•

•

•

19-06039

Public Utilities Commission of Nevada
Electronic Filing
Submitted: 9/26/2019 1:43:41 PM
Reference: 6e9f82e2-abc7-4935-bd90-1de5e7772ddb
Reference:
Filed For: Solar Partners XI LLC
In accordance with NRS Chapter 719,
this filing has been electronically signed and filed
by: /s CurtLedford

Davison Van Cleve PC
Attorneys at Law
TEL (702) 600-9949 • FAX (503) 241-8160 • crl@dvclaw.com
5795-B Rogers St.
Las Vegas, NV 89118

September 26, 2019

Trisha Osborne
Assistant Commission Secretary
Public Utilities Commission of Nevada
1150 E. William Street
Carson City, NV 89701

Re: Joint Application of Nevada Power Company d/b/a NV Energy and Sierra Pacific Power Company d/b/a NV Energy for approval of the third amendment to its 2018 Joint Integrated Resource Plan to update and modify the renewable portion of the Supply-Side Plan and the Transmission Action Plan.
Docket No. 19-06039

Dear Ms. Osborne:

Please find enclosed the Prepared Direct Testimony of Ryan Hledik on behalf of Solar Partners XI, LLC in the above-referenced docket.

Thank you for your assistance. If you have any questions regarding the enclosed filing, please do not hesitate to contact me.

Sincerely,

Curt R. Ledford, Esq.
Nevada State Bar No. 9101
Davison Van Cleve, PC
5795-B Rogers St.
Las Vegas, NV 89118
(503) 241-7242 (telephone)
(503) 241-8160 (facsimile)
crl@dvclaw.com
Of Attorneys for Solar Partners XI, LLC

Enclosures

BEFORE THE PUBLIC UTILITIES COMMISSION OF NEVADA

Joint Application of Nevada Power Company d/b/a NV Energy and Sierra Pacific Power Company d/b/a NV Energy for approval of the third amendment to its 2018 Joint Integrated Resource Plan to update and modify the renewable portion of the Supply-Side Plan and the Transmission Action Plan.)	Docket No. 19-06039

PREPARED DIRECT TESTIMONY OF

RYAN HLEDIK

ON BEHALF OF

SOLAR PARTNERS XI, LLC ("AREVIA")

September 26, 2019

TABLE OF CONTENTS TO PREPARED DIRECT TESTIMONY OF RYAN HLEDIK ON BEHALF OF AREVIA

LIST OF EXHIBITS

I. INTRODUCTION

Q.1 PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A.1 My name is Ryan Hledik. I am a Principal of The Brattle Group, an economics consulting firm. My business address is 201 Mission Street, Suite 2800, San Francisco, California 94105.

Q.2 ON WHOSE BEHALF ARE YOU SUBMITTING TESTIMONY?

A.2 I am testifying on behalf of Solar Partners XI, LLC ("Arevia").

Q.3 WHAT ARE YOUR QUALIFICATIONS AS THEY PERTAIN TO THIS TESTIMONY?

A.3 My consulting practice is focused on regulatory, planning, and economic matters related to emerging energy technologies. My areas of expertise include energy storage, distributed generation, load flexibility, electrification, retail tariff design, energy efficiency, and grid modernization.

Last year, I led a study for the Public Utilities Commission of Nevada ("PUCN") and the Governor's Office of Energy to estimate the potential for cost-effective statewide energy storage deployment.[1/] The study was cited by the PUCN in its decision to move forward with a proceeding to develop an energy storage procurement target for the state.[2/] I have published papers and articles on the economics of both utility scale and distributed solar and storage deployments, have provided due diligence support for potential solar and storage assets on behalf of investors and project developers, and have assisted regulated utilities in assessing the benefits of solar and storage projects on their systems. I currently serve as a member of the Energy Storage Association's Technical Advisory Committee.

1/ Hledik et al. (2018). The Economic Potential for Energy Storage in Nevada. Prepared for the Public Utilities Commission of Nevada and the Nevada Governor's Office of Energy (Oct. 1, 2018).

2/ See Public Utilities Commission of Nevada, Docket No. 17-07014.

My clients have included electric and gas utilities, state and federal regulatory commissions, power developers, independent system operators, government agencies, industry trade associations, technology firms, research institutions, and law firms. I have published more than 25 articles on electricity industry matters and have presented at industry events throughout the United States as well as in Brazil, Belgium, Canada, Germany, Poland, South Korea, Saudi Arabia, the United Kingdom, and Vietnam. My research has been cited in *The New York Times* and *The Washington Post*, and in trade press such as *GreenTech Media*, *Utility Dive*, and *Vox*.

I received my M.S. in Management Science and Engineering from Stanford University, where I concentrated in Energy Economics and Policy. I received my B.S. in Applied Science from the University of Pennsylvania, with minors in Economics and Mathematics. More details regarding my professional background and education are included in my Statement of Qualifications, which is provided in Exhibit Hledik-Direct-1.

Q.4 WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A.4 NV Energy has proposed to sign a 25-year power purchase agreement ("PPA") with Arevia for the output from its Gemini solar and storage generation facility ("Gemini" or "Project").[3/] The purpose of my testimony is to assess the net benefits of Gemini to NV Energy's customers. Specifically, I estimate the system-wide value of Gemini over its 25-year PPA term, and compare this value to the cost of the PPA to establish an estimate of the net economic benefits of the Project to NV Energy ratepayers.

[3/] NV Energy Volume 1: NV Energy Northern and Southern Service Territory IRP 3rd Amendment. PUCN Docket No. 19-06039. Joint Application of Nevada Power Company d/b/a NV Energy and Sierra Pacific Power Company d/b/a NV Energy for approval of the third amendment to its 2018 Joint Integrated Resource Plan to update and modify the renewable portion of the Supply-Side Action Plan and the Transmission Action Plan.

Q.5 PLEASE SUMMARIZE YOUR TESTIMONY.

A.5 An assessment of the value that Gemini – or any energy resource – will provide to NV Energy's customers must compare the project's costs to its system-wide benefits. In the case of Gemini, its costs are the total expected cost of the PPA plus the reimbursable cost of transmission upgrades necessary to bring the project online. Gemini's benefits to the NV Energy system include reduced energy costs (i.e., fuel and variable operations and maintenance costs), deferred investment in generation capacity, and added flexibility through the provision of fast-response ancillary services. Additionally, as a carbon-free resource, Gemini will provide environmental benefits by displacing generation from resources that otherwise would emit greenhouse gasses into the atmosphere.

I estimate Gemini's benefits to Nevada ratepayers using the same projections that I developed through last year's PUCN study titled, "The Economic Potential for Energy Storage in Nevada." The foundation for that study was a detailed forward-looking simulation of the Western U.S. power system, with a focus on Nevada. The modeling relied on many of the same assumptions that were used in NV Energy's 2018 Integrated Resource Plan ("IRP").

Under a range of scenarios regarding Gemini's future operation, I estimate that the present value of its net economic benefits to NV Energy customers will be between $497 million and $614 million over the 25-year term of the PPA.[4/] Across these scenarios, the benefits of the project exceed its costs by between 53 percent and 68 percent. Notably, my analysis indicates that the energy benefits of the project alone will exceed its costs.

4/ The estimate of $497 million is based on a case that only includes capacity and energy value and assumes that Gemini will operate at its maximum achievable capacity factor during the Full Requirements Period of the PPA. The estimate of $614 million includes spinning reserves benefits and assumes Gemini runs at a capacity factor of 65 percent during the Full Requirements Period, per the benchmark in the PPA payment schedule.

Gemini's benefits are driven in part by the presence of a significant amount of energy storage capacity. Energy storage allows the output of Gemini's solar facility to be shifted to the hours of the day when it is most valuable. This will allow NV Energy to mitigate the steep ramp-up in generation that is required to offset declining solar production in the evening, to serve as a substitute for generation capacity procurements necessary to serve NV Energy's net system peak demand, and to reduce potential solar generation curtailments. Additionally, the Project's batteries are very flexible resources that can respond nearly instantaneously to fluctuations in generation on the system, providing valuable grid balancing services.

Gemini presents a unique opportunity for NV Energy and its customers, because the pricing of the PPA reflects an expectation that the project will capture the full 30 percent project cost savings available through the Federal Investment Tax Credit ("ITC"). Between 2020 and 2022, the ITC is scheduled to drop from 30 percent to only 10 percent. Thus, a decision not to pursue the Gemini PPA means foregoing up to 20 percent in project cost savings due to the loss of investment tax credits. Under industry expectations about future declines in the cost of solar and storage technologies, it could potentially take up to a decade or more for technology costs to naturally decline to the levels currently obtainable through the ITC.

Q.6 HOW IS THE REST OF YOUR TESTIMONY ORGANIZED?

