White Paper

Renewables in Performance Incentivized Markets

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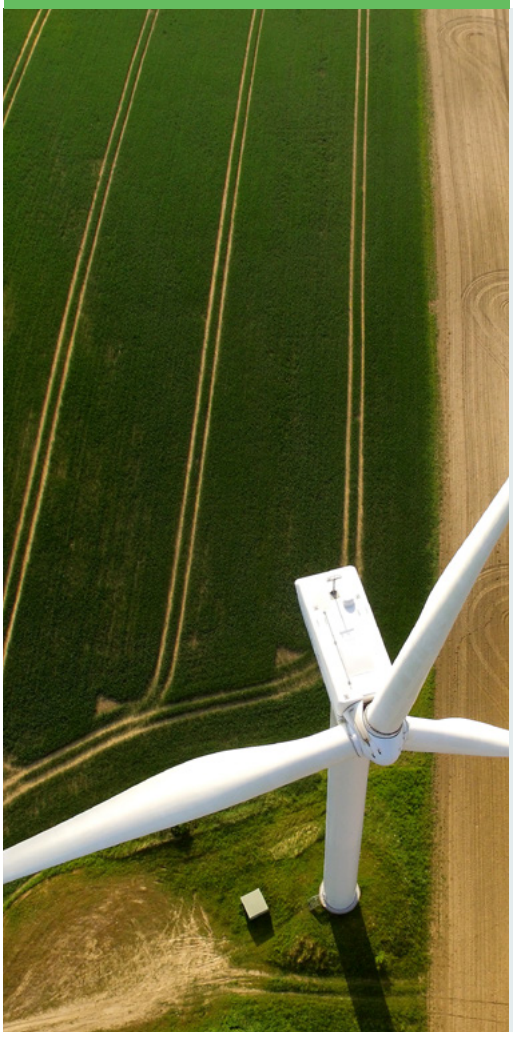


Shareables

- While the two-settlement processes for capacity payments rolled out by PJM and ISO-NE create uncertainty for variable output resources, they might not have any significant detrimental impact on their development.
- For renewables, performance-incentivized capacity markets present increased risk; however, potential new monetary opportunities from over-performance could outweigh the underlying risks.
- Carefully developed bidding strategy is required—bids must take into account risk tolerance, grid and unit output profiles, and capacity prices.

Executive Summary

The capacity market provides "missing money" for resources and supplements energy market sales. Resources, including renewables, recover a portion of their fixed and capital costs from the capacity market after netting energy margins. Some market participants believe that the implementation of performance incentives in the PJM and ISO-NE capacity markets will detrimentally impact the economics and development of variable output resources, namely wind and solar. Many market participants are concerned that the penalties associated with underperformance would outweigh the base capacity revenues for such resources. Furthermore, they are concerned that the uncertainty over net payment after penalties complicates planning. However, this structure may be

less at odds with renewables than expected for several reasons. First, renewable resources can actually reap additional benefits through bonus payments for the large portion of their capacity that is uncommitted. These bonuses depend on several factors, such as their performance and the performance of other units. Second, independent system operators (ISOs) provide more flexibility to renewable resources than thermal resources in the capacity markets. Third, any adverse effects are limited because of the secondary role capacity payments have played for these resources. This is in part because these resources often have an additional mechanism, compared to a thermal resource, to meet their missing money requirements, namely renewable energy credit (REC) markets.

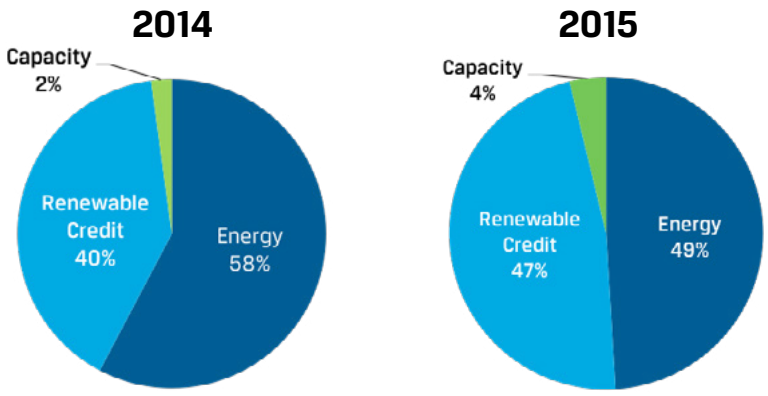
Participation of Renewables in Capacity Markets Before the Introduction of Performance-Incentivized Market Structures

Capacity revenues for renewable generators are based on their output during peak/reliability periods. For example, in PJM, an applicable rating (Unforced Capacity—UCAP) is established for intermittent resources based on their average June to August peak-hour availability over three years. In ISO-NE, the ISO determines the summer and winter qualified capacity levels. For a new resource, the qualified amount is based on site performance, and for existing resources, it is based on the energy produced during defined reliability hours.

