EVALUATION OF AUCTIONS AND CAPACITY MARKET DESIGN FOR ELECTRIC POWER

PREPARED FOR THE MEXICAN MINISTRY OF ENERGY BY POWER AUCTIONS LLC

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1. Executive Summary

Power Auctions LLC welcomes the opportunity to give its opinion on the design of auctions and capacity markets and identify potential improvements. The current design of auctions and capacity markets is pretty good. The long-term auctions have good incentives to encourage investment in capacity and procure clean energy certificates (Certificados de Energías Limpias, CELs) at market prices.

SENER (Secretaría de Energía) requested that Power Auctions LLC analyze three Market Bases documents, the Market Manual, five sets of comments and a document containing SENER responses to those comments. We generally agree with the SENER position on the comments. The commenters do raise some important issues, but their proposed solutions do not adequately address the issues they are raising.

Comment	Power Auctions LLC Opinion of Current Design
There must be a central buyer for CELs	▸ High-stakes electricity auctions have succeeded when there are multiple buyers and when there are single central buyers
CENACE must set the demand curve	▸ Demand has been successfully set by the buyer and set socially in other capacity auctions
Auctions for capacity and CELs must be held separately	▸ Joint optimization is feasible and more beneficial than separating the auctions
Payments for capacity must not be calculated ex post	▸ An ex-post calculation is unbiased; the risk of its variance from year to year is manageable
Three-product auctions with mixed integer optimization are not feasible	▸ Daily dispatch is solved routinely and is a much harder problem to solve
Only dispatchable plants should be allowed to bid for capacity	▸ Flexibility is priced in ancillary services market; any creditworthy entity should be able to bid
Winners must be granted interconnection or have a high expectation of it	‖ Interconnection rights should be a product in the auction where any generator can bid
Winners might not get a permit or might fail a social impact review and renege	‖ There should be graduated performance bonding requirements and fewer exclusions over time
The UK National Grid auction model is best at valuing common risk	‖ Improving iteration in that direction would be beneficial, but sealed bid is pretty good
Winners being paid as bid is inferior to winners being paid as cleared	▸ Uniform price is best for efficiency and price discovery, but paid as bid is pretty good
Open bidding is best for capacity and sealed bidding is best for CELs	■ Sealed is good and open better for both capacity and CELs, but the long-term auction manual has a novel hybrid of the two types of bidding

The current design of auctions and capacity market can be improved upon. There are some ways to improve the price and quantity discovery properties of the auction and to modify what is being auctioned to raise the surplus of the auction and improve the contract performance of the winners. The main opportunities we see for improvement are as follows:

- Improving the implementation of iteration in the auction manual (or going to sealed bid)
- Introducing a market process to allocate and trade access to interconnection
- Tightening contract requirements for conditional winning bids
- Having graduated performance bonding requirements for winners over time

2. Recommendation on Iteration Rule

The Long Term Auctions Manual provides for the possibility of iteration of bidding if the surplus is below a threshold announced prior to the auction. As a result, the design used by CENACE is neither a sealed-bid auction nor a truly dynamic auction. The disadvantages of this iteration rule are discussed in Section 2.1 below. Power Auctions LLC recommends changing the iteration rule to that of a truly dynamic auction, specifically a clock auction that uses a mixed integer program to determine the winning bids. If it is not possible to adopt a truly dynamic auction, our recommendation is to use sealed-bid auction without the possibility of iterating.

2.1 Iteration rule of current design

In the current design, an iterative process to receive and evaluate offers is conducted if the total surplus is below a threshold. The threshold is calculated by the Ministry or CENACE before the auction. If the auction proceeds to an iteration, CENACE announces the price and quantities of each selected offer. All bidders can submit counteroffers in the iteration. In the counteroffer, a bidder may reduce the price for one or more of its bids but may not modify the other attributes of its bids. This process is repeated until the value of the total surplus in the last solution is less than or equal to 101% of the surplus of the previous solution.

An important drawback of this iteration rule is that it may be difficult for bidders to decide how to bid. In particular, because of this iteration rule and the fact that in the current design winners are paid the prices in their bids, a bidder's bidding strategy strongly depends on the bidder's guess whether or not there will be an iteration. If it were common knowledge among the bidders that an iteration will not occur, this would effectively be a first-price sealed-bid auction. That is, each bidder would place a bid that seeks the desired combination of likelihood of winning and profitability in the event of a win. If bidders anticipate iteration, then they are likely to place initial bids that are higher than they would be in the case that they do not anticipate iteration. The iteration can then result in bidders reducing their bids. Some of the bidders that would have lost the sealed bid auction may be willing to bid substantially lower.

If a bidder is unable to predict whether there will be an iteration, the bidder's optimal strategy is not known. The hybrid of maybe having iteration and maybe not having iteration can be problematic. While there is a broad understanding in the economics literature of dynamic auctions and sealed-bid auctions, there is no understanding of this novel hybrid design.

A second drawback of the current iteration rule is that the surplus threshold (set by the Ministry or CENACE) may have a strong effect on the auction's outcome in some cases. Bidders may take into account the announced threshold when choosing their bids. If the threshold is far from the likely highest winning bid, then the surplus threshold is unlikely to affect the outcome. If the threshold is slightly above or below the likely highest winning bid, bidders may adjust their bids to be slightly below the threshold instead of what they were planning to bid. For instance, the threshold could become a focal point and lead to winning bids with surplus

just sufficient to meet the threshold. This may have the effect of increasing or decreasing the average winning bids.

2.2 Power Auctions LLC recommendation on iteration rule

Power Auctions LLC recommends that CENACE change the iteration rule. We rank iterative open auctions best and sealed bid auctions as a pretty good second best. We thus recommend using an iterative open auction; however, if that is not possible, we recommend using a sealed-bid auction without the possibility of an iteration. We note that iterative open auctions have been used successfully for the ISO New England, National Grid and the Texas Public Utility Commission capacity auctions; see Section 5 for more details about these auctions.

Our recommendation is that CENACE change the iteration rule to that of a clock auction. A clock auction is an iterative open auction format with a clock price for each product in each round. Bidders express the quantities that they are willing to supply at the round's prices, possibly using intra-round bids. A bidder is permitted to reduce its supply as prices decrease. The auctioneer compares aggregate supply to demand and conducts a new iteration, or "round", if there is excess supply for one or more of the products. Once all products have cleared, a final round is conducted where bidders can further improve their bids. After the final round, the auctioneer solves an optimization using all the bids submitted in the auction to identify the allocation that maximizes surplus. The auctioneer then applies a uniform pricing rule, with the possibility for a few bidders to be paid-as-bid. This design is described in more detail in Section 2.3.

The key differences between this clock auction design that we recommend and the current CENACE design are the iteration rule and the pricing rule. However, our recommended design is not a major departure from the current design. Bidders can still submit package bids for capacity, energy, and CELs. Moreover, once all bids have been submitted, the auctioneer determines the winning bids by solving a mixed integer program along the lines of the one that CENACE is currently using.

An important characteristic of our recommended clock auction design is that it uses *intra-round bidding*. That is, in every round, there is a range of prices associated with each product in each zone, and bidders are allowed to submit bids at any price in that range. Intra-round bidding minimizes the dependence of the auction outcome on the parameters that are set by the auctioneer, specifically the openings prices and the decrement percentages.

The main benefits of our suggested design are:

- **Higher efficiency**. If supply exceeds demand, the price drops and bidding continues. In particular, a bidder will improve its bids until either it wins or it is not willing to offer the supply at a lower price. This has an efficiency advantage leading to higher producer surpluses on average as the competition in an open auction is likely to drive prices somewhat lower, while ensuring that there are no unhappy losers who could have

profited more from winning than some of the winning bidders. The proposed iteration rule avoids the dilemma of having many rounds (potentially hundreds) with a very small minimum price decrease while still achieving very high efficiency as if there were hundreds of rounds. For example, the T-4 auction in the UK completed in 11 rounds on 8th December 2016. In the ISO New England's FCA #10, all but one interface of one zone closed within 4 rounds on 8th February 2016. Both of these auctions used "intra round bidding", described below, to achieve very high efficiency with a small number of rounds.

- **Bidding is easier.** The uniform pricing rule reduces the need to guess what others will bid, because all winners will be paid the same price per unit for each product in each zone. A bidder that has determined the lowest price at which it is willing to sell can reflect that price in its bid; if the bidder wins, it will be paid a uniform price that is at least as large as the price in its bid. This is in contrast to the paid-as-bid pricing rule where, to choose its bid, a bidder needs to trade off the likelihood of winning and the profitability in the event of a win because the latter depends directly on its bid. Bidders often prefer a dynamic auction with a uniform pricing rule to a paid-as-bid, sealed-bid auction because there is less risk of leaving money on the table.
- **Better price and quantity discovery**. In each round, a bidder submits only its preferred packages for the prices associated with the round. Sealed bidding tends to have worse price and quantity discovery. The bids in a sealed-bid auction are used primarily to update bidders' estimates for the subsequent auction as opposed to the current auction. This makes the prices and quantities found in an open auction somewhat better guides for determination of policy and business planning for the future.
- **Reduction in common valuation uncertainty**. Bidders are informed about the aggregate supply in each capacity zone (or each ad hoc capacity zone created where there is an interconnection maximum) after each round. This allows bidders to predict market clearing prices by inferring the likely clearing prices for capacity and energy in each zone and nationally for CELs. By reducing uncertainty, bidders are willing to accept a smaller risk premium and can reduce their bids versus a non-iterative process.