A.6 The remainder of my testimony is organized into the following sections:

- Section II provides relevant background on Gemini and the structure of the PPA.
- Section III includes a description of the benefits that Gemini will provide to the NV Energy system and an overview of my approach to estimating those benefits.

- Section IV provides a detailed description of my methodology for estimating each source of system value provided by Gemini.
- Section V presents my assessment of the cost-effectiveness of the Gemini project.
- Section VI summarizes the conclusions of my testimony.

II. BACKGROUND

Q.7 PLEASE BRIEFLY DESCRIBE THE GEMINI PROJECT.

A.7 Gemini is one of three PPAs that NV Energy has proposed in the Third Amendment to its 2018 Integrated Resource Plan. Gemini is a "solar-plus-storage" project with nameplate solar PV capacity (AC) of 690 MW and battery capacity of 380 MW and 1,416 MWh. This means the battery has enough storage capacity to discharge energy at its full output capability for a duration of 3.7 hours. A transmission interconnection limit will cap total output from Gemini to the NV Energy system at 690 MW at any given time. The project is located 25 miles northeast of Las Vegas, in NV Energy's Nevada Power service territory.

Q.8 WHAT ARE THE KEY ASPECTS OF THE PPA THAT ARE RELEVANT TO YOUR ANALYSIS?

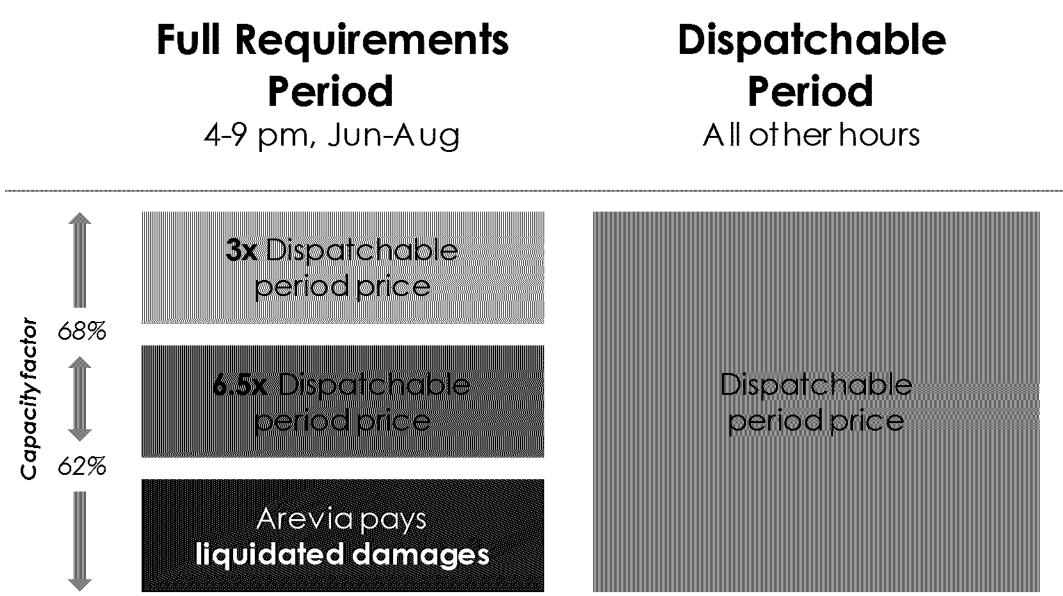
A.8 While there are many aspects to the PPA, a few key elements are worth highlighting as they relate to my assessment of the system benefits of the project:

- Output from Gemini will be compensated at two different rates. The "Full Requirements Period" ("FRP") covers the hours of 4 pm to 9 pm on all days during the months of June, July, and August, while the "Dispatchable Period" covers all other hours of the year. During the Dispatchable Period, output from Gemini is paid $24.79/MWh. During the FRP, output from Gemini is paid $161.14/MWh, which is 6.5 times higher than the price during the Dispatchable Period.

- Gemini receives the FRP price if it maintains an average output level between roughly 62 percent and 68 percent of its 690 MW nameplate capacity during FRP hours over the course of the year. Liquidated damages are owed to NV Energy if the average output falls below this range. If output exceeds this range, the incremental output above roughly 68 percent is compensated at a reduced FRP rate of $74.37/MWh, three times higher than the price during the Dispatchable Period.
- I understand that NV Energy has complete control over the dispatch of Gemini during the Dispatchable Period, and therefore can operate the project in a way that maximizes system benefits. During the FRP, Arevia is expected to output all available energy from both the solar PV facility and the storage facility. NV Energy has the option to curtail output during the FRP, but must compensate Arevia for any curtailed output at the applicable FRP rate.

Figure 1 illustrates the price that will be paid for Gemini's output during both the FRP and the Dispatchable Period, at different levels of average output over the year.

Figure 1: Gemini PPA Payment Structure



Q.9 WHY DOES THE PPA SPECIFY A HIGHER PAYMENT FOR OUTPUT DURING THE FRP?

A.9 Generation during FRP hours is significantly more valuable to the NV Energy system than during other hours of the year. During summer evenings, solar production declines but demand for electricity is high, driven by significant cooling load. Electricity produced during these evening hours will serve peak demand, reduce the need to run less efficient generating units, and address generation ramping challenges associated with declining solar output while load is still high.

I understand that the PPA structure was established by NV Energy to reflect this value of generation capacity on its system. The timing of the FRP aligns with NV Energy's net system peak. By providing a higher payment for output during FRP hours, NV Energy was able to encourage the development of projects that would provide not only energy value but also capacity value. For solar projects like Gemini, this payment structure encouraged the inclusion of energy storage, which could shift generation to the times of day when it is most valuable to the NV Energy system.

Q.10 WHEN IS GEMINI EXPECTED TO COME ONLINE?

A.10 Arevia and NV Energy expect Gemini to come online by November 30, 2023. NV Energy has proposed a 25-year PPA, which would provide the company with the output from Gemini effectively from December 2023 through November 2048.

Q.11 WILL GEMINI'S COSTS BE REDUCED DUE TO THE FEDERAL INVESTMENT TAX CREDIT ("ITC")?

A.11 I understand that Arevia has taken the steps necessary to capture the full 30 percent ITC. This effectively reduces the installed cost of the Project by 30 percent. The PPA pricing, therefore, reflects these ITC-related cost savings, which ultimately accrue to NV Energy's customers.

The ITC drops to 26 percent in 2020, to 22 percent in 2021, and to 10 percent for 2022 and beyond. Projects with construction dates in this later range would thus be limited to smaller ITC-related cost savings than are expected to be realized for Gemini.

Q.12 ARE SOLAR AND STORAGE PROJECTS BEING DEVELOPED IN OTHER JURISDICTIONS?

A.12 Yes. Solar and storage projects, including solar-plus-storage hybrid projects like Gemini, are among the most common types of generation currently being added to interconnection queues around the U.S. The high share of solar and storage capacity in interconnection queues is particularly apparent in regions with high levels of solar insolation (like Nevada). For instance, in California, 85 percent of all capacity in the interconnection queue consists of solar generation and/or batteries. In Texas, this share is 57 percent.[5/] While only a portion of the capacity in the interconnection queue ultimately will be built, this is a signal that solar and storage projects are a cost competitive generation resource.

III. ESTIMATING THE SYSTEM BENEFITS OF GEMINI

Q.13 AS BACKGROUND, PLEASE PROVIDE A BRIEF SUMMARY OF YOUR 2018 STUDY FOR THE PUCN AND GOVERNOR'S OFFICE OF ENERGY ON COST-EFFECTIVE ENERGY STORAGE POTENTIAL IN NEVADA.

A.13 The 2018 PUCN storage study, titled, "The Economic Potential for Energy Storage in Nevada," was commissioned by the PUCN and the Nevada Governor's Office of Energy. The study was developed to address the requirement of Nevada Senate Bill 204 (2017) to

---

5/ Based on analysis of public CAISO and ERCOT interconnection queue data as of September 2019. Also note that the average ratio of storage capacity to solar capacity among solar-plus-storage projects in the California interconnection queue is 0.78, which is roughly similar to that of Gemini (0.55), emphasizing the value of pairing significant amounts of energy storage capacity with solar PV projects.

"determine whether it is in the public interest to establish by regulation biennial targets for the procurement of energy storage systems by an electric utility."[6/]

I co-authored the 2018 PUCN storage study with colleagues at The Brattle Group and personally directed the supporting analyses. We used Brattle's bSTORE model to estimate the economic potential for statewide storage deployment.[7/] The analysis involved simulating the hourly operations of the entire western U.S. power grid for the years 2020 and 2030, with a focus on the Nevada system. Wherever applicable, our model inputs were based on assumptions consistent with NV Energy's 2018 Integrated Resource Plan ("IRP"). For instance, our natural gas price forecast and NV Energy generator characteristics were provided directly by NV Energy based on its IRP assumptions.

