 2016). This has made the cancellation of projects a win-win situation for investors and the government alike.

Sources: Dezem (2017) and Spatuzza (2016a).

carried out by countries between 2010 and 2016 (taking into account all winning bids).[16]

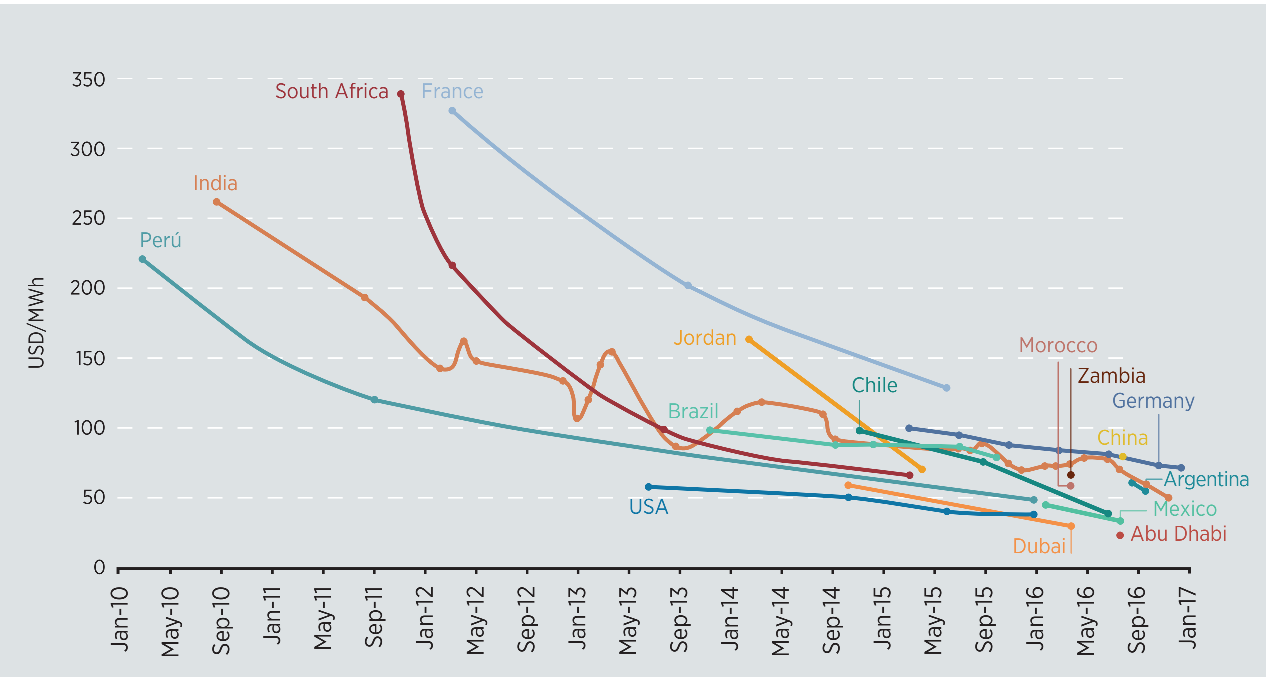
As shown in the figure, average prices fell in all countries between 2010 and 2016, with prices decreasing at a faster rate between 2010 and 2014 than between 2014 and 2016. Prices in Peru, for example, fell from USD 220/MWh in 2010 (IRENA, 2013) to USD 48.5/MWh in the last auction held in 2016 (BNEF, 2016a). In South Africa, the drop was even sharper, from USD 345/MWh in 2011 (IRENA, 2013) to USD 64/MWh in 2015 (Eberhard and Kåberger, 2016). Although the figure shows a universal convergence in average prices, reflecting the growing maturity of the sector, it also shows continued disparities between countries, albeit less pronounced in earlier years. This is the case, for example, in the price difference between South Africa, the country with the clearest downward trend, and Peru. The figure also shows sinuous patterns in India, remarkably lower prices in the United States, the persistence of prices in the upper range in Germany, and surprisingly higher prices in China. These elements are discussed in more detail below.

Downward trends in South Africa

As part of the South African Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), the steep price decrease observed in South African solar auctions, especially between the first and second rounds, can be attributed to learning-curve effects, increased investor confidence, development of a local industry and adaptations in the South African auction design (particularly regarding volume auctioned and the value of ceiling prices).

First, the bidders and the auctioneer were able to reduce prices considerably given more experience (learning-curve effect). This phenomenon is quite common, as project developers typically require higher risk premiums in countries that do not yet

Figure 2.3 Evolution of average auction prices for solar PV, January 2010-February 2017



Notes: Prices are averages. On the rare occasion when multiple auctions occurred within the same month, the average price of those auctions is shown. In case of ambiguity regarding the auction's date, the date when the winning bids were selected and announced was taken as the main reference.

Sources: Based on data from BNEF (2016 a, b,c), ANEEL (2016), BnetzA (2017a), Bridge to India (2017a), Coordinador Eléctrico Nacional (2016), Eberhard and Kåberger (2016), Elizondo-Azuela, Barroso et al. (2014), IFC (2016), Mahapatra (2016 a,b), MINEM (2016a, b), MNRE (2010), MNRE (2012), Ola (2016), Osinergmin (2016), Santiago and Sinclair (2017a, b), Shahan (2016).

16. On the rare occasion when multiple auctions occurred within the same month, the average price of those auctions is shown in the figure. In case of ambiguity regarding the auction's date, the date when the winning bids were selected and announced was taken as the main reference.

have a track record in renewable energy deployment. The success of early auctioning experiences leads to more successful subsequent bidding rounds, increasing investors' confidence over time (see IRENA and CEM, 2015, vol. 3). South African banks and financing institutions became increasingly comfortable with renewable energy technologies and the auctioning programme over time, which lowered the cost of capital. Moreover, it is possible that some potential bidders that had already qualified for the first round did not need to once again incur the cost of the documentation required for the second round, thus decreasing their transaction costs and their prices.

Second, the high prices resulting from the first round can be attributed to some elements of auction design. For example, a large volume of 3,750 MW was auctioned in one go and in a short time frame that did not give some developers enough time to prepare bids. Combined with the lower level of development of the domestic sector at the time, this limited opportunities for competition among suppliers. Moreover, the fact that ceiling prices were fully disclosed before the first round elicited bids close to the ceiling price, with little incentive to bid lower. In the subsequent rounds, a pipeline of projects had been built, which, combined with lower auctioned volumes, meant significant cost reductions. Margins were reduced across the value chain, with lower returns for banks, equity, engineering, procurement and construction (EPC), etc.

Finally, the development of a domestic solar sector may have been reflected in the cost of projects. As South African policy makers emphasised socio-development goals over minimising prices, local content requirements led to higher prices in the first round. As the local industry developed, the premium required to meet those requirements may well have fallen in subsequent bidding rounds (see Box 2.3).

Ups and downs and higher prices in India

The sinuous pattern in the price outcomes of Indian solar auctions is explained by the uniqueness of the different rounds of auctions that took place. Some utility-scale auction schemes are implemented under the National Solar Mission, with central public sector agencies acting as auctioneers and off-takers (*e.g.*, Solar Energy Corporation of India (SECI), National Thermal Power Corporation (NTPC). These agencies then sign power sale agreements with state distribution companies or another institutional off-taker. Another model involves individual states organising auctions to meet state-level renewable energy targets with state distribution companies as off-takers. A hybrid approach involves the development of solar parks where central and state institutions jointly create implementing bodies that undertake the tasks associated with land procurement and infrastructure development, and then invite the private sector to develop projects within these solar parks.

Across the different types of auction schemes, there are several factors that contribute to the varied outcomes in terms of the final price achieved. Some of the main factors include the credibility of off-takers, land costs and procurement process, resource quality, size of the project, remuneration profile (fixed or escalation) or financial support delivery (in the case of Viability Gap Funding), evacuation risks, PPA structure (*e.g.*, state government guarantee, deemed generation), level of competition and domestic content requirements. Section 4.5 provides greater detail on how each of these components are affecting recent auctions in India.

State-level auctions conducted in 2016 (*e.g.*, in Jharkhand) yielded higher bids compared to other auctions as a result of higher land costs, relatively low radiation levels and poor credit-rating of off-takers, among other factors (Chandrasekaran, 2016). Auctions under the National Solar Mission were more common in 2016. A key characteristic of these auctions is that both SECI and NTPC are highly bankable off-takers and substantially reduce the risks for investors. Furthermore, both entities are now part of a tripartite agreement between the Government of India, state governments and the Reserve Bank of India which protects them in the event of a payment default. These lower risks are already placing a downward pressure on the tariffs in these auctions.

Box 2.3 Local content in South African auctions

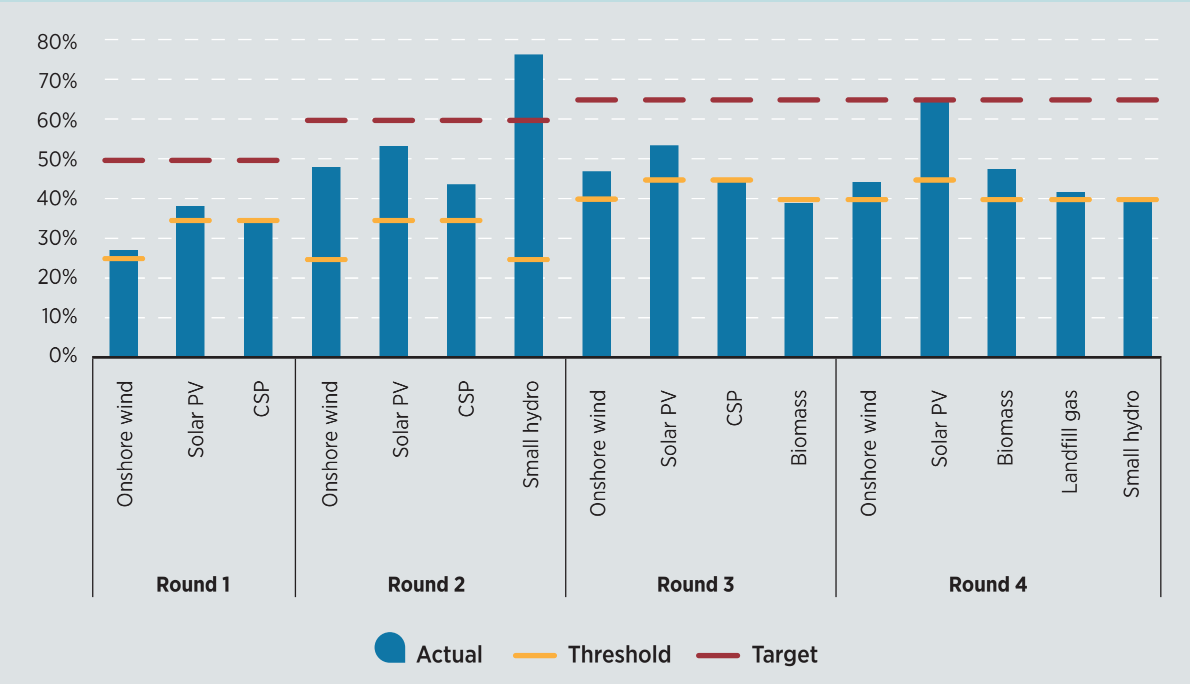
Socio-economic development is featured prominently in the South African Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) as part of the qualification requirements and winner selection criteria.[a]

For projects to be considered compliant, they need to pass defined economic development thresholds concerning job creation, local content, ownership, management control, preferential procurement, enterprise development, socioeconomic development and SME participation. In addition, a minimum of 40% South African Entity Participation in the bidding company and a Broad Based Black Economic Empowerment contribution are also required.

In the winner-selection process, factors are weighted as follows: job creation (25%), local content (25%), ownership (15%), management control (5%), preferential procurement (10%), enterprise development (5%), and socio-economic development (15%) (IRENA, 2017b, forthcoming).

Figure 2.4 illustrates the local content requirements, targets and actual percentages achieved for each renewable energy technology for the first four rounds of auctions in South Africa. In the first auction, developers could barely reach the minimum local content requirements to bid (threshold). In the second, offers incorporated higher levels of local content, as the first auction had stimulated the growth of local industry (another illustration of learning-curve effects). The percentage of local content stabilised at around 45% in later rounds, with highest rates achieved for small hydro in the second round and for solar PV in the fourth.

Figure 2.4 Local content requirements and achievements in South Africa



Note: CSP: Concentrated Solar Power

Source: CCRED Submitter, Montmasson-Clair, and Das Nair (2015).

a. Lessons and best practices related to the promotion of skills development, employment creation and gender equality that emerge from South Africa's large-scale renewable energy developments are studied as part of IRENA's ongoing work on renewable energy benefits.

Many of the national-level auctions carried out since 2015 have been project-specific, where land has been identified, and therefore subject to certain location effects (*e.g.*, solar resources, timely land transfer for project development). The diversity in the underlying conditions of these independent auctions results in oscillating prices, also impacted by the fact that domestic content requirements have been implemented in some cases, which yields relatively higher prices (see IRENA and CEM, 2015, vol. 4).

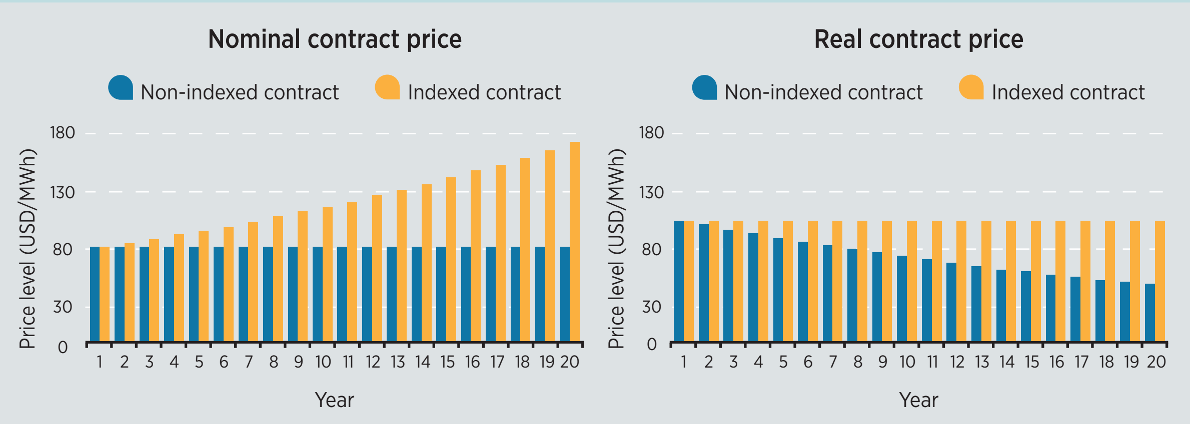
Furthermore, the relatively higher prices in India in 2016 compared to countries like Peru, the United States and South Africa, can also be linked to the remuneration profile and the type of contract offered. Unlike other auction contracts that are indexed to inflation (*e.g.*, South Africa) or denominated in U.S. dollars (as is the case all Latin American countries except Brazil), the Indian auctions offer contracts that are not hedged against inflation or foreign exchange rates (see IRENA and CEM, 2015, vol. 6). Taking into account the high inflation rates in India, the contract's value in real terms may be expected to decrease substantially over time (see Box 2.4), thus resulting in higher bids.

Calculating the net present value of a non-indexed contract under an inflation assumption of 5% per year, it is possible to obtain the "adjusted prices" corresponding to the actual prices offered in Indian auctions. These adjusted prices, which are around 25% lower than the actual prices, are more comparable to price outcomes for inflation-indexed contracts (Figure 2.6). This adjustment brings Indian auction price outcomes to almost the same level reached by solar power in Peru. A more comprehensive analysis of auctions in India is presented in Section 4.5.

Box 2.4 Remuneration profile in Indian auctions

The effect of inflation on remuneration profiles in contracts indexed for inflation versus those that are not is depicted in Figure 2.5. Looking at the nominal contract price[a] (left panel of figure), the non-indexed contract appears to yield constant remuneration, whereas the price in the indexed contract appears to rise. Taking inflation into account and looking at the contract price in real terms (right panel), the indexed contract will actually maintain the same value over time, whereas an non-indexed one will lose value. The perception that inflation adjustments make contracts more expensive is incorrect, as nominal prices do not fairly represent the price. Therefore, to shield developers from inflation risk, contracts are often indexed to inflation; when they are not, as in India, developers factor inflation into their bid price.

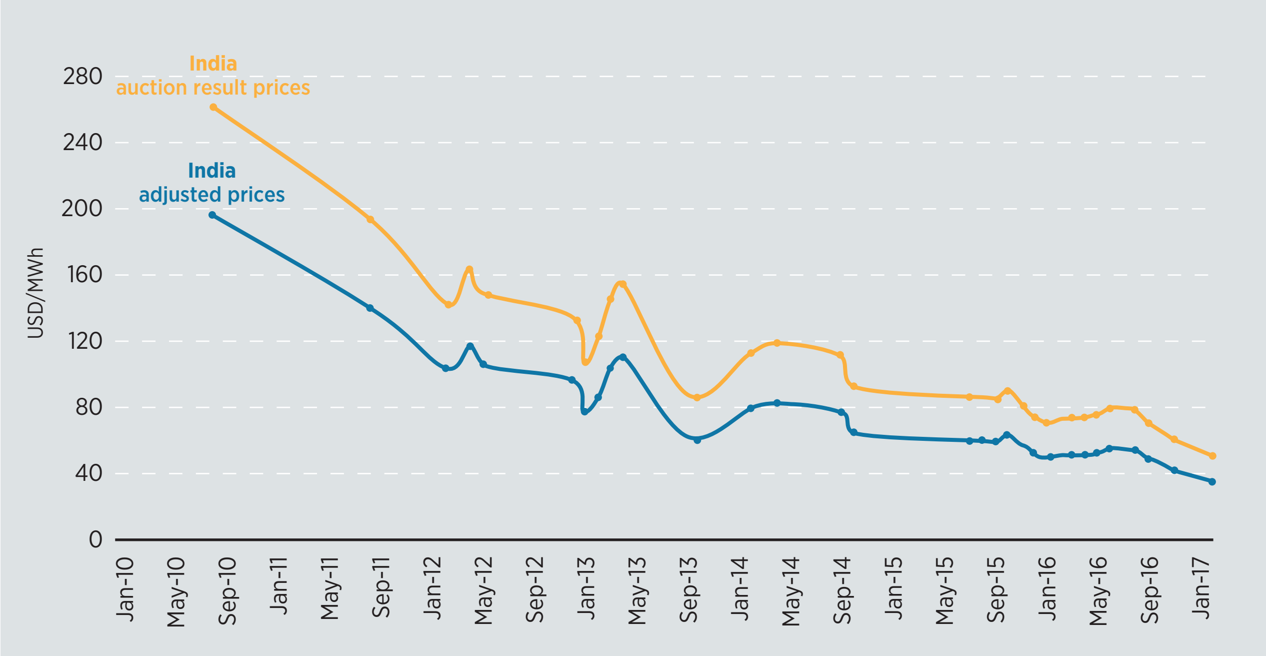
Figure 2.5 The effect of inflation indexing on contract price



Note: The figure depicts the remuneration of indexed/non-indexed contracts under nominal and real terms. A contract price of USD 100/MWh and 4% inflation were used in this example, for illustrative purposes.

a. Unadjusted price not reflecting elements such as inflation, seasonality, loan fees and interest compounding.

Figure 2.6 India's actual and adjusted solar prices, 2010-2017



Sources: Based on BNEF (2016a); Bridge to India (2017a); Elizondo-Azuela et al. (2014); MNRE (2010) and MNRE (2012).

Low prices in the United States

In a solar power auction conducted in Texas in 2013, contracts were awarded at a price of USD 60/MWh, substantially lower than the prices attained in most other countries in that same period (which were closer to USD 80/MWh). In all subsequent auctions in the United States, results continued to prove competitive, as shown in Figure 2.7; sometimes they have been noticeably lower than those recorded in other countries – among them France, Germany, Peru and South Africa. The main reason for these low prices is that the United States offers an investment tax credit, known as the federal solar tax credit, that reduces the cost of installation by about 30%.

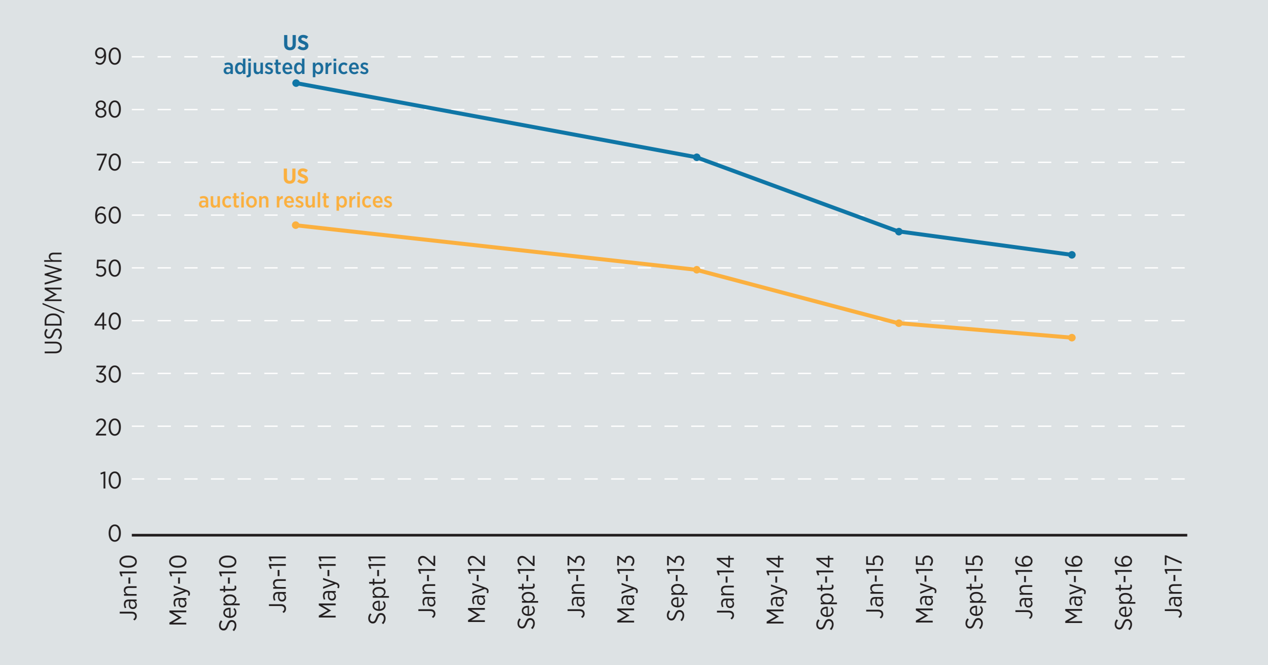
Figure 2.7 illustrates recorded prices in the United States versus adjusted effective prices, namely the prices that investors would have to bid if they were not eligible for the investment tax credit. The estimated adjusted prices are around 1.43 times higher, reflecting the original investment cost before applying the 30% reduction. After this correction, prices in the United States are commensurate with those recorded in other countries at the same time.

Higher prices in Germany

The case of Germany illustrates that other factors, such as the capacity factor and project costs, can explain price differences between countries – and sometimes even between regions of the same country. The capacity factor is the ratio of the actual output of a power plant divided by the theoretical output of the same plant running at full capacity. The ratio is determined over a specific period of time, typically a year.

A price resulting from a project with a capacity factor of 11%, which is common for Germany, cannot be compared to the record-low solar price in Chile, where the capacity factor averages 29%. Capacity factors vary with available solar resources and, to some extent, with the state of technology (such as increased efficiency, lower degradation and loss factors, and technological solutions such as PV panels with sun-tracking systems). However, solar resources are very site-specific, and therefore the average values for a country or region can be misleading when applied to a specific project. Germany's ban on building PV projects on agricultural land further decreased the availability of attractive sites.

Figure 2.7 The United States' actual and adjusted solar prices, 2010-2017



Source: Based on Shahan (2016).

Figure 2.8 illustrates the actual prices obtained for solar power in France and Germany versus hypothetical adjusted prices that would be obtained under the same conditions but with a higher capacity factor applied. As a solar generator's revenue is proportional to its generation, doubling its capacity factor should allow it to reduce by roughly one-half its selling price per MWh while yielding the same amount of revenue. The figure shows that the solar prices recorded in German auctions since 2015 could have dropped from around USD 85/MWh to USD 40/MWh if projects were to be located in sites where solar resources produced a capacity factor of 25% instead of the actual 11%. Similarly, in France, prices would become more competitive if the capacity factor were raised from 18% to 25%.

Moreover, the costs of installing and operating solar plants in Germany and France are higher than in emerging economies such as Chile, India, Mexico and South Africa, taking into account the cost of land, labour and other factors.[17] A more comprehensive analysis of auctions in Germany is presented in Section 4.4.

Higher prices in China

In September 2016, an auction for 1 GW of capacity in Inner Mongolia resulted in China's lowest bids for solar energy. The last time solar projects had been auctioned in China was in 2010, before feed-in tariffs for solar power were set (Elizondo-Azuela 2014). In the 2016 auction, 50 solar developers and manufacturers bid an average as low as USD 77.88/MWh.

These prices are still higher than the average solar bids awarded in 2016 worldwide, and much higher than auctions in Chile and Abu Dhabi, for example. Given Inner Mongolia's rich solar resources, ample availability of land for the development of large-scale solar power projects and China's strong domestic solar manufacturing sector, one could expect China to be one of the most competitive markets for solar. But its price outcomes have been even higher than those of countries such as Zambia and Morocco. Possible explanations could be the lack of adequate transmission capacity and an auction design that prioritises minimising the risk of underbidding.

17. The same observation can be made about the onshore wind prices obtained in Italy's auctions compared with those of other countries (see Figure 2.9).

Figure 2.8 Solar prices in France and Germany: actual and adjusted results assuming a capacity factor of 25%, 2010-2017

Sources: Based on BNEF (2016a) and NREL (2016).

The lack of adequate transmission capacity in Inner Mongolia could result in frequent curtailments and thus a reduction in the capacity factor of the plant. Developers are accounting for this risk, given that wind projects in the region have been facing the same curtailment problem over the past few years. As illustrated in Figure 2.8 for the case of Germany and France, the capacity factor has a significant impact on the price, which means that possible future curtailments are considered by project developers participating in the auction, increasing their bids.

Certain aspects of the auction design – a short lead time, the volume auctioned and the criteria for selection of winners – have also contributed to the high prices. Under the terms of the tender, the projects are due to be up and running by the end of 2017. The short lead time does not allow for further cost reductions, as do other auctions that are not due to be built before 2018 or 2019. Moreover, the volume auctioned (1 GW) is a large volume to auction at once, reducing the number of qualified competitors. Finally, the solar auction could be drawing on lessons learnt from the onshore wind auction, where policy makers' concern with the long-term sustainability of the industry led to the adoption of a winner-selection mechanism that favoured the bidder whose offer was closest to the average of all bids rather than the lowest one (IRENA, 2013). An auction design that tends to lead to a higher equilibrium price can be one way of ensuring a higher remuneration to project developers, in line with the government's policy goals.

Conclusion

The number of countries that have adopted auctions for solar power in the past few years is remarkable, as are the record-breaking outcomes obtained from relative newcomers to auctions. The substantial price decreases and other successes of auctions in countries that had previously relied on other mechanisms (*e.g.,* Germany and feed-in-tariffs) motivated many countries to launch their own auctioning programmes. However, while generally reflecting increased competitiveness in the solar sector, the price outcomes of auctions remain very sensitive to the context. The same can be said for onshore wind energy.

2.3. PRICE TRENDS: ONSHORE WIND

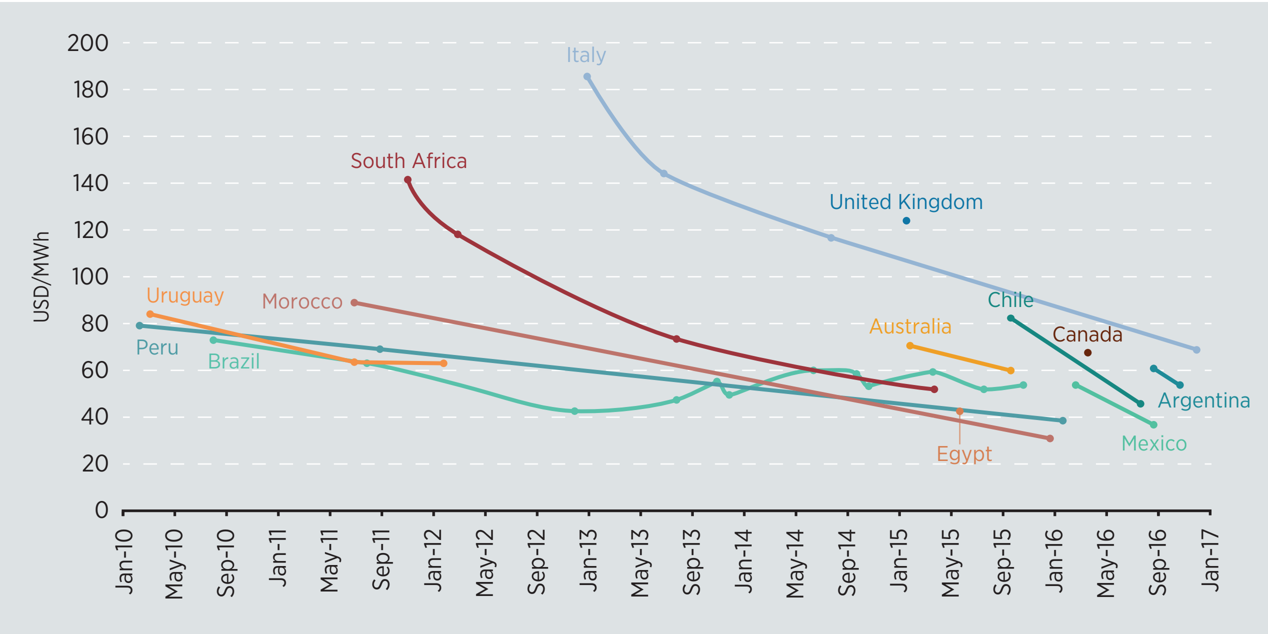
Prices for onshore wind have recently fallen in several countries. Figure 2.9 shows prices converging to around USD 40/MWh in 2016, with record-breaking results below that level in Mexico, Morocco and Peru. Spurred by high competition, growing investor confidence, developed local industries, and low financing costs in some countries, recent auction outcomes show an average price drop of 45% between the last two auctions in Chile (10 months apart), 33% in Mexico (6 months apart) and 10% in Argentina (2 months apart).

The figure also shows large disparities between countries before the recent convergence, with a steep drop in prices between rounds. In Chile, Italy and South Africa, prices started out much higher than in most other countries and dropped sharply from the first auction to the second, reducing the gap between these countries and other ones. The price drops may be attributed to increased experience, for the bidders and the auctioneer (learning-curve effect), as discussed in Section 2.1, and to the fact that some costs incurred in the first round are not repeated in further rounds, as bidders are able to use the same feasibility studies, resource assessments *etc.,* in later auctioning rounds. Changes in auction design, such as those related to project locations in Mexico, have also had an impact (see Section 4.6). Also apparent in the figure are some fluctuations in results, notably in Brazil, for reasons explained later in this Section. Prices in Italy remain in the upper range.