Our suggested design is especially well suited for common values, but at the same time does not cause any diminution for private values. It is an appropriate format to use to auction together multiple products with varying private value and common value components.

2.3 Iteration with a clock auction

In this section, we provide a more detailed description of the clock auction design that we recommend to use in order to improve the iteration rule.

Products. As in CENACE's current design, we recommend having three products in the auction, that is, capacity, energy, and CELs. A two-product market design is also a pretty good option

which is consistent with our proposed iteration rule. For example, capacity is one product and the other product is CELs paired with energy at a fixed ratio.

Opening prices and first round. The auctioneer sets an opening price for each product in each zone. The opening prices are the clock prices for the first round. The first round price would be the maximum allowable bid price for each product that is used in the current model. In the first round of the auction, each bidder submits its preferred package bid at those prices. For example, if the opening prices are $700,000 for capacity, $400 for energy, and $200 for CELs, a bidder could submit a bid for 30 MW, 120,000 MWh and 120,000 CELs which would imply that the bidder is willing to provide that package of quantities at a price of:

$$700{,}000 \times 30 + 400 \times 120{,}000 + 200 \times 120{,}000 = 93{,}000{,}000$$

Bid processing. When a bidding round ends, the auctioneer calculates the aggregate supply for each product in each zone at the round's clock price. If, for each product in each zone, the aggregate supply is less than or equal to demand at the clock price, then the auction proceeds to the final round. Otherwise, the auctioneer announces new (lower) clock prices and the auction proceeds to a new round.

Information policy. After the processing of a round, bidders are given aggregate supply information.

Setting clock prices after round 1. To set the clock price of a product in a zone for the next round, the auctioneer considers how much excess supply there was for the product in that zone at the last round's clock price. If aggregate supply exceeded the demand, then the auctioneer decrements the clock price by a certain percentage. If aggregate supply was somewhat lower than the demand, then the auctioneer decrements the clock price by a smaller percentage. If aggregate supply was significantly lower than the demand, then the auctioneer does not decrement the clock price.

Bidding in rounds after round 1. In rounds after the first round of the auction there is a range of prices for each product in each zone. The round's clock price is the lowest price in the range. The previous round's clock price is the highest price in the range. Each bidder can either maintain its supply from the previous round at this round's clock price or submit one or more intra-round bids to change its supply at intra-round prices. This functions similarly to the auctioneer naming a range of prices for which bidders can make offers in this round. For example, if, for capacity, the opening price is $700,000 and the Round 2 clock price is $600,000, then a bidder can reduce its supply at any price between $700,000 and $600,000.All bids will be subject to an activity rule, as described below.

Intra-round bids. A bidder can submit a bid to change its supply at any percentage (price point) between the last round's and current round's clock prices. By submitting a single intra-round bid, the bidder indicates that it is willing to offer its changed demand down to the clock price of the round. To formally define intra-round bids, we introduce the concept of price point. The *price point* indicates the percentage of the distance between the clock price of the previous round and the clock price of the current round. For example, the 0% price point refers to the last round's clock price, the 100% price point refers to the clock price, and the 50% price point

refers to the average of the last round posted price and the clock price of this round. Intra-round bids can be submitted at any price point between 0% and 100%.

Intra-round bids example: Suppose that the clock prices of the current and the previous round are given by the following table:

	Previous clock price	**Round's clock price**
Capacity	$100,000 per MW	$90,000 per MW
Energy	$200 per MWh	$190 per MWh
Clean Energy	$100 per CEL	$90 per CEL

In this example, all clock prices have been reduced by 10% from the previous round. We consider two bidders that submit intra-round bids:

- Bidder 1 is only interested in offering capacity in the auction. In the previous round, Bidder 1 submitted a bid for 30 MW at $100,000 per MW. In this round, Bidder 1 submits an intra-round bid for 20 MW at $92,000 per MW (which corresponds to a price point of 80%). This means that:
  - At any price between $90,000 (the round's clock price) and $92,000, the bidder is willing to offer 20 MW
  - At any price between $92,000 and $100,000 (the clock price of the previous round), the bidder is willing to offer 30 MW
- Bidder 2 submitted a bid for 30 MW, 100,000 MWh, and 100,000 CELs at the clock prices of the previous round. In this round, Bidder 2 submits an intra-round bid to reduce its supply to zero (that is, 0 MW, 0 MWh, and 0 CELs) at the 50% price point, i.e. at prices $95,000 per MW, $190 per MWh, and $95 per CEL. This means that:
  - At any price point between 0% and 50%, the bidder is willing to offer 30 MW, 100,000 MWh, and 100,000 CELs. For instance, this is the case at the 25% price point, which corresponds to prices: $97,500 per MW, $195 per MWh and $97.5 per CEL.
  - At any price point between 50% and 100%, the bidder is willing to offer 0 MW, 0 MWh, and 0 CELs. For instance, this is the case at the 75% price point, which corresponds to prices: $92,500 per MW, $185 per MWh and $92.5 per CEL.

Activity rule. In order to prevent bidders from waiting until the end of the auction to reveal their true intentions, a bidder's activity in a given round is required to satisfy a classical notion of revealed preference in relation to the bidder's prior bids. This ensures that a bidder does not increase its supply when the prices become lower. For example, consider a bidder that bid for 30 MW, 120,000 MWh and 120,000 CELs when the prices are $700,000 for capacity, $400 for

energy, and $200 for CELs. At a later round that the prices are lower (e.g. $600,000 for capacity, $300 for energy, and $150 for CELs) this bidder will not be allowed to submit a bid for 40 MW, 120,000 MWh and 150,000 CELs.

The existing feature of CENACE's current iteration rule where a bidder can reduce the price, but only change the quantity to zero would also be compatible with the rest of the proposed iteration rule. This was also the choice selected for the UK National Grid Auction. The two rules are nearly equivalent; if a bidder has a contingent project, it can reduce the quantity of the contingent project to zero which would mimic a single project with two possible quantities.

Final round of auction. In the final round of the auction, bidders are given lower clock prices than in the previous round. As in any round, each bidder can either maintain its supply at the new clock prices or submit intra-round bids to change its supply. After the final round, the auctioneer solves an optimization to identify the winners of the auction and then determines the clearing prices of the auction.

Winner determination after final clock round. The auctioneer solves an optimization problem to identify the allocation that maximizes surplus, taking into account all the bids submitted in the auction – not just the bids of the final round. The optimization can be formulated as a mixed integer program, along the lines of the formulation given in Annex 2 of the Long Term Auctions Manual.[1]

Uniform prices. The auctioneer calculates the clearing price for each product in each zone. The uniform clearing prices are determined by the price vector at which demand would be equal to aggregate supply if all bids were divisible (instead of package bids). In particular, bids are ranked according to the price path and then the clearing prices are determined by the highest bid that would not be winning if all bids were divisible. Most winners get paid these prices. However, it is possible that some winning bids are at higher prices than the clearing prices, because the optimization may determine that a better solution can be achieved by taking some bids out of order. A winner whose bid is higher than the uniform price is paid as bid.

Uniform prices example: Suppose that the clock prices of the final round and the previous round are given by the following table:

	Previous clock price	**Final clock price**
Capacity	$100,000 per MW	$80,000 per MW
Energy	$200 per MWh	$160 per MWh
Clean Energy	$100 per CEL	$80 per CEL

[1] Power Auctions LLC uses the Gurobi Solver for computing global optimums of winner determination problems. Gurobi and other commercially available solvers, such as CPLEX, can solve large winner determination problems with thousands of bids to optimality. These solvers typically use branch-and-bound algorithms which prove the optimality of the solution, if an optimal solution is found.

In this example, all final clock prices are 20% lower than the ones of the previous round. The following table summarizes the bids for this example.

	Previous round	**Final round**
Bidder 1	40 MW	30 MW starting at 10% price point (i.e. price $98,000)
Bidder 2	20 MW, 80,000 MWh, 80,000 CELs	0 MW, 0 MWh, 0 CELs starting at 20% price point
Bidder 3	20 MW, 20,000 MWh, 20,000 CELs	Maintains supply in final round
Bidder 4	30 MW	Maintains supply in final round

Suppose that the optimization problem determines that bidders win the following quantities:

	Winning quantities
Bidder 1	30 MW
Bidder 2	20 MW, 80,000 MWh, 80,000 CELs
Bidder 3	20 MW, 20,000 MWh, 20,000 CELs
Bidder 4	30 MW
Total	100 MW, 100,000 MWh, 100,000 CELs

That is, the bid of Bidder 1 to change its demand is applied, whereas all other bidders get the supplies they indicated in the previous round. In this example, the uniform prices can be based on the 10% price point, because all winners are willing to supply their winning quantities at those prices. Thus, all winning bidders will be paid $98,000 per MW, $196 per MWh, and $98 per CEL.

3. General Opinion Regarding the Current Design of Auctions and the Capacity Market

Power Auctions LLC sees that the existing formulation of the auctions and capacity market are beneficial, but there is potential for improvement. We discuss several areas that have drawn comment or may present opportunities for potential improvement.

