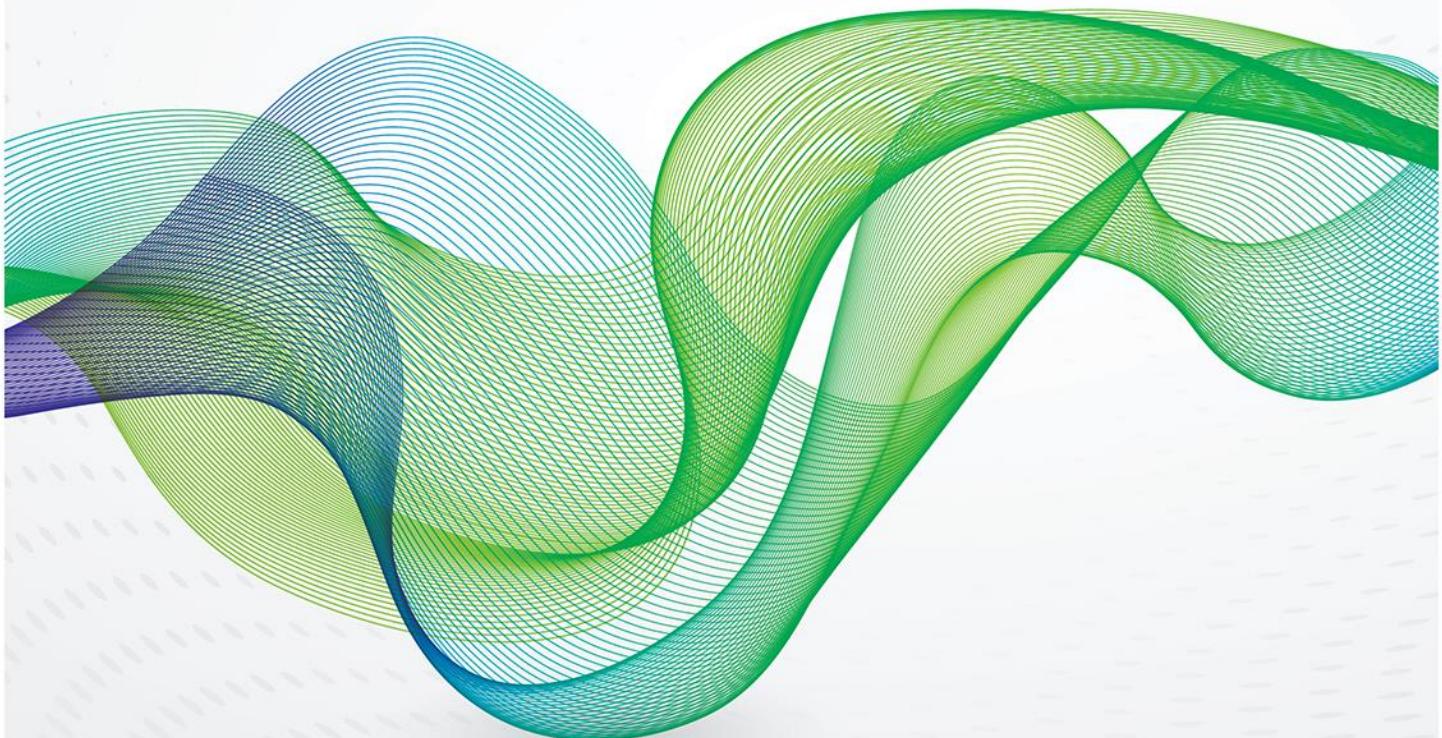




THE OXFORD
INSTITUTE
FOR ENERGY
STUDIES

April 2018

Renewable Auction Design in Theory and Practice: Lessons from the Experiences of Brazil and Mexico





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ISBN 978-1-78467-106-8

DOI: <https://doi.org/10.26889/9781784671068>



Renewable Auction Design in Theory and Practice: Lessons from the Experiences of Brazil and Mexico

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Abstract

Competitive tendering has become one of the preferred methods of contracting renewable energy generation capacity internationally. As of early 2015, at least 60 countries had adopted renewable energy tenders, compared to just six countries in 2005. However, there are limited country-specific comparisons which research the subject considering the importance and prominence of the issue. The aim of this study is to fill this research gap by examining the Brazilian and Mexican experiences in developing renewables and how their tendering programmes interact with the market and institutional frameworks in which they exist. Fundamentally, our study seeks to shed light on two simple questions: what auction design issues may serve as barriers to renewable development, and how can auctions be improved further? We provide a historical assessment of renewable and generation capacity development policies in both Brazil and Mexico, review auction design and results in both countries, and offer recommendations for the future design and implementation of renewable energy policy tools, and auctions in particular.

Keywords: Renewable auction, auction design, electricity market, renewable policy, Brazil, Mexico



Acknowledgement

The authors of this paper are thankful to David Robinson from OIES, Rolando Fuentes of the King Abdullah Petroleum Studies and Research Center, Jim Heidell of PA Consulting Group and Alexandre Viana Pacific Hydro for their invaluable comments and insights on the earlier version of this paper.



Glossary

ACL	Brazil's Free Contracting Environment; Ambiente de Contratação Livre
ACR	Brazil's Regulated Contracting Environment; Ambiente de Contratação Regulada
ANEEL	Brazil's National Agency of Electric Energy; Agência Nacional de Energia Elétrica
AURES	Auctions for Renewable Energy Support
BNDES	Brazilian Development Bank; Banco Nacional do Desenvolvimento
CC	Mexico's Compensation Chamber; Cámara de Compensación
CCEE	Brazil's Market Operator; Câmara de Comercialização de Energia Elétrica
CELS	Clean Energy Certificates; Certificados de Energía Limpia
CENACE	Mexico's National Center for Energy Control; Centro Nacional de Control de Energía
CFE	Mexican Federal Electricity Commission; Comisión Federal de Electricidad
CMSE	Brazil's Electricity Sector Monitoring Committee; Comitê de Monitoramento do Setor Elétrico
COD	Commercial Operation Date
CRE	Mexican Energy Regulatory Commission; Comisión Reguladora de Energía
EPE	Brazil's Energy Research Company; Empresa de Pesquisa Energética
FECs	Firm Energy Certificates; Garantías Fisicas
FiT	Feed in Tariff
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
kW	Kilowatt
LAERFTE	Law for the Development of Renewable Energy and Energy Transition Financing; Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética
LCOE	Levelised Cost of Energy
LMP	Locational Marginal Price
LSE	Load Serving Entity
LSPEE	Public Electricity Service Law; Ley del Servicio Público de Energía Eléctrica
MDA	Day Ahead Market; Mercado del Día en Adelanto
MEM	Mexico's Wholesale Electricity Market; Mercado Eléctrico Mayorista
MME	Brazil's Ministry of Energy and Mines; Ministério de Minas e Energia
MW	Megawatt
MWh	Megawatt hour



OFTO	Offshore Transmission Owner
ONS	Brazil's National Electric System Operator; Operador Nacional do Sistema Elétrico
PROINFA	Incentive Program for Alternative Electricity Sources; Programa de Incentivo às Fontes Alternativas de Energia Elétrica
SENER	Mexico's Secretary of Energy; Secretaría de Energía
SRMC	Short Run Marginal Cost
TSO	Transmission System Operator



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1. Introduction

Auctions provide governments with a market-based framework and an efficient allocation tool to meet policy objectives such as renewable deployment, tariff reduction, reliability improvements, carbon emissions control, economic development and increased foreign investment. While a variety of policies exist to promote the development of renewable energy, competitive auctions¹ have emerged as a preferred policy for utility-scale renewable energy development. Auctions can be designed to result in procurement of a specific quantity of electricity (or capacity to be built) at a strike price. Renewable procurement schemes can also be designed with a fixed budget, allowing quantity to be determined by the market. Auction volume can be set in a number of ways. In Mexico, volume is set by demand according to the quantities submitted in purchase bids; similarly, in Brazil's principal auctions, it is set by the distribution companies which pool together demand to determine total auction volume.

This approach to renewable procurement is often called a reverse auction as lowest-priced bids are most competitive, with investors underbidding one another (per unit of electricity, capacity, and/or other products) to win the right to develop their generation technology. To qualify for the auction, project developers must meet specific predetermined criteria related to development experience, technical specifications and financial standing. After bids are submitted, the offtaker (often a utility on behalf of the government) accepts winning bids, usually based on price. Additional criteria can also be considered when selecting winning bids, such as energy technology, local content and project location. Project developers then have a timeline, often from two to five years (depending on the generation technology, project size and market needs) to attain permitting and bring the project to commercial operation. The competitive nature of auctions helps drive down prices, which are ultimately passed on to end users, and the regulatory structure of auctions guarantees bidders with long-term contracts, which helps facilitate financing by ensuring long-term revenue streams for project developers.²

Latin America has been a global leader in implementing these auctions, with Argentina, Belize, Brazil, Chile, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Peru and Uruguay having developed electricity procurement tender programs (IRENA, 2016).³ While these countries have gained experience in auction design, implementation and renewable deployment to meet policy objectives, specific tendering structures tend to vary significantly from auction to auction, often even within the same country. The need to learn from the past and evaluate the successes and failures of these auctions is ongoing, and necessary to address the degree to which auctions satisfy government policy objectives and societal needs. While at least 13 Latin American nations have experience with renewable development through competitive tendering, for the purposes of this study, Brazil and Mexico will be the countries of focus. They are the region's largest economies, with the largest populations, and also lead in hydrocarbon production, installed power generation capacity and CO₂ emissions. Brazil and Mexico are also the top regional destinations for renewable energy investment (IRENA, 2016). Brazil was the first country to introduce both long-term electricity auctions (2004) and renewable specific auctions (2007) replacing its feed in tariff (FiT) scheme. Mexico, on the other hand, is one of the most recent nations to implement auctions in general and for renewable support (2015). The two cases make for an interesting point of comparison. As a pioneer, Brazil developed its auctions without an exact

¹ A note on terminology: auctions, tenders, tendering and competitive procurement are used interchangeably in the literature on renewable energy auctions.

² Depending on the design, contracts with successful bidders can only guarantee the price but not purchase of electricity. This depends on the electricity market structure. In non-liberalized or partially liberalized markets, successful bidders often sign a Power Purchase Agreement (PPA) with an offtaker utility. In some European countries, on the other hand, successful bidders are responsible for selling their electricity in the wholesale market. If sold, they are often entitled to a guaranteed fixed payment irrespective of market price (sometimes on top of market price).

³ In March 2018, Colombia's Ministry of Mines and Energy issued a decree permitting the long-term contracting of renewable energy, setting the legal framework for the introduction of renewable energy auctions.



reference model, while Mexico enjoyed a last-mover advantage, with the choice of many international cases on which to base its auctions.

There is considerable academic literature on renewable energy policy in Latin America, some of which has focused on history, policy, market structures, procurement mechanisms and environmental features of conventional and renewable power in Brazil and Mexico. There is also practitioner literature, mostly from professional service firms, which focuses on country-specific corporate strategy and investment opportunities. Building on these foundations, this paper provides a comparison of the experiences of the two nations in developing schemes for generation capacity procurement, with a focus on auctions and renewable energy in particular. To our knowledge, this work is the first academic study which compares electricity auction design as it relates to renewable energy development exclusively in Brazil and Mexico. As Mexico's electricity auctions began in 2016, this is also perhaps the first academic study that provides a detailed yet broad evaluation of Mexico's electricity auction design and wholesale market structure. This paper complements other publications related to renewable energy and competitive tendering in Latin America as a whole, and country studies focused exclusively on either Brazil, or Mexico.

We aim to offer insight into the current functioning of wholesale electricity markets and long-term procurement auctions in Brazil and Mexico, and the issues and options for auction design in these countries, with a particular focus on renewables. However, as renewable generation often competes with conventional technologies in auctions, and all generation technologies operate within the same market contexts and wholesale markets, the paper discusses electricity auctions in general, as well as renewable specific mechanisms and auctions. This report also aims to provide a solid informational foundation for deeper research into the specific market mechanisms and topics discussed in this paper. Section 2 outlines the fundamentals of electricity auctions design, explaining the features of salient design elements and their associated trade-offs. Section 3 of the study outlines the Brazilian and Mexican experiences in the power sector reform that have led to competitive generation and tendering. This assessment is necessary to fully understand auction design, its influences, and the contextual factors which facilitate or preclude specific design features. Section 3 also evaluates the current structure and functioning of the wholesale power markets in each country, and auction design in Brazil and Mexico. Section 4 briefly examines the effectiveness of the auctions in terms of meeting government objectives and fulfilling societal needs. Section 5 makes recommendations in terms of auction administration and design, providing suggestions to help correct deficiencies. Section 6 concludes.

2. Electricity Auction Design

2.1 Electricity auctions in context

In the liberalised electricity markets, reverse tendering for long-term contracts is the result of regulatory intervention often implemented in response to the absence of efficient short-term market price signals (in non-liberalised markets it is a step forward to introduce market mechanism for generation investment). Liberalised markets were initially designed with the expectation that market price signals alone encourage sufficient long-term investment in generation and coordination of an adequate generation mix. Roques and Finon (2017) provide several reasons why the market cannot always deliver adequate supply in the long-term.

The foundations of the security of supply issue are rooted in two phenomena. First, a lack of price-reactive demand (Roques and Finon, 2017). The fundamental need for scarcity pricing is created by the current limited ability of electricity consumers to react to real time spot market prices (Cramton, 2017). Access to real time electricity prices in the context of a well-designed demand response programme would, in theory, increase the price elasticity of demand. Such a situation would in turn allow consumers to react more quickly to reduce demand peaks and avoid extreme peaks. Second, the readiness with which policymakers adopt security of supply measures (i.e. reserve margin) creates



uncertainty around the belief that the (energy only) market is capable of meeting administratively set security of supply requirements and providing resource adequacy on its own (Roques and Finon, 2017).

More specifically, the “missing money” problem presents a major issue with respect to security of supply. Spot market price caps to prevent electricity prices which are perceived as unacceptably high (usually for political reasons, to help mitigate market power or to support other policy goals) can lead to revenue shortages for generators, which may depend on price spikes to recover large portions of their fixed costs. Even in cases without price caps, generators may be disinclined to depend entirely on short-term markets to recover fixed and variable costs and earn a rate of return on large capital investments. These issues are compounded by increasing penetration of zero marginal cost intermittent renewable energy generation, which increases price volatility in the short-term markets, especially at peak demand and for peaking units. In addition to long-term security of supply, Roques and Finon (2017) suggest that short-term energy prices may be insufficient to support decarbonisation objectives and an adequate generation mix.⁴ They contend that ‘out-of-market’ mechanisms within the hybrid market⁵ may help provide long-term risk sharing to lower the cost of capital and hurdle rates for investors, and encourage a more diverse generation mix. They also note that emerging economies have been quicker to adopt long-term arrangements, due to the stronger need for capacity investment when compared to developed economies.

The inefficiency of short-term markets in providing long-term investment signals is amplified for renewable technologies, due to intermittency and the inverse relationship between renewable dispatch and wholesale power prices. When renewable generators sit idle and baseload generation is relatively low, wholesale power prices are likely to rise, yet renewable generators will not claim these high prices if they are not available for dispatch. Yet when weather conditions permit high penetration of renewable energy dispatch, the low marginal cost of renewable technologies will cause peaking plants and some generation technologies with higher marginal costs to be uncompetitive on that particular dispatch curve. Accordingly, renewable technologies claim the unit on the margin of the dispatch curve which sets the marking clear price, which is lower during times of significant renewable production. Long-term electricity auctions therefore represent an important complement to short-term markets and have become increasingly popular as a means of coordinating and ensuring resource adequacy through a competitive, albeit interventionist mechanism. For renewables in particular, isolation from short-term markets through long-term power purchase agreements (PPA) helps facilitate project financing and reduces the cost of capital, which should translate into lower power costs.⁶

As a result of these issues, auctions have become increasingly popular, and have proven effective in stimulating competitive resource allocation and price formation through systematic procurement frameworks. While resources are expended on the part of buyers in preparing bids, and on the part of governments in establishing regulatory support regimes and tender rules, auctions provide a structure to answer a simple yet significant question, which Rego and Parente (2013) express as “who gets the goods, and at what price?” The ‘goods’ in electricity auctions can be energy (MWh), capacity (MW), certificates to support clean energy or other policy goals, financial transmission rights and ancillary services.

Electricity auctions could encourage aggressive pricing among project developers eager to take advantage of public tendering to enter new geographies, or to expand their presence in existing markets. For example, Mexico’s second generation procurement auction produced record-low prices regionally with an average of \$33/MWh for solar, \$36/MWh for wind, and \$33.47/MWh as the overall average for all clean energy technologies. Its third auction resulted in even lower prices, with energy +

⁴ The scope of this paper does not permit the detailed evaluation of this subject, which is covered in the literature.

⁵ Hybrid markets combine traditional short-term markets with a long-term component (i.e. competitive tenders).

⁶ Interventionist policies, however, may adversely impact the short-term market and the ability of existing conventional generators to recover all of their fixed costs.



clean energy certificates clearing at an average price of just over \$20/MWh. In one of Brazil's most recent auctions, wind averaged prices of less than \$30/MWh. As a consequence of low price outcomes internationally, FiT schemes are being replaced by auctions. The number of countries with FiTs fell 22 percent from 2014 to mid-2016 (Warren, 2016).

The types of auctions employed and specific design elements within each auction category can produce wide-ranging outcomes. In addition to pricing, auction design affects the diversity of market participants, project realisation rates, and determines which energy technologies are developed. Design shapes the geographical distribution of projects and the level of local economic development, among other important results. Auction type and design also determine the likelihood of collusive behaviour and predatory practices within the auctions.

Design elements interact with one another, creating continual trade-offs between reducing the likelihood of unwanted outcomes and achieving auction success.⁷ For example, severe noncompliance penalties or large bid bonds may increase the probability that winning projects are built; however, they also may reduce the number of participating bidders and increase the risk premium on the cost of capital, leading to less competitive bidding and higher electricity prices. Design elements also interact with the larger market and policy frameworks in which auctions exist. For example, if project developers are required to submit bids according to their short run marginal cost of generation, does the wholesale market have sufficient mechanisms for capacity or ancillary services to cover fixed costs for generators? Alternatively, if generators bid on their long-run marginal costs or levelised cost of energy (LCOE), does it lead to foreclosure of short-term markets?

2.2 Auction design

It is necessary to review the principal auction design concepts that impact results, beginning with the types of auctions used for electricity procurement.