Record-breaking low prices in Morocco

In January 2016, Morocco contracted 850 MW of wind power at the record-breaking average price of USD 30/MWh. The winning bid was submitted by a consortium composed of Enel Green Power (Italy), Nareva Holding (Morocco) and Siemens Wind Power (Germany). The consortium is responsible for the design, finance, construction, operation and maintenance of five projects under a 20-year build, own, operate and transfer contract. In addition to the auction design's provisions for site selection and grid connection, the low prices bid

Figure 2.9 Evolution of average auction prices for onshore wind energy, January 2010-January 2017



Note: Prices are averages. On the rare occasion when multiple auctions occurred within the same month, the average price of those auctions is shown. In case of ambiguity regarding the auction's date, the date when the winning bids were selected and announced was taken as the main reference.

Source: Based on BNEF (2016a, b), ANEEL (2016), Bailey (2016), Bierzwinsky and Felix (2016), Coordinador Eléctrico Nacional (2016), Eberhard and Kåberger (2016), Enel (2016), Elizondo-Azuela, Barroso et al. (2014), GSE (2016), MINEM (2016a, b), Osinergmin (2016), Santiago and Sinclair (2017a, b), Tsanova, 2016a.

can be attributed to investor confidence, attractive cost of financing, and local manufacturing of components.

The 850 MW auction is part of a plan to deliver an overall wind target of 2 GW by 2020, providing investors with a clear vision for development of the market. Morocco has already shown its commitment to wind power by developing 800 MW of capacity (IRENA, 2017a), some of which was awarded through auctions with a credible off-taker, the national utility (Office National de l'Électricité et de l'Eau Potable, ONEE). The increased investor confidence stems from the fact that the projects awarded by the auction will be built under a public-private partnership with ONEE, the Energy Investment Company (SIE) and the Hassan II Fund for Economic and Social Development. Together, they will jointly hold a 35% share in each of the five projects, an arrangement that lowers the cost of finance. The private partners will hold the remaining 65% (Enel Green Power, 50%; Nareva Holding and Siemans Wind Power, the rest).

The total investment is estimated at EUR 1.24 billion of which ONEE has already raised EUR 385 million from the European Investment Bank, KfW, the European Union's Neighbourhood Investment Facility and the African Development Bank, in addition to USD 31 million in concessional finance obtained from the Clean Technology Fund (Dodd, 2014). Enel Green Power will provide financing commensurate with its 50% ownership share through a mix of equity and debt, the latter through project finance facilities from international financial institutions. The company is leveraging its international knowledge and expertise, as it has acquired ample experience in developing large-scale renewable energy projects in Europe, the Americas, Africa and Asia, in line with the growth targets set out in its strategic plan for 2016-19 (Enel, 2016).

Moreover, as part of the bid, which was evaluated based on price and plans for local manufacture, the supplier of wind turbines Siemens (in the consortium) plans to build a rotor blade factory locally. A location in Morocco makes sense for the company, widening its access to expanding wind markets in Africa and the Middle East, as well as Europe. Morocco also offers a large internal market. Towers are already produced locally, with Delattre Levivier Maroc (DLM) able to produce up to 300 towers a year. The enabling environment for local manufacturing includes the country's strong economy, stable political climate and the availability of a young, skilled and motivated workforce[18] (Weston, 2016b).

A sharp decrease in Mexico

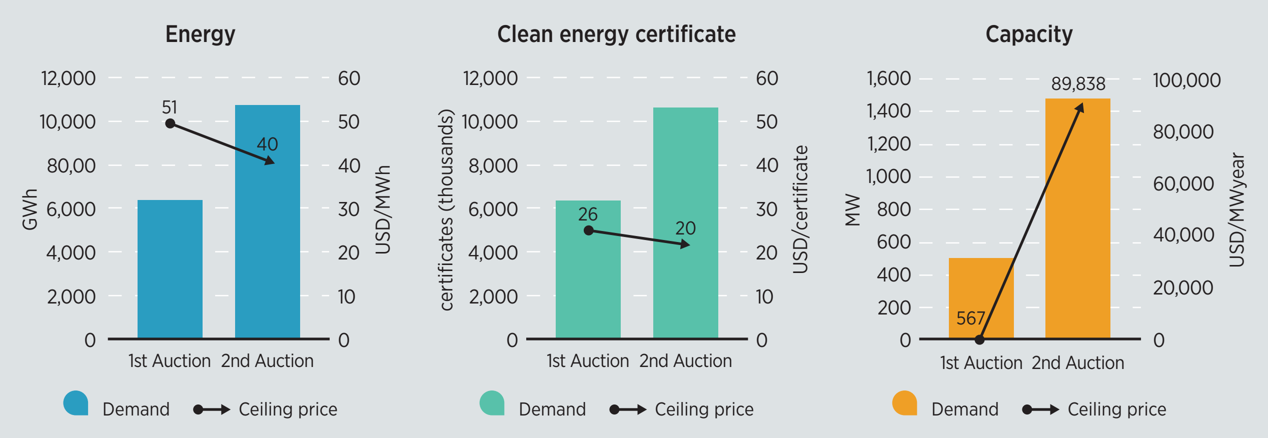
In the Mexican auctions, developers were allowed to bid for three products: electricity quantity in MWh, clean energy certificates (CELs), and firm capacity in MW. The second auction, which took place only seven months after the first, contracted a higher volume at lower prices (see Section 4.6). The price decrease in Mexico can be attributed to progress along the learning curve, increased investor confidence, changes in auction design (in terms of ceiling price and winner selection criteria), and depreciation of the local currency.

The learning curve effects and increased investor confidence exerted some effect on the price (as discussed in the South African example in Section 2.2). These were boosted by a power sector reform that underscored the commitment of the government to modernise the sector, encourage private participation and increase the share of clean energy. The considerable potential for future opportunities in Mexico also attracted investors to enter the market, resulting in high competition in both auctions as shown by the large quantities awarded as well as the low prices bid.

With respect to auction design, more bidders were attracted to the second round, partly owing to the adjustments made in terms of ceiling prices and volumes auctioned. In the second round, the ceiling prices for both energy products and CELs were reduced (see Figure 2.10), forcing bidders to reduce their bids to remain below the ceiling. As for the firm capacity product, since the first round was not successful in attracting bidders, the ceiling price was increased 172-fold, and attracted a

18. Development of the wind industry in Morocco is examined in Leveraging Local Capacity for Onshore Wind (IRENA, 2017c) and Evaluating Renewable Energy Manufacturing Potential in the Mediterranean Partner Countries(EIB and IRENA, 2016).

Figure 2.10 Price ceilings and contracted capacities in the first and second auctions in Mexico

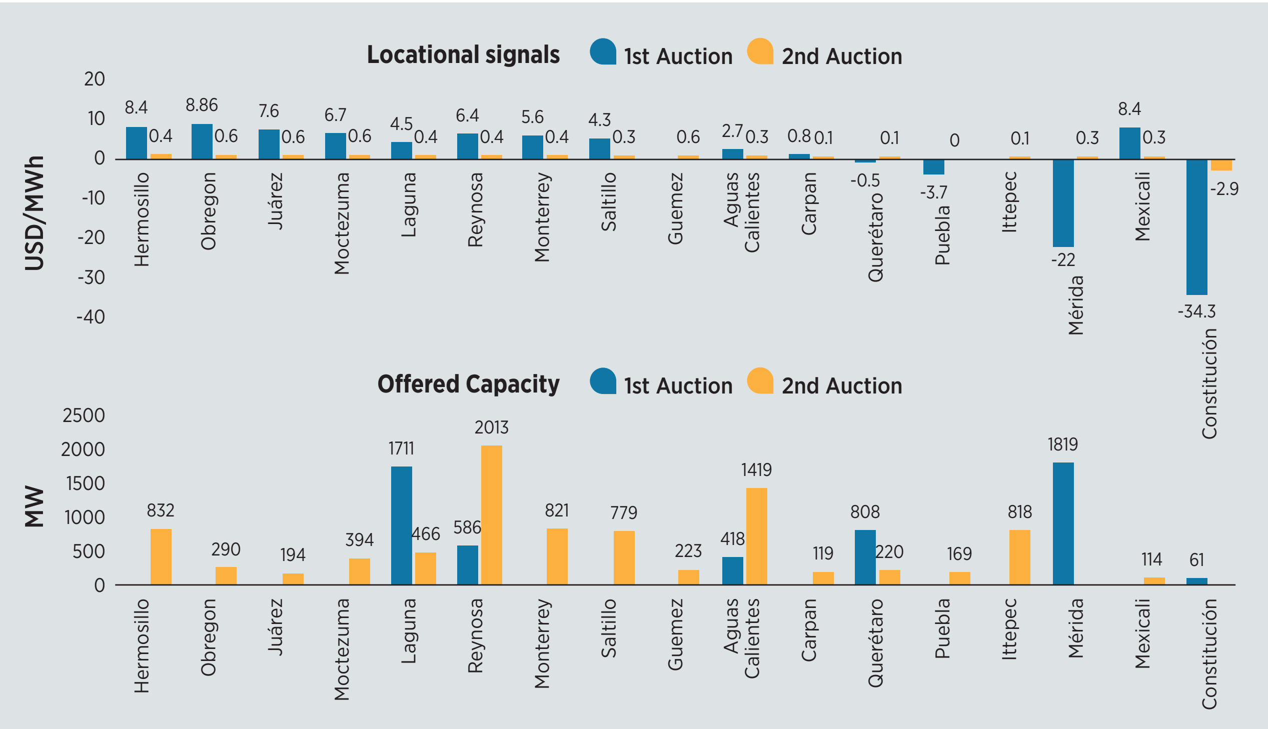


Source: Based on CENACE (2016).

high number of bidders. Figure 2.10 illustrates how the demanded quantities and ceiling prices for the three products evolved from the first to the second round.

The economic signals for project location also changed between the two rounds. The first auction offered incentives (or penalties) to locate new projects where they would most benefit (or harm) the power system. Figure 2.11 illustrates the change in economic signals for project location, by region, between the two rounds, as well as the amount of power (in GWh) offered in each region. As an example of how these signals worked, proj-

Figure 2.11 Economic signals for project location and offered capacity, by location: first and second auctions in Mexico, 2016



Source: PwC, 2016.

ects located in the Northeast of the country (Hermosillo, Moctuzema) were not contracted in the first round as a result of the high penalty applied to bids in those regions. The penalty comes in the form of a surplus that is added to the bid since projects are selected based solely on the price. This surplus is only considered for evaluation purposes and it will later be removed and the projects are remunerated as per the prices bid. Those projects, however, are rich in renewable energy sources (see Table 2.1).

In the second auction, when the locational incentives (or penalties) were reduced by 95%, significant quantities of power were contracted in regions with abundant resources. In Merida region, for example, 1,819 GWh of wind and solar were contracted in the first auction owing to the advantageous location signal (surplus of USD 22/MWh), even though the resource potential was not favourable. In the second round, as a result of reducing the economic signals for project location, locations were selected based on abundance of resources and therefore the projects contracted

Table 2.1 Summary of results of the first auction round in Mexico, March 2016

#	Company	Project	Technology	Capacity (MW)	State	Price in USD/MWh		
						Bid	Geo. Adj	FInal
1	Enel	Villanueva	Solar	330	Coahuila	35.43	4.46	39.89
2	Enel	Villanueva 3	Solar	250	Coahuila	38.27	4.46	42.73
3	Sunpower	Guajiro 2	Solar	100	Guanajato	44.21	-0.47	43.74
4	Enel	Don Jose	Solar	207	Guanajato	45.05	-0.47	44.58
5	Jinko	Las Viborillas	Solar	100	Jalisco	47.18	2.70	49.88
6	Canadian Solar/ Recurrent	Aguascalientes Potencia 1	Solar	63	Aguas Calientes	47.85	2.70	50.55
7	Thermion	Sol de Insurgentes	Solar	23	Baja California	47.90	-34.28	13.62
8	Sunpower/ Vega Solar	Ticul 1	Solar	500	Yucatan	56.28	-21.98	34.30
9	JInko	Concunul	Solar	70	Yucatan	58.23	-21.98	36.25
10	Sunpower/ Vega Solar	Ticul 1	Solar	500	Yucatan	58.59	-21.98	36.61
11	JInko	San Ignacio	Solar	18	Yucatan	63.24	-21.98	41.26
12	Alarde/Photomeris	Kambul	Solar	30	Yucatan	68.10	-21.98	46.12
13	Acciona	El Cortijo	Wind	168	Tamaulipas	42.81	6.38	49.19
14	Aldesa	Chacabal	Wind	30	Yucatan	59.66	-21.98	37.68
15	Aldesa	Chacabal II	Wind	30	Yucatan	59.66	-21.98	37.68
16	Envision/Viva Energía	Energía Renov. de la Penin.	Wind	90	Yucatan	65.83	-21.98	43.85
17	Consorcio Energía Limpia	Tizimin	Wind	76	Yucatan	66.86	-21.98	44.88

Source: Santiago and Sinclair, 2017a.

have slightly higher capacity factors than those in the first auction, which helps explain the average price decrease observed.

Finally, depreciation of the Mexican peso, which was the currency of both auctions, affected the results as reported in U.S. dollar terms. The currency exchange rate moved from 17.65 MXN/USD in March to 19.19 MXN/USD in September.

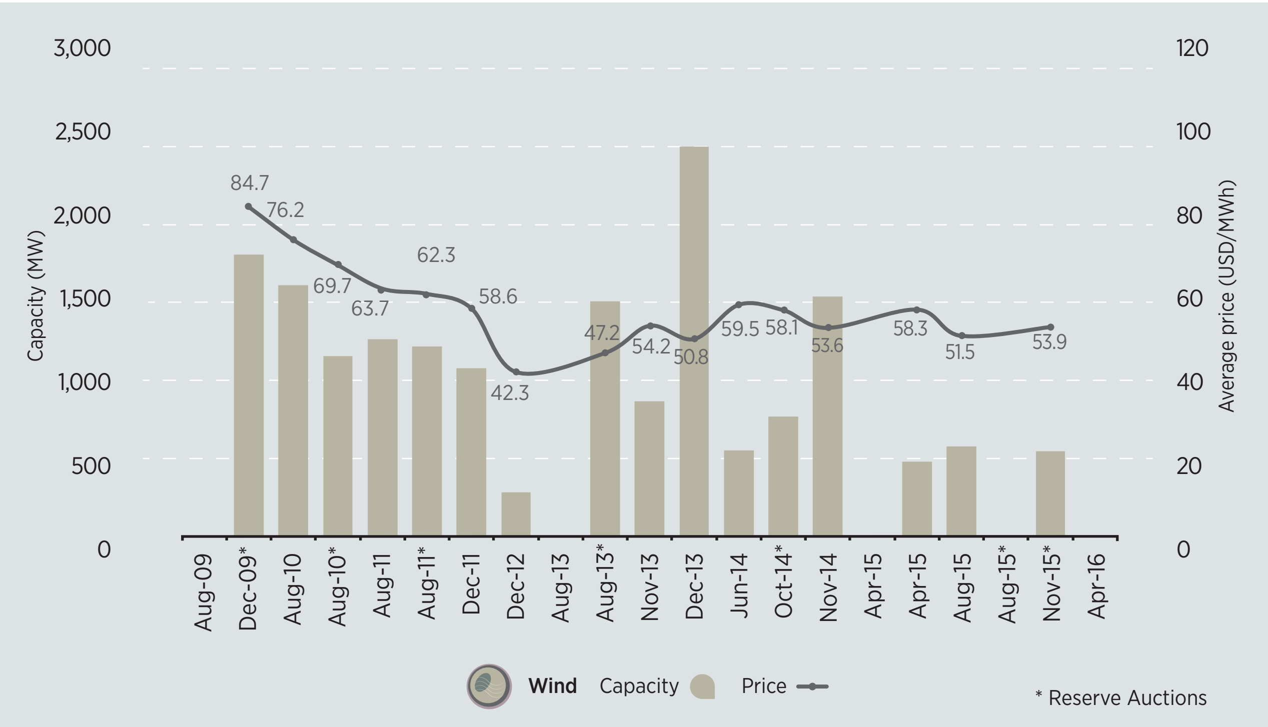
Fluctuating prices in Brazil

Brazil was among the first countries to have contracted wind energy through auctions, with significant accumulated experience. The price trend in Brazil appears largely flat from 2010 to 2016, with some volatility represented by fluctuations and changes of direction in the price curve shown in Figure 2.12. Most of these fluctuations can be traced to project lead times, intensified competition, auction design, the availability of concessional financing and depreciation of the local currency.

Brazil typically conducts two auctions each year: 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. As shown in Figure 4.1 , 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, and a similar price difference was observed between the November 2014 A-5 and the October 2014 A-3 auctions.

The dip in Brazil's curve at the end of 2012 marks the point when it had the world's lowest price for wind power, a distinction it earned (and retained for several years) owing to intense competition in the market. The one auction conducted in 2012 (as opposed to at least three in most years) was marked by very low demand from distributors: whereas the previous auction had contracted almost 1 GW of wind capacity and the subsequent

Figure 2.12 Wind auction results in Brazil, 2009-2016



Source: ANEEL, 2016.

one 1.5 GW, the 2012 auction closed contracts for just 289 MW. A large number of suppliers qualified to bid, which led to a major supply glut and depressed prices; only 2% of the subscribed capacity was ultimately contracted. After this point, prices slowly recovered and stabilised at a higher level.

The price increase in 2015 (opposing the international trend) reflects a reduction in the availability of loans from the Banco Nacional de Desenvolvimento Econômico e Social (BNDES), a state-owned bank that had been one of the main suppliers of financing for the energy sector. The BNDES National Climate Change Fund offered low-cost, long-term loans for up to 70% of the total capital requirements of renewable energy projects, and private banks could not profitably compete with the interest rates it offered, which were as low as 2% per year in real terms. Many energy projects were developed with a very low cost of capital. However, when Brazil's fiscal situation worsened in 2015, BNDES reduced its participation in loans to several segments of the energy sector and even temporarily stopped making new loans through the National Climate Change Fund (see Box 3.1). Without BNDES's attractive loans, the cost of capital of projects almost doubled, driving prices up. Moreover, the Brazilian real lost more than 40% of its value from mid-2014 through the end of 2015 (a development trend not shown in Figure 2.9). This led the regulator to increase the auction's ceiling price to accommodate imported equipment, raising prices (expressed in the local currency). Because the figure shows the price outcomes converted to U.S. dollars using the exchange rate at the time of the auction, this effect goes almost unnoticed.

Contributing to the price peaks were shifts in underlying economic conditions and in auction design. In 2013, for example, the domestic content requirements associated with BNDES loans became more stringent, reflecting the country's development priorities (although Brazilian auctions do not require domestic content directly, satisfying such requirements are needed for developers to be able to access the concessional financing offered by BNDES). The same year saw revisions in the auction design including: 1) the rules for calculating the maximum capacity factor that wind power plants could offer became more strict, 2) the ceiling price increased (in light of the depreciation of the local currency), and 3) the rule for determining the generators' responsibility in cases of transmission delay increased the developers' liabilities. All helped increase bid prices (Dezem, 2015).

Higher prices in Italy

Despite significant price decreases in each round of Italy's 2016 auctions, prices remained substantially higher than in many other countries. In fact, they were comparable to the prices observed in the United Kingdom in 2015.

The fact that European countries seem to exhibit higher prices than other regions can be explained partly by higher costs of labour and land. However, the expected capacity factor of wind power generation also exerts an influence. Wind power developers in Brazil and Peru, for example, have often declared high capacity factors, close to 45% on average and exceeding 50% in several cases. The operating results of existing wind farms in those two countries seem to indicate that generators are indeed capable of reaching this level of performance within a few percentage points (subject to yearly fluctuations). This is in stark contrast with European countries, where values closer to 30-35% seem to be the norm.

Conclusion

Analysing and comparing the results of various auctions around the world can be challenging.[19] Many factors contribute to the low prices that emerge from solar and wind auctions, and prices are heavily influenced by the country context and by auction design. Nevertheless, it is important to analyse each factor to gain a better understanding of the dynamics of auctions and allow for more informed choices among available policy instruments and auction designs. That is the purpose of the next chapter.

19. Analysing the prices emerging from biomass auctions is even more complicated, as these depend largely on the feedstock used (see Section 5.2).

3 ANALYSIS OF FACTORS INFLUENCING PRICES

As shown in Chapter 2, recent auctions have yielded competitive prices globally. The decrease in prices reflects the falling cost of technology and the competitive environment spurred by the auction. However, country-specific factors play a major role in individual auction results and can explain discrepancies in prices around the world. Such factors include 1) country-specific costs (for finance, labour and land, among other things) and conditions such as renewable energy resource availability; 2) investors' confidence related to the presence of a conducive environment, as shaped by the credibility of the off-taker, the periodicity of auctions, increased confidence and lessons learnt from past auctions; 3) other policies aimed at supporting renewable energy development, such as clear targets, fiscal incentives (*e.g.,* tax credits, exemptions, accelerated depreciation), grid access and priority dispatch; and 4) features of auction design pertaining to trade-offs between the resulting price and other objectives (*e.g.,* socio-economic development objectives, project size, strictness of compliance rules and remuneration of developers). These factors are explored in this chapter.

3.1 ACCESS TO FINANCE AND COUNTRY-SPECIFIC CONDITIONS

In addition to the potential of renewable energy resources in the country, the capital and operational expenditures (CAPEX and OPEX) incurred by project developers directly affect auction prices. Capital costs are largely related to the cost of finance, which is directly linked to the macroeconomic conditions of the country and investor confidence in the sector (see Section 3.2).

The CAPEX and OPEX of renewable energy projects vary significantly between countries. Variations are determined by 1) differences in installation and building costs, which depend on the cost of land, labour, energy, and so on; 2) asymmetries in ease of access to equipment; 3) fluctuations in foreign exchange rates, which affect equipment costs; 4) fiscal and labour legislation, which varies substantially among jurisdictions and affects both investment and operation costs; and, most importantly, 5) finance costs, which are closely tied to the economic situation of the country and investors' perception of risks related to the regulatory framework.

Reported capital costs from projects that won auctions help to illustrate some of the differences across countries (see IRENA, 2014b). Country-specific data may reflect structural aspects of individual countries. Capital costs of utility-scale solar projects in India, for example, seem to have remained consistently in the lower limit of the international range (see Figure 3.1), a tendency that is likely attributable to the country's low labour costs, strong domestic solar power sector, and possibly also to its proximity to China for certain imported components. In other countries, reported capital costs clearly reflect the sector's learning curves. In Peru and South Africa, for example, these costs dropped in successive auctions, and in South Africa from higher to lower than the international average.

Variations in the weighted average cost of capital, reflecting both the cost of debt related to financing conditions and the cost of equity related to the investor's perception of risk, account for much of the country-to-country difference in auction prices. By definition, attractive loan terms and other means of reducing the cost of debt lower projects' capital costs, permitting lower prices. Attractive financing may be offered by national banks, such as the Banco Nacional de Desenvolvimento Econômico e Social (BNDES) in Brazil (see Box 3.1), or by international development banks (as in Morocco, Peru and Zambia). In the latter case, macroeconomic conditions that can affect the availability and cost of financing include the country's ease of doing business, its credit rating, its country risk premium, and the general international perception of its economic, political, legal and regulatory sta-

Box 3.1 **Access to finance and the economic situation in Brazil**

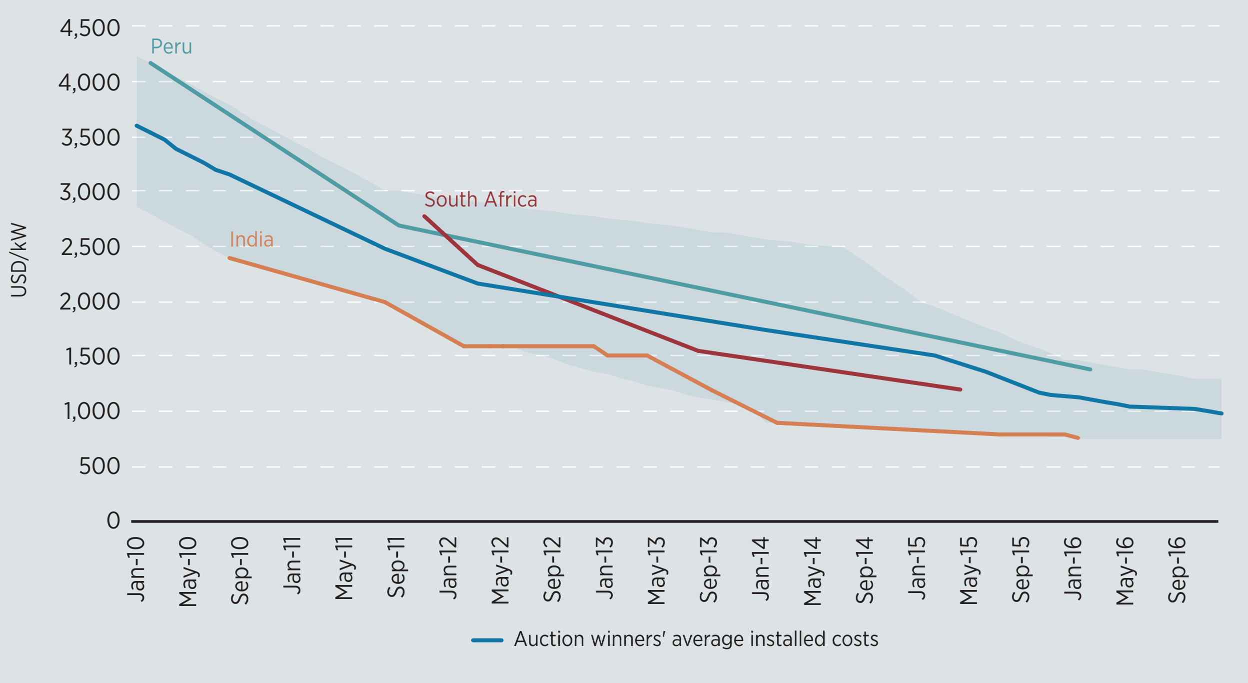
The Brazilian experience illustrates the impact of financing conditions on the outcomes of auctions. Up to 2015, the country had relied heavily on the Banco Nacional de Desenvolvimento Econômico e Social (BNDES), a state-owned social development bank, to finance winning projects that had a specified level of local content. By the end of 2016, BNDES had lent more than BRL 25 billion (USD 7.5 billion) to wind facilities that comply with local content rules and had disbursed financing for 9.9 GW of the total 19 GW of wind capacity contracted in Brazil through 2019. BNDES loans typically covered more than 70% of the invested capital, and at a rate significantly lower than that of Brazilian Treasury bonds.

In 2015, as part of a package of fiscal austerity measures, the bank announced a stark reduction in the availability of capital for new loans of this type. Loan approvals in the first 10 months of 2016 plunged 62% compared to the same period a year earlier.

With Brazil in an economic and political crisis, few international banks were able to fill the gap left by the state-owned bank. Contracts denominated in domestic currency were seen as an obstacle for international players, especially after the devaluation of the Brazilian Real over the course of 2015. These developments combined to reduce the amount of financing available and to increase the cost of debt, as reflected in the auction results shown in Figures 2.3 and 2.9.

Source: Spatuzza, 2016b.

Figure 3.1 Estimated evolution of capital costs of projects winning solar PV auctions and range of country averages (shaded), 2010-2016



Source: Based on BNEF (2016a), BNEF (2016b), Eberhard and Kåberger (2016), Elizondo-Azuela, Barroso (2014), MNRE (2010), MNRE (2012), Osinergmin (2016).

bility (Dobrotkova et al., 2017). Equally important are any regulations affecting foreign investments across borders and the degree of availability of foreign currency in countries where auctions are not denominated in hard currency (*e.g.,* in Ethiopia, Malawi). Such elements affect international institutions' willingness to offer attractive financing, which, in turn, affects prices.

Financing costs can differ widely even within the European Union. The EU-funded DiaCore project, which assessed the weighted average cost of capital for onshore wind projects in 2014, found that the average ranged from 3.5% in Germany to 12% in Greece, influenced by general country risks and the specific renewable energy investment risks (DiaCore, 2016).

Finally, it is important to highlight that a conducive environment for renewable energy investments can play a major role in reducing the rates of return required both by project developers (cost of equity) and by the financial institutions supporting them (cost of debt), as was the case in the United Arab Emirates (see Box 3.2).

3.2 CONDUCIVE ENVIRONMENT FOR INVESTOR CONFIDENCE

Renewable energy auctions award long-term contracts that guarantee a sustainable revenue to project developers, lowering risk perceptions and instilling confidence in banks and other financial institutions in the presence of a conducive environment. Investors' and project developers' sense of confidence and assessment of risk significantly affect auction results. In cases where risks are mitigated, investment costs can decrease substantially, resulting in lower bids. Several elements can instil confidence in the sector. These pertain to the credibility of the off-taker, the design of the auction (including the regularity of auctions and the remuneration profile), and the presence of a stable and enabling environment that is conducive to market growth.

An important way to reduce investors' risk perception is to ensure that demand-side responsibilities will be met – usually through the presence of a reliable contract off-taker and sometimes by offering additional guarantees to back the contract. In Peru, the Ministry of Mines and Energy itself is the contract off-taker as a representative of the Peruvian State, which means that suppliers are essentially offered sovereign guarantees from the government (Osinergmin, 2015). In the United Arab Emirates, the government utility that acts as the off-taker also holds equity in the project (see Box 3.2).

In Argentina, the government provides guarantees to the bidders that consist of liquidity guarantees, ensuring the continuity of cash flow to the developers, and termination guarantees shielding developers from counterparty risks that are also backed by the World Bank (see Section 4.1). In Zambia, the World Bank guarantees the offtake (see Box 3.3 and Section 4.9). This type of risk mitigation can greatly increase investors' appetite for an auction programme.

Box 3.2 Investor confidence in Dubai, United Arab Emirates

In Dubai, the results of the third phase of the Al Maktoum Solar Park (USD 29.9/MWh) reflect investors' confidence: Emirati and Saudi institutions were keen to submit competitive bids to meet the Emirates' long-term vision for solar deployment of a total capacity of 5 GW. The public commitment to a long-term market for renewables gave project developers a compelling interest in entering this promising market early, which intensified the competition and encouraged low bids.

Furthermore, the unique financing structure and design of the Dubai auction likely played an important role. The project's equity will be held jointly by the developer (40%) and the government-owned Dubai Electricity and Water Authority (DEWA) (60%). In this respect, the project more closely resembles a public-private partnership rather than a classical independent power producer model. DEWA's creditworthiness and the possibility of securing favourable loan terms (including low interest rates and long tenors) played a major role in reducing auction prices, as did the United Arab Emirates' low soft costs (land, energy, labour) and generally very low taxes.

Source: IRENA, 2016b.