3.1 Conditional and mutually conditional bids

Two types of bids are explicitly allowed by the Electricity Market Bases and the Long Term Auctions Manual: conditional bids and mutually exclusive bids. These two types allow bidders to submit bids that reflect their true costs. A large number of conditional and mutually exclusive bids were submitted in each of the two long-term auctions conducted so far.

Our first observation is that a bidder would be able to submit bids that reflect its true costs even if only exclusive bids were allowed (and conditional bids were not allowed). For example, consider a developer that has three size options (small, medium, and large) for its plant. Instead of conditioning its medium bid on its small bid and its large bid on its medium bid, the developer can submit three mutually exclusive bids (one for each size option) ensuring that at most one of those bids will be selected.

A potential advantage of allowing conditional bids in the auction is that, for certain complex preferences, a bidder may be able to express its preferences with fewer bids than in a setting where only mutually exclusive bids are allowed. However, very few such instances of complex preferences appear in the bids of the first two auctions and even in those cases the required number of bids in a setting without conditional bids would only increase slightly (e.g. from seven to nine). We conclude that it is not necessary to allow conditional bids in the auction when mutually exclusive bids are allowed.

With the current contracting procedures, conditional bids may result in selective defaults, as described below, which could be very harmful for the market. To address this issue, Power Auctions LLC recommends either to prohibit conditional bids in the auction or to address the selective default issue directly by changing the contracting procedures as described below.

Selective default issue with conditional bids. Our understanding is that currently a set of conditional winning bids does not result in a single contract. This creates a gaming opportunity for a selective default on the under-priced portion of the set of bids leaving delivery to the buyer only of the over-priced portion. For example, suppose that a bidder offers (a) 10,000 MW for $100, (b) 10,000 MW for $10, and conditions (b) on (a). If both of these bids are selected, the bidder could default on (b) and still have a contract for (a). In this example, it is plausible that (a) would not have been selected as a winning bid if bid (b) were not conditioned on it. A bidder might strategically condition an under-priced bid on an over-priced bid in order to maximize the probability that both become winning bids with the intention to default on the under-priced bid.

Power Auctions LLC recommends changing the contracting procedures so that a set of conditional winning bids results in a single contract for all parts. If the bidder defaults on one part of a set of conditional bids, payments should be suspended for all parts.

If it is not possible to change the contracting procedures as recommended above without changing the Market Bases because a separate contract is required for each winning bid, Power Auctions LLC recommends that each conditional bid result in a contract that is conditional on performance of all the contracts associated with the bids on which that bid was conditioned. That is, if a generator defaults on a contract the generator should be considered in default on all contracts that were conditional on the defaulted contract. For example, that bid B is conditional on bid A, and both A and B were selected. There would be two contracts: one for A and one for B. However, if the bidder defaulted on the contract for A, it would also be considered in default on the contract for B.

While not explicitly allowed by the Electricity Market Bases and the Long Term Auctions Manual, mutually conditional bids are not explicitly disallowed. That is, a bidder can condition two or more bids on each other ensuring that *either* all of those bids are selected *or* none of them is selected. A large number of mutually conditional bids were submitted in each of the auction that have been conducted so far.

Mutually conditional bids do not increase the expressiveness of the bidding language, since a bidder can simply submit one bid that corresponds to a set of mutually conditional bids. Allowing mutually conditional offers in the auction is not beneficial and in certain cases can be harmful as explained below. The selective default issue described above in the context of conditional bids is also an issue with mutually conditional bids. Having a set of mutually conditional winning bids result in one contract, as recommended above, would solve the selective default issue. In addition to the selective default issue, two other less severe gaming opportunities also arise with mutually conditional bids:

(1) One type of gaming is to place the following mutually conditional bids: a bid for capacity or energy with a low price and a bid for CELs with a high price. This would back-load payments into a 20-year timespan compared to the 15-year timespan for capacity. The opposite could also be done where CELs have an artificially low price to front-load payments.

(2) The formula for calculating the adjusted price of a package is not linear in the quantity of CELs. As a result, it is possible for a bidder to submit mutually conditional offers such that the sum of adjusted prices is different than the adjusted price of the sum. The bidder may be better off separating the products and strategically selecting the price of each offer instead of submitting everything together as a package.

Since all bidders have the same opportunity to submit mutually conditional bids, to the extent the payment terms are beneficial, all bidders with similar products can submit conditional bids in the same manner.[2] Any benefit associated with the payment terms would be reduced or

[2] Bidders placing capacity-only bids do not have the ability to obtain payments in years 16-20.

eliminated by competition forcing lower bids in order to win given that the payment terms are more beneficial.

While the harm of permitting mutually conditional bids may be small, allowing mutually conditional offers in the auction is not beneficial. An alternative approach would be to prohibit mutually conditional bids.

Another alternative approach would be to address (1) and (2) directly by requiring all conditional bids to have the same proportion of products. That is, a bidder would not be allowed to separate its bid for CELs from its bid for capacity. Then, the bidder would only be able to submit conditional bids to express scale. For example, if a small plant would produce 30 MW and 20,000 CELs and a medium plant would product 45 MW and 30,000 CELs, the bidder could condition the medium-sized bid on the small-sized bid. Under this rule, a bidder would not be able to condition one bid on another if their quantities are not proportional. For instance, a bidder would not be able to submit a bid for CELs and then condition a bid for capacity on that. But in any case, a bidder can offer CELs with or without capacity using mutually exclusive bids.

A possible solution for (2) is to make the payments in years 16-20 fixed prior to the auction so that, the payment in years 16-20 per CEL does not depend on any aspect of the bid. An example would be to have the payments for CELs in years 16-20 be a static estimate of the CEL portion of each winner's payments in years 16-20. Bidders would place a bid that would cause the payments in years 1-15 to vary, but the payment in years 16-20 would be fixed per CEL (for all winning bidders).

3.2 Interconnection

Power Auction LLC understands that there is a timing issue with respect to the interconnection process and the auction. For a winning bidder that does not already have interconnection, there is often not enough time to get the interconnection after the auction. On the other hand, generators are reluctant to spend money or put down a guarantee in the interconnection process before the auction because at that time they do not know whether they will win.

Interconnection is an unpriced scarce resource. Generators that interconnect first have a use-it-or-lose-it property right to use the interconnection capacity which may limit how much capacity a subsequent generator to interconnect can provide. The use of the interconnection may result in inefficiencies of a similar natural to the inefficiencies arising from use-it-or-lose it water rights or temporary natural resource extraction rights. If a lumber company has a temporary right to cut trees in a forest, it will harvest more than it would if it owned the forest. Similarly, a generator with interconnection rights will use the interconnection regardless of how efficient its plant is. If the generator with the earliest interconnection has a less efficient plant, it will have poor incentives to yield the interconnection rights to other more efficient plants. In this scenario, it might be possible that another generator could buy the existing plant and decommission it so that extra interconnection capacity is released, but this has a high transaction cost. Clear rules should be promulgated to facilitate transfers of seniority rights without the sale of the existing plant.

Power Auctions LLC recommends to allocate interconnection rights based on economic principles in order to minimize such inefficiencies. This could be done in two ways:

1. **Make interconnection rights transferrable independent of the plant**. Resale of the interconnection rights can potentially occur before a plant is built in the event that a winner of the auction has not yet started the interconnection process.

2. **Introduce interconnection rights as a product in the auction**. In particular, there would be four products in the auction: capacity, energy, CELs, and interconnection rights. As in the current design, each generator would be allowed to submit offers for packages; however, in contrast to the current design, it would also be possible to include interconnection rights in the package. A generator not interested in offering capacity, energy or CELs in the auction would still be able to bid for interconnection rights. Thus, this design would not provide preferential treatment to generators that are willing to contract capacity or CELs through the auction. Moreover, this would be a more transparent way of taking interconnection into account in the auction than the current approach where CENACE sets the parameters for interconnection limits. A package bid that includes a quantity for capacity may include a request for interconnection rights. If a bid that includes interconnection rights becomes a winning bid, then the bidder would be given interconnection rights for the quantity in its bid. A generator that is only bidding for interconnection rights would specify the capacity and the price it is willing to pay for the rights. The optimization problem that determines the winning bids can be modified to determine an interconnection price for zones where there is competition for interconnection.

It is also possible to combine the two approaches described above, that is, allocate interconnection rights via the auction but also allow generators to trade interconnection rights after the auction. This would result in an efficient allocation of interconnection rights.

In this year's concluded Forward Capacity Auction of ISO New England, the concept of "queues" was present. Two different projects competed for providing capacity but interconnection was available only for one of the two. The auction allocated the interconnection point to the lower bidder of the two. The auction design described above can be viewed as a modified version of the New England auction where the queue for the interconnection point includes a second type of bidder that only wants the interconnection and is not interested in providing any capacity to the buyers; thus, must pay for the interconnection access if it wins.

3.3 Penalties, liquidated damages and indemnification for non-performance

As is standard in high-stakes auctions, each bidder must submit a bid security in order to participate in the auction. Moreover, penalties are imposed to winning bidders that fail to have operational plants on the offered commercial operation date. Both of these rules are essential for the success of the auction, since they incentivize bidders to submit credible bids.

