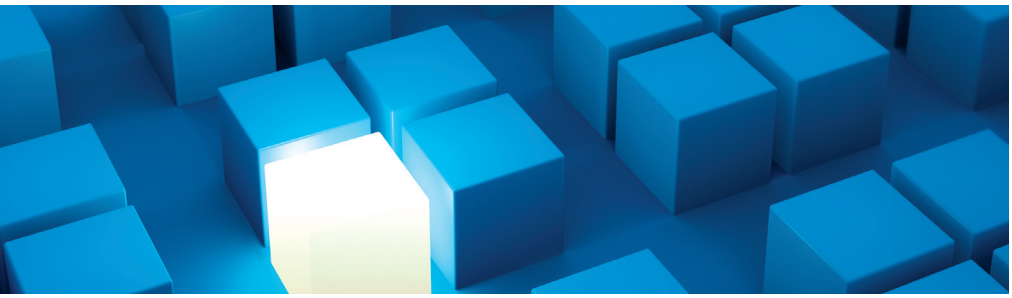
NERA
ECONOMIC CONSULTING

September 2017

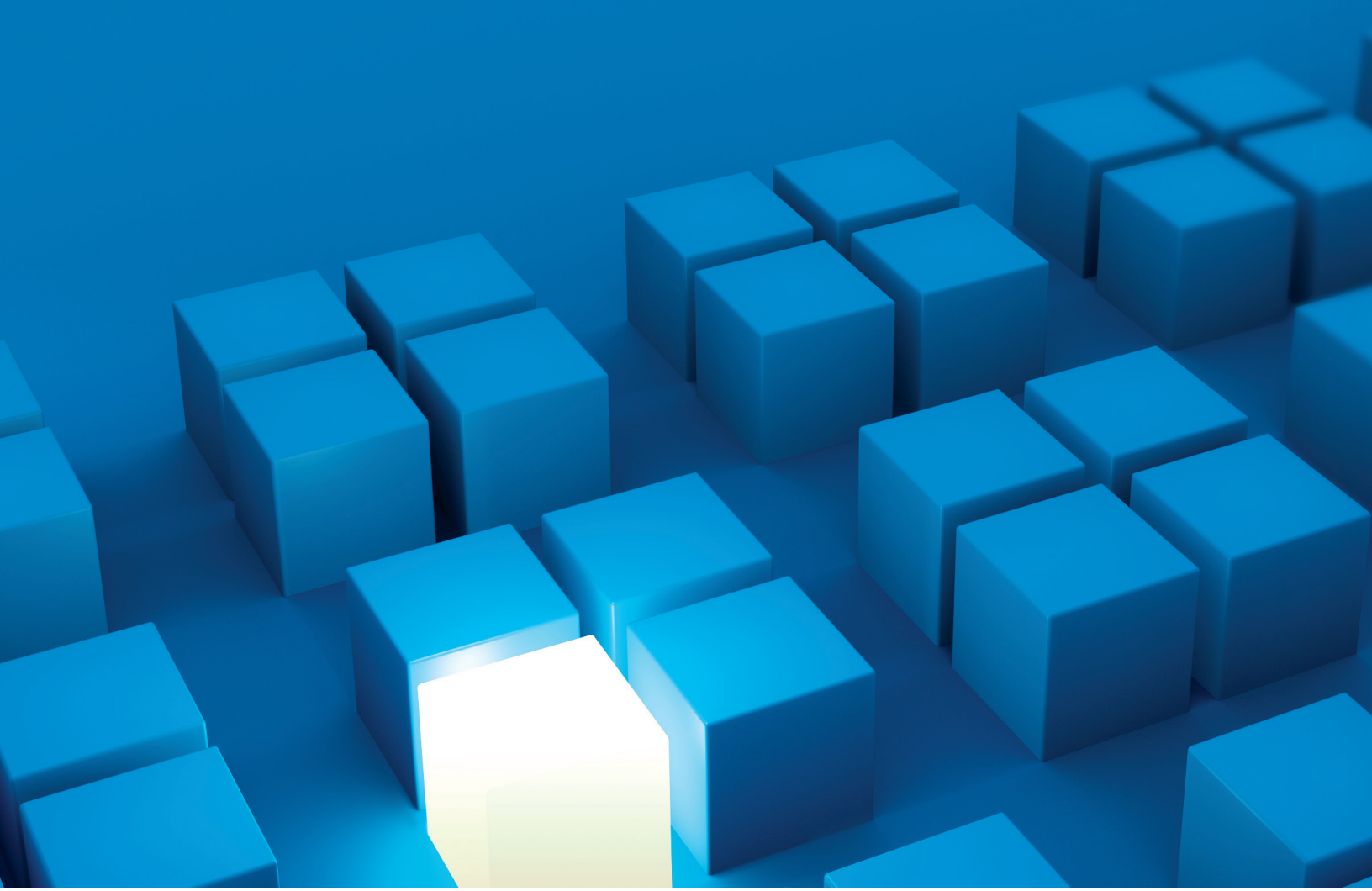


Lessons Learned from Auctions 1 & 2

Pilot Auction Facility for Methane and Climate Change Mitigation

By Benjamin Chee and Chantale LaCasse

Insight in Economics™



Acknowledgements

The authors gratefully acknowledge the World Bank team of Scott Cantor, Tanguy De Bienassis, Stephanie Rogers, and Caroline Ott for the many discussions guiding the auction design choices and parameters that had to be considered throughout the auction process, and for their invaluable input throughout the course of developing this report. Their contributions brought the PAF from concept to fruition.

Lastly, the authors are grateful to the NERA team for this assignment, which consisted of Alexandra Bowe, Stephen Buryk, Paul Cardona, Elizabeth Elcan, Molly Glandon, Dahye Han, Whitney Mann, Rachel Northcutt, Katie Orlandi, and Pa Ye who worked tirelessly and with unbounded enthusiasm in the management of the auctions held by the PAF, and to Michael Abernethy from Optimal Auctions for programming and technical support.