Box 3.3 Guarantees backing contracts in Zambia

The Zambian auction featured relatively standard mechanisms of liquidity support, notably letters of credit and World Bank payment and loan guarantees (which were to be invoked if required by commercial lenders). The market opted for the payment guarantees, but not the loan guarantees, indicating the superiority and sufficiency of the established payment guarantees, at least in this case.

The Zambian auction used a government support agreement to deal with the issues of the country's sovereign credit rating and the possiblity of default or insolvency of the off-taker. In the event of buyer default, the government does not step into the shoes of the off-taker to assume responsibility for all payments under power purchase agreements, as would be the case in a standard sovereign guarantee; instead, the government buys the asset or shares in the project company at a pre-determined price. Additional liquidity arrangements include letters of credit issued by a commercial bank and backstopped by a partial risk guarantee from the World Bank.

Source: IRENA, 2017b, forthcoming.

Investor confidence can be further strengthened through the mitigation of financial risks in the developer's remuneration profile. Among them are inflation, currency and production risks throughout the plant's useful life. In Chile, for example, auction contracts are denominated in U.S. dollars and adjusted periodically in line with the U.S. Consumer Price Index, thus shielding developers from both interest-rate risks and inflation risks (see IRENA and CEM, 2015, vol. 6). However, such an arrangement shifts the currency exchange risk to the government or another off-taker, especially in countries that regularly see significant currency depreciation (as in some African countries). In such cases, alternative methods of financing projects that do not entail significant exposure to foreign exchange fluctuations are needed.

Even though it is not always optimal to shield investors from all risk (as discussed in Section 3.4), offering more attractive conditions to the supplier tends to result in lower prices. Such conditions can include measures for greater certainty with respect to revenue (*e.g.* through floating market premiums) and costs (*e.g.* through transparent and fast permitting and grid access procedures). Through such measures, support policies can improve a project's weighted average costs of capital (DiaCore, 2016). Other attractive risk-mitigation mechanisms that can be made available to private developers are sovereign guarantees, currency-hedging instruments and liquidity reserves (IRENA, 2016c).

Confidence can also be built through the early involvement of stakeholders – project developers, manufacturers, investors and the auctioning authority – in discussions on the auction design. Inclusive discussions reduce risk perceptions and ensure that all stakeholders in the value chain have a chance to familiarise themselves with a given auction (or auctions in general) and adapt their business models accordingly. The German and South African governments, for example, organised expert workshops and consultations with stakeholders during the drafting of their auction guidelines. Similarly, the Mexican government shared a draft auction design with stakeholders, which was effective in increasing investor confidence in the programme. Further design elements that increase investors' confidence include the periodicity of auctions.

A systematic auctioning scheme that ensures regularity and predictability in the scheduling of auction rounds is also helpful to build trust among investors, financiers and equipment manufacturers in the government's commitment. A benefit of conducting several rounds within the same programme is the learning-curve effect for all parties involved – an effect that is especially clear in the decreasing price trends in India, Peru and South Africa (see IRENA and CEM, 2015, vol. 3). The fact that competition between equipment manufacturers and service providers also plays a major role in price decreases is another reason why the stability and visibility of the government's renewable energy policy is so important if the country's renewable energy industry is to thrive.

3.3 POLICY SUPPORT TO THE RENEWABLE ENERGY SECTOR

Firm, clear targets for renewable energy deployment, especially if accompanied by a clear strategy and backed by specific policies and measures, build and bolster investor confidence (IRENA, 2015a).[20] Many of the policies and measures detailed in Table 3.1 can be used in conjunction with auctions, and can affect the resulting prices.

In a renewable energy programme, auctions may be used alongside a quota scheme, such as in the state of New York (with renewable portfolio standards) or in Mexico where developers can bid for a package of energy and/or capacity with tradable renewable energy certificates (see Section 4.5). Such measures provide potential bidders with an indication of long-term potential demand, increasing their confidence and reducing prices (see Section 3.2). Other examples include the implementation of auctions together with fiscal incentives such as tax breaks or reduced import duties that directly influence project costs. In the United States, for example, an investment tax credit allows taxpayers to deduct from their federal taxes 30% of the cost of installing a solar energy system (see Section 2.2).

Policies for grid access also have a significant impact on auction prices. Ensuring priority dispatch and shielding investors from evacuation risk are important measures for the success of an auction (see IRENA and CEM, 2015, vol. 6), especially in cases where transmission infrastructure is not yet entirely in place. For this reason, location-specific auctions – in which land and grid access are provided by the government, as in the UAE – yield lower prices than auctions in which the developer is responsible for securing grid access and covering all or part of the site costs (in the presence of the institutional capacity needed to identify an appropriate site) (see Box 3.4). Increasingly, governments are predeveloping sites and grid access for offshore wind projects – for example in Denmark, Germany and the Netherlands (see Section 5.1).

Combining auctions with other policies and measures can also result in higher prices. Common examples are socio-economic policies, such as local content requirements designed to strengthen the domestic industry or achieve other social benefits (for example, community ownership). Such measures can impose greater costs and stricter constraints on developers, which can drive prices up in the short term. However, in a larger perspective,

Table 3.1 Renewable energy policies and measures

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

Source: IRENA, 2015b.

20. At the end of 2015, 173 countries had established renewable energy targets at the national or subnational level (REN21, 2016).

Box 3.4 **Grid access in South African auctions**

In South African auctions, securing grid access is primarily the responsibility of developers. In fact, to qualify to participate in an auction, bidders must obtain written assurance from the grid provider (Eskom) that the substations and distribution and transmission lines to which they intend to connect have sufficient capacity.

Projects may connect either to the transmission system or to the distribution system, depending on their size and location. Winners of the bid must, as part of their power purchase agreement, conclude with the relevant grid provider either a transmission agreement or a distribution agreement. If the grid provider is a municipality, bidders must ensure that the permits will be in place before financial close, as part of their bids.

Bidders are responsible for *shallow connection works* (connection to the system) whereas the grid operator is responsible for *deep connection works* (connection on shared assets).[a]

Shallow connection works can be handled in three ways: 1) Eskom builds them; 2) the bidder builds them and then transfers them to the grid provider; or 3) the bidder builds and retains ownership of the connection works – requiring an additional transmission license or distribution license. Bidders therefore must obtain and pay for a cost estimate letter from Eskom or a municipality – depending on where they intend to connect - which provides an indicative timeline and associated costs for the required deep connection works. Bidders are furthermore expected to provide a signed letter stating that they are able to comply with grid codes prior to commercial operation date. Bids must further clarify which parts of the grid connection works are to be performed by the bidder (including a cost estimate). Once bidders become "preferred bidders," the cost estimate letter must be replaced by an up to date and accurate budget quote from Eskom or the municipality.

Deep connection works can have significant cost implications for a country such as in South Africa. Therefore, guidance on project location and grid capacity is provided through the development of Renewable Energy Development Zones.

a. The grid provider must still undertake a portion of the shallow connection works, which should be included in the cost estimate letter.

Source: IRENA, 2017b, forthcoming

such measures can be desirable from a socio-economic and political point of view. With the appropriate policies to develop a local industry, a domestic content programme can ultimately pay off in the long run, as illustrated by the South African experience addressed in Section 2.2. The trade-off between developing a local industry and obtaining lower prices in the short term, among other trade-offs, is addressed in the following Section focused on auction design.

3.4 DESIGN OF THE AUCTION

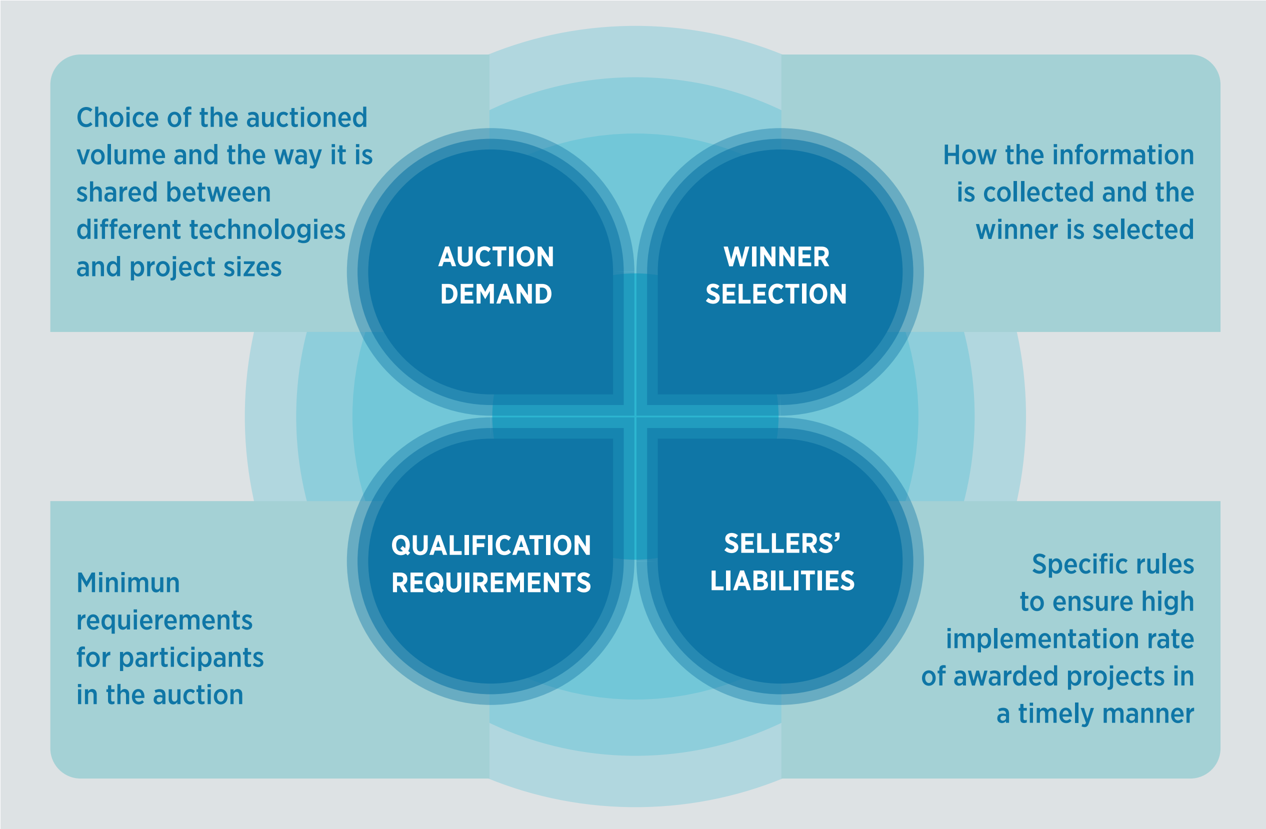
National and subnational energy and development objectives are often reflected in auction design, and the resulting design features may significantly affect auction prices. In fact, most design choices present a trade-off between reducing prices and another objective, including generating socio-economic benefits or ensuring the successful and timely delivery of projects. The following analysis of how auction designs affect prices is based on the four design categories described in IRENA and CEM (2015, vol. 2) and illustrated in Figure 3.2.

Auction demand

A well-structured and consistent auction programme can lead to lower prices by raising investors' confidence. A long-term auction programme, with a predictable schedule, stable and robust design, credible off-taker, and high degree of transparency all contribute positively to the level of robustness of the auction. Consistency instils confidence among potential bidders, which may increase competition in the auction.

However, consistency also implies that policy makers have less flexibility to adjust the auction

Figure 3.2 Categories of auction design elements



Source: IRENA and CEM (2015).

design in the face of changing market conditions. The possibility of adjusting design priorities can be very valuable, especially in a rapidly evolving sector, and the option to do so must be weighed against the possibility of making potential investors leery of the predictability of the country's auctioning programme.

Qualification requirements

There is a clear trade-off between setting more or less stringent qualification requirements on auction participants. If requirements are too demanding, they can significantly reduce the pool of potential bidders, limiting competition and potentially driving prices up. On the other hand, loosening qualification requirements (with regard to past experience or proof of financial capability, for example) may expand competition, lowering prices, but also raise the risk of underbuilding and delays. This is not to say that auctions with stringent qualification requirements – as in South Africa and Zambia – cannot attract investors. Zambia received 48 Expressions of Interest, and 13 bids were submitted. South Africa has received more than 400 bids for 100 projects. Although the auctioning process has been relatively complex in South Africa, its transparency and legitimacy have attracted bidders.

Elements such as the complexity of the auction can likewise play a role in affecting how many players are able to participate. Highly complex mechanisms that may be effective in achieving various policy goals tend to reduce the transparency of the auction process, which may discourage some potential bidders. The main motivation behind Peru's auction scheme was to attract international consortia to develop renewable energy projects in the country; entry barriers were low and the auction rules simple and straightforward.

The bureaucratic and administrative requirements that bidders must meet before qualifying for an auction can be another potential barrier, particularly for new entrants. Such requirements include environmental licenses, resource assessments and grid-access permits. The costs of meeting them, added to the cost of identifying a site, can represent up to 2% of the total installed cost of a project (AURES, 2016a). In a project-specific auction, the government assumes responsibility for some of these activities, such as resource assessments, site selection and grid connection, which can be an effective way of reducing barriers to entry and bidders' costs. Auctions in Dubai and Abu Dhabi are examples of this practice, as project developers are shielded from certain risks because the auctioneer is responsible for choosing the project site and securing all necessary documentation. A similar mechanism is applied in many offshore wind auctions in Europe. However, such an arrangement is not always optimal. In Zambia, for example, the data provided by the government were not sufficient, which may have contributed to project delays for which the developers have been held responsible.

Another class of qualification requirements is linked to socio-economic development. In the implementation of local content requirements, for example, there is a trade-off between developing a local industry (along with associated benefits such as job creation and domestic value added). and achieving lower prices (in the short term). For example, as explained in Section 2.2, South Africa's initial high prices can be explained by the fact that the country's auction design emphasised domestic content requirements and social development. These made it initially more costly to provide the energy services being auctioned and more difficult for international companies to participate, but they also reflected the importance of South Africa's priorities in terms of development goals. Socio-economic development objectives can figure in an auction either as a prequalification requirement or as a criterion for winner selection.

Winner selection

The winner selection process is at the heart of the auction mechanism, and the criteria for selection, the payment to the winner, along with other mechanisms for minimal competition, can significantly impact the price outcomes.

Selection criteria that express non-price objectives such as the development of a domestic industry, proximity to the grid, or project location can shape price outcomes significantly. For example, location constraints may force bidders to select sites that are not as rich in renewable resources as other sites. The locational signals adopted in Mexico's first auction illustrate this phenomenon, as explained in Section 2.3.

As for the payment to the winner, pay-as-bid schemes tend to produce lower average price outcomes than marginal pricing schemes. This is because pay-as-bid schemes offer bidders no more than their bid, which is supposedly the minimum required for developing the project in the presence of competition in the market. But bidders may assess the competitive position of their bid and add a mark-up to their development costs if they assume that their bid is more competitive than the bid of the competition. In a marginal pricing scheme, each of the many auction winners is remunerated at the same rate, which is either the highest of the accepted bids or the lowest of the rejected ones.

Although some bid prices may be lower in such schemes (as developers may count on being paid according to the highest of the accepted bids or to the lowest of the rejected bids), the final uniform price applied may be higher than the average of all bids. Despite their apparently higher price outcomes, marginal pricing schemes tend to be preferred over pay-as-bid mechanisms in auctions that seek to satisfy a certain demand for renewable energy. This is because, by making project developers' remuneration independent from their bid, bidders are encouraged to disclose their actual costs (IRENA and CEM, 2015, vol. 5). However, it is important to note that knowledge of the market clearing rule affects bidding behaviour. Therefore, the effect of this design choice is not entirely straightforward.

Another aspect of auction design that can affect bidding behaviour is the disclosure of a ceiling price as a way to ensure competition. Imposing a lower price ceiling, in principle, minimises prices, but those prices may come at the cost of not contracting enough capacity if the price ceiling is set too low. Disclosing the price ceiling also has disadvantages, notably the risk that bidders may offer prices very close to the ceiling, depending on the level of competition in the market.

Imposing an upper limit on project size is another measure designed to ensure competition. Such limits may be set to spread risk (*e.g.,* in case of project default, as in Zambia), protect the environment (as in Germany), encourage participation by small or new players, ensure a smoother generation profile, deal with grid constraints, or ensure diversification in the geographic distribution of projects. However, limiting project size may also deter economies of scale and lead to higher prices.

Sellers' liabilities

Sellers' liabilities as set out in the auction design play a major role in the prices elicited by an auction. The main factors that affect those prices are the contract schedule, the remuneration profile, the commitment to contract signing, and the settlement rules and penalties for underperformance and delays.

The project lead time, as specified in the bid, can significantly impact the price. In auctions with long lead times, it is possible for investors to speculate on a decrease in investment costs between the time they submit their bids and when they effectively execute the project. Indeed, such practices have been observed on several occasions, such as in Brazil and Germany. Although expectations of lower costs may elicit competitive bids, they may also lead developers to make offers that might become unviable if the anticipated cost reductions do not materialise. Such scenarios could lead to delays and cancellation of projects and, in more general terms, threaten the industry's sustainability. A prominent factor in this discussion is the optimal lead time of a solar plant, which can be as short as 12 months to as long as 36 months. This lead time must accommodate schedules for administrative procedures such as obtaining environmental permits and reaching financial closure; those schedules can vary widely from one country to another.

The outcome of an auction is also greatly affected by the contract duration and the length of the power purchase agreement. Although a common strategy is to calibrate the duration so it is close to the plant's likely useful life, it may also be chosen so as to reduce risks associated with inflation. For example, the Indian state of Uttar Pradesh attempted to shorten the contract's length from the default 25 years to 10 years to mitigate inflation risks to investors (as the contracts were not indexed to inflation). At the end of the term, project developers would be able to sell the electricity at market price. Sellers may view such an arrangement favourably if electricity market prices are expected to escalate with inflation over the years – offering the possibility of raising long-term revenues. However, in practice, Uttar Pradesh's 10-year power purchase agreement was perceived mostly negatively by bidders, because of the uncertainty it created about remuneration after the end of the term (IRENA and CEM, 2015, vol. 6).

The structure of the contract and its corresponding revenue streams may also affect prices emerging from an auction. Depending on how the rules spelled out in the contract determine the generator's effective remuneration level over the term of the contract, levelised contract revenue may be significantly different from the price awarded and announced at the auction. This is the case for most projects that are indexed to inflation, where the announced price corresponds to the first year of the project – before the yearly indexation begins. When contracts are not indexed and inflation must be factored into the price, as with Indian contracts, prices are higher, as explained in Section 2.2.

The ongoing auctions in Abu Dhabi are another interesting case of innovative design elements that result in a deviation between the project developer's true remuneration and the winning bid submitted in the auction (see Box 3.5). This is also the case in South Africa with concentrated solar power tenders where generators are paid a considerable premium for generating power during peak demand hours, leading developers to incorporate storage in their plants.

The last items related to sellers' liabilities that exerts a significant impact on an auction's price outcome are the settlement rules and penalties for underperformance and delays. When investors are exempt from risks such as production uncertainty, delays in delivering the project, and fluctuations in spot price, currency, or inflation, they can incorporate a lower risk premium into their bid. If risks are deemed too high, they may opt to not participate at all. However, reducing risks to investors typically implies that consumers will bear them instead, and if penalties are too lenient, investors may not be incentivised to do all they can to avoid delays and underbuilding.

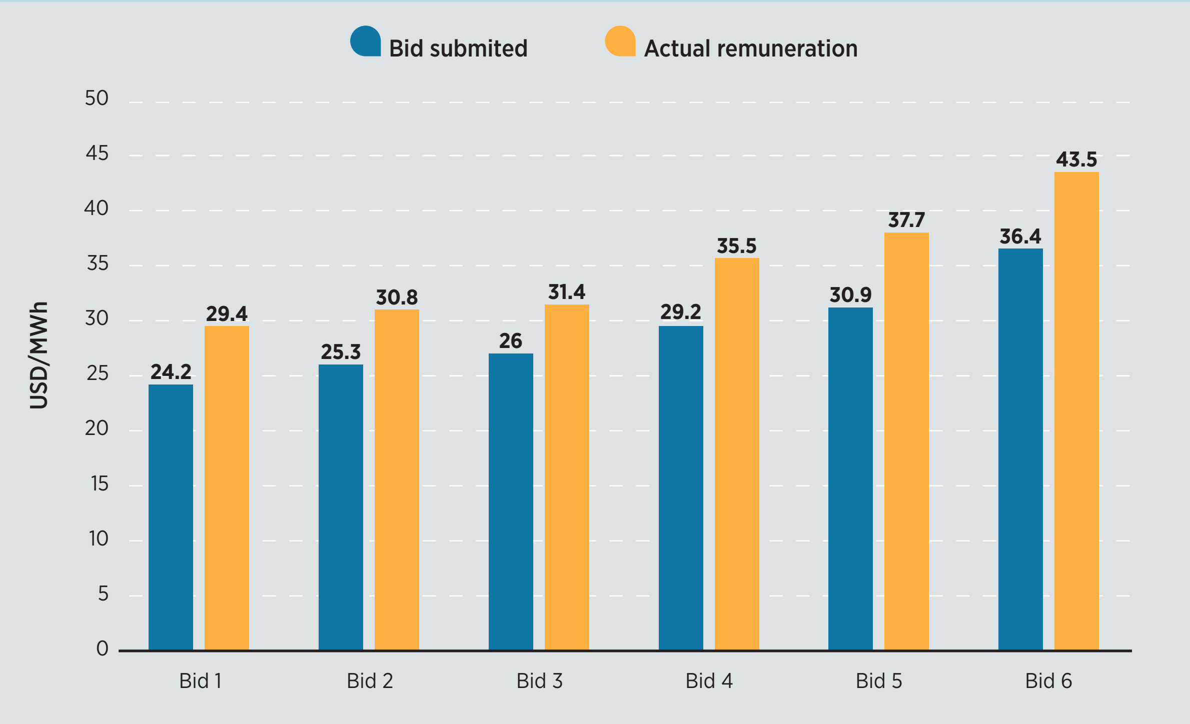
Box 3.5 **Remuneration profile in Abu Dhabi, United Arab Emirates**

In September 2016, the Abu Dhabi Water & Electricity Company (ADWEA) received proposals for its site-specific solar auction. On the closing date, the bids received set new records for solar prices. The lowest bid is of USD 24.2/MWh, followed by bids of USD 25.3/MWh and of USD 26/MWh (BNEF, 2016c). These prices represent almost a 20% decrement from the previous record of USD 29.9/MWh, attained in Dubai three months earlier (Bloomberg, 2016).

One relevant design innovation of the auction is that energy delivered from June to September, when Abu Dhabi's generation capacity is barely able to cover air conditioning demand, counts for 1.6 times as much as the energy delivered from October to May. Therefore, the bids do not reflect the actual remuneration of the project. Even though the exact payment details in the individual bids are not available, it is possible to observe that the seemingly unprecedented bid of USD 24.2/MWh does not truly reflect expected remuneration, as this "bonus" during the summer months needs to be taken into account.

If the seasonality of solar power production is ignored, an effectively 60% higher tariff applied during one third of the year translates into a 20% higher remuneration overall. This results in an adjusted price of USD 29.4/MWh, which is comparable to the bids received in recent solar power tenders in Dubai. A similar analysis has been carried out in by Bloomberg (2016), resulting in the adjusted price outcomes illustrated in Figure 3.3 to take into account the extra remuneration during the summer period. The difference between these results can be attributed to the representation of a yearly production profile for solar power and the calculation of a levelised cost over the project's lifetime.

Figure 3.3 Abu Dhabi's solar auction: Bid submitted vs. actual remuneration



Source: BNEF, 2016c.

4 COUNTRY CASE STUDIES

As discussed in Chapter 3, the outcomes of a renewable energy auction depend on several factors, ranging from the specific design of the auction, to the general conditions of the country where the auction is organised. This chapter discusses some of the key auction design choices and characteristics of countries that have recently adopted auctions, and provides an in-depth analysis of the factors driving their outcomes. A wide range of countries is covered, with diverse auctioning experience, encompassing multiple countries in different stages of renewable energy development.

4.1 ARGENTINA

Background

Since the new government took over in December 2015, Argentina's energy sector has been undergoing drastic changes. One of the new administration's priorities is the diversification of the energy mix, currently dominated by fossil fuel-based generation. The *Law 27.191* on Legal Regulations on National Promotion for the Use of Sources of Renewable Energy – Electric Power Generation has been introduced to incentivise private investment in generation expansion, especially in renewables. In this context, the RenovAR programme was established in 2016 to help achieve the set target of 20% share of renewables in the electricity mix by 2025, resulting in several PPAs, the costs of which would be passed on to consumers.

The first auction round under RenovAR was completed in September 2016. It aimed to contract 1 GW of renewable energy (600 MW of wind, 300 MW of solar, 80 MW of biomass and biogas and 20 MW of small hydro). The auction was oversubscribed by a factor of six, with 123 offers totalling 6.3 GW submitted (see Table 4.1). A total of 17 projects with 1108.6 MW of renewable capacity were contracted.[21]

While the wind and solar contracted capacity exceeded the volume auctioned, the hydro, biogas and biomass target was not met, as the hydro and biomass bids exceeded the auction's ceiling price, and only one of the six biogas projects offered was below it. The awarded projects represent 3,970 GWh/year, equivalent to 2.9% of the national electricity consumption. Considering the current capacity of renewable energy, the government estimates that when the projects awarded in round 1 go online, 5% of the energy mix will be renewable.

Given the large number of bids submitted in the first round, another round referred to as "1.5," was held in November, in which unsuccessful bidders from the first round could participate. In round 1.5, the government imposed additional requirements on the location of the projects: for solar projects, 100 MW had to be located in the North-eastern region (the other 100 MW could be located elsewhere in Argentina). The volume auctioned was 600 MW of renewable capacity: 400 MW of wind and 200 MW of solar (see Table 4.1).

Table 4.1. Summary of results of RenovAR auctions in Argentina

Auction	Tech	Volume auctioned (MW)	Offered capacity (MW)	Contracted capacity (MW)	Number of offers received	Number of offers contracted	Average price (USD/ MWh)	Minimum price (USD/ MWh)
RenovAR 1	Wind	600	3,469	707.4	49	12	59.4	49.08
	Solar	300	2,813	400	58	4	59.7	58.98
	Biomass	65	44.5	0	5	-	-	-
	Biogas	15	8.6	1.2	6	1	118	118
	Small hydro	20	11.4	0	5	-	-	-
RenovAR 1.5	Wind	400	1,561	766	19	10	53.3	46
	Solar	200	925	518	28	20	54.9	48

Source: MINEM, 2016a, 2016b.

21. The auction was expected to attract investments of up to USD 1.8 billion, create up to 8,000 jobs, enable annual savings on imported fuels for power generation of up to USD 300 million and reduce emissions by 2 million tonnes CO_2/year (MINEM, 2016c).

In addition to rounds 1 and 1.5 held in 2016, round 2 of RenovAR is planned to be launched in the second half of 2017, continuing with the country's ambition to increase the share of renewable energy in the electricity mix.

Drivers of the results: enabling environment

With respect to **access to finance and underlying economic conditions**, Argentina was going through an economic slowdown at the time of the auction. It was also facing challenges in the energy sector related to insufficient supply and subsidised tariffs.

To improve the environment for investment, the government made it a priority to offer conducive financing mechanisms and protect bidders from financial risks (discussed in the Section on the design of the auction). The renewable energy development fund (*Fondo para el Desarrollo de Energías Renovables* (FODER)) provides project financing and payment guarantees. It is funded by a mix of treasury funds, public offerings, the Argentinean government-administered pension fund (ANSES) and multilateral banks. It offers long-term project loans as well as interest rate subsidies and equity contributions to renewable energy projects, and project guarantees.Therefore, despite the instability caused by the country's economic situation, there are efforts to create a **conducive environment for investments** in the country.

In relation to **policies in the renewable energy sector,** *Law 27.191* is the most important instrument currently in force. It provides numerous fiscal and local supply chain incentives for renewable energy. It also establishes mandatory renewable energy targets for all consumers, aiming to add almost 10 GW of renewables over the next 10 years.

Argentina currently produces 1.8% of its electricity from renewable energy sources. The law sets progressive targets for renewable energy generation into the grid, starting from 8% by 2018 and reaching 20% by the end of 2025. The RenovAR auctioning programme is expected to be an important catalyst for achieving these targets in the next years with the support of the following incentives: foreign companies that invest in RenovAR before 2018 will receive exemption from minimum income tax, refunds on value added tax, tax deductions for all financial expenses and complete exemption from import duties. Such support policies help achieve low prices in auctions.

Drivers of the results: auction design features

With respect to the **auction demand**, RenovAR is still in its initial stages. Nevertheless, the realisation of two rounds within six months, with a third one scheduled within another six months period, shows significant commitment to continuity. Auctioning the total quantity over many rounds limits the volume auctioned and instils competition in the market. The enactment of *Law 27.191* set well-defined renewable energy targets and established specific mechanisms, such as FODER (aiming to ensure financing and payment guarantees to project developers), increasing confidence in the robustness of the programme. Another source of confidence is the fact that the contract off-taker is the Argentinean wholesale electricity market administrator (Compañía Administradora del Mercado Mayorista Eléctrico S.A. (CAMMESA)) acting on behalf of distribution utilities and large users (as the cost of the PPA would be passed through to them). Argentina's utilities and infrastructure issuers were upgraded from Caa1 to B3 by Moody's Investors Service in April 2016 (Moody's, 2016a).

As for **qualification requirements,** although the programme was designed in a way to encourage foreign investments, the winning bidder commits to creating a local Special Purpose Vehicle/Entity (SPV/SPE) in case of winning the bid. In addition, the auction design set out to ensure the successful completion of projects.

Bidders are required to provide legal and accounting documentation, obtain full environmental authorisation for the project, in addition to verifiable and irrevocable land rights. Each bidder should have a minimum net worth of USD 500,000/MW offered (individually or collectively) and have experience in the construction and operation of projects with similar technology that are at least a third of the size of the proposed project.

