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Renewable energy auctions in Japan:
Context, design and results

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ABBREVIATIONS

CCGT	Combined cycle gas turbine
COD	Commercial operation date
EIA	Environmental impact assessment
EPC	Engineering, procurement and construction
EPCo	Electric power company
FiT	Feedin tariff
GDP	Gross domestic product
IPP	Independent power producer
JPEA	Japan Photovoltaic Energy Association
JPY	Japanese yen
kWh	Kilowatt hour
kWp	Kilowatt peak
LCOE	Levelised cost of electricity
METI	Ministry of Economy, Trade and Industry (Japan)
MJ	Megajoule
O&M	Operation and maintenance
OCCTO	Organisation for CrossRegional Coordination of Transmission operators
OECD	Organisation for Economic Cooperation and Development
p.a.	Per annum (per year)
PPA	Power purchase agreement
PV	Photovoltaic
RPS	Renewable portfolio standard
TWh	Terawatt hour
USD	US dollar
WACC	Weighted average cost of capital

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Key findings

- In 2017, with the feed in tariff (FiT) scheme becoming increasingly fiscally unsustainable, Japan introduced renewable energy auctions. As of October 2020, Japan had conducted five solar photovoltaic (PV) and two biomass auctions, and launched a zone-specific offshore wind auction in June 2020. A feed in premium (FiP) scheme was announced in 2020 to be introduced in 2022.

- The five solar PV auctions have awarded almost one-third of the originally announced volumes (574 megawatt (MW) awarded out of a total 1,663 MW auctioned). In addition, no biomass project has yet been contracted through renewable energy auctions.

- The challenge in solar PV auctions has mainly been in retaining qualified bidders, as many dropped out during the process. Developers indicated that constraints regarding grid connection and land availability, as well as strict bond confiscation rules in the first round, reduced their interest in placing bids.

- At the solar PV auctions, average awarded prices fell by more than 35% between the first and fifth rounds. The first saw a weighted average awarded price of JPY 19.64 (Japanese yen)/kilowatt hour (kWh)[1] (USD [US dollar] 174/ megawatt hour [MWh]) in November 2017, while the fifth saw an average awarded price of JPY 12.57/kWh[2] (USD 115/MWh) in January 2020. Yet solar PV prices in Japan are still higher than the global average, which was USD 56/MWh in 2018. Solar PV prices in Japan are also high compared to those achieved in other countries with similar macro-economic conditions and level of development of the solar PV energy sector.

- Relatively high auction prices do not necessarily tarnish an auction's success. The average awarded prices were close to the cost of electricity for solar PV power in Japan, underscoring the price discovery attributes of auctions. At the same time, resulting prices were close to the auctions' ceiling prices, suggesting that higher competition, if issues causing undersubscription in various rounds were addressed, could potentially drive prices further down.

- The main factor behind the high cost of generation of solar power in Japan is the relatively high installation and building cost, as well as the cost of modules and inverters. Risk perception can also explain high prices. In Japan, developers must factorin the risk of high curtailment rates without compensation and grid connection uncertainties.

- In the Japanese context, economies of scale due to grid connection and land availability constraints do not play a major role. Consequently, the increased participation of small and new players in the fourth and fifth rounds did not prevent prices from falling.

- Many of the challenges that Japanese auctions have faced can be tackled through auction design elements that go beyond price reduction. These elements can focus on: smoother gridintegration of renewables, ensuring timely project completion, and/or supporting a just and fair energy transition.

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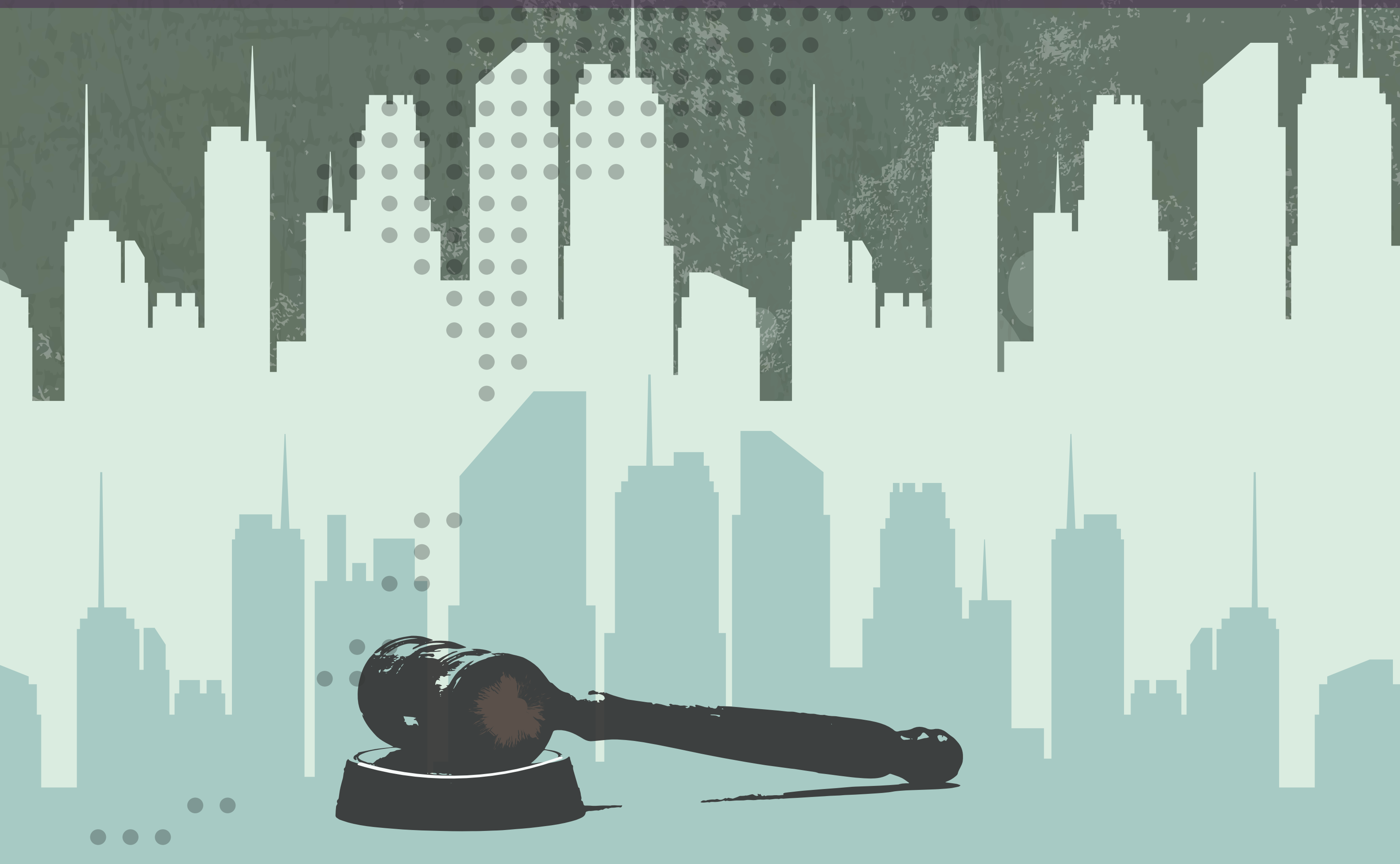
[1] JPY 1 = USD 0.00886 in November 2017.
[2] JPY 1 = USD 0.00915 in January 2020.

1 National context for renewable energy auctions



Renewable energy has yet to make a significant dent in Japan's energy and power mixes, which rely mainly on fossil fuels. The events at the nuclear power plant in Fukushima following the 2011 earthquake and tsunami marked a fundamental shift in Japanese energy policy into one where renewables should assume a more important role.

Although a FiT scheme initially fuelled rapid renewable energy deployment, this soon became fiscally unsustainable. Since 2017, therefore, Japan has opted for auctions as the key policy instrument driving the national transition to renewables.

1.1 JAPAN'S ENERGY AND ELECTRICITY SECTORS

Japan is the fifth largest energy supplier and consumer in the world (UNSD, 2020a). Per capita total final energy consumption (TFEC) peaked in 2002, but it has decreased ever since to levels from three decades ago, despite economic growth.[3] In fact, per capita TFEC in 2018 was below that of 1990 (UNSD, 2020a; UN DESA, 2020; METI, 2020a). The main reason behind this is Japan's emphasis on energy efficiency, with a myriad of policies and measures having been implemented since the 1970s and up to 2019 (IEA, 2019). Accordingly, its energy intensity improved by more than 29% over the 2000-2018 period, from 4.8 megajoules (MJ)/USD[4] to 3.4 MJ/USD (UNSD, 2020b; World Bank, 2020).

To meet its energy demand, Japan relies mainly on fossil fuels, which provided more than 95% of the total primary energy supply in 2018 (METI, 2020a). With almost negligible domestic production of fossil fuels, Japan depended on imports for 99.7% of its oil, 99.3% of its coal and 97.5% of its natural gas needs in 2018 (METI, 2020b).

Electricity represented almost a third (30%) of the country's TFEC in 2018 (METI, 2020a). This is a considerably higher share than the global average of 21.8% in 2017 (UNSD, 2020a). Historically, nuclear energy generated up to one-third of Japan's power. Following the 2011 Great East Japan Earthquake, however, and the consequent accident at the Fukushima Daiichi nuclear power plant, all nuclear power plants were shut down and only a small number have re-opened since.

[3] *Japan's gross domestic product (GDP) has grown every year since 2012, albeit at slow rates. Moreover, Japan is the world's fourth largest economy. IRENA's forthcoming report Socio-economic footprint of the energy transition: The case of Japan explores these topics in detail.*

[4] *USD purchasing power parity (PPP), constant 2017.*

Even though most of that nuclear capacity has been replaced by fossil fuels, since 2011, renewables have assumed a growing role in electricity generation. The share of renewables in the generation mix increased from around 10% in 2010 to 16% in 2018 (Figure 1). Nevertheless, this share was still much lower than the global average of 25% in 2018 (IRENA, 2020a).

1.2 DRIVERS OF RENEWABLE ENERGY DEPLOYMENT

The deployment of renewable energy in Japan has been driven by plans to diversify the electricity mix, achieve environmental and socio-economic goals, and increase energy security.

In addition, events at the nuclear power plant in Fukushima following the 2011 earthquake and tsunami marked an important turning point for Japan's energy policy (Kucharski and Unesaki, 2017) and the diversification of the electricity mix. The first energy policy revision following these events, namely the 4th Strategic Energy Plan (2014), aimed to minimise dependency on nuclear power and to accelerate the uptake of renewables.

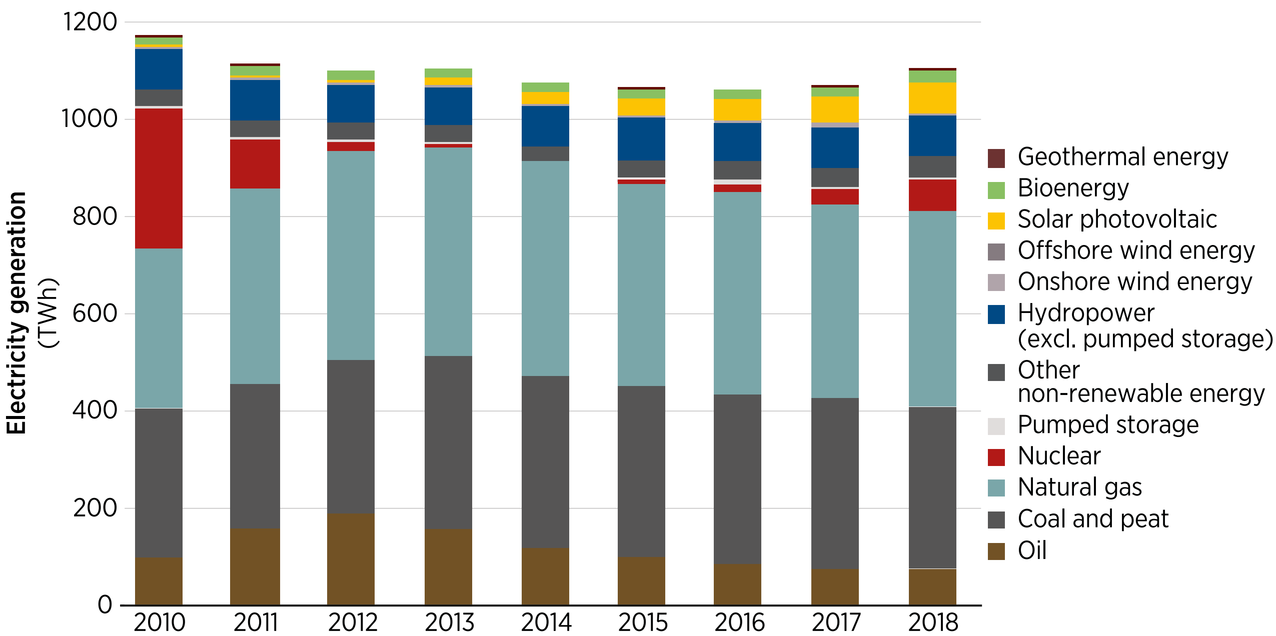
At the same time, Japan pledged to reduce total CO_2 emissions by 26% between 2013 and 2030 (METI, 2018) as part of its commitments to the Paris Agreement. This placed environmental concerns at the heart of the country's renewable energy plans.

Japan is currently on track to reach this emissions goal: emissions from the power sector in 2019 were 3% lower than they were in 2010. But the power sector still accounts for about 40% of total emissions, with these peaking in 2013, as fossil fuels replaced nuclear power. Renewable energy, along with energy efficiency, are thus now the main pillars of Japan's efforts to reduce emissions (IRENA, 2020b).