Lessons Learned from Auctions 1 & 2

Pilot Auction Facility for Methane and Climate Change Mitigation

By Benjamin Chee and Chantale LaCasse

September 18, 2017

Executive Summary

The Pilot Auction Facility for Methane and Climate Change Mitigation ("PAF") was created on the basis of the findings of a report from the Methane Finance Study Group, an international group of experts convened in 2012 at the request of the G8 to review innovative financing approaches to methane abatement. The Methane Finance Study Group estimated that, across all developing countries, methane projects could reduce as much as 8,200 million tCO_2e at less than $10 per ton in incremental cost financing, and recommended (among other things) the creation of a methane abatement facility that would auction put options to guarantee a floor value on independently verified emission reductions ("ERs").[1] The World Bank Group serves as Secretariat and Trustee for the PAF. NERA Economic Consulting ("NERA"), in its role as the auction manager, developed the detailed auction rules for the auctions and managed the development of the online auction platform held by the PAF. The PAF successfully held three auctions in July 2015, May 2016 and January 2017. The goal of this report is to compare and contrast the structure and results of the first two auctions.

In Article I, we explain the two key elements of the PAF. The first element is a tradable put option for emission reductions that is structured in the form of a zero-coupon puttable bond called a "PAF Emission Reduction Note" or "PAFERN". The second element is an auction platform that provides a transparent means of allocating and determining the value of the PAFERNs and the value of the ERs to be surrendered for payment under the PAFERNs.

Bidders participate in the auction to purchase PAFERNs. Winning bidders purchase the PAFERNs at the issue price. On their maturity date, the PAFERNs give the winning bidders the right, but not the obligation, to deliver qualifying ERs to the PAF in return for receiving a payment. This payment, less the price a winning bidder pays for the PAFERNs, locks in an effective guaranteed floor value for ERs, but does not prevent winning bidders from selling their ERs in the open market if they can get a better price during the redemption period of the PAFERNs. The PAFERNs are designed to be tradable, enabling winning bidders to transfer ownership and maximize the likelihood that the PAF achieves emission reductions.

Throughout the report, we use the term "put option" to refer to the PAFERN and terms such as the "option's premium" and "option's strike price" to refer to the issue price and payment under the terms of the PAFERN, respectively. While we caution the reader that the PAFERN is not a put option, it is a puttable bond that functions like a put option, and, as such, we use the terms associated with a put option in the interest of simplicity and readability.

In Article II, we describe the elements of the program and design choices in each of the two auctions. Many parameters and process elements were similar across the two auctions, which allows for a meaningful comparison of the results given the elements of the auction that do change.

Both auctions used a clock auction format. A clock auction proceeds in a series of rounds. In a round, bidders state how many put options they are willing to buy given the option's premium and the option's strike price. If bidders in aggregate are willing to purchase more than the number of options available, the economic proposition of the options is made less attractive in the next round (by increasing the option's premium or reducing the option's strike price) and bidders have another opportunity to state how many options they are willing to buy. This process continues until there are just enough options available to satisfy the demand.

Given that the auction is designed to set the effective guaranteed floor value of the ERs under a put option framework, the floor value may be determined either by fixing the option's premium and allowing bidders to bid down the option's strike price, or alternatively by fixing the option's strike price and allowing bidders to bid up the option's premium. The item (either the option's premium or the option's strike price) that bidders are bidding on is known as the "bid product" in the auction. The central difference between the two auctions is that the first auction used the strike price as the bid product (i.e., bidders bid down the payment to be received for qualifying ERs under the PAFERNs) while the second auction used the premium as the bid product (i.e., bidders bid up the issue price to be paid to purchase the PAFERNs).

In Article III, we discuss participation characteristics and auction results across the two auctions. The auctions were successful in attracting 28 bidders to participate in the first auction and 21 bidders to participate in the second auction.

Both auctions featured a diversity of bidders in relation to size as measured by the number of PAFERNs that a bidder was eligible to bid in the first round of the auction. However, the second auction featured a higher proportion of "larger" bidders, which suggests these are better capitalized entities bidding for multiple projects.

In the first auction, a total of $20.9 million was allocated for the exchange of about 8.69 million ERs and there was about $4.1 million of budget unspent, referred to as the "undersell". The premium was fixed at $0.30 per ER and the auction determined the strike price of $2.40 per ER. In the second auction, $20 million was allocated for the exchange of about 5.71 million ERs and there was no undersell. The strike price was fixed at $3.50 and the auction determined the premium of $1.41 per ER. Based on the premium and strike price in each auction, the effective guaranteed floor value was $2.10 per ER in the first auction and $2.09 per ER in the second auction – almost identical results.

In Article IV, we provide four key findings. First, the featured bid product attracted different types of bidders, and there were not many bidders from the first auction that returned to participate in the second auction. While there was a diversity of large and small bidders in both auctions, the second auction attracted a higher number of larger bidders, which appears to reflect the higher cost of participation in the second auction. Bidders that may not be able to meet the upfront payment for PAFERNs in the second auction may have chosen not to participate, and these bidders are more likely to be smaller entities that are not as well capitalized. Notwithstanding this difference in the bidder pool, both bid products given the auction format were equally effective in achieving price discovery and, as we noted, the results are almost identical between the two auctions.

Second, the optional feature of proxy bidding offered in both auctions was not used by most bidders and was not used in the manner that was expected. Proxy bidding is an optional feature by which the auction software can place bids on behalf of a bidder on the basis of a pre-determined threshold price provided by the bidder, and allows the bidder to submit its best and final offer prior to the start of bidding. The clock auction is a multiple round auction that typically lasts for several hours. Given the nature of the PAF, which attracted bidders internationally, proxy bidding was provided as a convenience for bidders that may be in a time zone where bidding would not take place during normal business hours. However, in both auctions, bidders that elected proxy bidding were not in those time zones that would have found the auction schedule particularly inconvenient. Bidders that submitted proxy bids were generally small bidders and none of the bidders that elected proxy bidding won at the auction.

Third, while both bid products, given the auction format, achieved almost identical results, whether one chooses to feature the option's strike price or the option's premium as the bid product may depend on program objectives. In general, the use of the strike price as the bid product (and hence the use of the descending clock auction format as featured in the first auction) will allow the program to transact for a greater quantity of potential emission reductions quicker. However, in this case, given the use of the strike price as the bid product in the descending clock auction will require the premium to be fixed, setting the premium at an appropriate level will be an important decision because if the premium is set too low, the risk of winners not trading the PAFERNs and not delivering the ERs will be greater. Ideally, the premium should be set so that it provides sufficient incentives to encourage the delivery of the ERs during the redemption period, but not so high that it becomes a barrier to participation.