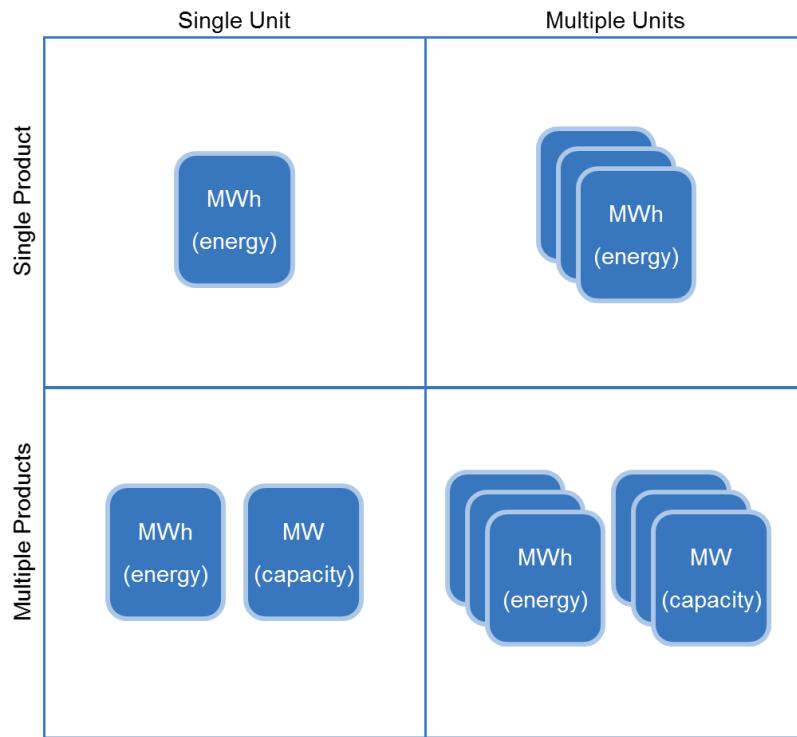
2.2.1 Auction classifications

As seen in Figure 1 below, auctions can be single-unit or multi-unit, meaning that either a single project or multiple projects are awarded to satisfy auctioned demand. At the same time, auctions are either single product or multiple product contests, depending on the number of distinct products offered in the auction. Single-unit, single product auctions are the simplest and easiest to design and participate in, yet in terms of renewables deployment, they offer less opportunity for new capacity development and complementary products. Multi-unit, multiple product auctions afford more opportunity for significant renewable capacity development and contributory products, yet are more complex for both the auctioneer in terms of design and implementation, and for bidders in terms of participation. Importantly, this auction design decision has significant implications for the most efficient clearing rules, in terms of using a pay-as-bid method (also known as discriminatory pricing) or applying a pay-as-clear scheme (also known as uniform pricing). This issue is discussed in detail in the conclusions section of this paper.

⁷ An auction is successful if it achieves efficient price discovery (prices that reflect costs plus a reasonable rate of return) and the realisation of projects without causing market distortions or unintended outcomes. While evaluating auction efficiency is a more common approach, efficiency traditionally considers that the bidders with the lowest costs win, and that the resulting projects correspond to the most competitive technologies. Auction efficiency does not however consider important factors such as the trade-off between competitive price outcomes and project realisation rates.



Figure 1: Representation of basic auction classifications



Source: elaborated by the authors of this report

Maurer and Barroso (2011) identify the below auction types, noting that they can be used to trade power contracts for both regulated and nonregulated customers on a short, medium and long-term basis, and that within specific auction designs, new capacity or the renewal of contracts for existing capacity can be targeted.

2.2.2 Auction and bid design options

In a typical reverse auction, all bidders submit schedules of prices and quantities for multiple units of the same product to be allotted. The auctioneer aggregates offer prices into a supply curve, linking it to the quantities to be purchased. The auction clearing price is determined at the price where supply and demand meet. Participants that submit bids at or below the market clearing price are the winners. Bids above the clearing price are disqualified. Below are brief explanations of fundamental design and bid options.

Sealed bid auctions:

First-price and second-price sealed bid auctions: All bidders simultaneously submit a single price sealed bid which corresponds to a single electricity asset or product. Bid amounts are unknown to all other bidders (hence the “sealed” bid). In a first-price sealed bid auction, the auctioneer selects the lowest bid as a winner, and the winner receives their bid price. In a second-price sealed bid auction (also known as Vickrey auction), the winner receives the price of the second most competitive bid, instead of their own bid price.

Pay-as-bid and pay-as-clear sealed bid auctions: In a pay-as-bid auction, winners receive their offer price (also known as a discriminatory price auction). In a pay-as-clear auction, winners receive the market clearing price (also called uniform price auction).



Example: Sealed bid auctions are typical when there is a single auction asset or product allotted to a single winner, such as concession for a new or existing generation or transmission asset.

Advantages: The simplicity of the auctions lowers the costs of participation, bid preparation and auctioneer administration. The possibility of retaliation or collusion among bidders is low, as participants are unable to use bidding to signal or communicate.

Disadvantages: There is risk of significant over or underbidding due to weak price discovery, as participants are unable to condition bids based on competitor bidding.

Descending clock auction (also known as an iterative auction):

The auctioneer begins the process by announcing a price that is considered high. Bidders reveal the quantities which they wish to offer at the stated price. If the quantity surpasses the procurement target, the auctioneer announces a lower price, and bidders reveal the quantities which they wish to offer at the new lower price. The process continues until supply meets demand, forming the clearing price. The winners receive payment equal to their offered quantities multiplied by the auction clearing price.

Example: Descending clock auctions can be used to auction a single product, or multiple products through concurrent auctions, i.e., to win the right to sell power for specific time-blocks. In this example, concurrent auctions for different time-blocks may permit bidders to shift offers from one auction / product to another as the bidding rounds progress.

Advantages: A distinct advantage of descending clock auctions is transparent price discovery, as bidders have the ability to view price formation through multiple rounds. Descending clock auctions are also less prone to corruption on the part of the auctioneer, as bids are conducted openly.

Disadvantages: Disadvantages include an increased chance of collusion among bidders, who can use tacit signalling via bids to communicate, increasing auction prices and bidder profits (Maurer and Barroso 2011).

Design in practice: In practice, auction designs routinely represent a hybrid structure, combining features of both sealed bid and descending clock auctions to meet policy objectives. Both Brazil and Mexico employ the method of combining features from different auction designs to fashion solutions that best fit their country-specific objectives and institutional frameworks.

2.2.3 Technology-specific, multi-technology and technology-neutral auctions

A second key design feature that affects auction outcomes is technology eligibility. Auctions include rules regarding technology participation, and depending on objectives, policymakers may seek to encourage a specific generation technology (technology-specific auctions), stimulate competition among a specific group of technologies (multi-technology auctions), or permit full competition across all energy technologies (technology-neutral auctions). Technology participation rules involve trade-offs in terms of cost, competition and other auction outcomes (AURES 2016c).

Technology-specific auctions are typically used to help provide the foundation for nascent or non-existent technologies to prove themselves viable and compete in future auctions. For example, to help expand the use of biomass and wind, Brazil held exclusive auctions for these two technologies in 2008 and 2009, respectively. Beyond supporting emerging technologies, technology-specific auctions can help diversify the generation mix, support the development of local industry and encourage diversity of market participants (AURES 2016d). While providing maximum control over generation mix development, the absence of competition among different technologies also precludes the development of least-cost generation. However, specific auction design according to particular technologies could have positive externalities, as pre-qualification requirements, regulatory procedures and other factors vary by technology. Accordingly, tailoring auction design for a single technology could enhance auction efficiency when technologies are at different stages of maturity.

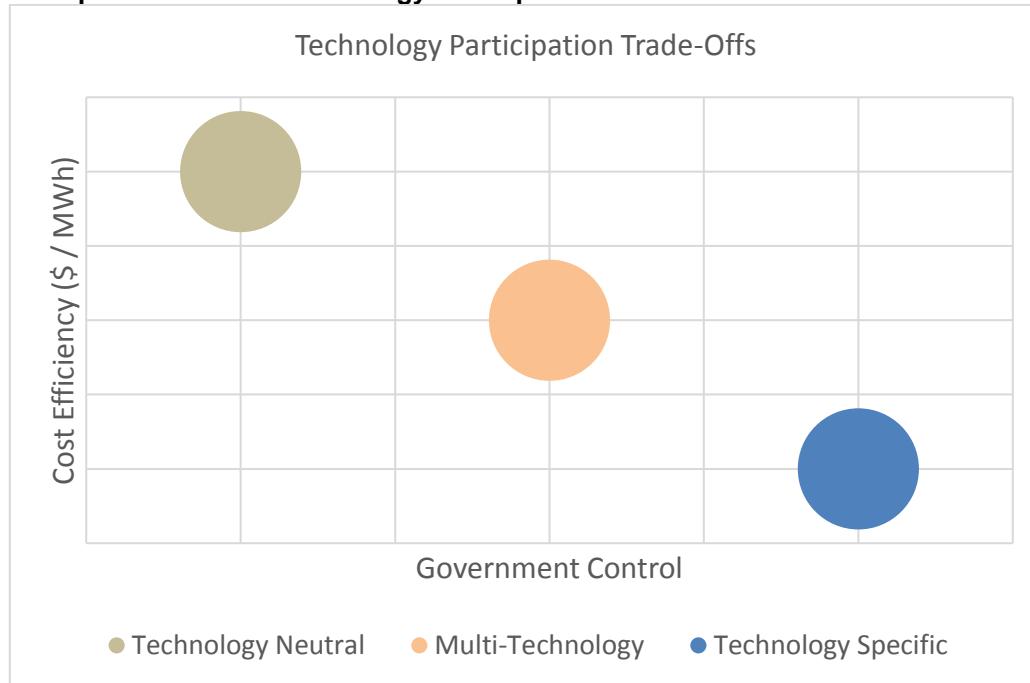


Multi-technology auctions for renewable energy allow two or more generation technologies to compete with one another. Auctions can be restricted to specific renewable energy sources, or can include specific renewable energy sources as well as conventional technologies. The auctions may also include demand bands, in which different technologies are allocated proportions of the auction's total capacity. Allowing the participation of multiple (yet not all) technologies provides policymakers control while maintaining competition (AURES 2016c).

In technology neutral auctions, all energy technologies and resources compete directly with one another. This can also include demand-side resources like energy efficiency and demand response, which may bid into the market as well (if they can demonstrate that savings are achieved or generation is offset during peak periods). These auctions increase the likelihood of the development of least-cost technologies, yet reduce or eliminate government control over which technologies are developed. If held when technologies are not at the same level of maturity, technology neutral auctions can sometimes lead to surprises and unintended consequences. Further, technology neutral auctions that include both conventional and green technologies could reduce the likelihood of meeting renewable energy targets (AURES 2016c).

The choice between technology-neutral and technology-specific auctions involves trade-offs among various goals such as cost efficiency and government control (see Figure 2). Achieving renewables targets and creating a market for immature technologies may also be considered. While the dollar per unit cost of electricity is likely to be higher in technology-specific auctions, this metric does not consider grid integration costs according to technology, local development benefits, generation mix diversity or resource adequacy (AURES 2016c). Accordingly, the ideal mix of technology-specific, multi-technology and technology neutral auctions depends largely on specific market and societal needs.

Figure 2: Representation of Technology Participation Trade-Offs



Source: elaborated by the authors of this report

2.2.4 Auction products

While the most common products offered through the auctions are energy and capacity contracts, the specific products made available for purchase and sale depend on market design and conditions. Energy only markets are feasible if energy payments cover all fixed and variable costs of generation



projects, and simultaneously incentivise new investment in generation to cover the given reserve margin. Generators are typically required to bid into the wholesale market at their short run marginal cost (SRMC) of generation, and therefore recover the marginal cost of fuel (which makes up about 90 percent of the SRMC for conventional generation) plus variable operations and maintenance costs.

Generators might not recover their fixed costs through pure energy payments if the market does not produce sufficiently high scarcity pricing; this is a particular problem for peaker plants which generate electricity for just a few hours per year. Establishing a capacity market, and offering capacity as a product in electricity auctions, is one way of permitting generators to recover fixed costs. However, relatively well functioning energy only markets do exist (such as New Zealand, and ERCOT in Texas), which include scarcity pricing and other mechanisms to recover fixed costs (although this depends on generation mix and level of penetration of renewables in the generation mix).

Additional products can be offered in long-term procurement auctions depending on market rules and specific policy goals. For example, Mexico offers clean energy certificates (CECs) as a product in its long-term procurement auctions as a means of supporting clean energy targets. Brazil offers firm energy certificates (FECs), a quasi-product that functions to provide signals regarding the country's supply-demand balance, in lieu of a formal capacity market. Financial transmission rights and ancillary services can also be offered through generation procurement tenders, but these products are typically traded through separate auctions for the sake of simplicity.

2.2.5 Auction volume

Auction volume, which can be determined according to forecasted demand plus a reserve margin, plays a central role in the level of competition in auctions. Determining the ideal volume to offer in a given auction is therefore a critical decision for policymakers. Auctioning large volumes through a single tender may lead to rapid development of new capacity, yet it could reduce competition and lead to higher prices. As bid prices are in large part a function of supply and demand, volume caps may be implemented in order to ensure that the volume offered in a given auction remains below the total volume that the market can absorb. Volume caps set below the total estimated market volume can therefore lead to lower bid prices due to limited supply and fiercer competition (AURES, 2015).

Disclosure of auction volume impacts competition. Revealing the auction volume in advance can raise interest among investors and project developers in the auction. Yet full disclosure could facilitate strategic behaviour if bidders seek to win all or the majority of offered capacity to gain market share, potentially leading to artificially low prices. Predatory pricing to gain market share could lead to project non-realisation, market power issues and the deployment of less efficient economic resources.

Auction volume can be set in terms of capacity (MW), energy (MWh) or budget (\$).

Volume as a function of capacity: Auction volume is set in capacity to be installed, with the option to assign different proportions of the total capacity to different technologies. Project developers bid to provide a specific amount of installed capacity by a predetermined date.

Advantages: Setting volume as a function of capacity facilitates electricity system planning. It also provides greater certainty and reduces risk to project developers, when compared with setting volume in generation, and supports the monitoring (and potentially the achievement) of renewable energy targets. In addition, it provides the clearest indication to manufacturers and developers about the future market size.

Disadvantages and considerations: Volume as a function of capacity does not ensure generation. There is less certainty regarding total project costs when compared with volume setting according to budget (which sets a maximum budget for products), yet this risk can be mitigated through establishing a ceiling price (AURES, 2016e).



Volume as a function of energy: Auction volume is set according to generation over a specified timeframe, and project developers bid to provide a specific amount of generation during the corresponding timeframe. This can also include generation blocks, in which project developers commit to provide a specified number of MWh during a particular time block (i.e. 17:00 to 22:00).

Advantages: It facilitates electricity system planning, and supports the monitoring (and potentially the achievement) of renewable energy targets.

Disadvantages: There is less certainty regarding total project costs when compared with volume set according to budget, yet this risk can be mitigated through establishing a ceiling price. Generation commitments present additional risk to project developers, as market, seasonal and weather conditions that impact dispatch can vary. Generation commitments also become problematic if future market conditions create a need to amend rules regarding priority dispatch (AURES, 2016e). Further, time block auctions could limit the ability of intermittent technologies to participate, depending on how the time blocks are set.

Volume as a function of budget: Auctioned volume is set according to a maximum budget determined by the auctioneer or government, yet the auction product is still set in generation or capacity. There are two approaches to volume as a function of budget. The auctioneer can define a maximum price per MW or MWh, or the auctioneer can define an aggregate budget without specifying total volume or prices.

Advantages: It sets a maximum for the prices paid for auctioned products, providing additional certainty regarding costs for end users.

Disadvantages: The level of capacity or generation to be acquired ex-ante can be uncertain, which can negatively impact system planning and the achievement of clean energy targets.

Upward adjustments to volume caps are common in electricity auctions. If overall offered volume is received at prices that the auctioneer interprets as highly competitive and thus beneficial for the given market and its consumers, the auctioneer may decide to increase the volume cap. Further, the volume cap may be increased in anticipation of project non-realization rates (AURES, 2015).

2.2.6 Auction frequency

Auctions should be held consistently at predetermined intervals in order to prevent irregular auction patterns. Setting regularly held auctions helps facilitate market predictability for investors, and could lead to lower bid prices. Further, increased certainty regarding the future and frequency of auctions is beneficial for renewable energy supply chains internationally and locally, and can be an advantage for local manufacturing. The signal to the market is fortified further when implemented in concert with clear long-term targets (set by law) with respect to renewable energy investment and decarbonisation. Exact auction frequency depends on the specific market, yet at least one auction per year is considered consistent. However, auctions should not be held simply for the sake of maintaining regular auction intervals. If a market is unprepared for an auction, due to oversupply, transmission constraints or other foreseeable issues, it is preferable to deviate from a regular auction schedule.

2.2.7 Lead time between auctions and commercial operation date

Lead time between announcing auction winners and corresponding deadlines for commercial operation can significantly impact auction efficacy and competition. Lead time should depend on the auctioned technology and the corresponding time to build, the urgency of resource adequacy needs, and consider any transmission constraints. It should also be set to allow project developers enough time to secure all necessary permitting and interconnection agreements to bring the project to a shovel ready stage and eventually to commercial operation. At the same time, it should be set to prevent project developers



from bidding at “highly competitive” prices in order to observe market and technology price developments before making a final investment decision.⁸

If too little lead time is provided, the risk of missing development related deadlines increases. Missed deadlines frequently result in mutual blaming on the parts of project developers and governments. Unrealistic deadlines also result in penalties for project developers, or the avoidance of payment if project developers are able to successfully shift blame to the government. In either case auction efficacy is diminished.

If too much lead time is provided, however, project developers may bid at excessively low prices in order to take a “wait and see” approach. If market conditions and technology price reductions become favourable, investors would go ahead with the project; if not, investors could cancel it. This issue is compounded when penalties for project non-realisation are low, or project developers feel that they can be avoided. Such was the case in Germany’s 2017 offshore wind auction, in which bid prices were far lower than expected. This was partially a result of the expectation of the cost of offshore wind technology declining significantly by 2025 (when the projects are required to begin commercial operation), combined with low penalties for project non-realisation. In this situation, the option value of maintaining the right to build may outweigh penalties in the case of project withdrawal, at least for some project developers (NERA, 2017).

A situation in which an auction is turned into an option for bidders is the result of the inevitable trade-off the auction designer faces between the probability of delivery and contestability. Increasing penalties for non-compliance with auction commitments and tightening prequalification criteria increases the probability of delivery but at the same time reduces competition due to the reduction of eligible bidders. The resulting “option to build” is an unintended consequence of this trade off, not the intention of the auction designer.

2.2.8 Auction prequalification and penalties

Prequalification and penalties greatly impact auctions in terms of overall efficacy. Bidders normally apply for prequalification, submitting official applications including a fee for application review and the purchase of auction rules. Bidders must demonstrate a relevant project development track record, submit a bid bond and comply with other legal and technical requirements.

Ensuring serious bids from competent project developers depends on the design and implementation of prequalification and penalties, as do project realisation and project delay rates. Penalties for non-realisation should be strict enough to dissuade investors from taking a post-auction “wait and see” approach. Harsh penalties should also reduce underbidding in auctions, as very low or negative returns can negatively impact project realisation rates.

As with most auction design elements, however, the severity of penalties imply a trade-off. Requiring bidders to post large bid bonds as collateral, and / or introducing strict penalties increases the risk premium on the cost of capital, applying upward pressure on bid prices and potentially limiting actor diversity. Prequalification requirements face a similar trade-off. While strict requirements regarding developer experience, financial wherewithal and other factors increase the likelihood of project realisation and decrease the probability of delays, strict prerequisites also reduce the number of eligible project developers, and decrease actor diversity. Regarding enforcement, the payment of penalties increases risk for project developers and adds a premium to the cost of capital in future auctions. Yet successful evasion of penalty payments undermines the credibility of auction rules, increases moral hazard and can lead to project developers missing deadlines with impunity.

⁸ The purpose of renewable auctions is to create investment incentives for the deployment of renewables. Auctions are not meant to create a market in which firms may purchase options to deploy renewables in the future.



2.2.9 Grid connections

The grid connection regulatory model determines the distribution of interconnection costs between parties, and can play a significant role in renewable investment incentives, impacting the competitiveness of renewables versus conventional technologies. There are four principal methods of connection cost allocation.