Moreover, a heavy reliance on fossil fuels, which are almost fully imported, has also meant a low level of energy self-sufficiency in the country. This level fell, in fact, from 20% in 2010 to just 9.6% in 2017 because of the nuclear phase out (METI, 2020b). Renewables currently account for 70% of Japan's domestic production of energy, with an increase in renewable energy supply therefore able to help the country reach its energy self-sufficiency target. This goal is 24.3% by 2030 (METI, 2015).

In addition, the renewable energy industry is a large employer and source of income for the country. In 2019, the Japanese solar industry alone employed around 240 000 people at various links of the value chain. Because solar PV capacity additions in 2019 were almost half the volume of the year before, this

Figure 1. Generation mix in Japan (TWh), 2010-2018



Source: IRENA (2020a)

Note: TWh = terawatt hour

was a reduction of 10 000 jobs from 2018 (IRENA, 2020c). The deployment of other technologies such as biomass, wind and geothermal can also add economic value, create jobs, and reinforce the country's position as a leader in technological advancement and innovation export.

Finally, renewables can help reduce the power system's costs by 2030. Indeed, falling costs and more mature technologies have already placed renewables as the lowest-cost source of power generation in many countries (IRENA, 2020d; IRENA, 2019a). While coal and combined cycle gas turbine (CCGT) are still cheaper generation sources than renewables in Japan, the levelized cost of electricity (LCOE) of solar PV decreased by 64% from 2011 to 2019, and could decrease another 62% by 2030 (IRENA, 2020d; IRENA, 2019a; IRENA Renewable Costs Database). Furthermore, policy makers aim to bring the generation cost of solar PV down from JPY 16.9/kWh (USD 153/MWh)[5] in 2018, to JPY 7/kWh (USD 64.1/MWh)[6] by 2025. This would imply a 59% reduction in cost (IRENA, 2019a; METI, 2019b).

1.3 RENEWABLE ENERGY POLICY AND REGULATORY FRAMEWORKS IN THE ELECTRICITY SECTOR

National plans and targets for renewables

The 4th Strategic Energy Plan of 2014 represented a fundamental shift in Japanese energy policy into one where renewables should assume a more important role. In July 2015, the Long-term Energy Supply and Demand Outlook was approved, which defined renewable energy targets of 13% to 14% in primary energy supply and 22% to 24% in the power mix by 2030 (METI, 2015).

The 5th Strategic Energy Plan of 2018 set energy policy objectives of ensuring, first and foremost, stable supply (energy security), while achieving low costs by enhancing efficiency (economic efficiency), but also safeness (safety). At the same time, the plan calls for maximum efforts to pursue environment suitability (environment). In keeping with this, renewables are set to play a more important role in achieving these priorities (METI, 2018). The renewable energy targets, however, have not been updated (METI, 2020b).

Electricity market structure and reforms

Market liberalisation efforts have fostered a friendlier environment for renewables in Japan.

These efforts began in 1995, with the liberalisation of power generation, allowing independent power producers (IPPs) to compete with the then vertically integrated electric power companies (EPCos). Following reforms in 2000, 2005 and 2008 that fostered retail competition and third-party access rules, the Act for Partial Revision of the Electricity Business Act was passed in 2013 with three objectives: 1) to secure a stable electricity supply; 2) to reduce electricity rates; and 3) to expand choices for consumers and business opportunities.

The reform was designed to be implemented in three stages. First, in 2015, the Organization for Cross-regional Coordination of Transmission Operators (OCCTO) was established, as the 10 EPCos had done little to coordinate supply and demand across their borders. One example of this was power being transmitted at different frequencies (The Economist, 2020) in different regions. Second, in 2016, full retail competition was enforced. Lastly, complete legal unbundling between generation, transmission and distribution activities was implemented in April 2020. Beyond market liberalisation, an enabling environment has also been put in place to support the development of the renewable energy sector in Japan, including renewable portfolio standards, feed-in-tariffs and more recently, auctions.

Renewable portfolio standard from 2003 to 2012

The first measure Japan used to promote renewables was a renewable portfolio standard (RPS). Introduced in 2003, this mandated generation targets for renewables (excluding large hydro). It has been difficult to assess the effectiveness of the RPS, however, as it allocated high risks to developers (Ito, 2015).

Administratively set tariff from 2009 to 2021

In 2009, the first FiT was introduced to remunerate excess solar production fed into the grid. That programme was expanded in 2012 (the "FiT Act") to cover all solar generation – not only the excess – as well as hydro projects below 30 MW

[5] *1 JPY = 0.009059 USD (average 2018)*
[6] *1 JPY = 0.009159 USD (average 2019 until September 10)*

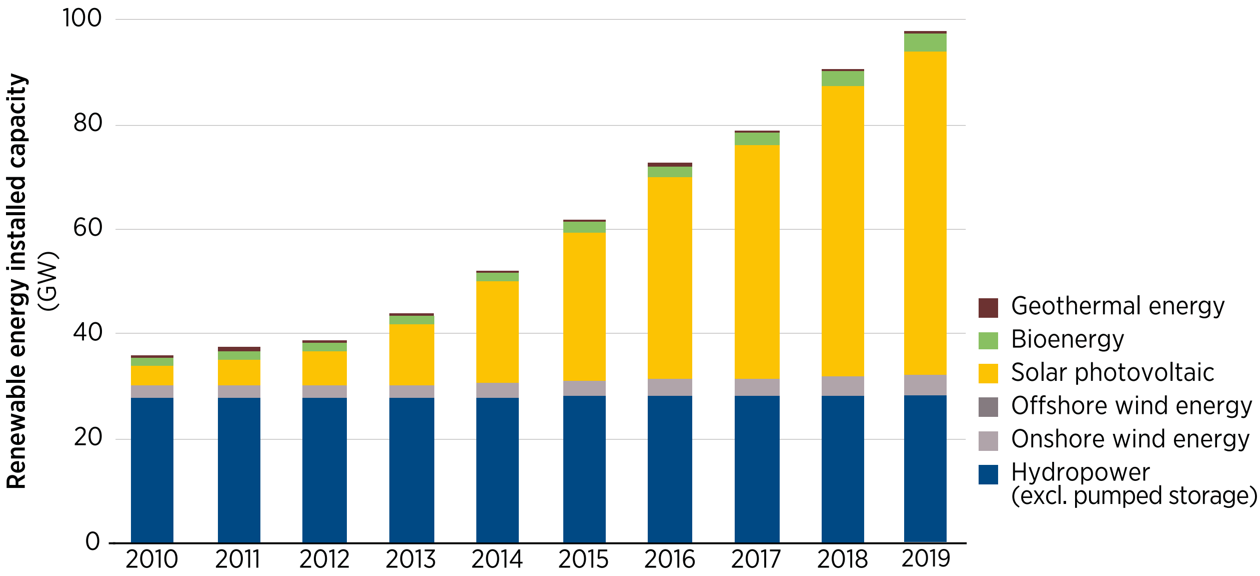
in size, wind, geothermal, biomass and any other sources recognised as renewable by the Japanese cabinet. The FiT Act replaced the RPS.[7]

The expanded FIT scheme of 2012 had been the main policy instrument promoting renewables in Japan. It resulted an annual renewable capacity growth rate of 22% by 2017 since it was introduced, compared to 5% under the RPS and 9% under the first FIT scheme (METI, 2019d). Between 2010 and 2019, the renewable capacity (excluding large hydro) expanded 2.7-fold (Figure 2) and the renewables share in the power mix (excluding large hydro) increased from 2.5% in 2010 to 9.1% in 2018 (see Figure 1). Strong growth of solar PV generation, which surged from 0.3% to 6% in the generation mix, led this increase. In fact, solar projects have accounted for around 90% of the added capacity since 2012, placing Japan as the second country in the world by solar capacity and the third in solar generation (IRENA 2020a; METI, 2017; IRENA, 2019b), followed by bioenergy.

Solar PV FiTs

The success of the FiT programme was largely attributed to the attractive rates offered, which were typically more than twice as high as those offered in Germany, Italy, or the UK (METI, 2012; Campoccia et al., 2014). Nevertheless, to adapt to changing market dynamics, the tariff was revised downwards on a yearly basis, while the eligibility criteria, based on different project sizes, also changed. Importantly, starting in 2017, projects that exceeded the project size eligibility criteria had to enter the auction scheme. Moreover, the changes in eligibility criteria and FiTs made the year in which a developer was certified an important factor. For instance, a 0.2 MW solar PV plant would have received a FiT of JPY 40/ kWh[8] (USD 500/MWh) in 2012, but only JPY 14/kWh[9] (USD 128.8/MWh) in 2019. Figure 3 shows how the eligibility criteria, based on project size, has changed following the introduction of auctions. By 2020, for example, only projects below 250 kW were eligible for the FiT, and the rest had to participate in an auction. Furthermore, the figure shows how the FiT prices have been reduced over time.

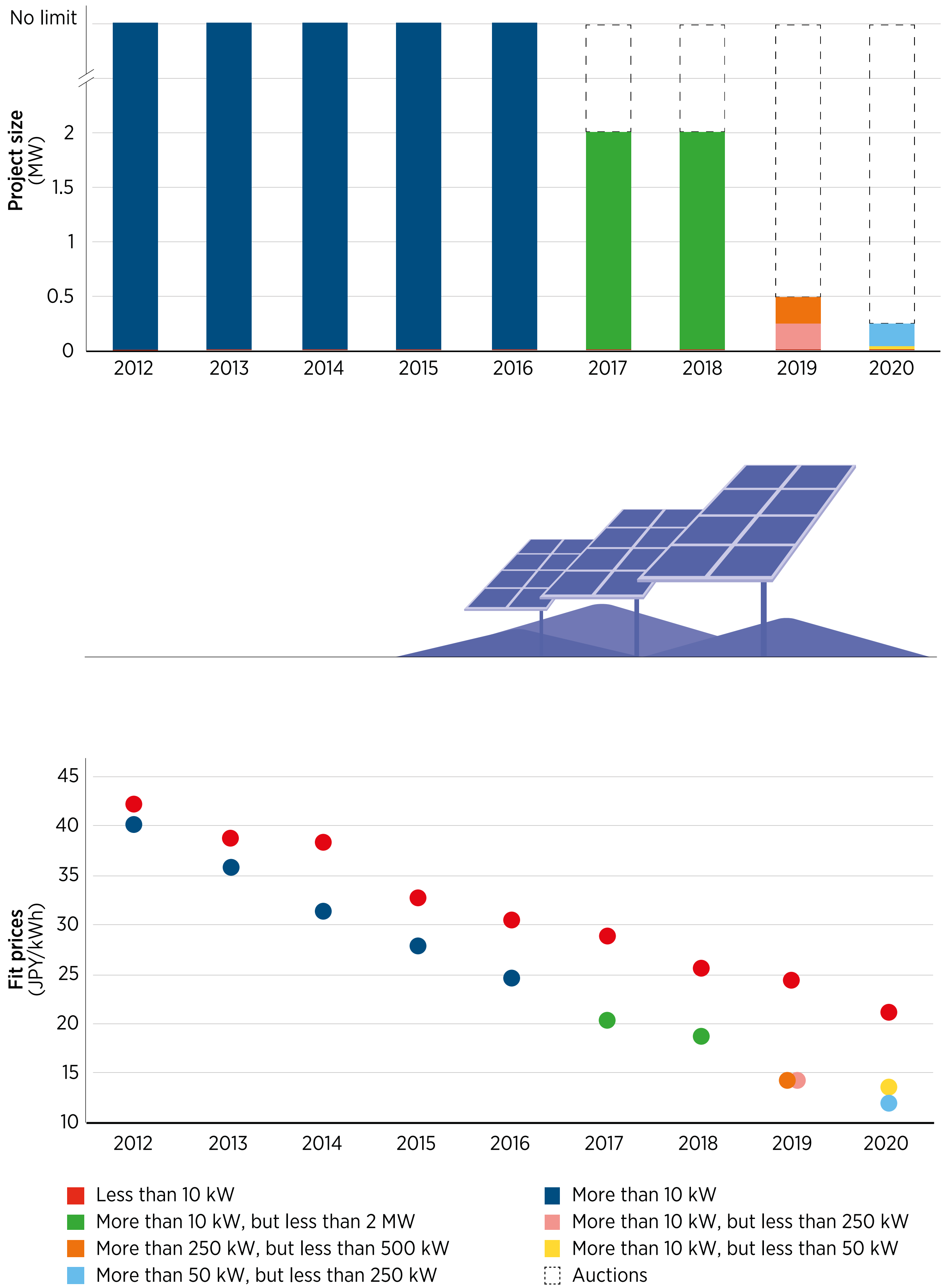
Figure 2. Renewable installed capacity (GW), 2010-2019



Source: IRENA (2020a)

[7] *See the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities (Japanese Cabinet, 2011).*
[8] *1 JPY = 0.0125 USD in 2012.*
[9] *1 JPY = 0.0092 USD in 2019.*

Figure 3. Solar PV FiTs project size eligibility criteria and tariffs



Source: METI (2020c)

Note: The FiTs depicted for less than 10 kW are those without double power generation and from 2015 to 2019, with no obligation to install equipment for output control. Double power generation systems combine residential PV system and fuel cells.

Bioenergy FiTs

Unlike solar PV, the FiTs for bioenergy have remained relatively constant. For instance, solid biomass plants smaller than 10 MW have received JPY 24/kWh[10] (USD 300/MWh) regardless of the year of certification, but different FiTs have applied to other biomass technologies according to the project size. Overall, certified FiT biomass installed capacity, including liquid biofuels, accounted for 10.9 GW as of June 2019, though a large part of this was not operating. Notably, these figures have increased sharply since 2016, with 4.5 GW having been certified since.