Power Auctions LLC understands that a winning bidder might be able to avoid paying a penalty if it fails to have an operational plant because the government did not fulfil its own deadlines.

In order to have an operational plant, a winning bidder first needs to perform social impact and environmental impact studies. The concern is whether when a social or environmental impact study fails because the project does not satisfy the social or environmental requirements the generator might be able to blame the government for the failure and avoid paying the penalties for not having an operational plant. A related concern is whether 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.

If bidders expect that they will be able to avoid paying penalties in situations where it is not the government's fault that the plant is not operational, bidders will expect that they will be able to renege on their winnings. This would be a serious issue for the auction as the credibility of the bids in the auction could be compromised.

Power Auctions LLC proposes to address this issue with graduated performance requirements. Specifically, we propose that CENACE restrict the time period in which winning bidders can avoid paying penalties for failing to have operational plants because the government did not fulfil its own deadlines with respect to the social impact and the environmental impact studies. If the time until the offered commercial operation date is more than three years, there would be a broad category of possible reasons for the bidder to declare a delay as the fault of the Government of Mexico—as long as such delays were declared prior to the T-3 date. If the time until the offered commercial operation date is three years or less, there would be fewer reasons for declaring a delay as the fault of the Government of Mexico. The reasons might exclude issues such as site surveys and social impact surveys. The reasons might continue to include the timely completion of transmission lines. If there are valid causes due to which a winner of the auction could not perform, the contract can be declared void. The quantity of capacity, energy, and CELs that have been delayed due to the default can be purchased in the next auction. The defaulting generator can bid again in the long-term auction with revised project dates. If the seller does not declare the contract null and void, then it must continue to abide by the original terms of the bid including any penalty provisions for non-timely performance.

With the graduated performance requirements described above, a bidder can hedge against the risk of delays caused by the government by bidding early, e.g. four years before the offered commercial operation date.

Graduated performance requirements can increase the credibility of bids and improve efficiency. If a plant cannot be built in a timely fashion because the government did not fulfil some of its own deadlines, the winner will have an incentive to report this at least three years in advance. Thus, there would be a timely indication of any additional needs for capacity due to delays. Further improvements can be achieved by incentivizing bidders to report any other delays timely, e.g. by introducing a reporting requirement for winners to announce quarterly or monthly how much delay has occurred—and crucially having a lower penalty for delays that are announced well in advance versus those that are not.

Various regulators have taken different approaches to how long before the operation date to conduct the auction. In the UK National Grid capacity auctions, there is a T-4 auction held four

years in advance and a T-1 auction held one year in advance. The second auction will have very accurate estimates, but will not leave time for much competition from new entrants.

The New Jersey BGS Auction chose to purchase full requirements service one third each year for three successive years. So in one auction they might be buying 1/3 of the power for 2019, 2020 and 2021.

3.4 Demand curve

Power Auctions LLC believes that the auction should utilize a demand curve, as is currently required. That is, the rules with respect to the demand curve do not need to change from an auction design perspective. The buyer should set its demand curve using elasticity to express its true demand and avoid the possibility of under-procurement. There may be an opportunity in the future to increase the demand curve to reflect reliability needs of the grid (or force certain higher-priced bids to win in order to address local reliability needs, which would be similar to the ISO New England Forward Capacity Auction).

The level of the demand curve

When setting the demand curve, the buyer should use elasticity to express its true demand. Starting the demand curve at a low level may leave open the possibility of under-procurement. If, for example, the buyer has set the maximum price at 10% above the expected clearing price level and has 10 more steps at 8% above, 6% above and so on down to 10% below, the auction is likely to result in purchasing only 50% of the maximum quantity on average and if there is a price shock of 8%, the auction might procure only 2/11 of maximum demand. We encourage the buyer to set the price for the first step of the demand curve higher than the cost of new entry. In FCA #11, ISO New England set the top step of the demand curve at $18.624/kw-Month when it estimated the cost of new entry at approximately $12/kw-Month.[3] They could do this with some confidence because the clearing price in FCA #10 was $7.03/kw-Month.[4]

The UK National Grid demand curve in one auction comprises 43165 MW of demand at its price cap of £75/kw/year and has 46165 MW of demand when the price has dropped to £0/kw/year.[5]

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[3] Slides 11-12, https://www.iso-ne.com/static-assets/documents/2016/10/20161017-10-fcm101-forward-capacity-auction.pdf

[4] https://www.iso-ne.com/about/key-stats/markets#fcaresults

[5] p. 5, https://www.emrdeliverybody.com/Capacity%20Markets%20Document%20Library/2015%20CM%20Update%20to%20Demand%20Curve%20Report%205th%20October%20final%20version.pdf#search=demand%20curve

Their cost of new entry is estimated at £49/kw/year.[6] The clearing price in the recently completed T-4 auction in 2016 is £22.50/kw/year.[7]

Demand curves are a valid successful tool for capacity auctions

One point of discussion is whether the auction should utilize a demand curve (as is currently required). Our advice is clearly affirmative on this point. First, using demand curves is consistent with the economic principles underlying the auction. Second, demand curves are also a deterrent to collusion by bidders. Third, demand curves have been used empirically, with considerable success. We elaborate on these points below.

Using demand curves is consistent with the economic principles underlying the auction. In theory, the marginal value of excess capacity decreases in the quantity of excess capacity: the initial increments of excess capacity are critical for avoiding brownouts at peak times; additional increments of excess capacity are nice to have, but not as crucial for the system. As such, these diminishing marginal values imply that an efficient auction would apply a demand curve in determining the level of procurement.

Demand curves are also a deterrent to collusion by bidders, as they increase the incentives for bidders to deviate from any tacit or explicit collusive agreements. Compare a first auction that lacks any demand curve, with a second auction that incorporates a demand curve. In the first auction, the bidder who cheats on the collusive agreement benefits only by taking quantity away from its competitors. However, in the second auction, the bidder who cheats on the collusive agreement benefits in two ways: by taking quantity away from its competitors and, additionally, by an increase in the quantity that is procured overall. This makes it more difficult to enforce any tacit or explicit collusive agreements, contributing to the competitiveness of the auction.

Third, demand curves have been used empirically, with considerable success, both in capacity auctions and elsewhere in the electricity sector. ISO New England's Forward Capacity Auction has included a variant on demand curves into its design in all of its annual auctions to date, and ISO New England's current design explicitly incorporates a demand curve. Meanwhile, the virtual power plant auctions operated by Electricité de France (EDF) from 2001 – 2011 successfully explicitly incorporated a supply curve (which corresponds to a demand curve in the current context, since these were auctions to sell rather than to buy). To make the point more generally, a demand curve is simply a generalization of a reserve price (i.e. it is effectively a sequence of different reserve prices at different quantities). As such, it should be viewed as an accepted part of the toolbox of techniques that auctioneers use everywhere.

One concern that has been raised is that the requirement for a lower price on each step of the demand curve, coupled with starting the demand curve at the pre-auction estimate of market

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[6] p. 5, https://www.emrdeliverybody.com/Capacity%20Markets%20Document%20Library/Auction%20Guidance_final.pdf#search=cost%20of%20new%20entry

[7] https://www.emrdeliverybody.com/CM/T42016LIVE.aspx

price, may create a serious risk of under-procurement. This concern is indeed valid. However, this difficulty is a consequence of attempting to start the demand curve at the pre-auction estimate of market price. The correct resolution of this issue—and the approach that is taken in other auctions—is to start the demand curve at well above the pre-auction estimate of market price, and to rely upon market forces to drive down procurement costs. (Further observe that even without any slope to the demand curve, setting the maximum bid at the pre-auction estimate of market price creates a serious risk of under-procurement.) For example, suppose that the demand curve will consist of five equal steps. The first step should be well above the pre-auction estimate of market value, and only the third or fourth step should be marked to any value estimate. This would reduce the risk of under-procurement while maintaining the advantages associated with demand curves.

3.5 Paid-as-bid vs. uniform pricing

One issue that some of the commenters allude to is that there is an alternative to paid as bid. Specifically, instead of paying winning bidders the prices in their bids, the auctioneer could use a "pay-as-clear" pricing rule and calculate a uniform clearing price for each product.

Our position is that a uniform price rule would be better, but a paid-as-bid pricing rule is also good. Commenters criticize the paid-as-bid pricing rule because it does not yield an individual price per product. We believe that a more important reason for preferring a uniform pricing rule is that it makes bidding easier by reducing the need to guess what others will bid.

The key advantage of a uniform pricing 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. Bidders face a very trying problem in a paid-as-bid sealed-bid auction. Every additional dollar per MW (or MWh or CEL) they bid results in extra profit, but a higher chance of losing. There are very high returns indeed for knowing what the highest accepted offer will be before the auction. Consider a simple paid-as-bid auction for one capacity product vs. a uniform-price auction where all winners receive the price bid by the highest losing bid. If the highest accepted offer is $100 per MW and the lowest is $60 per MW, the generator who bid $60 per MW could have been paid an additional $40 per MW had it guessed other bidders' bids. In contrast, if everyone is paid the highest losing bid, winners do not gain anything by guessing the market clearing price prior to the auction.