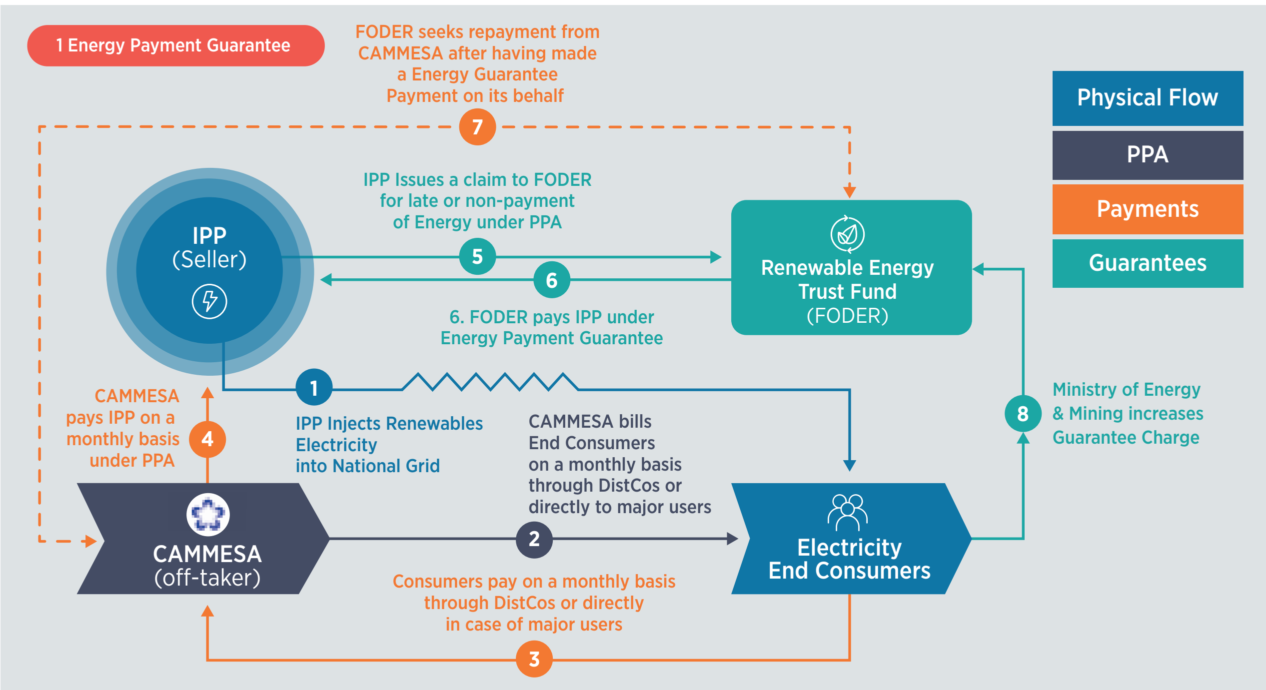
Technological requirements include a description of the project along with the technical characteristics, evaluation of the availability of renewable energy resources and estimation of the energy production. Grid connection permits are required, with approval from the transmission provider, in addition to proof that an authorisation process with the electricity wholesale agent has been initiated.

Winner selection is not based solely on price. It encompasses five criteria, which are weighted in the scoring of bids: the price (in USD/MWh), the location of the project and interconnection node, the date to reach commercial operation, compliance with the requirements in the bid documents and compliance with the requirements to obtain the certificate of inclusion. This certificate can be obtained after the developer registers as an agent for participation in the wholesale power market, provides given fiscal and tax information and submits the project details. The bidder must also post a bond together with the application for the certificate for 10% of the total value of all tax benefits requested.

To ensure that capacity will not be contracted at "unreasonable" prices, an undisclosed ceiling price was set for each technology in Round 1. Although the ceiling limited prices, it also resulted in uncontracted capacity in Round 1 for biomass, biogas and small hydro (Table 4.1). The non-disclosure of the price caps may have played a key role in this outcome, as agents with full knowledge of the price ceiling would have possibly adjusted their bids accordingly. Another criteria of minimal competition was the upper limit on the size of projects (100 MW for wind and solar, 65 MW for biomass, 15 MW for biogas and 20 MW for hydropower).

Regarding **risk allocation and liabilities to investors,** the RenovAR programme imposes compliance rules to ensure successful delivery of the projects, including a bid bond of USD 35,000/MW of offered power capacity and a performance bond of USD 250,000/MW. However, developers are provided with government guarantees, consisting of liquidity and termination guarantees. The liquidity guarantee ensures the continuity of cash flow to the developers. This account must always have on deposit at least 12 months' worth of payments due by the off-taker under the PPA. The guarantee mitigates the risk that the administrator of the wholesale electricity market (CAMMESA) will lack sufficient funds to purchase the power contracted under the PPAs (see Figure 4.1). On a monthly basis, CAMMESA pays the IPP under the PPA and co-

Figure 4.1 Liquidity guarantee in Argentina's RenovAR programme



Source: MINEM, 2016c.

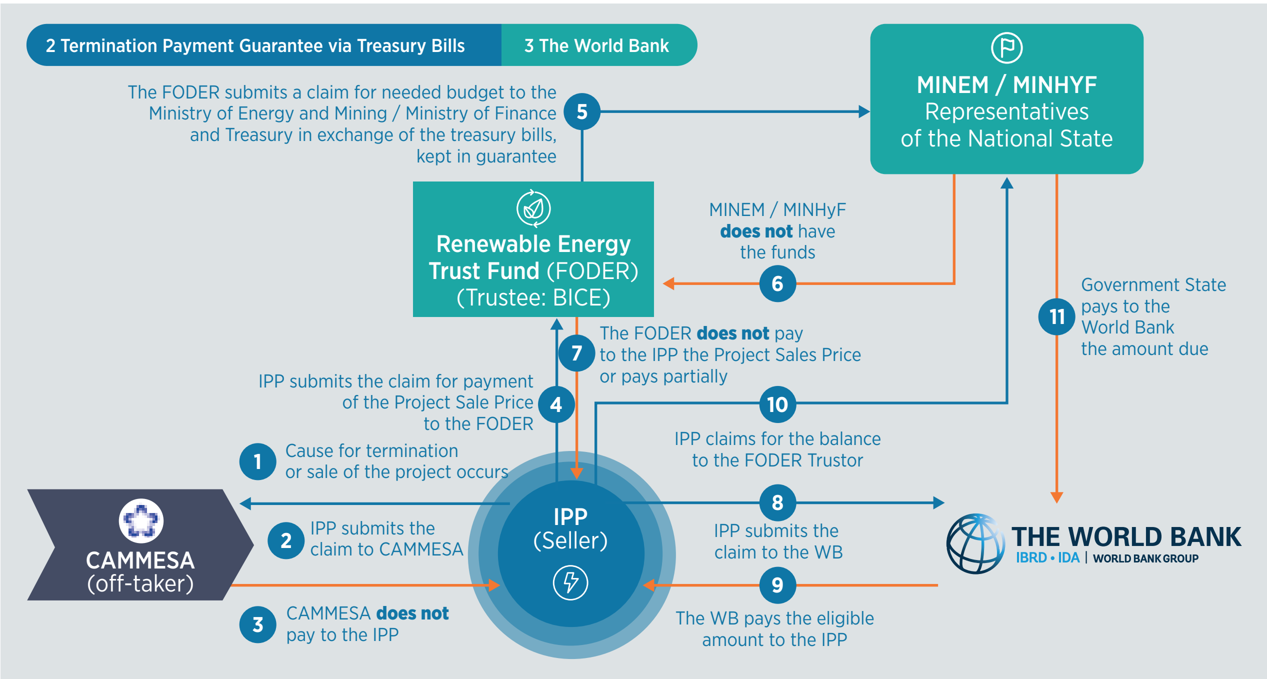
ordinates with FODER to ensure that all payments are covered in full. In case of late or non-payment from CAMMESA to the IPP, the latter issues a claim to FODER for payment under the Energy Payment Guarantee. FODER then seeks repayment from CAMMESA. If CAMMESA cannot repay FODER, The Ministry of Energy and Mining (MINEM) increases charges to electricity consumers to replenish FODER to ensure that it always holds 12 months' worth of eligible PPA payments as liquid reserves.

The solvency/termination guarantee aims to shield developers from counterparty risks. It gives the developer the option to transfer ownership of the project to the government (see Figure 4.2). If the IPP has reason to terminate or sell the project, a claim is submitted to CAMMESA. If CAMMESA cannot pay the IPP, the latter submits the claim for repayment of the project sale price to FODER which then submits a claim for the needed budget to MINEM and the Ministry of Finance and Treasury (MYNHyF) in exchange for the treasury bills that are held in guarantee. If MYNHyF has enough funds, the payment is made to the IPP through FODER. Otherwise, the IPP submits a claim to the World Bank who then pays the eligible amount to the IPP. The IPP then claims the balance from the FODER Trust at the Ministry. The government is responsible for the amount due to the World Bank.

This right can be exercised if: 1) the off-taker fails to make payments over a certain period; 2) the off-taker breaches a court judgment under the dispute resolution clause in the PPA; 3) the Argentinean currency becomes non-convertible or non-transferable to other currencies and countries; 4) there is a change in certain laws; and 5) the project is expropriated or if there is early termination of the PPA.

The occurrence of any of these circumstances allows the winning bidder to sell the project to FODER in exchange for payment (in USD) of the book value of the project assets based on the winning bidder's most recent audited financial statements (without depreciation). This FODER purchase payment will be guaranteed by the World Bank for up to USD 500,000/MW of capacity contracted for each project. FODER can also purchase an auctioned project if the off-taker terminates a PPA due to default (including failure to achieve a crit-

Figure 4.2 Solvency/termination guarantee in Argentina's RenovAR programme



Source: MINEM, 2016c.

ical milestone) by the winning bidder. Figure 4.3 summarises the risks and the ways they are mitigated in the RenovAR programme.

The auction design elements that impact the price in Argentina are shown in Table 4.2.

Figure 4.3 Risks and mitigation techniques in Argentina's RenovAR programme

RISK	MITIGATION
Project Quality	- Technical requirements - Certified energy production report - Environmental permitting and land rights required
Building	- Financial requirements on the bidders - High guarantee amounts - Construction milestones committed and penalised
Cash Flow (liquidity, repayment)	- Dispatch priority (by law) and priority payment - Energy payment guarantee through FODER - Annual adjustment factor/incentive factor
Exchange Rate and Repratriation of Capital	- Energy payment guarantee (on-time payment) - Inconvertibility /intransferability (cause for sale, put option)
Early Termination (off-taker, country risk)	- Put option (pre-estabilished in USD) - Sovereign guarantee (Treasury bills as guarantee to FODER) - International arbitration - World Bank guarantee

Source: MINEM, 2016c.

Table 4.2 The auction design elements that impact the price in Argentina

Auction demand	Two auction rounds carried out in a short span, allowing for learning Round 2 scheduled for the second half of 2017, sending positive signal to the market Limited volume auctioned, increasing competition
Winner selection	Appropriately set ceiling price
	Four non-price factors considered in the winner selection process
Qualification requirements	Legal, financial and technical requirements
	Project-specific documentation is required
Investor risks	Guarantee fund created to mitigate counterparty risks with the support of the World Bank
	Bid bond and project completion bond

4.2 BRAZIL

Background

Brazil has one of the world's richest experiences in renewable energy auctions, having carried out 29 auctions to date for wind, solar, biomass and small hydro power plants. The 2004 Brazilian market reform introduced several types of energy auctions, each designed to achieve a different policy objective. Two types of auctions have been instrumental in promoting renewable energy: regular new energy auctions and reserve auctions (IRENA, 2013).

New energy auctions are in principle technology-neutral, allowing a wide range of technologies such as hydro, biomass, gas, coal and oil-fired plants to participate on equal grounds. However, the government may limit participation to certain technologies, thereby transforming the auctions into technology-specific ones. This mechanism has been used to carry out renewable-exclusive new energy auctions, referred to as *alternative sources* auctions.

Reserve energy auctions were designed as a mechanism through which the government can contract supplementary (or surplus) energy to increase the system's reserve margin. In practice, they have been used to deploy renewable generation excluding large hydropower. Reserve auctions have been carried out every year since 2008 except 2012. They have been exclusive to renewable energy technologies covering small hydro, biomass, wind and solar energy. The auctions in 2008 and 2009 were biomass-specific and wind-specific respectively, and an auction in 2015 was exclusive for solar power, but other auctions allowed for the participation of multiple renewable energy technologies (albeit not always in direct competition). Figure 4.4 shows the capacities contracted and the final average prices of wind, solar and biomass in the new energy and reserve auctions in Brazil since 2008. Apart from solar, the implementation of which is recent, final prices in USD/MWh varied substantially from one auction to another. They seem to show a flat or slightly increasing trend starting in 2013.

Many factors affect auction prices in Brazil (see Section 2.3). In particular, Brazil's economic situation led to auction prices that are generally higher than prices in other countries, despite the rich experience in renewable energy and the high investor confidence in the sector.

Drivers of the results: enabling environment

The **access to finance and underlying economic conditions** in Brazil changed over the last decade. In the early 2000s, the country experienced an economic boom, which increased demand for electricity and boosted confidence in the economy. Finance was widely accessible, with the national development bank BNDES providing funds to infrastructure projects. Favourable financing conditions and a hospitable economic environment, coupled with the decrease in investment costs of wind and biomass plants, resulted in the downward trend shown in prices until 2013 (see Figure 4.4).

The economic downturn in 2014-2016 changed the investment environment, leading to the cancellation of the 2016 reserve auction due to system oversupply. The recession also reduced the availability of funds from BNDES, making it more difficult for developers to access low-cost financing, which translated into higher bids (see Section 2.3). Between mid-2014 and end-2015, the Brazilian Real lost more than 40% of its value. Prices in Reais increased to account for imported equipment. The prices shown in Figure 4.4 are converted to US dollars using the exchange rate at the date of the auction, so this effect goes almost unnoticed. All of these economic changes, combined with the political situation in the country reduced **investors' confidence** and increased the risk perception of the country. Credit rating agencies downgraded Brazil's rating.[22]

With respect to **policies in the renewable energy sector**, Brazil has been investing in the renewable energy sector for decades. It has set targets of 24 GW installed wind capacity and 7 GW solar capacity by 2024, increasing investors' confidence in the sector.

22. In February 2016, Moody's reduced it rating of Brazil two steps to Ba2. The rating is in line with Standard & Poor's and one level below Fitch Ratings (Sambo and Pacheco, 2016).

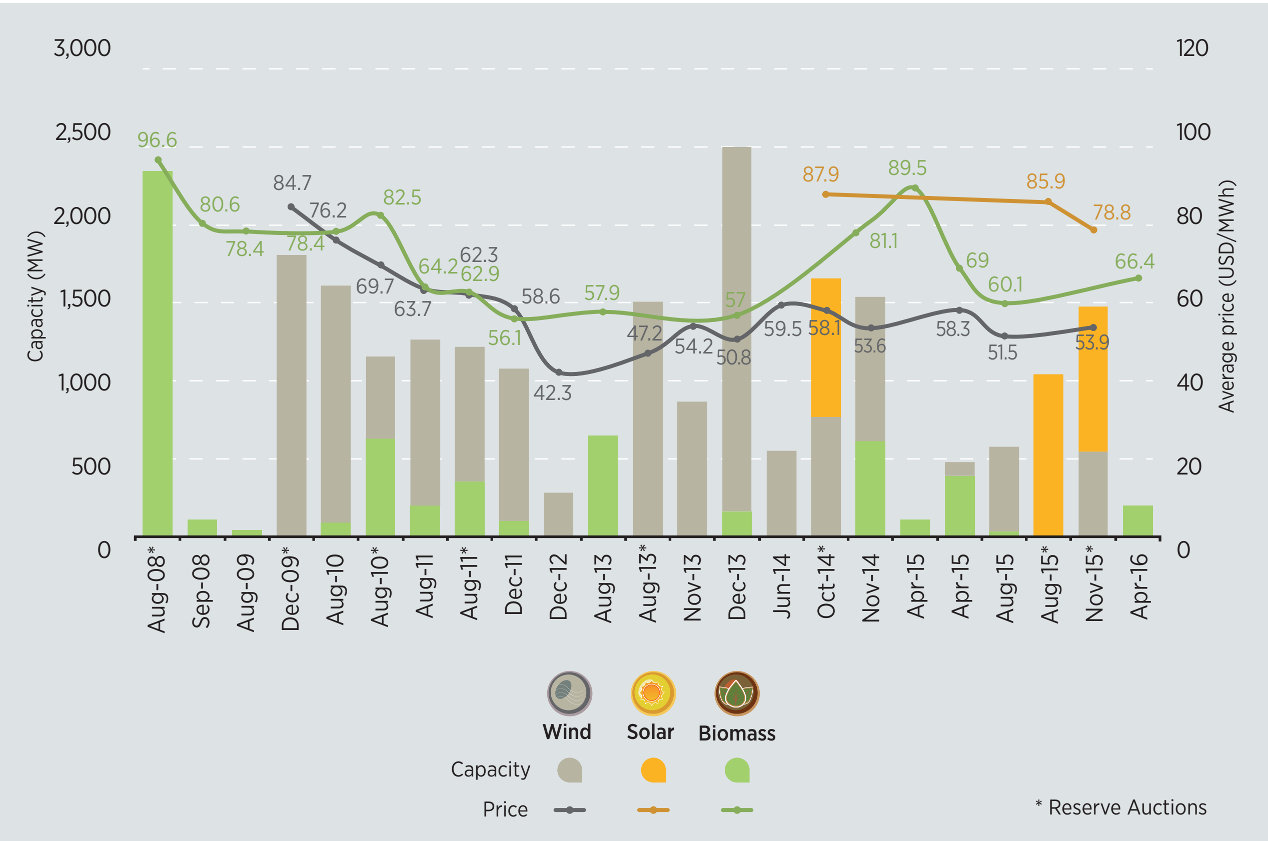
Drivers of the results: auction design features

Regarding **auction demand**, Brazil has been a pioneer in renewable energy auctions, having carried out 29 auctions to date. The government's decision to cancel the 2016 reserve auction took the private sector by surprise, given that the programme had been one of the country's main instruments for promoting renewable energy. However, Brazil is facing a power oversupply, caused by the economic recession of the last few years, which significantly affected electricity demand. It is expected that it will take a few years before business-as-usual growth rates return. In the meantime, instruments to attract more private financing can be introduced to overcome existing challenges and reap full benefits of auctions.

This helps to clear up the transmission line bottleneck and meet the country's non-binding goals of 32% non-hydro renewable power supply – all during a downturn in the economy (Spatuzza, 2016a).

In order for project developers to participate in energy auctions in Brazil, they have to meet a number of **qualification requirements.** The qualification requirement stage is highly standardised and fully automated (web-based), and it is tailored for each technology. Because developers are responsible for the site selection, substantial site-specific documentation is required, which can be costly to procure (although the recurrent nature of the auctions means that these licensed projects have a good chance of being selected in following rounds). Requirements include a prior environmental license, a preliminary grid access authorisation and natural resources studies. Qualification criteria for wind power are especially stringent, as generators must submit at least three years of wind measurement data, which a certifying company must use to estimate the maximum amount of energy the plant can offer in the auction. In the first few auctions, this maximum amount was equal to the expected generation given by the wind measurements; from 2013

Figure 4.4 Contracted capacities and average prices resulting from the auctions in Brazil, 2008-2016



Source: ANEEL, 2016.

the requirement became stricter and defined based on a probabilistic criterion (amount generated with 90% probability in a given year, given the historical measurements). The change was a contributor to the increase in wind power prices in 2013.

Regarding **winner selection,** both new and reserve energy auctions have adopted a hybrid auction design, divided into two phases. The first phase is a descending price clock auction; the second phase is a final pay-as-bid round through sealed-bids (see IRENA and CEM, 2015). One design element set to ensure minimal competition is the fully disclosed ceiling price, corresponding to the opening price of the descending clock round. This feature largely explains the fluctuation in prices achieved in biomass auctions between 2013 and 2015, as ceiling prices changed (see Table 4.3).

In December 2013, the ceiling price for biomass was BLR 144/MWh and it increased to BLR 209/ MWh in the second auction that awarded biomass in November 2014, largely to enable the procurement of a bigger amount of (more expensive) capacity seeing that the low ceiling price had resulted in some undersubscribed auctions. Ceiling prices also played a major role in the remarkable price difference between the two auctions held in April 2015: the first auction, in which biomass competed directly with natural gas, had a ceiling price of BLR 281/MWh, and resulted in an average price of BLR 272.5/MWh. The second auction in 2015 did not involve conventional thermal generation and therefore had a lower ceiling price of BRL 215/MWh (23.5% lower), resulting in an average price of BLR 209.9/MWh (corresponding to a 23% decrease).

The most significant difference between the two types of Brazilian auctions described in the case study impacts the **liabilities on the investor** substantially. In the reserve auctions, generators do not have the financial obligation to provide the contracted quantity to consumers, and therefore their risks are mitigated. The objective of the auction is to provide surplus energy to the system in order to guarantee its reliability and therefore the settlement rules are more relaxed: for example, a generator who fails to deliver sufficient amount of energy to meet contractual obligations is not subject to spot price risk. Projects awarded in reserve auctions are also protected against transmission delays that are beyond the control of the developer, whereas projects awarded in new energy auctions must purchase firm energy certificates in the market to meet their contractual obligations if they are not connected for any reason.

In addition, the government has the flexibility to determine the demanded quantity, frequency, and conditions of a reserve auction, whereas new energy auctions have a fixed periodicity, the demanded quantity must be driven by distribution companies' demand declarations, and they have to procure an amount of firm energy certificates sufficient to meet demand.

The auction design elements that impact the price in Brazil are shown in Table 4.4.

Table 4.3 Results of Brazilian biomass auctions, 2013-2015

Feature	December 2013	November 2014	April 2015 (1)	April 2015 (2)
Ceiling price (BRL/MWh)	144	209	281	215
Average price of winning projects (BRL/MWh)	133.8	205.8	272.5	209.9
Ceiling price (USD/MWh)	61.4	82.3	92.3	70.6
Average price of winning projects (USD/MWh)	57.0	81.1	89.5	69.0
Exchange rate (BRL/USD)	2.35	2.54	3.04	3.04

Table 4.4 The auction design elements that impact the price in Brazil

Auction demand	Long-running programme
	Generally predictable schedule, organised with high frequency (at least two auctions per year)
	Possibility of cancellation with no prior notice
Qualification requirements	Complex and bureaucratic procedure
	Strict requirement for wind power measurements
Investor risks	Provisions for multi-year settlement to reduce generator's quantity risk
	Significant penalties for delays and underproduction in the new energy auctions
Winner selection	Allows competition between technologies, to some extent
	Hybrid winner selection process (two phases) helps to decrease prices

4.3 CHILE

Background

In 1982, the Chilean electricity market became one of the first in the world to be liberalised under a unifying regulatory framework. Auctions were introduced in 2006 to meet the demand of distribution companies. The Chilean auctions have been designed with the objective of ensuring security of supply for the regulated market, giving distribution companies a high degree of autonomy to forecast their demand and organise auctions in order to manage their contract portfolio. The auctions are technology-neutral and, despite the lack of specific support for renewables, the last energy auction held in August 2016 resulted in renewable energy projects winning a significant share of the contracts. This represents an important milestone, as it proves the competitiveness of renewable energy compared with conventional sources – competing directly and without subsidies. The auction saw a high participation of wind projects, which secured 47% of the auction's demand. Another 47% of the volume auctioned was awarded to conventional energy projects. Solar (6%) and hydro (0.1%) accounted for the rest (Coordinador Eléctrico Nacional, 2016).

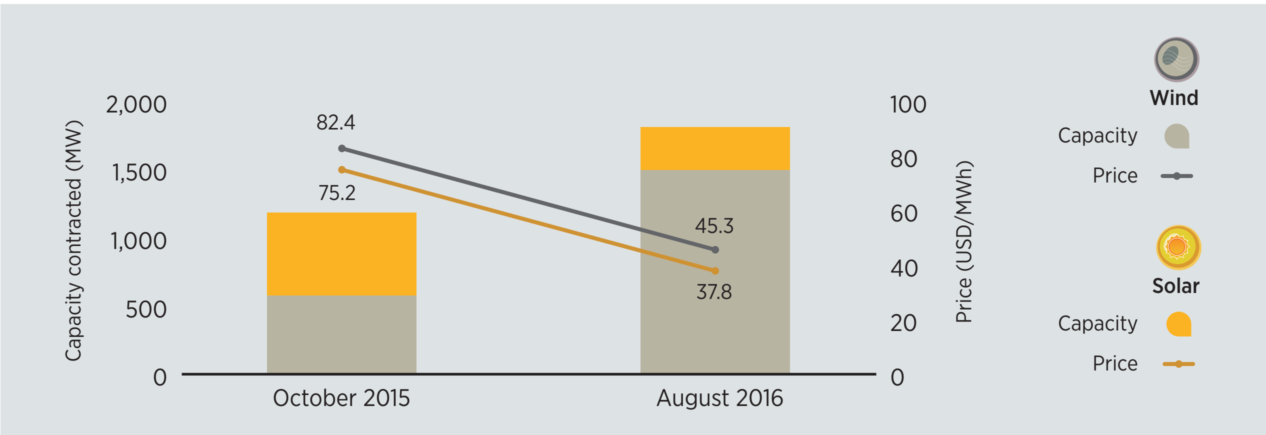
The average price of the contracts awarded in the pay-as-bid auction was USD 48/MWh, higher than the respective averages from wind and solar (see Figure 4.5). The lowest megawatt-hour sold in the auction pertained to the new 120 MW solar plant contracted at USD 29.1/MWh to the Spanish developer Solarpack, establishing a world record for solar at the time (although the auction design was not specifically tailored to solar power).

The auction resulted in a substantial decrease in prices from the previous round in October 2015. The average price of wind dropped by 45%, and solar prices by as much as 50%. This dramatic fall in prices is largely attributed to greater competition, particularly from the participation of incumbents seeking to renew their supply contracts in competition with bidders for newly-built renewable capacity.

Drivers of the results: enabling environment

The underlying **economic conditions** in the Chilean market are attractive for investments in renewable energy projects. Chile is ranked as a high-income country by the World Bank and it has one of the highest GDP per capita in Latin America with an Aa3 (Stable) credit rating (Moody's, 2016b). The country has consistently adopted a pro-market approach to policy issues, which has likely contributed to reducing the risk perception of both renewable energy investors and lenders, especially when compared with other countries in the region.

Figure 4.5 Contracted capacities and average prices resulting from the auctions in Chile



Source: Based on Coordinador Eléctrico Nacional, 2016.

The country's **abundant renewable** resources are a major contributor to low auction prices: Chile has large rivers for hydropower, strong winds near its coastline and among the world's highest solar radiation in the Atacama Desert. Moreover, Chile has considerable experience in renewable power with almost 1.3 GW and 1.6 GW installed capacity for onshore wind and solar PV in 2016 (IRENA, 2017a). The high level of i**nvestor confidence and interest** in the Chilean solar market is illustrated by the willingness of some private agents to sell electricity from solar plants in the spot market given the high prices of electricity.

Electricity prices in Chile remained consistently high in 2007-13, driven chiefly by the high international price of oil and the cost of importing liquified natural gas, which contributed to power producers' optimistic revenue expectations. More recently, electricity prices have fallen, as a result of: 1) greater integration of renewable energy with null variable cost, 2) a slowdown in electricity demand growth and 3) stabilisation of international fuel prices at a lower benchmark. Prices in the Chilean system have recurrently reached USD 0/MWh during the day in some nodes in the country's Northern subsystem, where solar power and mining are concentrated. That subsystem is expected to be connected to the Centre-South system in 2018. As the alternative of being exposed to spot prices becomes less attractive, generators' willingness to accept lower prices in contracts increases. Therefore, the Chilean auctions have been instrumental in increasing the portfolios of potential project developers and accelerating the deployment of renewable capacity while mitigating risks to investors.

Another major contributing factor to the low prices resulting from auctions is the **high level of competition** in the market, with large international players bidding for solar and wind contracts. Those players are attracted by the stable environment of Chile's energy sector and the falling cost of renewable technologies. Moreover, a slowdown in renewable energy investments in markets such as Europe may have led foreign investors to attractive new markets in Latin America such as Chile (Systep, 2016).

Chile has introduced **policies to support the deployment of renewable energy.** Renewable energy purchase obligations are the main instrument, in which generators must have a specified quota of renewable energy in their portfolios or buy tradable certificates to achieve the quota. *Law 20.698* provides that, for contracts signed after July 2013, the quotas correspond to 5% of contracted generation in 2013, increasing by 1% per year until reaching 12% in 2021, then rising by 1.5% per year until reaching 18% in 2024 in order to reach the policy quota of 20% in 2025 (BCN, 2013).

Drivers of the results: auction design features

Regarding the **auction demand**, the auctioning process in Chile has gained regularity a decade since its first implementation in 2006. Auctions have been organised recurrently as the main tool to meet distributors' demand at the lowest possible price. However, the success of the latest auctions is due largely to changes the government introduced after 2014. New design elements have enabled renewable power to pay a greater role in the auctions, in particular:

- Centralised entities assumed more responsibility for organising auctions, bringing contracting of demand for several distribution companies into a single process and reducing transaction costs. Before that, distribution companies were responsible for organising their own auction processes, coordinating bilaterally if they wished to organise a joint process.
- An opt-in mechanism was introduced to make it possible to adjust the contract's commercial operation date in case of project delays that are out of the generator's control. In auctions before 2014, generators would be required to purchase electricity in the spot market to fulfil their contractual obligations during the period of delay – which could lead to a substantial risk exposure. Indeed, the Southern Cross Group, which was to sell energy from a planned combined cycle power plant in 2009, went bankrupt in 2012 because its plant was delayed at a time when spot market prices were very high.
- The duration of the contracts was also revised. Whereas under the previous mechanism, contract duration was limited to 15 years (and often auctioned contracts had much shorter terms), more recent auctions have terms of up to 20 years.

- Rather than forcing generators to follow an hourly profile that matched the demand curve specified in the auctioned contracts, *hourly supply blocks* now allow renewable generators to concentrate their contractual commitments in the times of the day when they effectively generate (see Box 4.1).

The **qualification requirements** of Chilean auctions are among the least stringent in the countries studied. First, and as previously noted, the auctions are technology-neutral and make no distinction between newly built or existing plants. Although bidders must provide legal documentation and several signed declarations in their administrative offer (submitted along with the financial offer), very few requirements are imposed. Bidders must submit a report from an authorised financial consultant confirming that their company's risk rating is no lower than BB+ (incorporating in the risk analysis any project under construction), three years' worth of company accounts proving financial solvency, and relatively minimal technical documentation such as the planned interconnection to the grid. Despite the minimal administrative procedures for participating in the auction, the fact that players must be able to handle potential spot price risks can function as a de facto barrier to entry for some. In auctions prior to 2014, participation requirements were even less strict – but the auctions were heavily skewed towards the participation of incumbent generation companies that could more easily diversify their portfolios. Even though the innovations introduced in 2014 were certainly a step in the right direction, concerns about the bankability of new projects remain even under the revised mechanism.

Selection of winners is solely based on the minimum price offered (for each of the demand categories discussed), regardless of the technology. Winners' remuneration is determined in a pay-as-bid fashion. As Chile allows for direct competition among all possible bidders that could deliver the demanded energy product from various technologies, prices are expected to be driven down by competition among candidates with very different characteristics.

Finally, regarding the **risks and liabilities** of investors, Chilean auctions are denominated in U.S. dol-

Box 4.1 Reducing investor risk through hourly supply blocks in Chile

In Chile, the product auctioned is an aggregated yearly quantity of energy that is not differentiated by technology. Since 2014, that quantity or demand, is divided into continuous supply blocks (for generation of base load) and hourly supply blocks (which represent commitment to generate only at certain times of the day). The demand is apportioned to each of these blocks before the auction and fully disclosed ahead of time. For example, in the 2016 auction, only 17.8% of the auction's energy demand (or 2,000 GWh/year) was allocated to the three hourly supply blocks.