1. Generator model: Project developers are responsible for the entire grid connection cost, including any grid reinforcements corresponding to the connection. This is also known as “deep cost” allocation. In this model, project developers are incentivised to seek out a cost efficient connection, and ensure that the connection is viable without system upgrades prior to bidding. Under this approach, generators also typically avoid ongoing use of system charges (Stennett 2010). The generator model considerably increases investment costs for project developers and can have a disproportionately negative impact on renewable generators when competing directly with conventional technologies in auctions.⁹ As the site selection for renewable projects is limited by the availability of sun, wind or other naturally occurring resources, grid connection locations are equally limited. This can be an issue if optimal sites for renewable generation are far from the grid, or are in locations that are likely to cause system reliability issues if intermittent generation is absorbed in that particular area. Conversely, conventional generators do not face such site selection restrictions, and generally have more options to build assets in locations suited for cost efficient grid connection. Renewable technologies may need to increase bid prices to compensate for the estimated connection cost, and to avoid uncompensated risk for potential grid reinforcement costs, which can be uncertain. In a generator connection model, conventional generators factor the same risks into their bid prices, but can better manage connection cost uncertainty and are likely to face lower costs.
2. Transmission system operator (TSO) model: The TSO is responsible for the entire grid connection cost, including any grid reinforcements. The TSO model equalizes the risk associated with connection costs between renewable and conventional generators, and represents a substantial boon for renewable developers. However, this approach potentially reduces social welfare, as renewables are not exposed to full economic costs (costs of generation technology and connection). If grid connection costs are socialised, welfare is not maximised as project developers do not have an incentive to consider cost efficient connections when siting projects. As a result, investment in renewable generation will not occur in locations that promote economic efficiency and reduce system costs. Further, under the TSO model, generators are typically subject to ongoing use of system charges (Stennett 2010).
3. Hybrid model: The generator is responsible for connection costs and the TSO is responsible for grid reinforcement costs. This is also known as “shallow cost” allocation. There are various ways of implementing the hybrid model. For example, connection charges can be split by the generator and the TSO while the TSO assumes reinforcement costs. Conversely, the generator may be responsible for connection charges and a percentage of reinforcement costs. If connection charges are shallow, more of the costs are initially covered by the TSO and then socialised. If the charges are deep, the generator is responsible for more of the cost.
4. Third-party model: In the case of offshore wind in the United Kingdom, a tender is held to select a third party to build, own and operate the connection asset between the offshore wind generation and land. This model entitles the winner of the tender, the offshore transmission owner (OFTO), to a 20-year revenue stream, paid by the transmission operator. The OFTO is remunerated for keeping the connection asset available, and revenue therefore does not depend on output or wind farm

⁹ While potentially disadvantaging renewable development, it likely provides an incentive to locate where transmission costs are minimal.



performance. The third-party model is advantageous in that it permits the competitive entry of new market participants, and can therefore deliver grid connections more rapidly and efficiently. However, this approach is also more complex, involving various parties, a tender process and new regulation (Brown et al., 2015).

In each of the four regulatory models final users ultimately bear the costs of interconnection. Yet they vary in terms of overall costs, efficiency, support for renewables and alignment with broader energy policy goals (Brown et al., 2015).

2.2.10 Balancing responsibilities

To maintain reliable power supply, the supply-demand equilibrium of the system must be perfectly balanced in real time to ensure stable grid frequency. If combined output from all generators does not meet demand, frequency decreases; if combined output is greater than demand, frequency increases. Either case can result in serious consequences for generators and grid reliability. Balancing responsibilities of non-dispatchable renewables like wind and solar also impact the competitiveness of these resources, as their operational costs will differ based on these obligations. Balancing responsibility in this context means that renewable generators are obliged to stick with the schedule they submit to the market operator. Those who deviate from the schedule will be penalized with an imbalance price on the amount of their deviation. Balancing responsibility encourages renewable generators to improve their quality of forecast but at the same time it increases costs, because renewables need to contract with flexible resources to match their forecast, or be exposed to their imbalance costs. In locations where renewables are balancing responsible, additional costs that result from balancing obligations must be factored into bids in competitive auctions.

2.2.11 Curtailment risk

Curtailment risk occurs as a result of a constrained grid or other technical constraints that endanger operational security of the power system. While generators should be dispatched according to marginal cost, system operators must guarantee that the dispatched generation works reliably within system constraints. Accordingly, if, for example, generation resources with identical marginal costs face limited transmission capacity, some of this generation may be curtailed by the system operator (Gimon, Orvis, Aggarwal, 2015). As PPAs are paid out according to a set price for power generated, curtailment can be a serious risk for project developers, who would have less cash to provide return on equity or cover debt. Curtailment risk can be allocated fully to the buyer, the project developer, or be shared. If developers are required to bear all or a portion of curtailment risk, financing cost may significantly increase and would ultimately be passed through to be included in the bid price in a competitive auction.

3. Brazil and Mexico: power sectors in context

At different times and under different circumstances, both Brazil and Mexico have restructured their electricity sectors toward market liberalisation and competition. While specific reasons for power sector reform and deregulation differ, the underlying motives are the same: leverage competition to achieve efficient, reliable power generation, incentivise private investment in the sector and provide end users with electricity at the lowest possible cost. In terms of fundamental reasons for deregulation, both countries also became increasingly mindful of the limits of relying exclusively on government resources to fulfil electricity sector investment needs. In turn, the necessity of guaranteeing reliable, least-cost power helped curb energy sector nationalism and lay the theoretical foundations for market liberalisation.

Private sector participation in the Brazilian and Mexican electricity sectors, however, dates back to the early twentieth century, when the electric industries of both countries were dominated by private, mostly foreign investors from the United States and Canada. Disputes regarding issues including high tariffs led to government rate controls, which initiated private sector retreat. In response, the respective federal governments began playing increasingly prominent roles in sector regulation and expansion, ultimately



leading to power sector nationalisation¹⁰ (Tankha, 2008; Center for Energy Economics, 2013). For example, in 1934 the Brazilian government capped return on investment for electricity generators and distributors, and began regulating electric rates, ultimately leading to the private sector's sale of electricity assets to the government. While nationalisation programs oversaw electric network expansion and increased electricity access, financial crises and macroeconomic instability limited the ability of both national governments to ensure security of supply through generation capacity investment.

Following decades of limited private investment in generation, both Brazil and Mexico came to reform their electric sectors to encourage private participation, including renewable energy and technology-specific procurement processes. As part of the push towards introducing market mechanisms, both countries have chosen competitive tendering schemes as their mainstays of power generation capacity development, including renewables.

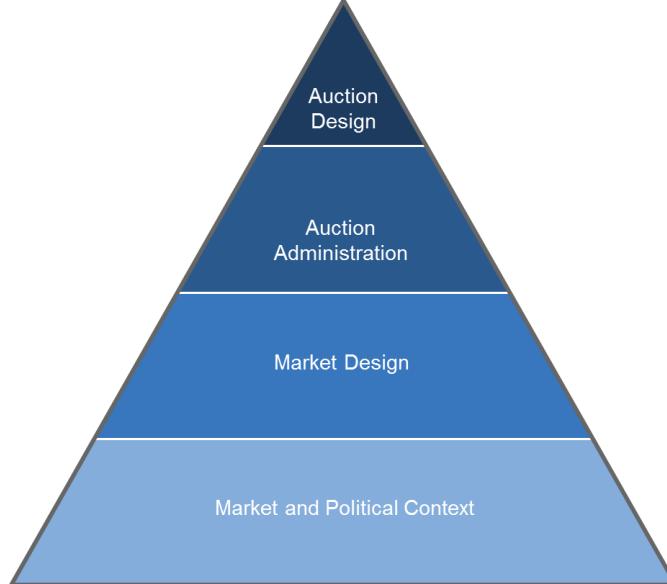
Renewable procurement programmes in Brazil and Mexico, however, were introduced at different stages of their respective market liberalisation processes, and were implemented for reasons different from the renewable procurement policies realised in developed countries. In the 1990s, power sector reforms in developed countries aimed to achieve efficiency gains and encourage private sector investment. In the early 2000s, developed countries began to implement renewable policies to promote sustainability, not in order to ensure sufficient reserve margin and increase security of supply.

In the early to mid-1990s in Brazil, privatisation in generation, transmission (on a limited basis) and distribution was employed to increase security of supply and to help the government clear its debts. Efficiency gains were also a driver of the initial reform. At this stage in Brazil, the focus was on thermal generation development to diversify the country's energy mix away from hydro; intermittent renewables were not considered. As a result of Mexico's 1992 power sector reform, private investment in generation was permitted on a limited basis to ensure security of supply; renewables were not explicitly considered. In both countries, however, renewable energy later became part of the supply security solution, and power sector reform was designed around incentivizing investment in generation capacity in general, with special provisions made to encourage non-hydro renewable generation.

To appreciate current auction administration and design in both Brazil and Mexico, it is necessary to understand the foundations on which auctions are designed and implemented (see Figure 3). Auctions do not exist in a vacuum but are the result of market and contextual factors including the history and politics surrounding power sector reform. Auctions and their stakeholders, including policymakers and project developers, therefore interact with these foundations as they pursue their auction related aims.

¹⁰ The Mexican government officially nationalized the electric sector with a constitutional amendment in 1960, which established that "it is the exclusive responsibility of the nation to generate, transmit, transform, distribute and provide electricity which will be utilized as a public service." However, the national utility began purchasing private electricity assets on large scale as early as 1944 (Center for Energy Economics, 2013). In Brazil, the government created the state-owned utility in 1962, yet began increasing the government share of installed capacity as early as 1952 (Silva, 2011).

Figure 3: Auction Design Foundations Pyramid



Source: elaborated by the authors of this report with perspectives from the CCEE, Brazil's market operator

3.1 Power reform and Brazil's path to competitive tendering

Latin America's largest power market by capacity with more than 160,000 megawatts (MW) (ANEEL, 2017), Brazil has experienced two major power reforms in the last three decades. Implemented in the early 1990s, the first reform focused on privatisation of distribution and generation utilities as a path to fiscal solvency, and the creation of a wholesale market to attract investment in generation. The second reform began in 2004, correcting deficiencies in the wholesale power market and employing generation capacity auctions as a means of guaranteeing long-term security of supply.

Prior to the first reform, Brazil's power sector primarily consisted of Eletrobras, the vertically integrated federally-owned utility charged with generation and transmission, and distribution companies owned by state governments. Several federally-owned distribution companies existed as well. Yet Brazil's fiscal deficits inhibited the capital investments needed to maintain and expand generation capacity to meet demand growth. From 1981 to 1991, capital investments in all infrastructure in the country fell from 25 percent to 14 percent of GDP, with almost no investments in new generation capacity (Kucinski, 1995). In the power industry specifically, almost 80 percent of the sector's financial resources were dedicated to investment in 1970, yet by 1980, nearly 75 percent of total power sector spend was redirected to debt service (Tankha, 2008). Security of supply was further eroded by Brazil's dependence on hydroelectric generation, which accounted for nearly 93 percent of generation and 86 percent of installed capacity in 1990 (IAEA, 2006).

To diversify generation and improve the government's fiscal situation, privatisation of power assets was seen as a solution. Brazil's power sector included some of the country's most valuable publicly-owned assets; their sale represented an opportunity to help replenish the treasury and clear national debts. Many Brazilian states at the time maintained outstanding debts owed to the federal government. The sale of state-owned distribution companies would present state governments with a path to payment, and allow federal government to collect arrears (Brown, 2002). To maximise revenue, the government did not base the concession prices on the book value of depreciated assets, but instead on the projected revenue of the assets during the concession period, some of which were valid for 35 years (Tolmasquim, 2012). Further, as domestic industry players had little to no experience in thermal generation technology, foreign expertise was likely perceived as useful in diversifying generation capacity (Brown, 2002).



3.1.2 Privatisation

In 1993, the federal government began preparing the sector for reform by permitting utilities to raise rates (via a cost-reflective tariff) which had been kept low artificially as a means of curbing inflation, and eliminating the uniform tariff across all customer classes which had provided an industry-wide cross subsidy.¹¹ Brazil's treasury also absorbed \$23 billion USD of sector debts to help lay sound foundations for reform (Rosa et al., 2013). From 1995 to 1998, regulations for independent power producers (IPPs) and private participation in public services in general were introduced, bilateral contracts between utilities and large customers were permitted (Tankha, 2008), an energy regulator and independent system operator were created, and the wholesale power market was launched. During this same period, Eletrobras was unbundled (Vagliasindi et al., 2013). In 1995, prior to the establishment of an energy regulator or finalised regulatory regime, privatisation began in practice, with a tender held for the sale of Escelsa, the first distribution company concession awarded to the private sector (Rosa et al., 2013; Viana 2018).

Privatisation occurred downstream first. Transforming insolvent and poorly managed distribution companies into productive and fiscally sound enterprises would provide generators with bankable offtakers for their power. Under the reform, PPAs between generators and distribution companies were required (Tolmasquim, 2012). This bottom-up approach would then facilitate privatisation further up the electricity value chain. At the time, the distribution network industry was perceived to be in poor condition. The state-level distribution companies often failed to adequately function in their service territories, experiencing high non-technical losses, lack of maintenance and overstaffing. As such, there was likely room for "quick wins" in terms of efficiency improvements (Brown, 2002).¹²

Through concessions awarded via auctions, private sector participation in the distribution segment reached approximately 60 percent in 1998 (Vagliasindi and Besant-Jones, 2013), with investors accepting existing regulated network tariffs. The decreased market risk that resulted from regulated tariffs and captive customers helped make the distribution companies attractive investments. As for transmission, private concessions were only accepted for new capacity, which would require approval from the grid operator and regulator (Rosa et al., 2013). Transmission was also a regulated business, with concession awards based on the largest discount on the maximum annual revenue, which thus translated into the lowest tariffs. The regulated tariffs were also indexed to inflation.

The reform was unsuccessful in incentivising sufficient generation to keep pace with growing demand. Investment was undermined by macroeconomic instability and the devaluation of the Brazilian *real* in 1999, wholesale market design failures, and the inability of thermal generation to compete in a hydro-dominated system with no gas market. For example, Mendonça and Dahl (1999) cite a 1998 government expansion plan which indicated that the marginal cost of adding new generation capacity was \$45 USD / MWh, 50 percent higher than power prices at the time. In addition, the cost of capital in Brazil was high, and project developers were not offered any indexing mechanism to hedge currency risk (Mendonça and Dahl, 1999). Additional obstacles on Brazil's path to attract private investment in generation are described further below.

3.1.3 Thermal Priority Program

Recognising the ineffectiveness of the initial generation privatisation effort, in 1999 the Ministry of Mines and Energy (MME) launched a new scheme to encourage private investment in thermal plants. Under

¹¹ In 1977 the federal government began restricting increases in electricity rates in order to limit inflation given the importance of electricity as input for production of goods and services. The policy of equalizing electricity prices and cross subsidizing was meant to help manage costs of expensive government infrastructure projects and to help parts of the economy with their electricity bill, yet it also reduced any incentives for efficiency gains in the power industry. Both policies helped contribute to the insolvency of Brazil's electric companies.

¹² The underlying reason for privatization was to raise the funds to finance state and federal government balance sheets (Viana, 2018).



the programme the Brazilian Development Bank provided long-term, low interest financing. Eletrobras, which still dominated transmission, served as the offtaker, and Petrobras, the state-owned oil and gas company, provided the gas (Oliveira et al., 2005). The plan aimed to encourage about 19,000 MW of gas-fired generation power plants by 2003.

However, developing a nascent thermal generation industry in a market dominated by hydropower proved difficult. First, the marginal costs of thermal gas-fired generation are much higher than hydroelectric generation, which limits thermal plant dispatch to demand peaks, drought years and other irregular occurrences. Second, Brazil's natural gas market was undeveloped, lacking a spot market or a pipeline capacity market; accordingly, gas was sold exclusively on a take-or-pay basis (Oliveira et al., 2005).¹³

The inflexible nature of gas supply, along with the dispatch risk associated with a hydro-dominated market, reduced the attractiveness of investment in gas-fired generation. As Brazil's hydro generation was equipped with ample pondage, short-term hydro scarcity and a subsequent increase in spot price was perceived as unlikely due to the prospect of heavy rain years. Volatile spot prices further exacerbated prospects for investment (Viana, 2018). Ultimately, the market did not send the appropriate signal to investors to build out significant thermal capacity. The programme resulted in about 9,000 MW of thermal generation, well below the approximately 19,000 MW target (Association of Brazilian Gas Distributors, 2015).¹⁴

3.1.4 Incentive Programme for Alternative Electricity Sources (PROINFA)

In 2001, Brazil experienced an electricity supply crisis, as years of demand growth outpacing investments in generation caused dam levels to fall to just 32 percent of their capacity. With limited dispatchable resources to call upon, the government responded with a rationing programme, mandating all power consumers to reduce their consumption by 20 percent (Lund, 2017).

The supply crisis provided further impetus to diversify generation, beginning with PROINFA, the first major effort to develop mainly non-hydro renewable energy capacity in Brazil. Launched in 2002, PROINFA sought to encourage 3,300 MW of wind, biomass and small hydro build (split equally between technologies). Eletrobras served as the offtaker, buying power via technology-specific feed in tariffs (FiTs), which were set at preferential prices and guaranteed for 20 years (\$150/MWh for wind, \$96/MWh for small hydro and \$70/MWh for biomass). The costs were absorbed by ratepayers through an additional charge (Barroso, 2012). PROINFA, which has been defunct since 2011, resulted in the deployment of almost 2,600 MW of capacity, of which 1,118 MW corresponded to small hydro, 936 MW to wind and 520 MW to biomass (Luomi, 2014).¹⁵

While PROINFA provided initial momentum in Brazil's renewable energy industry, it suffered from design flaws which helped lead to its premature discontinuation. The programme included a 60 percent local content requirement, which led to delays due to the lack of a domestic industry (Brazil had just one wind manufacturer) (Barroso, 2012). Furthermore, the mandated equal division of capacity development across energy technologies did not result in least-cost development. Importantly, within the technology quotas, projects were selected according to the date of issuance of environmental permits, with older permits taking priority. This project development merit order led to an environmental permit black market, which helped distort the economics of project development, resulting in excessive transaction costs and legal cases. While the FiT continued to attract project developers, the introduction of competitive tenders in 2004 and in particular renewable technology-specific tenders in 2007

¹³ The Brazilian gas market is still underdeveloped, particularly Petrobras' monopoly (Viana, 2018).

¹⁴ The data regarding thermal generation built vs. the Thermal Priority Program's target varies by approximately 2,000 MW depending on the source, yet actual thermal build under the programme falls below 50 percent of the target in all cases analyzed.

¹⁵ While PROINFA was replaced by auctions, PROINFA era contracts are valid until 2026 (Viana, 2018).



effectively created a competing renewable procurement scheme, which likely served to further erode PROINFA's efficacy.

3.1.5 Brazil's second power market reform: introduction of competitive auctions

Following the rationing crisis, energy became a significant issue in Brazil's 2002 presidential election. Then presidential candidate Lula de Silva campaigned to ensure security of supply, remove the risk of rationing and lower electricity rates. President Lula won the election, and in 2004 Brazil began the process of restructuring its electricity sector for the second time, introducing competitive auctions for generation procurement. The reform included a law requiring distribution utilities to contract 100 percent of forecasted load through purchasing electricity via public auctions, in order to serve regulated customers (Rosa, et al., 2013). The reform also updated the sector's regulatory bodies and wholesale market rules, and ultimately established a comprehensive auction system, including separate auctions for the contracting of new capacity, existing capacity, alternative energy sources and technology-specific capacity.

Brazil has contracted almost 80,000 MW of generation capacity since 2004. 60,000 MW of this total correspond to clean energy capacity, including large hydro generation (Lund, 2017). Brazil's auction process and design are discussed in detail in the next section of this report.

3.2 Overview of Brazil's auctions and wholesale power market

The primary objectives of Brazil's electricity auctions are to guarantee security of supply through attracting new generation capacity, encourage a diversified generation mix and promote competition and efficiency in generation to achieve cost reductions. Additional objectives include encouraging the participation of renewables in the country's generation matrix, and promoting transparency and effective price discovery in the generation procurement process.