FiTs Programme costs

With the certified volumes of both solar PV and bioenergy technologies increasing significantly – and despite the tariff decline for solar PV -, planners realised that the annual purchase cost of the FiT scheme would reach JPY 3.6 trillion[11] (USD 33 billion) by 2019, which would almost have reached the targeted yearly cost of JPY 3.7 trillion to JPY 4 trillion for the year 2030 (METI, 2018).

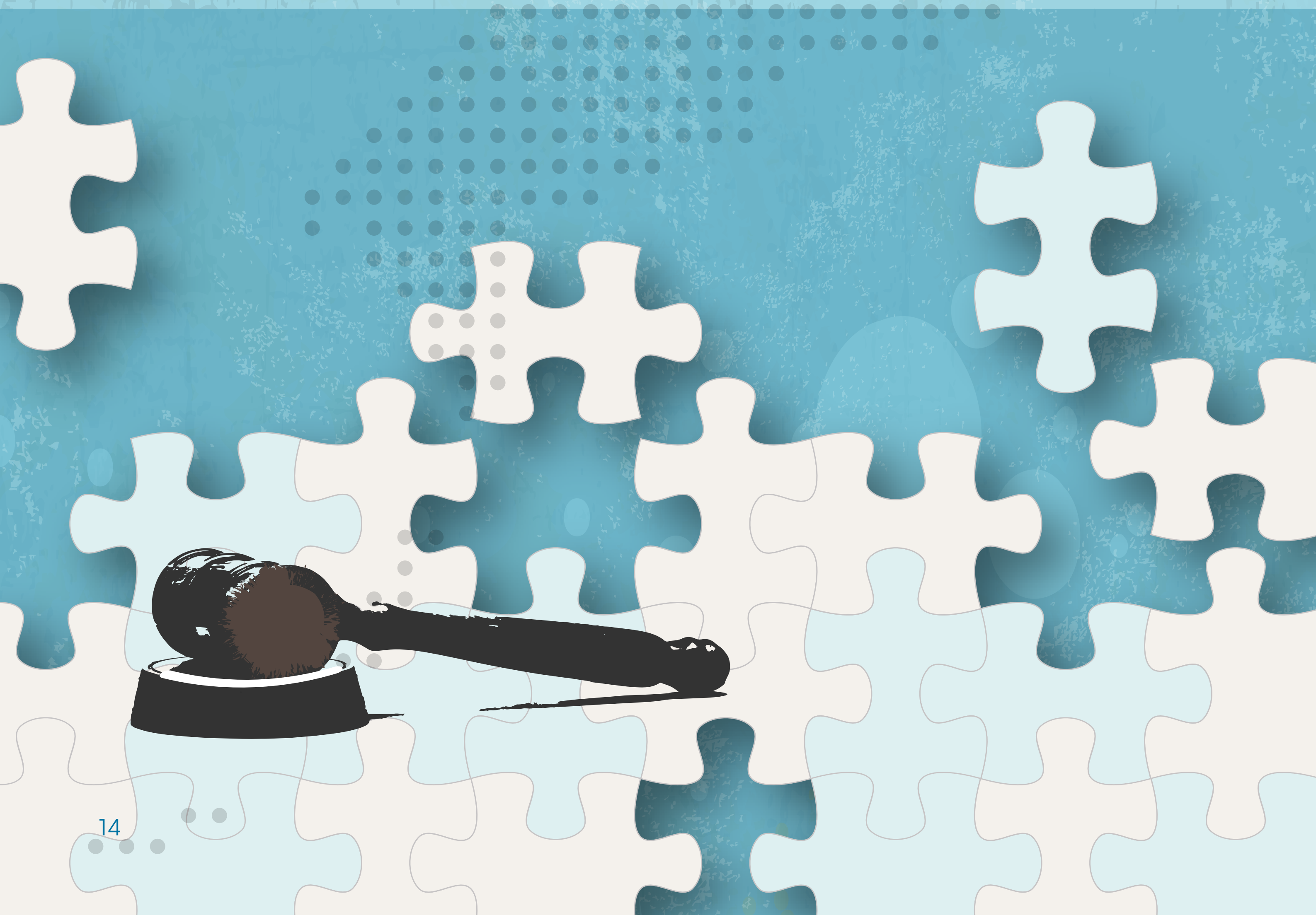
[10] 1 JPY = 0.0125 USD in 2012.
[11] JPY 2.4 trillion net, that is, after fuel savings (METI, 2020b).

Hence, even though significant amounts of renewable capacity have been added, this has been achieved at a relatively high cost. Indeed, one of the main challenges of a FiT scheme is to set an adequate tariff level in a rapidly changing environment (IRENA and CEM, 2015). Furthermore, between a quarter and more than a half of the projects that were approved during 2012 (23%), 2013 (49%) and 2014 (59%), had not been implemented by the end of 2018. Among the main causes for delayed FiT project implementation were a missing mandatory time frame and grid connection difficulties. As a result, the government announced a legislative change for projects that had not come online by a deadline. This reduced FiT support to JPY 21/ kWh or less, instead of initial price (Sheldrick and Tsukimori, 2018)

Moreover, the FiT scheme in general offers fixed prices to generators with no price signals, giving them little incentives to produce electricity when most needed. Although for solar PV, the bulk of generation coincides with periods of peak demand, especially in summer, more provisions can be considered for increased renewable energy deployment. A system in which renewables' generators could help manage supply-demand balances was thus considered necessary (REI, 2019).

Consequently, policymakers in Japan explored alternatives to deploy renewables more competitively, in a timely manner and addressing system's needs. They chose to adopt auctions, which can be designed in a way that eases the integration of renewable energy (see Chapter 3 of IRENA, 2019c) and ensures timely project completion (see Chapter 2 of IRENA, 2019c). In 2020, a feed-in-premium (FiP) scheme was announced. It will be introduced in 2022, in addition to FiT scheme.

2 Renewable energy auction results



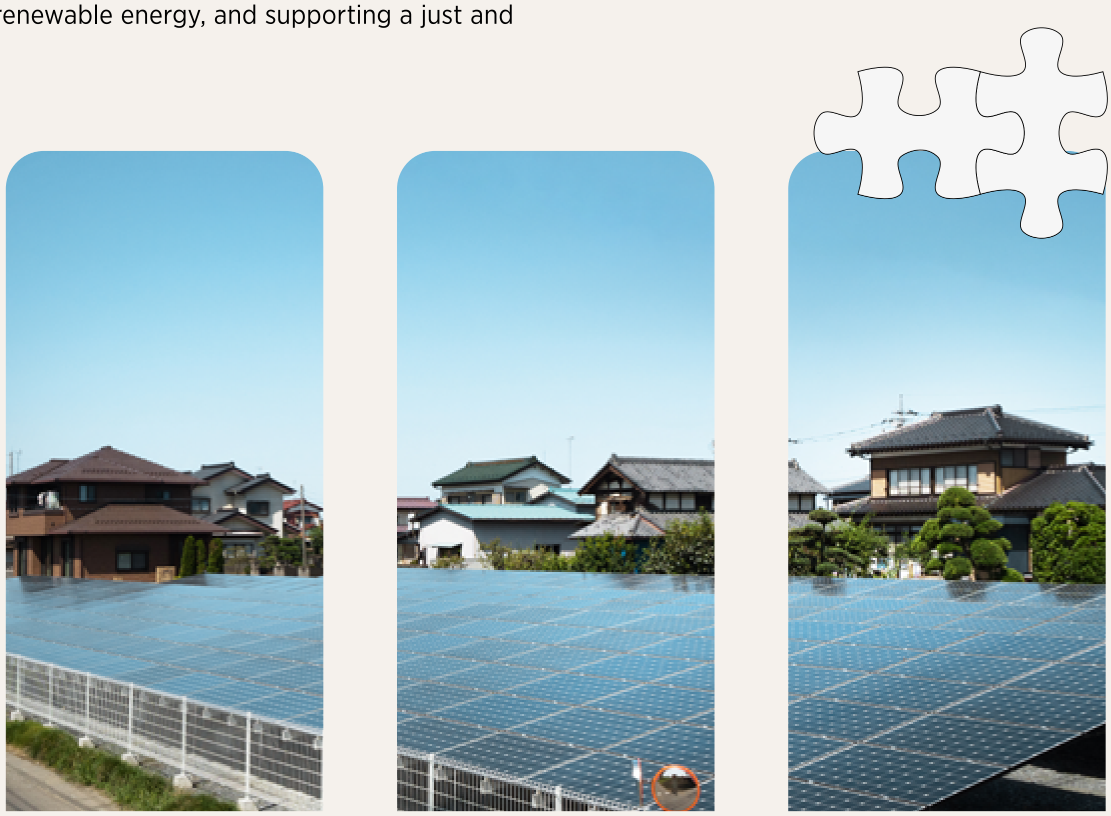
Auctions have the potential to support Japan's objectives given their following strengths:

- Through a power purchase agreement (PPA), auctions can provide stable revenues for developers and thus certainty regarding price – as a FIT does – while also committing quantities to help policy makers achieve renewable targets, which is comparable to an RPS.
- Their ability to discover real prices, if designed to achieve that objective, can help deploy renewables in a cost-effective fashion.
- Auctions are flexible in design and can help achieve broader policy objectives. Indeed, renewable energy auctions are increasingly being used around the world to achieve objectives beyond price, including timely project completion, the integration of variable renewable energy, and supporting a just and inclusive energy transition. IRENA's study *Renewable Energy Auctions: Status and Trends Beyond Price* highlights design elements that can support such objectives (IRENA, 2019c).

In 2016, the FiT Act was revised to enhance competition in the market and reduce prices, with Japan's first renewable energy auctions then announced (METI, 2017).

2.1 BIDDER PARTICIPATION AND COMPETITION

As of October 2020, Japan had conducted five solar PV auctions and two biomass auctions. Moreover, it had plans to conduct an offshore wind auction. Box 1 discusses the results of the biomass auctions to date, while the rest of this report focuses on auctions for solar PV.



BOX 1. BIOMASS AUCTIONS IN JAPAN

As of October 2020, Japan had conducted two biomass auctions. The first of these took place in late 2018 and had two demand bands: 180 MW for solid biomass projects of 10 MW and above; and 20 MW for liquid biomass, without project size limits.

This auction attracted developers, as the registered volumes far exceeded the demand targets. Solid biomass developers registered seven business plans for a total of 264 MW, while liquid biomass developers registered 26 business plans for 169 MW. Thus, the registered capacity exceeded the auctioned volumes by almost a half (47%) and more than eight-fold (845%), respectively.

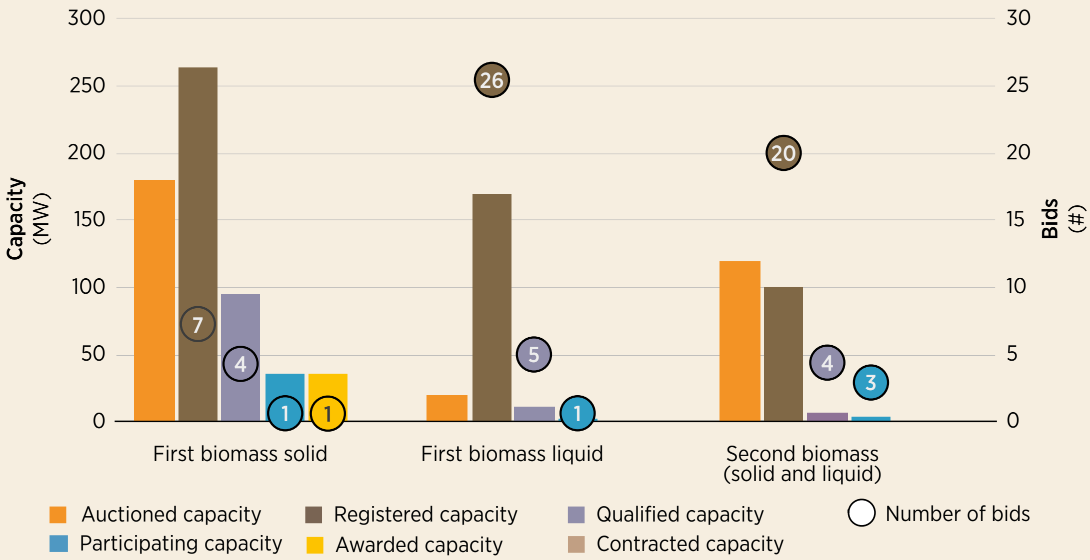
However, only 95 MW (four business plans) in solid biomass and 10.5 MW (five business plans) in liquid biomass met the qualification requirements. In addition, only one developer in each demand band submitted a bid: for 35 MW solid biomass at JPY 19.6/kWh[12] (USD 178.4/MWh) and 2.3 MW liquid biomass at JPY 23.9/kWh (USD 217.5/MWh). Since the latter bid was higher than the ceiling price of JPY 20.6/kWh (USD 187.5/ MWh) – a price which applied for both bands – only the solid biomass band awarded its single bid. Yet the awarded bidder did not pay the commitment bond and no bid was ultimately contracted.

Despite these outcomes, biomass continued deploying strongly (see Figure 2) under a FiT scheme that offered JPY 24/kWh (USD 220.8/MWh) for smaller installations in 2018 and 2019. In an effort to discover competitive prices for large projects, Japan conducted a second biomass auction in late 2019. This time, however, it merged the two demand bands into one. In other words, solid and liquid biomass projects competed for the same target volume of 120 MW. Only 83% of the volume to be auctioned was registered (20 business plans for 101 MW) out of which only four business plans for 6.4 MW qualified. The participation rate was higher, though, as only one qualified bidder dropped out (leaving 4.5 MW participating). In the end, the three bids were above the ceiling price of JPY 19.6/kWh[13] (USD 180/MWh) and no bid was awarded.

In sum, to date, no biomass project has been contracted in Japan through renewable energy auctions (Figure 4). The first outcomes suggest that the qualification requirements were either too strict, or that there is room for improvement in communicating business plan expectations to the developers.