Lastly, in using the strike price as the bid product as featured in the first auction, there is a higher risk that there could be budget left unspent in the final round unless additional complexity is added to the bidding rules. This unspent budget is commonly known as an "undersell", and is exacerbated by the fact that the quantity available to be purchased increases as the strike price ticks down. In contrast, simple rules can be implemented to limit the possibility of an undersell if the premium is used as the bid product in an ascending clock auction as featured in the second auction. In this case, a key decision to be made is the level in which to fix the strike price as this will fix the quantity of put options available to be purchased by bidders in the auction, which will not change across the rounds of the auction.

In Article V, we provide our conclusions based on our findings. Given both bid products and the associated auction formats were equally effective in achieving market reflective prices, we conclude that:

- If a priority is to encourage participation from a wide range of bidders, or if the objective is to transact for a greater quantity of potential emission reductions quicker, then the use of the strike price as the bid product as featured in the first auction should be considered ahead of the use of the premium as the bid product as featured in the second auction.
- If the objective is to ensure that the auction budget is fully spent in a single auction process while keeping bidding rules simple, then the use of the premium as the bid product as featured in the second auction should be considered ahead of the use of the strike price as the bid product as featured in the first auction. The fixed quantity of put options available to be purchased by bidders in the second auction limits the possibility of an undersell.

In regard to proxy bidding, this choice precludes bidders from incorporating auction information in their bidding strategy, which is a key feature of clock auctions to facilitate price discovery. This may have the unintended consequence of disadvantaging smaller, less sophisticated bidders. As an alternative, a well-paced auction that is sufficiently short may render moot the need to consider proxy bidding.

NERA hopes these lessons provide insights into the impact of various design choices that could prove useful for entities that want to replicate the PAF's successes for climate auctions in varying circumstances and program objectives.

I. Introduction

The Pilot Auction Facility for Methane and Climate Change Mitigation ("PAF") was created on the basis of findings of a report from the Methane Finance Study Group, an international group of experts convened in 2012 at the request of the G8 to review innovative financing approaches to methane abatement. Through its work, the Methane Finance Study Group identified 1,200 methane projects that were at risk of being decommissioned due to the low price of carbon credits. However, these projects required little additional revenue to continue their operations. The Methane Finance Study Group estimated that, across all developing countries, methane projects could reduce as much as 8,200 million tCO_2e at less than $10 per ton in incremental cost financing. To capture this opportunity, the Methane Finance Study Group recommended among other things the creation of a methane abatement facility that would auction put options to guarantee a floor value on independently verified emission reductions ("ERs").[2] One ER represents the successful emissions reduction equivalent to one metric ton of carbon dioxide equivalent (tCO_2e). The World Bank Group serves as Secretariat and Trustee for the PAF.

The PAF consists of two key elements. The first element is a tradable put option for emission reductions that is structured in the form of a zero-coupon puttable bond issued by the World Bank Group through the International Bank for Reconstruction and Development. This put option is called a "PAF Emission Reduction Note" or "PAFERN". Bidders participate in the auction to purchase PAFERNs. Winning bidders purchase the PAFERNs at the issue price. On their maturity date, the PAFERNs give the winning bidders the right, but not the obligation, to deliver qualifying ERs to the PAF in return for receiving a payment. This payment, less the price a winning bidder pays for the PAFERNs, locks in an effective guaranteed floor value for ERs, but does not prevent winning bidders from selling their ERs in the open market if they can get a better price during the redemption period of the PAFERNs. The PAFERNs are designed to be tradable, enabling winning bidders to transfer ownership which maximizes the likelihood that the PAF achieves emission reductions.[3]

Illustration

The price paid by winning bidders for the PAFERNs is called the issue price and represents the option's "premium". The payment made to the winning bidder under the PAFERNs is the option's "strike price". Suppose that:

- The option's premium is $0.50
- The option's strike price is $2.00
- The option's maturity date is December 31, 2020.
- Each option is associated with one ER.

A winning bidder would pay $0.50 to purchase the option and it would give the winning bidder the right on the maturity date to sell one ER at the strike price of $2.00 for a net benefit of $1.50 per ER ($2.00 - $0.50). Hence, the option provides a guaranteed floor value of $1.50 for each qualifying ER. The ERs may fetch a higher price in the open market and the winning bidder is free to take advantage of such opportunities.

The second element of the PAF, an auction platform, provides a transparent means of allocating and determining the value of the PAFERNs and the value of the ERs to be surrendered for payment under the PAFERNs. The competitive nature of the auction reveals the minimum price required by the private sector to make emission reduction investments, therefore maximizing the impact of public funds and achieving the highest volume of climate benefits per dollar. NERA Economic Consulting ("NERA"), in its role as the auction manager, developed the detailed auction rules for the auctions and managed the development of the online auction platform held by the PAF.

The PAF successfully held three auctions in July 2015, May 2016 and January 2017.

The Goal of this Report

The PAF aims to promote learning, replication, and scale. While the PAF's first two auctions tested its model in the methane sector, this model could be replicated elsewhere to incentivize emission reductions across a range of other sectors. On a country level, the model could be used by governments that need to meet commitments under the Paris Agreement. On the global level, the auction format could be scaled with increased funding for larger multi-country climate auctions. The World Bank Group will continue to pursue opportunities to replicate and scale the PAF model for climate results, targeting sectors and auction budgets beyond the piloting phase.

The goal of this report is to compare and contrast the structure and results of the first two auctions. NERA hopes the lessons provide insights into the impact of various design choices that could prove useful for entities that want to replicate the PAF's successes for climate auctions in varying circumstances and program objectives.

II. Program Elements

We start by describing the elements of the program and design choices in each of the two auctions. Many of the program elements are stable from the first auction to the second auction, but some elements are different. We then analyze whether those differences led to differences in the results.

Eligibility Criteria

The PAF only disburses funds once the emission reductions have been verified by a third party. In order for auction winners to redeem their PAFERNs, underlying projects must meet a set of requirements for how, where, and when emission reductions take place. The first auction targeted methane abatement activities registered under the United Nations-regulated Clean Development Mechanism ("CDM") that applied one of 35 eligible methodologies. The second auction targeted the same types of methane abatement activities as the first auction, but expanded eligibility beyond the CDM to include activities registered under the Verified Carbon Standard ("VCS") and the Gold Standard ("GS").