Auctions are led by the regulator, the National Agency of Electric Energy (ANEEL), with an auction committee comprised of four government agencies distributing tasks and executing primary auction responsibilities. Within this committee, the Ministry of Energy and Mines (MME), which is responsible for the formulation and implementation of all energy policy, defines auction guidelines. The CCEE (market operator) assumes significant responsibility, and is charged with calculating distribution tariffs, contract settlement and overall auction administration among other specific duties. The Energy Research Company (EPE), which operates under the direction of the MME, provides energy sector planning support. This committee defines all aspects of the auctions.

Brazil's wholesale power market is comprised of the Regulated Contracting Environment (ACR), the Free Contracting Environment (ACL) and the energy reserve market. Power purchases on behalf of regulated customers occur via auctions as part of the ACR, in which generators, distribution utilities and power marketers participate. Distribution utilities submit their 5-year load forecasts to the EPE, which then determines total auction volume (Rosa et al., 2013). Project developers also submit their technical specifications to the EPE. The MME ultimately announces the qualifying projects (Tolmasquim, 2012).

In the ACR, there are auctions for existing and new capacity. Brazil's first auction was designed for energy procurement from existing generation, to first account for existing capacity and then facilitate new investment. Auctions for existing capacity are referred to as A-1, as supply is expected to begin one year following the tender (Tolmasquim, 2012). New generation capacity auctions, known as A-3 and A-5 for their respective three year and five year commercial operations deadlines, are convened annually. A-3 auctions normally correspond to quick-build technologies like wind, solar and small-hydro, while A-5 auctions are used for conventional technologies with longer lead times. In 2017 Brazil added A-4 and A-6 auctions to provide further flexibility regarding commercial operation deadlines. These auctions permit Brazil's distribution utilities, the auction offtakers, to cover the forecasted demand of regulated customers with long-term power purchase agreements (forward contracts in MWh) (AURES, 2016). Contract durations are typically 30 years for large hydro and 20 years for small hydro, wind, biomass and solar.



Winning auction bidders sign contracts with participating distribution utilities. Total procured energy is divided among distribution utilities in proportion to each company's contracted share of purchased volume. In this pooled system, distribution utility demand is aggregated, with each generator receiving a contract with every distribution utility. This model may reduce market risk for both generators and distribution utilities, as risk of non-delivery (in the case of generator), or non-payment (in the case of the distribution utility), is spread among all parties (Araujo et al., 2008). Once contracts between bidders and offtakers have been signed, generators close financing, typically with the Brazilian Development Bank (BNDES) which provides concessionary financing for auction winners (Eberhard, 2016). As a balancing mechanism for the ACR, adjustment auctions exist, allowing distributors to buy and sell shorter-term contracts to account for updated demand forecasts. The adjustment auction contracts typically range from three to 24 months (CCEE, 2017b).

The ACR functions in tandem with the ACL, in which power consumers with demand of more than 3 MW, generators and power marketers can freely negotiate bilateral contracts. These customers must also contract 100 percent of forecasted load and are not eligible to participate in auctions, yet they may opt to continue under the ACR, buying power from a distribution utility (Rosa et al., 2013). Power marketers participate in the ACL as well.

All contracts must be backed by firm energy certificates (FECs). FECs represent the maximum amount of energy that can be offered through contracts, and are issued by the MME to every generator connected to the national grid. According to Alexandre Viana, former Auctions & Regulated Market Executive Manager at the CCEE, "the FEC of a plant is the maximum volume of energy that can be sold through contracts, and establishes the reliability assured by the generator backing up the contract." Compliance is verified "by comparing the volume of energy sold in a contract with the amount of FECs held by the seller...any shortfall is penalised at a maximum value between the cost of new energy and the spot price" (Viana, 2017).

The certificates provide a physical coverage requirement for generators and other market agents, helping track and ensure security of supply.¹⁶ The number of FECs awarded to each plant depends on technology, and the total number of FECs must correspond to total contracted capacity.¹⁷ FECs are procured by distribution companies, which determine the number of FECs needed according to their load forecasts. Free customers also purchase FECs through bilateral contracts. All contracts must be covered by FECs, and market participants can face heavy fines for noncompliance.

Contracts signed in both free and regulated environments are registered with the CCEE (market operator), which calculates distribution tariffs. The National Agency of Electric Energy (ANEEL) uses the CCEE's tariff to calculate final rates for regulated customers. The CCEE also administers the spot market, accounting for differences between contracted and produced electricity, with financial settlements made monthly. PPAs in the ACR are regulated by ANEEL, which has regulatory oversight over the CCEE, as well as generation, transmission, distribution, commercialization and tariffs (Araujo et al., 2008).

Reserve auctions were introduced in 2009, and are convened as needed in order to increase the electric system's reserve margin. CCEE administers the reserve auctions and acts as the offtaker, recovering an energy reserve charge from all customers connected to the national electric grid (AURES, 2016). New and existing generation capacity are eligible to participate in these auctions, which do not require FEC coverage (CCEE, 2017). In terms of system operation, generation dispatch and transmission coordination is controlled by The National Electric System Operator (ONS). The regulatory regime also

¹⁶ FECs do not take into account water availability variations

¹⁷ For non-dispatchable generation technologies, the FECs are calculated by using the maximum energy that can be generated in a year (Porrua, et al., 2010)

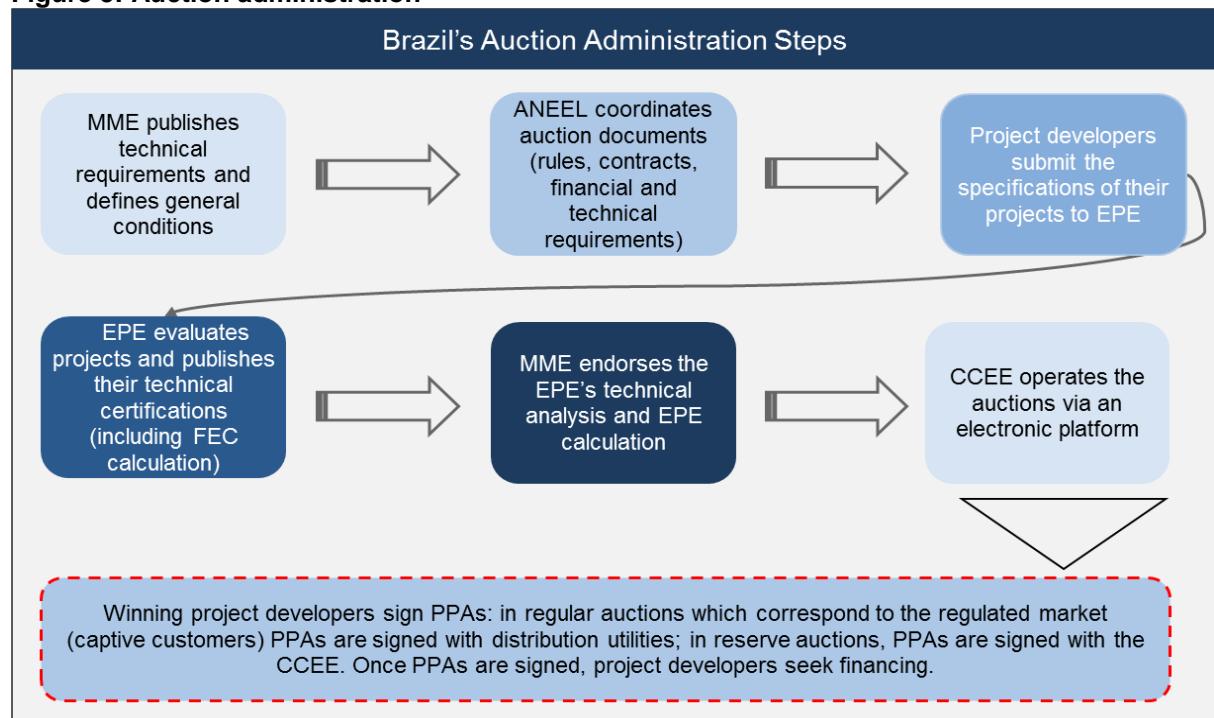
includes the Electricity Sector Monitoring Committee (CMSE), charged with the continuous monitoring of security of supply. Figures 4 and 5 below further illustrate market structure and auction administration.

Figure 4: Brazil's market design for long-term electricity auctions



Source: elaborated by the authors of this report with information from Brazil's electricity sector agents

Figure 5: Auction administration



Source: The CCEE, Brazil's market operator

3.3 Electricity auction design in Brazil

3.3.1 Prequalification and bid bonds

To participate in the auctions, bidders must demonstrate preliminary grid access, environmental permitting, environmental impact assessment, land use rights, and financial qualifications, such as demonstrating net worth of at least 10 percent of the project's estimated cost. There are no



requirements related to track records or experience. Bidders must submit a bid bond equal to one percent of the project's estimated cost to enter phase one of the auction. To participate in phase two, bidders must increase the bond to five percent of the estimated investment costs. Depending on the auction, bonds are returned after the auction (for winners, they are returned once the contract is signed) (AURES, 2016), or according to specific project milestones (IRENA, 2013).

3.3.2 Bidding

Historically, Brazil has employed a two-phase hybrid auction design, combining a descending clock auction in phase one, with a pay-as-bid sealed bid process in phase two. In phase zero of the auction, bidders submit the amount of electricity (in GWh per year) that they would like to offer at the auction's ceiling price, which is set by the MME and disclosed ahead of the auction. The quantity offered in phase zero cannot be adjusted as the auction proceeds. The phase one descending clock auction begins with the auctioneer announcing a high price, which is intended to create excess supply. Bidders then decide if they will remain in the auction and supply their quantity offered in phase zero at the price disclosed in the first round of the descending clock auction.

The process continues through sequential rounds with the auctioneer decreasing the price and calculating the excess supply per round. As long as offered supply exceeds the auction's supply target, the price is lowered. The rounds continue until offered energy exceeds auctioned demand by a set margin (not disclosed to bidders), which is used during the second phase of bidding to maintain competition among bidders who advance (IRENA, 2013). The descending clock employed in the first phase aims to accomplish efficient price discovery. The price established in the first phase functions as a ceiling price for the second phase of the auction. In the second phase, only winners of the first phase descending clock auction participate. Using the same quantities initially offered in round zero, participants bid a final sealed-bid price, which cannot exceed the price disclosed in the previous phase.¹⁸ Contracts are denominated in Brazilian reals and are adjusted annually for domestic inflation (IRENA and CEM, 2015). Project developers are fully exposed to currency exchange risk.

For Brazil's most recent 2017 auctions, however, an updated bidding process was employed. The new methodology is called a continuous trade reverse auction. It was developed by the CCEE (market operator) and formally published by the Ministry of Energy and Mines (MME). In this process there is a first phase in which bidders submit sealed bids with a price and quantity. Bids are evaluated with lowest prices being most competitive, and accepted until auction demand is met. Upon conclusion of this first phase, the auctioneer classifies the "temporary winners" as the lowest bids up to the market clearing quantity (demand), while all uncompetitive bidders are considered temporarily disqualified. The next phase is a descending clock iteration of three or five minutes (depending on specific auction rules), in which any temporarily disqualified bidder can replace a temporary winner by submitting a bid lower than the marginal price minus a decrement. The decrement (the minimum difference between the marginal price of temporary winning bids and the new bids) is set by the auctioneer prior to the auction (Viana, 2018).

If any temporarily disqualified bidder succeeds in submitting a bid lower than the marginal price of phase one (minus the decrement), a new list of temporary winners and temporarily disqualified bidders is presented, and the clock begins again with three or five minutes. This mechanism continues until no temporarily disqualified bidders submit a bid capable of ousting a temporary winner. This new structure was introduced as a market power mitigation mechanism, as under the previous bidding rules bidders could tacitly agree to conclude the auction at a higher price by simultaneously arresting the submission of new bids in the same round (Viana, 2018). There may have been opportunities for large generators to tacitly collude in the first phase of the previous bidding structure by limiting the number of rounds in

¹⁸ The same quantities are used because the quantities are set from the initial bid in the first round. Bidders submit bids for the same quantity in the second round, with the price established in the descending clock phase functioning as a price ceiling for this next round.



which supply exceeded demand. By colluding to ensure that supply offered equalled pre-set demand after only a few rounds (instead of perhaps many more rounds), a higher ceiling price could be set for phase two, which would lead to extra income. This is thought to have occurred when many bidders stopped submitting new bids in the same round (Viana, 2018).

3.3.3 Volume setting

In renewable energy auctions, two methods are employed to set auction volume. The first is a demand function, which regulates total offered volume to ensure a suitable supply-demand ratio, with the aim of safeguarding competition. For example, a demand function of 1.3 requires that the auction's supply be 30 percent higher than the total offered volume. The auction's volume is reduced if supply is insufficient. The second method allots total volume to different renewable energy technologies, according to the proportion of bids that corresponded to each technology in the first round of bidding. For example, if total auction volume is 400 MW, and first round bids are 1,000 MW of wind, 700 MW of solar and 100 MW of biomass, auction volume would be distributed as 250 MW for wind, 175 MW for solar and 25 MW for biomass.

For solar and biomass, a separate 'reference factor' is used to determine the maximum share that these technologies can represent in an auction; this essentially represents a cap on the proportion of these two technologies. If the volume allocated to solar or biomass (in the process described above) exceeds the cap, the proportion of the technology which exceeds the cap is reduced, and the least-cost technology participating in the auctions makes up the difference in order to achieve the total auction volume. In the above example, solar represents 43.8 percent of total volume. If a cap on solar is set for 30 percent of total auction volume, solar participation would be reduced to 30 percent, and wind (which typically is the least-cost renewable technology in Brazil), would increase its participation by 13.8 percent. While the processes for determining auction volume are made available to auction participants, the specific functions are not disclosed. Total auction volume is also kept undisclosed with the aim of inhibiting collusion (IRENA and CEM, 2015).

3.3.4 Special provisions for renewables

Renewable energy technologies receive discounts on transmission and distribution tariffs, with biomass, small hydro, and wind receiving a 50 percent discount, and solar PV receiving an 80 percent discount.¹⁹ In addition, non-firm renewable generation is subject to settlement rules to accommodate intermittency. The settlement occurs through an adjustment factor to account for the time value of generation in relation to spot prices. For intermittent technologies that generate electricity when the spot price is high, an adjustment factor is applied, creating additional compensation. Yet when intermittent technologies generate electricity when the spot price is low, the adjustment takes the form of a penalty. By using the bidder's generation profile and the CCEE's spot price projection, an adjustment factor, either positive or negative, is applied to the bid price (IRENA and CEM, 2015).

3.3.5 Penalties and compensations for over- and underproduction

Penalties depend on the type of auction and the specific renewable energy technology. In auctions for new generation, if there is more than a 10 percent difference between contracted energy and annual generation a penalty is applied. The generator is subject to a payment which equals either a) the average spot price in the year of underperformance times the undelivered quantity, or b) the contract price multiplied by the undelivered quantity – whichever is higher. Production is also assessed on a four-year basis for intermittent energy technologies. If average generation over the four-year period is less than energy contracted in the corresponding auction, the generator must pay either a) the average spot price during the four-year period times the undelivered energy, or b) the contract price increased by six percent times the undelivered quantity – whichever is higher. Compensation for additional unanticipated generation is also provided by permitting generators to sell excess generation to the spot

¹⁹ Solar PV commissioned after 2017 will receive a 50 percent discount



market. The quantity of excess generation eligible for sale on the spot market depends on the technology and production year (IRENA and CEM, 2015).

In reserve auctions, the same 10 percent difference between contracted energy and annual generation is applied, yet the penalty requires the generator to purchase the missing electricity at six percent more than the contract price. Conversely, if the reserve auction upper limit of 115 percent of contracted energy is surpassed, excess generation is eligible for purchase at a 30 percent discount from the contracted price.

3.3.6 Penalties for delays and non-completion

Winning bidders are required to submit a bond worth five percent of the estimated value of the project's cost. Delay penalties use the methodology for under-production described in section 3.3.5, and assumes that 100 percent of the contracted energy has not been delivered. If project delays extend beyond one year, the government may cancel the contract and keep the bid bond (IRENA and CEM, 2015).

3.4 Mexico's path to competitive tendering

Mexico's experience reforming its power sector to introduce competitive tendering is more straightforward than Brazil's. Whereas Brazil engaged in two separate electricity market reforms almost a decade apart from one another, Mexico undertook only one comprehensive reform, which began in 2013. While sector restructuring that resembles Mexico's 2013 market liberalisation was proposed by the Mexican executive branch in both 1999 and 2001, the reform packages did not pass muster in the Mexican Congress (Center for Energy Economics, 2013). Beginning its electricity sector reform twenty years after Brazil's initial reform, Mexico enjoyed a wealth of international experience from which to draw upon, and privatised generation in a world in which competitive tendering schemes were commonplace.

Mexico's first contemporary private sector investments in power generation began in 1992, with the reform of the Public Electricity Service Law (LSPEE). While the original 1975 law established that electric service is a public service and the exclusive responsibility of the state, by the early 1990s electricity consumption in Mexico was growing at four percent annually (SENER, 2013), yet the Federal Energy Commission (CFE, the public utility) and the Mexican state lacked the financial wherewithal to fund projects. To mitigate the risk of a supply crisis, the 1992 amendment permitted private investment in generation, excluding five categories of generators from the definition of public service: self-supply, import and export, cogeneration, small production and independent power production for exclusive sale to CFE. Under this scheme, CFE was responsible for central planning, including volume setting, and convening pay-as-bid auctions in which IPPs would compete to build, own and operate new generation. IPPs were awarded long-term PPAs with a two-part payment structure: one payment for firm capacity offered to CFE and a second payment to ensure recovery of dispatch related variable costs (Maurer et al, 2011).

To enable gas supply for electric generation, the 1995 reforms created a semi-competitive gas market through sanctioning the private ownership and operation of natural gas transmission, distribution and storage. To oversee this new market, the Energy Regulatory Commission (CRE) was created (Center for Energy Economics, 2013). Despite these efforts, initial response to the 1992 reform was limited, with investors requesting a firm guarantee to finance projects. In 1997, the federal government created the Long-Term Productive Infrastructure Projects (PIDIREGAS) programme, which provided a sovereign guarantee to investors from the federal government (Cámara de Diputados, 2003). The programme helped drive the success of the 1992 reform, with major generation companies developing mostly gas-fired combined cycle plants throughout the country (Maurer et al, 2011).

Further yet limited measures were taken to support renewable capacity development under the regulatory structure of LSPEE. In 2001, CRE established regulation requiring CFE to give priority grid access to solar, wind and small hydro power, and required CFE to provide transmission and connection



discounts to renewable systems of more than 500 kW (IEA, 2013). In 2008, the Law for the Development of Renewable Energy and Energy Transition Financing was passed, creating a fund to help finance renewable energy and energy efficiency projects. From its creation to 2013, the fund received \$668 million of federal funds, \$150 million of which was dedicated to renewable energy financing, with the remainder used for energy efficiency measures (IEA, 2015).

In 2009, national energy plans outlined greenhouse gas emissions reduction targets and renewable capacity and generation goals. Yet beyond permitting private investment under limited circumstances, no price, quantity or budget-based incentive schemes were implemented to encourage private investment in renewable energy or electric generation capacity in general. As a result, by 2014 nearly 24 percent of installed generation capacity (12,851 MW) in Mexico corresponded to IPPs, yet only four percent of this private generation was renewable energy capacity (511 MW of wind) (CFE, 2014).

3.4.1 The Mexican Energy Reform

The Mexican power market has experienced profound change since 2013 as it has transformed from a monopoly with a single vertically integrated utility charged with generation, transmission and distribution, to a partially-liberalised market, with functioning wholesale and retail markets open to private investment. The changes are a product of the 2013 Mexican energy reform, which amended the country's constitution and provided secondary legislation to end monopolies in both the power and hydrocarbon sectors, permitting large-scale private investment in energy for the first time since 1937. For the power sector, the government's aim is to lower power costs and increase renewable generation capacity.