Prior to pay-for-performance (PI) in ISO-NE and capacity performance (CP) in PJM, intermittent resources' capacity revenues could be estimated based on their UCAP megawatts and the auction price. In both the PJM and ISO-NE capacity markets, such resources were not subject to any significant penalties for underperformance. Thus, once the amount of capacity and price were established, the resource could rely on that income stream. However, due to their more limited capacity contribution (i.e., significantly lower UCAP than installed capacity rating) and great source of revenue options, capacity revenue has not historically been a significant portion of total revenue. Exhibit 1 shows the breakdown of revenue for a wind unit in ComEd in 2014 and 2015 from PJM's 2015 State of the Market Report. As can be observed, capacity revenue accounts for only approximately 4% of a wind unit's total revenue on average.

Note: PJM calculates energy market net revenues for a new wind installation on an hourly basis by assuming that the unit was generating at an average capacity factor if 75% of existing wind units in the zone were generating power in that hour. PJM also assumes revenue from Production Tax Credit of $23/MWh, $1/MWh from Investment Tax Credit and $.81/MWh from RECs.

EXHIBIT 1: NET REVENUE FOR A WIND UNIT IN COMED ($/MW-YR)



Source: PJM 2015 State of the Market Report

Participation of Renewables Under a Performance-Incentivized Market Structure

A performance-incentivized capacity market involves a two-settlement process. The first settlement provides the base capacity payment, and the second settlement redistributes payments from underperforming resources (penalties) to overperforming resources (bonuses). All committed resources are assessed for their performance during emergency (scarcity) events and bear all financial burden of a penalty if they fail to meet their capacity commitment. However, under the new regime, variable-energy resources have the flexibility to commit any amount of capacity from zero to their prior de-rated MW level (i.e., UCAP level), but not higher. Any bid of capacity above zero exposes the plant to penalties proportionate to the extent that its output is below its cleared capacity level. This new system adds financial risk where there was previously guaranteed revenue.

For example, in PJM's 2019/2020 BRA, the financial penalty in the worst case scenario far exceeds the potential capacity payment. At the PJM RTO CP clearing price of $100/MW-day, a 100 MW wind resource portfolio could earn $475,000[1] in capacity payments accounting for an 87% capacity de-rate or a 13% credit.[2] On the other hand, if the entire portfolio fails to perform during all scarcity hours, it could incur a maximum underperformance penalty of $1 million,[3] assuming a penalty rate of $3,245/MWh[4] and 30 scarcity hours.[5]

In ISO-NE, a 100 MW resource with capacity de-rate of 80% (capacity credit of 20%) would potentially earn $1.6 million in capacity revenue (based on the FCA#10 price of $7.03/kW-mo).[6] However, with a penalty rate of $2,000/MWh,[7] it could potentially face a maximum penalty of $660,000[8] if it does not perform in any of the ICF-assumed 20 scarcity hours.[9] While not as extreme as the PJM example,

[1] 100 MW *13%* $100/MW-day* 365 days.

[2] ISO de-rates the capacity of renewable resources to account for their variable output, thereby reducing their contribution to peak demand. For example, PJM applied a 13% capacity factor for wind and a 38% capacity factor for solar, respectively.

[3] Penalties/bonuses are calculated by penalty rate* (actual performance – capacity supply obligation* balancing ratio) *scarcity hour.

[4] Penalty rate is calculated as (net cone number of days in delivery year)/30 hours.

[5] PJM assumes 30 hours of scarcity based on 2013/2014 capacity period when polar vortex was observed. 30 total scarcity. Hours are broken out to 15 hours in winter and 15 hours in summer with a summer and winter balancing ratio of 80%.

[6] 100 20% 7.03 12.

[7] The penalty rate in ISO-NE, starting in the 2018/2019 capacity auction is $2000/MWh and then increases to $3500/MWh in the 2021/2022 capacity auction. The penalty rate further increases to $5455/ MWh starting with 2024/2025 and remains constant thereafter. Considering the penalty rate of $5455/MWh, the penalties—a resource—could face increase to $1.8 million.