Other elements, which may also be affecting the performance of solar PV auctions, are discussed in the following sections. These include the continuation of an attractive FiT scheme that can discourage participation in auctions, strict bond confiscation rules, or the role of (undisclosed) ceiling prices in low competition environments.

Figure 4. Undersubscription in Japan's biomass auctions



Source: METI (2019c)

[12] 1 JPY = 0.0091 USD in 2018.
[13] 1 JPY = 0.0092 USD in 2019.

The first five rounds of solar PV auctions succeeded in attracting bidders initially, but participation was deterred further along in the process.

Figure 5 shows auctioned, registered, qualified, participating, awarded and contracted bids in solar PV between 2017 and 2020. The first five rounds attracted a large number of participants, with 29, 19, 38, 146 and 110 bids registered, respectively, and the majority of those bids were qualified. In fact, in the second, third and fourth rounds, the capacities of the qualified bids exceeded the volumes auctioned (corresponding to 15, 32 and 107 bids, respectively). Even in the first auction, qualified bids (23) corresponded to almost 80% of auctioned volume. However, only 9, 9, 16, 71 and 72 bids were placed after qualifying. As a result, the first, second, fourth and fifth rounds were undersubscribed, with participating capacity below auctioned capacity.

As shown in Figure 5, although the auctions succeeded at attracting bidders initially, design elements —including strict qualification requirements, selection criteria, and compliance rules (discussed in Chapter 4) – may have deterred participants further along in the process. This was likely coupled with difficulties in securing land and grid access (Section 3.3).

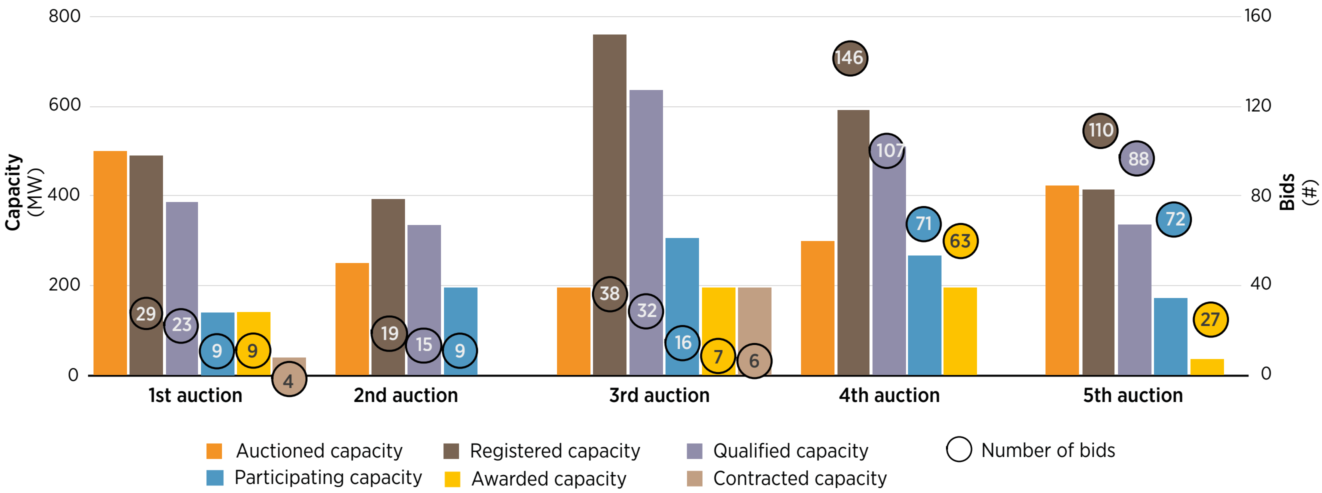
2.2 PRICE OUTCOMES

Five solar PV auctions took place between November 2017 and January 2020. The volumes auctioned and awarded, as well as the average price and price ceilings for each round are shown in Table 1.

The first auction awarded 141 MW at an average awarded price of JPY 19.64/kWh (USD 174.1/ MWh)[14]. The second auction, held in September 2018, awarded no capacity, as the bids were above the ceiling price (see Section 4.3). The third auction, held in December 2018, awarded 197 MW at JPY 15.17/kWh (USD 135/MWh)[15], while the fourth, in September 2019, awarded 196 MW at JPY 12.98/kWh (USD 123/MWh)[16]. Finally, the fifth auction, held in January 2020, awarded 39.8 MW at JPY 12.57/kWh (USD 115/MWh)[17].

Interestingly, while prices continued falling in the fourth and fifth rounds, at the same time, there was an increased participation by small and new players. Indeed, many winners were not established market players, suggesting that experience is not a determining factor in winning an auction in Japan.

Figure 5. Auctioned, registered, qualified, participating, awarded and contracted bids in solar PV auctions in Japan



Source: METI (2019c); Bellini (2019a, 2019b, 2020); Publicover (2017, 2018); Matsuda *et al.* (2018); GIO (2019a, 2019b); BNEF (2019); Kageyama (2018a, 2017a)

Note: The contracted capacities for the fourth and fifth rounds were unknown as of June 2020.

[14] *JPY 1 = USD 0.008866 (November 2017).*
[15] *JPY 1 = USD 0.00892 (December 2018).*
[16] *JPY 1 = USD 0.00945 (September 2019).*
[17] *JPY 1 = USD 0.009229 (January 2020).*

Table 1. Results of the first five rounds of solar auctions in Japan

Date	Volume auctioned	Volume awarded	Weighted average awarded price	Ceiling price
Round 1 Nov. 2017	500 MW	141 MW	JPY 19.64/kWh (USD 174.1/MWh)	JPY 21/kWh (USD 186/MWh)
Round 2 Sept. 2018	250 MW	0 MW	-	JPY 15.5/kWh (USD 138.3/MWh)
Round 3 Dec. 2018	197 MW	197 MW	JPY 15.17/kWh (USD 135/MWh)	JPY 15.5/kWh (USD 138.3/MWh)
Round 4 Sept. 2019	300 MW	196 MW	JPY 12.98/kWh (USD 123/MWh)	JPY 14/kWh (USD 131.9/MWh)
Round 5 Jan. 2020	416 MW	40 MW	JPY 12.57/kWh (USD 115/MWh)	JPY 13/kWh (USD 119/MWh)
Total	**1,663 MW**	**574 MW**		

Source: METI (2019c)

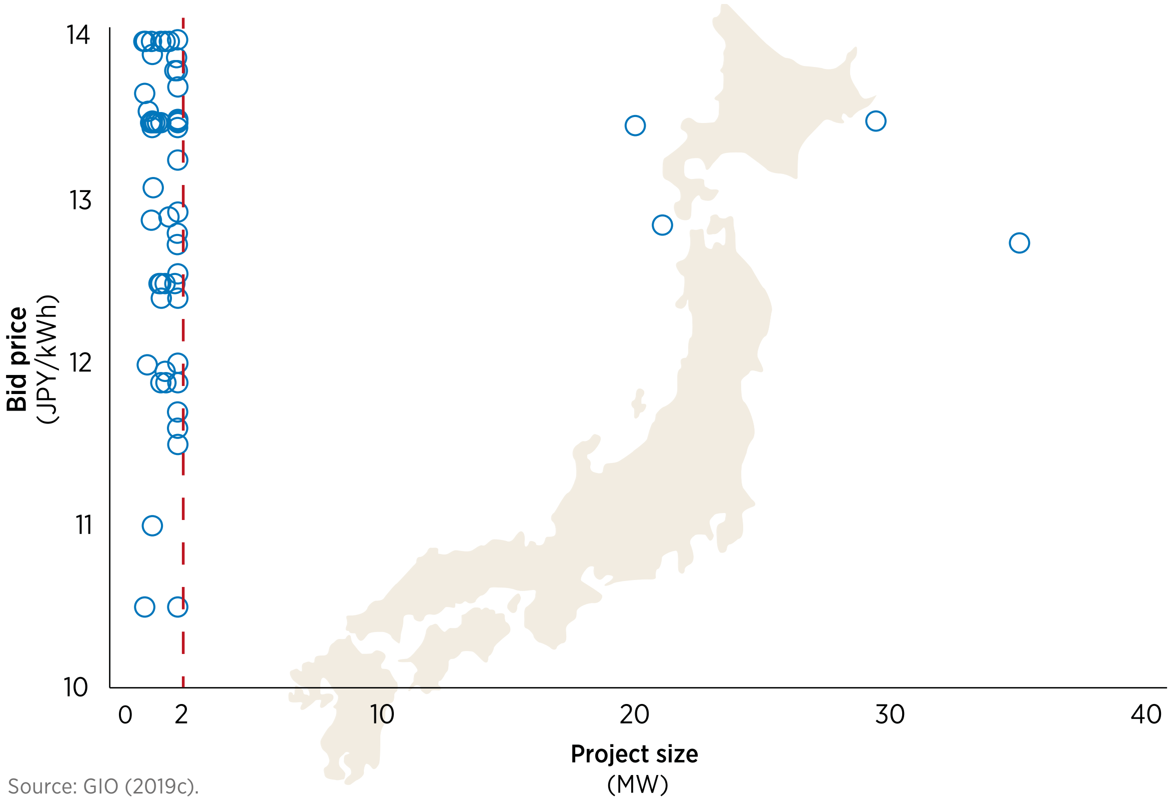
Figure 6 shows the project size and bid price of the projects awarded in the fourth auction: the majority of the projects below 2 MW – the size limit in previous rounds – bid lower than the four projects above 20 MW. The lowest bids – as low as JPY 10.5/kWh (USD 99/MWh) – were all for projects below 2 MW, implying that economies of scale do not seem to play a major role in the Japanese context. This is mainly due to the difficulty of securing land and obtaining grid-connection permits – factors which mostly impact large-scale projects (BNEF, 2019). In fact, large solar PV projects (above 40 MW) will be subject to stricter environmental assessment rules (IT Media, 2019).

In the fifth round, all the awarded projects ranged between 792 kW and 2 MW. This may have contributed to a significant drop in capacity allocation, however, with a total of less than 40 MW awarded out of the 416 MW auctioned. Initially, 450 MW had been planned, with some of the capacity not awarded in the fourth round being rolled over. Importantly, the prevalence and competitiveness of plants below 2 MW is related to the requirement of appointing a dedicated chief electrical engineer above that project size, which raises costs significantly (see Section 3.1).

All in all, despite a price decrease by one-third from the first to the fifth auction, the average winning bids were still high compared to other countries with similar context (income, resources and level of development of the renewable energy industry) (Figure 7).

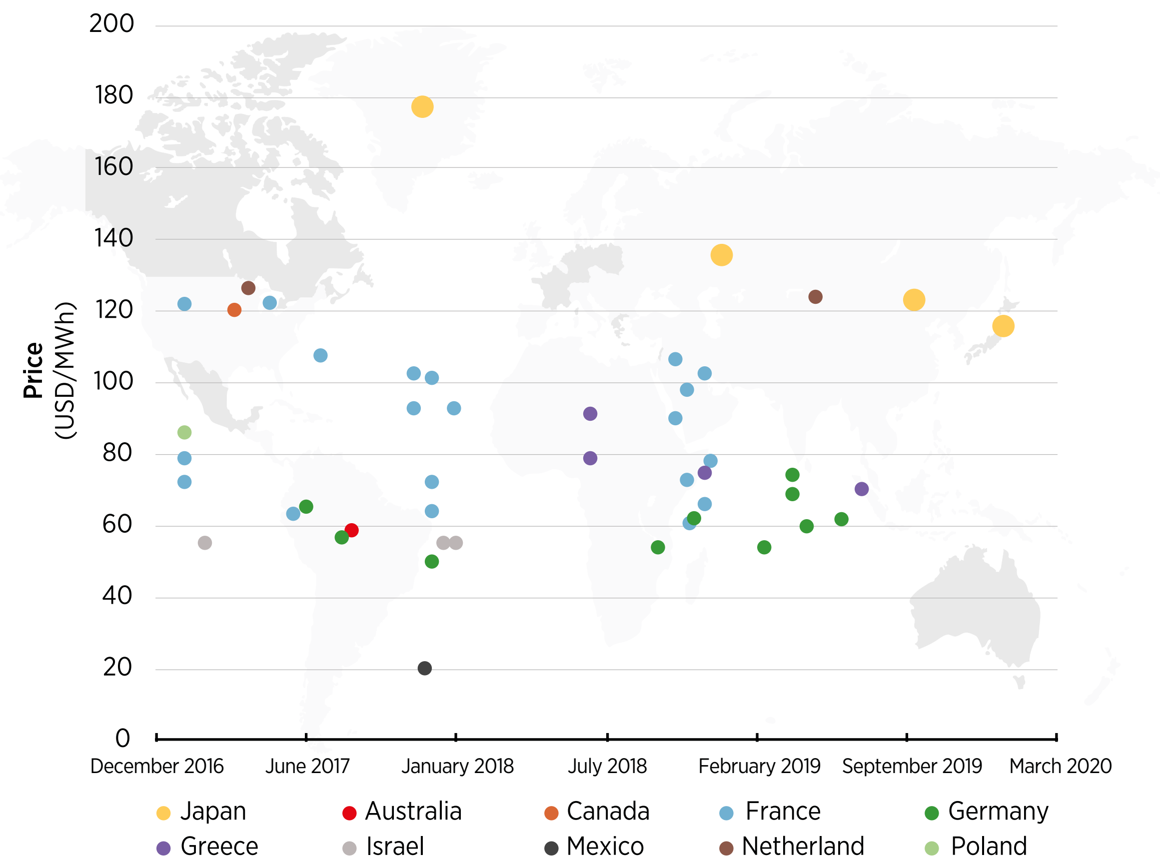
Comparing auction prices between countries must be done with caution, however, as these depend on many context-specific factors, including solar resource quality, local supply chain maturity, macro-economics, developer experience and preferences, investor confidence, electricity sector regulations and broader energy policies, as well as auction designs. Thus, an international price comparison does not determine an auction's success. To determine this, a deeper analysis of the factors impacting solar prices is needed. This would have to include: understanding what best practice is in terms of total installed costs; capacity factors driven by the choice of technology and local resource quality; operation and maintenance (O&M) costs; and the cost of capital for renewable projects – which in turn can be influenced by policy. In addition, auctions are increasingly adopted with the objective of achieving complementary development goals, in addition to electricity price reduction.