Budget

The put options are supported by funding from the PAF donors, which are Germany, Sweden, Switzerland, and the United States. The budget for the first auction was U.S.$25 million and for the second auction it was U.S.$20 million. The budget for an auction represents the total amount that can be paid to winning bidders in exchange for qualifying ERs during the redemption period of the PAFERNs. Thus, the budget divided by the strike price determines the number of ERs that can be received by the PAF during the redemption period of the PAFERNs.

Auction Format

The first two auctions held by the PAF used a clock auction format. A clock auction proceeds in a series of rounds. In a round, bidders state how many put options they are willing to buy given the option's premium and the option's strike price. If bidders in aggregate are willing to purchase more than the number of options available, the economic proposition of the options is made less attractive in the next round (by increasing the option's premium or reducing the option's strike price) and bidders have another opportunity to state how many options they are willing to buy. This process continues until there are just enough options available to satisfy the demand.

In general, the clock auction format is attractive in that it provides information to bidders in each round and allows bidders to revise their strategy if they wish on the basis of this information. The format is also simple for bidders to understand and encourages straightforward bidding so that the final price is reflective of market conditions.

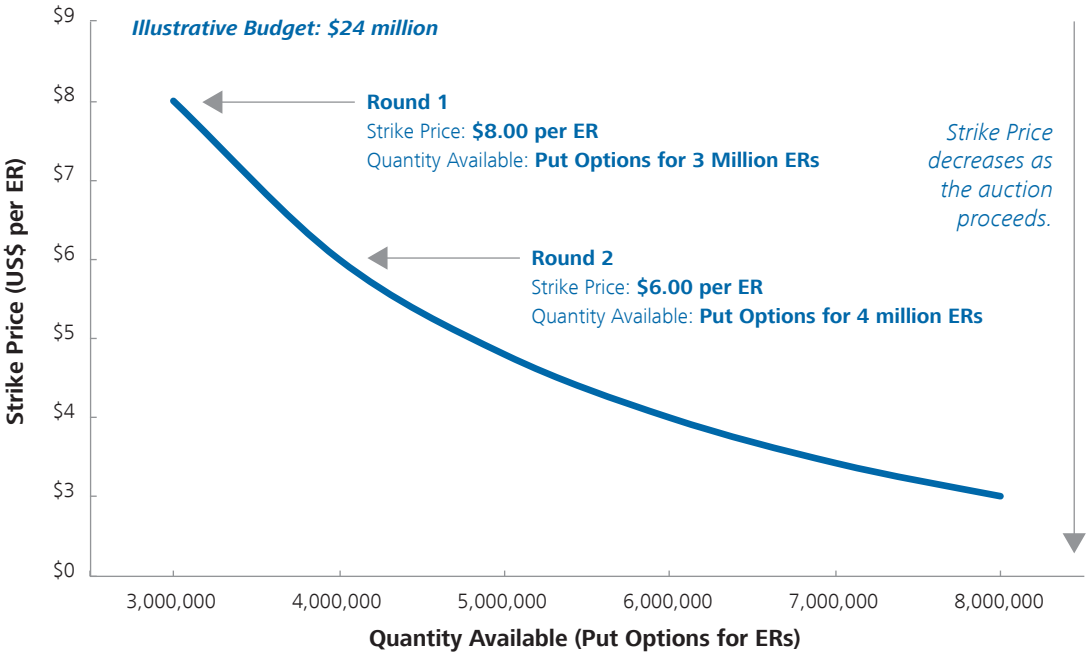
NERA managed the development of an online multiple round clock auction platform to facilitate the bidding of the first and second auctions held on July 15, 2015 and May 12, 2016, respectively.

Bid Product

Given that the auction is designed to set the floor value of the ERs under a put option framework, the floor value may be determined either by fixing the option's premium and allowing bidders to bid down the option's strike price, or alternatively by fixing the option's strike price and allowing bidders to bid up the option's premium. The item (either the option's premium or the option's strike price) that bidders are bidding on is known as the "bid product" in the auction. The central difference between the two auctions is that the first auction used the strike price as the bid product (i.e., bidders bid down the payment to be received for qualifying ERs under the PAFERNs) while the second auction used the premium as the bid product (i.e., bidders bid up the issue price to be paid to purchase the PAFERNs).

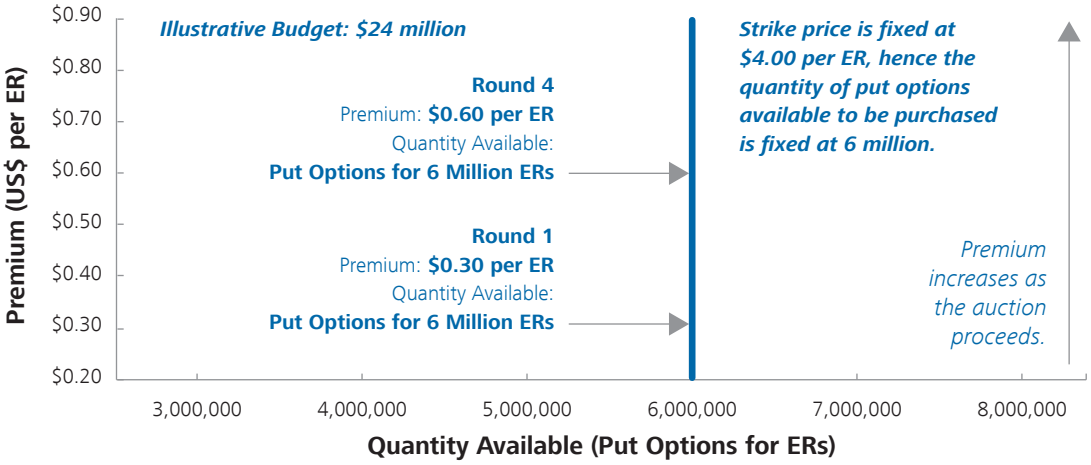
Thus, in the first auction, the PAF featured a descending clock auction where the option's premium is fixed in advance of the auction and bidders bid down the option's strike price. In a round, the auction manager announces a strike price and each bidder states the quantity of put options that the bidder is willing to buy at the premium given that strike price. If, in a round, the quantity that bidders bid in aggregate exceeds the quantity available to be purchased in that round, the auction proceeds to the next round and the auction manager announces a new reduced strike price and the new quantity available to be purchased in the new round. The quantity available to be purchased by bidders in the new round is equal to the budget divided by the strike price, and thus increases as the strike price is reduced. From one round to the next, bidders may maintain or reduce the quantity bid, but may not increase the quantity bid. Bidding continues and the strike price is reduced round by round until the quantity that bidders bid in aggregate equals to or falls short of the quantity available to be purchased. Based on the bids made by bidders in the final round, the winners as well as the strike price (and hence the guaranteed floor value of the ERs) are established.

