

# **RENEWABLE ENERGY AUCTIONS**

**ANALYSING 2016  
EXECUTIVE SUMMARY**



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# RENEWABLE ENERGY AUCTIONS

## ANALYSIS 2016

### EXECUTIVE SUMMARY

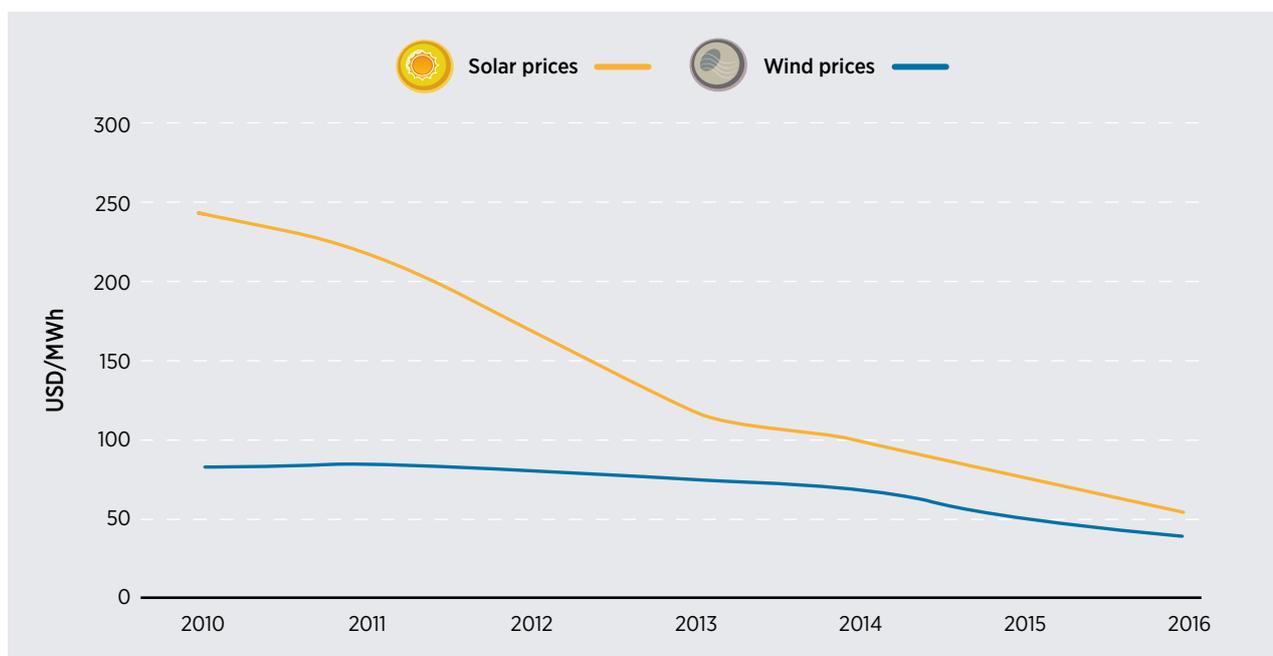
Over the past decade, auctions have spread quickly as a means of eliciting supplies of energy from renewable sources, growing faster than feed-in tariffs (or premiums) and quotas (or renewable portfolio standards) in the past few years. The spread of auctions can be ascribed to the increasing maturity of the technology and other developments in the sector.

The potential of auctions to achieve low prices has been a major motivation for their adoption worldwide. As Figure 1 illustrates, 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 more mature in 2010.

Following a summary of the main trends over the recent past, this brief analyses the evolution of prices resulting from auctions and their key determinants.<sup>1</sup> 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.

**Figure 1** Average prices resulting from auctions, 2010-16



Source: IRENA, 2017.

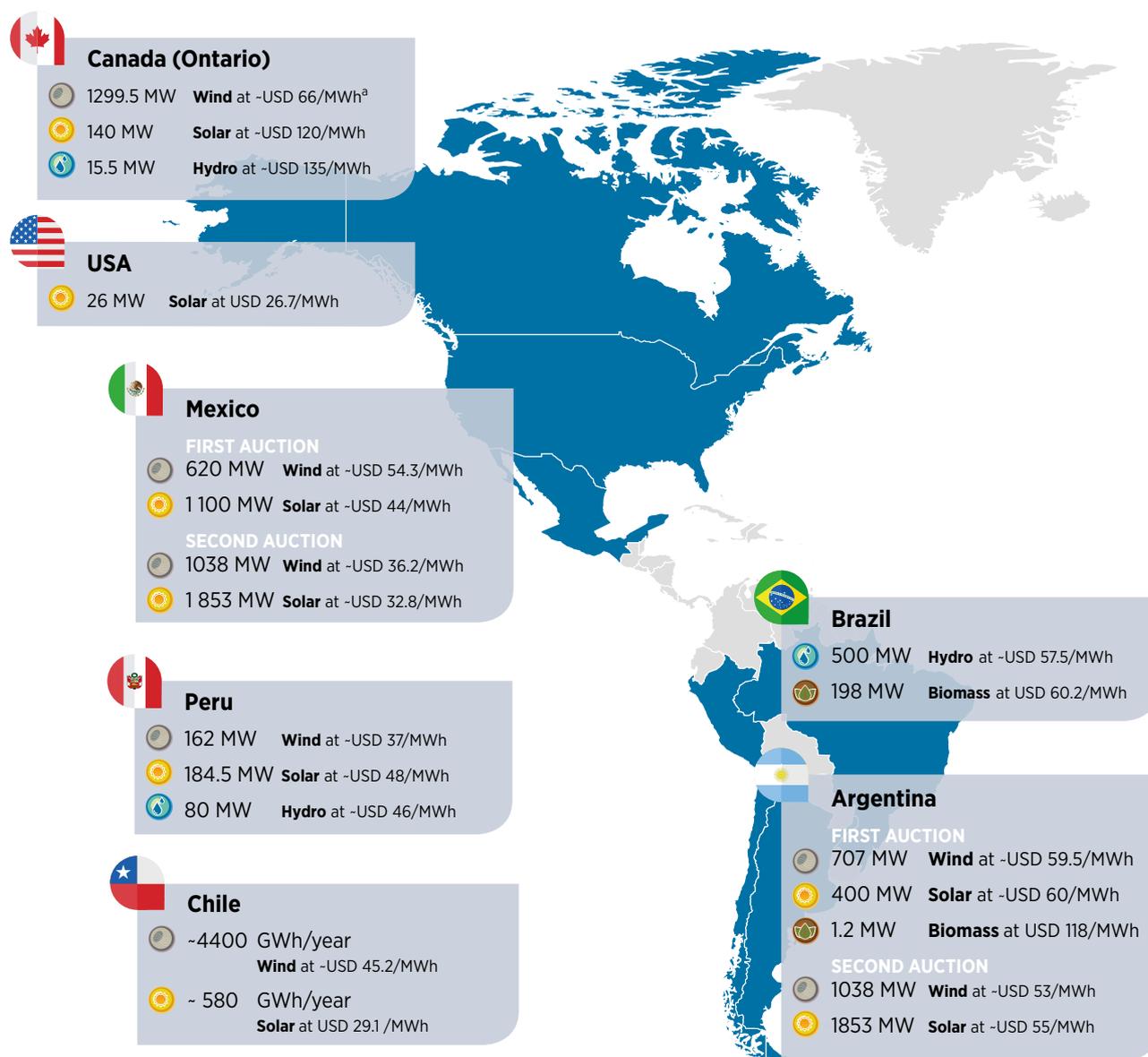
1. This brief is a summary of *Renewable Energy Auctions: Analysing 2016* which can be downloaded from [www.irena.org/Publications](http://www.irena.org/Publications) starting March 2017.

# 1 HIGHLIGHTS OF RENEWABLE ENERGY AUCTIONS IN 2016

Renewable energy auctions passed several important milestones in 2016. Countries such as Argentina, Canada, Mexico and Zambia kicked off auction-based programmes for promoting renewable power. Auctions for technologies less mature than onshore wind and solar photovoltaics (PV) have emerged – with offshore wind auctions held in Denmark and the Netherlands, biogas capacity auctions in Argentina and Peru, and an auction for solar thermal power announced in Dubai