In the document with SENER responses, SENER states that the industry requested a "pay as bid" scheme because it is easier to understand. The comparison there is made to uniform prices that are calculated by solving a dual optimization problem. In Section 2.3, Power Auctions LLC recommends using uniform pricing instead of paid-as-bid along with a change in the iteration rule. The approach described there does not require solving a dual problem to calculate uniform prices. The uniform clearing prices are calculated by identifying the point at which aggregate supply is equal to demand. Bidders often prefer a uniform pricing rule (along the lines of the pricing rule described in Section 2.3) to a paid-as bid sealed-bid auction because there is less risk of leaving money on the table.

We also recommend allowing for the possibility to accept a few bids above the uniform price; such bids would be paid as bid. This can achieve a higher surplus by enabling a better fit between supply and demand quantities. A pretty-good second best would be to have a completely uniform-price auction. This was the choice made in the UK National Grid auction. The efficiency loss would be small and the ease of explanation may make it best for there to be no exceptions to the uniform-price rule.

3.6 Currency of payments

Power Auctions LLC has the general opinion that giving the bidders a choice of currencies is a way for the auction to obtain the most competitive bids. Bidders may have different transactions costs for hedging currency risk and different appetites for unhedged risk. Since all bidders have access to the same payment selection, any advantage of one currency versus another in the formula will result in the advantage it provides the winner being competed away by lower bids given that each winning bidder is being paid in its preferred currency.

3.7 Clean energy certificates

There are two issues around clean energy certificates addressed in this section: sequential vs. simultaneous auctioning of CELs and capacity and energy and the parameters of generator bids to provide CELs.

- The pros and cons of holding a CEL auction at the same time as a capacity and energy auction

    Pro:

    - Joint optimization

        The only way to know which combination of projects leads to the lowest net payments for the required number of CELs is to jointly optimize with the purchase of capacity and energy. If this is not done, then there is likely to be a more inefficient and more expensive net purchase cost of the CELs compared to a jointly optimized purchase.

    - No risk of exposure to selling only the CEL or only the capacity and energy

        In sequential auctions, there is an inherent risk that a bidder will win the first auction and lose the second. This will result in an increased likelihood of default and more cautious bidding in the first auction given the chance of losing the second. This exposure can be eliminated in a sequential auction by including

capacity as part of the bid in the stand-alone auction, but that would imply the capacity purchase would be less efficient.

- Competition

  Bidders who lose in the first of a set of auctions are going to be much less competitive in a subsequent auction because they are less likely to build their project at all after losing the first auction. This curtails the number of bids and the aggressiveness of the bids in the auction for the second product.

  Con:

- A separate auction for CELs from capacity and energy is conceptually simpler.

Power Auctions LLC and its personnel have operated auctions and designed auctions that price clean energy in a stand-alone auction. They do not represent a big efficiency loss from auctioning clean energy together with capacity, and therefore a stand-alone CEL/energy auction would be a reasonable alternative to a joint auction with capacity. Nevertheless, the general opinion of Power Auctions LLC is that any problems the proponents of separate auctions cite, such as non-firm sources getting too much payment for capacity and the indeterminacy of the shadow price of CELs versus energy, will occur whether the auctions are held jointly or separately. Given that CENACE has successfully run two auctions that include clean energy jointly with capacity from other sources, the complexity appears manageable and little of the complexity of valuing non-firm capacity disappears if CELs are auctioned separately. Therefore, Power Auctions LLC recommends keeping the auctions together.

- The bid parameters of a bid to provide CELs if it may include capacity and energy or may be conditional on another bid that includes capacity and energy
  - Our understanding is that CENACE has proposed requiring bidders to place a bid with up to three parts with separate bid prices for capacity, energy and CEL components

    Regardless of whether a bid has three components or one, if the project is all or nothing (and Power Auctions LLC does not see why it should not be), then no information is learned from the component bid prices. The shadow price for each component may bear little relation to the attribution the bidder places on each component. At this time, we do not understand the advantage of disaggregating bids for capacity, energy and CEL that are then combined into a single bid for the purpose of optimizing the allocation. If it is desirable to discern a price for each product, CENACE can use the uniform pricing rule described in Section 2.3.

3.8 Establishing a central buyer

Power Auctions LLC understands that a number of generators have expressed interest in the creation of a “central buyer” or “house of clearance” that will administer, in a centralized fashion, the contracts awarded by the auctions.

A central buyer would reduce the risk that generators face with respect to CELs. CELs are uniquely challenging to make bankable because the CEL requirement is more likely to change over time versus the capacity requirement. It is also a thinner market because 100% of generation affects the capacity market while only a small fraction of the generation produces CELs. This suggests that a centralized scheme is more likely to be necessary for CELs than for capacity. On the other hand, as a result of the volatile price of energy, the centralized buyer would likely also need to be the centralized buyer for the energy associated with the CELs.

Power Auctions LLC sees some good elements in the building blocks of the central buyer approach described in the Long Term Auctions Manual. For example, the manual defines the requirements for the clearing house to have cross indemnification of all the buyers and sellers.[8]

There are pros and cons to establishing a central buyer that would do more than a neutral clearing house. Centralization vs. decentralization is an eternal debate in economics and politics. Assessing whether the pros outweigh the cons is a hard problem and there are significant unwanted side effects to both possible approaches. We next describe the pros and cons of having a central buyer. Then, we provide a high-level description of an approach that would eliminate the need for a central buyer by changing the definition of a CEL to eliminate the problem of declining CEL prices. However, that approach also has undesired side effects. We conclude that this is a very difficult problem with no clear solution.

Pros

- Lower credit risk that the buyer will pay for the CELs enabling lower prices
- Elimination of the risk of customers moving their load from one buyer to another. In contrast separate buyers may end up being long or short due to such moves.
- A central buyer can be subsidized to take on the credit risk of load serving entities and generators so that an orderly transition occurs in the event one of them fails.
- Transactions cost of managing CEL acquisition is centralized

[8] “Long Term Auctions Manual,” p. 26.

Cons

- Declining CEL costs mean that an asymmetric contracting requirement between centralized and decentralized buying could result in market failure without forcing all market participants to participate in the centralized buying program or paying a high opt-out fee. Therefore, if there is a centralized buyer, it probably needs to be a compulsory centralized buyer unless there is a radical change to CELs such as the straw-man proposal below. The best chance of having a bilateral market coexist with a centralized market without changing the definition of a CEL is to structure the standard auction contract to have declining real prices paid to the generator over time at the estimated rate of reduction in cost per clean MWh.
- A central buyer, if selling to the central buyer is compulsory (and we must assume it will be), will not have competition so there will be no alternative to its policies and choices.
- A central buyer is likely to be slow to innovate.
- The centralized approach makes it more difficult (or impossible) for a market participant to avoid participating in auctions and capacity markets. This leads to atrophy (or elimination) of the bilateral market.
- If the centralized buyer for CELs is supported by a tax to socialize the costs, capacity market and energy market participants will attempt to shift as much cost as possible to the centralized buyer and try to grow its scope leading to a slippery slope toward further centralization of related markets.

We next offer a third option as a strawman to illustrate how difficult it is to avoid the dilemma between a compulsory centralized buyer and a bilateral market with declining prices over time that encourages short-term contracting.

Changing the CEL definition to facilitate both centralized and bilateral buying

Currently, CELs may be sold to retailers only after the associated clean energy has been produced. In the strawman approach described here we relax this requirement and allow CELs to be sold to retailers even *before* the clean energy has been produced (but after the plant has been built). Retailers pay for the CELs at the time of the sale (potentially before the clean energy has been produced), but generators are paid only after the clean energy has been produced. The money paid by the retailers is placed in an escrow account until the clean energy has been produced.

For instance, consider a plant of 50 MW that has been built by year 1. Under the current approach, this generator can sell 50 MWy of CELs in year 1, 50 MWy of CELs in year 2, …, and 50 MWy of CELs in year 20. Under our strawman approach, the generator is allowed to sell 1000 MWy (that is, 20 times 50) of CELs in year 1. The generator will then not sell any CELs in years 2-19. Retailers will pay for the 1000 MWy of CELs in year 1, but the generator will be paid for

50 MWy of CELs each year in years 1-20 after the corresponding clean energy has been produced.

Given the required amount of CELs for each year, CENACE can calculate the capacity that needs to be built each year under the strawman approach. For instance, assume the following requirements: 1000 MWy of CELs in year 1, 2000 MWy of CELs in year 2, 3000 MWy of CELs in year 3,…, 9000 MWy of CELs in year 9 and 10000 MWy of CELs each year in years 11-30.

- Base Case: Under the current CEL definition, these CEL requirements can be satisfied by building 1000 MW of new capacity each year in years 1-10 and no new capacity in years 11-30. Thus, 10000 MW are built in total so that, in the “steady state” of years 11-30, 10000 MWy of CELs can be produced each year.
- Strawman: Under the strawman approach, these CEL requirements can be satisfied by building 50 MW in year 1, 100 MW in year 2, …, 450 MW in year 9, 500 MW each year in years 11-20, 450 MW in year 21,…, 50 MW in year 30. Note that the amount of CELs sold each year are the same as the amounts sold in the Base Case. Also, the payments made by the generators are the same. Finally, the total capacity built is the same as in the Base Case, but capacity is generally built later with the strawman approach.