Figure 1. **Quantity of Put Options Available to be Purchased Increases as the Strike Price is Reduced**



In the second auction, the PAF featured an ascending clock auction where the strike price is fixed in advance of the auction and bidders bid up the premium. In a round, the auction manager announces a premium and each bidder states the quantity of put options that it is willing to buy at that premium given the strike price. If, in a round, the quantity that bidders bid in aggregate exceeds the quantity available, the auction proceeds to the next round and the auction manager announces a new increased premium in the new round. From one round to the next, bidders may maintain or reduce the quantity bid, but may not increase the quantity bid. Bidding continues and the premium increases round by round until the quantity that bidders bid in aggregate equals to or falls short of the quantity available to be purchased. Based on the bids made by bidders in the final round, the winners as well as the premium (and hence the guaranteed floor value of the ERs) are established.

Figure 2. **Quantity of Put Options Available to be Purchased Remains the Same Regardless of Changes in Premium**



Bid Unit, the Minimum Bid, and the Maximum Bid

In the auctions, bidders bid to purchase PAFERNs and PAFERNs are sold in quantities denominated in "Bid Units". Each Bid Unit is associated with 10,000 ERs. For example, a winning bidder that is awarded 50 Bid Units would be entitled to exchange 500,000 ERs (i.e., 50 Bid Units x 10,000 ERs per Bid Unit) for payment under the terms of the PAFERNs. The size of the Bid Unit, namely 10,000 ERs, was the same in the first auction and the second auction.

In addition, the auction also specified a Minimum Bid and a Maximum Bid.

The Minimum Bid represents the minimum number of Bid Units that a bidder may purchase (and thus the minimum quantity for which the bidder may place a bid). Given the possibility that bidders may include project owners seeking to sell ERs associated with particular projects, the Minimum Bid mitigates the risk that a bidder may end up winning a small number of Bid Units that would not be useful because the bidder would only receive payment for an insignificant portion of ERs generated from the project. The Minimum Bid also discourages bidders lacking the minimum required capacity from participating in the auction process. The Minimum Bid was 10 Bid Units in the first auction and 20 Bid Units in the second auction.

The Maximum Bid represents the maximum number of Bid Units for which a bidder may place a bid. The Maximum Bid ensures that there would be multiple winners at the auction. Furthermore, the certainty that no one bidder would be able to win all of the Bid Units at the auction encourages participation by smaller bidders. The Maximum Bid was 200 Bid Units in the first auction and 250 Bid Units in the second auction.

Proxy Bidding

Proxy bidding is a feature by which the auction software can place bids on behalf of a bidder on the basis of a pre-determined threshold price provided by the bidder. In both the first and the second auctions, proxy bidding was offered as an optional feature to bidders. If the bidder elects proxy bidding, the bidder will not be able to subsequently place a bid actively in the rounds of the auction.

In the first auction, a proxy bid was a quantity of Bid Units and a pre-determined strike price (known as the proxy payment) below which the bidder was unwilling to buy PAFERNs. In the first round in which the strike price is below the proxy payment, the bidder is deemed to have withdrawn all Bid Units.

In the second auction, a proxy bid was a quantity of Bid Units and a pre-determined premium (known as the proxy price) above which the bidder was unwilling to buy PAFERNs. In the first round in which the premium is above the proxy price, the bidder is deemed to have withdrawn all Bid Units.

Bid Deposit

To participate in the auction, an applicant must provide a bid deposit. The bid deposit is collected prior to the auction date. The bid deposit serves to deter bidders that may win at the auction from reneging on their obligation to follow through on the post-auction payment of the issue price (i.e., option's premium) to purchase the PAFERNs.

The deposit is refunded to bidders that fail to qualify or that fail to win at the auction. If a bidder wins at the auction and becomes a successful bidder, the bidder must purchase the PAFERNs at the issue price. The bid deposit amount is applied to this purchase amount.

The amount of the bid deposit in the first auction and in the second auction was identical at U.S.$600 per Bid Unit based on the maximum number of Bid Units for which the bidder intends to place a bid. The bidder's initial eligibility at the auction, which is the greatest number of Bid Units that a bidder may bid in round 1, is simply equal to the bid deposit paid by that bidder divided by U.S.$600.

Summary of Auction Parameters and Process Elements

Table 1 below provides a comparison of the key auction parameters and process elements for the two auctions.

Table 1. **Auction Parameters**

Auction Date	**July 15, 2015**	**May 12, 2016**
Bid Product	Strike Price	Premium
Premium	Fixed at U.S. $0.30 per ER	
Strike Price		Fixed at U.S. $3.50 per ER
Auction Format	Multiple Round Clock Auction (Descending)	Multiple Round Clock Auction (Ascending)
Eligibility	CDM	CDM + VCS + GS
Budget	U.S. $25 million	U.S. $20 million
Bid Unit	A series of 5 PAFERNs (equivalent to 10,000 ERs)	A series of 4 PAFERNs (equivalent to 10,000 ERs)
Number of Bid Units available in round 1	312 Bid Units	571 Bid Units
Proxy Bidding	Available for use by Bidders	Available for use by Bidders
Minimum Bid	10 Bid Units (equivalent to 100,000 ERs)	20 Bid Units (equivalent to 200,000 ERs)
Maximum Bid	200 Bid Units (equivalent to 2,000,000 ERs)	250 Bid Units (equivalent to 2,500,000 ERs)
Bid Deposit	U.S. $0.06 per ER (equivalent to $600 per Bid Unit)	U.S. $0.06 per ER (equivalent to $600 per Bid Unit)

As shown above, many parameters and process elements were similar across the two auctions, which allows for a meaningful comparison of the results given the elements of the auction that do change. For example, the bid deposit, the election of proxy bidding as well as the number of ERs associated with each Bid Unit is the same across both auctions, while other elements such as key eligibility requirements, the Minimum Bid, and the Maximum Bid are similar but not identical.