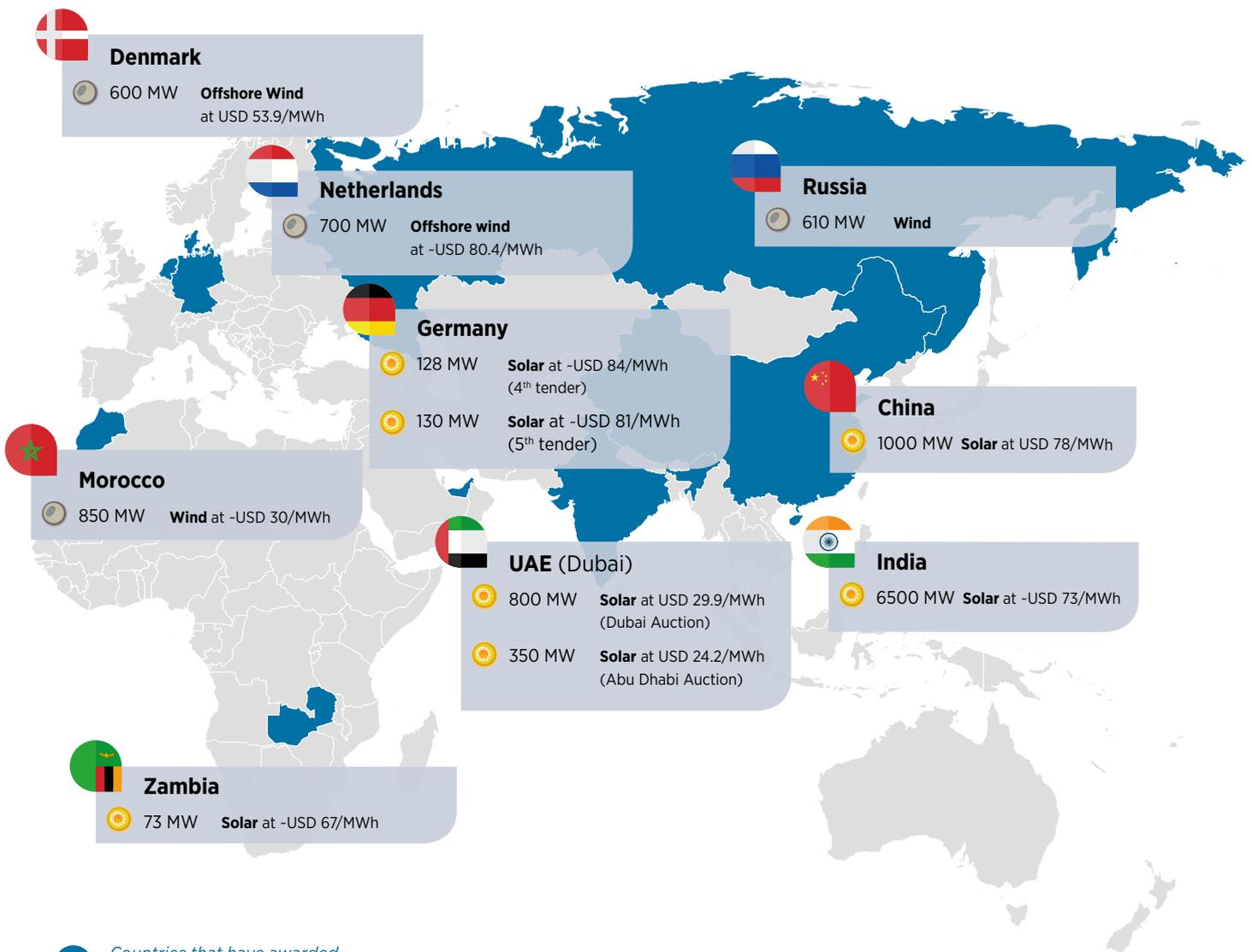
in the United Arab Emirates. Several price records were set during the year: in Chile and the United Arab Emirates for solar PV, Morocco for onshore wind, and Denmark for offshore wind. In countries such as Chile and Mexico, renewables were more competitive than conventional energy technologies and won a large share of contracts at record-breaking prices. The 2016 highlights for 16 countries, discussed below and shown in Figure 2, illustrate the current status.

**Figure 2** Highlights of renewable energy auctions, 2016



Note: a) ~ refers to the average price resulting from the auction.

Sources: Bailey, 2016 (Ontario); Bierzwinsky and Felix, 2016 (Mexico); BNEF, 2016a (Peru); BNEF, 2016b (Abu Dhabi); Dezem and Martinez, 2016 (Argentina); Escritt, 2016 (Netherlands); IFC, 2016 (Zambia); Parkinson, 2016 (Morocco); Kenning, 2016 (Ontario);



Mahapatra, 2016a (Dubai); Mahapatra, 2016b (China); MNRE, 2016 (India); Morais, 2016 (Brazil); Newbase, 2016 (2016); PV Magazine, 2016a (Chile); PV Magazine, 2016b (Germany); Vattenfall, 2016 (Denmark)<sup>2</sup>.

2. The sources listed were used in the following section.

## RENEWABLE ENERGY AUCTIONS



Throughout the year, **India**, one of the countries with the vastest experience in solar auctions, awarded solar power in at least 13 different auctions organised by both state-level and national entities, for a total capacity of more than 6 500 MW. The high number of auctions is part of the Indian Solar Mission and reflects the country's pledge to deploy 100 GW of solar energy by 2022.



In January, **Morocco** contracted 850 MW of wind power at the record-breaking average price of USD 30/MWh (with the lowest price at USD 28 USD/MWh). 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 this year, which will result in the addition of 170 MW to the Noor-Ouarzazate solar power complex. At this same site, 510 MW of solar thermal capacity has already been awarded from past auctions.



In February, **Peru** held its fourth renewable energy auction since 2010, setting record-low wind and solar energy prices for Latin America at the time. Greenergy (Spain) offered a bid of USD 36.8/MWh<sup>3</sup> for wind, and Enel Green Power (Italy) a bid for USD 47.9/MWh for solar PV.



**Mexico's** two energy auctions, carried out in March and September this year, are tied to the country's newly reformed electricity market, operational since January 2016. Although the auctions allow the participation of different technologies, several products auctioned (electricity, firm capacity, and clean energy certificates) are exclusive to renewable energy projects, and wind and solar power proved to be extremely competitive. USD 42.8/MWh was offered for wind by Acciona (Spain) in March; just seven months later, the wind record for the Latin American region was broken in the second auction with the submission of a USD 32/MWh bid by ENEL Green Power (Italy). Meanwhile, for solar PV, USD 34.8/MWh<sup>4</sup> was reg-

istered in the first round in March, only weeks after the auction in Peru, confirming that those were indeed viable renewable prices in Latin America. Solar prices fell even further in the country's second round, establishing a Latin American record for solar energy of USD 27.0/MWh, offered by FRV (Spain/Saudi Arabia).



In April, **Canada's** province of Ontario organised its first renewable energy auction to replace its feed-in tariff scheme for large-scale projects (above 500 kW). The auction resulted in the lowest cost of solar power contracted in Ontario to date (USD 120/MWh).



In April and September, **Germany** continued its auctioning programme initiated in 2015, with the fourth and fifth solar rounds. These auctions represent the country's pilot scheme for replacing solar feed-in 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 and EUR 72.3/MWh (USD 84/MWh and USD 81/MWh<sup>5</sup>) were obtained in April and September, respectively.



In two auctions in April and September, **Brazil** contracted more than 200 MW of small hydro and almost 200 MW of biomass at an average price of BRL 198.59/MWh (USD 57.4/MWh<sup>6</sup>). A third auction exclusive to wind and solar projects had been scheduled for December but was cancelled, mainly in expectation of a continued economic slowdown and power oversupply. The country has a lengthy experience with both technology-neutral and technology-exclusive renewable energy auctions.



In May, **Zambia** became the first country to organise solar auctions under the Scaling Solar program in Sub-Saharan Africa, designed and implemented by the International Finance

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 approximated, as the Mexican auctions do not reveal the bidder's price per form of energy, but per package of products (lump-sum yearly amount to be received for the offered quantity of capacity, energy and green certificates).

5. Exchange rates of USD 1.13/EUR and USD 1.12/EUR for April and September, respectively.

6. Exchange rate of USD 0.289/BRL at the time of the auction.

Corporation (IFC) 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. Senegal and Madagascar have also subscribed to the Scaling Solar program.

 In June, the **United Arab Emirates** announced the results of its second solar PV auction in Dubai. The winning price of USD 29.9/MWh, offered by Masdar (UAE) and FRV (Spain/Saudi Arabia), was the lowest solar price worldwide at that time. 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), although a final contracting decision will not be made until the first quarter of 2017.

 Also announced in June 2016 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 in 2019, and 260 MW in 2020) with a total investment of RUB 83 billion (USD 1.3 billion<sup>7</sup>). The country's sharp economic downturn, stringent domestic content requirements, and a reduction in the project's subsidy payment all contributed to the poor response from potential investors.

 In July, the **Netherlands** organised its first offshore wind auction for a large-scale 700 MW project, which yielded an average price of USD 72.6/MWh. The Dutch auctions draw significantly on Denmark's similar auctioning programme, and have benefitted from the extensive Danish experience.

 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 price of the renewable energy auction was USD 47.6/MWh, proving the competitiveness of renewable energy technologies.

 In September, **China** organised its largest solar auction, contracting 1 GW of new capacity at an average price of USD 78/MWh.

 Also in September, **Argentina** organised its first renewable energy auction under the RenovAr program, leading to the contracting of wind, solar PV and biomass capacity at average prices of USD 59.4, 59.7 and 118/MWh, respectively<sup>8</sup>. The success of the experience led to the scheduling of a second round for November, that awarded 765.4 MW of wind at an average of USD 53/MWh and 516 MW of solar at USD 55/MWh.

 In September and November, **Denmark** carried out two offshore wind auctions as part of its long-running programme, which had resulted in the contracting of four large-scale projects. The contracts were awarded for the Vesterhav (350 MW at 47.5 øre/kWh or USD 71.5/MWh<sup>9</sup>) and Kriegers Flak projects (600 MW at 37.2 øre/kWh or USD 53.9/MWh<sup>10</sup>). These prices represent reductions of 39% and 53%, respectively, from the prices attained in the 2015 auction.