A base case without new Nevada energy storage was compared to alternative cases that included between 200 MW and 1,000 MW of storage additions in Nevada. Reductions in system costs in the storage deployment cases determined the value of the storage additions. This value was compared to a projection of standalone battery storage costs to estimate cost-effective storage deployment levels in Nevada.

Under the base case simulation and storage cost assumptions in that study, we estimated that there could be up to 150 MW of cost-effective potential for standalone energy storage in Nevada in 2020, and up to at least 1,000 MW of cost-effective storage potential by 2030. The study was filed by the PUCN in October 2018 in Docket 17-07014 and has been the basis for ongoing stakeholder discussions regarding statewide storage deployment targets.

6/ Nevada Senate Bill 204 (2017). Posted at: https://www.leg.state.nv.us/Session/79th2017/Bills/SB/SB204_R1.pdf

7/ The bSTORE model is a unit commitment and dispatch model designed to evaluate the value of storage. bSTORE includes a detailed electricity system simulation module, which utilizes Power System Optimizer ("PSO") software to determine impacts on system-wide electricity production cost. For more information, see www.brattle.com/storage

Q.14 WHAT ARE THE BENEFITS THAT GEMINI WILL PROVIDE TO THE NV ENERGY SYSTEM?

A.14 Gemini will provide many of the same benefits that were quantified in the 2018 PUCN storage study. I have analyzed the following benefits of Gemini for this testimony:

- Energy cost savings: Both the solar PV facility and the storage facility of Gemini will provide energy cost savings. Output from the solar PV facility will displace output from more expensive generating units that otherwise would need to operate, reducing NV Energy's fuel and variable operations and maintenance ("O&M") costs. Energy storage enhances this benefit. The energy storage facility will charge from output of the solar facility during hours when the energy is less valuable, and discharge the energy when it is more valuable, effectively shifting the solar output to times of day when it provides the most value to the NV Energy system.
- Reduced generation capacity investment: NV Energy has an open capacity position of more than 1,000 MW over its planning horizon. The utility must procure capacity from the market each year.[8/] Gemini will reduce NV Energy's need to procure capacity. Some of that capacity value is attributable to the average solar output that is expected during the time of NV Energy's net system peak, and some is attributable to the battery discharging during those net system peak hours. The structure of the PPA ensures that Gemini will operate in a way that maximizes this capacity value.
- Ancillary services: NV Energy procures "spinning reserves" capable of responding rapidly to any contingency (e.g., unexpected tripping of generators or transmission lines). NV Energy procures a quantity of spinning reserves to cover their single largest contingency.

8/ See Docket No. 19-06039, NV Energy Volume 1: NV Energy Northern and Southern Service Territory IRP 3rd Amendment at page 39.

Storage can provide spinning reserves if operated such that the battery's state of charge is sufficient to provide the service. Operating Gemini in this way will offset the need to provide spinning reserves from other resources.

- Environmental benefits: Gemini is a carbon-free resource. By displacing output from fossil generation units that otherwise would need to run during NV Energy's net peak periods, Gemini reduces emissions of CO_2 and other greenhouse gasses. My analysis estimates the value of carbon reductions based on the social cost of carbon.

Q.15 ARE THE CATEGORIES OF BENEFITS THAT YOU JUST DESCRIBED THE SAME CATEGORIES OF BENEFITS THAT YOU ANALYZED IN YOUR 2018 STORAGE STUDY FOR THE PUCN?

A.15 Yes, each of these benefits was included in my 2018 storage study for the PUCN.

Additionally, the 2018 PUCN storage study quantified transmission and distribution ("T&D") investment deferral benefits and the benefit of reduced distribution system outages. It is possible that Gemini could provide T&D benefits if its location at Crystal substation reduced transmission congestion in Southern Nevada. However, I have not quantified these potential benefits in my analysis of Gemini.

Q.16 IS YOUR APPROACH TO ANALYZING THE SYSTEM BENEFITS OF GEMINI CONSISTENT WITH THE METHODOLOGY YOU USED FOR THE 2018 PUCN STORAGE STUDY?

A.16 Yes. My analysis of the system benefits of Gemini relies heavily on the methodology, assumptions, and estimates from the 2018 PUCN storage study.

Wherever relevant, I have relied on data from the 2018 study in my analysis. For instance, my assessment of Gemini's energy cost savings is based on the simulated Nevada marginal energy costs that resulted from the 2018 PUCN storage study modeling. My estimate of the capacity value of the storage portion of Gemini relies on the same observations about the ability of energy storage to serve system peak demand as the 2018 study. Environmental benefits are calculated using the same assumptions about marginal generation emissions rates and the social cost of carbon. I also used a similar approach to modeling the optimal dispatch of the battery in both the 2018 PUCN storage study and my analysis for this testimony, though as I discuss later in my testimony, Gemini's operation is additionally modeled to be consistent with the terms of the PPA.

Q.17 PLEASE PROVIDE AN OVERVIEW OF YOUR METHODOLOGY FOR ASSESSING THE NET ECONOMIC BENEFITS OF GEMINI.

A.17 The first step was to establish an estimate of marginal costs. Specifically, this refers to the costs of energy, generation capacity, and spinning reserves that would be avoided or deferred once Gemini is online and being operated optimally on NV Energy's system. As I describe later in my testimony, wherever applicable I used marginal cost values that are consistent with the 2018 PUCN storage study.

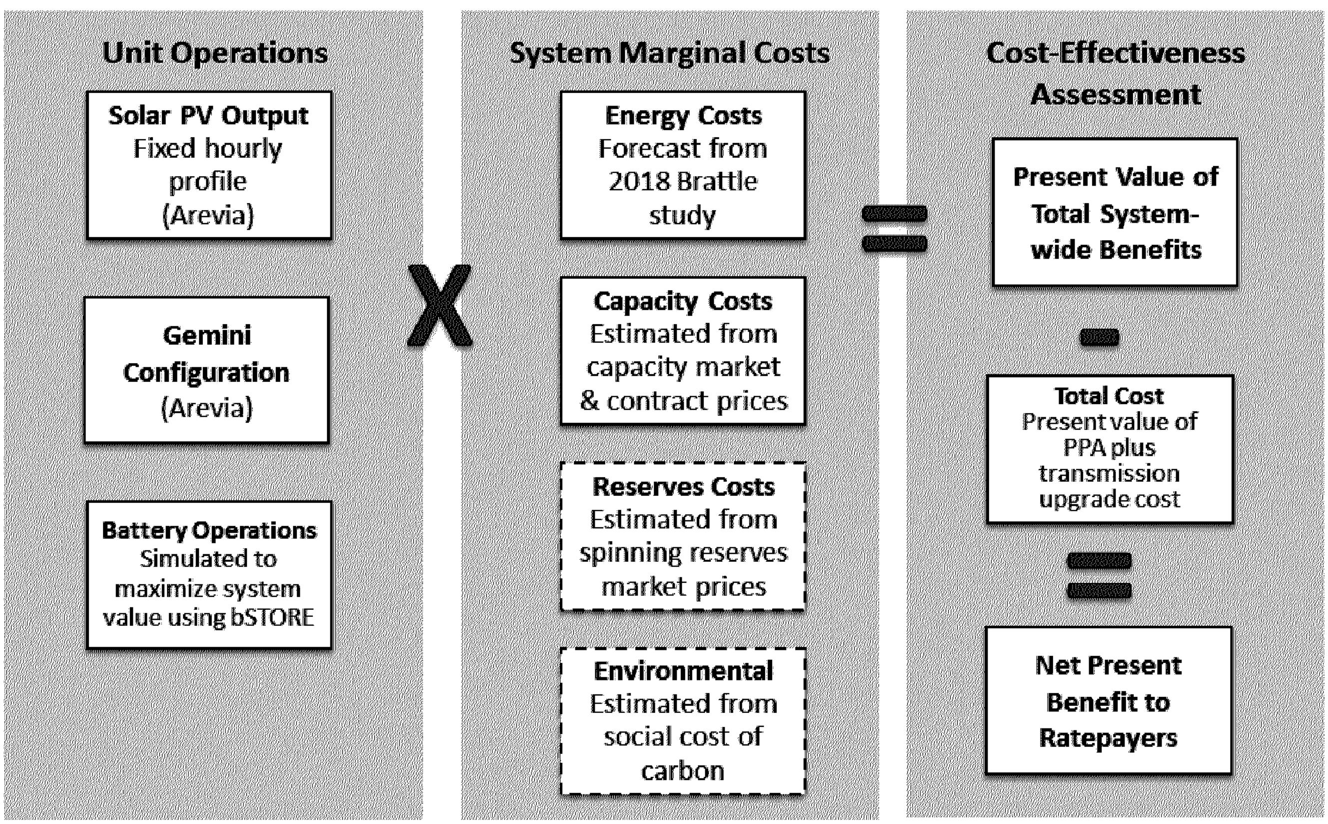
The second step was to determine the total costs that Gemini will avoid. Doing so required simulating the operation of Gemini on the NV Energy system. I assumed that NV Energy will operate Gemini in a manner that maximizes its benefits to the system, subject to the project's technical limitations and any constraints and incentives embedded in the terms of the PPA. The benefits were calculated for the 25-year life of the PPA. Consistent with NV Energy's methodology for calculating the present value of the PPA, for each value stream I calculated the present value using NV Energy's discount rate of 7.94 percent.[9/]

[9/] Unless otherwise noted, the present value of benefits and costs is discounted back the beginning of the PPA in 2023, and presented in 2023 dollars. This is consistent with NV Energy's methodology for calculating the present value of the PPA when determining the PPA's levelized cost of energy.