[8] IBID 3

[9] 20 total scarcity hours are broken out to 10 hours in winters and 10 hours in summer with a summer and winter system balancing ratio of 75% and 90%, respectively.

this example illustrates that intermittent resources losses from penalties could be significant compared to their original capacity payment.

However, the possibility of having a loss—and the associated amount—is dependent on the amount of capacity the intermittent resource commits in the capacity auction (and of course, the actual performance). These terms also influence the potential for intermittent resources to receive bonuses if their output is above cleared capacity and if there are enough underperforming resources. Therefore, the new capacity market structure can potentially allow such resources to hedge against any potential losses because they have uncommitted capacity that is available for bonuses. In certain scenarios, the bonuses received could be significant and even exceed the capacity payments. For example, in PJM, a 50 MW wind unit with a capacity commitment of 13 MW will have 37 MW of uncommitted capacity. If there are 30 scarcity hours and enough underperforming resources, this unit could earn a bonus of up to $1.5 million[10] on top of its capacity payment, assuming it provides output of 25 MW during each scarcity hour. In this example, the share of capacity revenue to total revenue can increase from 2% to 4% to up to approximately 18%.

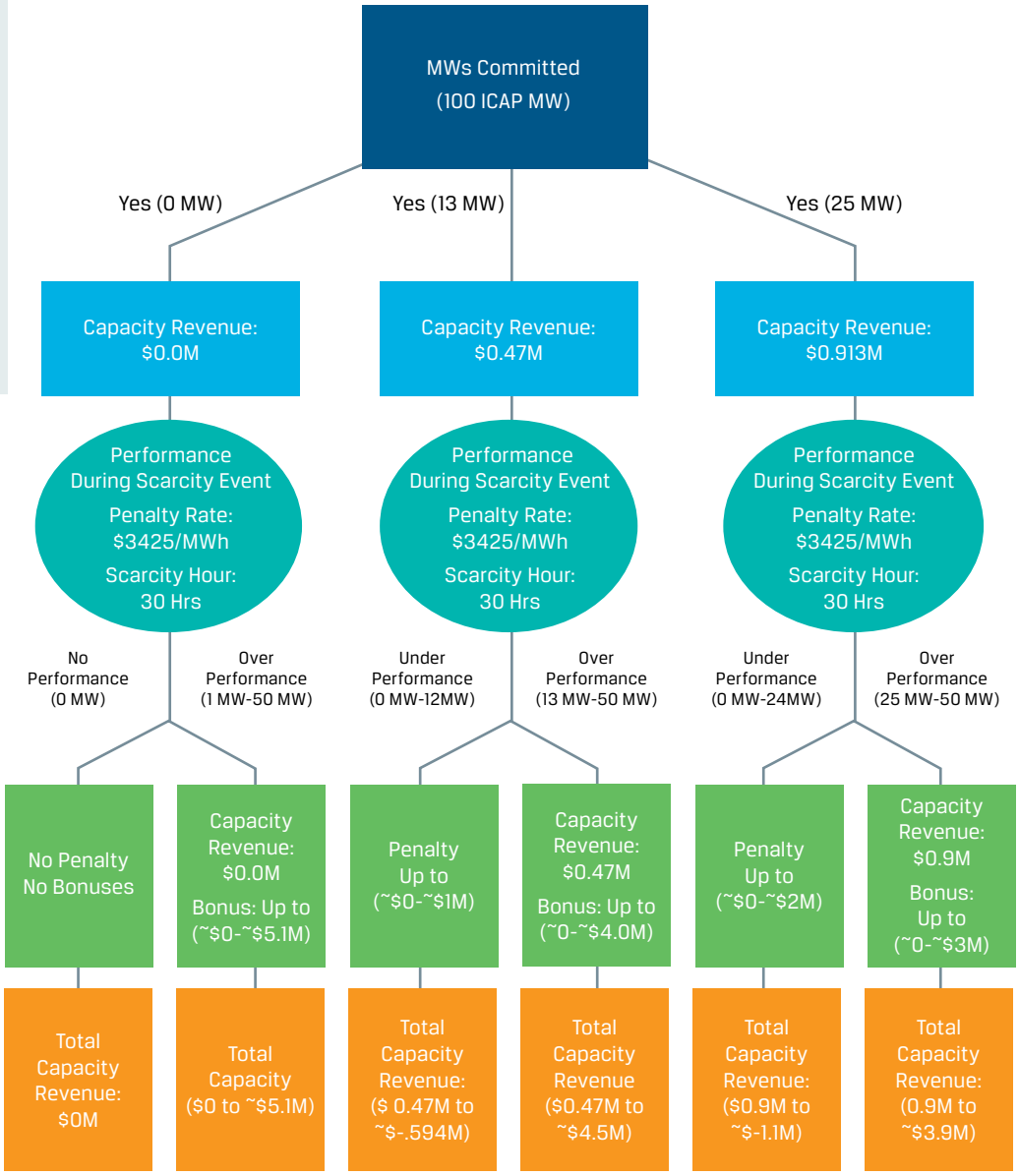
Exhibit 2 provides a decision tree illustrating and exemplifying different decisions (megawatts committed) and outcomes (capacity revenue, penalties, and bonuses) for an intermittent resource in PJM's performance-incentivized capacity market structure.