All contracts awarded in the Chilean auction are financial and differences between the contracted quantity and the plant's generation must be settled at the electricity spot price. Because renewable plants have a variable generation profile, a solar power plant for example would systematically need to buy electricity from the spot market during night-time hours in order to meet contractual obligations in a continuous supply block. Even though it can recoup some of its losses by selling surplus electricity to the spot market during daytime hours, this system exposes the project developers to market risks. In contrast, the hourly supply block for generation between 8 am and 6 pm only involves a commitment to deliver electricity during the daytime when solar resources are available, with no commitment during night time hours, therefore reducing exposure to spot prices. Nonetheless, solar and wind projects have competed and won more than 40% of the volume auctioned in the continuous supply blocks (where they are subject to greater risk exposure).

The lowest bid received in the auction for the 120 MW Solarpack project which set a record price of USD 29.10/MWh was competing in the hourly supply block that most resembled solar power's generation profile, indicating that reducing risks to investors indeed has an effect on price.

lars and indexed (either to U.S. inflation or another index such as the Henry Hub, according to the investor's preference). Nevertheless, risk related to the project's performance is substantial, as the generator is completely exposed to the spot energy prices if generation deviates from the contracted amount at any time. Investors' aggressive bidding behaviour despite this significant exposure seems to indicate a high confidence in their plants' performance, and an expectation that they will be able to manage electricity price volatility in a robust manner. Since contracts offered in Chile are financial, if a project is delayed or cancelled the penalty investors pay is simply equal to the difference between the spot price and the contract price. That penalty can be harsh in practice, but if investors can prove that delays were not their responsibility, they can request a postponement of the date of onset of commercial operations, effectively avoiding any delay penalties. It could be argued that a speculative component may be affecting auction prices in Chile; any strategy that relied on postponing construction would be very high-risk, but it might be feasible for some more aggressive market players.

The auction design elements that impact the price in Chile are shown in Table 4.5.

Table 4.5 The auction design elements that impact the price in Chile

Auction demand	Long-running programme
	Centralised process increasing simplicity
Qualification requirements	Transparent and standard qualification requirements
	Open to small and large, national and foreign enterprises
Winner selection	Technology neutral auction
	Price is the only winning selection criteria
Investors risks	Generators are exposed to the spot price when not respecting the contract generation profile
	Hourly supply blocks reduce investor risk
	Contracts are in USD and indexed to inflation

4.4 GERMANY

Background

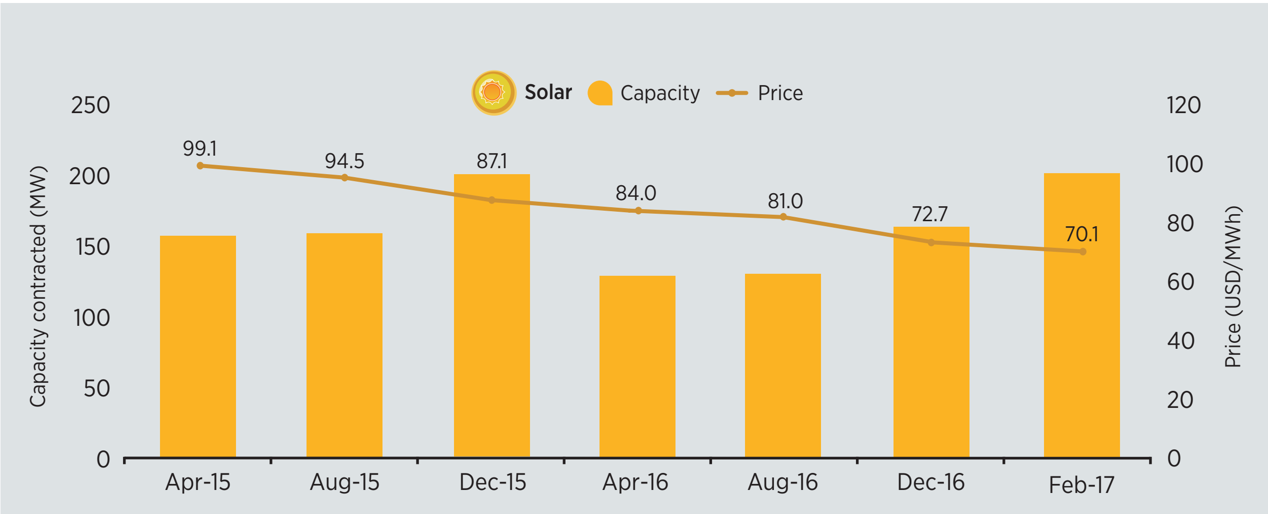
The development of renewables in Germany, as in many other European countries, has been supported by an administratively set feed-in tariff for several years. This mechanism, combined with the dispatch priority given to renewables, ensures fixed revenues for generators proportional to the energy generated, allowing them to recoup their investments at very limited risk. Feed-in tariffs have been generally recommended when renewables are still at a relatively incipient level of maturity. In Germany, this mechanism was crucial for consolidating the country as the world's second-largest solar energy producer, with almost 41 GW of installed capacity at the end of 2016 (IRENA, 2017a).

However, with technological advances, renewable technologies such as solar PV have become increasingly accessible and affordable. Their rapid development over the years resulted in a mismatch between the tariff set by the government (originally fixed with slightly outdated information, but updated later in regular intervals depending on the previous installation) and investment costs as perceived by investors. Moreover, given that the feed-in tariff policy did not set a limit for the installed capacity, it resulted in the installation of more capacity than was expected or needed. The high costs were passed on to consumers.

In 2015, a review of the renewables policy in Germany replaced the feed-in tariffs with auction mechanisms for installations above 100 kW to improve control over installed capacity, raise competition and implement the EU State Aid Guidelines by introducing market-based support mechanisms. The first auction for solar PV was organised in April 2015. Since then, seven more auctions have been organised, the latest occurring in February 2017. By this time, the average price dropped by 29%, from USD 99.1/MWh to USD 70.1/MWh. Figure 4.6 shows the average price results and capacities contracted in each of the auctions.

The programme was designed to include periodic auctions beyond 2017, with expansion to other renewable technologies, including rooftop-mounted solar and onshore and offshore wind power (AURES, 2015). A joint PV auction with Denmark took place in 2016. In this pilot cross-border auction, the two countries opened part of their PV auctions to bidders from the other country. A project from Denmark won the German auction, at an average price of EUR 53.8/MWh (USD 58.48/MWh) (BNetzA, 2016).

Figure 4.6 Contracted capacities and average prices resulting from solar auctions in Germany, 2015-2017



Source: based on data from BNetzA (2017).

All rounds of German auctions have been highly competitive, with the number of bids and offered capacity being much greater than the number of winners and contracted capacity (see Table 4.6). Given the high interest from bidders, auctions seem poised to become the primary mechanism to promote solar energy in Germany.

Drivers of the results: enabling environment

Germany's conducive **economic environment,** as well as the substantial share of solar energy in its electricity mix and the well-developed domestic solar power sector (including panel manufacturing, installation and other services), made for active participation in the German auctions. A robust financing sector and a stable regulatory framework also enable reliable access to financing, contributing to the success of auctions. Investors seem to favour the less-volatile revenue from auctioned contracts to trading strategies in the energy spot market, especially since spot prices are highly volatile (and can even be negative) where penetration of renewables is high.

The decrease in average prices is further driven by the reduced investment costs of solar projects and the rise in investor confidence in the post-feed-in-tariff environment. Bidders in Germany have also speculated on the approaching end of EU import duties on Chinese PV modules, expecting to be able to purchase cheaper models in time to use them in their projects.

In terms of r**enewable energy policies,** the 2014 Renewable Energy Act (EEG) introduced targets of a maximum share of 45 percent renewable power in the electricity mix by 2025 and no more than 60 percent by 2035. The increased share of variable clean energy in Germany has put pressure on the grid, and auctions can better help control the quantities of contracted renewables than other support mechanisms. The first auction in Germany resulted in an average price that was USD 1.6/MWh higher than the feed-in tariff in force at that time (USD 97.5/MWh in April 2015). This result gave rise to a series of questions about the auction mechanism's merits, since there was a general expectation of lower prices. With the downward trend observed in subsequent auctioning rounds, however, those concerns have been dispelled.

The unexpected price increase in the first auction may have been due to 1) the transaction costs of preparing and submitting the documentation to participate in a newly created mechanism (which may have reduced competition in this first auction and led agents to adjust their bids accordingly); 2) the costs of meeting the qualification requirements; and 3) the fact that the level of feed-in tariffs at the time was determined following a series of cuts and revisions and might have been too low for the market.

Table 4.6 Contracted capacities and bids received in solar auctions in Germany, 2015-2017

Auction date	Contracted capacity (MW)	Number of winners	Offered capacity (MW)	Number of bids
April 2015	150	25	700	170
August 2015	150	33	558	136
December 2015	200	43	562	127
April 2016	125	21	540	108
August 2016	130	25	311	63
December 2016	160	27	423	76
February 2017	200	38	488	97

Drivers of the results: auction design features

Regarding **auction demand,** although Germany's auction is a relatively new programme, there have been seven auctions since 2015, strictly adhering to the schedule that was set when the programme kicked off. The very specific roadmap established for the German auctions, combined with the country's position as a leader in solar energy globally, contribute to a strong perception of a long-term and stable demand for auctions. In addition, from the evolution of auction price outcomes and the high participation of bidders, it is also clear that the stakeholders are building experience in the auctioning process. Moreover, stakeholders have been involved at an early stage of the auction design consultations, contributing to an auction design that is suitable for the market.

In terms of **qualification criteria,** there are a number of rules meant to guide the development of solar projects and ensure their timely delivery. Rules that guide development include restrictions on the size of ground-mounted PV plants (between 100 kW and 10 MW) and the limitation of project sites to specified locations to avoid the use of land of high agricultural value. The rationale behind that rule is to avoid conflicts between the two sectors, but it may imply higher prices if high-potential sites cannot be used for solar projects.

Combining qualification criteria with **liabilities allocated to investors**, bidders need to provide a bid-bond (worth 4.5 USD/kW)[23] to be installed in order to be considered in the auction. This deposit is reduced to 2.27 USD/kW if a building permit is obtained, as this eases the after-auction work and decreases the auctioneer's risk of not having a signed contract. Lowering the bid bond also can facilitate the participation of smaller players. Moreover, winners in Germany's auctions need to provide a completion bond (worth 57 USD/kW and reduced to 28 USD/kW if the building permit is in place) to the regulatory agency, Bundesnetzagentur, within 10 working days of the auction. Moreover, if the project is not complete and commissioned within two years, winning bidders lose their right to remuneration for the electricity produced (see IRENA and CEM 2015, vol. 6). If the building permit is not obtained, the bid bond is doubled – which is typically reflected in the bid. In addition, Germany contracts are denominated in euros and do not include a price-escalation clause, which implies that they could lose value over time according to inflation. This exposure must be taken into account by project developers, which also affects the price.

For the **winner selection** process, the Bundesnetzagentur sorts the bids starting from the lowest to highest price, and projects are selected until the auction volume has been filled. Bids beyond the auction volume do not receive the right to remuneration for their output and get their bid bond back. Another particular feature of German auctions is the design of the winners' remuneration. Germany adopted a pay-as-bid mechanism for its first auction, in line with most auction implementations involving sealed bids. In the second and third rounds, a pay-as-clear marginal pricing scheme mechanism was adopted (with the intention of acquiring experience with this auction design before returning to the pay-as-bid scheme) and all winners received the same marginal price. In the fourth auctioning round, Germany returned to the pay-as-bid scheme. German auctions also include a fully disclosed ceiling price equal to the current feed-in tariff for roof-mounted PV plants.

The auction design elements that impact the price in Germany are shown in Table 4.7.

23. An exchange rate of 1.13 USD/EUR was used, compatible with the exchange rate in end 2014-early 2015.

Table 4.7 The auction design elements that impact the price in Germany

Auction demand	Relatively recent programme
	Exceptional implementation of pay-as-clear auctions in two rounds
	Gain in experience with auctioning rounds every 3 months
	Volumes auctioned in each round defined *ex ante*
Qualification requirements	High transparency, standard qualification requirements
	Bidders must procure site documentation
	Bid and project bonds can be reduced by obtaining building permit
Winner selection	Minimum price criteria
	Disclosed ceiling price
	Locational restrictions and 10 MW maximum size constraint
Investors risks	Standard requirements to ensure project delivery
	Lack of escalation clauses (minor impact)

4.5 INDIA

Background

When India introduced its National Solar Mission programme in 2008, it set a target of 20 GW of utility-scale solar power to be attained by 2022. In late 2014, the government set a new target of 100 GW to be met within the same timeframe. With a current installed capacity of over 12 GW and around 8 GW expected to come online in 2017, India is substantially scaling up deployment to meet its ambitious goal (Bridge to India, 2017). The target, coupled with policy action, has given project developers, financing institutions and other market participants confidence in the country's solar programme.

Even as the Indian government has remained true to its stated policy targets, maintaining flexibility with regard to policy instruments has been an important strength of India's National Solar Mission. In its original policy document (MNRE, 2010), the government intended to adopt auction-based schemes almost exclusively in the early phases of implementation. Such schemes were to work in tandem with existing mechanisms to promote renewable energy based on renewable purchase obligations, renewable energy certificates, and capital subsidies and accelerated depreciation schemes. Challenges related to distribution companies' compliance with renewable purchase obligations and the associated effects on the market for renewable energy certificates drove policy makers at both the national and state-level to turn to feed-in tariffs initially (*e.g.*, in the state of Gujarat) and then mostly to auctions to contract solar capacity (India held its first wind auction in 2017, see Box 4.2).

By adapting the policy over time, India has been able to capitalise on the success of the auction-based approach for both utility-scale and rooftop-scale solar projects. In general, the government has tried and tested different auction designs and implementation approaches, focusing primarily on auctions for solar energy. India also has experimented with different mechanisms to award payments to the project developers. Contracts with and without escalation and viability gap funding mechanisms were discussed in Section 2.2. In early iterations, differentiated tariffs were even offered, depending on whether the projects qualified for fiscal incentives such as accelerated depreciation. India's experience represents a valuable case study in renewable ener-

Box 4.2 Introduction of wind auctions in India

Wind energy development in India has taken place chiefly through well-defined feed-in tariffs given in various states (varying from INR 4 to INR 6 per unit), along with central fiscal incentives such as accelerated depreciation and generation-based incentives. As of March 2017, over 32 GW of wind had been deployed (MNRE, 2017).

In June 2016, the Ministry of New and Renewable Energy sanctioned a scheme to set up a 1,000 MW wind power project connected to the interstate transmission system to provide a framework for interstate sale of wind power at a price determined through transparent competitive bidding. This will help the non-windy states and territories fulfil their non-solar renewable purchase obligations while also boosting investment in the sector, thus achieving the goal of 60 GW of wind power capacity by 2022 (MNRE, 2016).

In February 2017, India's first wind auction took place. Four developers secured rights to develop a cumulative capacity of 1,000 MW (250 MW each). The tariff achieved was INR 3.45/kWh (USD 51.3/MWh), markedly lower than the prevailing state-level feed-in tariffs (Mahapatra, 2017). The auction was organised by the Solar Energy Corporation of India, and the developers will sign power purchase agreements with PTC India Ltd, a trading company selected by the Solar Energy Corporation of India (SECI), which will in turn sign back-to-back power sale agreements with the distribution companies of states looking to meet their non-solar renewable purchase obligations. The duration of the power purchase and sale agreements will be 25 years (PIB, 2016).

With the success of the first wind auction scheme in May 2017, MNRE announced another round of wind auctions for wind power projects totalling 1,000 MW of capacity (PIB, 2017).

gy auctions – allowing for the comparison of multiple implementations undertaken in response to local conditions.

In practice, India's solar auction scheme consists of a large number of national-level and state-level programmes. Selected editions of the programme are summarised in Table 4.8 although several other states (such as Odisha, Chhattisgarh, Haryana, and Uttarakhand) have also carried out auctions for smaller quantities.

During the three-year gap between the last batch of Phase I of the NSM national-level auctions and the first batch of Phase II, the state-level programmes gained importance; currently the state- and national-level auctions coexist. As observed in Figure 4.7, however, over the past year most auctions have been under the national scheme. Some of these have been unique in that they have targeted capacity development within designated solar parks[24] in specific states. Recent examples of solar park auctions include the 250 MW Bhadla Solar Park in Rajasthan, the 250 MW Kadapa Solar Park in Andhra Pradesh and the 750 MW Rewa Solar Park in Madhya Pradesh. The latest auction for Bhadla Solar Park yielded an all-time low price of

Table 4.8 Indian solar auctions, 2010-2016

Auction programme	Year	Number of auctions	Contracted capacity (MW)
National Solar Mission	**2010-ongoing**		
Phase I, Batch I	2010	1	150
Phase I, Batch II	2011	1	350
Phase II, Batch I	2014	1	750
Phase II, Batch II	2015-16	12+	2,800
Phase II, Batch III	2016	3+	975
Phase II, Batch IV	2016	6+	1,700
State-level auctions	**2012-ongoing**		
Karnataka	2012-16	5	1,590
Andhra Pradesh	2013-14	2	1,500
Jharkhand	2016	1	1,200
Punjab	2013-15	2	800
Telangana	2014-15	2	700
Madhya Pradesh	2012-15	3	625

Sources: based on Bridge to India (2017a), BNEF (2016a), Elizondo-Azuela (2014).

24. *To meet the 100 GW by 2022 target, several solar parks totalling 20 GW of capacity have been proposed across various states. The solar parks are being developed through partnerships between the central and the state government, under which financial assistance will be provided to establish the necessary infrastructure, such as transmission systems, water, roads, and a communication network. This would reduce developers' risk and the gestation period of the projects.*

INR 2.62/kWh (USD 38/MWh) in May 2017. In the upcoming phases of the Indian solar sector development, it is expected that the National Solar Mission will remain a key driver, with important contributions from state-level policies. Auctions are also expected to cover different market segments, ranging from large-scale solar parks to mid-size utility-scale plants and roof-top installations.

Analysing the trend of auction results over the past years, it is noticeable that, despite the overall downward trend of prices, individual auction prices vary widely within short periods. The key underlying factors behind these price movements have been addressed in Section 2.2, and are explored further in the subSections below.

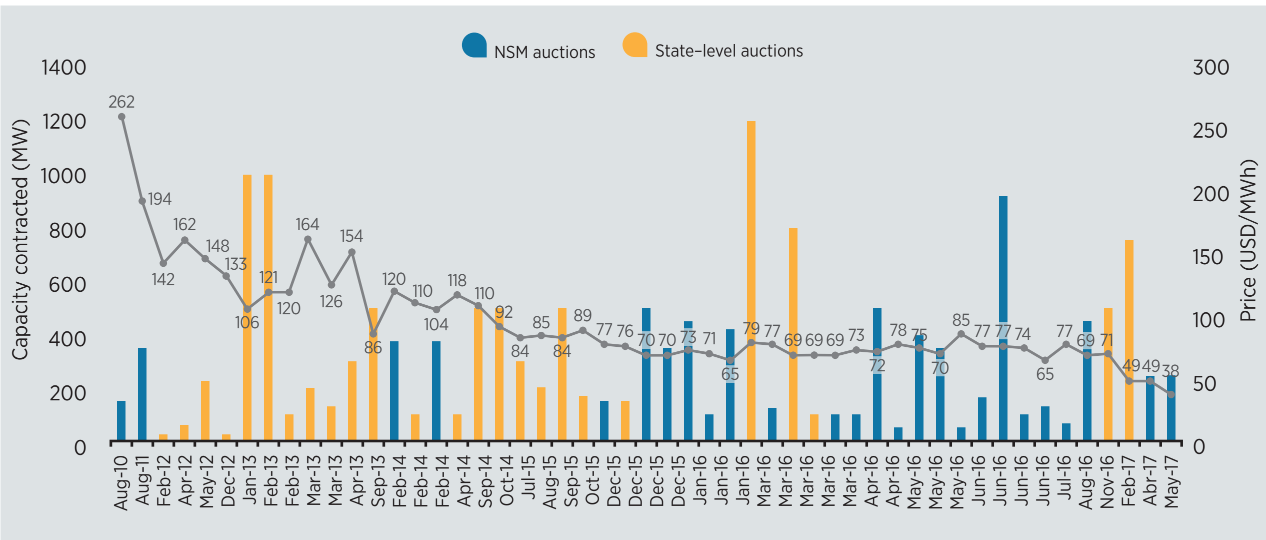
Drivers of the results: enabling environment

Policies in the renewable energy sector have been a major catalyser of investments in solar energy in India. The implementation of the National Solar Mission, with its clear roadmap, has played an important role in signalling the government's commitment and attracting potential bidders to the Indian market.

Recent solar auctions have benefitted greatly from the rapidly decreasing cost of modules and other engineering, procurement construction costs. Optimistic assumptions about the continuation of this trend have translated into aggressive bidding behaviour, contributing to record-low prices. There has also been a slow-down in the organisation of auctions owing to the macro-conditions surrounding the Indian power sector, including slower-than-expected demand growth, oversupply, and reluctance among off-takers to agree to new auctions or, in some cases, to sign power purchase agreements with winners of auctions that have yielded higher prices. This means that the competition in future auctions is expected to intensify, evidence of which is already being seen – the 2016 auctions of the Solar Energy Corporation of India (SECI) were oversubscribed at most by double, compared with a factor of 12 for the latest Bhadla auctions (Bridge to India, 2017a).

The Indian solar market is dominated by domestic debt, with the exception of a few players who have been able to access the international market. Recently, the **cost of debt** has dropped as interest rates have fallen, thus contributing to lower bids. At the same time, the ambitious target set by the government has meant that investments are also needed from international sources. Attracting needed capital meant having to internalise currency risks as contracts are denominated in Indian rupees. This keeps the market from benefiting from lower-cost capital and, therefore, lower prices at

Figure 4.7 Contracted capacities and average prices resulting from auctions in India, 2010-2017



Note: the figure highlights the results of selected auctions in India.
Source: BNEF (2016a), Elizondo-Azuela, Barroso et al. (2014), MNRE (2010), MNRE (2012).

auctions. The government did contemplate issuing dollar-denominated power purchase agreements to overcome the currency risk, but it has not yet implemented such a programme (Bridge to India, 2015). **Concessional finance,** particularly from development finance institutions, such as the World Bank and KfW, is playing an increasingly important role in leveraging private capital into the sector. Besides investing in complementary infrastructure projects (*e.g.*, Green Corridor), such institutions are also providing concessional financing for the development of solar parks. Recently the World Bank approved USD 100 million in concessional loans for the Indian Renewable Energy Development Agency Limited to on-lend to states for the development of infrastructure critical for solar parks (World Bank, 2017a). Such financing enables solar park promoters to offer land and associated infrastructure to developers at lower costs and in a timely fashion, thus reducing tariffs.

Other non-design factors driving results vary from auction to auction but include the cost of land, the timeframe associated with gaining access to land for project development, the state of grid evacuation infrastructure and local currency appreciation.

Drivers of the results: auction design features

The **auction demand** is based on a roadmap to the 2022 target of 100 GW set under the National Solar Mission. Auctions at the national level are conducted in phases and batches, guidelines for which are announced beforehand by the MNRE. The announcement identifies the auctioneer in the particular case (*e.g.* the National Thermal Power Corporation (NTPC) or SECI), the capacity demanded, bidding format, tariff structure (*e.g.*, fixed, escalating), type of auction (*e.g.*, reverse e-bidding), completion timeline, etc. State-level auctions are conducted by a state entity. Although state renewable energy policies and related renewable purchase obligations can provide some insights into auction demand in the future, there is higher uncertainty compared with national-level auctions.

The roadmap notwithstanding, the exact timing of auction rounds can vary depending on macroeconomic conditions (*e.g.*, appetite for solar power among state off-takers) and on the time needed to determine the auction design best suited to achieve the intended deployment and development targets, which may vary from auction to auction. The most noticeable differences across rounds are with respect to the contract off-taker (national public sector undertakings such as NTPC and SECI being more creditworthy than state-level utilities), payment schedules (such as the implementation of viability gap funding (VGF) , see Section 2.2.), domestic content requirements (typically covering a portion of the auction's demand, although the policy varies from case to case), and whether the auctions are project-specific or not (*e.g.*, situated within a solar park).

The process of **winner selection** has been similar across most recent major Indian auctions, involving an e-bidding along with e-reverse auction based on bidders submitting discounted tariffs and/or minimum Viability Gap Funding sought with fully disclosed ceiling prices and a pay-as-bid arrangement. Early implementations of state-level auctions had a controversial pricing rule known as lowest-bid (or "L1") contract pricing (IRENA and CEM, 2015, vol. 6). Under this scheme, adopted by the states of Odisha, Rajasthan, Tamil Nadu and Andhra Pradesh, all developers had to meet the lowest offer of the auction in order to be awarded a PPA. While such an approach could be successful in reducing prices in the short term, in a competitive market it is likely to lead some bidders simply to refuse the agreement at the lowest price.

The product offered in Indian auctions is typically a 25-year PPA with no escalation clause. This makes it difficult to compare Indian prices with international prices, as the non-indexation scheme may cause prices to lose value over time, usually to the detriment of the investor (see Box 2.4). In 2013, the state of Uttar Pradesh offered a 10-year PPA, rather than the typical 25-year contract. As the auctioned contract loses value over time, it was speculated that a shorter PPA, which would allow generators to sell their electricity in the spot market sooner (debt-repayment cycles are usually 10 years), would be desirable. However, the high risk associated with such a strategy, coupled with the poor financial situation of the state utility functioning as the off-taker, led to relatively higher prices. A predetermined escalation of the contract price was implemented in a few state-level auctions, including Tamil Nadu.

Regarding **qualification requirements,** besides the financial and technical criteria for projects and companies, a unique feature of the auction programme has been the handling of local content requirements (LCR). Phase I of the NSM explicitly required that any crystalline silicon PV modules used must be manufactured in India, which led the United States to bring a formal complaint to the World Trade Organization. When national-level auctions resumed in Phase II of the NSM, a share of the auction's demand was still subject to local content requirements. The first two auctions stipulated a 50% share for compliant projects, but in subsequent rounds the requirement was lowered substantially. Bidders may elect either the "LCR Category," the "Open Category" or both categories. Prices are stated separately for each of the two categories, and the projects subject to local content requirements have consistently been awarded at prices 10% to 15% higher than those not requiring local content.

Regarding **liabilities and risk allocation to generators,** the off-taker's creditworthiness – in addition to the inflation and domestic currency risks discussed earlier – has been a source of concern in several Indian auctions. The NTPC, a company with an A+ credit rating, has been the counterparty of Indian solar contracts auctioned in Phase I and in the second batch of Phase II of the NSM, offering reliable guarantees to generators. The other important counterparty of the national-level auctions, particularly in batches 1, 3, and 4 of Phase II, was SECI, whose credit rating provides similarly attractive guarantees to investors (see Box 4.3). The state-level utilities that have been auction counterparties have ratings that range from C to A+. The resulting variations in risk perception on the part of investors are clearly evident in final prices.

Several NSM auctions that involved SECI as a counterparty implemented a VGF mechanism for **contract remuneration.** This type of scheme, which has been adopted in other infrastructure investments, involves a fixed tariff to be paid over the plant's useful life. That tariff constitutes a baseline remuneration. Beyond it, solar plants receive an additional capital subsidy that is paid over the first few years of operation, which effectively reduces their upfront capital costs (see Box 2.4 for more details). The VGF scheme changes how agents prepare their financial simulations; with VGF, they submit their bids for a capital subsidy, rather than for a contract price[25]. Combining the VGF mechanism with an escalating tariff, the end remuneration profile resembles that shown in Figure 4.8.

Even when Indian auctions introduced an adjustment of the contract price level over time, this was introduced as a fixed escalation clause: the price

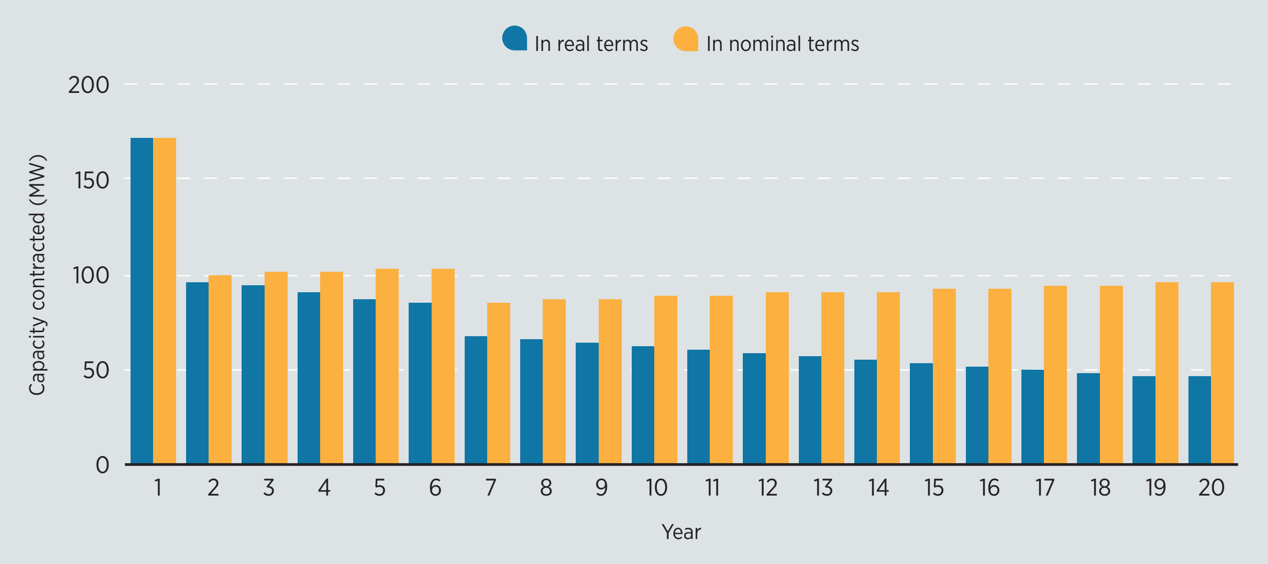
Box 4.3 Addressing off-taker bankability risk through payment security mechanisms

One of India's largest procurers of solar power, the Solar Energy Corporation of India (SECI), has been included as a beneficiary in a tripartite agreement between the government of India, state governments and the Reserve Bank of India. The agreement serves as a payment-security mechanism meant to offset the risk of defaults in payments by a state distribution company. SECI's inclusion in the agreement had an immediate effect on its domestic credit rating, which rose from AA- to AA+. The reduced off-take risk is also contributing to reducing tariffs, as seen in the recent 250 MW auction held for Bhadla Solar Park in Rajasthan in May 2017.

Source: Bridge to India, 2017.

25. Auction design allows bidders to quote zero VGF and offer discounted tariffs, if needed. Recent auctions have seen this occurrence.