The costs of the project were calculated as the present value of the PPA plus reimbursable transmission upgrade costs associated with bringing Gemini online. These are the costs that would be passed on to ratepayers. The cost of the PPA was calculated by multiplying FRP generation by the FRP price, multiplying Dispatchable Period generation by the Dispatchable Period price, and adding a transmission upgrade cost of $9.795 million.[10/] The present value of benefits was compared to the present value of costs to determine the net economic benefits to NV Energy ratepayers.

Figure 2 illustrates my methodology for estimating the net economic benefits of the Gemini PPA.

Figure 2: Overview of Methodology for Estimating Net Economic Benefits of Gemini



10/ Gemini Large Generator Interconnection Agreement, as of September 17, 2019.

Q.18 WHAT SCENARIOS HAVE YOU CONSIDERED WHEN MODELING THE OPERATION OF GEMINI?

A.18 Gemini could operate at a range of output levels under the terms of the PPA, so I modeled two cases reflecting different assumptions about the project's operation. In the first case, which I refer to as the "PPA Benchmark" case, I assumed that Gemini will operate at an average output level of 65 percent of its nameplate 690 MW capacity during the FRP. This is consistent with the assumptions filed by NV Energy in the Third Amendment and ties the assumed output of Gemini directly to the benchmark output level upon which the FRP payment price schedule is anchored. In the second case, which I refer to as the "Technical Potential" case, I simulated the operation of Gemini assuming its maximum output capability is utilized during the FRP, subject to technical constraints and the requirements of the PPA. This second case resulted in a larger share of generation occurring during the FRP, when the energy is most valuable to the NVE system.

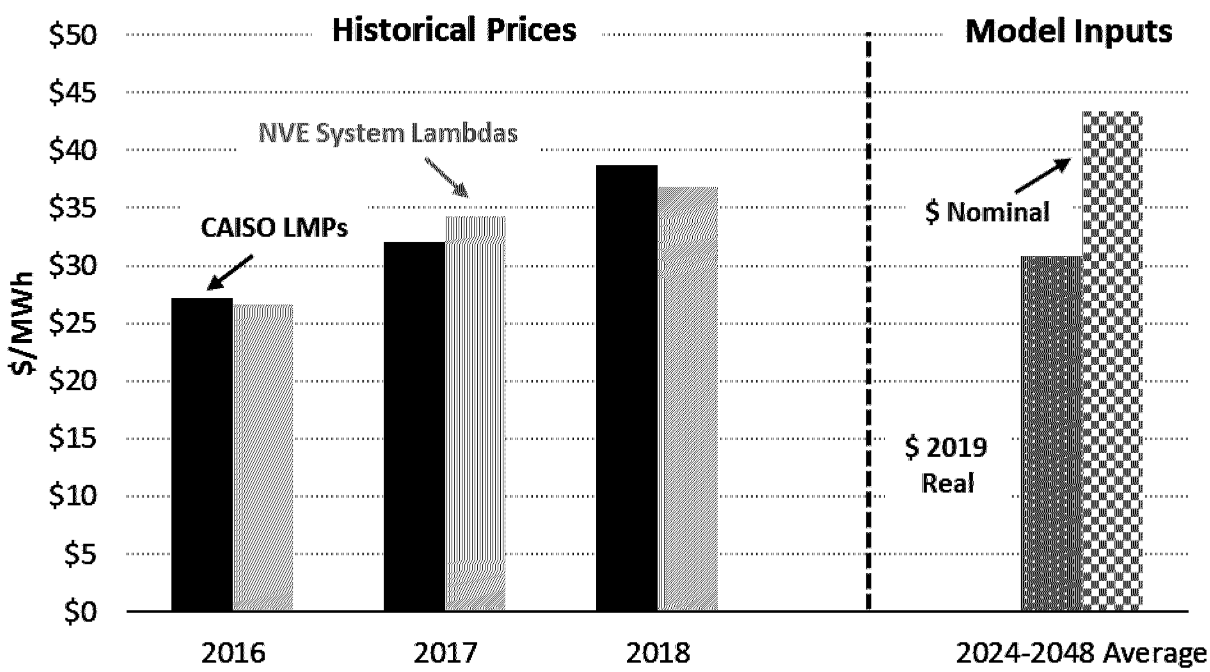
IV. METHODOLOGY DETAILS

Q.19 HOW DID YOU ESTIMATE THE ENERGY COST SAVINGS THAT GEMINI WILL PROVIDE?

A.19 First, I established hourly marginal energy cost estimates for Southern Nevada in 2020 and 2030 using the results of the 2018 PUCN storage study. I then used the bSTORE model to simulate the optimal dispatch of Gemini in each hour relative to those marginal costs. My simulation accounted for technical constraints of the Gemini system, such as the capacity of the solar generator and the battery, point-of-interconnection injection limits, and the losses associated with the DC-coupled solar and storage configuration. My simulation of Gemini's operations was consistent with the terms of the PPA. For instance, the battery was dispatched with a goal of discharging energy specifically during the FRP period.

Figure 3 illustrates how the marginal energy costs used in my analysis compare to relevant historical costs. Average annual NV Energy system lambdas (a measure of marginal energy costs) and CAISO energy market prices at the Southern Nevada border have ranged between roughly $25/MWh and $40/MWh in the past three years. By comparison, the average marginal energy cost forecast across all years of my analysis is roughly $30/MWh in 2019 dollars, and slightly less than $45/MWh in nominal terms.

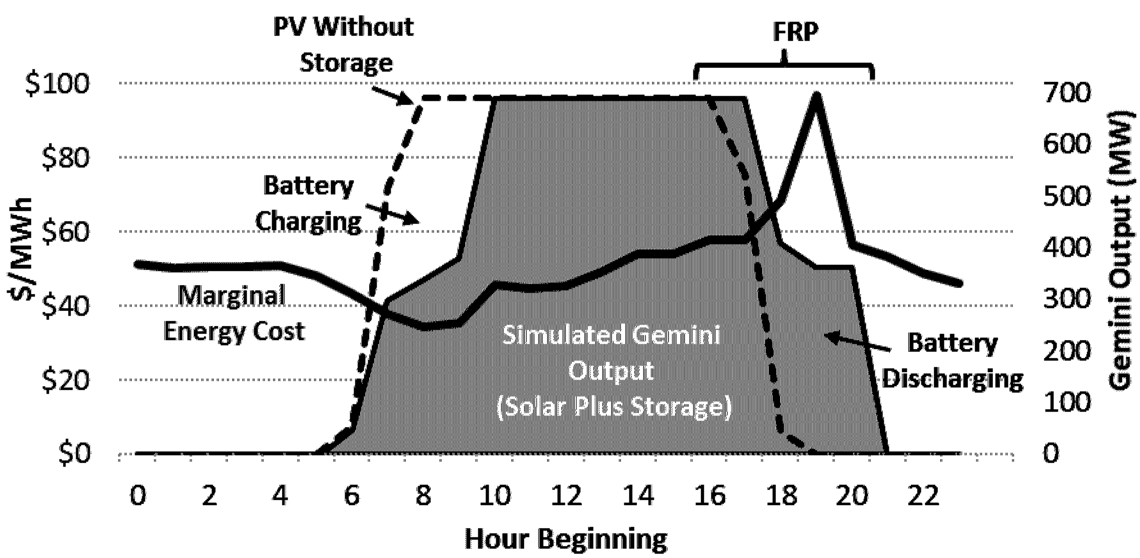
Figure 3: Marginal Energy Costs and Market Prices (Annual Average)



Note: Historical energy price data from CAISO Open Access Same-time Information System (OASIS). Energy prices are taken from the node reflecting the CAISO market price at the Mead 230 kV intertie between Nevada and California. NV Energy system lambdas are reported by Velocity Suite. Modeled Southern Nevada Marginal Energy Costs show the average between 2024 and 2048.