[10] IBID 3.

Note 1. ICF has assumed 30 scarcity hours for illustration purpose; however, in actuality the number of scarcity hours depend on supply demand balance and could be significantly lower. Historical 5-year average for scarcity hours in PJM RTO is 8 hours and in MAAC/EMAAC is 16 hours.

Note 2. In this example, which is used for illustration purposes, ICF assumes that the maximum output of an intermittent resource during scarcity hours is limited to 50% of its nameplate capacity.

EXHIBIT 2: ILLUSTRATIVE DECISION TREE FOR A 100 MW INTERMITTENT RESOURCE IN THE PERFORMANCE INCENTIVIZED PJM CAPACITY MARKET STRUCTURE



Source: ICF

Given this increased level of uncertainty—resulting in potential risks and opportunities in two-settlement capacity markets—all renewable resources need to carefully assess their participation in such markets.

The ISOs also recognize that renewable resources' variable output exposes them to a greater level of uncertainty with potential downside in the performance-incentivized capacity markets. Therefore, markets like PJM and ISO-NE have provided measures and flexibility to mitigate the impact of this new capacity market structure on renewable resources.

ISO-NE: In ISO-NE, only pivotal suppliers[11] are required to offer into the capacity market. Therefore, small resources such as renewable units can bid capacity into the market only up to their risk appetite. To support renewable participation in the capacity auction, as part of their demand curve negotiations, the ISO-NE market participants agreed on an exemption that allows up to 200 MW of (de-rated) new capacity from renewable resources (renewables exemption) to participate in each auction without being constrained by buyer-side mitigation.

PJM: While ISO-NE has already fully integrated the two-settlement system (PI) into its market, PJM temporarily maintained a portion of its annual capacity product as "base product." In the 2018/2019 and 2019/2020 capacity auctions, 20% of the region's reserve requirements were procured as base product with the market transitioning to 100% CP product by 2020. This gradual transition to an incentivized capacity market facilitated the continued participation of intermittent resources that mostly cleared as base product in the PJM capacity auctions. During the transition phase, unlike thermal resources, renewable resources were not required to participate as CP product. They could participate in the market by offering their capacity as only base product, only CP product, or as both. Going forward, as the market transitions to 100% CP in the next auction, all intermittent resources will be exempt from CP must offer requirements. An additional flexibility afforded to renewable resources is that they can couple with other variable-output resources (such as demand response) to bid in the capacity market as an annual CP product. As an illustration for this sort of arrangement, PJM cited a wind unit combining with a storage unit.[12]

PJM has also created a Seasonal Capacity Resources Senior Task Force to analyze solutions that would facilitate continued participation of intermittent resources and demand response once the market transitions to the 100% CP requirement. In the September 8, 2016, committee meeting, the task force released a proposal that would change the existing business rules for the aggregation of seasonal resources to facilitate their increased participation. Seasonal resources would be allowed to aggregate across the local deliverability areas. Furthermore, the proposal would allow seasonal CP commitment for intermittent resources: storage, environmentally limited resources, demand response, and so on. This implies that such resources could have only a summer or winter commitment depending on their availability or output. However, PJM's BRA clearing algorithm would be modified to ensure that the auction procures equal amounts of summer and winter capacity from such resources so that these commitments, in aggregate, satisfy the year-round availability and performance requirements of a CP resource. In summary, PJM would facilitate the aggregation of resources through its auction clearing algorithm. PJM plans to make a Federal Energy Regulatory Commission filing consistent with this proposal in November 2016.

[11] A supplier is considered pivotal if its capacity is needed to satisfy system or local level requirements.