The change in the bid product from the strike price to the premium, and hence the change in the auction format from a descending clock auction format to an ascending clock auction format, is the most significant change between the two auctions.

III. Participation Characteristics and Auction Results

Participation in the Auctions

Table 2 below provides a summary of participation and bidder characteristics.

Table 2. **Bidder Characteristics**

Auction Date		**July 15, 2015**	**May 12, 2016**
No. of Bidders		28	21
No. of Countries Represented		17	12
No. of Proxy Bidders		4	1
No. of Winners		12	9
% of Bidders are Winners		43 %	43 %
Bidders with Initial Eligibility:	Bid Units	Number of Bidders	
	< 30	10	5
	30 – 75	6	5
	76 – 125	6	2
	> 125	6	9
Winners with Initial Eligibility:	Bid Units	Number of Winners	
	< 30	3	1
	30 – 75	2	2
	76 – 125	2	2
	> 125	5	4

The auctions were successful in attracting over 20 bidders in each auction. The number of bidders and number of countries represented were reduced between the first auction (28 bidders from 17 countries) and the second auction (21 bidders from 12 countries). The number of winners was reduced proportionately (from 12 winners in the first auction to 9 in the second auction). In each auction, 43% of the bidders that qualified to participate won Bid Units.

One way to characterize bidders is by "size" as measured by the number of Bid Units that bidders were willing to purchase at the beginning of the auction. This is known as the bidder's initial eligibility at the auction. As discussed above, the bidder's initial eligibility at the auction is simply equal to the bid deposit paid by that bidder divided by U.S.$600. Both auctions featured a diversity of bidders in relation to the initial eligibility. However, the second auction featured a higher proportion of "larger" bidders with initial eligibility greater than 125 Bid Units, which suggests these are better capitalized entities bidding for multiple projects.

Auction Results

Table 3 shows the results of the two auctions.

Table 3. **Summary of Results**

Auction Date	**July 15, 2015**	**May 12, 2016**
No. of Rounds	11	10
	Bid Units	
Total Won	869	571
Minimum Won	10	20
Maximum Won	200	147
Average Won	72	63
Median Won	48	56
	U.S. $	
Premium	0.30 per ER	1.41 per ER
Strike Price	2.40 per ER	3.50 per ER
Net Value	2.10 per ER	2.09 per ER
Budget Spent	20.90 million	20.00 million

In the first auction, the budget was $25 million, for which a total of $20.9 million was allocated for the exchange of about 8.69 million ERs. There was about $4.1 million in undersell. The auction lasted 11 rounds. The premium was fixed at $0.30 per ER and the auction determined the strike price of $2.40 per ER. Based on this, the effective guaranteed floor value was $2.10 per ER. On average, each winning bidder was awarded 72 Bid Units and the median award was 48 Bid Units.

In the second auction, the budget was $20 million, all of which was allocated for the exchange of about 5.71 million ERs and there was no undersell. The auction lasted 10 rounds. The strike price was fixed at $3.50 and the auction determined the premium of $1.41 per ER. Based on this, the effective guaranteed floor value was $2.09 per ER. On average, each winning bidder was awarded 63 Bid Units and the median award was 56 Bid Units.

IV. Lessons Learned

Finding 1: **The featured bid product attracted different types of bidders, but both bid products given the auction format were equally effective in achieving price discovery**

Given the success of the first auction, the expectation was that many of the bidders that participated in the first auction would return. However, this was not the case. In fact, only 8 of the 28 bidders that participated in the first auction returned for the second auction, and only 4 of the 12 winning bidders from the first auction returned. Interestingly, of the 8 bidders that participated in both auctions, none were winners in both auctions.

In general, the differences in the auction design features and parameters between the first auction and the second auction attracted bidders of visibly different characteristics. The first auction featured a descending clock auction format where bidders bid down the option's strike price whereas the second auction featured an ascending clock auction format where bidders bid up the option's premium. In the first auction the premium was fixed at $0.30 per ER, and in the second auction the premium determined through the auction was $1.41 per ER. The winning bidders in the second auction had to pay $1.41 per ER for the PAFERNs regardless of whether they would exercise the option compared to a premium of only $0.30 per ER that winning bidders in the first auction had to pay. While there was a diversity of large and small bidders in both auctions, the second auction attracted a higher number of bidders with larger initial eligibilities. This appears to reflect the higher cost of participation in the second auction. Bidders that may not be able to meet the upfront payment may choose not to participate, and these bidders are more likely to be smaller entities that are not as well capitalized.

While the bid product drew different types of bidders, both auctions were equally effective in encouraging straightforward bidding by bidders and in achieving a market reflective price:

- The results from the two auctions are almost identical. Given the structure of the PAFERN as a zero-coupon puttable bond, the net value of the PAFERNs to bidders is simply the strike price less the premium of the put option. This value corresponds to $2.10 per ER in the first auction and $2.09 per ER in the second auction. This is a result of strong competition with 28 bidders participating in the first auction and 21 bidders participating in the second auction.
- There were many winning bidders in each auction such that about 43% of bidders that qualified in each auction won. There were 12 winning bidders in the first auction and 9 winning bidders in the second auction – and no bidder won in both auctions.

- There was diversity among the winning bidders, including a good mix of small and larger winning bidders in each auction. This means that while the bid product and the auction format attracted different types of bidders to the auction, it did not necessarily favor a particular type of bidder.
- Of the 8 bidders that participated in both auctions, we found no evidence that suggested that these bidders had different bidding strategies across the two auctions.

Finding 2: **A well-paced auction that is sufficiently short may render moot the need to provide proxy bidding as an optional feature**

The clock auction is a multiple round auction that typically lasts for several hours. Given the nature of the PAF, which attracted bidders internationally, proxy bidding was provided as a convenience for bidders that may be in a time zone where bidding would not take place during normal business hours. For example, an auction held between 7AM and 11AM New York time would require a bidder in Wellington, New Zealand to submit a bid in each round of the auction between 11PM and 3AM local time. Instead, such a bidder could elect proxy bidding, which would allow the bidder to submit its best and final offer prior to the start of bidding. The downside of such a choice is that once a bidder elects proxy bidding, the bidder is not able to change its bid on the basis of the information provided to bidders during the course of the auction.