7. Exchange rate of USD 0.016/RUB.

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

9. Exchange rate of USD 0.150/DKK in September 2016.

10. Exchange rate of USD 0.145/DKK in November 2016.

## 2 TRENDS IN RENEWABLE ENERGY AUCTIONS

Factors that influence policy-making have shifted dramatically in the past decade, creating a need for tailored policies that build on past experiences and lessons learnt to address prevalent barriers to renewable energy deployment. These factors include the rapid decline in the costs of renewable energy technologies and the growing share of variable renewable energy in the energy mix. To account for these dynamics, support policies are continuously being adapted to maintain a stable and attractive environment for investments in the sector while ensuring the long-term reliability of the energy system in a cost-effective manner (IRENA, 2014). In this context, auctions for renewable energy development have become increasingly popular in developing and developed countries and are often implemented in combination with other measures. The number of countries that have adopted renewable energy auctions increased from six in 2005 to at least 67 by mid-2016.

### 2.1. THE STRENGTHS OF AUCTIONS

Auctions have gained popularity in different contexts as they are not tied to any specific market arrangement or regulatory and institutional framework. They are equally compatible with vertically integrated electricity markets, single-buyer models and completely liberalised markets. The growing interest in auctions is due largely to their ability to achieve deployment of renewable electricity in a well-planned, cost-efficient and transparent manner while also achieving a number of other development objectives such as job creation, social growth, and domestic value creation and ownership. The strength of auctions lies in some of their key characteristics (see IRENA and CEM, 2015, volume 2).

- **Flexibility of design**, making it possible to combine and tailor different elements to meet deployment and development objectives and cater to a jurisdiction'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**, allowing policymakers to control both the price and quantity of renewable energy produced by providing stable revenue guarantees for project developers (in the manner of feed-in tariffs) while at the same time ensuring that the renewable-generation target is met more precisely (in the manner of quotas and tradable green certificates).
- **Degree of commitment and transparency**, as auctions yield contracts that clearly state the commitments and liabilities of each party. Therefore, they offer regulatory certainty to investors and minimise the likelihood that their remuneration is challenged in the future even as the market and policy landscape change. Stating clear penalties for underbuilding and delays can also ensure that auctioned projects deliver 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. Auctions' power to discover real prices is of particular relevance given recent market developments, notably the rapid downward evolution of technology costs. The effect of price discovery is clearly shown in the global trends of auction prices for both solar and wind projects, and it is especially important for the development of local supply chains and the maturity of the market.

The potential to achieve low prices has been acclaimed as one of the most important strengths of auctions and has been a major motivation for their rapid dissemination worldwide. This strength can largely be attributed to their ability to promote competition among potential developers and lead to accurate price discovery in a robust and transparent manner. 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 fallen at a slower pace, as the technology was already fairly mature in 2010, making investment costs more stable – but a decreasing trend can still be seen, especially after 2014.

## 2.2. PRICE TRENDS: SOLAR PV

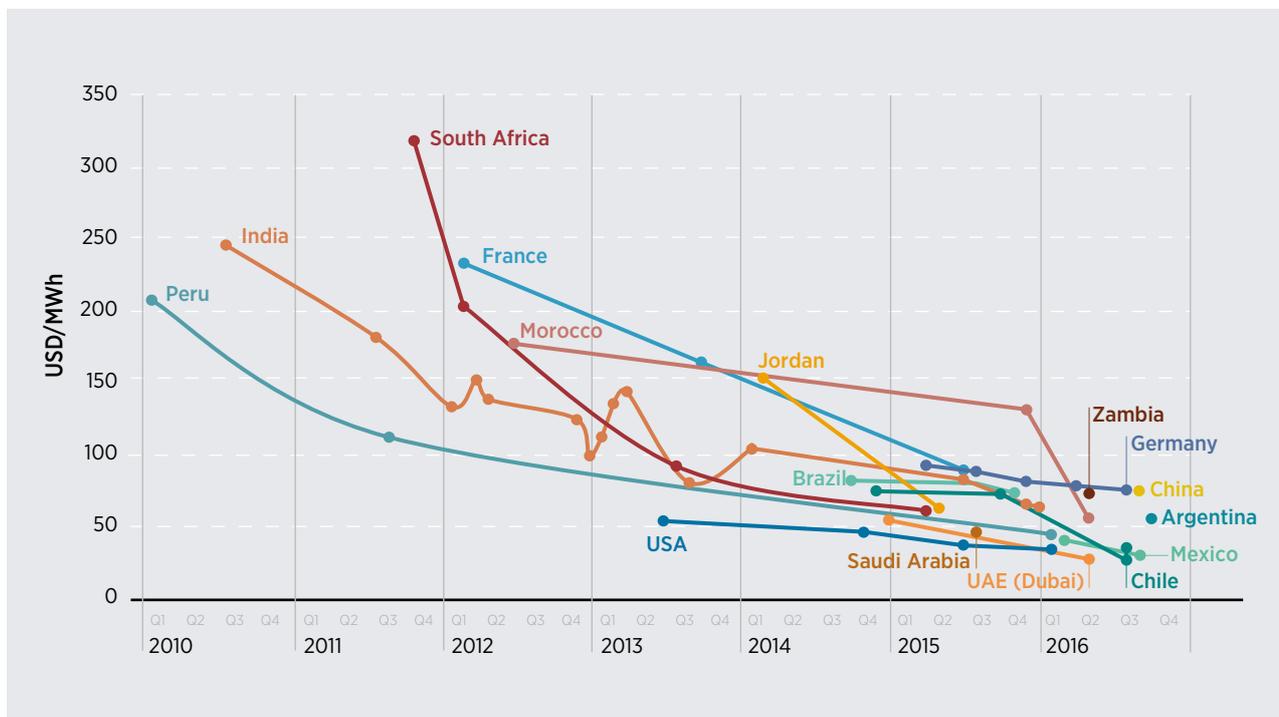
Solar PV modules have been deployed at a fast rate with a steep learning curve. The total global installed capacity grew from 2 GW in 2012 to 222 GW by the end of 2015 (IRENA, 2016a). Driven by technological improvements and manufacturing advances, and with the overcapacities in the market peaking in 2011, PV module prices decreased by around 80% between 2009 and 2015. Moreover, 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, 2016b). The decreasing costs of installing solar PV projects were reflected in the falling prices of auctions.

Figure 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. As shown in the figure, average prices fell in all countries between

2010 and 2016 (with prices in the period between 2010 and 2014 decreasing at a faster rate 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 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 convergence in average prices, reflecting the increased maturity of the sector, it also shows large disparities between countries in earlier years. Such disparities are shown, for example, in the price difference between Peru and South Africa, the country with the clearest downward trend. The figure also shows sinuous patterns in India, remarkably lower prices in the United States and a persistence of prices in the upper range in Germany. These elements are discussed in more detail below.

**Figure 3** Evolution of average solar prices in auctions, January 2010-September 2016



IRENA, 2017 (forthcoming).

**Downward trends in South Africa.**

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 disclosure of ceiling prices).

First, a learning curve achieved by the bidders and the auctioneer reduced the gap in prices considerably. This phenomenon is quite common, as project developers typically require higher risk premiums in countries that do not yet 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, volume 3). Moreover, it is possible that some potential bidders who had already qualified for the first round did not need to reinvest in obtaining the necessary documentation in the second round, decreasing their transaction costs and thus resulting in lower prices.

Second, the presence of a domestic solar industry made itself felt in the cost of projects. As South African policymakers sought to prioritise social development goals beyond minimising prices, the local content requirements imposed in the first round led to higher prices, with subsequent reductions as the local industry developed (see Box 1).

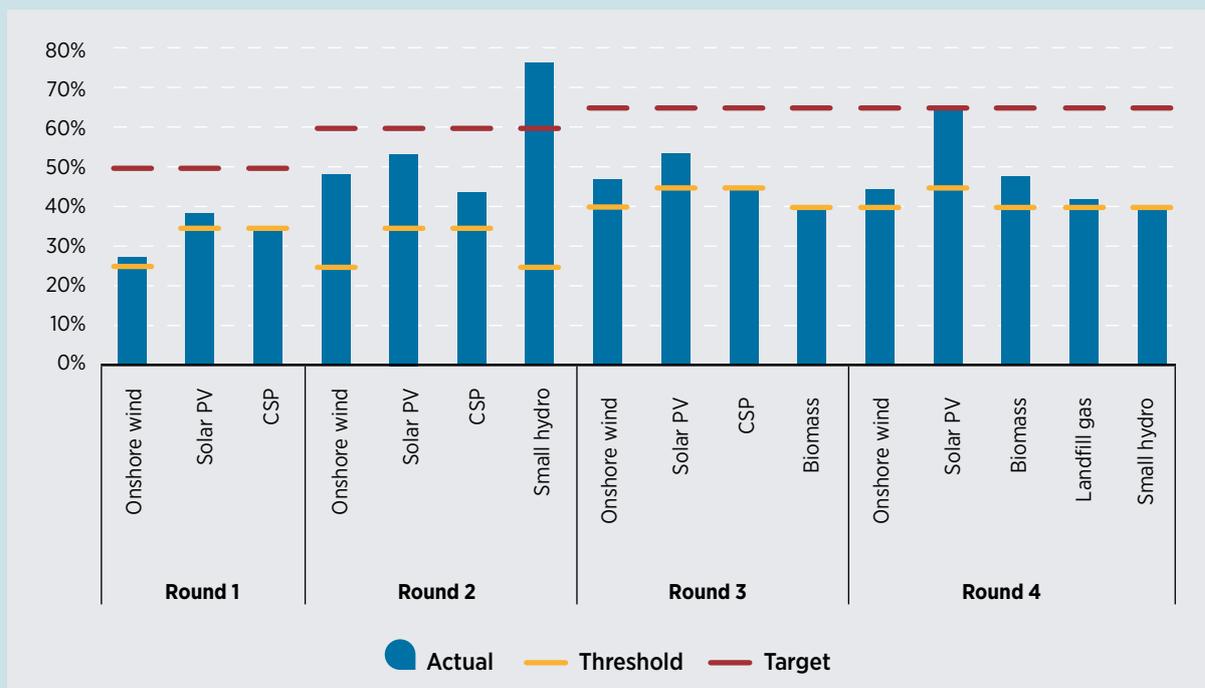
Third, the design of South Africa's auctions contributed to the high prices resulting from the first