Figure 6. Project size and bid price of awarded projects in the fourth auction



Source: GIO (2019c).

Figure 7. Solar auction results in Japan compared to other OECD countries



Source: IRENA (n.d.); BNEF (2019); METI (2019c); Bellini (2020)

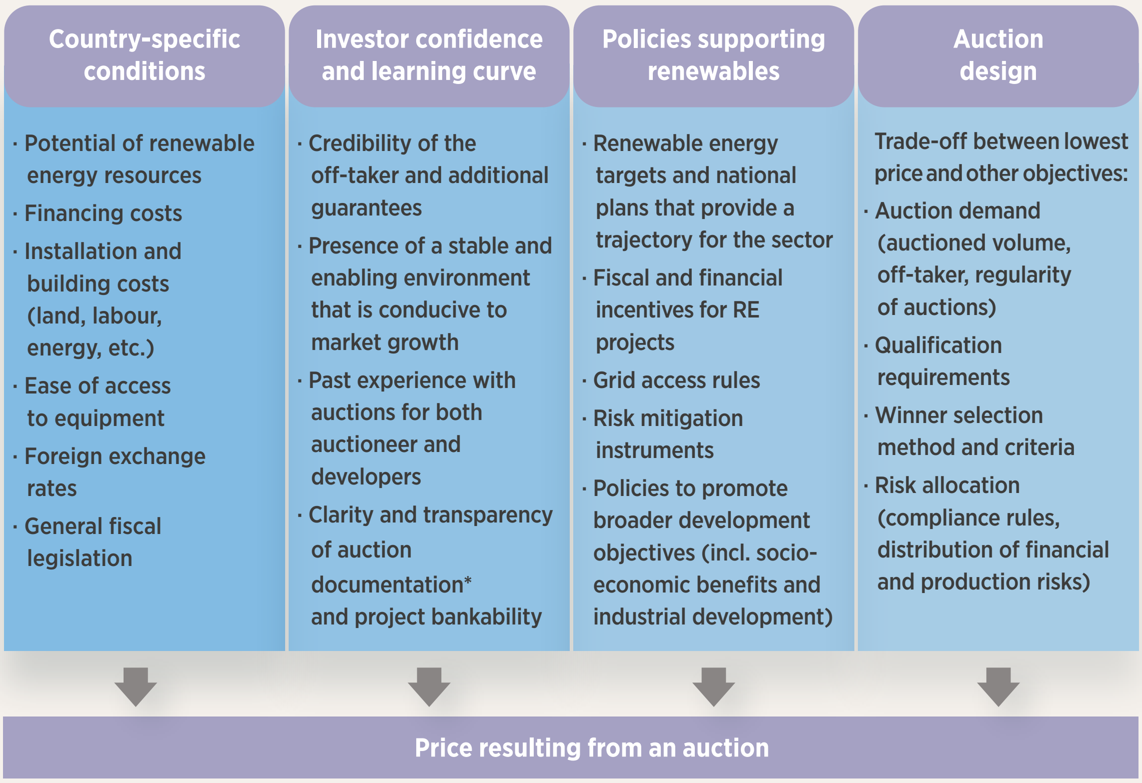
3 Factors affecting auction price results

The relatively high auction prices in Japan do not necessarily tarnish an auction's success, as much depends on the relative competitiveness of the options available. In fact, renewables are not the only expensive power generation sources in Japan; the country has also some of the world's costliest coal-fired and CCGT generation (IEA and NEA, 2015). That said, a combination of factors drives prices in any country's renewable energy auctions.

These can be grouped into four categories: 1) country-specific conditions such as resource availability, the maturity of local supply chains, power market design and the costs of finance, land and labour; 2) the degree of investor confidence related to, for example, the experience of the bidder and auctioneer, and credibility of the off-taker; 3) other policies related to renewable energy, including clear targets, grid policies, priority dispatch, and local content rules; and 4) the design of the auction itself, taking into consideration the trade-offs between obtaining the lowest price and achieving other objectives (Figure 8).

The first three categories are discussed in this chapter, while Chapter 4 analyses the design elements of Japanese auctions and how they have influenced results.

Figure 8. Factors affecting auction price results



Source: IRENA (2019c)

3.1 COUNTRY-SPECIFIC CONDITIONS

Cost of electricity for solar PV

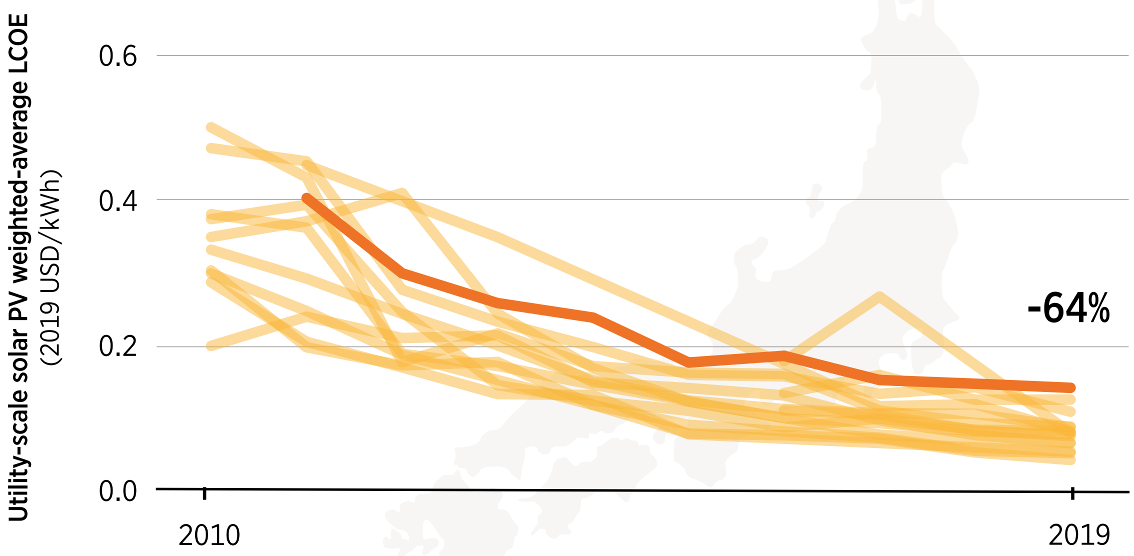
Figure 9 shows the utility-scale solar PV weighted-average LCOE trends in Japan and other selected countries[18] between 2010 and 2019. Although the Japan's LCOE declined by 64% from 2011 to 2019, it was still the highest in the sample. In fact, between 2018 and 2019, the LCOE in Japan declined only 4%, the lowest rate observed among the markets analysed. The LCOE of newly commissioned utility-scale solar PV in Japan was twice as high as that of India's and was more than twice the global weighted-average LCOE of USD 0.068/kWh (IRENA, 2020d).

High total installed costs are considered the main factor behind the high prices resulting from solar auctions.[19] The data for Japan suggest that at USD 2 070/kW, the total installed costs of newly commissioned utility-scale solar PV projects in 2019 were more than twice the global average (USD 995/kW). Compared to Germany and France, which had total installed costs for new projects in 2019 of USD 899/kW and USD 979/ kW, respectively, the gap is even larger (IRENA, 2020d). This is predominantly due to the high cost of equipment (modules and inverters) and of installation in Japan, whereas 'soft costs' were relatively competitive compared to international benchmarks (Figure 10).

Cost of equipment. In Japan, the average cost of modules and inverters is significantly higher than in comparable markets. This can partly be explained by the preference for higher-cost locally manufactured products. Indeed, half of all modules and almost threequarters of all inverters installed were produced by domestic manufacturers (Höller et al., 2019). Although these are of higher quality and require less maintenance in the long run, locally sourced modules and inverters are associated with higher upfront costs (Kimura and Zissler, 2016).

More recently, and even though average yearly module prices between 2013 and 2019 declined by 53% in Japan (IRENA, 2020d), Japanese manufacturers have not kept pace with decreasing module prices around the world. Consequently, developers have noted the increasing difficulty, from an economic perspective, of using modules produced in Japan. In fact, the share of imported modules and inverters has been increasing on a yearly basis and the share of the domestic market is expected to continue shrinking in the future (Kimura, 2019). However, this has done little so far to reduce average module and inverter costs.

Figure 9. Utility-scale solar PV weighted-average LCOE trends in Japan, 2011-2019

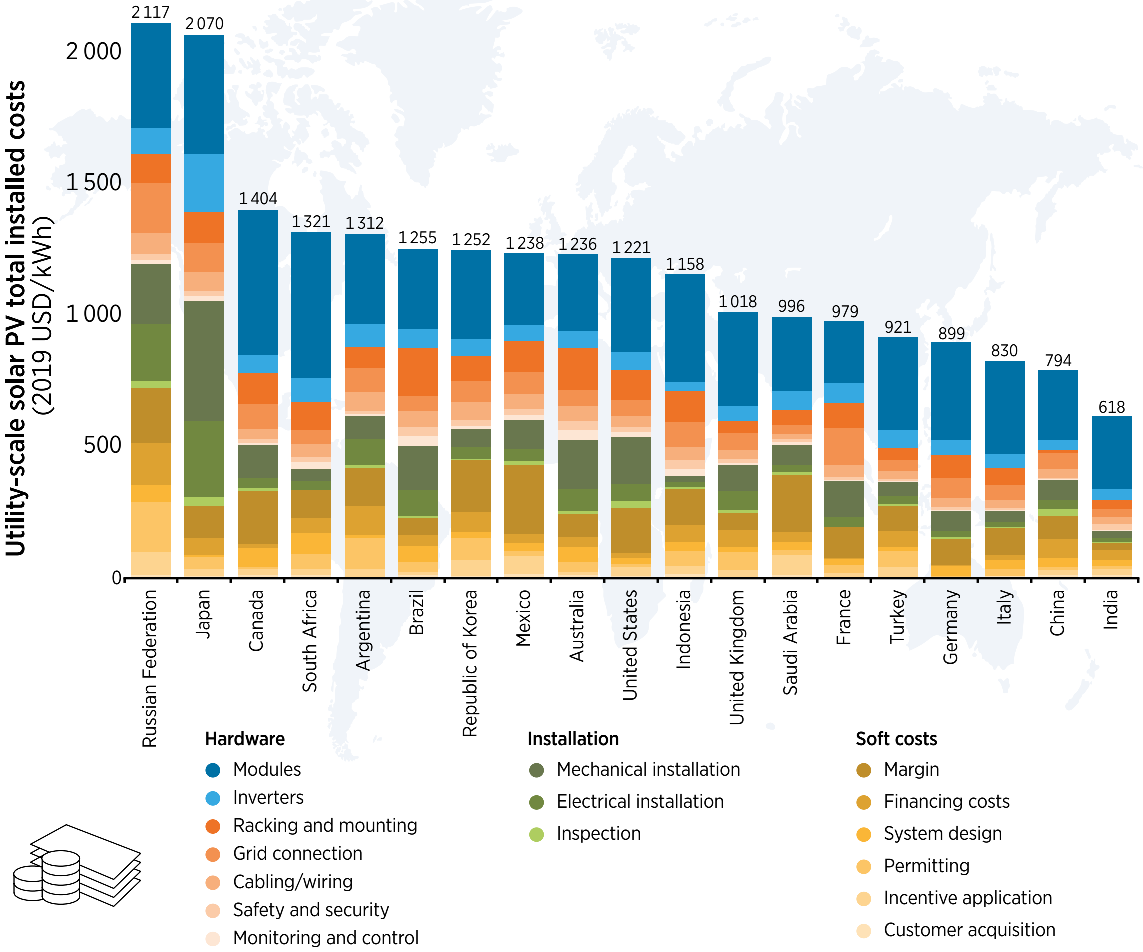


Source: IRENA (2020d)

[18] *Australia, China, France, Germany, India, Italy, Netherlands, Republic of Korea, Spain, Turkey, Ukraine, United Kingdom, United States and Viet Nam*

[19] *It must be said that installed cost data for Japan are difficult to obtain.*

Figure 10. Breakdown of utility-scale solar PV total installed costs in selected countries, 2019



Source: IRENA (2020d).

Installation costs. For a variety of reasons, installation costs for solar PV in Japan are significantly higher than in other countries. First, Japan is mountainous and its population density is high, which increases the costs of building solar (and wind) plants compared to flat or empty lands (The Economist, 2020). Moreover, the installation process takes longer and international best practice is not typically followed. As a result, construction and installation time can be up to seven times longer than in Germany, rendering the process up to four times more expensive (Kimura and Zissler, 2016). Second, the higher costs may be linked to a shortage of skills and a lack in the availability of human resources to undertake such activities (Höller et al., 2019). Third, the installation costs significantly vary according to the entity responsible for conducting the connection works. Normally, the developer pays the transmission or distribution companies to conduct the power line installation. In the few cases where this has been done by the developer, however, the costs have been significantly lower.