Figure 4 illustrates the average simulated output from Gemini in 2030, compared to average forecasted marginal energy costs. The dashed line indicates the output profile of the solar facility if there were no on-site battery storage. The "dip" in solar projection in the middle of the day and the "bump" in solar production in the evening hours illustrates the effect of the battery on Gemini's output. Output is shifted from hours when marginal energy costs are low to hours when energy costs are spiking - such as when the sun is setting - which aligns with the timing of the FRP.[11] As discussed later in my testimony, output during the FRP would also provide capacity value, which is not reflected in this chart.

Figure 4: Hourly Marginal Energy Costs with Simulated Gemini Dispatch (August 25th, 2030)



Note: Marginal energy cost estimate is from 2018 PUCN storage study model outputs and shown in 2030 dollars. Simulated Gemini output reflects modeled production under the Technical Potential case. The dotted black line shows hourly solar PV output without storage, the solid black line and area underneath represents the modeled output of the Gemini solar-plus-storage system. Output is capped at the injection limit of 690 MW for both solar only and solar-plus-storage.

[11] As discussed later in my testimony, output during the FRP would also provide capacity value, which is not reflected in this chart.

The cost savings created by Gemini were calculated by multiplying the marginal energy cost in each hour by Gemini's injections to the grid during that hour.[12/] I estimated annual savings for the years 2023 through 2029 by interpolating savings from the 2020 and 2030 simulations. For the years 2031 through 2048, I assumed energy cost savings would be constant in nominal dollars at 2030 levels (i.e., declining in real terms).[13/]

Q.20 DID YOU ACCOUNT FOR THE SUB-HOURLY FLEXIBILITY OF BATTERY STORAGE IN YOUR ASSESSMENT OF GEMINI'S ENERGY VALUE?

A.20 Yes. Batteries are highly flexible resources that can respond to price signals on a minute-by-minute basis. It is important to account for this operational flexibility when estimating energy value. NV Energy would be able to charge and discharge the battery in real-time to maximize energy cost savings. In fact, participating in the Western Energy Imbalance Market ("EIM") operated by the California Independent System Operator ("CAISO") represents an opportunity for NV Energy to monetize this sub-hourly flexibility value, as the real-time market settles in 5-minute intervals. Even if NV Energy does not sell the output of Gemini into the EIM, 5-minute prices from that market are a useful proxy for estimating Gemini's sub-hourly value.

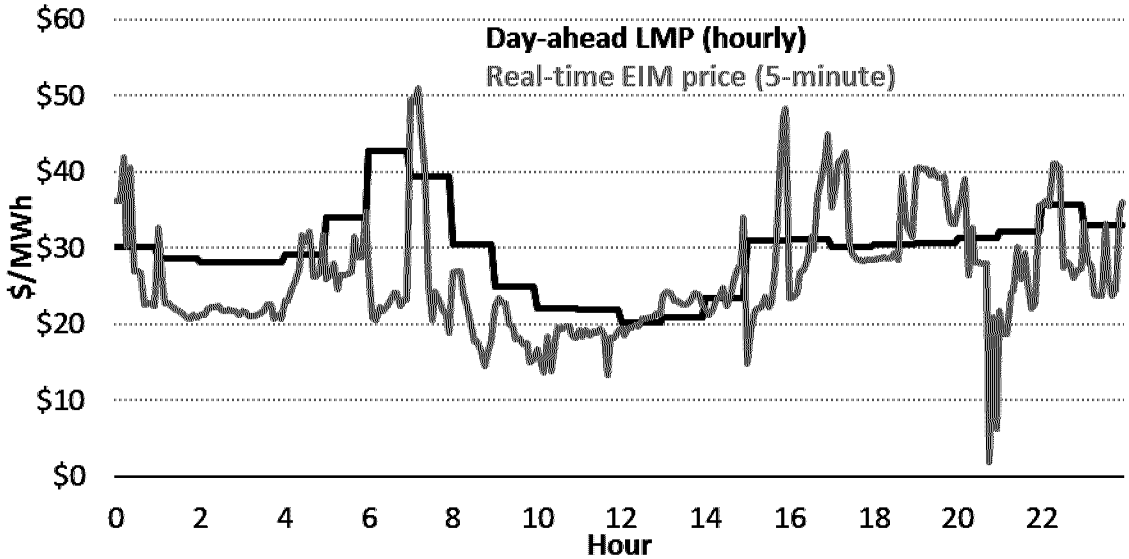
I used historical prices from the EIM to estimate the incremental value provided by operating the Gemini battery on a sub-hourly basis. Accounting for a realistic degree of operator foresight into future energy prices, revenues from simulated dispatch into the 5-minute EIM real-time market were around 17 percent higher than if the battery had only been dispatched against the hourly day-ahead prices. This percentage was applied to my estimates of forecasted hourly energy value to represent Gemini's incremental real-time energy value.

[12/] There are not direct costs of charging the storage facility, because it is assumed to charge exclusively from the solar facility through the PPA term.

[13/] Throughout my analysis, I assume output of the solar facility degrades at a rate of roughly 0.5 percent per year, and that the battery is augmented to maintain its nameplate capacity across the 25-year term of the PPA.

Figure 5 provides an illustration of the difference between hourly day-ahead energy prices and sub-hourly real-time EIM prices. The example below shows prices for December 1, 2017. The energy price comes from the Mead pricing point (i.e., Southern Nevada border) in the CAISO energy market, and the EIM price reflects the price available to NV Energy in the EIM.

Figure 5: Comparison of Energy Prices (December 1, 2017)



Note: Historical energy price data from CAISO OASIS. Day ahead LMPs are taken from the node reflecting the CAISO market price at the Mead 230 kV intertie between Nevada and California. The EIM prices are for NV Energy, as reported by CAISO OASIS.

Q.21 HOW DID YOU QUANTIFY THE GENERATION CAPACITY INVESTMENT DEFERRAL BENEFITS THAT GEMINI WILL PROVIDE?

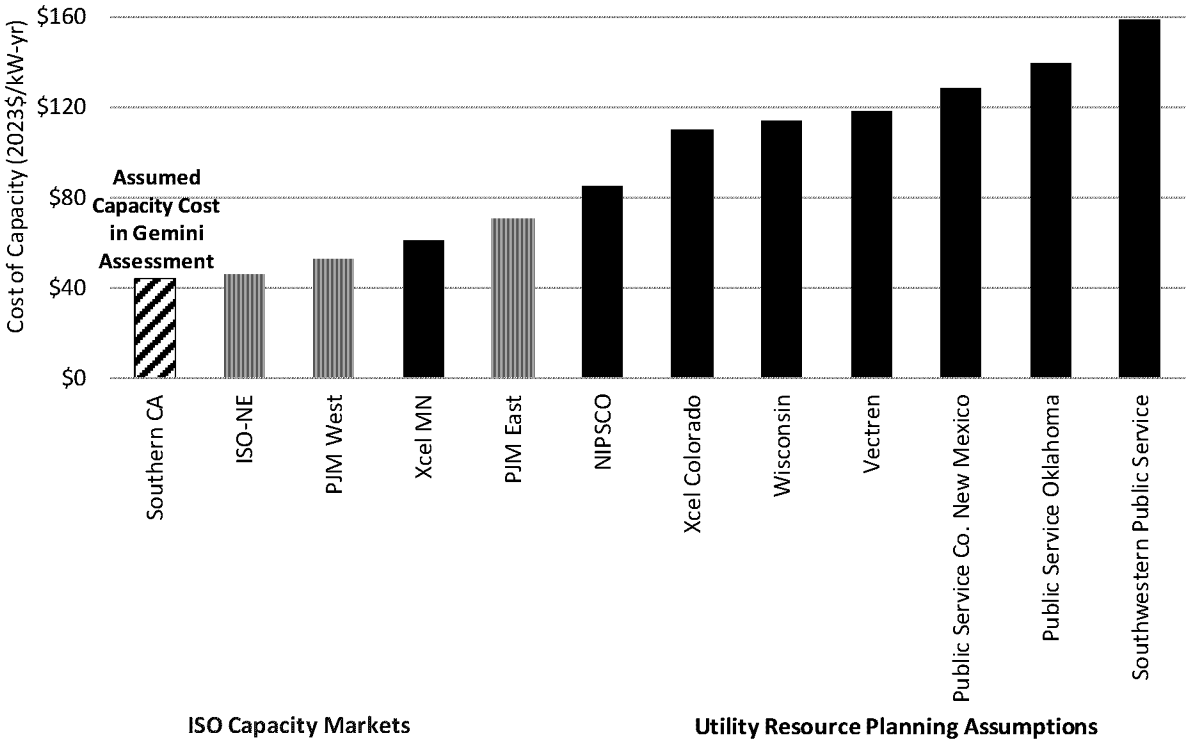
A.21 First, I established an estimate of NV Energy's marginal cost of capacity. NV Energy does not publicly release forecasts of capacity costs. As a proxy, I used public data released by the California Public Utilities Commission ("CPUC") on the cost of system resource adequacy contracts in Southern California between 2018 and 2022. The 85th percentile of these contracts implies a capacity cost of $44.57/kW-yr in 2023 dollars, growing with inflation.[14/]

I chose the California capacity contract costs as a benchmark due to Southern California's geographic proximity to Nevada. Additionally, by using contracted prices of capacity, my analysis is based on a price that reflects the actual value that the market is placing on capacity; it is not a hypothetical number.