**Box 1 Local content in South African auctions**

Figure 4 illustrates the local content requirements, targets and actual percentage 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 domestic content requirements to bid (threshold). In the second round, offers incorporated higher levels of local content, as the first auction had pushed local industry growth (another illustration of learning curve effects). The percentage of local content stabilised at around 45% in later rounds, with higher rates achieved for small hydro in the second round and for solar PV in the fourth.

**Figure 4** Local content requirements and achievements in South Africa



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

round, where a large volume of 3 750 MW was auctioned at once. This and the lower level of development of the domestic industry at the time meant that opportunities for competition among suppliers was limited (see IRENA and CEM, 2015, volume 3). Moreover, ceiling prices were fully disclosed prior to the first round, which led to bids close to the ceiling price, with little incentive to bid lower (see IRENA and CEM, 2015, volume 5).

### Ups and downs in India.

India has held at least 47 solar auctions since 2010, more than any other country. The prices resulting from these auctions are characterised by their sinuous pattern, with their average slightly on the higher side.

The sinuous pattern is explained by the fact that auctions are decentralised: while some are organised at the national level, most are state auctions, with each state adopting its own auction design

which have an impact on the final bid. The diversity in the underlying conditions of these independent auctions results in oscillating prices. Among other reasons, some auctions yielded higher prices owing to strict local content requirements (see IRENA and CEM, 2015, volume 4).

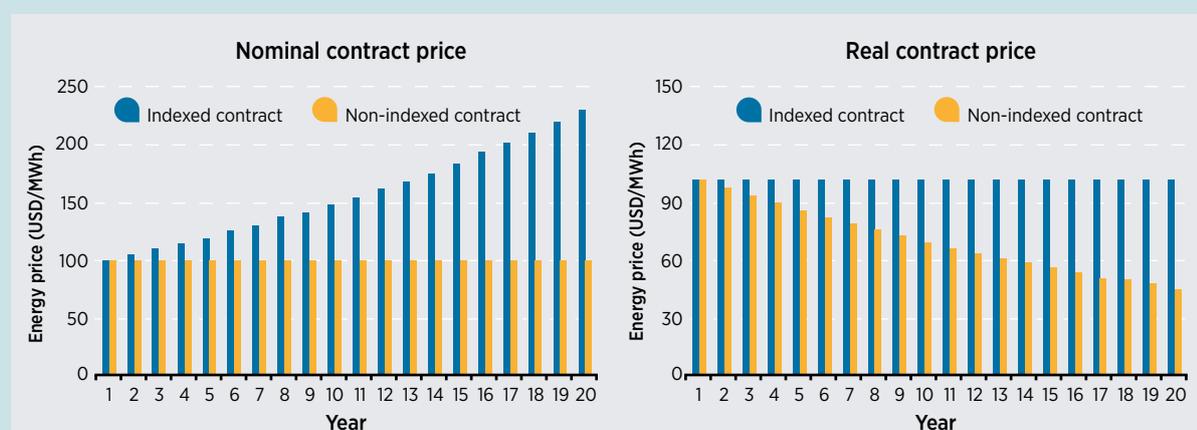
The relatively higher prices in India compared with Peru, the United States and South Africa can often be traced to the remuneration profile and the type of contract offered. Unlike other auction contracts that are indexed to inflation or denominated in US dollars, as is the case in all Latin American countries (except Brazil), the Indian auctions offer contracts in the local currency and are not corrected for inflation or foreign exchange rates (see IRENA and CEM, 2015, volume 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).



### Box 2 Remuneration profile in Indian auctions

Figure 5 illustrates the effect of inflation on remuneration profiles in contracts indexed for inflation versus those not indexed. Looking at the nominal contract price<sup>11</sup>, the unindexed contract appears to yield constant remuneration, whereas the energy price in the indexed contract appears to rise. In fact, taking into account factors such as inflation, and looking at the contract price in real terms (second panel of figure), the indexed contract will maintain the same value over time, whereas an unindexed one will lose value. The perception that inflation adjustments make contracts more expensive is incorrect, as nominal prices have no economic meaning. 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. The resulting bids are higher so that developers can recover their investment despite the contract's loss of value over time.

**Figure 5** The effect of inflation indexing on contract price



Note: the figure aims to show 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.

11. Unadjusted price without considering elements such as inflation, seasonality, loan fees and interest compounding.

## RENEWABLE ENERGY AUCTIONS

### Lower prices in the United States.

In a solar power auction conducted in Texas in 2013, contracts were awarded at a price averaging USD 60/MWh, substantially lower than the prices attained in most other countries in the same period, which were closer to USD 80/MWh. In all subsequent auctions up to the present, auction results in the United States have continued to prove extremely competitive (see Figure 6), and sometimes are noticeably lower than those recorded in other countries – among them Peru, Germany, France and South Africa. The main reason behind these low prices is the fact 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 6 illustrates actual prices in the United States versus estimated effective prices, namely the prices that investors would need to bid if they were not eligible for the investment tax credit. The estimated effective 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.



**Figure 6** US solar prices: actual vs. estimated effective prices, February 2013-May 2016



Source: based on data from Shahan, 2016.

**Higher prices in Germany.**

The case of Germany illustrates that other factors, such as the capacity factor<sup>12</sup> and the project costs, can explain price differences between countries – and even between regions in the same country.

A price resulting from a project with a capacity factor of 11%, as is mostly the case of Germany, cannot be compared to the record-low solar price in Chile, where the capacity factor is on average 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.

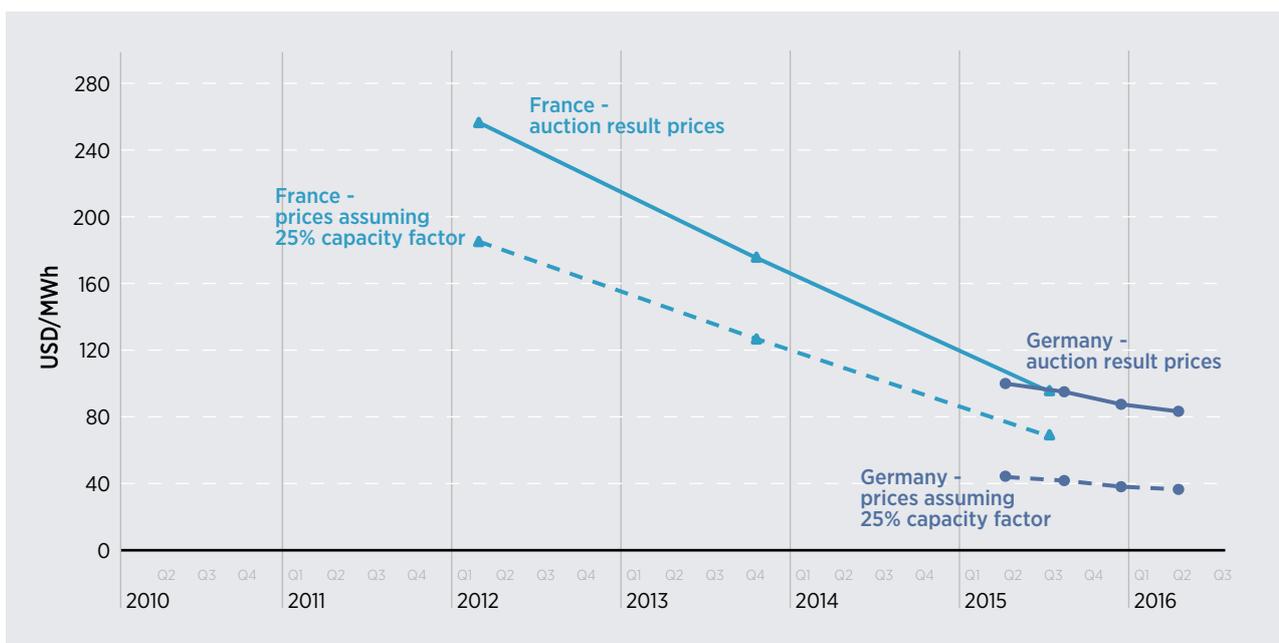
Figure 7 illustrates the actual prices obtained for solar power in Germany and France versus hypothetical adjusted prices that would be obtained under the same conditions but where a higher capacity factor applied. As a solar generator’s revenue is proportional to its generation, doubling its capacity factor should allow its selling price per MWh to be

reduced by roughly one-half while yielding the same amount of revenue. The figure shows that solar prices recorded in German auctions since 2015 might fall from around USD 85/MWh to USD 40/MWh if projects were located in sites where solar resources produced a capacity factor of 25% instead of the actual 11%. Similarly, assuming a capacity factor of 25% instead of 18% in France, prices would also become more competitive.