Finally, perhaps the most relevant cost component is the mandatory appointment of a chief electrical engineer, which accounts for 50% of the O&M costs. Under Japan's Electricity Business Act, 50 kW or above solar PV plants must appoint a chief electrical engineer. Importantly, 2 MW or above plants must in general appoint a dedicated engineer, who cannot hold any position at another power plant, nor be outsourced. This limitation could explain the prevalence of projects below 2 MW and the lower prices they offer. Given such regulations, for a larger solar PV plant to make economic sense, its generation capacity would have to be at least 10 MW (Kimura, 2019).

Even though **soft costs** in Japan are competitive, there is still room for improvement to help achieve lower overall costs. Regarding system design, for example, the type of contract can affect solar PV costs. In Japan, it has been observed that developers that outsource the engineering, procurement and construction (EPC) phase have higher costs, as the EPC contractor demands a premium for bearing responsibilities and risks during the construction phase. In contrast, when developers handle the design, procurement, and construction of the plants themselves, they have been able to optimise design arrangements and operations (Kimura, 2019).

Going forward, considerable cost reductions are possible in Japan, if market scale and international best practices are unlocked. Indeed, solar PV costs could decrease by two-thirds by 2030, mainly driven by module/inverter and installation cost reductions and a shift to best practice in mechanical and electrical installations (IRENA, forthcoming). If these significant cost reductions are achieved, solar PV could become the cheapest technology for new plant deployment by 2030 (Kimura, 2019).

Resource availability

Japan is not blessed with abundant solar resources, as in arid and semi-arid regions (the Middle East, North Africa, and North America). The country's average annual global horizontal irradiation ranges between 990 kWh/m² and 1 660 kWh/m². The highest levels (greater than 1 400 kWh/m²) fall on just 33% of the country's total land area, which is mostly located in eastern and southern regions (Figure 11). The average specific PV power output over these areas is 1 372 kWh/kilowatt peak (kWp) per annum (p.a.), which is comparable to the average of 1 376 kWh/kWp p.a in northern Bangladesh or 1 365 kWh/kWp p.a. in south-western Cameroon (World Bank, 2019a). Yet, the development of solar PV projects in these locations, specifically Hokkaido in the Northeast and Kyushu in the South, presents great challenges, as they are far from load centres and have limited grid capacity.

3.2 INVESTOR CONFIDENCE AND LEARNING CURVE

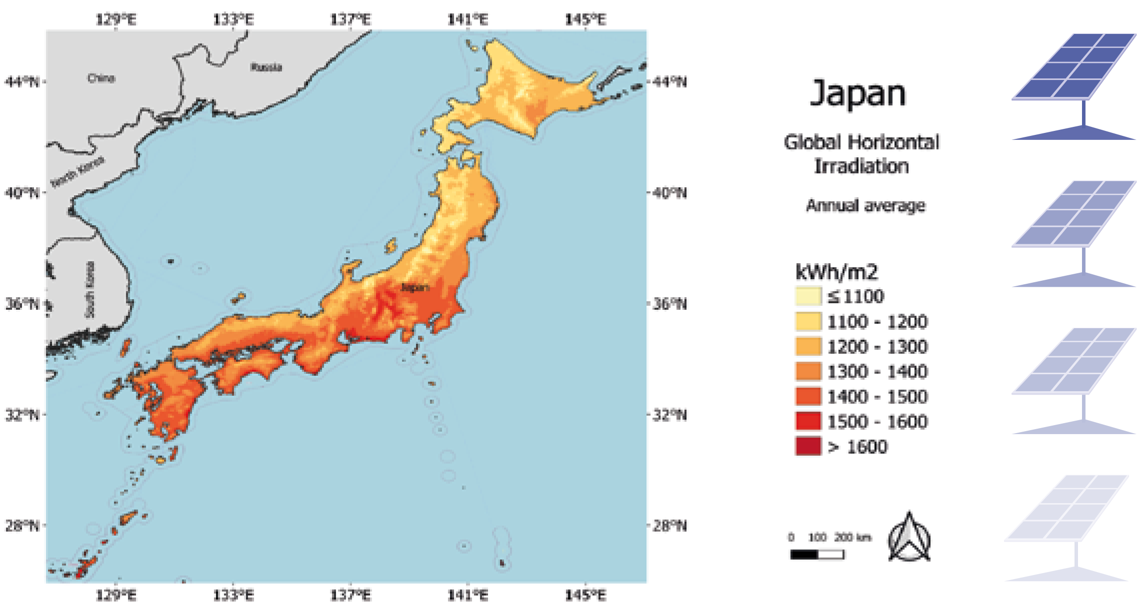
Credibility of the off-taker

The creditworthiness of Japanese public utilities improved between 2012 and 2018, when the World Bank's Regulatory Indicators for Sustainable Energy (RISE) gave the country the highest indicator score. This improvement occurred just in time for the utilities to be able to shoulder the additional responsibilities allocated to them through the revision of the FiT act in 2016. Consequently, Japan's counterparty risk assessment ranks among the best in the world (World Bank, 2019b) and is therefore not considered a constraint.

Past experiences with auctions

Auctions were designed building on the FIT scheme in which both the Japanese government and project developers already had considerable experience. Moreover, with five rounds of auctions, all the relevant stakeholders benefited from a learning curve, especially developers

Figure 11. Solar irradiation in Japan



Source: World Bank (2019a)

Note: Copy in IRENA's "Global Atlas for Renewable Energy" web platform.

Disclaimer: The boundaries shown in these maps do not imply official endorsement or acceptance by IRENA.

that became familiar with the bidding process and were able to reuse some of the bidding documentation in subsequent rounds.

Nevertheless, developers had little certainty over medium- and long-term market prospects. This constrained potential economies of scale in project development pipelines, as developers could not clearly anticipate how much volume would be offered in upcoming auctions. This was a result of Japan conducting stand-alone auctions, for which it established volumes without showing a long-term pathway. In fact, beyond 2018, there was no clear outlook for auctions and the lack of a prospective bidding frame was identified among developers as a main concern (Kimura, 2018; REI, 2019). To address this, a systematic auction scheme (see IRENA and CEM, 2015) is critical in improving investor confidence in Japan. In such a scheme, volumes are announced for several years ahead -at least three to five years would be needed in Japan-, in a multi-year plan that also establishes the number of auctions (and volumes) in each year (Kimura, 2018; REI, 2019). In 2018, Japan's Ministry of Economy, Trade and Industry (METI) took the first steps in tackling this issue by announcing plans to schedule two solar auctions (and one biomass auction) per year (GIO, 2019a; GIO, 2019b; Matsuda et al., 2018).

Presence of a stable and enabling environment

Incorporating stakeholder feedback is another measure that can improve investor confidence. After 14 developers dropped out of the first auction's bidding stage (see Figure 5), the Japan Photovoltaic Energy Association (JPEA) investigated the reasons behind this result through a survey among project developers. In this survey, developers indicated that their main reasons for not participating in the auction were: difficulties securing land (26%); no available system capacity (23%); the hard capacity limit (16%); and the strict confiscation requirements of the commitment bond (26%) (Kageyama, 2017b). Government bodies considered this input and modified the auction design for further rounds. Chapter 4 discusses at length these changes and their implications.

3.3 POLICIES SUPPORTING RENEWABLES

Renewable energy targets and national plans

Generally, Japan has a strong policy and regulatory framework supporting renewables, compared to the average high-income Organisation for Economic Cooperation and Development (OECD) country (World Bank, 2018). Nevertheless, while Japan has defined targets for various renewable energy sources, an increment of the energy mix targets that go handinhand with long-term plans for systematic auctions and mid- and long-term transmission planning, are needed to support the energy transition (REI, 2019).

Grid access rules

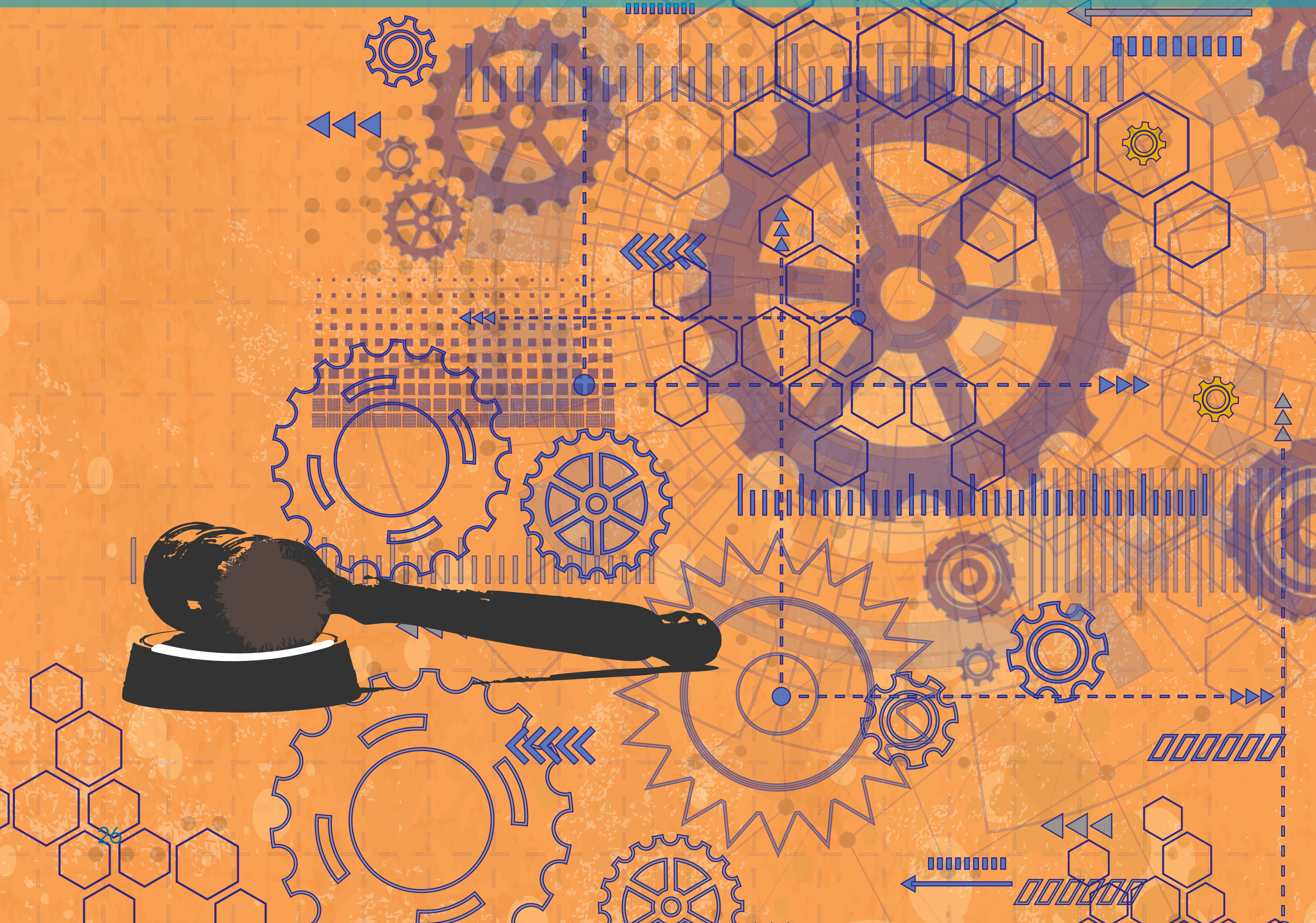
Transmission companies struggle to cope with the grid access needs of renewable developers, as their studies and reinforcement plans take longer than the actual construction of a renewable plant (REI, 2019). This results in constraints that raise interconnection costs for new projects (Kenning, 2020). Thus, network connection offers room for improvement – particularly regarding grid access – as do planning and expansion indicators (World Bank, 2019b).

In fact, even though Japanese utilities are obligated to accept grid connection requests, the cost is determined by them and fully allocated to the project developer (Matsubara, 2018). Notably, in extreme cases, the grid connection cost can double the total cost of a project in Japan (Isono, 2019).

Other instruments supporting renewables

Other supporting policies can have direct and indirect impacts on auction prices. The FiT scheme, for instance, has allowed developers to obtain certification at generous tariffs and wait for the solar PV costs to decline before starting operations, thereby maximising their profit margins. This comes at a high cost for consumers and has led to the labelling of renewables as "high cost" sources in Japan (Kimura, 2018). Moreover, as long as developers are allowed to hold on to early certifications and delay plant construction or operation, they will have less interest in participating in an auction (see Section 2.1), thus hurting auction participation rates and hindering their ability to discover lower and more competitive prices.

4 Auction design



The analysis of the Japanese auctions follows IRENA's framework (IRENA, 2019c; IRENA and CEM, 2015), which classifies design elements into four main categories: 1) auction demand; 2) qualification requirements and documentation; 3) winner selection and contract award process; and 4) risk allocation and remuneration of sellers (Figure 12).

4.1 AUCTION DEMAND

Product and technology specificity

The product auctioned in Japan is power in the form of installed capacity in MW. The country has opted to conduct technology-specific auctions for solar PV and biomass, with offshore wind launched in June 2020.