In the first auction, a proxy bid was a quantity of Bid Units and a pre-determined strike price below which the bidder was unwilling to buy PAFERNs. In the second auction, a proxy bid was a quantity of Bid Units and a pre-determined premium above which the bidder was unwilling to buy PAFERNs. Proxy bidding was not used to the extent expected in either the first auction or the second auction.

- Proxy bidding was used by 4 bidders in the first auction and 1 bidder in the second auction.
- Bidders that elected proxy bidding were not in those time zones that would have found the auction schedule particularly inconvenient.
- Bidders that submitted proxy bids were generally small bidders.
- None of the bidders that elected proxy bidding won at the auction.

Thus, it appears that proxy bidding, as a means to avoid placing bids at inconvenient times of the day, is not one that was of value to bidders. This may be because bidders valued the information that was provided to them during the auction rounds more highly than the convenience of placing a single bid at a particular time.

One benefit of a clock auction format is that bidders are provided with certain aggregate information regarding bids, including information on aggregate demand after each round. This feature is particularly important in that it encourages price discovery and allows bidders to account for aggregate auction information in their own bidding strategy so that the final price incorporates this information.

Proxy bidding was elected generally by smaller entities, but not those entities that were in time zones that would have found the auction schedule particularly inconvenient. This suggests that proxy bidding was selected by entities that may not have had the sophistication to integrate aggregate auction information into their bidding strategy or that did not expect their valuations to change on the basis of such information. Such bidders elected proxy bidding due to the ease of submitting a simple final and best offer prior to the first round. In light of this, a key finding is that offering bidders a more sophisticated multi-tier proxy bid structure, which would allow bidders to submit multiple quantities and price points, would probably be of little value given that the bidders that elected proxy bidding appeared to be those bidders with bidding strategy of a lesser degree of sophistication and those bidders that bid on fewer Bid Units, perhaps corresponding to a single project.

Based on these observations, the option of proxy bidding seems to be of little value and unnecessary as long as the auction is well paced and sufficiently short.

Finding 3: **If a primary objective is to transact for a greater quantity of potential emission reductions quicker, then the bid product and auction format of the first auction should be preferred**

In each auction, the auction budget consisting of contributions by the PAF donors was used to determine the quantity of put options that is available to be purchased by bidders and hence the quantity of ERs that could be received by the PAF. This quantity is calculated as the budget divided by the strike price.

In the first auction, as the strike price is reduced through the rounds of the auction, the quantity of put options available to be purchased by bidders increases (see figure 1). This is not possible in the second auction as the strike price is fixed and hence the quantity of put options that is available to be purchased by bidders is fixed and does not increase over the rounds of the auction. The budget therefore corresponds to the amount of money that would be paid to winning bidders should all of the put options purchased be exercised.

While the premium to be collected could be added to the budget to determine the quantity of put options available to be purchased by bidders in each round of the auction, the PAF has not done so because such calculation would be based in part on money that has not yet been collected.

In principle, the premium collected post-auction could be used towards buying more ERs through the issuing of more put options in a secondary process. After accounting for the premium collected, and assuming the net value of the put options is the same, the quantity of ERs that can be received by the PAF would be the same regardless of whether the auction featured the option's strike price or the option's premium as the bid product.

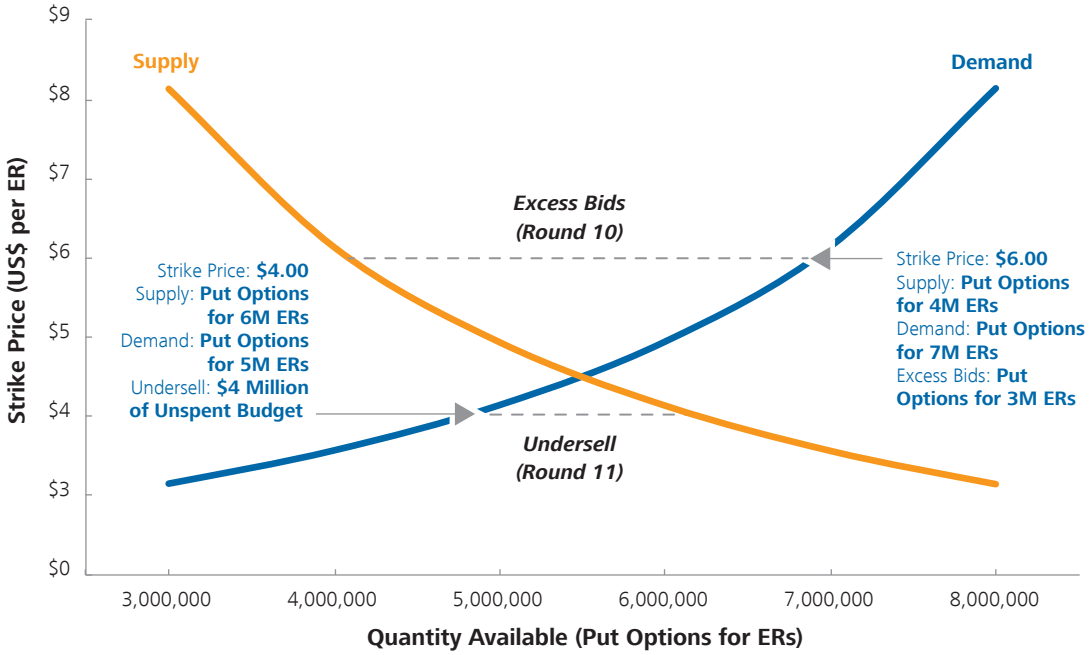
Based on this observation, we find:

- Whether one chooses the option's strike price or the option's premium as the bid product may depend on program objectives. The use of the strike price as the bid product allows for the possibility that the program will transact for a greater quantity of potential emission reductions quicker if the premium is set low enough that it does not become a barrier for bidders to meet as an upfront payment.
- Given that the descending clock auction format will require the premium to be fixed, setting the premium at an appropriate level will be important. The expectation is that if the premium is set too low, then the risk of winners not trading the PAFERNs and not delivering the ERs will be greater. Ideally, the premium should be set so that it provides sufficient incentives to encourage the delivery of the ERs during the redemption period, but not so high that it becomes a barrier to participate in the auction.
- Given the higher premium paid by winning bidders in the second auction vis-à-vis the winning bidders in the first auction, it is expected that winning bidders from the second auction will be more likely to deliver qualifying ERs for payment or trade the PAFERNs.