The power sector reform created major overhauls in the organisation and regulatory structure of the sector. The Federal Energy Commission (CFE), the state-owned vertically integrated utility which has controlled most of Mexico's electricity business since its creation in 1937, has been divided into nine separate subsidiaries in order to end the company's monopoly in electricity generation. Six of these enterprises are dedicated to generation, with the remaining three split between transmission, distribution and retail. Transmission and distribution continue to operate as a monopoly, yet private sector participation is now permitted for related infrastructure investments. The new structure should also contribute to scaling back electricity subsidies for residential and agricultural customers (IEA, 2017). In 2017, the state paid 119 billion Mexican pesos (\$6.2 billion USD) in domestic electricity subsidies alone (Rodriguez, 2017).

The reform also created an independent system operator, the National Centre for Energy Control (CENACE). Importantly, the reform mandates that auctions are held to contract energy, capacity and clean energy certificates (CELs), and that an escalating proportion of generation is derived from clean energy sources. Mexico's three long-term auctions held to date under the new structure have achieved highly competitive prices resulting in long-term contracts for new clean generation. Yet there are numerous aspects of auction outcomes unrelated to price that must be evaluated to determine auction efficacy. To effectively evaluate auctions, however, the market and energy policy contexts in which they exist must be understood.

3.5 Overview of Mexico's auctions and wholesale power market

As in Brazil, the specific objectives of Mexico's electricity auctions depend on the type of auction held, i.e., short vs. medium vs. long-term auctions, vs. auctions for financial transmission rights. General objectives include the creation and maintenance of a contract market to allow retailers to meet their supply obligations, the promotion of investment in renewable energy generation and power price reductions. To support auctions, an entirely new wholesale electricity market (MEM) and regulatory structure has been created.

In the new MEM, generation dispatch is controlled by the power system operator, the National Centre for Energy Control (CENACE). CENACE also convenes, organises and coordinates Mexico's electricity auctions. The Federal Energy Commission (CFE, the public utility) previously controlled the dispatch of



generation units, but this function was removed from CFE to allow transparency, private sector competition and reduce conflicts of interest. The regulatory regime also includes the Secretary of Energy (SENER), charged with energy policy, and the Energy Regulatory Commission (CRE), which regulates the wholesale market, as well as transmission and distribution.

3.5.1 Nodal Market and Auctions for financial transmission rights (FTRs)

The wholesale market is cost-based, with CENACE operating the market through the dispatch of generation units based on nodal pricing or locational marginal prices (LMPs). In the nodal market, electricity is injected into the grid by generators, and withdrawn from the grid by offtakers, at points on the grid known as nodes, with each node assigned its own LMP. In Mexico, CENACE sets the nodes, and reports the hourly LMPs for more than 2,300 nodes across the country (NERA, 2016).

The nodal market structure is more efficient than the pre-liberalisation dispatch formula, as the LMP reflects the costs of energy, congestion and losses, and therefore encourages investors to build new generation capacity in areas which lessen costs to the grid. The MEM is also comprised of a short-term energy market, a balancing capacity market, a clean energy certificate market, medium and long-term auctions (for energy, capacity and clean energy certificates) and auctions for financial transmission rights (FTRs).

FTRs are financial instruments that provide wholesale market participants with a hedge against nodal price variations (namely congestion price risks associated with the nodal market) (IEA, 2017). FTRs provide a means of hedging nodal price variations, through which the holder of the FTR receives the price difference between the delivery and withdrawal nodes. FTRs awarded through auctions are valid for trimesters, the remainder of the auction year, a full year or three years (SENER, 2017). In Mexico's long-term auctions the delivery point is the point of interconnection, so the bidders do not bear any congestion cost risk. In the mid-term auction, the bid is for a point of delivery, so the seller bears congestion cost risk (Heidell, 2018). The long and mid-term auctions are described in greater detail below.

3.5.2 Market Participants

MEM participants are generators, power marketers, large load customers and small load customers. Large load customers, known in the Mexican market as "qualified users," are permitted to participate directly in the MEM to purchase electricity and related products, or exercise their retail choice via "qualified suppliers" (retail service providers)²⁰. Participating directly in the MEM permits the purchase of electricity in day ahead and real-time (spot) markets via contracts with generators, which means that CFE (state-owned utility) competes with independent power producers for qualified users. Direct MEM participation, however, requires a permit from the CRE (regulator), and a connection agreement from CENACE. Qualified user eligibility status was initially reserved for customers with aggregate demand of at least 3 MW, yet this requirement was reduced to 2 MW in August 2016 and has since been reduced to just 1 MW of aggregate demand.

Customers that do not meet the 1 MW requirement are considered "basic users," and must purchase power from "basic service providers." Basic users purchase power at a regulated rate. Currently, CFE's retail subsidiary is the only basic service provider, however interested parties may apply for a CRE-permit to provide basic service (also known as "basic supply"). Additional wholesale market participants include "last resort suppliers" and "non-supplying brokers." Last resort suppliers maintain electric service reliability in the event that qualified suppliers fail to perform their functions. Non-supplying brokers may engage in the power retail business without supplying physical power or the backing of physical assets.

²⁰ Electricity retailers are "qualified" under law to buy electricity from the wholesale market and sell electricity to "qualified customers" or large customers.



3.5.3 Short-term energy market

The short-term energy market is characteristic of most power markets, in that plants are dispatched in a merit order based on short-term marginal costs. Generators receive payment for the market clearing price, which is the generation unit on the margin. Fixed costs are covered through other products including capacity payments and clean energy certificates, which generators must offer to the market. Correspondingly, electricity consumers and their suppliers are required to purchase clean energy certificates and capacity.

Within the short-term energy market, there is a day-ahead market (MDA) as well as real-time trading functions. The purpose of the MDA is to help determine generation, dispatch and demand on a 24 hour forward basis by providing a framework for buyers and sellers to agree on the supply of power for the following day at a predetermined price. As generators are dispatched based on forecasts of demand and generation availability, the real-time market provides a method to ensure that differences between contractual obligations and actual demand/supply are settled. Prices are established for each node of the grid, reflecting the LMPs.

3.5.4 Capacity market

The capacity market serves to permit investors to recover fixed costs (as energy payments correspond to the short-run marginal cost of generation) and increases system reliability by maintaining physical production availability, and incentivising sufficient investment in generation capacity. Qualified users and load serving entities are required to purchase capacity, with specific quantities determined by the CRE (IEA, 2017). Capacity can be purchased bilaterally (exclusive to qualified suppliers), via medium and long-term auctions, as well as through the capacity balancing market (Heidell et al., 2017). The capacity balancing market facilitates the buying and selling of capacity among market participants which have not met their assigned capacity requirements through the auctions. Accordingly, it permits market participants to sell excess capacity, or alternatively, to cover capacity requirements (CENACE, 2017b). Capacity payments, however, are limited to capacity that is available during the 100 “critical hours” of the year.²¹ Intermittent generators are eligible for capacity payments based on average generation during the 100 critical hours (PWC, 2015).

3.5.5 Clean energy certificate market

Clean energy certificates (CELS) provide a market mechanism for Mexico to meet its clean energy policy goals of 25 percent of electric generation deriving from clean sources by 2018, 35 percent by 2024, 40 percent by 2035, and 50 percent by 2050. To support these targets, SENER created clean energy consumption requirements of five percent of total electricity consumption deriving from clean sources by 2018, 7.4 percent by 2020, 10.9 percent by 2021 and 13.9 percent by 2022. (SEGOB, 2017b). Hydro, nuclear, wind, solar, geothermal that were in place before the law count toward the total clean energy requirement, however they do not get CELS (Heidell, 2018). Qualified suppliers (retailers) and large load customers are subject to these targets and are required to comply, through the purchase of CELs. Failure to purchase the required number of CELs will result in fines.

Generators receive one CEL for each MWh of clean energy produced (CRE, 2016), defined as power deriving from wind, solar (in any form), tidal, geothermal, biomass, hydro, nuclear, waste to energy, carbon capture and efficient cogeneration (SENER, 2017b). Generation technologies that use both clean energy and fossil fuels will only be awarded CELs for the corresponding percentage of fossil fuel free generation, as determined by the CRE. CELs are awarded through the Clean Energy Certificate and Compliance Management System (the system), and generators which fulfil the system’s requirements are awarded CELs by the CRE.

²¹ In 2016 and 2017, the 100 critical hours are the 100 hours of greatest demand nationally. In 2018 and beyond, the term corresponds to the 100 hours when reserve margin is lowest (CENACE, 2017c).



Once CELs have been awarded, generators may offer their CELs to the market. Under the supervision of the CRE, large load consumers can purchase CELs via bilateral contracts with generators, monthly auctions held by CENACE or in an annual liquidation process (CRE, 2016). Yet basic service providers purchase CELs in long-term auctions, and are awarded 20-year contracts. Qualified suppliers may participate in the long-term auctions and / or procure CELs via bilateral contracts. In long-term auctions, purchase bids include the quantity of desired CELs per year for 20 years, and the maximum price the buyer would pay. The offer bids include the quantity of CELs that can be delivered for 20 years. As such, a functioning market for CELs has been created.

3.5.6 Mid-term energy auctions

Mid-term auctions are run by CENACE and aim to reduce or eliminate spot market exposure for LSEs by using auctions as a means to cover mid-term energy and capacity needs (CELs are not traded via these auctions). Contracts must begin one year following the auction, with contract durations of three years (SEGOB, 2017). The mid-term auctions are effectively a financial hedge against the price uncertainty of the short-term markets.

3.5.7 Long-term energy auctions

Auctions for long-term energy, capacity and CEL contracts are the cornerstone of Mexico's power sector reform in terms of opportunities for private sector investment. These auctions offer 15-year contracts for energy and capacity, and 20-year contracts for CELs. As the auctions guarantee long-term contracts, they are fundamental in facilitating financing for project developers. Auctions are held once a year, with CENACE reserving the right to convene additional auctions, and the CRE establishing ceiling prices for energy, capacity and CELs. Projects must enter into commercial operation three years following the conclusion of the auction, which favours wind and solar PV, which have shorter construction lead times than other technologies (IEA, 2017).

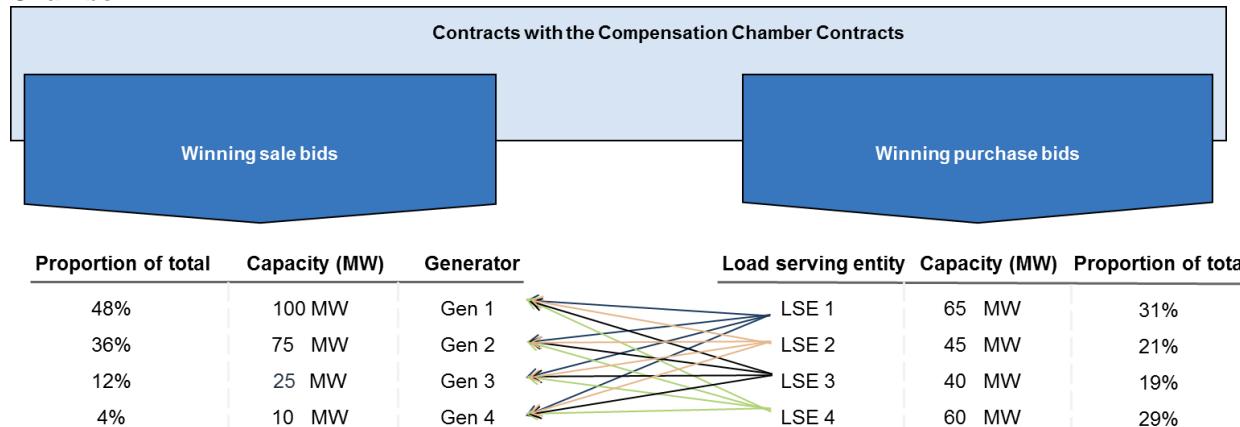
In the first two auctions, CFE (the public utility) was the only buyer, which provided project developers with an investment grade offtaker with a long history and an implied guarantee from the Mexican government. In the third auction, and moving forward, a new clearing house, the Compensation Chamber (CC) serves as *the wholesale intermediary between project developers and offtakers*.

All LSEs, including qualified suppliers, basic service suppliers, last resort suppliers and non-supplying brokers may participate in the third and future auctions via the CC (see Figure 6 below). The CC will match bid sale prices from generators with the bid purchase offers from LSEs, and each generator and LSE will sign a single PPA with the CC. However, the CC will not act as a contract guarantor, but will administer contracts, and perform credit analysis on each LSE. While each generator and LSE will only have one PPA, the electricity trading system is pooled. Each LSE will purchase electricity from each generator, according to the proportion of generation capacity that each generator has won the right to build, and the proportion of capacity that each LSE has won the right to purchase.

This pooled system creates risk sharing between market participants. The cost of any unrecoverable payments will be absorbed among all generators, proportional to respective outstanding balances from the unrecoverable payment. The cost of undelivered electricity or other products will be absorbed by all LSEs proportional to their payment obligations for the corresponding undelivered products (CENACE, 2017).



Figure 6: Contracts between generators and load serving entities via the Compensation Chamber



Source: Original graphic published by the National Centre for Energy Control (CENACE)

3.6 Electricity auction design in Mexico

For Mexico, this paper focuses on the nation's long-term electricity auctions, which are the foundation for investment in renewable energy under the new market structure.

3.6.1 Prequalification and bid bonds

Bidders must comply with prequalification requirements to participate in Mexico's long-term electricity auctions. Prequalification applications, which include financial and technical requirements, as well as payments to CENACE for application evaluation and the purchase of auction rules, must be submitted to CENACE by the date indicated in the auction calendar (SENER, 2015).

In terms of technical requirements, bidders must demonstrate experience in financing, building and operating a project similar to the proposed project (either directly or through a subsidiary). Past projects must have operated successfully within the last 10 years, using a similar technology, and total capacity of at least 33 percent of the proposed project's capacity. As for financing, the bidder must demonstrate having successfully achieved financing for projects of equal or greater size (combining the capacity of multiple projects is permitted).

Registration also includes a bid bond, which is returned to bidders that are not selected to participate in the auction. In the case of winning bids, the bid bond is used to cover fees associated with the interconnection process, with any positive difference between the bid bond and the interconnection fees being returned to the winning bidder. The bid bond includes a fixed fee of 300,000 UDIs²² (~99,000 USD) regardless of the number of bids submitted by the same generator, an additional 65,000 UDIs (~21,000 USD) per MW of capacity offered in the auction in one year, plus 30 UDIs (~10 USD) per MWh offered in the auction in one year, plus 15 UDIs (~5 USD) per CEL offered in the auction in one year. The bid bond can be deposited in US dollars or Mexican pesos.²³

²² UDIs (Mexican Investment Units) are value units established by the Bank of Mexico to settle financial obligations. Their value is adjusted daily according to the Consumer Price Index, which UDIs follow with a short lag. Payments in UDIs therefore are constant in real terms (Graf, 1998).

²³ UDIs converted using fx-rate.net using the July 18, 2017 exchange rate of 1 USD = 3.04 UDI



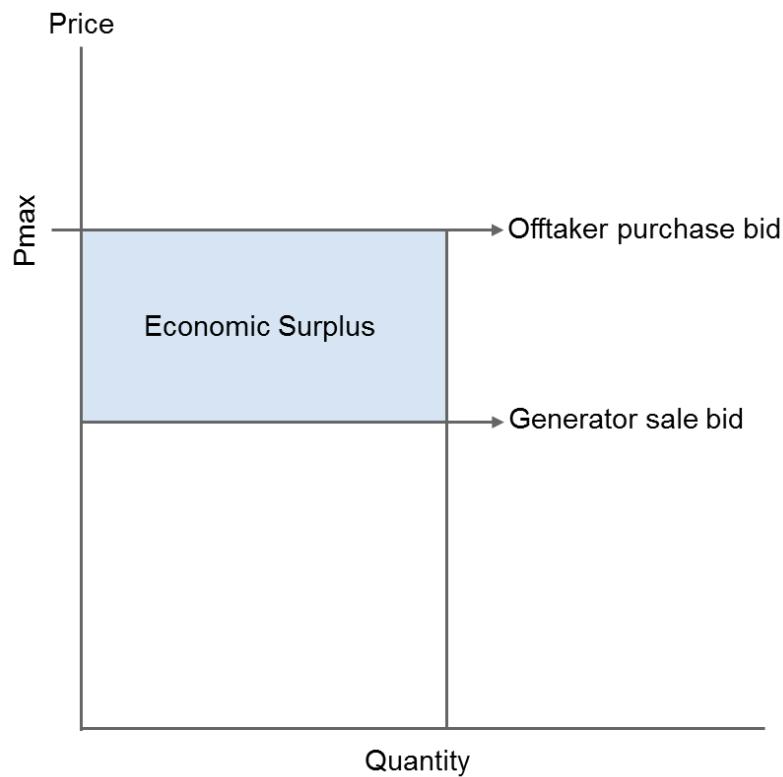
The prequalification application also must contain a description of the pack of products offered; this includes capacity (MW), energy (MWh) and CELs, to be sold for 15 years beginning on the commercial operation date (COD) (CEL contracts are for 20 years) (SENER, 2015).

3.6.2 Bidding process

The Mexican long-term auction is a pay-as-bid sealed bid auction. Project developers submit their packaged offers, including separate bids for capacity, energy and CELs, which are indexed to inflation (in USD or MXN). Bids may be submitted at “zero” for a particular product that a bidder prefers not to offer, for example, capacity. Sale bids must include the interconnection point (to take into account hourly and regional price adjustments), and the proposed COD. In the event of capacity bids, at least 10 MW or five percent of total capacity demand in the specific auction (whichever is less) must be offered. CEL bids must offer at least 20,000 CELs per year or five percent of total CEL demand in the specific auction (whichever is less).

The auction offtakers (hitherto only CFE) also submit bids, which include the prices at which they would purchase capacity, energy and CELs. The purchase bids of the auction offtakers set the auction volume. Generators then submit corresponding sale bids. CENACE then selects winning bids based on the ‘maximisation of economic surplus,’ or the net positive difference between the offtaker purchase bid price, and the project developer sale bid price (SENER, 2015). See Figure 7 below.

Figure 7: Representation of economic surplus factor used in bid selection



Source: elaborated by the authors of this report

In practice, however, the algorithms for determining the winning bid are subject to CENACE's optimisation process, which takes into account the quantity of electricity, location, exchange rate, and the time elapsed between opening of the bids and the bid submission. There is also a mechanism for resolving tied bids, in the case that two winning bids are identical. In each auction, there is a minimum



threshold established for the net positive difference, which is calculated by CENACE. Failing to reach the minimum threshold triggers an iterative process in which bidders must successively lower their bid prices.

The CRE has the ability to set a price cap for each auction product, yet to date has not done so. As a result, maximum prices have been set by CFE's highest bids for each product. Sale bids that exceed this maximum price or come within 10 percent of it are automatically disqualified (SENER, 2015).

3.6.3 Locational pricing

Each individual auction sets its own generation zones, which take into account the locational value of electricity, and are comprised of sub-zones including interconnection, sub-exportation and exportation zones. The locational value is determined by the difference between the LMP of the generation zone in which the electricity is delivered, and the average of all LMPs in the country. These 'expected differences' are published by SENER prior to the auction and are used to compare and weigh bids in the auctions. The generation zones are also used to help determine hourly generation adjustments (which depend partly on location), and to limit energy and capacity acquisition and generation build in certain exportation and interconnection zones (as a means of correcting supply / demand imbalances).