To operationalize this, retailers would buy CELs from a CEL bank that could also function as a centralized buyer or retailers could self-provide by building a plant. The CEL bank would escrow the auction price that the winners would receive and pay out the agreed price over time as the clean energy is produced. If the CEL producer does not perform the contract, the extra money remaining in the CEL bank could be used to purchase additional CELs in subsequent auctions. A retailer and a clean energy provider could make the same deal bilaterally as long as the money set aside for the stream of CELs is escrowed at some bank in Mexico.

In a steady state, there would be multiple overlapping vintages of CELs that have declining prices, but each year’s vintage will have been purchased at auction at a competitive price or purchased in a competitive bilateral market. Prices could decline in both markets and there would be no systematic reason why either would have an advantage so both could potentially coexist. (This could be approximated without changing the definition of the CEL by having a front-loaded 20-year standard contract for CELs at the anticipated real price reduction rate of clean energy, but if technology improves faster, the centralized market will be stuck with stranded costs and if slower, the bilateral market may disappear.)

The advantage of the strawman approach is that it eliminates merchant risk without the use of a central buyer. Generators have 20 year contracts with the CEL bank and do not face regulatory risk with respect to CELs. Moreover, generators do not need to worry about the possibility that a retailer defaults, since the money for 20 years’ worth of CELs are already in escrow. The retailers do not need to risk overpaying or underpaying for CELs bought in the future, they can pay for CELs in the year they are produced at a price likely tracking the price of the current least expensive technology.

The scheme also has the advantage of allowing an orderly buffered increase or decrease in the clean energy certificate requirement. If, for example, the CEL requirement is eliminated, no new construction need occur, but the escrow payments would continue until the funds were exhausted. If the CEL requirements were doubled from 5% to 10%, then there would only need to be an additional 0.5% of all generation that is clean built each year to produce the requisite certificates.

The obvious drawback is that there is a delay in the construction of clean energy plants and a delay in the generation of the clean energy. In the example described above, it takes 10 years to build up the 10000 MW of capacity under the current approach, but 30 years under the strawman. This delay in generation is an inherent feature of the strawman proposal.

Without such a radical revision of the CEL requirement, we do not see an alternative to a fundamental binary choice between a centralized solution with full participation and a decentralized solution where all parties bear merchant risk.

3.9 Review of results of the long term capacity auctions

Based on our understanding of the bidding data, both the 2015 auction and the 2016 auction appear to have been successful. Both auctions attracted significant participation. In both auctions, the number of winning bidders is significantly smaller than the number of bidders, suggesting a competitive outcome. We did not observe signs of collusion.

- In the 2015 auction, 18 bids were selected as winning bids out of the 468 submitted bids; 5,402,880 MWh and 5,380,911 CELs were assigned. There were 69 bidders in the auction and 11 of them had one or more winning bids.[9] Thus, 58 out of the 69 bidders did not win anything.
- In the 2016 auction, 56 bids were selected as winning bids out of the 579 submitted bids; 1,187 MW, 8,909,819 MWh, and 9,275,534 CELs were assigned. There were 57 bidders in the auction and 23 of them had one or more winning bids.[10] Thus, 34 of the 57 bidders did not winning anything.

In both auctions, a significant number of bids included quantities for more than one product (e.g. energy and CELs or capacity, energy, and CELs) which suggests that it is beneficial to include all three products in the same auction.

No iteration was conducted in either of the auctions. That is, in each auction, the surplus from the initial set of bids was above the threshold set by the Ministry, so CENACE did not ask

[9] https://www.gob.mx/cenace/prensa/comunicado-sener-cenace-ofertas-1-subasta-electrica-de-largo-plazo?idiom=es

[10] http://www.gob.mx/cenace/prensa/con-precios-altamente-competitivos-se-anuncian-los-resultados-preliminares-de-subasta-de-largo-plazo-2016?idiom=es

bidders to make any counteroffers. If all bidders had expected that there would not be an iteration, the auction was effectively a sealed-bid auction. As discussed in Section 2, Power Auctions LLC recommends changing the existing iteration rule to either never iterate (i.e. sealed-bid auction) or iterate as long as supply exceeds demand, along the lines of a clock auction.

In both auctions, bidders submitted large numbers of conditional and mutually exclusive bids. A number of bidders used both of these types of bids to express their preferences. That is, generally bidders have been using the capability of making conditional and mutually exclusive offers. As discussed in Section 3.1, bidders would be able to express their preferences even without conditional bids.

The majority of the conditional bids were in pairs expressing mutual conditionality, e.g. bid A conditional on bid B and bid B conditional on bid A. A small number of bidders submitted conditional bids that involve longer chains; e.g. bid A conditional on bid B and bid B conditional on bid C.

4. Evaluation of Comments and Suggestions

Power Auctions LLC reviewed five sets of comments and a set of responses provided by the Mexican Ministry of Energy and attended conference calls to hear further comments and suggestions from CENACE and market participants. Our general opinion of the SENER responses to the comments is that they are well reasoned, comprehensive and for the most part are tightly logical and effectively disprove or defuse almost all of the concerns raised. There is, however, still room for improvement in the auction design. We address each comment or meeting in turn and call out any individual points we want to amplify or attenuate and make some new points, primarily about the auction design.

4.1 Comments

Comment A: A Definition Error in the Electricity Market Bases: Delivered Capacity

Quoting from the document's conclusion, "Summing up, Investors and banks cannot take the risk implied by the definition of Delivered Capacity contained in the [Electricity Market Bases], because actual capacity payments depend on rather obscure ex post calculations derived from the observed state of the grid during the critical hours of a given year."

The comment makes the case for using a clear ex ante calculation that is based on rated capacity. The Power Auctions LLC position is that actual average availability during peak periods of the year over a series of years converges toward a correct ex ante calculation of average availability. Most ex ante calculations are likely to be biased and miss some factors that will make the plant unlikely to be dispatched or unlikely to be available during peak times. Any ex ante calculation of availability has no expectation of its average converging to being unbiased over time. This availability discovery property of the Electricity Market Bases cleverly arrives at

payments for actual results including unobservable factors that can increase or decrease the availability of the generators and incentivizes each generator to be available during peak times. Regarding the risk being unmanageable, random annual payment in the neighborhood of an expected figure is exactly the kind of risk that investors find easiest to manage.

Comment B: Long-Term Capacity Auctions: Conceptual Problems and Reformulation

This comment advocates reformulating the way the Electricity Market Bases and the Long-Term Auctions Manual determine the demand curve, pre-select thermal efficiency and operation and maintenance values by technology, and create a net capacity price by technology.

Power Auctions LLC finds the existing ex-post method of determining capacity to be a better method of calculating payments for capacity. By using actual availability, any hidden factor that CENACE cannot measure ex ante is accounted for. Average payments should converge to the theoretical mean expected payments over time if the theoretical availability is an unbiased estimate of actual availability. This cleverly keeps the Electric Market Bases simple. So we do not agree that the added complexity required by the comment is necessary or more beneficial.

Power Auctions LLC does not agree that “The current capacity auction formulation should be redesigned in order to have basically private value auctions, so as to minimize the uncertainty related to common value variables and also maximize incentive compatibility.” To the extent there are common value variables, an auction can be designed to mitigate common value uncertainty through price discovery and forcing the auction to be a private values auction is likely to be an unattainable goal. The current design does a good job in attempting to avoid introducing additional extraneous common risks, for example, by allowing payments to be made in part in US dollars if the generation plant was financed in that currency.

We do believe that there are other options to improve price discovery other than attempting to make the auction a private value auction. In Section **¡Error! No se encuentra el origen de la referencia.**, we explain several of these options. A better narrative is that the goal for the design of the auction be allowing bidders to focus on estimating what their own revenue requirements are to provide capacity rather than estimating what the auction clearing price will be. To the extent the auction has better incentives to do this, the transaction cost of participating in the auction declines, bids are more likely to reveal the most efficient suppliers and the result is likely to minimize all sources of common value uncertainty permitting a higher-surplus outcome.

Comment C: Concept problems in the Electricity Market Bases; Long-Term Auctions

This comment makes some sweeping statements that Power Auctions LLC disagrees with, but does identify some issues where there is room for improvement even if the solution that the comment proposes to address each issue is not best.

On p.1, the comment states, “The [Electricity Market Bases] defines a scheme of simultaneous three-product auctions (Capacity, Cumulative Electric Power and CEL). There are no algorithms in the world that would make it possible to handle a problem of such complexity reasonably, above all if the number of bidders starts to increase.”

There is, of course, a large number of existence proofs to the contrary. Power Auctions LLC has designed and implemented auctions that include optimization of bids for hundreds of products. For example, we built auction software for the US Federal Aviation Administration that allowed all airlines to place thousands of all-or-nothing bids for hundreds of different take-off and landing slots at each of several airports. We designed and implemented an auction for telecommunications frequencies for Industry Canada that allowed each bidder to submit thousands of all-or-nothing bids for hundreds of different products that differed by location and frequency. In our auctions for ISO-New England, the ISO uses the bids our software has gathered and undertakes a mixed integer optimization of thousands of resources bidding step functions with tens of steps in different zones with each generator or demand resource having various other characteristics that are subject to constraints such as being mutually exclusive or a cap for a particular type of technology.