Figure 4.8 Remuneration profile of an Indian auction featuring viability gap funding with fixed escalation



level would increase by INR 50/MWh each year for a fixed duration (MNRE, 2015). Even though this measure helps to mitigate the loss of value of the contract over time, it is a very small offset, representing a yearly adjustment of around 1%. Furthermore, this measure does not protect investors from inflation risk. The auction design elements that impact the price in India are shown in Table 4.9.

Table 4.9 The auction design elements that impact the price in India

Auction demand	Long-running programme
	Multiple programmes in one, with different design elements
	Uncertain signals to national project developers on the topic of domestic content requirements
	Relatively similar designs, as the programmes draw inspiration from each other
Qualification requirements	Standard qualification requirements
	Financing conditions can be difficult for players outside of India
Winner selection	Domestic content requirement increases prices
	Reported prices tend to be higher due to lack of escalation
	Successful implementation of transparent e-reserve auction
Investors risks	Relatively high currency risk and inflation risk assigned to investors
	Counterparty risk is significant in several auctions

4.6 MEXICO

Background

Unlike most Latin American countries that carried out electricity market reforms in the 1980s and 1990s, Mexico maintained a state monopoly over its power sector until the Electricity Industry Law was published in August 2014. In January 2016, the electricity wholesale market came into operation. Private generators can now sell electricity to the state-owned *Comisión Federal de Electricidad* (CFE) on the spot market or directly to high-volume consumers (also known as qualified or non-regulated consumers).

Power auctions are conducted by the system operator, *Centro Nacional de Control de Energía* (CENACE). Generators of renewables can participate, competing with conventional producers for PPAs with the buyer (CFE) for sales of capacity, electric energy, or clean energy certificates *(Certificados de Electricidad Limpia-* CELs).[26] The duration of the PPAs is 15 years; CELs are valid for 20 years.

Technology-neutral capacity auctions are open to project proposals offering firm capacity from conventional and clean energy technologies. They result in a contract requiring generators to have a specific amount of capacity available in a given zone for dispatch to the spot market when required.

Auctions for CELs are specific to clean energy technologies (bioenergy, geothermal, hydropower, nuclear, efficient cogeneration, wind and solar installations). Projects dispatch power to the node within their generation zone set by CENACE (CENACE, 2016).

Qualified consumers, retailers, self-generation users and producers of electricity from sources other than clean energy sources are required to purchase CELs. The Ministry of Energy (*Secretaría de Energía* - SENER), has established a minimum CEL purchase requirement of 5% of total energy consumption in 2018 and 5.8% in 2019 (Mayer Brown, 2016).

In the two rounds conducted to date, the Mexican auctions were successful in contracting new renewable capacity. In the first auction, a total of 2,085 MW was contracted, 81% from solar PV and 19% from wind. In the second auction, 3,462 MW was contracted, 54% from solar and 43% from wind. One 25 MW geothermal project and six hydro projects totalling 68 MW were also awarded. Table 4.10 summarises the results of both auction rounds. For both rounds and all three products, it shows the total volume demanded, the percentage of the total volume awarded, the ceiling price, the contracted capacity and the minimum and average price received for the energy and CEL sold together as a package.

Figure 4.9 illustrates the price and quantity outcomes for solar and wind in both auctions. The bids for solar power were even lower than for wind power, even though the auction design makes no distinction between the technologies.

The results of the first round of Mexico's newly launched auction in its recently established market can be deemed a success. This is even more true for the second round, which raised the amount of energy contracted and at lower average prices. In terms of contracted quantities, the first round resulted in about 5.4 TWh/year of energy and 5.4 million CELs, both representing almost 85% of the auction's demand; in the second round these numbers increased to 8.9 TWh/year and 9.27 million CELs, equivalent to 84% and 87% of the auctioned demand, respectively. Although all generators eligible for the energy product always receive 1 CEL for each megawatt-hour of delivered energy, the different settlement rules led certain bidders to bid differently for the two products, leading to the observed difference in the contracted quantities.

With respect to price results, there was a substantial decrease in the average bid price over only a few months (March to September) – as much as 29% for solar and 35% for wind. This reflects a learning curve and an increase in investor confidence from the first to the second round, the depreciation of the local currency (the PPAs are de-

26. CELs are tradable certificates granted to generation companies that produce clean energy.

Table 4.10 Summary of first and second rounds of renewable energy auctions in Mexico

Feature	First round	Second round
Total volume auctioned	6,361,250 MWh/year	10,629,911.25MWh/year
	6,361,250 CEL/year	10,629,911.15 CEL/year
	500 MW firm capacity	1,483.10 MW firm capacity
Total volume awarded (%)	84.9% of energy	83.8% of energy
	84.6% of CELs	87.3% of CELs
	0% of firm capacity	80% of firm capacity
Ceiling price set by *Comisión Federal de Electricidad*	USD 51.04/MWh	USD 40.01/MWh
	USD 25.64/CEL	USD 20.00/CEL
	USD 567.37/MW	USD 89,838.31/MW
Contracted capacity	Wind 394 MW	Wind 1,038 MW
	Solar PV 1,691 MW	Solar PV 1,853 MW
		Geothermal 25 MW
		Hydro 68 MW
		Combined Cycle 899 MW
Minimum Package Price (USD/MWh + CEL)	Wind USD 42.85	Wind USD 32.0
	Solar PV USD 35.46	Solar PV USD 25.03
		Geothermal USD 36.0
		Hydro USD 6.27[a]
Average Package Price (USD/MWh + CEL)	Wind USD 55.33	Wind USD 35.77
	Solar PV USD 45.06	Solar PV USD 31.81

a. The price of hydropower is significantly lower because the awarded plants only committed clean energy certificates in the auction, which implies they would receive additional revenues from selling energy and capacity in the market.

Source: Garcia and Pinzon (2016).

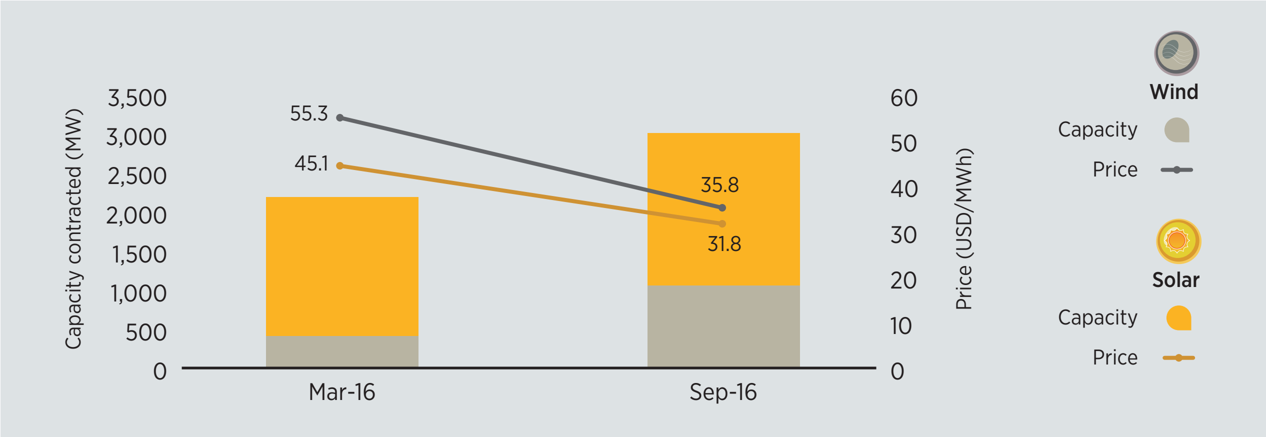
nominated in Mexican pesos), in addition to other factors related to the auction design (*e.g.,* price adjustment according to location) and changing ceiling prices.

Drivers of the results: enabling environment

The **underlying economic conditions** in the Mexican market are attractive for investments in renewable energy projects, given that it is the thirteenth-largest economy in the world in nominal terms and eleventh-largest by purchasing power parity (IMF, 2017). The Mexican economy has experienced unprecedented macroeconomic stability, which has reduced inflation and interest rates to record lows and increased per capita income. In addition, Mexico ranks highest within Latin America in the World Bank's Ease of Doing Business database in 2017, and the contract's off-taker, CFE, holds an investment-grade rating of Baa1 from Moody's.

Moreover, Mexico's abundance of diverse renewable energy resources (some of the highest wind speeds and insolation levels in the world), growing demand for power and historically high electricity

Figure 4.9 Contracted capacities and average prices resulting from auctions in Mexico, March and September 2016



Source: CENACE (2016).

prices position the country as one of the most attractive destinations for investments in renewable power generation.

Investor confidence was high in the first two rounds, boosted by a power sector reform that underscores the commitment of the government to modernise the sector, encourage private participation and increase the share of clean energy. In terms of policies, the enactment of the Electricity Industry Law institutionalised auctions for the procurement of electricity as well as the renewable purchase obligations that will drive the market for clean energy certificates. The government's official target is to reach 35% of electricity generation from clean energy plants by 2024, 40% by 2030 and 50% by 2050, up from approximately 17% in 2016, in addition to the aforementioned minimum CEL purchase requirement of 5% and 5.8% of total energy consumption in 2018 and 2019, respectively. These steps reveal the government's commitment to support the development of a renewable energy sector.

The considerable potential for future opportunities in Mexico has attracted investors to the market. Competition was stiff in both of auctions, as shown by the high awarded quantities and low prices.

Drivers of the results: auction design features

With respect to the **auction demand**, the first two auctions were held as planned and announced on time, with a third round scheduled in 2017. The clear schedule and periodicity of auctions in the context of a well-defined target for renewables gives investors clear indications of the roadmap for the sector.

The volume auctioned increased in the second round, following competition spurred in the first round. Moreover, the firm capacity product, which was undersubscribed in the first round, was 80% contracted in the second. One reason may be the increase in ceiling price for this product: It was raised more than 150-fold from USD 567/MW-y to USD 89,838/MW-y,[27] along with a tripling of the demanded quantity (from 500 MW to approximately 1.5 GW) (BNEF, 2016d).

With regard to **qualification requirements**, Mexican auctions aim to attract new players and so impose relatively few qualification requirements – which may have contributed to the competition observed in the market. Bidders are required to identify the plants (existing or future) that will back their bids for electricity products and to submit a technical proposal that demonstrates the legal, financial, technical and executive capacity to honour the commitments made in the auction.

27. MXN 10,000/MW-y to MXN 1,723,992/MW-y.

In addition, all documentation for the auctions is made publicly available for consultation *ex ante*, facilitating international participation. Participants must still pay a charge to receive the auction documents (as well as additional fees to qualify as a bidder for every bid submitted). Moreover, Mexican auctions are not site-specific, and investors are responsible for identifying potential sites and producing the relevant documentation (resource assessment, grid connection), which may constitute a barrier for some potential bidders.

Winner selection criteria in the Mexican auction are highly sophisticated. The winner is selected based on an optimisation model that maximises the economic surplus of the buyer,[28] the state-owned company CFE, on behalf of regulated consumers (see Box 4.4). As an input for this model, agents submit their bids for *packages* of energy, capacity, and clean energy certificates: a single price is given for the whole package (in USD/year), and the only options available on the demand side are to accept or reject the bids.

The treatment of locational signals was a significant change from the first to the second auction that decisively affected the selection of winners. These price signals were determined before the auction for each possible node where bidders might connect new projects; they were then published on the auctioneer's website. The signals were designed to incentivise the construction of new projects where they are most needed, *i.e.*, in regions where the supply-demand balance is tightest. Therefore, every package bid was adjusted based on a market simulation, so that the "good" locations (where nodal prices should be rewarded) were distinguished from "bad" locations (which ought to be discouraged). Even though the same methodology was implemented in both auctions, location signals were much lower in the second round.

In the first round, location signals were strong enough to promote the development of capacity in sites with lower renewable resource availability, whereas in the second renewable resource availability was the main driver for site selection (see Figure 2.11). Although the precise assumptions used to produce the long-term price signals were not made public, the change in the locational parameters suggests that policy makers expected much less congestion in the transmission grid in the second auction than they did in the first.

With regard to the **liabilities and risks faced by investors**, a main element of the design is that generators' remuneration is not simply proportional to the power they generate in a given year, but they are subject to a predefined correction factor based on when they generate the electricity. Each month of the contract's duration has 24 correction factors

Box 4.4 Mexico's bid-comparison mechanism

The Mexican auction mechanism follows a surplus maximisation objective function, where an optimisation tool is used to determine which bids will achieve the best possible outcome. This mechanism is used to provide a mathematical solution to the following trade-offs:

- Between an oversubscribed auction at higher costs for consumers or an undersubscribed auction with unmet demand: if the auction demand is, for example, 50 MW but the two lowest bids are for 40 MW each, assuming that partial bids are not accepted, should the auctioneer contract both (the auction would be 30 MW oversubscribed and consumers would have to pay the additional cost) or only the cheapest one (in which case the auction would be 10 MW undersubscribed)?
- Between an oversubscribed auction and meeting the targets for all three products (energy, capacity, and clean energy certificates): if the only way to meet the target for purchase of the capacity product is for the auctioneer to buy more energy than needed, would the best strategy be to remain oversubscribed in the energy product or undersubscribed in the capacity product?

28. The economic surplus of the buyer is defined as the difference between the maximum price the buyer is willing to pay for the product (ceiling price) multiplied by the quantity purchased, minus the sum of all the prices of the packages awarded in the auction.

(one for each hour of the day) that are calculated *ex ante* based on the system's expected needs and energy availability. A bonus or penalty is assigned to each hour of each month before the auction, based on these expectations, and the assigned values are applied to the energy delivered over the contract's duration regardless of how the system's supply-demand balance actually evolves. These positive or negative corrections, which may be less than USD 1/MWh or as much as USD 10/MWh, are individually determined for each node in the system and are equal to zero on average. These correction factors are preferable to being subject to spot price risk, as they limit the generator's exposure to a range of parameters defined *ex ante*, but they imply that the generators are subject to some degree of production risk if their generation profile deviates from expectations. The main benefit of this design is that it makes it easy for the auctioneer to compare bids for energy generated from different renewable technologies with little knowledge of their generation profile.

The 15-year duration of the energy and capacity contracts, which is shorter than the useful life of the plants, also represents a risk to investors, as they will have to procure a new contract by the time the auctioned contract expires or follow a merchant strategy (subject to spot prices). The shorter duration is often applied to contracts for conventional generation, as it is usually sufficient to cover the critical debt repayment period for most financing contracts, during which stability of revenues is most valuable for project developers. In contrast, the CELs have 20-year contracts, which means that a renewable generator has some degree of certainty over a fraction of its remuneration in years 16-20, although it must devise strategies to sell its energy in the market. The auction design elements that impact the price in Mexico are shown in Table 4.11.

Table 4.11 The auction design elements that impact the price in Mexico

Auction demand	Framework oriented towards system expansion, technology-neutral
	Recent programme
	Two auctions organised over a short period of time
Qualification requirements	Transparent process, with information publicly available
	Investors must provide site-specific documentation
	Complex process
Winner selection	Complex optimisation model to define the winners, maximising the economic surplus of the buyer
	Disclosed price cap
	Location indices heavily penalised some regions in the first auction
Investors risks	Remuneration adjusted *ex post* according to the generator's delivery hours
	15 years contract, shorter than in other markets

4.7 PERU

Background

Peru has had four rounds of auctions since the start of its programme in 2010, and the design has changed little since its inception. Aside from one auction which was exclusive to small-scale hydropower, all auctions involved the contracting of solar PV, wind, hydro, and biomass energy generation. The experience acquired with the first installations of wind and solar plants and the greater maturity of the renewable energy sector and supporting services in general, have helped decrease prices over time.

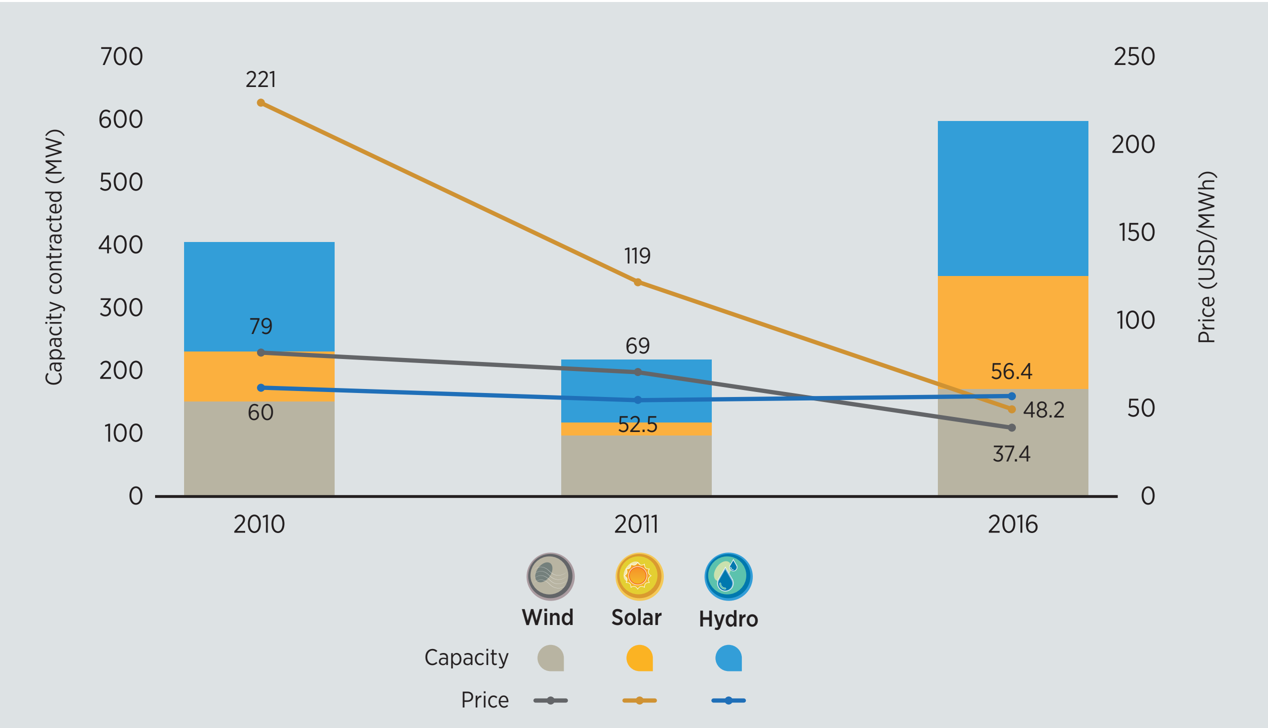
It is important to mention that, among all the countries analysed in this study, Peru was the first to auction solar power, in its very first auction in 2010. That year, solar contracts were awarded at an average price of USD 221/MWh. This has since dropped by almost 80% in the latest auction in 2016 to around USD 48/MWh. Wind energy prices have also fallen almost 50% since the first auction, to below USD 38/MWh. The price of small hydro, a technology at a more mature stage of development, changed little across auctioning rounds. Figure 4.10 summarises the results of Peru's auctions in 2010, 2011, and 2016.[29]

Biomass has attracted less interest from bidders: the contracted capacity fell from an already modest amount of less than 30 MW in the first auction to 2 MW in the second. This increased only slightly to 4 MW in the fourth auction (see Section 5.2 on undersubscription in biomass auctions). The most recent auction attracted only two bids for biomass, versus 34 for wind and 48 for solar power. The final prices of biomass projects were also slightly higher than those of other technologies; for example, the 4 MW contracted in the fourth auction was procured at USD 77/MWh (Osinergmin, 2016).

Drivers of the results: enabling environment

The abundance of renewable resources in Peru is one major contributor to low prices for solar and wind: Peru's location near the Equator results in a solar yield very close to the theoretical maximum

Figure 4.10 Contracted capacities and average prices resulting from auctions in Peru, 2010-2016



Sources: based on BNEF (2016a), BNEF (2016b), Osinergmin (2016).

29. The third auction in Peru was for hydro only.

of 25%, and the capacity factor of its awarded wind power plants is similarly high, at around 52%. The overall business environment in Peru is also attractive to investors: the World Bank has ranked the ease of doing business in Peru second in all of South America (World Bank, 2017b).

The major price decrease observed over successive auctions is largely attributed to the decrease in installation costs, the learning achieved over four auction rounds, and the boosted **investors' confidence** in the market – as reflected in the highly competitive prices achieved in the fourth round of auctions in 2016. The auctions are open to international players, and contracts shield investors from currency and inflation risks. The fact that generators' remuneration is indexed to the US inflation and exchange rate (being effectively nominated in US dollars), attracts **international institutions as major financers** of renewable energy projects in Peru. Even though most of the costs of developing new renewable capacity indeed follow the US dollar, as equipment is mostly imported, the devaluation of the Peruvian sol (by around 20% since late 2013) may have also played a role in auction price outcomes, by decreasing labour costs and other balance-of-system components in US dollars. Moreover, the Peruvian auctions have succeeded in attracting large international players, such as Enel Green Power. Given the volume of their purchases, these multinationals can push suppliers for lower prices, start construction off the balance sheet, finance with corporate debt and possibly use other tools like green bonds (EGP, 2016).

Peru's **policies to foster the development of renewable energy** started in 2008 with the enactment of *Legislative Decree 1002/2008* that set the grounds for renewable energy auctions, and set a mandatory target of 5% of generation from non-hydro renewable energy sources by 2013. While this target had not been revised as of 2016 (Climatescope, 2016), Peru's 2014 National Energy Plan outlines the intention to achieve 60% of renewable energy in total generation by 2024, including large hydro (IRENA, 2014). Given that renewables already composed more than 50% of the electricity mix in 2015 (with large hydro accounting for 41.2%), achieving this goal seems realistic. Considering the country's background and experience, auctions can play a major role in the process of increasing renewable capacity.

Drivers of the results: auction design features

Peru's renewable energy auction has functioned as the main mechanism for deployment since 2010. Regarding the **auction demand**, Peru is one of the first countries to contract solar power through an auction and has since gained a lot of experience in the design and implementation of auctions with revisions on the design based on the lessons learnt. The target for renewable energy's share of the electricity mix is clearly communicated although not particularly high. The auction process has been transparent, and information regarding previous auctions is made available on a web-portal, instilling confidence in the market and attracting investors into the sector.

With respect to **qualification requirements,** Peruvian auctions are relatively loose. Designed to attract international investors, auctions involve few administrative barriers. The only restrictions are a minimum of two years of experience in electricity generation for the developer and that equipment is manufactured within two years before it is installed. There is no dedicated qualification phase, and no local content requirements for project developers. The documentation required is relatively minimal and it includes resource assessments carried out for a period of at least one year. This simple and straightforward design attracts a wide range of bidders, including international project developers.

The auctions are technology-specific, with demand bands defined for each eligible technology. The **winner selection** is based exclusively on the lowest prices until the volume auctioned per technology is covered and the remuneration is determined using a pay-as-bid mechanism. The Peruvian regulator the *Organismo Supervisor de la Inversión en Energía y Minería* (Osinergmin) determines a ceiling price for each technology, above which no offer will be accepted. In the first few auctions, this price was not disclosed and many bidders were disqualified for bidding above the ceiling, but in later rounds it was disclosed before bid submission.

One aspect of the Peruvian auctions that contributes to low prices is that there is no limit on the percentage of the auction's demand that can be awarded to a single company. In the fourth auctioning round, Enel Green Power submitted the lowest bids for both wind and solar, taking advantage of economies of scale. Bidders were then allowed to compete for the unmet demand (for biomass capacity) by resubmitting their offers in a new bidding round. The wind and solar projects contracted in this second round, although much smaller than Enel's, were awarded at similar prices. They included a 40 MW solar project from Enersur (at USD 48.50/MWh) and two 18 MW wind projects from Grenergy.

Regarding **risks and liabilities**, the financial conditions of the Peruvian auctions are generally very favourable to investors. Contracts are nominated in Peruvian sol, but are indexed to the US dollar exchange rate and to US inflation, guaranteeing a stable real remuneration in US dollars and shielding international investors from foreign exchange and inflation risks. The auctioned projects are also guaranteed grid access and priority dispatch, which minimises developers' operational risks. Moreover, in Peru, the Ministry of Mines and Energy itself is the contract off-taker as a representative of the Peruvian State, which means that suppliers are offered essentially sovereign guarantees from the government (Osinergmin, 2015).

The generators' biggest liabilities are the guarantees and performance penalties. Bidders need to deposit a bid bond equivalent to USD 50,000/MW to be installed and a completion bond of USD 250,000/MW installed. In case a project is delayed, Osinergmin requests the developer to increase their guarantee of completion by 20%. Compliance with volume of energy generation contracted is ensured by penalising shortages. In the case of delays, extension can be granted and/or performance bond value is increased. In the event of non-compliance, the Ministry of Energy and Mines may terminate the contract (IRENA, 2013). The auction design elements that impact the price in Peru are shown in Table 4.12.

Table 4.12 The auction design elements that impact the price in Peru

Auction demand	Long-running programme with lessons learnt from past experience
	Clear and transparent rules
	Targets not too high compared to current status
Qualification requirements	Transparent process, with information publicly available
	Bidders must provide site-specific documentation
Winner selection	Based only on the price
	Following pay-as-bid mechanism
	Price ceiling disclosed and drives competition
Investors risks	Contracts indexed to USD and inflation
	Guaranteed grid access, priority dispatch
	Generators are penalised if they deviate from committed quantities
	High bid bond and project completion bond

4.8 UNITED ARAB EMIRATES

Background

The United Arab Emirates (UAE) is among the first Gulf Cooperation Council members to introduce an energy diversification strategy, put in place to ensure a more sustainable energy future. The country has set a target of 44% renewable energy in the energy mix by 2050. This has been translated into policies and measures at the subnational level, with auctions at their heart. The solar auctions that were held in both Emirates of Dubai and Abu Dhabi were widely known as they all set global records for low prices at the time they were awarded.

In 2012, the Emirate of Dubai launched the Mohammed bin Rashid Al Maktoum Solar Park that hosts 5 GW of solar on 40 square kilometres of land located south of Dubai. In 2013, a 13 MW PV power plant was commissioned as phase I of the project. In November 2014, the Dubai Electricity and Water Authority (DEWA) auctioned a 100 MW PV power plant as phase II, with record-breaking results at the time: USD 58.5/MWh for a re-negotiated capacity of 200 MW that has been brought online.

In May 2016, DEWA auctioned another 800 MW as phase III. The auction set a new world record for solar power, with a winning bid of USD 29.9/MWh. This marked the lowest price for solar power at that time, and was cheaper than all fossil-fuel options in Dubai. The lowest bid was submitted by a consortium of Abu Dhabi's Masdar and FRV (Spain/Saudi Arabia).[30] The bid was 19% lower than the second-lowest bid and 50% lower than the winning bid submitted just 18 months earlier in the phase II auction, as shown in Figure 4.11.

In 2016, the Emirate of Abu Dhabi received bids for a 350 MW auction that resulted in yet another record-breaking price. Following negotiations, a price of USD 24.2/MWh was awarded to Jinko Solar (China) and Marubeni (Japan), for 1.17 GW capacity in March 2017. These record-breaking prices for solar PV are a result of many factors, some related to overall conditions in the country and others to the auction design.

Drivers of the results: enabling environment

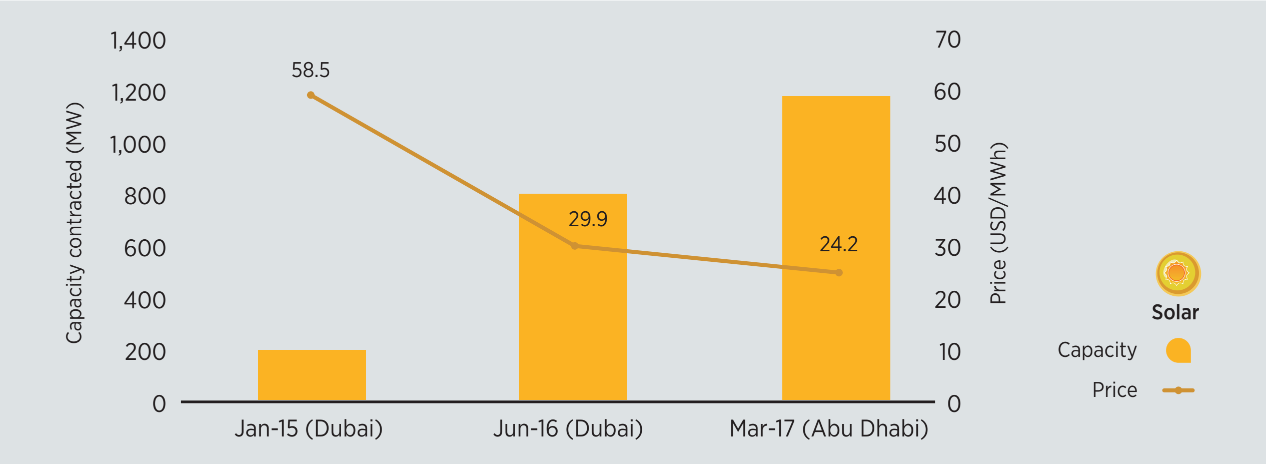
The availability of solar resources and vast land, project ownership, and **access to finance** are among the largest contributors to the United Arab Emirates' highly competitive price outcomes. The country boasts large surfaces of land with solar irradiation levels among the highest in the world year-round. The land is also provided as part of the site-specific auction, along with grid access.

As for financing, the country's high credit rating (AA with stable outlook by Standard & Poor) and ease of doing business help keep the costs of capital low. Moreover, the particular equity structure of the awarded projects may have played a role in enhancing investor confidence and reducing the cost of financing. Government-owned utilities, who are also the off-takers, own the majority share of project equity. In Dubai, the utility Dubai Electricity and Water Authority (DEWA) has a 60% stake in the projects, leaving 40% to the developer. The same holds true in Abu Dhabi, where the Abu Dhabi Water and Electricity Company (ADWEC) has a 60% stake. This signals the nation's commitment to renewable energy, and alongside the fact that both utilities are creditworthy, boosts **investor confidence**.

As for **renewable energy policies**, in addition to the national target of 44 percent renewable energy by 2050, the Emirate of Dubai announced its target to provide 7 percent of its energy from clean energy sources by 2020. This target will increase to 25 percent by 2030, and to 75 percent by 2050. Abu Dhabi is in the process of revising its target of 7 percent renewables in the electricity mix by 2020. Part of the demand in Dubai will be met by the expansion of the Mohammed bin Rashid Al Maktoum Solar Park to a total capacity of 5 GW, and by equipping rooftops with solar PV by 2030. Moreover, the United Arab Emirates has low cost of labour and energy, reducing both capital and operational expenditures.

30. In March 2017, EDF Energies Nouvelles (EDF EN) bought FRV's stake in the project (Tsanova, 2017).

Figure 4.11 Contracted capacities and average prices resulting from auctions in the United Arab Emirates, 2015-2017



Sources: Based on BNEF (2016a,c) and Hartenstein (2016).

Drivers of the results: auction design features

Regarding the **auction demand**, one major strength related to the robustness of the auction is the announcement of the long-term plan. At the launch of the auction in Dubai, the authorities announced that the Mohammed bin Rashid Al Maktoum Solar Park would eventually host 5 GW of installed solar power, which indicates regular scheduling of auctions in the future. The high creditworthiness of the off-taker, which is also a stakeholder in the project in both auctions, boosts investor confidence. Moreover, both auctions are project-specific with predefined sites for the construction and connection to the grid, which significantly reduce risks and costs on developers.