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. The same observation can be made about the onshore wind prices obtained in Italy’s auctions compared with those of other countries (see Figure 8).



**Figure 7** Solar prices in France and Germany: actual results vs. adjusted result assuming a benchmark capacity factor of 25%, February 2010-August 2016



Source: based on data from BNEF, 2016c.

12. 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.

### 2.3. PRICE TRENDS: ONSHORE WIND

Prices for onshore wind have fallen recently in several countries. Figure 8 shows prices converging to around USD 40/MWh in 2016, with record-breaking results below that level in Morocco, Peru and Mexico. Spurred by high competition, growing investor confidence and developed local industries, 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 South Africa, Italy and Chile, 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 three countries and other cases. The price drops may be due to a learning curve, as discussed in Section 2.1. Another factor is that some costs incurred in the first round are not repeated in further rounds, as bidders can use the same feasibility studies, resource assessments, and so on. Changes in auction design, such as those related to project location in Mexico, have also had an impact. Apparent in the figure are some fluctuations in results, notably in Brazil, for reasons explained below. The figure also shows that prices in Italy remain in the upper range.

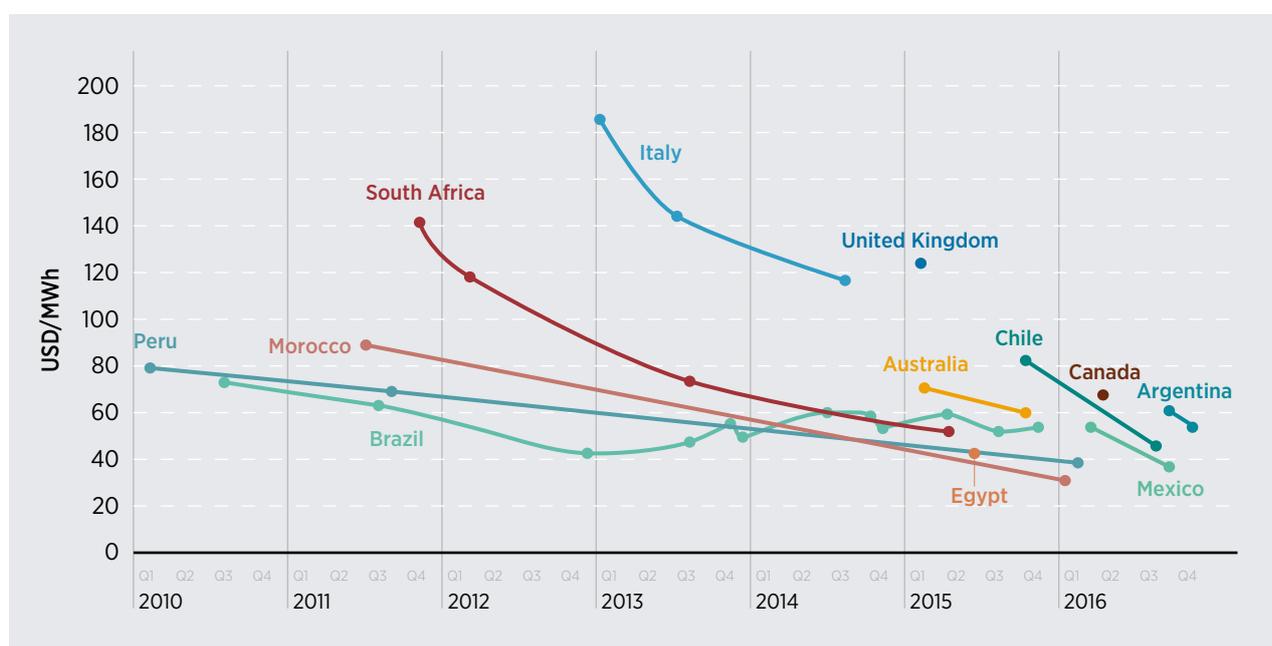
#### A sharp decrease in Mexico.

Following the liberalisation of the Mexican power market, many investors found the first energy auction in March 2016 an opportunity to enter the market. The second auction, which took place only seven months after the first, had as its main objective to contract the portion of demand that had remained unmet. The price decrease in Mexico can be largely attributed to the learning curve and to changes in auction design related to project location (see IRENA and CEM, 2015, volume 3).

The learning curve effects (as discussed in the South African example in Section 2.1) exerted some effect on price. More bidders were attracted to the second auction, partly owing to its higher demand in terms of volumes auctioned. While the first auction focused only on electricity quantity (in MWh) and clean certificates from wind and solar projects, the second one focused on also contracting capacity products. Therefore, the quantity demanded by the auction increased three-fold.

Another significant change was in the economic signals for project location provided. Strong signals in the first auction were meant to incentivise the location of new projects where they would most benefit the power system, as indicated by expected congestion prices obtained from a long-term system simulation. Every package bid was adjusted: the "good" locations (where the nodal

**Figure 8** Evolution of average auction prices for onshore wind energy, January 2010-July 2016



IRENA, 2017 (forthcoming).

prices are high) were rewarded and the “bad” ones (those with lower nodal prices) were for bid comparisons in the auction. However, in the second auction, the locational signals were significantly reduced, as the auction focused instead on the quality of the resources. The figures in Box 3 illustrate the change in the locational signals by region and the amount of electricity (in GWh) offered in each of the regions.

**Fluctuating prices in Brazil.**

Brazil is among the first countries to contract wind energy through auction; the country now has accumulated experience from 13 auctions. The price

trend in Brazil seems largely flat from 2010 to 2016, with some volatility represented by fluctuations and changes of direction in the price curve shown in Figure 8. Most of these fluctuations can be traced to project lead times, intensified competition, availability of concessional financing and depreciation of the local currency, and auction design.

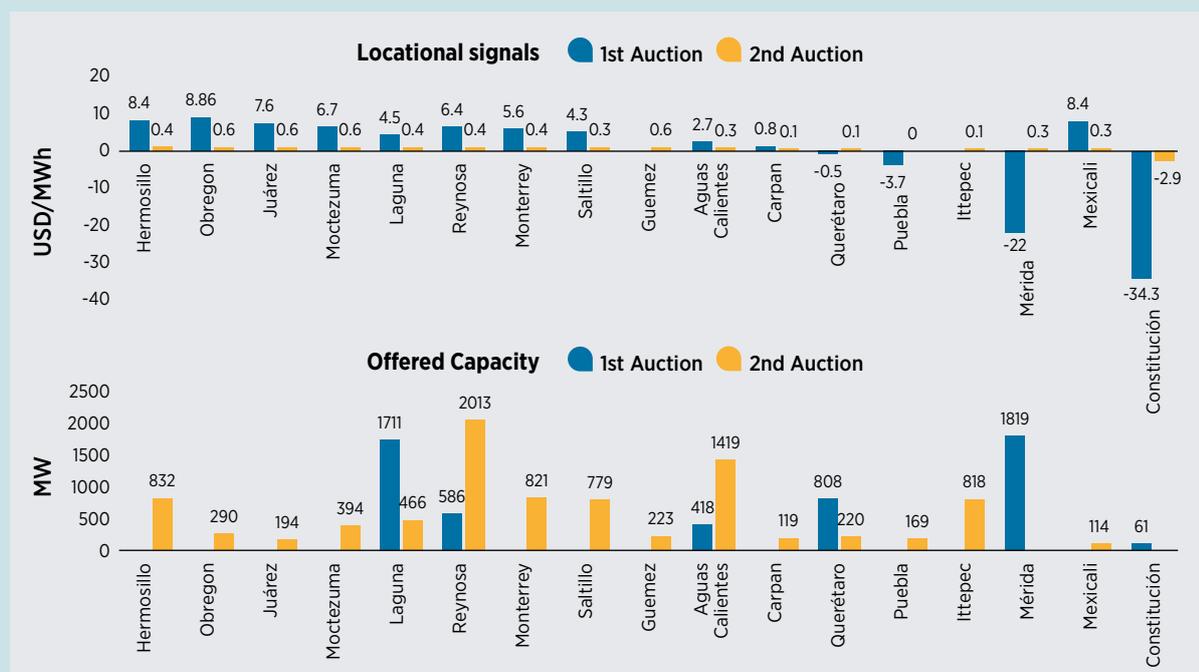
Brazil typically conducts two auctions each year: one for project delivery in three years (A-3) and another one for delivery in five (A-5) (IRENA, 2013). The five-year lead time allows more flexibility for planning construction and commissioning the project, while also minimising the risk of pen-



**Box 3 Locational signals in Mexican auctions**

Figure 9 illustrate the change in locational signals, by region, between the first and second rounds of the auctions held in Mexico in 2016 and the amount of power (in GWh) offered in each region. For example, projects located in the Northeast of the country (Hermosillo, Moctuzema) were not contracted due to the high “penalty” applied to the bids in those regions, which are, however, rich in renewable energy sources. Therefore, in the second auction, when the locational penalty decreased by 95%, significant quantities of power were contracted in these regions. The reverse effect took place in Merida region, where 1 819 GWh of wind and solar were contracted in the first auction owing to the advantageous location signal (USD 22/MWh), even though the resource potential was not favourable. Therefore, in the second auction the renewable energy plants have slightly higher capacity factors than in the first auction, which can also explain the average price decrease from one auction to the other.