My assumption for capacity value is on the low end of the range of capacity costs estimated by other utilities in resource planning activities, and similarly on the low end of the range of recent capacity market clearing prices in PJM and ISO New England. Figure 6 illustrates how my assumed capacity cost compares with capacity costs across multiple utilities and wholesale markets.

14/ The 85th percentile statistic indicates the price under which 85 percent of the contracted MW values fall. The CPUC has historically reported the 85th percentile as a key indicative statistic on the cost and availability of resource adequacy contracts within the state.

Figure 6: Marginal Cost of Capacity Across U.S. Utilities and Wholesale Markets



Sources and Notes:
Utility costs from Baatz (2015) unless otherwise noted.[15] California costs from CPUC (2019).[16] Public Service New Mexico costs from PNM (2018).[17] Xcel MN costs from Hledik (2019).[18] PJM prices for 2021/22 Base Residual Auction (PJM West is Rest of RTO, PJM East is average of all other zonal prices). ISO-NE prices for 2022/23 delivery. NYISO prices average of 2018-19 winter and 2019 summer (NYISO Upstate is NYCA zone, NYISO Downstate is average of all other zones).

15/ Baatz (2015). Everyone Benefits: Practices and Recommendations for Utility System Benefits of Energy Efficiency (June 2015). Posted at: https://aceee.org/sites/default/files/publications/researchreports/u1505.pdf

16/ California Public Utilities Commission Energy Division (2019). 2018 Resource Adequacy Report (August 2019). Posted at: https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Electric_Power_Procurement_and_Generation/Procurement_and_RA/RA/2018%20RA%20Report.pdf

17/ Public Service Company of New Mexico (2017). PNM 2017 – 2036 Integrated Resource Plan. July 3, 2017. Posted at https://www.pnm.com/documents/396023/396193/PNM+2017+IRP+Final.pdf/eae4efd7-3de5-47b4-b686-1ab37641b4ed

18/ Hledik (2019). The Potential for Load Flexibility in Northern States Power's Service Territory (June 2019). Posted at: https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId=%7b10FBAE6B-0000-C040-8C1D-CC55491FE76D%7d&documentTitle=20197-154051-03.

I estimated that Gemini will provide a firm capacity value of approximately 442 MW. This firm capacity value is the sum of 138 MW firm capacity value provided by Gemini's solar facility and 304 MW firm capacity value provided by the storage facility.

To estimate the capacity value associated with Gemini's 690 MW nameplate solar facility, I derated its nameplate capacity by 80 percent to 138 MW, consistent with NV Energy's approach in the Third Amendment.[19/] As I understand it, this derate roughly accounts for the coincidence of the solar output profile with the timing of NV Energy's net system peak.

To estimate the capacity value of Gemini's 380 MW, 1,416 MWh storage component, I applied two adjustments. First, consistent with NV Energy's IRP, I assumed the storage component has capacity value equal to its maximum continuous four-hour discharge level of 354 MW. Second, consistent with the 2018 storage study, I applied a further 14 percent derate to account for the declining marginal capacity value of storage as it is deployed at increasing levels to NV Energy's system. After applying these derates I estimated the capacity value of Gemini's storage component to be 304 MW.

Q.22 HOW DID YOU QUANTIFY THE ANCILLARY SERVICES BENEFITS THAT GEMINI WILL PROVIDE?

A.22 Because of its quick ramp rate, energy storage is well suited to serve NV Energy's spinning reserve requirement. At any point in time, if the storage component of Gemini has the physical capability to discharge more energy onto the grid than its scheduled amount, Gemini can use the excess available capacity to provide spinning reserves to the NV Energy system.

19/ See Page 114, Docket No. 19-06039, NV Energy Volume 1: NV Energy Northern and Southern Service Territory IRP 3rd Amendment

To quantify this flexibility benefit, I used average historical market prices for spinning reserves from several U.S. wholesale markets[20] as a proxy for the value of spinning reserves that could be provided by Gemini on NV Energy's system. Using the 2020 and 2030 model outputs from the energy value analysis, I calculated Gemini's hourly available capacity to provide spinning reserves. Multiplying the capability to provide spinning reserves by the hourly average historical prices provided an estimate of total system-wide ancillary service value. It is possible that the storage portion of Gemini could provide additional ancillary service value to the NV Energy system in the form of frequency regulation, though I did not include an estimate of such value in my analysis.

Q.23 HOW DID YOU QUANTIFY THE EMISSIONS REDUCTION BENEFITS THAT GEMINI WILL PROVIDE?

A.23 I quantified emissions reduction benefits by first estimating the total CO_2 emission reductions provided by Gemini and then valuing those emissions reductions at an estimate of the social cost of carbon. I quantified CO_2 emissions reductions by first estimating the emissions rate of the marginal generator supplying power to southern Nevada in each hour. I then multiplied these hourly marginal emissions rates by the hourly output from Gemini to estimate total emissions reduced in each hour. I estimated that Gemini will offset natural gas generation in most hours. In these hours, I calculated the "implied marginal emissions rate" (i.e., the emissions rate of the marginal gas plant) as the hourly marginal cost of energy, divided by the natural gas price, multiplied by the carbon content of natural gas. In hours where hourly

[20] Consistent with the historical energy price analysis, I use 2016 through 2018 day ahead historical prices for the southern CAISO reserve zone, SPP reserve zone 2, and ERCOT. Note that the comparable product to spinning reserves in ERCOT is called "responsive reserves." To account for seasonal differences in spinning reserve value, I separately consider summer and winter hourly average prices.

system costs were low, I assumed renewable generation is on the margin and thus Gemini's output provides no emissions benefits in these hours. I utilized a study from the 2016 Federal Interagency Working Group ("IAWG") to develop my estimate of the social cost of carbon.[21/]

I did not analyze the benefits of reducing other pollutants. NV Energy's 2018 IRP found these benefits to be small relative to CO_2 emission reduction benefits.

V. GEMINI COST-EFFECTIVENESS ASSESSMENT

Q.24 WHAT ARE THE COSTS OF GEMINI TO NV ENERGY RATEPAYERS UNDER THE "PPA BENCHMARK" CASE?

A.24 Recall that the PPA Benchmark case assumes that Gemini will operate at an average 65 percent capacity factor during the FRP, consistent with NV Energy's assumptions as filed in its Third Amendment. Under these conditions, I have estimated the present value of the cost of the PPA over its full 25-year term, plus the cost of transmission upgrades, to be $902 million. On a levelized cost of energy ("LCOE") basis, this is $37.79/MWh.[22/] I used the same calculations as NV Energy to develop these estimates.[23/]

21/ Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (August 2016). Both the 2018 PUCN storage study and NV Energy's 2018 IRP utilized this source to develop social cost of carbon estimates. The IAWG study provides four social cost of carbon estimates that differ depending on the assumed societal discount rate at which future environmental damages are valued: average damages under discount rates of 5 percent, 3 percent, and 2.5 percent, and a "high impact case" that models the 95^{th} percentile of damages with a 3 percent discount rate. I assumed a social cost of carbon consistent with the average damages and a 3 percent discount rate as it represents a midpoint across all values. I then subtracted out the carbon price assumed in the 2018 PUCN storage study, which reflects the component of societal carbon value captured in the energy market.

22/ My estimate of the LCOE of the Gemini project is slightly lower than NVE's estimate, and my estimate of the present value of the project cost is slightly higher than NV Energy's estimate. My analysis has accounted for reduced "clipping" of Gemini's solar output that the DC-tied battery will enable, which leads to a slightly higher estimate of total energy generated by the facility during the Dispatchable Period.

23/ NCARE 2-11.

Q.25 WHAT ARE THE NET CUSTOMER BENEFITS OF GEMINI UNDER THE "PPA BENCHMARK" CASE?

A.25 I estimate that Gemini's energy cost savings alone will outweigh the Project's total costs. The present value of energy cost savings is estimated to be \$1,167 million over the 25-year life of the PPA, compared to a present value of project costs of \$902 million.[24/]

Avoided capacity costs significantly further contribute to the benefits of the project, increasing the total benefit by \$253 million, to \$1.4 billion (present value). Considering only the energy and capacity value of the project – which I consider to be Gemini's primary benefits – the project's benefit-to-cost ratio is 1.57-to-1. The *net* system-wide benefit is \$518 million under these conditions (present value).[25/]

Reduced ancillary services costs are an additional benefit that accrues to Nevada customers, though there is more uncertainty in this calculation given the absence of public information on the price or cost of operating reserves on NV Energy's system. Including my estimate of ancillary services benefits would increase the total present value of benefits by \$97 million, to \$1.5 billion. In this case, the benefit-to-cost ratio increases to 1.68-to-1 and the present value of system-wide *net* benefits to Nevada customers increases to \$614 million.