Qualification criteria are most often stringent, limiting participation to experienced players in the solar market. The bidders have been required to present rigorous, detailed technical and financial proposals. In Dubai's phase III auction, for instance, out of the 97 parties that offered an expression of interest, only 14 consortia were prequalified and invited to submit bids. The costs of submitting a bid are high, and eventually only 5 consortia submitted final proposals. Moreover, publicly available information on auctions is restricted, which may limit participation of interested developers and create an artificial barrier to entry.

In terms of the **winner selection criteria**, UAE auctions are straightforward, adopting a minimum-price criteria. This is a common approach to auctions that include a detailed qualification phase, with the underlying assumption that all qualified players are equally capable of developing the project in question. Therefore, among the players that are qualified to participate in the auction, the PPA is awarded to the lowest price offered.

Moreover, there are no restrictions on the size of the project, resulting in 800 MW being awarded at once in Dubai and up to 1.17 GW in Abu Dhabi. Although this practice permits significant economies of scale that are reflected in price outcomes, it has two repercussions for the industry. First, in case the developer defaults, the government would be left vulnerable to risk; and second, the big winner effectively drives other players out of the market, leaving little room for the development of local industry.

In terms of the **liabilities and risks** faced by investors, the substantial participation of utilities in the project (60% of equity) significantly reduces bidders' risk exposure. The direct involvement of the local authority as a participant in the project's equity provides noteworthy safety against any bureaucratic and development risks that could emerge.

The auction design elements that impact the price in the United Arab Emirates are shown in Table 4.13.

Table 4.13 The auction design elements that impact the price in the United Arab Emirates

Auction demand	Relatively recent programme
	Ambitious target of 5 GW announced in Dubai
	Project-specific with available land, resource assessments, grid access and needed permits
Qualification requirements	Lack of widely available information on the process
	Very stringent qualification requirements, to allow only big and experienced players
Winner selection	Based only on the price
	Following pay-as-bid mechanism
	No upper limit on project size
Investors risks	Contracts awarded in USD and indexed to inflation
	Co-ownership project with public authority

4.9 ZAMBIA

Background

Sub-Saharan Africa has experienced unprecedented economic growth over the past years. Tapping into the region's abundant renewable energy resources seems to be a clear path toward achieving long-term economic and social goals. In this context, the deployment of solar power has recently emerged as a potentially major contributor to the diversification of the region's energy mix. Although the merits of solar power as a solution for off-grid and small-scale electrification efforts have long been known and new initiatives are constantly being sought, utility-scale solar solutions are becoming increasingly important as costs become more competitive. Zambia was the first country in which the Scaling Solar programme was implemented, with the Industrial Development Corporation (IDC) of Zambia officially engaging the International Finance Corporation (IFC) as lead transaction advisor.[31]

The Scaling Solar Programme aims to provide a one-stop-shop including advisory services, standardised contracts, and a stapled offer of investment products (financing) and risk management services/products (guarantees and insurance) for which bidders are free to apply. The IFC, the World Bank International Development Association (IDA), the International Bank for Reconstruction and Development (IBRD), and the Multilateral Investment Guarantee Agency (MIGA) jointly drafted a set of template documents including a PPA and government support agreement (GSA). These agreements offer a fair, balanced and bankable allocation of risk between the government and private parties, based on which the IFC, the World Bank and MIGA would offer project-specific financing and guarantees.

The programme aims to make privately funded grid-connected solar projects operational within two years and at competitive tariffs to mitigate Zambia's power shortage, estimated at 560 MW in 2015. In May 2016, Zambia completed its first solar auction, designed to develop two PV projects of up to 50 MW in the Lusaka-South Multi-Facility Economic Zone. The auction was very competitive and it attracted a total of 48 solar power developers, out of which 11 were prequalified to submit full bids.

Two winning bidders were announced in June 2016: Neoen/First Solar, with 52 MW at USD 60.2/MWh, and Enel Green Power, with 34 MW at 78.4/MWh. The prices bid were much lower than expected, and among the lowest in the world (see Table 4.14).

Table 4.14 Results from the auction in Zambia

Bidders	Bids received for the West Luga Site (USD/MWh)	Bids received for the Mosi-oa Tunya Site (USD/MWh)
Neoen / First Solar	60.15	61.35
Enel Green Power	77.99	78.40
Access / EREN Zambia 1	82.88	89.51
MULILO Zambia PV1 Consortium	84.00	84.00
EDF Energies Nouvelles	100.40	99.85
SEP / AVIC Intl	106.00	106.00

Source: IFC (2016).

31. An in-depth analysis of the case of Zambia is presented in IRENA, 2017b forthcoming.

The contract tariffs are fixed, nominated in US dollars with no indexation for the entire 25-year PPA term established with the state-owned utility Zambia Electricity Supply Company (ZESCO). This means that the USD 60.2/MWh is comparable to a price of about USD 50/MWh in real terms[32] (see Section 2.2).

Drivers of the results: enabling environment

Following real GDP growth averaging 6.4% per year between 2010 and 2014, Zambia now faces declining economic growth rates. This is partly due to falling commodity prices, expensive borrowing on international markets and a weakening currency (World Bank, 2015). Although the economic conditions in Zambia are not very favourable to investments, auction winners that opt to apply for pre-approved credit may receive **competitive financing** and insurance. This financing and guarantee scheme, designed in partnership with reputable international institutions, intends to boost **investor confidence** in the Zambian solar market and to send a positive signal to market agents.

As for **policies in the renewable energy sector**, the Scaling Solar Programme is the most significant in the region and it aims to develop 1 GW of solar power in neighbouring African countries within three years. New initiatives have already been announced in Ethiopia, Madagascar and Senegal, and a second round of auctioning in Zambia (PV Magazine, 2017).

Drivers of the results: design factors

Regarding **auction demand**, the programme is relatively new and there has been only one auction round so far. However, a key goal of the Scaling Solar Programme is to create a standardised PPA and systematic auction design to be used in multiple initiatives across Sub-Saharan countries. The 100 MW auction was the first round of a systematic programme, with a target of 600 MW. The government's commitment to a second round of auctions in Zambia also signals a degree of commitment and regularity.

With respect to **qualification requirements**, the Zambian auction involved a pre-qualification round in which potential bidders were accepted or rejected before they could submit their bids. Detailed legal, financial and technical due diligence was completed before interested bidders could proceed to the request for proposal (RFP) stage. The pre-qualification stage proved to be quite stringent: only 11 of 48 interested bidders were able to submit a bid. However, some design elements encouraged bidders' participation. For example, bidders were not required to register a special-purpose entity/vehicle (SPV) in Zambia, as this would be done together with the IDC post-award. And the financial health of Zambian companies was analysed in special way to help them qualify.

The auction was site- and project-specific, with the aim of reducing costs and risks of developers (land acquisition being a significant risk in most African countries) and ensuring the rapid implementation of projects. Choosing a project site beforehand not only ensures that the required transmission infrastructure is in place, but also that required data (*e.g.* on solar resources) and permits have been handled and coordinated by the government. The IDC leased the land for the two solar plants and will on-lease it to the SPVs for the duration of the PPA – significantly reducing the project development and capital expenditure costs for developers. Although developers are responsible for grid connection works, the project sites already had suitable substation and transmission infrastructure in place. Bidders were therefore only required to fund and build the grid interconnections and hand over the infrastructure on the buyer's side of the supply point to ZESCO.

While local content was encouraged, it was not a requirement for bids to be considered compliant, signalling that socio-economic benefits were perhaps not the main priorities of the auction. In the face of significant power shortages and economic pressures, it might be that the main priority is to contract additional power at the lowest cost possible, in a short time frame.

Finally, the auction process is transparent and simple, aiming to ensure strong participation and competition from committed industry players. Template financial models and auction documents

32. Considering 2% US inflation and a project rate of return of 8%.

are used to speed up the process, which also serve to reduce the bureaucratic costs of participation and encourage rapid financial closure and construction post auction award.

The **winner selection** is based solely on the minimum price offered for each project in the auction; other relevant criteria are incorporated in the pre-selection of sites and pre-qualification of participants. The auction adopted a pay-as-bid model for paying the winner. This strong commitment to price competition signaled the importance of low tariffs to the market, and ensured that bidders responded accordingly. In this spirit, bidders had the flexibility of sizing their plants between 33 MW and 55 MW in order to minimise costs. The two winning bidders made use of this provision, with the winning bid of Enel Green Power sized at 34 MW, and that of Neoen/First Solar at 52 MW. While no official ceiling price was communicated, the IFC set USD 160/MWh as the maximum it would consider as a lender.

Regarding **sellers' liabilities**, the need for significant power supply within a short time frame led to rather strict compliance rules. Bidders were required to post a bid bond of USD 1.3 million per project (equivalent to USD 26,000 per MW, assuming 50 MW per project). Regarding settlement rules and underperformance penalties, projects are expected to maintain a performance of at least 75% (a test is to be carried out at the end of each contract year). If this minimum is not maintained, the developer would have to pay ZESCO liquidated damages at the rate of USD 7,500 for every 0.1% below 75% (up to USD 750,000 per year). As for delay and underbuilding penalties, bidders must present a construction bond of USD 15 million, set to expire after the project reaches its commercial operations date (COD). Failure to complete commissioning by the COD would result in the PPA being terminated. Winning bidders are also required to post a decommissioning bond of USD 100,000 per MW (USD 5 million for a 50 MW plant) at least one year prior to the PPA's expiration. After this, non-generation is a seller risk.

The Zambian programme offers no bid indexation. Tariffs are denominated in US dollars, potentially exposing the Zambian government to significant foreign exchange risk, especially given the significant depreciation of the local currency in recent years. This risk is becoming increasingly common, and problematic, in many African countries.

Regarding assigned liabilities for transmission delays, ZESCO is responsible for providing solar PV plants with a point of connection five months prior to the scheduled COD. Failure to do so would enable project developers to claim *deemed energy payments* for the period during which they were unable to deliver power due to transmission delays. If the delay affects the plant's commissioning date, the contract would be extended by one day for each day's delay.

As for guarantees and credit enhancement mechanisms, the Zambian auction had relatively standard liquidity support mechanisms in place, including payment guarantees and (if required by commercial lenders) loan guarantees, but the market opted for the payment guarantees. The issue of possible off-taker default/insolvency and risks due to host government sovereign credit ratings were addressed by using a government support agreement. In the event of buyer default, the government does not to assume responsibility for all PPA payments, as would be the case in a standard sovereign guarantee; instead, the government buys the asset or shares in the project company at a pre-determined price. There are also further liquidity arrangements in place, such as letters of credit issued by a commercial bank and backstopped by a Partial Risk Guarantee (PRG) covering six months' worth of PPA payments. The presence of the PRG means that ZESCO does not have to cash collateralise the letters of credit, since the banks are essential providing credit to the World Bank.

The guaranteed financing options are set out in clear terms and linked to required documentation. This significantly reduces risks associated with financial closure and negotiations after the signing of auctioned contracts, freeing bidders to focus on the technical and commercial benefits of their submissions.

The auction design elements that impact the price in Zambia are shown in Table 4.15.

Table 4.15 The auction design elements that impact the price in Zambia

Auction demand	No history of renewable energy auctions
	Part of a robust programme targeting 1 GW solar installation in Africa (Scaling Solar)
	Very robust support of the IFC and WB
	Site-specific with data, permits and grid access provided by the government
Qualification requirements	Transparent, straightforward standardised set of rules and documents
	No local content requirements
	Strict legal, financial and technical requirements
Winner selection	Minimum price selection criteria
	Pay-as-bid mechanism
	Upper limit on project size
Investors risks	Contract does not include escalation clauses
	Strict compliant rules (bid bond, completion bond, performance penalties)
	Risk mitigation guarantees for developer (loan guarantees and payment guarantees)

5 TECHNOLOGIES IN FOCUS: OFFSHORE WIND AND BIOELECTRICITY

5.1 OFFSHORE WIND

Until very recently, offshore wind was a high-cost source of renewable electricity, but costs are falling as governments and the private sector undertake concerted efforts to make it more competitive. In June 2016, energy ministers from nine European countries signed a memorandum of understanding to reduce offshore wind costs, only days after 11 major energy companies issued a statement that offshore wind costs could fall to USD 85/MWh by 2025. Indeed, costs have already fallen far below that.

In 2016 alone, the generating costs of auctioned offshore wind projects fell by 22% (BNEF, 2016e). Besides economies of scale, this is due to a growing and competitive supply chain, cross-industry collaboration, ongoing technological innovation, and continuous improvements in foundation design and installation methods (IRENA, 2016d). Bigger turbines and enhanced construction know-how are also factors, as are experimental technologies such as floating platform solutions. Meanwhile, the investment climate for long-term infrastructure projects has been favourable in recent years, expanding access to finance.

Offshore wind auctions are adopted in a growing number of countries, including China, Denmark, France, Germany, Japan, the Netherlands and the United Kingdom. In 2016, prices decreased substantially in Denmark (by almost 25%) and in the Netherlands (by almost 30%). Table 5.1 summarises the results of offshore wind auctions in 2016 and Figure 5.1 shows the trend in prices in countries that have adopted auctions since 2010.

In 2017, Germany held its first auction for offshore wind (so far supported by a feed-in tariff) where developers showed high confidence in the offshore wind industry. Developers were to bid by offering a strike price of EUR 0/MWh and EUR 60/MWh:

- Bidding a EUR 0/MWh strike price means that the developer only receives the wholesale market price for electricity generated with no premium.
- Bidding a EUR 60/MWh strike price means that: if the wholesale market price is below EUR 60/MWh, the generator is entitled to a premium top up equal to the difference between the strike price (EUR 60/MWh) and the market price. If the wholesale market price is above EUR 60/MWh, the generator receives the market price.

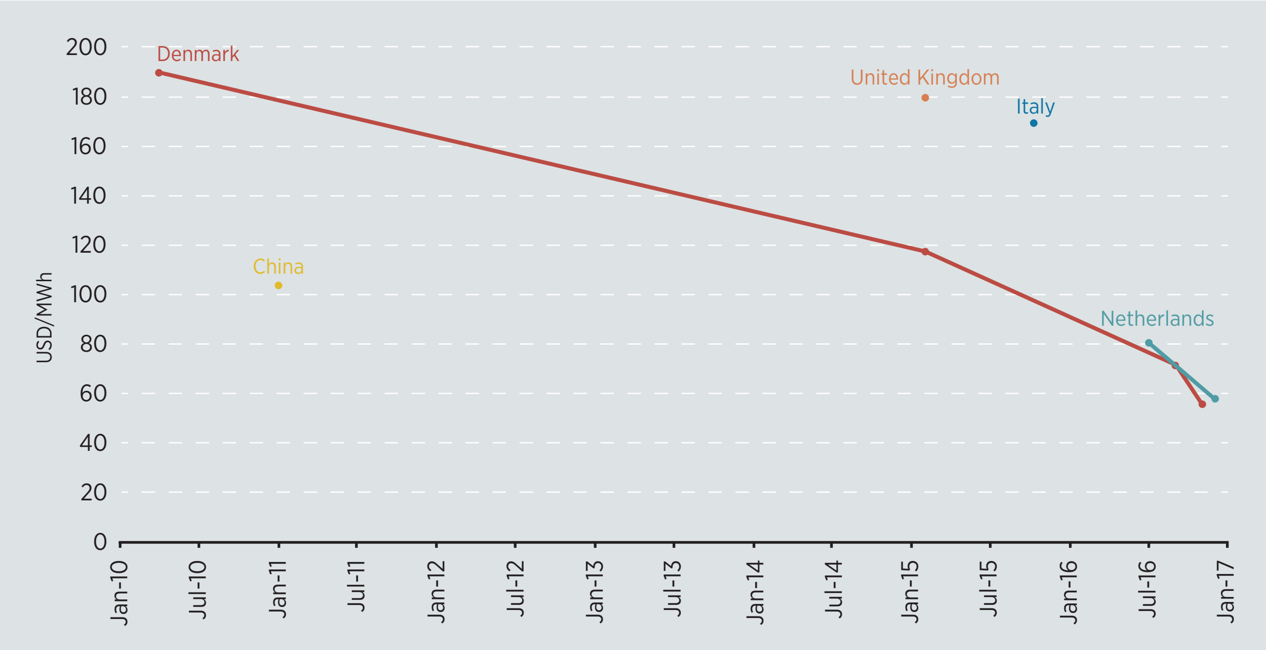
Out of the four winning projects, three (1,380 MW out of the total 1,490 MW) offered a strike price of EUR 0/MWh meaning that they did not request any support on top of wholesale electricity prices (see Table 5.2).

Table 5.1 Auctions for offshore wind in 2016

Country	Date	Winner(s) of the bid	Capacity (MW)	Price (USD/MWh)	Total contracted to date
Denmark	Sept 2016	Vattenfall	350	71.5	2,350 MW
	Nov 2016	Vattenfall	600	53.9	
The Netherlands	Jul 2016	DONG	700	80.4	1,400 MW
	Dec 2016	Shell-led consortium	700	57.4	
Japan	Jan 2017	Kyuden Mirai-led consortium	229	ND	229 MW

Sources: Based on Escritt (2016), Roselund (2016), Kitakyushu city government (2016), Vattenfall (2016), Weston (2016a).

Figure 5.1 Evolution of average auction prices for offshore wind, 2010-2017



Note: In Germany, auctions for offshore wind award a strike price, not a fixed price as part of a power purchase agreement. In the United States, offshore wind auctions award rights for exploration in a given area, rather than awarding a power purchase agreement

Sources: Based on AURES (2016b), BNetzA (2017b), Escritt (2016), GSE (2016), IRENA (2013), Roselund (2016), Vattenfall (2016), Weston (2016a).

Some developers have successfully won more than one bid in the same area, benefiting from economies of scale, past experience and market power. Given the volume of their purchases, these developers can push suppliers for lower prices. As of September 2016, Vattenfall, for example, had installed 1,325 MW of offshore wind capacity (out of a total of 2,265 MW wind installed) in Denmark, Germany, the Netherlands, the United Kingdom and Sweden. DONG secured three projects in Germany totalling 590 MW, following its 700 MW win in the Netherlands.

As can be seen in Figure 5.1, China has organised only one auction, in 2011, and this resulted in much lower prices than those attained in Denmark at the time. In 2015, the United Kingdom organised an auction, and this resulted in a higher price than in Denmark in the same year. Following a steady decrease in prices, Denmark achieved the lowest price in November 2016, with 600 MW contracted at around USD 53.9/MWh (almost a 25% decrease since its 350 MW auction only two months before) in the project-specific auction for the Kriegers Flak plant, located in the Baltic Sea.

Table 5.2 Results of the German offshore wind auction

Project	Owner	Capacity (MW)	Strike price (EUR/MWh)	Delivery year
He Dreiht	EnBW	900	0	2025
OWP West	DONG	240	0	2024
Borkum Riffg W 2	DONG	240	0	2024
Gode Wind 3	DONG	110	60	2023

Source: NERA, 2017.

In the Netherlands, a country less experienced in offshore wind than Denmark, two 700 MW offshore wind farms were auctioned in July and December 2016, at average prices of USD 80.4/MWh and USD 57.4/MWh, respectively. This is a decline of nearly 30% between two auctions only six months apart.

These new prices are comparable to onshore wind and solar PV (especially in the case of German projects selling at wholesale market price). The rapid decline has been driven by factors discussed in Chapter 3, including country-specific conditions, investors' confidence and access to finance, renewable energy support policies and auction design. Several design elements are particularly relevant to price. These include specifying the project site to reduce investor risks and costs, setting up qualification requirements so as to minimise bidders' transaction costs, setting winner selection criteria that favour lowest prices and designing contracts, and defining liabilities so as to encourage bidders.

Auction demand: Site-specific auctions can help reduce investor risks

Site-specific auctions are suitable for markets and technologies at early stages of maturity; they reduce project developers' risks and facilitate the procurement of necessary permits and documentation by centralising this task to the government. Indeed, site-specific auctions have been the norm for offshore wind auctions in China, Denmark, Germany, Japan, the Netherlands and the United States. Pre-selecting a site typically implies that the installed capacity and grid interconnections are determined beforehand, allowing policy makers and project developers to concentrate their efforts on the particular challenges and features of the chosen site, and to tailor the auction design and awarded contract to these conditions.

In some cases, developers can choose a preferred site from a pre-selected list. This can help identify the best sites. For example, Denmark introduced a multi-site tender for nearshore wind, with six predefined areas in which developers were allowed to bid to build a project with a maximum capacity of 350 MW. This provision also provides the flexibility to allocate the auction demand to multiple winners, whereas a project-specific auction typically awards the entire concession area to one winner.

In the United Kingdom, projects are not site-specific, which in part explains why prices were higher than in Denmark. In fact, the design of the auction does not follow the traditional site- and technology-specific norm for offshore wind, since the auction in the United Kingdom is technology-neutral (see Box 5.1). The auction passes on costs to the project developers for activities such as grid connection, transmission, resource assessments and environmental impact assessments, unlike in Denmark and the Netherlands where they are paid by the government or the transmission system operator (TSO). In addition, projects in the United Kingdom are located in deeper waters than Danish and Dutch projects, which can also impact installation costs.

While the UK auction design serves the purpose of letting markets decide the most cost-competitive technology, its results indicate that mitigating the risks and responsibilities assigned to bidders (or not) can have a substantial impact on the auction price.

Box 5.1 **Technology-neutral auctions in the United Kingdom**

In the United Kingdom, the volume auctioned in the first round (determined by strict budgetary constraints) was divided into two bands: one for mature technologies (onshore wind, solar PV, energy from waste, 5–50 MW hydropower, landfill gas and sewage gas), and another for less established technologies (offshore wind, biomass, wave, tidal, stream, anaerobic digestion and geothermal). By allowing competition between different technologies within each group, the auction design enabled the discovery of the lowest-cost technology while allowing less mature technologies to develop. Official policy statements indicate an intention to move towards full technology neutrality in the future (AURES 2016b).

Qualification requirements: Site-specific auctions can help reduce transaction costs

The qualification requirements tend to be less stringent in site-specific auctions, since sites are pre-determined and bidders only need to prove their technical and financial capability to deliver the project. In Denmark, for example, qualification criteria focused on the bidders' experience in the construction, operation and management of offshore power plants; the type of turbine and foundation likely to be used; and the financial viability of the project. Similarly, in the Netherlands, pre-qualification requirements ensure that only those able to undertake the task, both financially and technically, can participate in the tendering procedure. In the United Kingdom, where bidders propose their own sites, qualification requirements tend to be more stringent and bidders must present additional documentation, such as (AURES, 2016b):

- A connection agreement ensuring ability to connect to the grid;
- Proof that the project does not receive financial support from other renewable energy incentives (Renewable Heat Incentive, Renewables Obligation, and the Capacity Market Scheme);
- A plan detailing how the project will promote competition, innovation and skills in the local supply chain (for projects with installed capacity above 300MW); and
- Spatial planning requirements and permits.

One considerable source of risk with regards to site selection is the impact that an offshore project could have on the marine life, fisheries and other economic activities in the area. Environmental licensing for offshore wind tends to be a complex and costly endeavour, especially compared with onshore wind and solar, and conflicts with the fishing industry can lead to administrative difficulties (see Box 5.2 for a case study of New York in the United States).

In addition to facilitating the participation of bidders through a streamlined qualification process, a simplified auction design that aims to award projects only based on the price offered can help increase the competitiveness of offshore wind technology.

Winner selection process and criteria that favour the lowest price

How winners are selected can impact the resulting price. Most countries, including Denmark, the Netherlands, the United Kingdom, and the United States, have adopted a minimum-price criterion to select the winner. In Japan, however, a weighted score considering multiple aspects was used, highlighting other important policy objectives besides attaining the minimum price possible (see Box 5.3).

China also adopted a multi-criteria selection process, following the model used for onshore wind and solar PV mostly as a mechanism to avoid underbidding (IRENA, 2013).

Box 5.2 Complications in site-selection for offshore wind in New York

In 2016, the Bureau of Ocean Energy Management (BOEM) announced a bid to lease 79,350 acres in New York for offshore wind.

The United States competitively awards rights for exploration in a given area, rather than awarding a power purchase agreement directly. This assigns substantially more risk to the developer, who has little assurance that the investment will be recovered or even that the project will be built. The US BOEM has gathered rich experience in awarding competitive leases: by the end of 2016, it had awarded nine commercial wind leases worth more than USD 16 million over an area exceeding a million acres.

In the New York case, BOEM had to remove about 1,780 acres from the lease area after an environmental assessment identified the seafloor as a sensitive habitat to be avoided for the placement of structures. Moreover, in response to environmental concerns regarding commercial fishing interests, bidders were required to develop a publicly available fisheries communications plan and work with a fisheries liaison to facilitate communication with the fishing industry.

Source: DOI, 2016.

Box 5.3 Winner selection criteria in Japan's offshore wind auction

In early 2017, Japan adopted offshore wind auctions for the first time. The government approved legislative changes that give project owners the right to operate wind farms for 20-year leases - up from the original port occupancy limit of 10 years - with the possibility of renewal at the end of the period.

One of the main qualification requirements is past experience in developing or operating offshore projects of at least 10 MW. The winner selection process involves a score-based system, with different weights assigned to various criteria that include bidder credentials, project documentation and feasibility, proposed financing structure, and socio-economic contributions to the port area and local companies.

A consortium led by regional Japanese utility Kyuden Mirai won the auction for developing what would be Japan's largest offshore wind farm to date. The project will cost USD 1.5 billion[a] and is expected to add 229 MW to the current fleet. The wind farm will consist of 44 turbines installed on jacket foundations roughly 10 km off the port of Hibikinada. Construction is to start in 2022 following an environmental impact assessment expected to take three to four years to complete.

This auction could help kick-start the Japanese offshore industry, partly by increasing the bankability of offshore projects and opening up new financing channels. The construction and financing of offshore wind projects in Japan has been stifled largely due to difficulties in obtaining legal rights to offshore sites. The recent legislative amendments are likely to be a game changer, but some obstacles remain. For example, Japan's environmental impact assessment requirements remain costly, despite ongoing efforts by the Ministry of Environment to streamline the process.

a. Almost JPY 170 billion. Exchange rate considered: 1 JPY = 0.0088 USD in March 2016.

Source: Kitakyushu City Government, 2016.

In both off- and onshore wind auctions, the project developer and turbine manufacturer have to submit a joint bid, offering a detailed manufacturing plan for complying with domestic content requirements. As part of its multi-criteria winner selection methodology, the highest score for the price obtained is that closest to the *average* price, accounting for 55% of the bid score. This average price criterion protects against adventurous bidders who might not be able to honour the contract, and it discourages bidders from offering below-market prices. This scheme presents two main drawbacks: it encourages bidders to bid based mostly on their competition instead of their costs, and tends to harm the most competitive bidders (*e.g.,* those with higher technology productivity etc.). This scheme was first implemented in onshore wind auctions in 2007, and was then adopted for offshore wind.

While the majority of global offshore wind auctions have involved a single-stage sealed bid procedure, some Danish auctions adopted a two-round procedure, with a *first indicative offer* round followed by a *best and final offer* round. After the indicative offer, meetings with the bidders are held individually to determine the conditions for the final bid round. This might have contributed to the low prices achieved in Denmark. As for the payment to the winner, Denmark and the Netherlands adopted a pay-as-bid mechanism, and the United Kingdom used a mechanism for remunerating developers based on the bid strike price and the reference electricity price which is based on the market price (see Box 5.4).

Contract design and sellers' liabilities

As discussed in Section 3.4, the price outcome is heavily impacted by: the date of project delivery; structure of the contract, including the remuneration profile of the developer; and the penalties and liabilities involved.

One very important factor that contributed to the low bids in the German offshore auction is the date of project delivery, which is not until 2024–25 for most of the projects. Projects commissioned in later years are expected to incur lower technology costs, as turbine and construction costs decline and technology advances (*e.g.,* bigger and more corrosion-resistant turbines). In contrast, projects awarded in the United Kingdom are expected to come online between 2017 and 2019, leaving little time for costs to fall.

In the case of offshore wind, countries employ various kinds of contract terms. France, for instance, awards a PPA of 20 years, while in the United Kingdom and the Netherlands, contracts are for 15 years. Denmark, on the other hand, employs a scheme that remunerates a capped number of hours. The duration of support for all wind farms contracted in Denmark is for a fixed amount of production that corresponds to 50,000 full load hours. With a potential of around 4,000 full load hours per year, the expected support period is between 12 to 15 years.

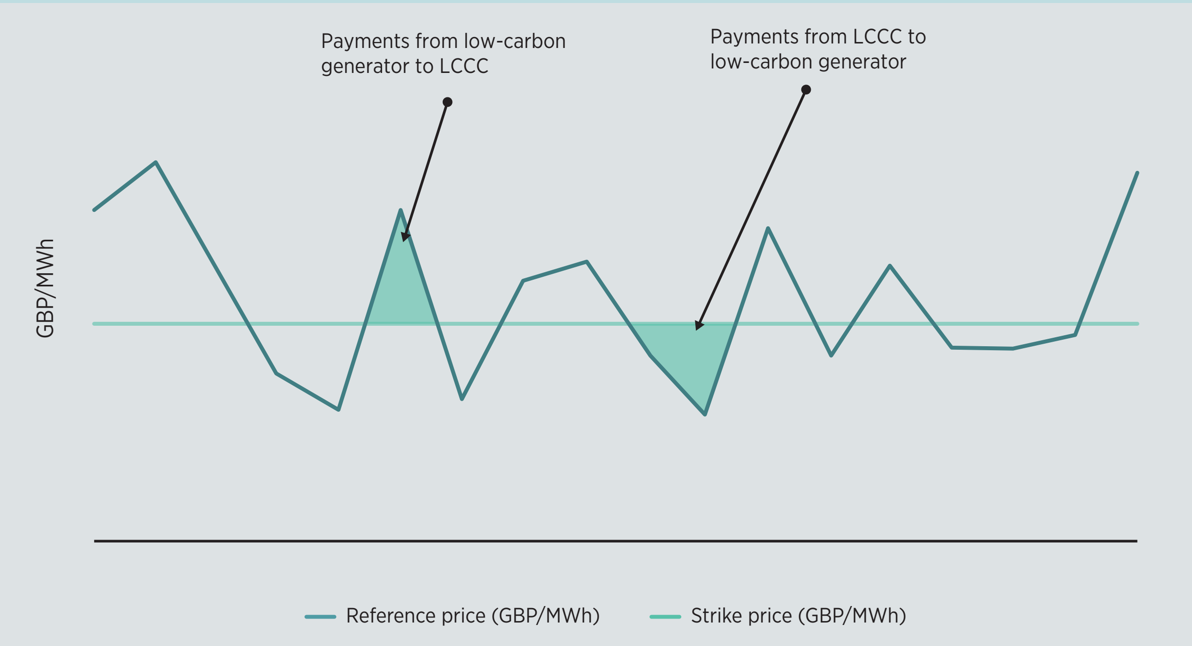
The volume cap effectively mitigates upsides and downsides associated with the plant's mean production factor: if the project generates more than expected during the early years, for example, the length of the support is automatically reduced. The price awarded is also not inflation-indexed, as in the United Kingdom.