**Figure 9** Locational signals and offered capacity in each location: first vs. second auction



Source: Strategy &, 2016.

## RENEWABLE ENERGY AUCTIONS

alties for delays. The A-5 auctions should, therefore, be expected to yield lower prices than the A-3 auctions, as shown in Figure 8 at the end of 2013 and 2014, where two auctions only months apart resulted in prices for the A-5 auctions that were 6% and 10% lower than those for 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. Only one auction was carried out in 2012 (as opposed to at least three in most years), with very low demand from distributors; whereas the previous auction contracted almost 1 GW of wind capacity, and the subsequent 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 Brazilian state-owned bank institution 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 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. This led to many energy projects being developed at a low cost of capital. However, when the fiscal situation of the Brazilian Treasury worsened in 2015, BNDES reduced its participation in loans for several segments of the energy sector and even temporarily stopped making new loans through the National Climate Change Fund. Without BNDES's cheap loans, the cost of capital of the projects almost doubled, which drove prices up.

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 (Brazilian auctions do not require domestic content directly.) The rules for calculating the maximum capacity factor that wind power plants could offer in the auction, the revision of the ceiling price in light of the depreciation of the local currency, and the rule for determining generators' responsibility in cases of transmission delay were also revised that same year, which contributed to an increase in bid prices (Bloomberg, 2015).

### Higher prices in Italy.

Despite significant price decreases in each round, prices remained substantially higher in Italy than in many other countries; they were comparable to the prices observed in the United Kingdom in 2015. The fact that European countries seem to show a systematically higher price can be explained partly by higher costs of finance, labour and land compared with other regions.

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 in several cases exceeding 50%. 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 (although subject to yearly fluctuations). This is in stark contrast with European countries, where values closer to 30-35% seem to be the norm.

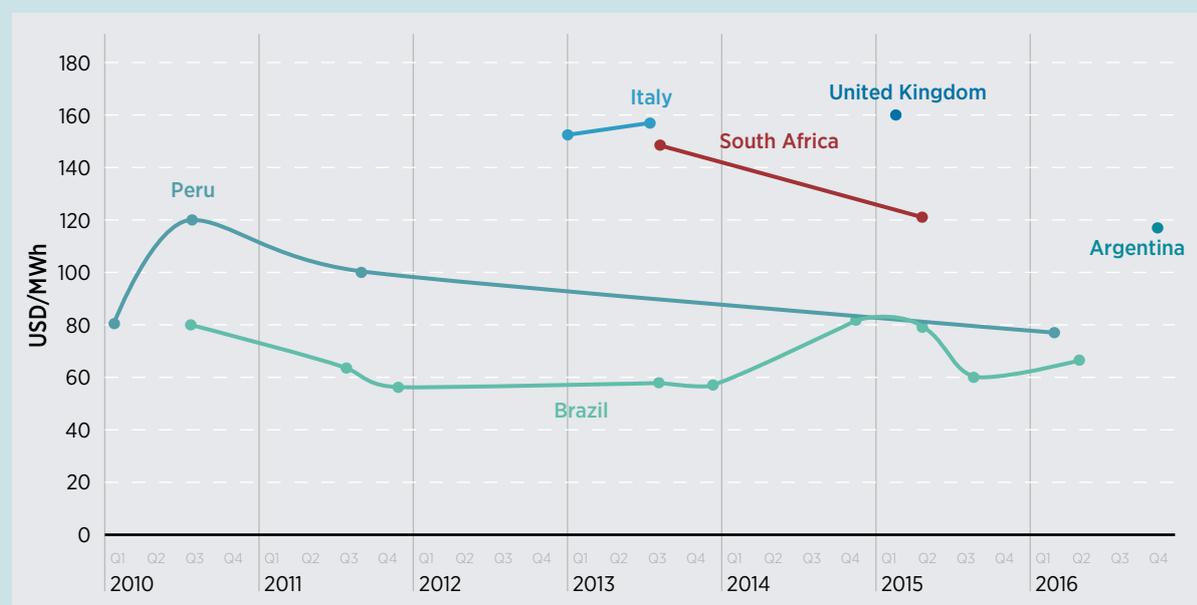
As shown in this section, many factors contribute to the low prices that result from solar and wind auctions. Analysing and comparing results of various auctions globally can be challenging, as prices are heavily influenced by factors related to the country context and to auction design. Analysing the prices emerging from biomass auctions is even more complicated, as these depend largely on the feedstock used (see Box 4). Nevertheless, it is important to analyse those factors in order to provide policy makers with a good understanding of the dynamics of auctions and enable them to make informed decisions about the choice of policy instruments and the design of auctions.

**Box 4 Price trends of bioelectricity**

Bioenergy production is very diverse, encompassing a wide range of technologies and feedstock materials. In general, the most competitive bioelectricity solutions involve the use of solid biomass residues from forestry and agricultural activities such as wood chips, rice husks, and sugarcane bagasse. The capacity of the plant, as well as its competitiveness, depends greatly on the volume of residues generated. Urban biomass and biogas solutions have recently gained attractiveness, as they present an opportunity to reduce sanitation costs for the government while also producing electricity. Their competitiveness has increased over the years, but they typically involve smaller capacities and therefore lower economies of scale.

Figure 10 illustrates the price outcomes from selected auctions globally. Because the range of feedstock choices is wide, it can be difficult to make reasonable country comparisons or draw meaningful trends and conclusions. For example, whereas Peruvian auctions typically award contracts for municipal solid waste or biogas, its 2010 auction was dominated by sugarcane agricultural residue – which explains the noticeable shift in prices. Similarly, even though sugarcane bagasse has been the most prominent technological route in Brazil, the country’s 2014 and 2015 auctions had significant contributions from generation based on wood chips, which along with the country’s delicate economic situation (see Section 2.2), contributed to the increase in the price.

**Figure 10** Evolution of average biomass prices in auctions, January 2010-July 2016



IRENA, 2017 (forthcoming)

The results are influenced by the design of auctions, chiefly the price ceiling. Policymakers generally favour some biomass technologies over others owing to resource availability and targeted socio-economic benefits. As a result, their priorities are translated into different price ceilings. In Peru’s 2016 auction, the highest price ceiling was attributed to solid waste (USD 106/MWh), followed by forestry residues (USD 90/MWh), biogas solutions for municipal waste management (USD 77/MWh), and the lowest price ceiling was attributed to agricultural waste solutions (USD 68 /MWh) (Osinergrmin, 2015).

The varied ranking of favoured technologies across countries illustrates the degree to which a country’s characteristics affect not only pricing but also the choice of the most strategic technologies in line with the socio-economic objectives. It is therefore important to consider the positive externalities of biomass, which include 1) its positive contributions to the electricity grid for baseload generation; 2) synergies with the agricultural sector and rural economic development; and 3) synergies with municipal needs for urban sanitation and waste management.

## 3 ANALYSIS OF FACTORS INFLUENCING PRICES

As shown in Section 2, auctions have been driving renewable energy prices down as they spur competition in the market and allow for real price discovery. However, falling technology prices and increased competition are not the only factors bringing prices down. Country-specific factors play a major role in individual auction results and must be evaluated with care. Such factors include 1) access to finance and country-specific economic conditions; 2) investors' confidence (related to the presence of a conducive environment); 3) other policies aimed at supporting renewable energy development; and 4) auction design elements.

### 3.1. ACCESS TO FINANCE AND COUNTRY-SPECIFIC CONDITIONS

The prices resulting from renewable energy auctions depend largely on the costs incurred by project developers, including the cost of finance. 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 credible off-taker. Attractive loan terms and other means of reducing the cost of debt lower projects' capital costs, permitting lower prices. Attractive financing can

be offered by national banks, such as BNDES in Brazil (see Box 5), or by international development banks, as in Morocco, Peru and Zambia and the high level of debt versus equity such as the case of Dubai in the United Arab Emirates, can bring down the cost of financing (see Box 6).

In addition, the macroeconomic conditions of each country affect the availability and cost of financing. These conditions 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 stability. These elements affect international institutions' willingness to offer attractive financing, which, of course, affects prices.

Moreover, there can be a significant variation in the capital and operational expenditures (CAPEX and OPEX) of renewable energy projects between countries. This variation is determined by: 1) the differences in installation and building costs, which depend on the cost of land, labour, and so on; 2) the asymmetries in ease of access to equipment; 3) the fluctuations in foreign exchange rates, affecting equipment costs; and 4) the fiscal and labour legislation that can also vary substantially among different jurisdictions and affect both investment and operation costs.



#### Box 5 Access to finance and 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. BNDES loans typically covered more than 70% of the invested capital, and the cost of debt was significantly lower than the interest rate on 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. With Brazil in a difficult economic and political crisis, few international banks were interested in filling the gap left by the state-owned bank. Contracts denominated in domestic currency were also seen as an obstacle for international players, especially in the face of 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 3 and 6.