[12] Page 25; Intermittent/Storage/DR/EE Resources can be combined to offer as a Capacity Performance Resource.; ANSWER OF PJM INTERCONNECTION, L.L.C.

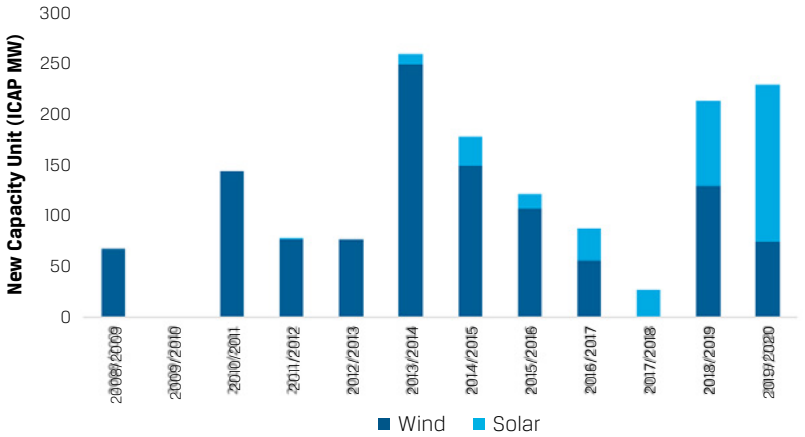
What Are We Currently Observing in the Market?

In PJM's 2018/2019 auction (held in August 2015), the first BRA with capacity performance rules, all of the participating wind and solar resources cleared the auction. Approximately 857 MW of wind resources were offered and cleared in the 2018/2019 BRA, representing roughly 6,594 MW of nameplate capacity. Approximately 184 MW of solar resources were offered and cleared in the auction representing 484 MW of nameplate capacity.[13] The majority of these resources cleared as base product, which is scheduled to be phased out by 2020. A similar trend was observed in the latest 2019/2020 auction.

Interestingly, there was a marked uptick in new renewable capacity participation in the 2018/2019 and 2019/2020 auctions compared to the past few years. Exhibit 3 provides a breakdown of new solar and wind resources offered over the 2008/2009 period to 2019/2020. While the majority of these renewables cleared as base product in the 2018/2019 and 2019/2020 auctions, it is important to remember that this product was always scheduled to be eliminated in the 2020/2021 auction. Because new power plant construction is a long-term investment that accounts for economics beyond the first few years, these facilities would have taken into account the impact of CP-only market post 2020. This implies that the potential of transitioning to a CP-only market was not a deterrent to the development and long-term economics of these new renewable resources.

Furthermore, in PJM, there is approximately 3.6 GW of UCAP renewable resources (existing and new) that cleared as base-only resources in the last PJM auction (i.e., these resources did not submit any CP offers or coupled offers). Going forward, as the market transitions to 100% CP, these resources could potentially take the risk and continue to participate in the auction at their existing or lower UCAP levels or may not participate at all. These resources' decision to participate in the upcoming auction will have a significant impact on the overall capacity pricing and capacity revenues of thermal resources.

EXHIBIT 3: NEW WIND AND SOLAR UNITS OFFERED IN HISTORICAL PJM AUCTIONS

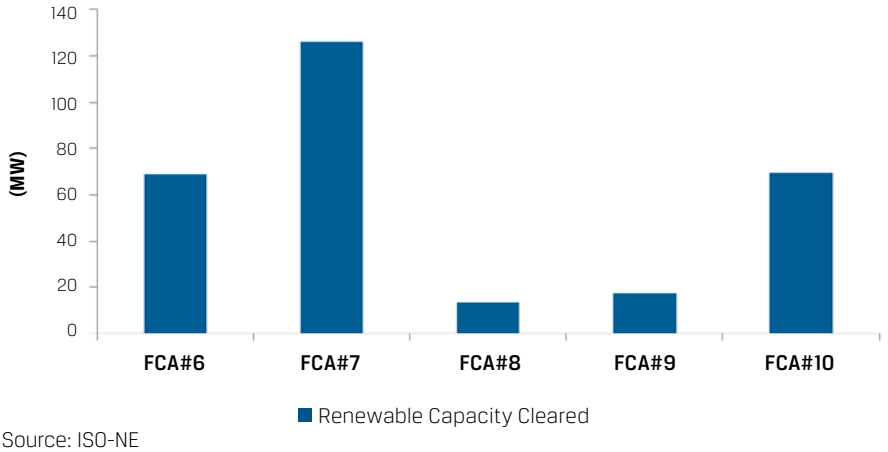


Source: PJM

[13] BID 2.