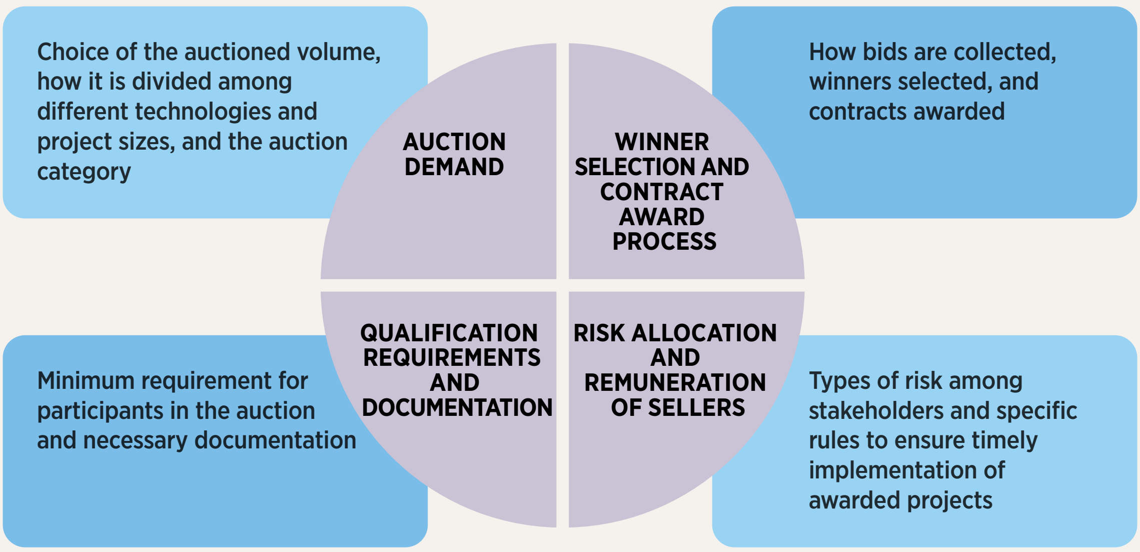
Technology-specific auctions allow policy makers to pursue capacity targets for each renewable technology and support the development of these technologies according to the needs of each technology and the system. The main strengths of such auctions are: 1) they can introduce specific technologies and ensure the diversification of the mix; and 2) they can support local industry, which relies on the continued uptake of the technology. Additionally, this type of auction avoids the need to compare different technologies with varying generation profiles.

Yet technology-specific auctions also have downsides. They can result in a reduced pool of participants and, potentially, less competition (IRENA and CEM, 2015) – a major concern in the Japanese context. Moreover, the technology supported might not necessarily be the most cost-competitive. For instance, in Japan, offshore wind, geothermal or hydropower might be more cost-competitive than solar PV. A technology-neutral auction would allow the discovery of the most cost-competitive technology.

Locational constraints

The solar PV (and biomass) auctions had no locational constraints. While assigning the task of site selection to bidders can lead the selection

Figure 12. IRENA's framework for the design of auctions



Source: IRENA (2019c), based on IRENA and CEM (2015).

of the most promising sites, this option can also increase administrative costs, as developers would be responsible for obtaining permits, engaging with national and local stakeholders and securing land and grid access. With that in mind, offshore wind auctions in 2020 will be zone-specific (Box 2).

Volume auctioned

The volumes auctioned in solar auctions have been fixed in each tender. Auctioning fixed volumes is the simplest way to determine renewable energy capacity additions, compared to price-sensitive demands or multi-criteria volume setting auctions (see IRENA and CEM, 2015). Targeting around 1 GW, solar PV auctions were introduced via three rounds between 2017 and 2018. Yet less than 600 MW have so far been awarded, with five rounds now carried out, when two additional rounds from the initial plans are included. This underperformance is the result of undersubscription, meaning that the auctions have not received enough bids to meet the demanded volumes (see Section 2.1).

Project size

High project size floor limits may also discourage participation, especially for small players that do not have the capacity to develop large projects. The first three solar PV auctions had a project-size floor limit of 2 MW. This was reduced to 500 kW in 2019 for the fourth and fifth auctions, with plans for a further reduction to 250 kW in the future (Kageyama, 2018a).

BOX 2. ZONE-SPECIFIC AUCTIONS FOR OFFSHORE WIND

Offshore wind deployment in Japan has historically been hindered by a variety of factors. These have included regulatory uncertainty, with land use rights at sea not clearly defined; environmental impact assessments (EIA), which have often taken over four years to complete, and limitations in areas with promising wind potential in northern Japan due to poor grid infrastructure (JWPA, 2017).

A first attempt to ease the regulatory uncertainty was an amendment to the Port and Harbour Act in 2016. This ensured usage rights of 20 years (with an option for extension) for winners of forthcoming wind auctions. This period was significantly longer than the previous one, which required an extension every 3-5 years (Eguchi et al., 2018). As the name of the Act implies, however, it only applied to the port area – that part of Japan's shores controlled by local port authorities. The port area offers pre-existing infrastructure, but this is also used for other economic activities, creating substantial competition with other stakeholders (JWPA, 2017).

In 2018, the Bill on Promotion of Use of Territorial Waters for Offshore Renewable Energy Generation Facilities increased the area that could be exploited. It also authorised exclusive use of the General Common Sea Area for offshore wind, which was otherwise and previously mainly used for fishing (JWPA, 2018). The contract duration was extended to 30 years, but it added research, construction, and decommissioning responsibilities for developers during the contract period (Eguchi et al., 2018).

Thus, offshore wind auctions are planned to be zone-specific. Zone-specific auctions are a broader version of site-specific auctions and thus share many of their advantages and limitations (see IRENA, 2019c; IRENA and CEM, 2015). The cost and time of an EIA can be greatly reduced, for instance, if the location is thoroughly evaluated by the government. Similarly, grid access could also be ensured through parallel planning in line with the auctions.

Those are to be held in at least five different so-called Promotion Areas, selected by national authorities based on information provided by local governments. Local councils and relevant stakeholders will analyse the requirements for project bidding in each specific zone. Next, METI will publish the auction guidelines for developers. In addition, relevant information on the environmental conditions, such as the sea floor depth and wind conditions, will be provided, thus reducing the technical workload for project developers (Matsuda et al., 2019).

Lastly, off-shore wind auctions in Japan will include criteria beyond price. In particular, selection of the winner will be guided by how well the business plan aligns with local development plans, notably regarding competition with fisheries, in order to minimise crowding-out (MacPherson, 2018).

As seen in Section 1.3, these limits have been linked to the FiT scheme. Lower limits have increased participation rates in auctions, given that this eases land acquisition challenges, reduces the need for a dedicated electrical engineer and can improve grid access possibilities.

Between the third and fourth rounds, the auction saw a three-fold increase in the number of bids registered, indicating an increased interest from market players, and a nine-fold increase in the number of bids awarded. As shown in Figure 5, the majority of projects awarded were below the previous 2 MW floor.

4.2 QUALIFICATION REQUIREMENTS AND DOCUMENTATION

Documentation and reputational requirements

The requirements to participate in an auction are fairly basic. To register for the auction, developers must follow the following steps. First, they need to register on the electronic application system and fill out the business plan form according to the user manual. General information such as the business name, location and the type of facility is requested. Additionally, information about the cost structure, the inspection and maintenance system, and a disposal plan is required (Kobayashi et al., 2017). Each bidder needs to present a participation fee of JPY 127,000 (USD 1,150)[5] (GIO, 2019b).

Similarly, requirements to qualify are not strict. While not required as documentation, the need to conform with local regulations and to hold consultations for large-scale solar PV (and biomass above 2 MW) projects is stated.

Although the relaxed requirements reduce entry barriers and administrative burdens for bidders, they may result in a higher risk of underperformance in the construction and operation stages (see Chapter 2 of IRENA 2019d). Consequently, lax qualification requirements in Japan are balanced with strict compliance rules (see Section 4.4).

Technological requirements

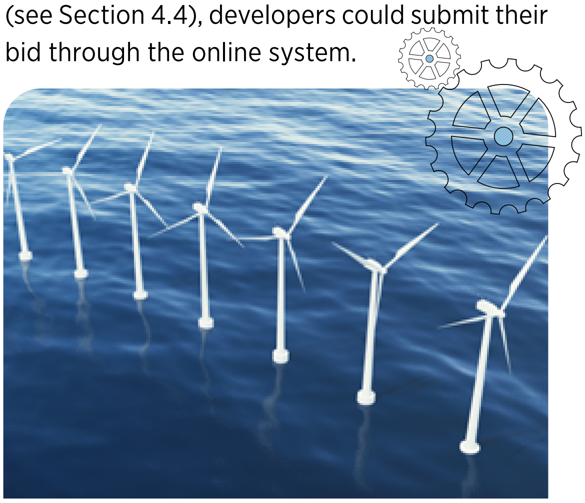
The lack of technical requirements can lead to a mismatch between the system needs and the developers' generation profiles. To mitigate this mismatch, once the business plan has been approved by METI, changes that affect the performance of the plant need the consent of the agency. Even changes to the operation and management plan require a notification to METI, but not its approval (Kobayashi et al., 2017).

Grid access requirement

Securing grid access is not a requirement for participation in Japanese auctions: proof of application for an agreement is enough. In fact, that is the main difference in qualification requirements compared to the FiT programme. Noting the long time needed to obtain a grid access permit under the FiT programme, the auctioneers have now waived this requirement, which otherwise appeared to deter bidders. Indeed, dropping this requirement generally allows for more bidders to partake in the auction, as transaction costs decrease. However, this could also lead to delays in project implementation. Moreover, grid connection delays are often not under the control of the developers, who still assume some penalty risks nevertheless (see Section 4.4).

Furthermore, high-voltage connection to substations is costly, which may be another factor (in addition to trouble securing land and grid access) that impedes economies of scale in bid prices for large-scale projects in Japan (Kenning, 2020).

In sum, Japan's qualification requirements are relatively lax. They are limited to a timely business plan submission, alignment to local government guidelines and the payment of fees. After receiving approval from METI for the plan and providing the corresponding commitment bonds (see Section 4.4), developers could submit their bid through the online system.



4.3 WINNER SELECTION AND CONTRACT AWARD PROCESS

Bidding procedure

A sealed-bid procedure is used in Japanese auctions, with the auction volume awarded in ascending order until either the target volume is reached, or the bids surpass the ceiling price. On the day of the auction, all the sealed-bids are opened and the business plans are evaluated by the auctioneer. Compared to an iterative or a hybrid process, this is the simplest method (see IRENA and CEM, 2015). A weakness, however, is that bidders need to disclose their information prior to the auction, which takes away their ability to react and adjust their bids. Nevertheless, from the auctioneer's perspective, this can be considered an advantage, as it reduces the risk of bid manipulation.

Winner selection criteria

The price is the only selection criterion, which is the simpler and more cost-effective method compared to the alternatives: adjusted price and multi-criteria auctions. Yet the latter in particular have been increasingly adopted globally to support a just and inclusive energy transition and ease renewable energy integration (IRENA, 2019c).

Payment to the winner

As is common around the world, Japan has opted for a pay-as-bid pricing scheme. Because developers get paid what they bid, this scheme can lead to higher prices than with marginal bidding, where every bidder is paid according to the last accepted bid. This is because with pay-as-bid, developers seek rents, while with marginal bidding, developers are encouraged to bid closer to their (marginal) costs. Marginal bidding does come with a potential risk of underbidding, however.

In any scheme, though, the combination of insufficient competition and disclosed price ceilings may lead to prices very close to the ceiling, which seemed to be the case in Japan's first round (see ceiling price discussion below). That said, pay-as-bid pricing schemes tend to be more politically and socially acceptable than marginal bidding and more transparent and binding than nonstandard pricing schemes (see IRENA and CEM, 2015).

Ceiling price

To avoid contracting capacity at too high prices, Japan has used ceiling prices. Naturally, given that the main objective of these auctions is to reduce the system costs relative to the FiT, awarding projects at prices higher than the applicable FiT would be defeating the purpose of the auction system. That said, and similar to defining a FiT, establishing an appropriate ceiling price is challenging. If too low, it will discourage participation and hurt competition. In the first solar auction, the disclosed ceiling price was pegged to the FiT. One main disadvantage of disclosing ceiling prices is that it may anchor bids and thus limit price discovery. Indeed, half of the contracted volume in the first auction was at the ceiling price of JPY 21/kWh (USD 186/MWh).[20]

As of the second round, all further auctions – both solar and biomass – worked with undisclosed ceiling prices. An unexpectedly large decrease in the (undisclosed) ceiling price – to JPY 15.5/ kWh (USD 138.3/MWh) [21] – resulted in not a single bid being awarded in the second solar auction. The third auction kept

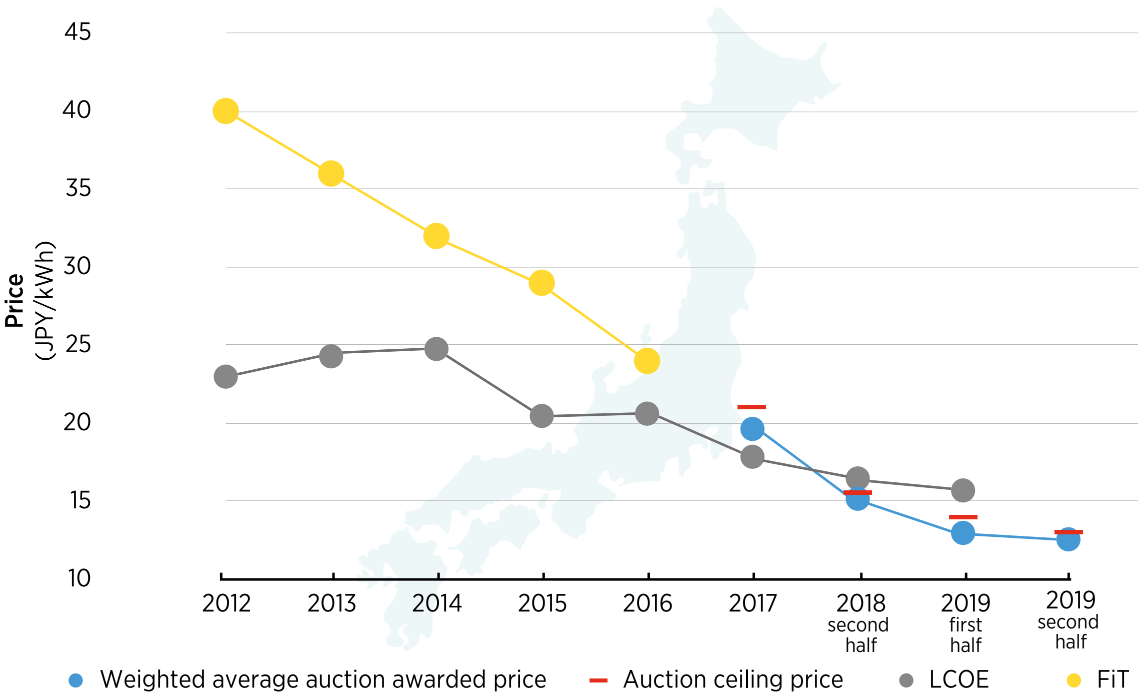
[20] *JPY 1 = USD 0.0088.*
[21] *JPY 1 = USD 0.0089.*

the same ceiling price as the second one, but this fact was not disclosed. Possibly because bidders anticipated a lower ceiling price this time around, they submitted 13 out of 16 bids below the ceiling price level. By the time the fourth auction rolled around, the FiT had been reduced to JPY 14/ kWh (USD 131.9/MWh) [22] and the fourth auction's ceiling price was pegged to this – as in the first solar auction.[23] In the fifth round, the ceiling price was further reduced, to JPY 13/ kWh (USD 119/MWh)[24] (Bellini, 2020). Ultimately, the average awarded prices were close the ceiling prices throughout all five rounds, suggesting lack of competition. That said, the ceiling prices were close to the LCOE, and even below it in 2018 and 2019. In the end, the auction prices have revealed prices closer to electricity costs than the FiTs did during their operation (Figure 13).