Interconnection zones signal the capacity for interconnection available in a specific geographic area, and exportation zones limit the amount of energy that can be purchased in a specific area. The capacity for interconnection in each interconnection zone corresponds to the total interconnection capacity of the zone minus the interconnection capacity already utilised or accounted for. Exportation capacity of each exportation zone is calculated in the same way (total exportation capacity minus the exportation capacity already utilised or accounted for). The zones can be as limited as one substation, and as large as deemed necessary by CENACE. Sub-zones within these zones may also be created to provide a more granular approach to balancing supply and demand. As the supply-demand ratios are constantly evolving, specific zones are defined in the rules of each separate auction.

Generators which have interconnection contracts, either through pre-reform legacy rights, or via obtaining new interconnection contracts through the application process, make up portions of the interconnection and exportation already accounted for, and are therefore not subject to the zonal limits mentioned above. Yet generators who do not have interconnection contracts must essentially pass through these zonal filters for their bids to be considered in the auctions (SENER, 2015).

Generation projects are required to dispatch electricity to the node that corresponds to their specific location and generation zone. Generators include specific interconnection points in their bids, with each point corresponding to a node with its own reference price. When considered by CENACE in the auctions, bid prices are adjusted either upwards or downwards depending on location, aiming to correct supply and demand disparities. However, this adjustment is only used to help CENACE allocate winning projects in locations to correct supply and demand imbalances. In the case of winning bids, bidders receive their auction bid price regardless of any locational adjustments considered by CENACE. The calculation of the expected differences in price per generation region, and the hourly adjustment factors²⁴ which depend on technology and location, are estimated and published by the SENER prior to the auctions (SENER, 2015). Locational pricing played an important role in the first Mexican auction, as explained further below.

3.6.4 Special provisions for renewables

Intermittent technologies are subject to an adjustment factor in order to reflect the time value of generation. Intermittent generators receive monthly adjustments (either positive or negative) equal to the product of the hourly adjustment factor and MWh generated in each hour. The positive or negative

²⁴ Unlike locational adjustments, winning bidders of intermittent sources are either rewarded or penalized in the \$ / MWh amount paid.



adjustments result from multiplying the hourly quantity produced by the hourly adjustment factor for the corresponding month, hour and location during the year. Further, while firm electricity generators are required to deliver specific amounts of power hourly (according to individual bid specifications), intermittent generators may deliver electricity at any time (SENER, 2015).

3.6.5 Penalties and compensations

Penalties for non-realisation of projects include the withholding of the bid bond (as described in section 3.6.1). Further, a delay in the COD would result in financial penalties for the project developer.

4. Evaluating electricity auction design

Standardised measures of auction success have been developed in the literature. Auctions for Renewable Energy Support (AURES), the world's only research outfit focused exclusively on renewable energy auctions, developed a set of seven criteria to assess renewable energy tenders in 2015. The International Renewable Energy Agency (IRENA), and other independent academic studies have also developed their own sets of evaluation criteria. Building on these foundations, we evaluate auction design according to two benchmarks: official government policy objectives of Brazil and Mexico and additional criteria that build on the literature, tailored by the authors of this report and applied specifically to Brazil and Mexico.

4.1 High-level assessment of auctions

In both Brazil and Mexico the auction process seems to have led to efficient price discovery through transparent, competitive processes that have attracted billions of dollars in investment, enhancing security of supply through clean energy. However, the key features of auctions in the two countries differ (see Table 1 on following page).



Table 1: Auction characteristics summary

Country	Brazil	Mexico
Auction type	Regulated Market (ACR) Auctions	Long-Term Auctions
Degree of centralization	Auctions are centrally organized, yet volume is determined by aggregated offtaker load forecasts	Auctions are centrally organized, yet volume is determined by aggregated offtaker load forecasts
Offtakers	Distribution utilities, serving Brazil's regulated customers	Initially, the Federal Energy Commission (CFE, public utility). In the future the Compensation Chamber will serve as an intermediary between project developers and offtakers.
Volume setting responsibility	Distribution utilities are required to cover 100 percent of forecasted load through auctions	Basic Suppliers and Qualified Suppliers
Prequalification	Moderate; Financial and related to preliminary permits. No experience requirements or track records required.	Strict; financial and technical. Project developers must demonstrate significant experience and track records
Technology eligibility	Auction specific rules; auctions can be technology-specific, multi-technology or technology neutral	Multi-technology; Wind, solar, geothermal, biomass, hydro, nuclear, waste to energy, carbon capture, efficient cogeneration and tidal wave
Provisions for renewables	Discounts on transmission and distribution tariffs, and settlement rules according to spot market prices to accommodate intermittency	Adjustment factor to reflect the time value of generation. Intermittent generators may deliver electricity at any time, while firm generators must deliver specific amounts of power hourly
Auction process	2 phase hybrid auction	Pay as bid, sealed bid auction
Auction products	Forward contracts for contracted energy	Forward contracts for contracted energy, capacity and clean energy certificates
Lead time	2 – 6 years	2 – 3 years

4.1.1 Brazil's experience summarised

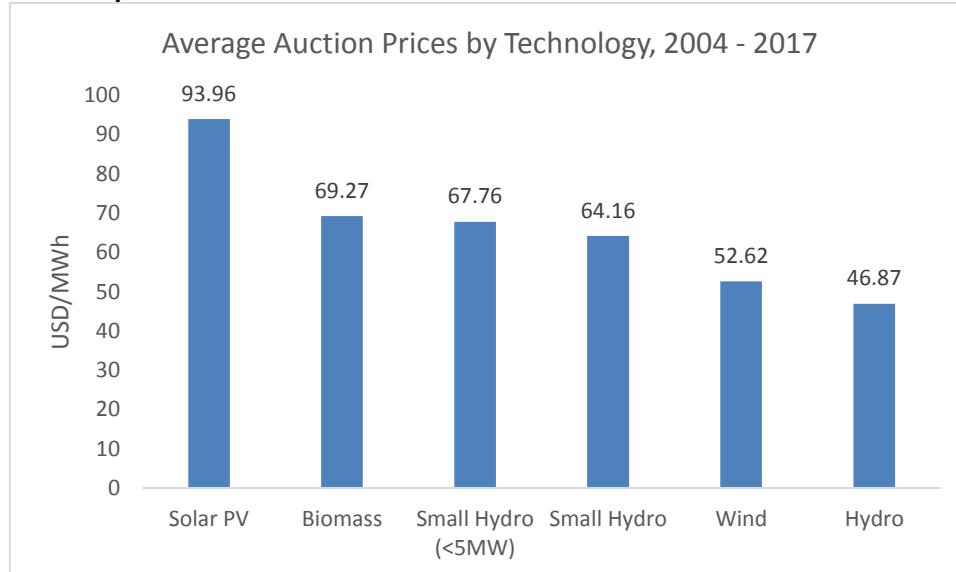
From December 2004 to April 2017, Brazil held 74 electric generation auctions, resulting in more than 8,700,000 GWh of electric generation capability and 488 billion USD in investment (CCEE, 2017c).²⁵ Under the auctions, renewable electricity prices have decreased considerably when compared to the PROINFA programme's feed in tariffs of \$150/MWh for wind, \$96/MWh for small hydro, and \$70/MWh

²⁵ Exchange rate of \$1 USD = \$3.28 Brazilian real



for biomass. Moreover, additional renewable technologies have been deployed through auctions as well. See Figure 8 below for average auction prices by technology.

Figure 8: Auction prices in Brazil



Source: CCEE, Reverse Auctions to Scale Renewable Energy: Brazilian Approach

To achieve low pricing, the Brazilian Development Bank (BNDES) provides the majority of debt financing for projects, provided that project developers meet local content requirements. With macroeconomic instability and Brazilian real denominated contracts in Brazil, the BNDES plays a key role in providing project financing to developers at a reasonable cost.

Brazil's most recent auctions were held in December 2017. The auctions, A-4 and A-6, require corresponding commercial operation dates for 2021 and 2023, respectively. Both were multi-technology auctions, while A-4 was exclusively for renewables and A-6 included renewables competing directly with natural gas. The outcome for A-4 is expected to result in additional installed capacity of 674.5 MW, of which around 85 percent will be solar PV. Auction A-6 resulted in 2,736.6 of new capacity, most of which will come from natural gas and wind (EPE, 2017). The pricing of Brazil's December 2017 is summarized in Table 2.

Table 2: Pricing from Brazil's December 2017 long-term electricity auctions²⁶

Technology	Auction "A-4" – USD/MWh	Auction "A-6" – USD/MWh
Hydro	\$55.1	\$66.5
Biomass	\$71.27	\$65.78
Wind	\$32.76	\$29.92
Solar PV	\$44.19	N/A
Natural Gas Thermal	N/A	\$64.76
Auction Average	\$43.84	\$57.5

Source: EPE

²⁶ Exchange rate of \$0.303386 USD = \$1 Brazilian real



These auctions are considered efficient, especially given the low prices for wind and solar PV, as well as the winning gas technology. The new thermal capacity may help provide the impetus for developing pre-salt gas reserves in the country, according to the EPE, an auction and government planning body (EPE, 2017). Further, the auctions represent a strong recovery from Brazil's cancelation of auction-awarded projects earlier in 2017 through a de-contracting auction (explained further in section 5.4).

4.1.2 Mexico's experience summarized

Mexico has had three long-term auctions and one mid-term auction to date. Very low pricing in the long-term auctions has been celebrated by the national government, yet the resulting low prices are also a cause for concern due to the potential for substantial project non-realisation. Further, this can create a new missing money problem in terms of what auction winners can lose due to the low bids. The auction clearing prices have been below expectations of market prices. As a result, some potential builders of renewables have no interest in participating in the auctions, which may suggest that the value of a fixed price 15-year auction contract is less than the risk adjusted cost of selling into the market to qualified suppliers without a long-term contract (Heidell, 2018).

Results of auctions thus far include:

The first auction (A1): A1 resulted in 84 percent of energy and CELs requested by CFE (the only offtaker) being purchased (yet no capacity was acquired). The auction concluded in March 2016, resulting in solar and wind contracts averaging \$45/MWh and \$54/MWh, respectively, and an average auction price of \$47/MWh + CEL. The price cap for energy + CELs was approximately \$75/MWh, and 75 percent of the awarded energy + CELs corresponded to solar, with the remainder corresponding to wind.

The auction was highly competitive, with project awards representing approximately 10 percent of total submitted bids. The competitiveness of the auction helps explain the low bid prices. Capacity, however, was 100 percent undersubscribed, with no winning bids including capacity offers. This was largely the result of the low price cap of approximately \$8,200/MW. Locational pricing played an important role in the first auction, with locational pricing adjustments ranging from -22 to +10 USD/MWh.

The second auction (A2): In A2, total acquired energy equalled three percent of Mexico's total annual generation. 83.28 percent of energy, 80 percent of capacity and 87.26 percent CELs requested by CFE were purchased, with a total of 8.9 million MWh-year, 1,187 MW-year and 9.3 million CELs covered. Compared with CFE's maximum purchase bids, savings of 44.2 percent for energy and 64.1 percent for capacity were achieved. The economic surplus indicator was 32.91 percent, exceeding the minimum threshold of 14.6 percent established for the auction; accordingly the iteration process was not triggered.

Solar PV and wind led the auction in terms of energy and CELs, with 54 percent of energy and 53 percent of CELs corresponding to solar, and 43 percent of energy and 41 percent of CELs corresponding to wind. Capacity was dominated by combined cycle technology, corresponding to 72 percent capacity won. Solar PV, wind and geothermal won 15, 11 and 2 percent of total capacity, respectively. Average prices for winning bids in the auction were 33.47 USD/MWh + CEL, and 32.26 USD/MW-year.

Locational pricing played a far less significant role in the second auction, with locational adjustments ranging from -0.06 to +0.06 USD/MWh. As a result, projects were awarded in 14 generation zones, as opposed to just 5 generation zones in the first auction. This is mostly due to the estimated "expected differences" between the different price zones and the average system LMP, which is published by SENER prior to auctions and serves as a guide to bidders for locational price differences. A projected 15 percent reduction in LMPs compared to the first auction illustrates a trend toward price convergence for generation in Mexico, and explains why location played a far less important role in the second auction.



The third auction (A3): At an average price of \$20.57 USD/MWh + CEL, A3 resulted in some of the world's lowest electricity auction prices ever seen, and record-low prices for Latin America. Solar and wind were the two winning technologies for the energy + CEL product, capturing 55 and 45 percent of contracts, respectively. Gas (which won only capacity) accounted for approximately 84 percent of sold capacity, while solar and wind accounted for about 14 percent and 2 percent, respectively. The winning bids are estimated to represent nearly 2.4 billion USD in investment in 15 electric generation facilities, and the auction was highly competitive, with at least 46 submitted bids, and only 15 bids preliminarily selected (CENACE, 2017d).

Importantly, buyers other than CFE Basic Supply (the national utility's retail business) were permitted to submit purchase bids in the auction through the recently established Compensation Chamber. Iberdrola Clientes and Menkent (on behalf of CEMEX, a Mexican multinational cement company) purchased a combined 126 MW of capacity and more than 540 thousand MWh + CELs (CENACE, 2017e). While this represents less than 10 percent of the total purchased, it marks the opening of the competitive auction process to large energy consumers, which should ultimately make the process more competitive and permit large consumers to achieve lower prices. Table 3 presents the accepted purchase bid summary of Mexico's third auction.

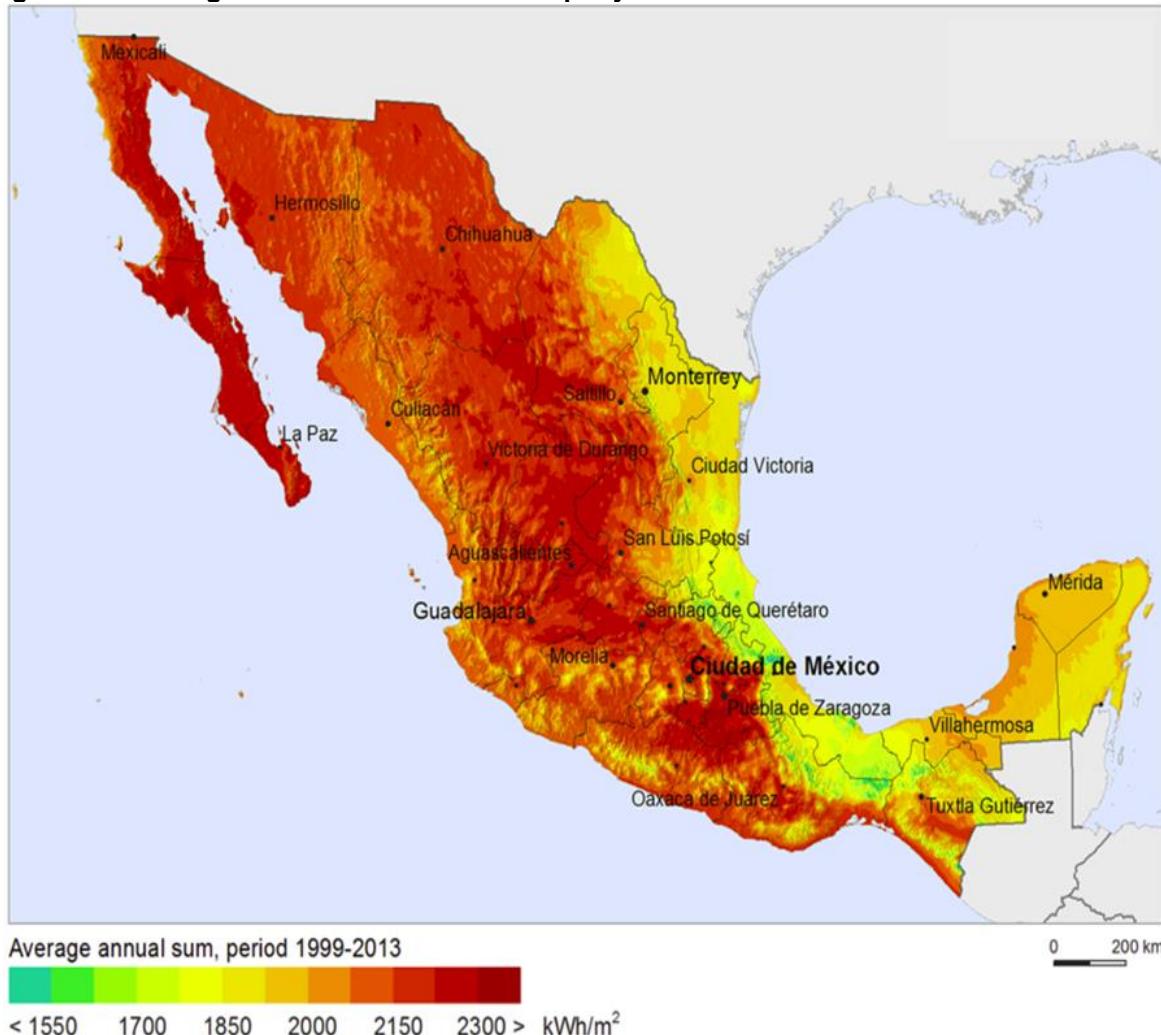
Table 3: Accepted purchase bid summary of Mexico's third long-term auction (A3)

Product	CFE Basic Supply	Iberdrola Clientes	MENKENT (CEMEX)
Capacity (MW)	1288	122.17	3.84
Energy (MWh)	5,546,896	526,136	16,500
CELs	5,546,896	526,136	16,500

Source: CENACE, Presentation of the Verdict of the 2017 Long-Term Auction

Yet what explains the seemingly excessively low pricing? While less than 10 percent of winning purchase bids derived from new players, this additional competition may have contributed to helping drive down prices. Mexico also has great fundamentals for renewables investment. Figure 9 on the following page illustrates that much of Mexico receives more than two thousand kWh per square meter of solar irradiation year to year; these are very favourable conditions. Germany's sun conditions are only about half as favourable (Davis & Irastorza, 2017), yet the country consistently ranks in the top three nations globally in MW of installed solar capacity. Mexico's prime solar locations are also mostly available, as only negligible solar capacity existed prior to the recent energy reform.

Figure 9: Sum of global horizontal irradiation per year in Mexico



Source: SOLARGIS

Further reasons for the low pricing include long-term PPAs denominated in USD, the possibility of avoiding noncompliance penalties, low interest rates globally, the impact of large developer participation on capital costs, and overall comfort with and knowledge of the Mexican auction process. While project lead times in Mexico are sufficiently tight to prevent investors from taking a “wait and see” approach, low pricing and potentially avoidable penalties indicate that a significant percentage of projects will not be built.

4.1.3 Areas for improvement

Both Brazil and Mexico have room for improvement in terms of their auction administration, design and results. For example, while a source of celebration, the very low pricing that results from auctions is simultaneously a cause for concern, as decreasing returns may negatively affect project realisation rates in the future. Echoing this sentiment, in 2016 the President of the Brazilian Clean Energy Generation Association mentioned that the prices presented in an A-5 auction “showed the floor not the ceiling,” according to Brazilian media (mabnacional, 2016). This, along with a number of other issues described below, represent concerns for both Brazil and Mexico, and should be thoroughly considered to prevent issues in the future.



5. Recommendations and considerations

The below recommendations are initial observations of the authors of this report regarding the potential for improvements to current auction design in Brazil and Mexico. They are not meant to identify and outline the concrete steps, including the specific studies, legislation and regulatory approvals that would be necessary to amend auction design. The complexities of auction design reform implementation go beyond the scope of this report. Instead, the recommendations are an initial step in providing detailed qualitative analysis regarding aspects of theory, design features and auction implementation that warrant serious consideration and regular review. The recommendations examine specific design issues and auction elements that could be amended or further developed in order to improve auction outcomes. These recommendations are not mutually exclusive, and could be applied concurrently to achieve optimal results.