Finding 4: **If a primary objective is to maximize the allocation of the budget while keeping bidding rules simple, the option's premium should be preferred as the bid product**

In the first auction, given the nature of the bid product (namely the strike price) in the determination of the quantity of put options available to be purchased by bidders, there is a higher risk that there could be budget left unspent and quantities not purchased in the final round unless additional complexity is added to the bidding rules. This unspent budget is commonly known as an "undersell", and is exacerbated by the fact that the quantity available to be purchased increases as the strike price ticks down.

Figure 3. **Higher Risk of an Undersell with the Strike Price as the Bid Product**



Illustration

Round	Strike Price per ER	Supply (Quantity of Put Options Available)	Demand (Quantity Bids)	Excess/Unsold Quantity
10	$6.00	4,000,000 ERs	7,000,000 ERs	3,000,000 ERs
11	$4.00	6,000,000 ERs	5,000,000 ERs	(1,000,000 ERs)

When Strike Price ticked down to $4.00 per ER in Round 11, bidders withdrew bids for a quantity of put options associated with 2,000,000 ERs. The auction ends, but there is an undersell of $4 million (corresponding to a strike price of $4 and an unsold quantity of put options associated with 1,000,000 ERs).

In the second auction, the quantity of put options available to be purchased by bidders is fixed (given that the strike price is fixed). With a fixed quantity, simple rules can be implemented to limit the possibility of an undersell. Given that the specified strike price will set the quantity of put options available to be purchased by bidders, the decision regarding setting the level of the strike price is an important one as we consider the use of the premium as the bid product.

As an alternative, a descending clock auction format under a multi-solicitation process could feature a fixed quantity structure where the quantity of put option available to be purchased is fixed and does not increase with each reduction in the strike price. In this case, the amount of unspent budget would simply be added to the budget for the next auction under the multi-solicitation process.

V. Conclusion

One key difference between the first auction and the second auction held by the PAF is that the first auction featured the strike price as the bid product (hence the use of a descending clock auction format) where bidders bid down the strike price while the second auction featured the premium as the bid product (hence the use of an ascending clock auction format) where bidders bid up the premium. Given both bid products and the associated auction formats were equally effective in achieving market reflective prices, we conclude based on our findings that:

- If a priority is to encourage participation from a wide range of bidders, or if the objective is to transact for a greater quantity of potential emission reductions quicker, then the use of the strike price as the bid product as featured in the first auction should be considered ahead of the use of the premium as the bid product as featured in the second auction.
- If the objective is to ensure that the auction budget is fully spent in a single auction process while keeping bidding rules simple, then the use of the premium as the bid product as featured in the second auction should be considered ahead of the use of the strike price as the bid product as featured in the first auction. The fixed quantity of put options available to be purchased by bidders in the second auction limits the possibility of an undersell.

In regard to proxy bidding, this choice precludes bidders from incorporating auction information in their bidding strategy, which is a key feature of clock auctions to facilitate price discovery. This may have the unintended consequence of disadvantaging smaller, less sophisticated bidders. As an alternative, a well-paced auction that is sufficiently short may render moot the need to provide proxy bidding as an optional feature.

Notes

[1] World Bank. 2013. *Methane finance study group report: using pay-for-performance mechanisms to finance methane abatement*. Washington DC: World Bank

[2] World Bank. 2013. *Methane finance study group report: using pay-for-performance mechanisms to finance methane abatement*. Washington DC : World Bank

[3] Throughout the report, we use the term "put option" to refer to the PAFERN and terms such as the "option's premium" and "option's strike price" to refer to the issue price and payment under the terms of the PAFERN, respectively. While we caution the reader that the PAFERN is not a put option, it is a puttable bond that functions like a put option and as such, we use the terms associated with a put option in the interest of simplicity and readability.

About the Authors

NERA Director Benjamin Chee and Managing Director Chantale LaCasse led the NERA team responsible for the detailed design choices and implementation of the auctions held by the World Bank's Pilot Auction Facility for Methane and Climate Change Mitigation ("PAF"). The NERA team consists of market design and auction implementation specialists passionate about making competition work. The NERA team has been involved in the successful design and implementation of over 200 auctions and competitive bid processes.

Chantale and Ben advise on market design issues, and have specific expertise in introducing competitive mechanisms including auctions in new sectors to the benefit of ratepayers and program sponsors. At NERA, Chantale and Ben provide end-to-end auction management services including bid product design, choice of auction format, market assessment and benchmarking, development of bidder documents, contract and credit requirements, regulatory support, stakeholder engagement, bidder communications, bidder qualifications, bid evaluation, and post-bid contract administration. The NERA team has a long history of working with utilities, regulators, governments, and state agencies to design and implement competitive bid processes across a wide variety of sectors.

Inquiries may be directed to:

Benjamin H. Chee
NERA Economic Consulting
1166 Avenue of the Americas, 24th Floor
New York, New York 10036
Tel: +1 212 345 0091
benjamin.chee@nera.com

About NERA

NERA Economic Consulting (www.nera.com) is a global firm of experts dedicated to applying economic, finance, and quantitative principles to complex business and legal challenges. For over half a century, NERA's economists have been creating strategies, studies, reports, expert testimony, and policy recommendations for government authorities and the world's leading law firms and corporations. We bring academic rigor, objectivity, and real world industry experience to bear on issues arising from competition, regulation, public policy, strategy, finance, and litigation.

NERA's clients value our ability to apply and communicate state-of-the-art approaches clearly and convincingly, our commitment to deliver unbiased findings, and our reputation for quality and independence. Our clients rely on the integrity and skills of our unparalleled team of economists and other experts backed by the resources and reliability of one of the world's largest economic consultancies. With its main office in New York City, NERA serves clients from more than 25 offices across North America, Europe, and Asia Pacific.

Contacts

For further information, please contact:

Dr. Chantale LaCasse
Managing Director
Washington, DC: +1 202 466 9218
chantale.lacasse@nera.com

Benjamin H. Chee
Director
New York: +1 212 345 0091
benjamin.chee@nera.com

NERA
ECONOMIC CONSULTING

Visit **www.nera.com** to learn more about our practice areas and global offices.