*Source: Costa, 2016.*

Finally, the availability of renewable energy resources in sites that can be exploited also affects the resulting price. As shown in the cases of Germany (see Section 2.2) and Italy (see Section 2.3), the solar radiation and the wind speed greatly impact the capacity factors of solar and wind projects, thereby creating the difference in prices obtained in various countries.

### 3.2. INVESTOR CONFIDENCE AND A CONDUCTIVE ENVIRONMENT

Investors' confidence in the renewable energy sector and the risks faced by project developers significantly affect auction results. In cases where these risks are mitigated, investment costs can decrease substantially, resulting in lower bids. 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 through certainty and regularity in the scheduling of auction rounds (see Box 6). A systematic auctioning scheme also implies a learning curve effect for the auctioneer, the project developers, as well as financiers that also contributes to lower prices, as seen in India, Peru and South Africa (see IRENA and CEM, 2015, volume 3).

Investors' confidence can be further strengthened through the mitigation of financial risks, as when public finance institutions make available to private developers risk mitigation instruments such

as guarantees, currency-hedging instruments and liquidity reserves. In Chile, for example, auction contracts are denominated in USD and adjusted periodically in line with the United States' Consumer Price Index, thus shielding developers from both interest-rate risks and inflation risks (see IRENA and CEM, 2015, volume 6). Auction price differences among countries are notably shaped by variations in the weighted average cost of capital, either in the cost of equity related to the perception of risk of the investor, or in the cost of debt related to financing conditions.

### 3.3. POLICY SUPPORT TO THE RENEWABLE ENERGY SECTOR

At the end of 2015, 173 countries had established renewable energy targets at the national or subnational level (REN21, 2016). Renewable energy targets can gain credibility only if they are accompanied by a clear strategy and backed by specific policies and measures (IRENA, 2015a). Table 1 provides an overview of policies and measures that have been implemented to translate targets into projects. Many of these support schemes can be used in conjunction with auctions and can affect the resulting prices.

Auctions can, for example, be implemented together with fiscal incentives. Tax breaks or import duties that reduce project costs (and thus prices), as in the United States (see Section 2.1), can promote deployment. Other examples include the use



#### Box 6 Investor confidence in Dubai in the United Arab Emirates

In Dubai, the results of the third phase of the Al Maktoum Solar Park (USD 29.9/MWh) were made possible largely by investors' confidence: Saudi and Emirati institutions were very interested in submitting competitive bids to meet the Emirates' long-term vision for solar deployment of a total capacity of 5 GW. The strategic goal of entering a promising market not only intensified the competition and encouraged low bids but also provided investors with confidence in a long-term market for renewables. 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 way, the project more closely resembles a public-private partnership program 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.

*IRENA, 2016c.*

**Table 1** Renewable energy policies and measures

NATIONAL POLICY	REGULATORY INSTRUMENTS	FISCAL INCENTIVES	GRID ACCESS	ACCESS TO FINANCE <sup>a</sup>	SOCIO-ECONOMIC BENEFITS <sup>b</sup>
<ul style="list-style-type: none"> <li>• Renewable energy target</li> <li>• Renewable energy law/strategy</li> <li>• Technology-specific law/programme</li> </ul>	<ul style="list-style-type: none"> <li>• Feed-in tariff</li> <li>• Feed-in premium</li> <li>• Auction</li> <li>• Quota</li> <li>• Certificate system</li> <li>• Net metering</li> <li>• Mandate (e.g., blending mandate)</li> <li>• Registry</li> </ul>	<ul style="list-style-type: none"> <li>• VAT/ fuel tax/ income tax exemption</li> <li>• Import/export fiscal benefit</li> <li>• National exemption of local taxes</li> <li>• Carbon tax</li> <li>• Accelerated depreciation</li> <li>• Other fiscal benefits</li> </ul>	<ul style="list-style-type: none"> <li>• Transmission discount/exemption</li> <li>• Priority/dedicated transmission</li> <li>• Grid access</li> <li>• Preferential dispatch</li> <li>• Other grid benefits</li> </ul>	<ul style="list-style-type: none"> <li>• Currency hedging</li> <li>• Dedicated fund</li> <li>• Eligible fund</li> <li>• Guarantees</li> <li>• Pre-investment support</li> <li>• Direct funding</li> </ul>	<ul style="list-style-type: none"> <li>• Renewable energy in rural access/cook stove programmes</li> <li>• Local content requirements</li> <li>• Special environmental regulations</li> <li>• Food and water nexus policy</li> <li>• Social requirements</li> </ul>

IRENA, 2015b.

of auctions to fulfil a set national target, or as part of a renewable energy strategy or programme, or along with a quota scheme, such as the renewable portfolio standards of the state of New York. Such measures provide potential bidders with an indication of long-term potential demand, increasing their confidence and reducing prices (IRENA and CEM, 2015). Nevertheless, combining auctions with other policies and measures may result in higher prices. Common examples are socioeconomic policies such as local content requirements designed to strengthen the domestic industry or achieve other social benefits (for example, community ownership).

### 3.4. AUCTION DESIGN

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 the price and another objective, including generating socio-economic benefits or ensuring the successful and timely delivery of projects. The analysis of how auction designs impact prices is done following the same framework that presents the four design categories described in (IRENA and CEM, 2015, Volume 2) (see Figure 11).

**Consistency of auction demand.** An auction programme that is structured and consistent can lead to lower prices by raising investors' confidence. A long-term auction programme, with a predictable schedule, a stable and robust design, a credible off-taker, and a high degree of transparency are all elements that contribute positively to the level of robustness of the auction. Consistency instills confidence among potential bidders, which may increase competition in the auction. However, it also implies that policymakers have less flexibility to adjust the auction design in the face of changing market conditions.

**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 reduce significantly the pool of potential bidders, limiting competition and potentially driving prices up. On the other hand, loosening qualification and documentation requirements may increase the risk of underbuilding and delays, as occurred in the wake of Peru's early auctions.

Other ways of lowering barriers to new bidders include reducing the complexity and increasing the transparency of the auction process, as well as centralising some of the necessary bureaucratic procedures (such as obtaining environmental licenses and grid-access permits). Design ele-

ments that can contribute to lower prices include the government assuming responsibility for some tasks, such as resource assessments, site selection and grid connection. This is the example offered by auctions in Dubai and Zambia, where project developers are shielded from certain risks because the auctioneer is responsible for choosing the project site and securing all necessary documentation.

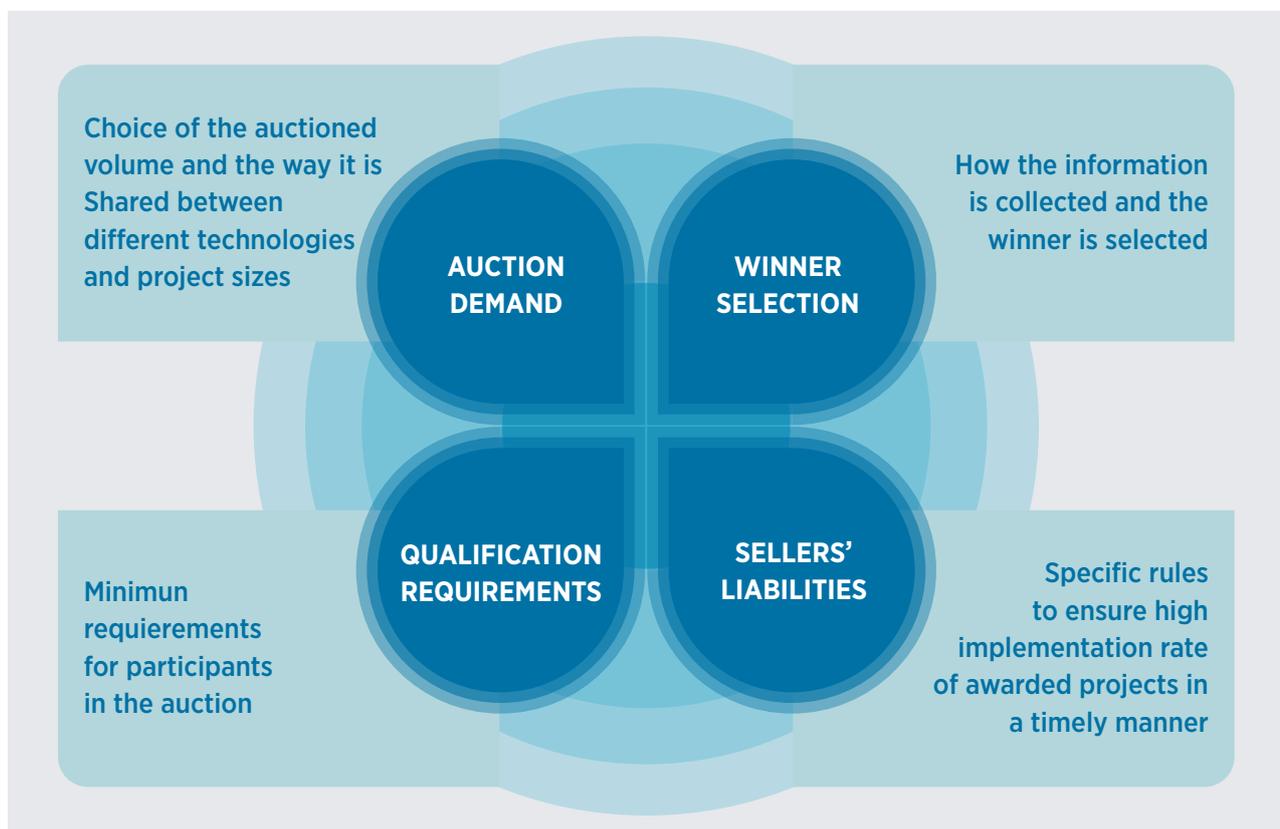
In the implementation of local content requirements, there is a trade-off between developing a local industry (along with benefits such as job creation and improved trade balance) and achieving lower prices. For example, as explained in Section 2.1, South Africa’s high prices can be explained by the fact that the country’s auction design emphasised domestic content requirements and social development. This made it more costly to provide the energy services being auctioned and more difficult for international companies to participate, but also reflected the importance of South Africa’s priorities in terms of development goals.