Similar to PJM, ISO-NE implemented its new capacity market structure beginning with FCA#9 (2018/2019). Although renewable participation was not significant in this auction, it was still higher than the previous auction (FCA#8). FCA#10 also observed an increase in renewable resource participation, despite having a performance-incentivized structure in place (Exhibit 4).

EXHIBIT 4: RENEWABLE CAPACITY CLEARED IN HISTORICAL ISO-NE AUCTIONS



Source: ISO-NE

The continued strong participation of intermittent resources in both PJM and ISO-NE's capacity markets—despite full or partial implementation of a performance-incentivized market structure—highlights that the new market structure may not be as detrimental to the development of such resources as expected by some market participants. Both PJM and ISO-NE are working to ensure that capacity markets are attractive for such resources by providing flexibility. Additionally, while the new market structure brings uncertainty and risk, it also brings potential opportunities in terms of bonus payments, which could be significant for intermittent resources.

For thermal resources, capacity markets are often seen as a driver of new entry and exit in a region; the same does not hold true for renewables. Factors such as state Renewable Portfolio Standards (RPS), along with state and federal incentives such as the renewed Production Tax Credit or Investment Tax Credit, play a significant role in incentivizing renewable activity in a region. The increasing pipeline of new renewable projects is a testament to these other drivers.[14] New legislation and regulations may also increase renewable development. For example, the Massachusetts legislature's passage of bill H.4568 will result in approximately 9.45 TWh of clean energy by 2022 and 1.6 GW of off-shore wind by 2027. In the recently held annual meeting of the Organization of PJM States Inc., stakeholders also discussed how RPS is the largest driver of renewable expansion. As such, capacity markets may not be driving renewable

[14] As of Oct 26, 2016, there were approximately 17 GW and 5 GW of renewable resources in the PJM and ISO-NE interconnection queue. ICF understands that not all the renewable resources in the interconnection queue are feasible to come online; however, the queue still provides a good benchmark on future development of renewable resources.

development, but they certainly provide an additional source of revenue in recovering capital cost. With the provisions for flexibility in the new capacity market structure and the potential for significant bonuses, renewable resource participation in the capacity auctions may not be deterred. Nonetheless, given the intermittent nature of renewable resources, it is critical that resource owners/operators understand the nuances involved to develop appropriate strategies for committing their capacity into a performance-incentivized capacity market.

About the Authors

Abhishek Josh Ghosh specializes in modeling and analysis of the U.S. wholesale power markets. He has experience in the areas of market assessment, asset valuation, and development support for private sector clients. He joined ICF in 2013 after graduating from the University of Minnesota-Twin Cities and holds a bachelor's degree in Electrical Engineering.

Himanshu Pande joined ICF in 2007 and is an expert in U.S. electricity markets. Mr. Pande has four years of experience in modeling and analysis of U.S. wholesale power markets and his six years of project portfolio experience includes U.K., Singapore, and Australian energy markets. Mr. Pande has expertise in statistical, optimization, and simulation modeling, along with power market asset valuation and risk analysis.

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Himanshu has a bachelor's degree in Civil Engineering from the Indian Institute of Technology, Delhi, and a master's degree in Operations Research from the London School of Economics.

George Katsigiannakis joined ICF in 1997 and is an expert in U.S. electricity markets, with deep understanding of all factors affecting U.S. wholesale electric markets including market design, environmental regulations, fuel markets, transmission, renewable, energy efficiency, and demand side management (DSM). He has been involved in a large number of projects including several forward price curve assessments, development support, and financial performance of generation assets. He works in the areas of energy modeling, wholesale market assessments, asset valuations, restructuring, and litigation support, as well as contract evaluation and risk assessments.

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Judah Rose joined ICF in 1982 and has 30 years of experience in the energy industry with clients such as electric utilities, financial institutions, law firms, government agencies, fuel companies, and independent power producers (IPPs). He is an ICF Distinguished Consultant, an honorary title given to three of ICF's 4,500+ employees. He has served on the ICF Board of Directors as the management shareholder representative.

Mr. Rose has supported the financing of tens of billions of dollars of new and existing power plants and is a frequent counselor to the financial community. He provides expert testimony and litigation support, addressed approximately 100 major energy conferences, and authored numerous articles.

Mr. Rose has a B.S. degree in Economics from Massachusetts Institute of Technology and an M.P.P. degree from the John F. Kennedy School of Government at Harvard University.

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