The inclusion of CO_2 emissions reduction benefits provides an additional \$649 million of value when valued at the social cost of carbon. If CO_2 emissions reductions were included as a benefit in the cost-effectiveness assessment, the present value of total benefits would

---

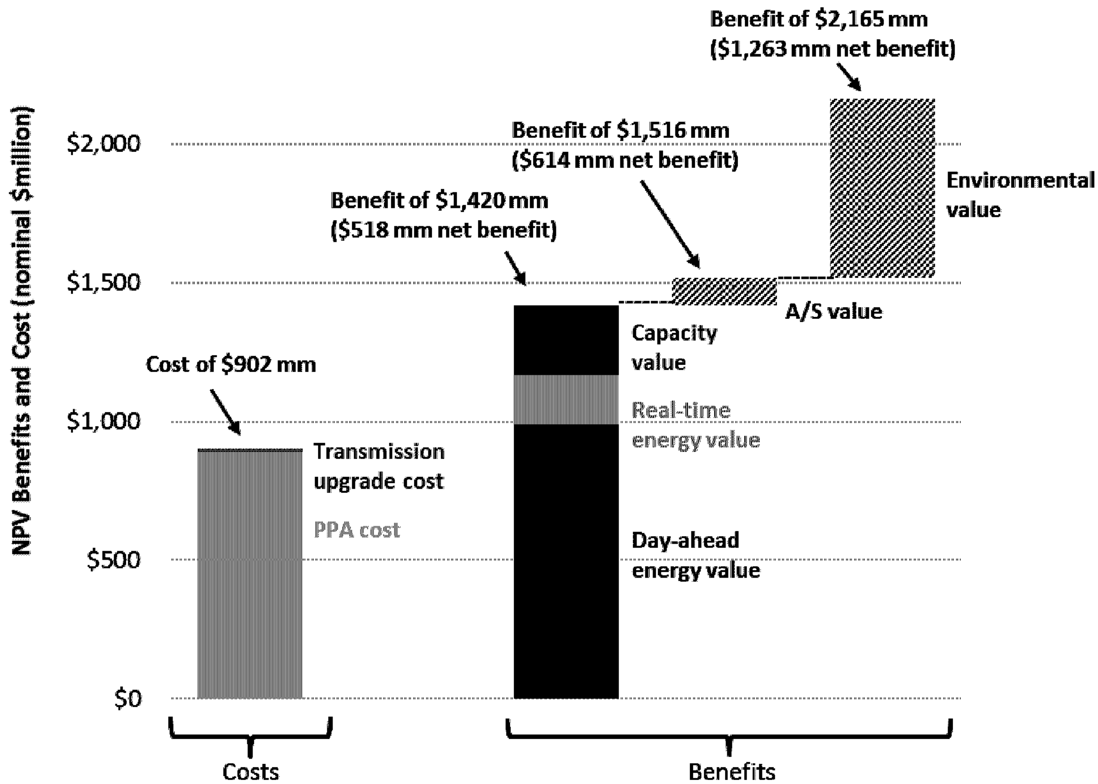
24/ My understanding is that the PPA includes a provision for NV Energy to purchase Gemini in year 10. At that point, NV Energy would have the option to charge the battery from the grid rather than exclusively from onsite solar facility; there would be no loss of ITC. This would remove an operational constraint, and I would expect the result to be higher energy value than I have estimated in my testimony.

25/ To test the sensitivity of my findings to the capacity cost assumption, I analyzed a case which reduced my capacity cost assumption by 50 percent, to only \$22.75/kW-yr. Under that assumption, the project is still significantly cost-effective, with net economic benefits of \$391 million (present value).

increase to $2.2 billion, *net* benefits would increase to $1.3 billion, and the benefit-to-cost-ratio would increase to 2.40-to-1.

Figure 7 illustrates the comparison of benefits and costs in the PPA Benchmark case.

Figure 7: Customer Costs and Benefits of Gemini (PPA Benchmark Case)



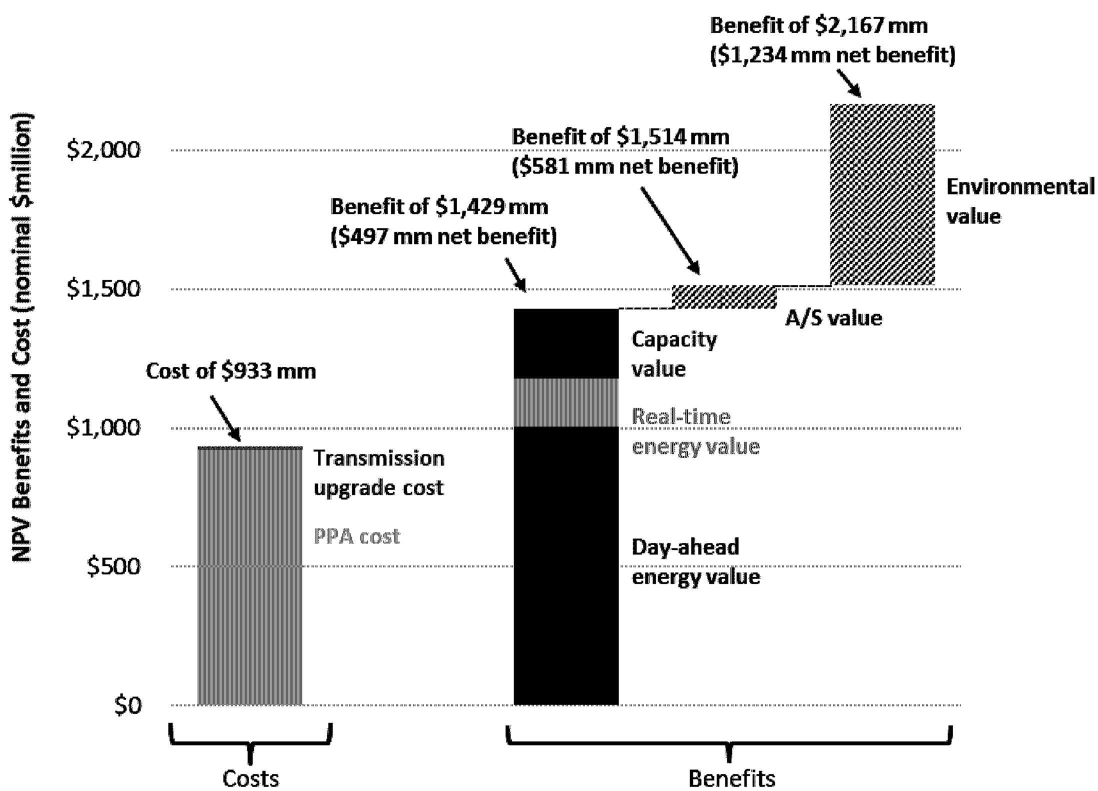
Q.26 HOW DO THESE NET BENEFITS FROM THE PPA BENCHMARK CASE COMPARE TO THE NET BENEFITS FROM THE TECHNICAL POTENTIAL CASE?

A.26 In the Technical Potential case, I have assumed that Gemini would be dispatched to utilize the technical potential of its output capability during the FRP, subject to constraints such as the 690 MW injection limit. The result is a greater share of its output during the FRP period.

Shifting more generation to the FRP period has the primary effect on benefits of increasing the energy value of the project, since there is more output during hours with higher marginal energy costs. Spinning reserves value decreases and emissions reduction value increases. Due to the structure of the PPA, with a higher price being paid during the FRP period, the total PPA cost is higher than in the PPA Benchmark case as well.[26/]

Accounting for these differences, the Technical Potential case results in net economic benefits of $497 million (present value) when accounting only for energy and capacity value, with a benefit-cost ratio of 1.53-to-1. This net benefit to ratepayers is slightly (3 percent) lower than in the PPA Benchmark case. Figure 8 summarizes the costs and benefits of the Technical Potential case.

Figure 8: Customer Costs and Benefits of Gemini (Technical Potential Case)



[26/] Under the Technical Potential case assumptions, the present value of PPA costs plus transmission costs is $933 million and the LCOE is $39.09/MWh.

Q.27 BASED ON THIS ANALYSIS, WHAT DO YOU CONCLUDE ABOUT THE COST-EFFECTIVENESS OF GEMINI?

A.27 Gemini is a highly cost-effective project for NV Energy and its customers. My analysis indicates that the project's cost-effectiveness is robust across a range of assumptions about future operations. Gemini's value is enhanced in particular by the inclusion of 380 MW of energy storage capacity. The energy storage component of the project allows NV Energy to realize much greater capacity and system flexibility benefits than if Gemini were a standalone solar project or had more limited storage capabilities.