We agree with SENER's response on this point and here is a representative quote: "The problem of the daily operation of the system (day market ahead) is also between 50 and 100 times bigger/more complex than the problem of an auction."

On p. 2, the comment states, "[N]obody has attempted something similar in the world." Every auction for electricity capacity in the world is different. The same comment could therefore have been made for each auction before it was attempted. Nevertheless, they were successful.

The comment makes a very weak case for a central buyer stating that no auction has been attempted with multiple buyers and multiple sellers. Power Auctions LLC personnel co-designed and led the implementation of the New Jersey BGS Auction for full electricity requirements where there were four separate distribution companies as buyers and many sellers. Power Auctions LLC personnel led the auction design and drafting of regulations for the Public Utility Commission of Texas auction for electricity capacity and energy which simultaneously auctioned hundreds of products for three separate sellers and many buyers and included a mixed integer optimization each round to pack buyer bids within their credit limit.

The comment makes a weak argument in favor of sequential auctions for CELs separate from power. We see the benefit of auctioning certificates and energy together with capacity. For those sellers of CELs, capacity and energy are clearly complementary with CELs. Only an auction that permits those to be sold together in an all-or-nothing package can minimize risk jointly held by buyer and seller after the auction. In turn, buying capacity from the clean energy providers needs a price that's codetermined with the capacity from other sources. Given that a clean energy project has to meet its revenue requirements from both auctions, this would introduce exposure for the clean energy generator to winning one auction but not the other. Like mitigating currency risk by paying in a choice of currencies that match debt costs, having a single auction determine the allocation of both power and CELs reduces risk for the clean energy generator without increasing risk for anyone else.

The comment advocates delegating the determination of the demand curve to CENACE. (We discussed desirable features demand curves above in Section 3.4.) At one end of the spectrum for how the demand curve is determined, in New England, there is an annual deliberative process to determine the demand curve by all stakeholders including the ISO, the load and the

generators. Ultimately the demand curve is finalized by approval of the US Federal Energy Regulatory Commission. At the other end of the spectrum, Power Auctions LLC conducted a private procurement auction in Colombia for power for BHP Cerro Matoso S.A.'s nickel smelter where the buyer determined its own demand curve and the generators, regulators, and grid were not part of the decision. Both auctions were successful. How the demand curve is determined for the capacity auction in Mexico is ultimately a political question.

We do not agree with the comment on p. 9, "Seemingly paradoxical, the auctions Capacity contemplated in the BME become more of common value auctions than private value." We do, however, agree that the New Jersey, ISO-New England, UK and Colombia open descending price capacity auctions have merit. This should not be surprising considering Power Auctions LLC and its personnel designed and implemented three of these auctions and was Subastador for the fourth. We discuss the advantages primarily in Section **¡Error! No se encuentra el origen de la referencia.**.

<u>Comment D: Comments on the meeting held on November 11</u>

This comment makes the claim that, "Given the fact that [a stand-alone CEL auction] is an only one variable and private value auction it should be conducted as a closed envelope and second price auction."

First, clearing the CEL auction efficiently depends on how the long-term capacity auction is cleared. Different types of clean energy require the buyer to purchase different amounts of other capacity to achieve the same reliability. Second, it does not follow that if a bid can be written as a single number on a slip of paper, that the best auction type is sealed bid. Iterative auctions have advantages in both efficiency and price discovery. Third, it does not follow that a CEL provider will necessarily only have a single number to bid. In the ISO New England Forward Capacity Market, most bidders have the option to reduce the quantity of MW bid at different prices.

"We still think that two-product auctions must be made (Capacity and CEL), also, in our opinion, auctions must be sequential and not simultaneous and that the common value element must be reduced as much as possible so as to have private value auctions which characteristics with regard to incentive and efficiency are easier and better known."

Saying the auctions "must be sequential" seems to require more proof than an opinion that it would be easier and is contrary the experience in hundreds of successful high-stakes multi-product auctions. It's tantamount to arguing that the capacity in different zones should be auctioned separately in sequence because they are partial substitutes.

While it's desirable to structure the product of what's being auctioned as focusing on things that only have known costs to the bidders, this is only one concern of many. In some cases shifting a risk from the bidders to the buyer actually exacerbates it. It may be that bidders are better than the buyer at assessing certain risks such as the likelihood of timely interconnection or the residual value of a plant after 15 or 20 years. In these cases, it may be socially best for the risk to remain with the bidder even if that means a bidder must evaluate a risk that is to some degree a common risk. The bidders may have private or common values to discern, but

there are good auction types that work well over a broad spectrum of bidder value distributions and degree of commonality.

We agree, however, with the sentiment that the auction strategy problem for bidders should not be about estimating extraneous common value uncertainty like what the clearing price of the auction is going to be. Instead it should be about the estimates of private values (like their debt cost) and common values (like future capacity prices) that effect what the price would be where they are indifferent between winning and losing the auction.

Most of the other issues are the same issues as those addressed in previous comments.

Comment E: Answers to the Comments expressed by CMS/WLL

The author recommends the following (p. 1):

- *Recommendation 1: The certified Capacity should be redefined*
- *Recommendation 2: Sequential 1-product Auctions should be carried out instead of simultaneous three-product Auctions*
- *Recommendation 3: The payment related to the Clean Energy Certificates in the Auctions should be reformulated ("CEL")*
- *Recommendation 4: The Cumulative Electric Power should be deleted ("EEA")*
- *Recommendation 5: The CENACE's role should be reassessed as a possible Clearing House*
- *Recommendation 6: The Capacity Auctions should be reformulated*

The standards of proof for determining the desirability of large changes are higher than for small changes. The commenter's strongest argument appears to be that the UK National Grid did not do it this way so Mexico should not either. This line of argumentation is quite succinctly rebutted in the comment itself on p. 3, "If the best-known markets on the subject of Auctions (for instance, PJM, Great Britain, and Colombia) follow totally different procedures, there must be a reason for doing so."

We have argued the following above:

- The certified Capacity calculation is pretty good
- Sequential 1-product auctions are inferior in efficiency to a simultaneous 3-product auction and that such auctions are feasible (which CENACE has also proven twice)
- Any flaws in the payment for CELs that result in an advantage to bidders will also result in lower bid prices as the bidders compete to win thereby offsetting the flaw in the payment
- Establishing a central buyer is a political question and is it neither strictly necessary for a well-functioning auction nor is it strictly necessary for there not to be a central buyer for a well-functioning auction

We do not see any compelling case for deleting Cumulative Electric Power. As the comments state on p. 4, "[O]nly the combined value of the three products matters for the clean Generators, because the total income is the most relevant economic variable to finance the corresponding project." So if Cumulative Electric Power is deleted, it will need to be un-deleted in some form for the clean energy generators to know what to bid without guessing what the price will be in the future.

We do agree that there are some possible advantages to modifying the auction to improve its incentives to achieve higher efficiency, but other than the proposal to run sequential auctions, this comment had no concrete proposal other than to study the auction and make the new one look more like the National Grid auction.

<u>Suggestions from meetings with industry held on November 23 and 30, 2016</u>

Power Auctions LLC disagrees with the point that the CEL auctions should be held separately from the capacity auctions. This argument appears to be a vehicle to delay the capacity payments to clean energy. We agree with SENER's position provided in its response document that any adjustment in the value of capacity provided by clean sources should be made to the definition of capacity for the capacity market and that the long-term auction should use the same definition.

Industry representatives on the call expressed an interest in excluding existing plants from long-term capacity auctions. While it is a worthy goal to encourage installation of modern plants, the incentives are in place to do this. Better heat rates are incentivized through the energy market. Flexible dispatch is incentivized through the ancillary services market. Cleaner energy is incentivized through the CEL requirements. All legal sources of capacity—including existing capacity—should be permitted to participate in the auction. Even financial-only capacity bids, which are not currently allowed, would have an advantage to be permitted in the auction assuming that the bidder has posted sufficient bid security to pay penalties in the event it does not subsequently buy and deliver capacity.

We discuss above in Section **¡Error! No se encuentra el origen de la referencia.** a way to resolve the dilemma of a high and credible bid deposit deterring entry into the auction and a low or non-credible bid deposit resulting in default. Key elements of the proposal are to have successive higher commitment levels as the time to delivery approaches and that winners must announce delays as they are occurring while there is still time to buy additional capacity to cover the shortfall.

We are concerned that without capacity zones being present in the long-term auction, there is no workable way to reward the desirability of the location of the plant when selecting the winner. CENACE's practice of limiting the amount of capacity purchased according to the availability of interconnection by location has the effect of imposing an ad hoc capacity zone in that area. It may be beneficial to formalize these into capacity zones such as the ISO New England "Export-constrained Zones" that have limited transmission capacity to export power to other zones.

We addressed the issue of the dilemma of a centralized clearinghouse for clean energy in section 3.8.

4.2 SENER Response

SENER provided a document that compiled internal responses to all of the comments that we were asked to review. We agree with almost all of SENER's responses. On some of them Power Auctions LLC would like to amplify SENER's response or provide a counterpoint to it.