5.1. Pricing rules

In terms of auction pricing theory, the revenue equivalence theorem suggests that payments or revenues deriving from the differing auction pricing methods, including pay-as-bid and uniform pricing, should be identical. Accordingly, if revenue equivalence reflected the reality of auction price outcomes, the selection of pricing rules implemented in Brazil and Mexico would be irrelevant. However, revenue equivalence depends on equal risk appetite and information symmetry among bidders, particularly regarding the value of the auctioned goods and the costs of competitors (Oren, 2004). Literature on the subject (Engelbrecht-Wiggans, 1988) indicates that in addition to the above requisites, revenue equivalence between pricing methods only applies to single unit auctions. Under these conditions, both the auctioneer and bidders should be indifferent regarding the auction pricing method employed, as any method would yield equal results.

However, the revenue equivalency theorem is unlikely to hold true in the cases examined in this paper, as risk appetites vary widely among investors and there can be significant information asymmetry in electricity procurement auctions. Further, as multi-unit auctions are utilised in both Brazil and Mexico, neither country meets the revenue equivalence requisite of only auctioning single units. The issue of implementing a pay-as-bid or uniform price (also known as pay-as-clear) pricing rule is therefore significant for renewable procurement in both countries, as the two methods can result in different outcomes in terms of pricing and support costs, actor diversity, market competition, sector innovation and efficient resource allocation.

Selecting a pricing rule in a multi-unit auction setting involves trade-offs and depends on auction environment parameters and the specific objectives of the auctioneer. The pricing rule decision is thus an empirical question at its root. As such, there is no single answer or consensus on the best pricing rule in the corresponding literature, yet given its importance, the issue is worth exploring in terms of implications for auctions in both Brazil and Mexico. The below considerations provide a qualitative theoretical overview of pay-as-bid vs. uniform pricing.

5.1.1 Pay-as-bid vs. uniform pricing

Currently pay-as-bid pricing rules are in place in both Brazil and Mexico. Yet uniform pricing has several benefits when compared to pay-as-bid pricing, and is therefore worth considering.

As pay-as-bid auctions imply that project developers receive the price of their own bid, there is significant incentive to attempt to estimate the market clearing price in order to bid the highest price while remaining competitive enough to be the unit on the margin of the supply curve. In a pay-as-clear auction (also referred to as a uniform price auction), all winning bidders receive the clearing price at which aggregate supply meets demand, or alternatively, the price bidders receive can be set to equal the highest rejected bid²⁷ (known as a second-price auction or Vickrey auction). In this case, when there

²⁷ The bid directly above the market clearing price, which is the lowest uncompetitive bid.



is enough competition, any single bidder is unable to impact the market clearing price unilaterally thus he is incentivised to bid at his lowest acceptable price to increase the chances of clearing in the auction. A rational investor would therefore bid at cost, plus a reasonable rate of return. This incentive differs greatly from that of a pay-as-bid auction, where rational investors are incentivised to guess the market clearing price, and bid at or right below that price.

Theory suggests that pay-as-bid auctions could result in higher prices than their uniform price counterparts, because pay-as-bid auctions incentivise bidders to bid above cost (Pfeiferberger et al., 2017). However, this may only hold true if perceived competition is low. If competition among bidders is perceived as high, the incentive to bid at (or just below) the estimated market clearing price may not result in higher prices when compared with pay-as-clear auctions, as the estimated market clearing price may be very low.

Actor diversity

Consequently, pay-as-bid pricing may disadvantage small project developers, as profits largely depend on the bidder's capacity to accurately estimate the clearing price. Large developers, which often enjoy significant resources and experience, may guess clearing prices more precisely than their smaller counterparts. Auction design that limits actor diversity could have long-term implications for the market and sector as a whole, as providing a level playing field between large and small participants would be more likely to lead to the inclusion of both, which has positive implications for competition and innovation. Pay-as-bid pricing can also limit actor diversity due to favouritism for market incumbents and excessively low pricing (discussed further below).

Alternatively, some auctioneers may perceive that it is advantageous to create circumstances which favour large project developers with long track records and ample financial resources, under the presumption that prospects of project realisation increase with developer experience and resources. Yet design issues like penalties for noncompliance and lead times are more likely to help shape project realisation rates than the size of the project developer.

Strategic behaviour

Beyond actor diversity, pay-as-bid pricing can encourage strategic behaviour as project developers are incentivised to expend excessive amounts of time, financial resources and human capital to guess bid prices. Walking the line between revenue maximisation and bid competitiveness can be risky, as project developers may overestimate the maximum winning bid and lose the auction. However, pay-as-bid auctions still provide a strong incentive for price guessing. For example, in a pay-as-bid auction, if the highest accepted bid for energy is \$75/MWh, a project developer that bid \$40/MWh would leave an additional \$35/MWh on the table. Using this example, a project that wins five million MWh in an auction would forego hundreds of millions dollars over the lifetime of the project. Accordingly, the incentive to expend resources on guessing the auction bid prices is high.

There are indications that such behaviour may be taking place. In an investor presentation, one project developer mentions its success in being awarded wind projects in four auctions in Brazil from 2013 – 2015, with the second highest bid in all four auctions in Brazil, and the highest capacity factors in each auction. The auction types included A-3 (new capacity to be brought online with three years) and reserve auctions. Winning the second-best price in four auctions with the best capacity factors implies a savvy bid team that have developed a method of estimating the highest bid price in different types of auctions. Low capacity factors would normally imply a higher bid price in order to make up for fewer MWh produced. Yet in this case, profits associated with the second highest price are further increased by the highest capacity factors in the auction (more than 50 percent and in some cases almost 60 percent) (Rio Energy, 2017).

There is nothing illegitimate or dishonest associated with such behaviour; rather, it is a for profit enterprise doing its job well. The pay-as-bid approach that results in higher economic rents for savvy investors could also have positive unintended consequences. For example, it can be inferred that teams



with the know-how to maximize profits in such a manner are equally astute and meticulous during project development in terms of managing the regulatory process, bringing the project online sustainably and on schedule, and operating in a mutually beneficial manner (the project developer alluded to above has invested more than \$2 million USD in programmes supporting local services). The higher economic rents provide further incentive to bring the project to fruition.

There are also opportunities to behave strategically under uniform price auctions, especially if multiple units are auctioned. For example, developers which bid for multiple units in a uniform price auction could bid in such a way to ensure that a maximum number of its units (projects) clear the auction, while attempting to guess and subsequently bid the highest possible competitive price with an additional unit. While a single project developer could conceivably have multiple units in an auction and set the market clearing price while bidding all projects at cost plus a rate of return, the developer may also be able to coordinate bid prices to maximise its number of winning units and the market clearing price which those units will claim. Thus, it can be argued that pay-as-bid pricing may be more apt for multi-unit auctions in certain situations.

Further opportunities for strategic behaviour in uniform price auctions are likely limited and less complex. For instance, a bidder could conceivably offer an excessively low price in order to ensure a winning bid, predicting that the market clearing price (or lowest rejected bid) would ensure cost recovery and return on investment.²⁸ Yet if implemented on a wide scale, bidders would risk applying excessive downward pressure on the clearing price, undermining their own strategy and the economics of their projects (AURES, 2016b). Accordingly, rational investors would likely avoid this approach due to excessive risk.

Low pricing and the winner's curse

Pay-as-bid schemes may make bidders more susceptible to the winner's curse, the phenomenon of bidders unintentionally bidding below their costs. In this case, a winning bidder may receive a project award as a result of unrealistic estimations of unknown costs. The winner's curse, in a way, is the inverse of the strategic behaviour phenomenon, which causes bidders to submit optimal (deliberately high) bid prices that correspond to their capabilities (price estimation) and business needs (profit maximisation). Conversely, for project developers with different business needs (i.e. increased market share or guaranteed market presence even at lower returns), the desire to win the right to build a project can inspire aggressive bidders to bid excessively low prices.

Very low pricing, as seen in Mexico, can be positive and is typically viewed this way and even celebrated, as auctions appear to be fulfilling their role in encouraging high levels of competition and least-cost power. However, underbidding can lead to underbuilding, as overly aggressive pricing may result in investors exposing themselves to excessively low or even negative returns, which can lead to higher non-completion rates for projects, or cause insolvency at some point in the project lifecycle. The competitiveness of auctions has led a 'race to the bottom' phenomenon in which project developers bid record low prices to win PPAs. Very low bids are partially a result of cost reductions for intermittent renewable sources; from 2010 to 2015, the LCOE of solar PV declined 58 percent (BMI Research, 2016). Low pricing, even if truly feasible under the economic conditions in which the auction occurs, provides a low margin for error, and could quickly become unviable due to fluctuations in currency value, credit access, cost of capital or other macroeconomic issues. While some of the projects awarded under aggressive pricing will be built and provide low cost electricity, it is likely that a percentage of projects will "race through the bottom" and never be realised.

Lastly, low pricing is likely to limit actor diversity in the auctions, by favouring large project developers, especially market incumbents. In addition to greater economies of scale and more development experience, large project developers typically have cheaper and easier access to financing.

²⁸ This happened in the second round of CfD auctions in the UK.



Accordingly, it can be difficult for smaller or local developers to compete. For example, in Mexico's first two long-term auctions, the lowest bid in each auction was either claimed by a large multinational developer, or a smaller developer backed by an experienced and established private equity firm. Such has been the case in Brazil, where small project developers seem to have been at least partially excluded from auctions due to low prices. A 2012 statement from Desenvix Energias Renováveis, a leading project developer at the time, mentioned that "the returns are far too low for us," and accordingly did not participate in a 2012 auction (Deutsche Bank, 2012).

Pay-as-bid auctions tend to favour incumbents over new developers even if economies of scale, access to capital and financing issues, and all other factors are equal. As incumbents have accumulated information about bid offers, and likely have experience estimating bid prices based on the specific market conditions, new players can face additional difficulty in entering the market (Pfeifenberger et al., 2017), which has negative implications for competition and innovation in the long-term.

Impact on provisions for renewables and social welfare

Pay-as-bid pricing can also be misaligned with other renewable cost incentives provided by policymakers. In the case of Brazil, wind receives a 50 percent discount and solar PV receives an 80 percent²⁹ discount on grid tariffs. Yet as developers are not encouraged to bid at cost under the pay-as-bid scheme, the grid discount provision may serve to increase investor returns without translating into less expensive electricity for end users. This effectively creates a subsidy in the case that there are special provisions to reduce the cost of renewables for the project developer. Further, uniform price auctions provide benefits by incentivising investors to bid at their lower acceptable price (so end users are more likely to enjoy the benefit of the grid tariff provision, as in the case of Brazil).

As the market clears the lowest cost generation mix under uniform pricing, social costs (expense to society as a whole) are also reduced, which in turn reduces end user costs in the long-term. Equalising the value of identical products also provides incentive for investors to innovate to achieve cost reductions and efficiency improvements as they compete with their peers (Pfeifenberger et al., 2017). On the other hand, pay-as-bid auctions may encourage inefficient resource allocation if low-cost resources bid too high and do not clear, causing higher-cost resources to take their place. These inefficiencies can drive higher system and end user costs in the long-run (Pfeifenberger et al., 2017).

Institutional preferences

In Brazil there is an institutional preference for pay-as-bid auctions. The assumption is that pay-as-bid auctions yield lower rents from project developers and thus lower electricity prices, as auction winners are paid their specific price, as opposed to the market clearing price. While such thinking is intuitive, it ignores fundamental marginal pricing theory and overlooks the potential for bid prices to increase if auction participants win their offer price. Perhaps most importantly, such institutional preferences fail to recognise the promotion of long-term competition and innovation as a pivotal issue in pricing rule design. According to Alexandre Viana who served as the Auctions and Regulated Market Executive Manager at Brazil's market operator (CCEE) where he worked for more than 18 years, "Brazilian policymakers and control entities, such as The State Compliance Court (TCU – Tribunal de Contas da União), have a passion for pay-as-bid," for the reasons described above. Dr. Viana believes that any effort to alter the pay-as-bid approach would be met with great resistance (Viana, 2018).

Pay-as-bid vs. uniform pricing: considerations

The above considerations indicate that the uniform pricing rule is better suited in most long-term electricity auctions, including renewable energy auctions. The most important factor that tips the balance in favour of uniform pricing (under most circumstances) is the fostering of long-term competition and innovation through the encouragement of new (and perhaps small) market entrants. However, this

²⁹ Solar PV commissioned after 2017 will receive a 50 percent discount.



does not suggest that the uniform pricing rule is always ideal. For example, Ausubel et al. 2014 indicates that pay-as-bid pricing can be optimal in settings with symmetric bidders³⁰ and flat demands in terms of efficiency and revenue maximization for bidders, and may also be optimal in symmetric information environments with decreasing linear marginal utility. While Brazil and Mexico may not face these circumstances, the auctioneer must make an informed decision regarding pricing rules given the trade-offs and the given objectives of the auction. Auction designers should seriously consider uniform pricing, and only abandon this pricing strategy when there is sufficient evidence that the auction environment is not suitable for this pricing rule.

Power Auctions LLC (2016), a consultancy hired by Mexico's SENER also recommended that a uniform pricing structure "makes bidding easier by reducing the need to guess what others will bid...the key advantage of a uniform price rule is that bidders can spend more time focusing on the minimum price they need to provide capacity, energy or CELs and less time focusing on what the other bidders are going to bid." Similarly, the Brattle Group (2017), a consultancy, identified some of the abovementioned advantages and disadvantages (in the context of capacity markets) and identified uniform pricing auctions as the "evolving as best-practice approach based on international experience" and are "expected to achieve lowest societal costs and lowest customer costs in long-run."

To adopt a uniform price auction in Brazil under the two phase-hybrid auction that was employed until 2017, only phase two of the current auction structure would change. Phase one of the auction, in which a descending clock scheme is employed to phase out less competitive bids and determine the ceiling price for phase two, would remain the same. Phase two, a pay-as-bid sealed bid process, would change to a uniform pricing sealed bid process. Under Brazil's new continuous trade reverse auction, the structure appears compatible with uniform pricing as is, yet uniform pricing could change the incentives associated with replacing the temporarily disqualified bids. Further analysis would be required regarding uniform pricing and the replacement bid scheme. In Mexico, the first phase of the auction, which also operates as pay-as-bid sealed bid structure, would be replaced with a pay-as-clear sealed bid process, in which sale bids and purchase bids are matched the same way as under the current structure. The iterative process, which is only triggered if the minimum level of economic surplus is not reached, would remain the same. In the above cases, auction winners could receive the lowest rejected bid (the bid directly above the market clearing price, which is the first uncompetitive bid), or the market clearing price.

If Latin America's two largest economies seek to limit strategic behaviour and non-completion rates, as well as hold inclusive auctions that encourage dynamic efficiency and innovation, the specific trade-offs between pay-as-bid and uniform pricing in each respective market should be considered.

5.2 Technology-specific, multi-technology and demand response participation in auctions

A combination of technology-specific and multi-technology auctions have worked well in Brazil, and Mexico's multi-technology auctions have functioned as well. However, both countries could benefit from additional (yet limited) technology-specific auctions to further diversify generation. For example, a greater proportion of technology-specific, or targeted multi-technology auctions, may help Brazil to further diversify its generation mix, which is still overly dependent on hydro. While Mexico's multi-technology auctions are encouraging the deployment of significant solar and wind generation, further diversity among winning auction technologies could be beneficial, particularly for dispatchable renewables.

While technology eligibility requirements may present one opportunity to help both countries diversify renewable generation, further support for specific technologies should be implemented on a select

³⁰ Symmetric bidders in this case alludes to cases in which all bidders obtain their bid values from an identical probability distribution



basis. Limiting auctions to several specific technologies can help immature technologies to become competitive and achieve carbon reduction targets, however, these same limits are not helpful for cost reduction and innovation in the long-run, particularly when they support mature technologies. Additionally, both Brazil and Mexico could benefit from including demand response as an eligible participant in auctions.

5.2.1 Brazil

In 2007, Brazil held a multi-technology auction for biomass and small-hydro. Based on the success of this 2007 auction, Brazil held its first true technology-specific tender in 2008, exclusive to biomass, and held technology-specific auctions for wind in 2009 and 2010. Technology-specific auctions provided the opportunity for biomass and wind to develop in Brazil and become important components of the generation mix. For example, in a 2011 multi-technology auction, wind and biomass competed against conventional technologies, resulting in lower average prices than natural gas generation. With 10,434 MW and 11,404 MW now installed respectively, wind and biomass make up more than fifteen percent of Brazil's installed capacity. Overall, Brazil has succeeded in increasing the competitiveness of once-nascent technologies and integrating them into its generation mix.

However, hydro generation, at 98,730 MW, still represents 65 percent of Brazil's installed capacity, and typically accounts for more than 70 percent of electric generation. This makes Brazil the world's second largest hydro generator behind China. Overdependence on hydro inhibits security of supply, as seen in south-eastern Brazil in the 2012 – 2015 drought period, when reservoirs reached their lowest levels in 35 years, and water rationing and blackouts became the norm in major cities in the region. During this period, the Brazilian government spent more than \$5 billion to subsidize distribution utilities, which substituted hydro generated power with more expensive fossil-fuel generation. While generation diversification should be driven by overall system planning and expansion of transmission capacity, limiting hydro's eligibility to participate in auctions could be useful in helping Brazil to diversify its generation matrix and bolster security of supply.

5.2.2 Mexico

While a variety of clean generation sources were eligible to participate in Mexico's two auctions, wind and solar represented more than 90 percent of winning energy, capacity and CELs in the first two auctions. In the third auction, wind and solar made up 14 of the 15 winning projects. Solar is highly underdeveloped compared to its potential in the country, and there is ample room for further wind development as well. The auctions created a path to significant wind and solar build at low prices, despite the lack of technological diversity among winners (and doubts related to the financial feasibility of projects which yielded very low returns).

Yet in addition to solar and wind, there are at least eight clean energy technologies eligible to participate in the auctions, including geothermal, biomass, hydro, nuclear, waste to energy, carbon capture, efficient cogeneration and tidal wave. In the first auction, only solar and wind won projects, while in the second auction, geothermal, small hydro and efficient combined cycle plants represented a minority of winning projects. In the third auction, only one non-wind or solar project (gas) submitted a winning bid (winning only capacity, with no accompanying energy or CELs).

To further encourage baseload renewable technologies such as biomass, biogas or geothermal, Mexico can consider holding technology-specific auctions for these individual generation sources, or holding multi-technology auctions for baseload renewables (as Brazil did in the early days of its auctions). Providing a framework for these technologies to prove themselves competitive in Mexico would contribute to system reliability, as dispatchable renewables complement intermittent technologies.

Technology-specific or exclusive multi-technology auctions for baseload renewable energy sources would also provide a means of helping these technologies to take advantage of Mexico's abundant resources (for example, the country has an estimated 13.5 GW of geothermal potential, yet currently has only around 900 MW of installed capacity) (NREL, 2017). While holding auctions for these



technologies may not encourage least-cost development in the short-term, maximising all of Mexico's renewable energy sources may increase efficiency, enhance system reliability and create more long-term economic opportunity.

5.2.3 Demand response as an eligible auction participant

Demand-side resources like energy efficiency and demand response can participate in capacity market auctions, through bidding a per MW price for offset generation. Reducing demand through load shedding or energy efficiency can reduce the short-term price of electricity and result in long-term avoided costs of generation, as well as transmission and distribution. As such, consumers which effectively respond to price signals or implement efficiency measures provide value to the overall system by increasing available capacity and reducing system costs. These consumers should be entitled to compensation for the value they provide to the grid. Including a remuneration mechanism to provide consumers with an economic incentive to offer these grid services could help reduce system costs and increase efficiency.