**Winner selection for minimum price.** It is quite common to find auction designs that give impor-

tance to non-price objectives such as project location, domestic industry development, and the developer’s experience and reputation. Nevertheless, there are just as many ways to use the design to minimise prices, such as by imposing a lower price ceiling. Other elements that can affect the resulting price are whether the auction adopts a pay-as-bid or pay-as-cleared rule and whether it imposes potentially costly constraints on winning projects (such as an upper limit on the project size to encourage small/new players into the market that could deter economies of scale).

**Liabilities on investors.** 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 refuse to 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.

**Figure 11** Categories of auction design elements



## RENEWABLE ENERGY AUCTIONS

Another important aspect that influences the price results of the auction lies in the auctioned contract and the resulting revenue streams. In some cases, the auctioned contract price may give a misleading indication of the total remuneration of the investor over the project's lifetime. One way to compare the remuneration level of different auctioned contracts is by calculating an average levelised cost<sup>13</sup> of the contract's remuneration over its lifetime, recognising that revenue typically varies in real terms over the duration of the contract. Depending on the contract's rules for determining effective remuneration over the project's lifetime, this levelised contract revenue can be significantly different from the price awarded at the auction. This is the case with Indian contracts not indexed for inflation, which result in decreasing remuneration over time, as explained in Section 2.1. Also, the ongoing auctions in Abu Dhabi are an interesting case of innovative design elements that diverge the remuneration profile of the project from the actual bid submitted (see Box 7).

Finally, the lead times of projects can affect the prices offered. It is possible in auctions with long lead times for investors to speculate on a further decrease in investment costs between the time they submit their bids and when they effectively execute the project, as in the case of Brazilian A-5 auctions. However, this type of strategy can be a double-edged sword: On one hand, the expectation of lower costs enables more competitive bids and contributes to cheaper renewable energy, but, on the other, it may force the project developers to make an offer that is not economically viable if their projections do not materialise. Such downside scenarios could lead to delays and cancellation of projects and, in more generally, harm the industry's sustainability.



13. Based on the Levelised Cost Of Electricity (LCOE), which is a measure of the total cost to produce electricity, including capital costs, operating and maintenance costs, and the fuel costs. It can be calculated as the ratio of lifetime costs to lifetime electricity generation, both discounted back to a common year using a discount rate.



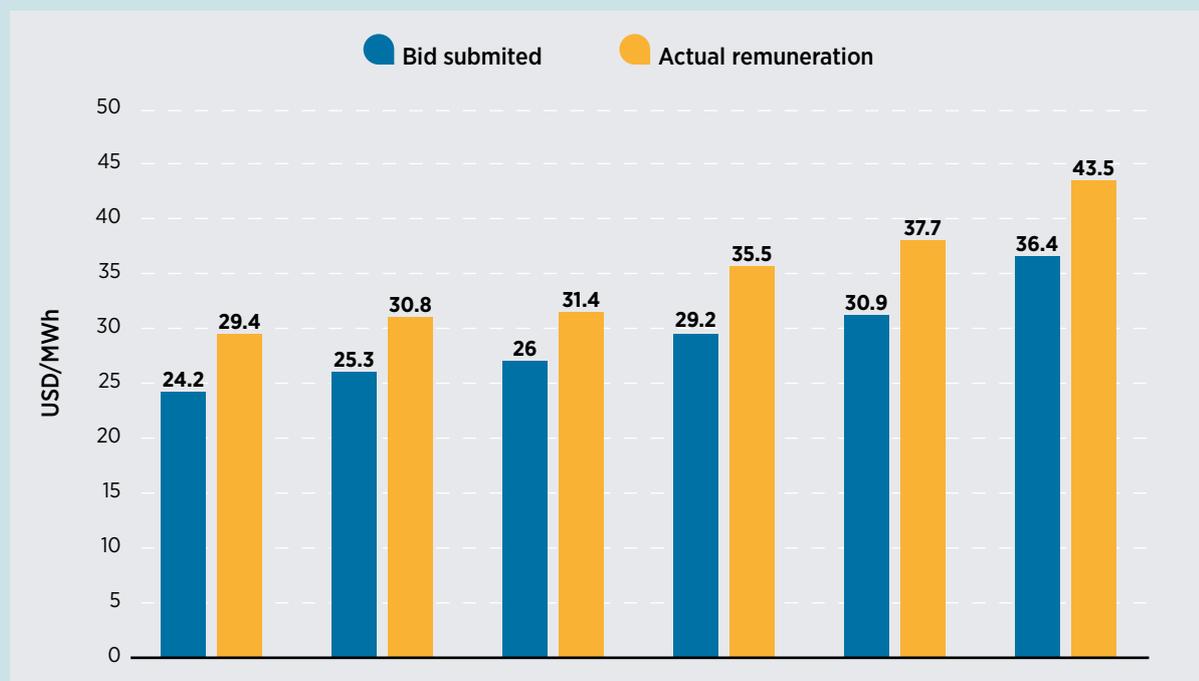
### Box 7 Remuneration profile in Abu Dhabi in the United Arab Emirates

In September 2016, the Abu Dhabi Water and Electricity Company (ADWEA) received proposals for its solar auction, the official results of which are to be announced in first quarter of 2017. On the auction closing date, the lowest bid of USD 24.2/MWh was received, followed by bids of USD 25.3/MWh and USD 26/MWh. These prices represent an almost 20% decrease from the previous record of USD 29.9/MWh attained in Dubai's most recent solar auction.

One relevant design innovation is that energy delivered from June to September, when Abu Dhabi's generation capacity is currently barely able to cover air conditioning demand, counts for 1.6 times as much as energy delivered from October to May. Therefore, the bids do not reflect the actual remuneration of the project.

Incorporating the extra remuneration for the summer period and making additional assumptions, an estimate of the agents' true remuneration compared to the amount bid in the auction is illustrated in Figure 12. The exact payment details are in the individual bid and are not available. But it is still possible to observe that the seemingly unprecedented bid of USD 24.2/MWh is comparable to the bids received in recent solar power tenders in Dubai, as the agent would be remunerated according to a flat contract price of approximately USD 29.4/MWh without the summer months' premium.

**Figure 12** Abu Dhabi's solar auction: bid submitted vs. actual remuneration



Source: BNEF, 2016b.

## 4 THE WAY FORWARD IN PLANNING AND DESIGNING AUCTIONS

The steep downward trend in renewable energy prices resulting from recent auctions suggests that a transition towards renewable and sustainable power systems is already economically justifiable and feasible. This brief shows the impressive reduction in auction prices for solar PV and wind and analyses the factors that explain these trends. While increased price competitiveness is a major driver of deployment, understanding the reasons behind the recent low prices is important to better inform policy makers.

The low prices attained do not always reflect the true remuneration profile of the auction. Several elements – such as additional financial support, indexed contracts, and additional remuneration during periods of peak demand – can result in investors receiving a higher remuneration than the nominal auctioned price. Nevertheless, even after correcting for these factors, there is a major concern among both policy makers and industry players that auctions may be underestimating the true costs of renewable energy. This is because auction prices do not factor for the balancing costs of renewable energy and also due to a potential “winner’s curse”, whereby the winner of the auction faces negative profits. The winner’s curse can result from overly aggressive bidding in the competitive environment of the auction, which could pose a significant risk of underbuilding and delays, with serious repercussions on the sector on the long run.

Delays and underbuilding can be avoided if the auctioning mechanism and awarded contract are solid, penalties are credible and enforceable, and the country has a reasonable degree of legal and regulatory stability. The same best practices would also minimise the adoption of overly aggressive bidding strategies by suppliers. However, stringent compliance rules may deter the participation of small and/or new players, which is another well-known weakness of auctions, given their relatively high associated transaction costs for both the bidders and the auctioneer. The extent to which this may affect the results of an auction depends on choices regarding its design elements and how well adapted they are to the country’s specific context in terms of economic situation, structure of the energy sector, maturity of the power market and level of renewable energy deployment.

The complex and dynamic environment of renewable energy auctions motivates constant innovation in the mechanisms’ design. In this context, the assessment of previous implementations and the most recent experiences is crucial. It is also essential that the industry take solid steps towards maturity, relying on sustainable economic practices, so as to maintain the attractiveness of investments and to encourage the participation of new players in the sector.



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**ANALYSING 2016**  
**EXECUTIVE SUMMARY**

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