Another important liability that affects project development risks are the penalties imposed in case of non-compliance. Denmark, for example, implemented strict penalties in some of its offshore wind auctions, involving a decrease in contract remuneration for delays up to 1 year (1% reduction in remuneration for delays up to 5 months, 2% for delays up to another 4 months and 3% for delays up to 1 year). If all turbines are not online within one year of the PPA being signed, a penalty of

Box 5.4 **Offshore wind contracts in the United Kingdom**

In United Kingdom, auction winners are awarded a contract for difference (CfD), a financial instrument designed to create long-term price stability. This consists of a contract between a low-carbon generator and a counterparty, the Low Carbon Contracts Company (LCCC), which stipulates that the generator will provide electricity at a pre-determined strike price. When the reference electricity price, which is based on the market price, is above the contracted strike price, the generator pays the LCCC for the surplus revenue. When the wholesale electricity price is below the contracted strike price, the LCCC pays the generator for the shortfall. This is shown in Figure 5.2.

Figure 5.2 Illustration of contract for difference payments



DKK 400 million (USD 71 million) applies (IRENA and CEM, 2015, vol 6). If the winner of the bid opts out within the first six months, the second winner has to take over the contract and undertake the project within the same time frame, having an increased risk of running into penalties due to time constraints.

The Netherlands also implements penalties on projects not realised within the required period, and developers stand to lose their support. In the United Kingdom, penalties apply for failure to deliver a project, or to meet various milestones during construction. Along with pre-qualification criteria, penalties help avoid project delays and underbuilding. Germany, however, has adopted less strict compliance rules to encourage the participation of bidders. This has contributed to investor willingness to sell at zero support (see Box 5.5).

The way forward

The year 2016 was a significant one for offshore wind. Several countries (including Japan and the Netherlands) adopted offshore wind auctions for the first time (and Germany later in 2017), and prices fell substantially over a matter of months. In 2017, German developers showed confidence that offshore wind would be competitive by 2024. It remains to be seen whether current price levels are sustainable going forward. If so, the prospects for offshore wind are promising.

The diversity of international experience with offshore wind auctions indicates a number of viable design options that can be tailored to specific needs. Project-specific auctions seem to be the preferred approach at this stage. These allow the government to centralise certain tasks such as environmental and grid connection studies, while also mitigating the risks faced by project developers. Containing developers' risk is particularly crucial for offshore wind, an emerging technology with relatively few large-scale projects to draw

Box 5.5 **Compliance rules in Germany's offshore wind auction**

Germany's offshore auction contains a bid bond of EUR 100/kW (i.e., equivalent to EUR 90 million in the case of the EnBW 900 MW project). The next milestone is the initiation of the planning approval process, and must be met within 12 months after the auction's conclusion. The next milestone need not be met until 24 months before the expected completion date (which in the case of EnBW's project is not until 2023). If the project is behind schedule at this point, the award is cancelled with a penalty as low as 30% of the bid bond (i.e., EUR 27 million in the case of EnBW).

The penalty structure limits the losses associated with non-delivery in case market conditions do not develop as expected for example, if large turbines are not available in time or wholesale power prices do not rise as anticipated. The bidder can potentially abandon the project at a relatively low cost - as late as the end of 2023 in EnBW's case.

This encourages developers to bid aggressively today in order to win what is called a *real option* to abandon a contract in the future, rather than bidding cautiously and losing the bid. In principle, the value of the *real option* increases alongside several factors. These include the grace period during which the winning bidder is allowed to wait and see how trends develop; the volatility of factors affecting project value (*e.g.*, technology and wholesale market prices), and the extent to which waiting reduces uncertainty regarding these elements; low discount rates, as the present value of future cash flows is not discounted significantly compared to the cost of *buying the option* (posting the bid bond) today; and the cost limit at which the project can be abandoned (*i.e.*, the lower the penalty for non-delivery at different stages of the process, the higher the option value).

Under the German scheme, the option to back out of a project comes at a relatively low cost for developers, raising the risk that auctioned projects may not be delivered.

Source: NERA, 2017.

experience from, and that may be subject of concern regarding environmental issues and lead to potential conflict with other industries such as fisheries.

Going forward, and as the industry matures, efforts to protect project developers against given risks may no longer be needed. Mechanisms that allow bidders to propose their own projects, as in the United Kingdom, could become more common, as they foster competition not only among offshore wind projects but also among different renewable energy technologies.

5.2 ELECTRICITY FROM BIOENERGY

In auctioning electricity from bioenergy (also referred to as bioelectricity), various subcategorisations of technologies also known as technological routes and feedstock are adopted by countries. The most commonly used are:

- *Solid biomass residues from forestry and agricultural activities.* Wood chips, rice husks and sugarcane bagasse are some of the feedstocks most commonly used for thermal electricity generation. The volume of residues generated affects the capacity of the biomass plant, and its competitiveness compared with conventional generation technologies.
- *Urban biomass and biogas including municipal waste*. Generating solutions based on these materials have significantly increased in competitiveness over the years, although they typically involve smaller capacities and therefore lower economies of scale. A strong point in their favour is that they present an opportunity to reduce sanitation costs for the government while also producing electricity.
- *Crops planted and harvested specifically to maximise yield for bioelectricity generation* (rather than residues from other agricultural activities). Brazilian auctions, for example, have awarded contracts to facilities using elephant grass and wood chips obtained from continuous reforestation.

The wide diversity of biomass implementations makes it difficult to compare prices across countries or draw meaningful trends and conclusions as the price outcome of an auction is significantly affected by the feedstock used, even within the same country.

In Brazil, for example, auctions for bioelectricity are categorised under sugarcane residue, wood chips, other agricultural waste and biogas. Sugarcane residue had been the most prominent technological route until the 2014 and 2015 auctions which had significant contributions from generation based on wood chips. Along with the country's delicate economic situation, this change in feedstock contributed to the increase in the price (see Figure 4.1). In Peru, bioelectricity auctions are categorised as biomass from municipal waste (with incineration), agricultural waste, forest residues and biogas resulting in different prices. In the first round in 2010, biomass from municipal waste was awarded at USD 110/MWh (falling to USD 99/MWh in the next round in 2011), while agricultural waste was awarded at USD 52/MWh. Agricultural waste received no interest from bidders in subsequent rounds, perhaps suggesting that the ceiling price was set too low.

In many countries, auctions for bioelectricity have failed to attract bidders and remained undersubscribed (see Table 5.3), mainly due to the risk perceptions of investors. In South Africa, all three technological routes (biomass, biogas and landfill gas) have had very high percentages of undersubscription. Investor risks mostly relate to the security of supply of the feedstock and the level of maturity of the sector, which remains low in many countries. As such, risks particular to bioelectricity should be considered in the design of its auction.

Technology-specific auctions to promote bioelectricity and deliver socio-economic benefits

The first decision to make regarding auctions for bioelectricity is whether it should be part of a technology-neutral auction competing with other technologies, or part of a technology-specific auction designed to introduce a specific technological route in the mix. In Brazil, for example, one biomass-exclusive auction was carried out in 2008. In most subsequent auctions, biomass competed with other renewable energy sources (and in some cases even conventional sources). Brazil's choice is partly explained by the country's very rich biomass resources, as well as the high level of experience in the sector that enabled developers to compete with other technologies. However, Brazil is the exception, not the rule.

In other countries such as Italy, Peru, South Africa and Spain, biomass typically features under predetermined demand bands that are further broken down into specific technological routes (see Table 5.3). A special feature in the Peruvian auction is that unmet volume demand resulting from undersubscription in biomass can be met by contracting additional volumes of other renewable technologies. Peru's practice can be explained by the fact that the country normally uses auctions to add capacity quickly, rather than to meet other socio-economic objectives.

Biomass technologies can benefit from focused auction designs that address technology-specific challenges, such as attracting a sufficient number of bidders, addressing risks of underperformance associated with agricultural yields outside of the developers' control, and supporting the most strategic technologies in line with broader socio-economic objectives. It is therefore important to consider the positive externalities of biomass, which include 1) its contributions to base-load generation; 2) synergies with the agricultural sector and rural economic development; and 3) synergies with municipal needs for urban sanitation and waste management (see Box 5.6). Socio-economic objectives of specific biomass technologies can also be met through the process of winner selection in the auction.

Winner selection criteria to meet broader socio-economic objectives

Policy makers generally favour some biomass technologies over others due to resource availability and the potential for socio-economic benefits. Differential treatment for various technological routes is typically translated into different price ceilings (that also reflect the various costs).

In Peru's 2016 auction, the highest price ceiling was attributed to incineration solutions for urban solid waste (USD 106/MWh), followed by forestry residues (USD 90/MWh) and biogas solutions for municipal waste (USD 77/MWh). Agricultural waste solutions had the lowest price cap (Osin-

Box 5.6 Value of biomass technologies

When policy makers weigh the merits of biomass generation, they should consider the benefits that such projects can have across multiple sectors. Although these impacts vary depending on the technology and project characteristic, some common benefits include:

- **Contribution to baseload generation.** Biomass can complement, or even, displace fossil-fuel based generation which is often more expensive and carbon intensive. Depending on feedstock availability, biomass technologies can be deployed for base-load generation, thus posing fewer challenges for the grid operators when compared to variable renewable sources such as wind and solar. It can also contribute to the system's stability by providing reserves, especially where the penetration of variable renewables is high.
- **Synergies with the agriculture sector.** These are especially important in developing economies, as investing in technological solutions in rural areas can have economic and social benefits. Bioelectricity can bring economic benefits to rural business owners, as it enables them to diversify their energy portfolios and reduce their input costs. Agricultural residues that are abundantly available in many rural areas are often disposed off inefficiently and sometimes with a negative impact on health and the environment. Using residues to generate electricity or fuels to meet cooking/heating energy needs solves several problems at once.
- **Synergies with municipalities' needs for urban sanitation.** Urban biomass solutions, such as biogas production from landfills or the incineration of solid waste, can generate electricity while disposing of waste, raising generation capacity while improving sanitation. Urban biomass offers the added advantage of proximity to load centres, which minimises flows through the transmission and distribution networks, providing opportunities to reduce losses.

Table 5.3 Selected biomass auction results

Country	Round	Biomass technologies	Volume auctioned	Volume contracted	Percentage of under-subscription	Contracted price (USD/MWh)
Brazil (15 rounds since 2008)	All rounds	Sugarcane residue	14,000 MW in total for all technologies	5,226 MW	57%	74.3
		Wood chips		750 MW		71.2
		Biogas		20.9 MW		70.7
		Other agricultural waste		38 MW		88.4
Peru (4 rounds since 2009)[a]	Round 1	Biomass (Agricultural waste)	813 GWh/year	115 GWh/year	82.4%	52
		Biomass (Urban waste)		28.3 GWh/year		110
	Round 2	Biomass (Agricultural waste)	593 GWh/year	115 GWh/year	100%	N/A
		Biomass (Urban waste)	235 GWh/year	14 GWh/year	94%	99
	Round 4	Biomass (Forestry waste)	125 GWh/year	0 GWh/year	100%	N/A
		Biomass (Agricultural waste)	125 GWh/year	0 GWh/year	100%	N/A
		Biomass (Urban waste/incineration)	31 GWh/year	29 GWh/year	6.5%	77
		Biogas (Urban waste)	31 GWh/year	0 GWh/year	100%	N/A
South Africa (4 rounds since 2011)	Round 1	Biomass	12.5 MW	0 MW	100%	N/A
		Biogas	12.5 MW	0 MW	100%	N/A
		Landfill gas	25 MW	0 MW	100%	N/A
	Round 2	Biomass	12.5 MW	0 MW	100%	N/A
		Biogas	12.5 MW	0 MW	100%	N/A
		Landfill gas	25 MW	0 MW	100%	N/A
	Round 3	Biomass	60 MW	17 MW	72%	139.40
		Biogas	12 MW	0 MW	100%	N/A
		Landfill gas	25 MW	18 MW	28%	93.59
	Round 4	Biomass	40 MW	25 MW	37.5%	120.97
		Landfill gas	15 MW	0 MW	100%	N/A
Italy (4 rounds since 2012)	Round 1	Biomass > 5 MW	120 MW	13 MW	89%	141.07
		Biogas > 5 MW	350 MW	33 MW	91%	126.46
	Round 2	Biomass > 5 MW	107 MW	34 MW	68%	147.14
		Biogas > 5 MW	317 MW	0 MW	100%	N/A
	Round 3	Biomass > 5 MW	64 MW	17 MW	73%	N/A
		Biogas > 5 MW	249 MW	18 MW	93%	117.83
	Round 4	Biomass > 5 MW	50 MW	20 MW	60%	118.5
Spain (1 round in 2016)	NA	Wood chips, municipal solid waste	200 MW	200 MW	0%	0 premium on top of the market price

a. The third round of auction in Peru was for hydro only.

Sources: Based on IRENA (2013, 2017b forthcoming), Lucas and Gomez (2017), Ministero dello Sviluppo Economico (2016).

ergmin, 2015).[33] In South Africa's 2015 auctioning round, biomass and biogas solutions were given the same ceiling price of USD 123/MWh, whereas generation based on landfill gas had a ceiling of USD 82/MWh.

Brazil does not discriminate among subcategories of biomass, choosing to let the more-competitive technologies win. The range of different biomass products used in projects that have won at auctions is diverse. Sugarcane bagasse remains the most common, but wood chips, rice husks, elephant grass and biogas have all appeared in winning bids.

In Italy, auctions are used only for projects of capacity above 5 MW. Below that level, projects benefit from a feed-in tariff (see Box 5.7). Those tariffs reflect technological preferences and technology costs and act as a ceiling price for auctioned projects (based on which the reductions are offered in the bids): biomass using agricultural by-products receive USD 178/MWh; municipal waste USD 150/ MWh. Biogas technologies receive lower tariffs, depending on the feedstock: agricultural by-products receive USD 124/MWh; waste, USD 104/MWh; or biological products, USD 112/ MWh. Landfill gas (USD 111/MWh) and sewage gas (USD 105/MWh) have tariffs comparable to biogas solutions. The Italian mechanism allows for additional premiums to be awarded on top of this tariff if the project meets additional criteria – for example, biogas facilities recovering nitrogen for use as a fertiliser can secure an additional USD 37/MWh.

Setting the right winner-selection criteria and ceiling prices in biomass auctions can help meet socio-economic objectives. However, the benefits materialise only if the projects are built. For that reason, compliance rules must be effective but not so stringent that they deter potential developers from participating in the auction.

Lower sellers' liabilities to reduce undersubscriptions

Biomass auctions are often undersubscribed, as was shown in Table 5.3. In the Italian mechanism introduced in 2012, for example, the demand for biomass projects was set at 120 MW and biogas demand was 350 MW. The volume bid and not awarded in any round is passed on to the following

Box 5.7 Support mechanisms for bioelectricity in Italy

In the Italian support mechanism, bioelectricity producers with capacity above 5 MW compete for support in an auction, with the administratively set baseline feed-in tariff (which is applied to smaller projects) functioning as a price ceiling.

Projects smaller than 0.2 MW for biomass or 0.1 MW for biogas are subject to a direct access mechanism, according to which they may apply to receive the baseline feed-in tariff in an ex post fashion when they start operations. Medium-sized projects (up to 5 MW) are subject to a registry mechanism, according to which they must apply for the incentive *ex ante* when they obtain the construction permit. In this category, the selection of the projects that will receive the feed-in tariff is not based on price bids, but rather on other criteria such as the date of the permit, date of application, and project size. The regulatory framework also establishes a maximum budget for all types of incentives awarded to renewable plants.

Almost half of the total renewable energy capacity that the Italian government was willing to purchase from medium-sized projects using the registry mechanism involved biomass-fired plants. This is because biomass technologies typically are of a lower scale, such as municipal solid waste and biogas. Smaller biomass projects benefiting from baseline feed-in tariffs enjoyed prices that were 10-50% higher than those received by their larger counterparts that had to go through the auction, reflecting the impact of scale on price.

Source: Ministero dello Sviluppo Economico (2016).

33. Officially published price ceilings were converted to U.S. dollars using the exchange rate of the date of their publication but were not further adjusted for inflation.

round. After four bidding rounds, only 84 MW of biomass and 51 MW of biogas projects were contracted, corresponding to about 53% and 15% of the respective targets.

South African auctions also did not contract any bioelectricity projects in their first or second round, despite demand for 12.5 MW of biomass, 12.5 MW of biogas, and 25 MW of landfill gas capacity. When projects were finally proposed in the third round, the amount contracted was still below the set demand: only 17 MW of biomass was awarded toward a target of 60 MW, and 18 MW of landfill gas capacity out of the 25 MW target. No biogas capacity was contracted despite a stated demand of 12.5 MW.

Peruvian auctions have had a similar experience: the demand for biomass projects in the 2010 auction was set for nearly 120 MW of new capacity (estimated using typical capacity factors) but only 27.4 MW was awarded. Similarly, in the second auction, carried out in 2011, a demand for 120 MW of new biomass projects resulted in only 2 MW awarded. More recent auctions adopted less aggressive goals: the demand of the Peruvian 2016 auction was only 45 MW of biomass split across four subcategories; of this, just 4 MW was awarded.

There are various explanations for the persistent undersubscription across different countries. The most straightforward explanation is the possibility that policy makers have been overestimating the capacities achievable and setting high demand quantities; this implies that the amounts contracted are a more reasonable reflection of what the country can effectively deliver. Another explanation is the possibility that ceiling prices are set too low.

Undersubscriptions can be reduced by encouraging the participation of a higher number of bidders with more lenient and flexible compliance rules and penalty structures that are sensitive to the risks of feedstock shortages and price fluctuations. Brazil, for example, offers bioelectricity plants two options for discharging their energy to the power system: a *must-run* mechanism, according to which the plant is treated as an inflexible genera-

tor and given priority dispatch with a marginal cost close to zero; or a *flexible* mechanism, according to which the plant commits to deliver bioelectricity whenever the system's spot prices surpass a given threshold. This flexibility in the risk assumed by the generators encourages participation of bidders in the auction. Spain also adopted an innovative mechanism whereby developers bid for contracts based on the cost of setting up the plant in accordance with the government's specifications. This provides an indication of the support needed, which is later provided as a premium on top of the market price for electricity (see Box 5.8).

The difficulty in attracting bidders in many countries may suggest that auction design has to be more focused on reducing developers' risks. An additional consideration is that the remuneration levels that governments set for biomass plants (expressed in the form of ceiling prices for example) are calculated using parameters (rate of return and risk exposures) that are typical of the electricity sector. These may be insufficient to attract players that have traditionally operated in other sectors, such as agriculture or waste management.

The way forward

The development of bioelectricity affects several social and economic sectors and can bring many benefits in addition to greater generating capacity. In some countries, auctions for bioelectricity projects have succeeded in developing new capacity and introducing new technologies in line with the broader objectives. However, for bioelectricity initiatives to realise their maximum potential, more incentives are needed to attract investors in the sector.

The small capacities offered in most bioelectricity auctions, coupled with the fact that several have been undersubscribed, implying that the auction's conditions were unable to attract enough bidders to meet the desired demand, suggests that there is room for increasing the attractiveness of such investments. One way to promote them would be working with potential project developers to devise auction designs that are better tailored to the needs of the biomass sector – or, more accurately, to the needs of individual biomass technologies, in view of the fact that various technological routes of bioelectricity have significantly different technical and economic fundamentals. Finally, there is a need to build synergies with other sectors, notably municipal sanitation and agriculture, helping to reduce investor risks stemming from fluctuations in the supply and price of feedstocks. Such synergies present immense opportunities to deliver socio-economic benefits such as waste management in urban settings, and broader development goals in rural areas that depend on agriculture for their livelihood.

Box 5.8 Bidding procedure for biomass auctions in Spain

In Spain, rather than bidding for a tariff, auction participants compete for the opportunity to invest in a power plant, offering a discount on the reference capital cost set by the government. The developers' remuneration consists of a premium provided on top of the market price for electricity. The premium is calculated based on the outcome of the auction, along with other parameters that are centrally determined. One of the objectives of this scheme is to determine the actual level of investment needed to build biomass power plants, and this parameter becomes one of the inputs used to calculate remuneration of other plants in the system.

Spain's 2016 auction contracted 200 MW of biomass capacity at a 100% discount from the reference capital cost, originally set at EUR 3,350/kW (USD 3,500/kW). This implies that projects will receive no extra remuneration for their investment and that they are competitive with conventional generation technologies – seeing that the revenues from selling electricity directly in the market alone would be sufficient to ensure their financial viability.

It is possible that some of the bidders in fact expected to receive a positive remuneration for capacity under the auction's uniform pricing rule (as long as at least one of the accepted bids had offered a discount lower than 100%, all auction winners would have benefit from a higher remuneration). However, biomass proved to be extremely competitive, which resulted in this unique outcome.

6 KEY CONSIDERATIONS IN DESIGNING RENEWABLE ENERGY AUCTIONS

RECENT AUCTION RESULTS REFLECT THE GROWING COMPETITIVENESS OF RENEWABLE ENERGY

In 2016, renewable energy auction prices continued on their downward trajectory as countries around the world contracted capacity at record-low prices. Solar photovoltaic (PV) energy was contracted at a global average price of USD 50 per MWh – about a fifth of the 2010 average. The prices of the relatively more mature onshore wind energy fell to half their 2010 level – to about USD 40 per MWh.

In several Latin American countries - Brazil, Chile, Mexico and Peru – solar PV and onshore wind have gone head to head with conventional energy technologies and won a large share of contracts at very competitive prices. Record-breaking prices were also attained in other regions – notably in Egypt and Morocco for onshore wind and in the United Arab Emirates for solar PV – proving that the price trend is indeed global.

Recent auction prices for both solar PV and onshore wind have highlighted that these technologies are now more cost-effective or at par with conventional technologies in a growing number of countries. The virtuous cycle of falling equipment costs, improved technology and optimised supply chains, coupled with competition, is expected to continue driving price reductions.

AUCTION DESIGN NEEDS TO BE ADAPTED TO COUNTRY CONDITIONS

Less mature technologies, such as offshore wind, were also contracted at lower prices across a wide range of countries in Asia, Europe and North America. In 2016, prices in Denmark and the Kingdom of the Netherlands dropped by more than 25 percent within a matter of months between two auctioning rounds. In the first half of 2017, Germany held its first offshore wind auction; most developers sought no premium beyond wholesale electricity prices. Although driven chiefly by technological advancement, the recent developments in offshore wind are also a result of auctions designed to reduce risks and transaction costs and encourage participation of bidders.

Auctions for bioelectricity were held for the first time in countries such as Argentina and Spain, but with very scattered results. This reflects the complexity of comparing different auctions depending on the technological route and the feedstock used. From a government perspective, the growing interest in contracting bioelectricity capacity stems from its potential to contribute to base-load generation, rural economic development, and urban sanitation and waste management. However, most of the auctions analysed in this report for bioelectricity were markedly undersubscribed, indicating that further efforts are needed to adapt the auction design and address certain specific risks, such as feedstock supply and the less developed nature of the sector.

For renewables to achieve their full potential, the auction design needs to be adapted to the specific conditions of the country, which include: the economic situation, the structure of the energy sector, the maturity of the power market and the level of renewable energy deployment. In addition, the design of the auction needs to be aligned with the country's overall objectives, which may go beyond the achievement of deployment rates at minimum costs. Although there is no doubt that auctions have improved the price competitiveness of renewables, a full understanding of the factors that have contributed to the recent prices is essential to making well-informed decisions regarding future auction design.

FACTORS THAT IMPACT RENEWABLE ENERGY AUCTION PRICES

The prices attained in recent auctions are influenced by several factors; some relate to the auction design and others to an enabling environment, including: 1) country-specific conditions and access to finance; 2) investors' confidence related to the presence of a conducive environment; and 3) the presence of other policies aimed at supporting renewable energy development.

Chief among the **country-specific conditions** that directly affect the winning auction price are 1) the country's renewable energy resources and 2) the capital costs and operating expenditures that project developers face. For example, adjusting the results obtained in Germany to higher capacity factors, from 11 to 25 percent (the norm in Latin America), could yield prices close to half of the actual results. The higher cost of labour and land in Germany (and other European countries) compared to Latin American countries also contributes to the price difference.

Installation costs of renewable energy projects may be affected by policies adopted to support the development of renewable energy. In the United States, for example, investment tax credits have been offered to attract investments in solar PV projects, reducing investment costs by about 30 percent, a reduction that has been reflected in the price outcomes. **Access to finance** considerations are largely related to the variations in the weighted average cost of capital, reflecting both the country's financing conditions (the cost of debt) and investors' perception of the risks of owning renewable assets in the country (the cost of equity). These factors explain many of the country-to-country differences in auction prices.

Investors' confidence can be strengthened by a stable, enabling environment that is conducive to market growth through a clear target backed by a strategy and policy actions. For instance, the commitment of the Government of India to its ambitious solar target of 100 GW by 2022, coupled with strong policy action, has given project developers, financing institutions and other market participants confidence in the country's solar programme, despite challenges faced in some states related to off-taker credibility. Off-taker risks are common in emerging economies and they strongly influence the risk perception among investors. These risks can be mitigated by ensuring that demand-side responsibilities will be met by offering additional guarantees to back the contract, if needed. In Argentina, the government provides liquidity guarantees ensuring the continuity of cash flow to the developers as well as termination guarantees shielding developers from counterparty risks that are also backed by the World Bank.

The impact of investors' confidence on the price outcomes is mainly illustrated by countries where accumulated experience from recurring auctions has resulted in persistently lower prices (*e.g.*, South Africa and India). A long-term auction programme, with a predictable schedule of auction demand, and a high degree of transparency all contribute positively to the level of competition in the auction.

THE DESIGN OF THE AUCTION HAS A SIGNIFICANT IMPACT ON THE PRICE

- The design features of auctions, namely the auction's demand, qualification requirements, winner selection, investors' risks and liabilities, all strongly influence the price outcomes. Across the different auction design elements, policy makers should carefully consider the inherent trade-offs between potentially the most cost-effective outcome and other objectives.

Auction's demand

In defining the auction's demand, ambition for a greater role of renewables in the energy mix must be weighed against cost-effectiveness.

- When the objective is to develop a particular technology, a technology-specific auction can be selected. If the goal is minimising costs, a technology-neutral auction can be introduced, allowing competition between technologies (*e.g.*, Brazil).
- When the objective is to meet urgent capacity needs while retaining flexibility in holding auctions, the total volume can be auctioned at once, through a standalone auction. If the objective is to further enhance investors' confidence for a more cost-effective outcome, the total volume auctioned can be divided into different rounds in a systematic auctioning scheme. This facilitates long-term planning by policy makers, bidders, and equipment suppliers, which may be beneficial to the grid planning and to the country's renewable energy industry.
- If the objective is to meet broader development goals, the auction design can include additional selection criteria. Local content requirements, for example, can support the domestic industry, job creation and other socio-economic benefits. Such requirements are most effective when aligned with other design elements, such as a long-term auction schedule, and applied with other supporting policies.

Qualification requirements

Qualification requirements are key determinants of the competition in the auction and the prices offered by developers. They can be focused on 1) ensuring that the project will deliver as per the contract by requiring bidders to conduct assessments and obtain permits as a prerequisite to be able to bid, and 2) ensuring the capability of the developer to successfully deliver the project through technical, financial and reputational requirements. Some of the trade-offs to consider in defining qualification requirements include:

- If requirements in terms of permitting and documentation processes are too demanding, the transaction costs incurred by developers can be reflected in higher prices. Transaction costs can be reduced through site- or project-specific auctions where the government (or another entity) takes on the responsibility of site selection, resource and impact assessments, grid connection and obtaining necessary permits. This approach is increasingly common in diverse contexts, including off-shore wind development in Denmark, Germany and the Netherlands.
- Auctions can be designed in a way to attract large international companies and achieve the lowest prices through strict qualification requirements. While the requirement for an extensive track record in the field, for example, can help ensure timely project completion, it may also limit the participation to traditional, large players in the sector, which in turn affects the overall development of the sector.

Qualification requirements can also be designed to meet broader development goals, related to domestic industry development and job creation, such as in South Africa and China. These goals are further supported by a winner selection mechanism based on criteria other than the price.

Winner selection

The winner selection process is at the heart of the auction. The criteria for selection, ceiling prices and limits on project size can significantly impact the price outcomes, with the possibility of facing the following trade-offs:

- While a simple winner selection process based solely on the price can improve cost competitiveness, other objectives can be achieved by incorporating non-monetary criteria, such as socio-economic benefits and project location. Regarding the latter, location signals adopted in the first round in Mexico resulted in the selection of sites that are not optimal in terms of renewable resource availability. Adjusting those signals in the second round contributed to a price decrease of about 30 percent.
- When the main objective is to ensure cost effectiveness, a low ceiling price can be set, above which bids are not considered. However, there is a risk that a sub-optimal amount of renewable energy will be contracted, as it could lead to the rejection of some reasonable bids. Experience has shown that keeping the price ceiling undisclosed can help increase cost effectiveness, but at the risk of disqualifying potentially good projects that are just above the ceiling (*e.g.*, early auctions in Peru). Disclosing the ceiling price in auctions where competition is not fierce might result in equilibrium prices right below the ceiling (*e.g.*, the first round in South Africa).

- A limit on the project size or on the volume that can be won by one bidder also impacts the price. Such measures were put in place in Zambia to diversify the portfolio of generators and reduce risks in case projects do not materialise. Auctions that have no limit on project size can benefit from economies of scale, as in the case of Dubai and Abu Dhabi in the United Arab Emirates, where 800 and 1,170 MW of solar was contracted respectively, at record-breaking prices.

Investor risks and liabilities

In determining the sellers' liabilities in the power purchase agreement, there are various ways to allocate financial, operational and production risks between the project developer, the auctioneer and the off-taker. Trade-offs that need to be considered in the allocation of risks and liabilities to developers include:

- Auction design features can limit the developers' risks resulting in lower prices, but these risks would then be passed on to the off-taker. Currency, inflation and production risks can be reduced through auction design. In Chile, contracts are denominated in U.S. dollars and indexed to U.S. inflation, protecting developers from currency exchange and inflation risks. In addition, the newly introduced hourly supply blocks protect generators from production risks, reducing exposure to spot energy prices in case of deviation from the contracted amount. This is one of the factors that led to the record-breaking solar prices in Chile's 2016 solar auction.
- Liabilities can be reduced to encourage participation and increase competition, but at the risk of facing project delays or underproduction. Investor liabilities involve commitment to contract signing and project completion as well as compliance rules and penalties. These are important measures to ensure that projects are developed as per schedule to meet the capacity needs of the power sector. However, if these measures are too strict, competition in the auction will be reduced, leading to higher prices. There are innovative ways to address these trade-offs, as in the case of Germany, where bidders with building permits saw their bid bond and completion bond requirements reduced by almost half.

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