While implementing such a mechanism is complex, it is feasible. Markets in the United States and the United Kingdom have such mechanisms in place. In the short-term, Mexico is more equipped to implement the market participation of demand-side resources, as it has a functioning capacity market, and is already planning to implement demand response services in 2018. Brazil would first need to establish a formal capacity market (discussed further below), and then establish and implement a regulatory framework for demand-side resources, part of which would include their eligibility for participation in capacity auctions. Both countries would also benefit from demand-side resource aggregators, which could participate in the capacity auctions on the behalf of consumers. The aggregation service could be provided by existing energy service companies who wish to enter a new business, or new companies.

5.3 Determining auction product(s)

While Brazil's complex market mechanisms have worked well to increase installed capacity and improve reliability, security of supply remains uncertain. Including a formal capacity product and a corresponding market may help resolve this issue. Conversely, Mexico has offered three products in its long-term auctions: energy, capacity and clean energy certificates (CECs). This approach has worked well for Mexico thus far, though its mid-term auction requires corrective action, but given the market's short track record it may still be too early to make a proper evaluation. Further, the products sold through Mexico's mid-term auction can be utilized more efficiently.

5.3.1 Brazil

While forward contracts and firm energy certificates (FECs) may somewhat resemble capacity market features, currently energy is the only official product in Brazil's long-term auctions. The specific energy products are forward contracts which cover the distribution companies' load forecasts, which helps reduce risk for generators, and increases security of supply. Further, in an energy + capacity bundle, auction winners receive firm energy certificates (FECs), which are required to cover their contracts, and are tradable. The FECs serve to monitor and maintain the nation's supply-demand balance, and as each participant is in charge of its own load, FECs and contracts, the certificates are essentially a decentralised mechanism to secure supply.

The introduction of a proper capacity market may help encourage investment in capacity and mitigate the likelihood of supply shocks. In fact, according to Alexandre Viana, former Executive Manager of Auctions and the Regulated Market in Brazil's Chamber for the Commercialisation of Electric Energy (CCEE), there is discussion within the CCEE of creating a separate capacity market. To this end, a proposal was sent to the Brazilian Congress with the objective to create a capacity market by 2021. The initiative could unbundle capacity and energy, and possibly introduce renewable certificates. The capacity market would potentially include centralised auctions five years ahead of project delivery, with



costs shared by all customers. The mechanism would operate under the management of the CCEE (Viana, 2017).

Instituting a capacity market based on international best practices with auctions as the capacity allocation mechanism would achieve several ends. First, replacing the FEC scheme with a proper capacity mechanism would provide investors with a familiar market framework in which to operate, particularly considering that the FEC calculation method is quite complex, and varies significantly depending on the generation technology. Second, providing investors with an additional source of income to include on their balance sheets may help installed capacity keep up with demand growth. For example, annual demand growth of 4.24 percent from 2011 – 2013 exceeded the expansion of installed capacity, which increased just 3.79 percent in the same period. Coupled with drought, this helped lead to a supply crisis, causing widespread rationing in Brazil. Lastly, a traditional capacity market could help lower the cost of capital for generators, and increase the diversity of auction participants. Existing generators should be eligible for any capacity market mechanism implemented if they do not already receive any other form of subsidy. If more capacity is built, wholesale power prices could fall, so existing generators will require extra remuneration through the new capacity markets to avoid revenue shortfalls or, in the extreme case, a stranded asset situation.

5.3.2 Mexico

Mexico's tri-product system in long-term auctions seems to be functioning successfully in terms of creating demand for and auctioning the three products in long-term auctions. Most notably, the government has successfully created demand and a marketplace for CELs. Part of the reason for the success of the CEL market to date is its simplicity. While Mexico's CELs and Brazil's FECs serve different functions, one reason Brazil may choose to move away from FECs and migrate closer to a traditional capacity market is the complexity of the system. Conversely, the CEL market is quite straightforward, with clean energy generators receiving one CEL per MWh of output, and the CEL requirements mirroring national clean energy goals.

However, Mexico's first mid-term auction which offers products of its own proved inefficient, and should be improved to encourage making the best use of its products. The mid-term auctions serve as a market hedge for load serving entities which seek to offload uncontracted energy and /or capacity in advance. The results for Mexico's first mid-term auction were released in late February 2018, however no electricity or capacity contracts (the auction's only two products) were awarded. This was the result of a significant mismatch between demand bid prices and supply bid prices.

The mid-term auctions cause generators to face a trade-off between locking in contracts through this mid-term hedge market, or selling directly into the short-term markets. In the auction, demand submitted very low purchase bids, perhaps with the prices of the long-term auctions in mind. Yet the two contests offer very different products; long-term auctions serve to allocate the right to build and secure financing, while mid-term auctions offer a hedge for existing generators. Demand may have failed to recognize this distinction. The mid-term auctions represent a meaningful opportunity for load serving entities to secure contracts with end users. Auction participants on the demand side should fully recognize the purposes of each type of auction to avoid submitting unrealistically low bids based on expectations from a different type of contest. To avoid inefficient outcomes in the future, the auctioneer should also ensure that auction participants are fully aware of such distinctions.

5.4 Determining auction frequency, volume and lead time between auctions and commercial operation

5.4.1 Frequency and volume

Both Brazil and Mexico maintain regular auction patterns, which helps decrease market uncertainty for investors, can lead to lower bid prices, and has other secondary benefits for supply chains and local industry. Since 2005, Brazil has typically held three to four auctions per year. Mexico held its first auctions in 2016, yet is on track to convene two to three auctions per year. While increasing the



predictability of auctions through exact auction intervals would be ideal, such timing is also unrealistic given system and administrative constraints and realities. Accordingly, Brazil and Mexico are both largely efficient in terms of the frequency with which they hold auctions (in Mexico, it still may be early to make a proper evaluation).

However, tenders should only be held when a market is able to absorb the auctioned generation and is prepared to facilitate project development. Recession in Brazil has led to weaker demand growth than expected, and an excess of power supply. Accordingly, in 2017 Brazil held a de-contracting auction to cancel projects (mostly solar PV and wind) that it had awarded in reserve energy auctions in 2014 and 2015. Beyond the recession, it is likely that delays related to project finance, permitting and other administrative issues were responsible for significant project delays, which led to a backlog of projects. Combined with the economic downturn, this provided the government with the pretext to cancel auctions and start fresh.

Winners of the de-contracting auction avoided non-completion fines and forfeiture of their project bonds. The auction functioned as an ascending auction, where bidders place progressively higher bids with a starting price of approximately \$10 USD /MWh. The bid value is then multiplied by the electricity that would have been delivered during one year of the contract. For example, at the auction's starting price a generator with a 1 MW plant would pay $1\text{MW} \times 8760\text{ hours} \times 10/\text{MWh} = \$87,600$ USD. Each generator therefore had the opportunity to evaluate whether it made more economic sense to relinquish the five percent project bond and pay the penalty fee of one year of electricity at contract price, or participate in the auction. For the majority of generators, participating in the auction proved a better option.

While this de-contracting mechanism was innovative and resolved the issue, it may have simultaneously created a degree of moral hazard, as project developers were able to avoid full penalties. Project developers may assume the same mechanism will be available in the future if a similar situation arises. Further, the mechanism required significant time and effort to develop on the part of the Brazilian government. The exact opportunity cost of this time and effort is unknowable, however if Brazil had not contracted too much capacity, the time and effort could have been better spent. Lastly, cancelling projects across the board from multiple auctions negatively impacts investor confidence, which could affect the cost of capital and bid prices.

This example serves as a lesson for Brazil, Mexico and other markets which use centralised auctions for power procurement. Due to macroeconomic conditions in Brazil, typical annual demand growth of approximately four percent dropped to 0.9 percent in 2016 and is forecast as 2 percent for 2017. When determining auction dates and volumes, governments should take into account worst-case demand scenarios, and develop precautionary measures, or a means to cope with excessive capacity if demand unexpectedly drops due to external factors. For example, policymakers can start with minimum demand and correct this estimation in subsequent re-configuration auctions. Governments should also ensure that a certain number of projects from the most recent auction are making tangible progress toward development before holding a follow up auction.³¹

For example, instituting a requirement for a percentage of projects to achieve certain milestones before holding a follow up auction would reduce project backlog. If 50 percent of projects from the first auction were required to have achieved project financing and permits before holding a second auction, bottlenecks would be reduced. Allowing additional time between auctions would allow for initial projects to develop while demand scenarios play out. Increasing the likelihood that the market is able to absorb the auctioned capacity and that developers are able to achieve project milestones can also be achieved through decreasing auction volumes. Fewer project developers pursuing financing, permitting, interconnection agreements and other project milestones may facilitate quicker development.

³¹ This issue is further complicated in Brazil by industry lobbies which seek to increase the demand of the specific technologies, and apply political pressure for new auctions even when the distribution companies do not necessarily require them (Viana, 2018).



5.4.2 Volume setting

In both Brazil and Mexico, volume is set by the expected demand of the offtakers, which is self-reported by offtakers in both countries. Offtakers have much better insight into their future short- and long-term energy needs than policymakers do, and have an economic incentive to procure the amount of electricity and related products that correspond to their business needs.³² Accordingly, this is the appropriate approach. Policymakers should intervene to reduce the offered demand if the expected supply in the auction is expected to be less than the aggregate demand of the offtakers, in order to ensure a competitive process. Further, one factor that increases the risk of errors in demand forecasting is the penetration of distributed generation. While offtakers include such variables in their demand forecasts, policymakers can attempt to facilitate a more precise calculation of distributed generation penetration through full disclosure of upcoming distributed generation policy and legislation, and by ensuring that government studies on the subject are made public.

5.4.3 Lead time

The moral hazard associated with evading penalties is amplified by long project lead times, as described in section 2.2.7 of this paper. Mexico requires that projects reach commercial operation by January 1 of the third calendar year, after the initial date of the request for proposal (RFP). For bids that are submitted in the calendar year after the RFP, commercial operation must be achieved within two years of bid submission. Two to three years of lead time, combined with enforceable noncompliance penalties, is reasonable and should not provide project developers the luxury of bidding in the present, only to “wait and see” how market trends develop before making a final investment decision.

Brazil typically implements auctions with project lead times of three and five years, yet held a multi-technology auction in December 2017 with a lead time of six years (A-6). The six-year lead time, with projects not required to reach commercial operation until 2023, is Brazil's longest yet. The majority of the auction capacity was claimed by gas (56 percent) and wind (36 percent), with biomass and small hydro making up the remainder (CCEE, 2017). Prices averaged approximately \$30 USD for wind, and from \$64 to \$67 for the remaining technologies.

The project development process in Brazil likely requires slightly more lead time than in Mexico. At 160,000 MW of installed capacity, Brazil's power system is more than double Mexico's 73,500 MW, and also covers a much larger area, serving more people. Further, Brazil's system is more fragmented, with many transmission and distribution companies, and depends heavily on non-drought hydrology conditions, which add complexity to system planning. Still, six years of lead time between auctions and commercial operation may be excessive, particularly given the timing.

Instating Brazil's longest lead time immediately following the de-contracting auction may cause project developers to bid in the auction without committing to a final investment decision. The December 2017 A-6 auction may have resulted in highly competitive pricing for wind, for example, with the expectation that some technology prices will fall before projects are shovel ready. Long-term assumptions regarding fuel prices, project financing, electricity demand and other trends may also help drive down bid prices.

In Brazil's December A-4 auction, projects must reach commercial operation two years sooner than the A-6, and prices were about \$3 USD/MWh higher. Long-term pricing and market assumptions could be the reason. If project developers view the risk-reward profile of submitting uncommitted bids as favourable, they are incentivised to take this approach. For example, if estimated lifetime profitability of a project at the price of the uncommitted bid exceeds the estimated penalty (in a de-contracting auction or otherwise) by millions of dollars, project developers may decide to take the “wait and see” approach.

³² This statement generally holds true, except in situations in which the offtaker is a system operator that is responsible for security of supply; this may lead to a tendency to over-procure.



5.5 Penalties

Prequalification requirements and the prospect of harsh penalties in the case that project developers do not fulfil their plans is essential to auction efficiency. While both Brazil and Mexico have established prequalifying requisites and harsh penalties, further steps should be taken to ensure that penalties are implemented and institutionalised. Opportunities for non-compliant project developers to recover their bid bonds or avoid additional penalties outlined in the auction rules should therefore be limited.

For example, as Power Auctions LLC (2016) points out in its study for SENER, winning bidders in Mexico may be able to avoid paying penalties by shifting blame to the Mexican government, highlighting the possibility that “a winning bidder might be able to avoid all penalties for having a non-operational plant even if only a very small part of the delay was caused by the government not fulfilling some of its own deadlines.” Specifically, the consultancy emphasises that it may be easy for project developers to avoid penalties if initial social and environmental impact studies are rejected by the government.

Power Auctions LLC suggests performance standards as a means of dealing with this issue, which may include a CENACE-enforced restriction in which project developers are limited in their ability to delay a project’s commercial operation date due to social and environmental impact studies. If a project must be delayed due to legitimate reasons, CENACE could create a scheme in which project developers can declare their contracts void, with the quantity of electricity products under the contract available for purchase to the same project developer in the next auction. This would allow the project developer to continue with the initial project under revised dates. Yet if the project developer does not declare the contract void, the initial bid and contract terms would remain, with any delays resulting in penalties (Power Auctions LLC, 2016). Under this scheme, there would be a process for limited force majeure requests (i.e. transmission delays).

The above approach certainly creates additional risk for project developers, who risk losing the projects outright in the follow up auction once initial contracts are declared void. However, under the current structure in both Brazil and Mexico, there may be scope for project developers to continuously delay projects for business reasons, such as lack of available financing, or waiting for technology costs to decline further. If delays are avoidable, project developers should be held accountable, and should not be afforded the opportunity to shift blame to the government. Brazil’s recent de-contracting auction, in which project developers that offered the highest price avoided non-completion penalties, while at least somewhat punitive, may still be a form of amnesty for noncompliant investors.

In addition, in terms of prequalification, Mexico’s bid bond calculation methodology may result in relatively low bid bonds. For example, to be able to win a project in Brazil, bidders are required to submit bonds worth five percent of the project’s estimated investment costs. In Mexico, on the other hand, the bond includes a fixed fee of about \$99,000 (regardless of the number of bids submitted by the same generator), approximately \$21,000 per MW of capacity offered in the auction in a year, plus \$10/MWh and \$5/CEL (Clean Energy Certificates) offered in the auction in a year. Auction participants can reduce this bid bond up to 50 percent by securing an early interconnection agreement. Depending on technology and country-specific capital costs and specific offers, Mexico’s bid bond may prove low when compared with a fixed percentage of estimated project costs (particularly if no capacity product is offered).

For the 14 winning solar and wind projects in Mexico’s third auction, the average bid bond submitted was 11 percent (nearly 900,000 USD) lower than it would have been under Brazil’s 5 percent of investment cost methodology (not including any discounts from early interconnection agreements). Including the one winning gas project (which won capacity only) increases this difference to 13 percent, more than 1.3 million USD lower than under the 5 percent methodology. The design of the bid bond in Mexico is not fixed and highly sensitive to offer capacity offers; this could be an intentional attempt to encourage lower financial commitments from intermittent renewables which may be less likely to seek winning significant capacity in the auctions. However, lower bid bonds can also result in lower project realization rates and increase speculative bidding among auction participants.



5.6 Grid connection regulatory model

The grid connection regulatory model is extremely important for generation development, and for renewables in particular. In Brazil, developers are exposed to most costs associated with interconnection, including any necessary improvements to grid infrastructure like substations (Viana, 2017). In Mexico, CENACE (the system operator) publishes a list of substations with available capacity, yet it is still the responsibility of the bidders to pay for the interconnection. Accordingly, in both Brazil and Mexico, bidders could be liable for significant system upgrade costs if they must connect to a substation that does not have available capacity.

If renewable generators are exposed to deep cost allocation, meaning the full costs of interconnection, this can put renewable developers at a disadvantage when competing with conventional resources. Site selection for renewables is already reduced by the availability of sunlight, wind and other natural resources, and could be limited further if prospective areas are far from the grid or so remote the grid is nonexistent. However, from a social welfare perspective, it can be argued that renewables should be exposed to their full economic costs, including integration and grid interconnection. If renewables avoid full cost exposure through inefficient siting, welfare is not maximised, as renewable investment would occur where it is uneconomical.

Special provisions for renewable interconnection costs in Brazil and Mexico do not appear necessary. While such provisions could help reduce risk, lower the cost of capital, and open a variety of additional renewable siting opportunities, the two nations are already experiencing success in auctioning renewables under their respective models, and achieving very low prices. Accordingly, their deep cost allocation models appear sufficient.

6. Conclusions

Auctions are an efficient policy instrument for allocating renewable energy resources and risk among parties, while encouraging price formation through a competitive competition. Yet fundamentally, the institution of these auctions is due to the shortcomings of market liberalisation and the originally planned short-term, time-differentiated markets in providing adequate investment signals for renewable energy investment, appropriate generation mixes and resource adequacy (in non-liberalised markets auctions are a step forward towards improving efficiency by introducing a market mechanism). Still, competitive auctions are likely the most effective out-of-market mechanism to encourage renewable deployment and related policy objectives.

While exploring the ins and outs of auction design and policy is necessary for policymakers, investors and other practitioners, it is important to note the overarching question surrounding the future role of auctions: are they a permanent feature of future electricity sectors, or a temporary patch that allows governments to lower the costs of achieving certain policy objectives? This question remains quite open-ended and uncertain. The development and reform of short-term markets (or lack thereof) to provide more effective investment signals for renewable energy technologies will ultimately provide an answer.

This paper contributes to the continuous review of auction design in Latin America's two largest economies and power markets. Through our overview and analysis:

- 1) We clarify the relationship between long-term electricity procurement auctions and the markets and policy frameworks in which they exist. We also interpret specific auction design elements and illustrate how these design elements interact with one another and create trade-offs within and among the major auction design elements.
- 2) We present our understanding of how the histories of both Brazil and Mexico led each nation to ultimately pursue auctions as their principal mechanisms of contracting electric generation and renewables in particular. We also present our understanding of the functioning of the wholesale power



markets and long-term electricity procurement in these two nations, the auction design and procedure, and the interaction between markets and the auctions.

3) We outline recommendations for both Brazil and Mexico with respect to markets, auction design and process. Auctions are complex and must be planned and administered with prudence and judiciousness, reviewing the successes and mishaps of others as well as the existing literature. While there is no single model which serves as a reference, several successful models should be considered when designing auctions, with specific best practices moulded and applied to meet the needs of a particular geography and market.

In summation, successful auctions that meet the goals of both policymakers and society are a constant balancing act, which includes weighing the trade-offs between specific design elements, and simultaneously ensuring that auction procedures are apt for the electricity market design and context in which it exists. Ultimately, auction design seeks to be consistent with the broader market context, while spreading risk efficiently among primary auction participants so as to ensure that the auction trade-offs do not weigh too heavily in favour of, or against, one particular class of auction participants (i.e. investors, government, rate-payers). There are numerous trade-offs along every step of the auction design process that impact the per-unit price of electricity resulting from the auction, the generation technology employed and resulting carbon emissions, as well as other critical outcomes such as local content, investor confidence and the likelihood of project completion.

Accordingly, there is no one-size-fits-all auction design mechanism or policy. Each country implementing auctions must consider the broader market design and context as well as the myriad of trade-offs that appear along each step of auction design, from determining what type of auction to hold, to deciding lead times and penalties. There is no correct answer to these or other auction design decisions. As seen in the cases of Brazil and Mexico, auctions came about in each country in their own way and time.

Electricity markets and contexts are constantly and rapidly changing, and new auctions will breed new short-term results and long-term outcomes. As auctions gradually become the mainstays of generation procurement in an increasing number of nations, and more auctions are held, new innovations, design flaws and unintended consequences will emerge. Therefore, auction administration and design must be constantly reviewed and when necessary, updated or amended.



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