A. SENER writes, "3. In general, both schemes are equally valid economically speaking: with "pay as clear", almost all bidders receive the higher of what they had accepted, which results in a waste for the purchaser. However, in "pay as Bid", the bidders have an incentive to try to guess the highest price and increase their offers up to that level. Therefore, it is considered that there is no peculiar disadvantage in "pay as bid"." (pp. 21-22 in the "SENER Response" document.)

This analysis is incomplete. Pay as clear (uniform price) means that price is discovered by the market mechanism itself so effort spent on guessing the highest winning price is no longer necessary. This occurs automatically as if driven by an "invisible hand," to paraphrase Adam Smith, as bidders determine their own minimum they are willing to bid. In an open descending auction, bidders will start by bidding higher than they would in a sealed bid. Competition, however, forces them to bid lower to continue to win. There ends up being less waste for the purchaser due to the lower transaction cost and the competition. A more detailed case for uniform price is made in section 3.5.

B. SENER writes, "Ironically, distortions might be created if there were different terms for one only product (Capacity) and if the same price were offered for all terms. This is what the commenter proposes when he suggests that different generators should offer Capacity at 1, 5 and 15 years and that the cheapest offers should win regardless of the term they had. Treating different products as if they were the same would certainly create distortion."

It is possible, but not necessarily desirable in this context, to create an auction where there are separate durations bid in the same auction and a demand curve that demands different amounts for near-term and long-term products.

C. SENER disagrees the with a position taken by industry in a meeting that, "It must be established that the cogenerators have no Capacity."[11] We want to add to SENER's response disagreeing with this.

Cogenerators reduce somewhat the capacity requirements for the rest of the grid. It therefore does not follow that cogenerators have no capacity. If a unit is not dispatchable, it cannot compete in the ancillary services market, but it does provide capacity.

[11] p. 17 of the "SENER Response" document.

For the other issues, we are either in complete agreement with SENER or we have addressed the issue in other sections.

5. Review of Capacity Auctions

In earlier sections, we described some of the desirable features of other capacity auctions. In this section, we provide a more comprehensive set of details about each auction to provide context. These three example auctions have different purposes. The purpose of the first two auctions is to promote investment in capacity, the purpose of the third auction is to facilitate a transition to a deregulated market. These three auctions have a wide variety of features and often take different approaches to various aspects of the auction for a variety of reasons.

5.1 ISO New England Forward Capacity Auction

This auction's iteration rule is the model we generalize from just capacity to more than one product per zone when making our recommendation in Section 2. It represents a more centralized approach to purchasing capacity than is currently used by Mexico. Its concept of queues illustrates how an auction can be used to resolve contention for interconnection rights. Its approach to selecting a demand curve takes into account the preferences of all parties, not just the buyer's. It also illustrates the feasibility of an auction that has both open bidding and a final mixed integer optimization.

<u>Key features</u>

- Initially, all generators were required to participate in the auction.
- At a low enough capacity price, if the "resource" was not considered required for integrity of the grid, the resource could "delist" at that point, if it returned to the auction in a subsequent year, it could bid to resume its obligation
    - A bidder that was required for the integrity of the grid would be paid their delist bid, not the possibly lower price for the rest of generators in the zone.
    - Different types of generation had different maximum and minimum prices where they could place bids.
        - "New" resources can bid down to the minimum price associated with a particular technology type
        - "Existing" resources cannot delist until the price fell to a "dynamic de-list threshold price" that was below the cost of new entry. An exception to this is an
- The auction was a simultaneous descending price clock auction
- There were various zones within the service area and various interfaces to Canada and the state of New York that all had their own auction determined price

    - Zone types included “Import” zones that had a price equal to or higher than the “rest-of-pool” price and “Export” zones that had a price equal to or lower than the “rest-of-pool” price

- The basic auction design is very simple, but there are a large number of special cases to handle various circumstances. Examples include the following:
    - “Queues” where multiple bidders want to create new plant at an existing interconnection point
    - Bidders who are willing to string their own transmission line to increase transmission capacity to accommodate their generation
    - “Repowerings”
- Starting price is typically twice the cost of new entry of the lowest cost capacity technology
- In some years the auction has a “floor price”
    - In the event the floor price is reached, all winners were pro-rated and received the floor price for a portion of their capacity bid at the floor price. The rest of the capacity could be used for other purposes during the year associated with the auction.
- Optimization of which bids to accept was handled internally by ISO New England after the auction concluded
- Initial auctions were less than three years before the service year, but more than one auction was held per year until the auction became three years in advance
- There is an annual consultation process to determine how the forward capacity auction rules will change
- Each year the Federal Energy Regulatory Commission makes an order to implement the rules

5.2 UK National Grid Capacity Auction

The iteration rule in this auction is another successful implementation similar to ISO New England’s, but sacrifices maximum efficiency for simplicity in winner determination. Its demand curve has some similar features to ISO New England, but is simpler because there is only one zone. The variety of lengths in advance of the commitment period was the inspiration for our recommendation of graduated guarantees as the commitment period approaches. Power Auctions LLC believes that the other features of the National Grid Auction that were not recommended above are not essential features for Mexico.

Key features

- Simultaneous descending auction to buy capacity
  - Very similar to ISO New England's Forward Capacity Auction
- Sloped demand curve, fixed in advance of the auction
  - This is similar to ISO New England, but ISO New England has special cases where the demand curve is adjusted during the auction
- No "floor price" like sometimes in ISO New England, but if the auction price reaches zero the auction is annulled
- In the 15-year auction, bidders can choose at a price level to reduce their commitment to 1 year
- They also hold a T-4 auction four years in advance of the commitment period, then a T-1 auction
- There are demand-side resource transitional auctions that are also held one year ahead of the delivery period
- Bidders can choose to drop their quantity to 0, but cannot reduce quantity to amounts between the full amount and 0 as they can in ISO New England
- There are no separate zones as in ISO New England so England and Wales are treated as a single zone for the purpose of the auction
- If there is a generator that is considering refurbishing, it may reduce its quantity at a particular price to the pre-refurbishment capacity level and may reduce its quantity to 0 at the same price or a lower one
- There is no "grid integrity check" during the auction as ISO New England has so that if a generator can participate in the National Grid auction at all, their bids to reduce quantity will be accepted
- National Grid has fewer special cases of zones, demand curves and types of bids than ISO New England

5.3 Public Utility Commission of Texas Capacity and Energy Market

The Public Utility Commission of Texas (PUCT) did not think Texas had insufficient capacity when it initiated a new capacity market. Rather than incentivize new capacity, it redistributed capacity to new retailers to facilitate a transaction from regulated integrated utilities to a free market for separate generators and retailers.

To facilitate the transition, the three largest utilities in the Electricity Reliability Council of Texas (ERCOT) which served were required to have their generators sell 15% of their capacity and energy by an auction. This mandate affected 20 million people, approximately 80% of the Texas

population, and priced capacity and energy for a market that represented approximately $30 billion/year at retail prices. This auction provided aggregators and independent distribution companies with a source of supply to facilitate the transition, while also providing clear market prices for what was purchased. Those prices, in turn, helped determine how much “stranded costs” were reimbursed to the utilities over the course of the transition. Once a threshold percentage of the customers in the distribution company’s original service area had elected to move to another distribution company, the generation arm was freed from the requirement. The transition ran from 2002-2005.

This example shows that an iteration rule and the payment rule can successfully be changed. It also is another feasible implementation of an auction that has a mixed integer optimization component with multiple products (in this case hundreds).

Key features of the first implementation

- Products were divided by zone (roughly corresponding to the three distribution company service areas, who the seller was, and technology (e.g. base load, gas intermediate, peaking) and delivery month; in the annual auctions this led to hundreds of separate products which were in turn subdivided into lots with relatively small quantities
- Prices were paid as bid
- An English ascending auction was used for each product in parallel
- Bidders were not told the level of demand, only when the auction was over or not
- There was a fixed maximum number of rounds
- Bidders were required to bid every round on each product they were interested in for the full amount that they wanted at that price and could not increase that quantity under any circumstance. That is, the only way in the auction to express demand for substitutes was to bid for both substitutes and reduce demand on one or both. They could not move demand from one product to another

The general opinion of Power Auctions LLC personnel at the time was that this was a poor design. As an analogy, it was like building a 6-lane highway with walls between the lanes. The actual experience in the first several quarterly auctions was that there was a big price dispersion between identical products from different sellers solely due to the price path that the seller chose for the limited number of rounds.

After Power Auctions LLC personnel personally lobbied the PUCT, the auction was modified. The new auction design led to lower price dispersion, lower transactions costs because both buyers and sellers no longer had to hire game theorists to conduct their bid strategy and their price setting strategies. The design led to higher efficiency. The PUCT was convinced that the 2nd price auction rule would result in higher prices for sellers minimizing the stranded cost payments that would ultimately come from ratepayers.

Key features of the second implementation

- Winners paid the highest losing bid
- A simultaneous ascending auction permitted bidders to move demand from lot to lot, but only to the extent that demand exceeded supply on the lot they were moving from
- A strict credit limit was enforced on the bidders which required solving a packing problem for each bidder each round
- There was a soft close when bidders stopped bidding instead of a fixed maximum number of rounds
- Bidders were required to bid to maintain a pool eligibility which could be deployed across all lot by bidding every round
- A single bidding system was used for all three sellers' auctions