Clearing mechanism

Regarding the clearing mechanism, Japan demanded supply-side flexibility, where the last (marginal) bidder could be awarded a lower quantity than bid. While this approach makes auction targets more attainable, it can also compromise business plan viability and discourage auction participation due to uncertainty about contracted quantities. Indeed, the marginal capacity of 1 MW awarded in the third auction was ultimately not contracted (Solar Journal, 2018). Developers have indicated that enabling conditional bidding – where the bid price varies depending on the quantity that is contracted – can be a driver to encourage their participation in future auctions (Kageyama, 2017b).

Figure 13. Solar PV auction results in Japan compared to LCOEs and FiTs



Source: IRENA (n.d.); IRENA (2019a); METI (2019c); BNEF (2019); GIO (2017, 2018ad, 2019c); Bellini (2020)

Note: The second auction did not award any bid and thus is not depicted. Although the LCOE values in IRENA (2020b) are in USD 2019 (constant), they are depicted here in nominal values to show the difference between them and deployment policies (vertically) at a given time, rather than a downward trend (horizontally). That said, auction prices are not directly comparable to the LCOEs, as the latter requires making multiple assumptions, for instance, regarding weighted average cost of capital (WACC) or capacity factors.

[22] *JPY 1 = USD 0.00941.*

[23] *Ceiling prices and FiTs also affected the biomass auction. The liquid biomass auction received only one bid, which was just below the FiT of JPY 24/kWh (USD 214.16/MWh) at JPY 23.90/kWh (USD 213.2/MWh). This bid could not be awarded as it was much higher than the ceiling price of JPY 20.60/kWh (USD 183.8/MWh).*

[24] *JPY 1 = USD 0.00915.*

4.4 RISK ALLOCATION AND REMUNERATION OF SELLERS

Commitment bonds

Strict compliance rules in Japan are in contrast to lenient qualification requirements (see Section 4.2). Japan relies on two types commitment bonds: a bid bond to ensure contract signing, and a completion bond to ensure project implementation (see Chapter 2 of IRENA 2019d). The bid bond requirement in Japan is JPY 500/kW (USD 4.5/kW)[5] and the main criteria for its confiscation include failure to sign the contract, or evidence of bid-rigging. The bid bond is usually counted towards the completion bond, or returned if the project is not awarded.

The completion bond, in turn, is 10 times higher than the bid bond, at JPY 5,000/kW (USD 45.3/ kW).[5] This significant difference can influence developers' behaviour regarding commitments, even after they qualify to bid. This was the case in the first round, when developers incurred risks of commitment bonds being confiscated for events or delays that were out of their control (Box 3). As a result, less than 30% of the volume bid in the first round elicited interest from participants (see Figure 5).

Taking into account the feedback received from developers, the government relaxed the confiscation rules for subsequent rounds. If METI's certification could not be procured within the deadline, the completion bond could be carried forward to the next auction.[25] Furthermore, the deposit would not be confiscated if the developer failed to deliver owing to external factors.

While these changes may explain why, since the second round, the registered capacity has exceeded the auctioned capacity, the challenge remained in retaining bidders beyond that point. This was because once qualified, many bidders dropped out and did not place bids. These findings suggest that risk perceptions among developers have remained high in more recent rounds, possibly reflecting grid connection and land availability challenges (Bellini, 2020), rather than strict bond confiscation rules.

Moreover, for the fourth and fifth rounds, local public projects funded by local governments, or those promoting a revitalisation of rural areas, are exempted from commitment bonds (Teitanso, 2019). This allowed smaller and local players to participate in the auctions, for whom the financial burden of these guarantees could have otherwise been prohibitive.

Lead time

The first solar auction allowed project developers to set their lead time, but this was influenced by the FiT scheme's lead time of three years. Indeed, although the first auction allowed the lead time to go beyond that period, the contract duration would be shortened for the amount exceeding the three years. Nevertheless, because the commitment bonds were high and the penalties for not meeting the commercial operation date (COD) were strict (see above), more than half of the developers set their lead time above three years, and 13.6% of the developers set starting dates exceeding eight years from the date of certification (Kageyama, 2018b).

BOX 3. STRICT COMPLIANCE RULES IN THE FIRST SOLAR PV AUCTION

After being selected in the first round of the solar auction, developers were given only two weeks to submit the completion bonds, with failure to meet this deadline resulting in the bid being forfeit.

Moreover, if a developer failed to obtain certification from METI within three months of being awarded, or then failed to settle the grid connection agreement a month later, the contract would also be void and the bond confiscated.

As a result, five awarded projects, accounting for 100 MW, did not pay the commitment bond, as they doubted that this timeline could be observed. Ultimately, the government could thus only contract 41 MW out of the 141 MW initially awarded (see Figure 5).

Source: GIO (2019a, 2019b); BNEF (2019); Kageyama (2018b); Matsuda *et al.* (2018)

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

Contract duration

Winners of the auctions have been awarded a PPA with a 20 year duration. This ensures predictable long-term revenues over the useful lifetime for solar projects, thus improving developers' risk perception. Shorter contract durations could be discussed once the market liberalises and generators can continue selling electricity to the market upon PPA expiration.

Post-contract provisions

In Japan, demand-side responsibilities end upon contract expiration and developers are responsible for the disposal of the power plant. This is an element that must be detailed in the business plan and factored into the bid.

Financial risks

Financial risks are important considerations in any contract. Risks associated with currency exchange rates and inflation can be particularly significant for project developers, as these can have a considerable impact on the viability of a business plan that may span several decades. In Japan, contracts are awarded in the national currency (JPY) and are not indexed to inflation (Kobayashi et al., 2017). Since most of the developers are locally-based with a considerable level of domestic manufacturing – and since inflation rates are low – developers do not perceive currency and inflation risks as high.

Production and curtailment risks

Regarding production risks, or quantity liabilities, in similarity with the FiT programme, developers receive a fixed price for the energy fed into the grid.[26] This system most closely resembles an energy-oriented agreement, compared to capacity-oriented or financial agreements (see IRENA and CEM, 2015). Nevertheless, while in an energy-oriented agreement, the risk allocation between the developer and the off-taker is, as a norm, balanced, in Japan, the former assumes greater risks. Utilities can curtail renewable generation for up to 30 days per year without offering any compensation to developers. Furthermore, if the anticipated curtailment in a given region is above a centrally determined "acceptable capacity", newly connected renewable generators must accept being curtailed without compensation. Alas, this is not atypical in regions with high potential for renewables, as these are simultaneously regions with low demand centres. Developers must then internalise the risk of high curtailment rates without compensation, even when their projects can connect to the grid (Kimura, 2017).

In the end, curtailment risks can drive prices up: in Japan, a 10% curtailment can increase generation costs by up to JYP 6.3/kWh (around USD 57.8/ MWh) (Kimura, 2019). Seven regional utilities[27] have adopted these curtailment measures, among them those in regions with the highest natural potential for renewables.

Developers' risk perception is also hurt by auction projects neither having priority connection, nor priority dispatch guaranteed (Matsubara, 2018)

Settlement rules and penalties

Finally, contracted developers – those expected to enter the construction and operation stages – must factor in the risk of delay and its corresponding penalties. In general, delays can be penalised in three ways: 1) through a one-time financial penalty (i.e., confiscation of a fraction of the project's completion bond in proportion to the delay observed); 2) reduction of the project's contractual remuneration (a recurring cost) or duration; or 3) contract cancellation, if the delay extends beyond a defined deadline (see Chapter 2 of IRENA, 2019c).

Japan uses two different tools to penalise delays. First, the completion bond is forfeited in its entirety, if the project does not meet the commercial operational date. Second, the procurement period is shortened by one month for each month of delay, i.e., in the case of a six-month delay, the contract will only be valid for 19.5 years instead of 20.

In sum, developers assume risks regarding: power plant disposal upon contract expiration; high curtailment probability; and bonds entailing strict confiscation and delay penalties. The higher the perceived risks, the higher the auction prices, as developers expect a premium to assume those risks.

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[26] The winner is awarded a contract akin to the FIT, but with a pay-as-bid pricing scheme (Kobayashi et al., 2017).
[27] Chugoku, Hokkaido, Hokuriku, Kyushu, Okinawa, Shikoku and Tohoku.

5 Conclusions

Renewable energy has yet to make a significant dent in Japan's energy and power mixes. This is despite the fact that in its early years, Japan's FiT scheme fuelled rapid renewable energy deployment. But this deployment soon became fiscally unsustainable. Japan used two-thirds of its intended budget for renewable deployment to get only one-third of the way towards its renewable targets (METI, 2019b).

In this context, auctions were chosen as the next policy instrument to support Japan's energy transition in a cost-effective fashion. Accordingly, Japan's renewable energy auctions are price-centred and prioritise simple design elements over complex ones.

At time of writing in late-2020, five rounds of solar PV auctions had been conducted since 2017, with two biomass auctions conducted since 2018. Zone-specific wind off-shore auctions were launched in June 2020.

The price between the first and fifth solar PV auction (2017-2020) decreased by more than one-third (36%). Investors' increased confidence in auctions may have played a role, but the impact of falling costs in solar PV modules and total installed costs may have been bigger. That said, the module, inverter and installation costs remain high when compared internationally and thus represent the major cost reduction potentials in Japan.

Indeed, of the major utility-scale solar PV markets in the world, costs in Japan are among the highest. Consequently, the auction price outcomes are also still relatively high when compared to international benchmarks, even after considering resource quality differences. That said, a closer look shows that the auction prices are in fact close to the country's solar PV costs, underscoring the auction's attributes to discover competitive prices in a determined context.[28]

Auctions still have challenges, however. In particular, undersubscription has been a persistent issue. First, a FiP scheme will be introduced in 2022 in addition to an existing FiT scheme, which may discourage the participation in auctions. Second, strict completion bond confiscation rules, paired with land availability and grid access constraints, were identified early on as factors hurting developers' interest in entering auctions, or submitting bids once qualified. Even though these confiscation rules have since been relaxed, undersubscription has persisted, suggesting that grid connection and land availability constraints remain core developer concerns.

To that end, auction design elements that go beyond price minimisation can be contemplated. While auctions that pursue complementary development goals may not reduce electricity prices in the short-term, the long-term benefits may outweigh the costs. These benefits include ensuring timely project completion (an issue observed in the FiT scheme), supporting a just and fair energy transition, or a smoother integration of renewables into the grid (IRENA, 2019c). The introduction of zone, site, or even project-specific auctions, for instance, can help overcome the grid and land barriers in Japan. In fact, this type of auction is planned for the first offshore wind round, where transmission needs can be addressed in advance and the risk of land access and grid connection can be carried by the auctioneer, instead of the developer.

[28] *Auction prices are not directly comparable to the LCOEs, as the latter requires making multiple assumptions – for instance, regarding WACC or capacity factors.*

Importantly, design elements beyond price must foster the connectivity and co-ordination between the energy sector and the rest of the economy. For instance, renewable energy auctions, if designed accordingly, can create new employment opportunities (see Chapter 4 of IRENA, 2019c). While Japan still is second in the world by number of people employed in the solar PV sector, the 240 000 jobs it had in 2019 have fallen for two consecutive years (IRENA, 2020c, IRENA, 2019d). That said, new employment opportunities able to support the sector's development will require the workforce to possess a certain set of skills and knowledge.

Thus, for deployment policies, such as auctions, to maximise socio-economic benefits, they need to be introduced in coordination with enabling policies that in turn link five crucial types of policies: 1) industrial, 2) labour market, 3) social protection, 4) education and skills, and 5) financial policies.

At the same time, deployment and enabling policies must be designed in tandem with integrating policies (i.e., behavioural policies or measures to enhance system flexibility) (IRENA, 2020b).

Lastly, auctions can indeed help Japan keep on track with its renewable energy targets, but they cannot carry the load alone. They are ultimately an element of a broader electricity sector. Given the challenges that large-scale projects are facing in Japan, distributed energy is becoming increasingly relevant (Asian Power, 2020; Kenning, 2020).

Looking forward, Japan will need a framework in which both distributed energy deployment and auctions can co-exist. In early 2020, the Ministry of Environment was planning financial support for community projects, including renewable energy, storage systems and transmission grids (Asian Power, 2020). Germany, to take an existing example, has encouraged participation by community energy projects in onshore wind auctions (see Chapter 4 of IRENA, 2019c).

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