Q.28 IS YOUR CONCLUSION ABOUT THE COST-EFFECTIVENESS OF THE GEMINI PROJECT CONSISTENT WITH YOUR FINDINGS FROM YOUR 2018 STORAGE STUDY FOR THE PUCN?

A.28 Yes, although it is difficult to make a perfect comparison between my analysis in this testimony and the 2018 PUCN storage study. That is because this testimony is focused on a specific solar-plus-storage project in a specific location, whereas the 2018 PUCN storage study analyzed the statewide deployment of generic, standalone storage resources. However, a basic comparison can be made between the two analyses.

I have applied a few adjustments to the results of the 2018 PUCN storage study to account for differences between Gemini and the standalone, distributed storage technology assumed in the 2018 study. The first adjustment was to reduce the 2018 study's estimates of the marginal benefits of storage to reflect that I have not assigned any T&D deferral benefits or customer reliability benefits to Gemini. The second adjustment was to reduce the study's 2020 storage cost estimates of $1,200/kW to reflect that Gemini would be eligible for the ITC and to account for expected cost reductions between 2020 and 2023 (when Arevia will purchase the storage equipment for Gemini).

After applying these adjustments, the results of the 2018 PUCN storage study would indicate that 400 MW to 600 MW of energy storage capacity would be cost effective by 2024, greater than the storage capacity of Gemini and approximately equal to the storage capacity included across all three PPAs that have been proposed by NV Energy in the Third Amendment.[27/]

Q.29 HAVE YOU ANALYZED THE IMPLICATIONS OF DEFERRING THE DEVELOPMENT OF GEMINI?

A.29 Yes. There would be two significant effects of deferring the development of Gemini. First, waiting to pursue the project (or a project like it) would result in a reduction in the ITC. Projects beginning construction in 2022 and beyond will receive only a 10 percent ITC, rather than the 30 percent ITC available to Gemini. On the other hand, a deferred project could potentially benefit from declines in future technology costs. I have analyzed how this tradeoff would change the economics of the Gemini project in a case where its development is deferred.

Q.30 WHAT DID YOU ASSUME ABOUT FUTURE DECLINES IN SOLAR AND STORAGE TECHNOLOGY COSTS?

A.30 Based on a review of public forecasts of solar and storage technology cost declines, I estimated that the aggregate cost of systems like Gemini will fall at a rate of one to four percent per year (nominal) through 2030. This is the weighted average of the solar and storage shares of Gemini's total installed capacity.

Storage costs are projected to decline at a rate of 3.0 to 6.7 percent per year (nominal) between 2020 and 2030. This estimate is consistent with the 2018 PUCN storage study and the

[27/] This is an approximate comparison. Other factors to consider, which fall outside the framework of the 2018 PUCN storage study, include cost savings associated with hybrid solar-plus-storage projects, and constraints on battery operations associated with charging from the on-site solar facility.

medium and high cost decline cases from the 2019 National Renewable Energy Laboratory ("NREL") Annual Technology Baseline ("ATB") report.[28] Installed solar costs are projected to decline at a rate of 0.2 to 2.7 percent per year (nominal) over the same time period, consistent with medium and high cost decline cases in the 2019 NREL ATB report. The NREL ATB is a widely cited source of energy technology cost projections.

Q.31 WHAT HAVE YOU CONCLUDED ABOUT THE IMPLICATIONS OF DEFERRING THE DEVELOPMENT OF GEMINI?

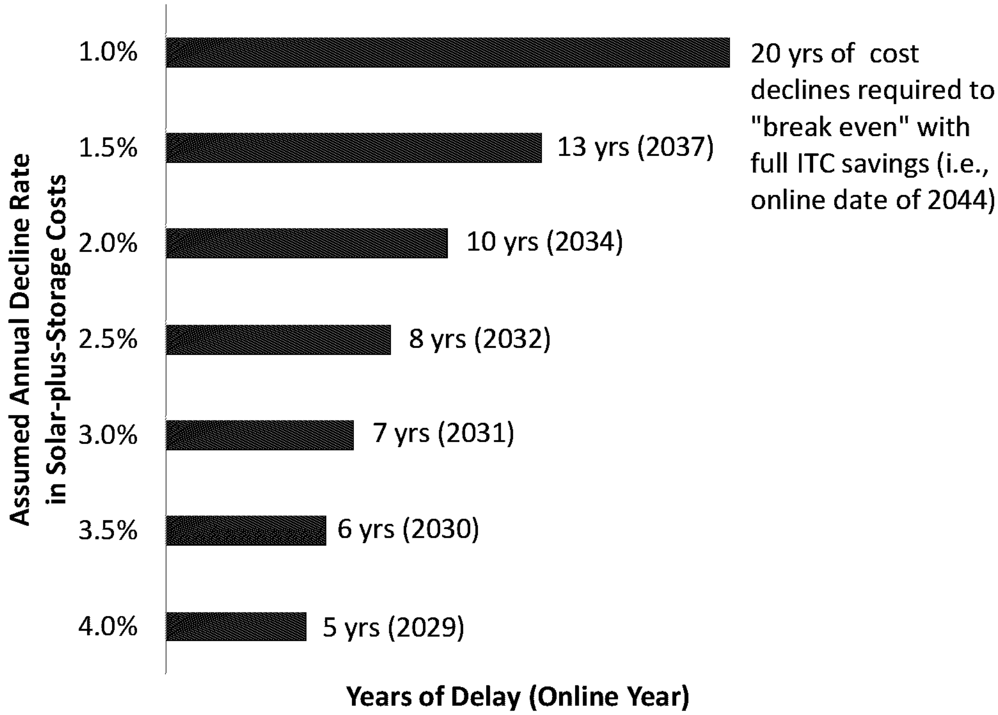
A.31 The development of Gemini likely would need to be deferred beyond 2030 in order for the projected declines in solar and storage technology costs to offset the loss of the ITC reduction from 30 percent to 10 percent. In other words, the 20 percent effective increase in costs due to the loss of the full ITC would need to be offset by approximately 20 years at 1 percent annual cost declines, or 5 years at 4 percent annual cost declines.[29] Figure 9 summarizes the number of years that would be required to offset the loss of the ITC under various assumptions about the annual decline in solar-plus-storage technology costs.

---

[28] 2019 Annual Technology Baseline. Golden, CO: National Renewable Energy Laboratory (NREL). Posted at: https://atb.nrel.gov/. Accessed September 2019. Both my estimate from the 2018 PUCN storage study and the NREL ATB estimate are derived from a survey of publicly available storage cost forecasts.

[29] The simple illustration described here assumes no compounding of the annual cost declines. Accounting for compounding would lead to slightly larger estimates of the number of years that would be needed to offset the loss of the full ITC.

Figure 9: Years of Consecutive Solar-plus-Storage Technology Cost Declines Required to Offset the Loss of the Full ITC, at Various Assumed Annual Technology Cost Decline Rates



Notes:
Gemini is expected to come online end of November 2023, with 2024 being the first full year of operation. Therefore, 2024 is presented as the effective online year in the figure.

Additionally, delaying development of Gemini would forego the cost savings and environmental benefits of the Project over those years when the Project otherwise would be online. Deferred benefits have less value to the system on a present value basis, and therefore would amount to higher costs for NV ratepayers than if the PPA were implemented as proposed by NV Energy.

VI. CONCLUSION

Q.32 PLEASE SUMMARIZE THE FINDINGS OF YOUR TESTIMONY.

A.32 My analysis indicates that the Gemini PPA will provide benefits to NV Energy ratepayers that significantly outweigh its costs. These benefits are derived from the production of clean, low cost energy from Gemini's solar facility, and from the significant operational flexibility and peak-coincident generation capacity that is enabled through the storage facility.

My estimates of the economic value of the Gemini project are based on projections developed through prior modeling work in Nevada, the assumptions, methodology, and results of which were reviewed and vetted with PUCN Staff and industry stakeholders.

The Gemini PPA is a unique opportunity for NV Energy ratepayers, because its pricing reflects an expectation that the project will capture the full 30 percent reduction in installed cost savings available through the ITC. As such, deferring the project would otherwise increase the net cost of meeting Nevada's aggressive decarbonization goals.[30/]

Q.33 DOES THIS CONCLUDE YOUR TESTIMONY?

A.33 Yes, it does.

[30/] See SB 358 (2019), Sec. 8.

EXHIBIT HLEDIK-DIRECT-1

STATEMENT OF QUALIFICATIONS OF RYAN M. HLEDIK

RYAN M. HLEDIK
Principal

San Francisco, CA | +1.415.217.1000 | Ryan.Hledik@brattle.com

Mr. Ryan Hledik is a principal of The Brattle Group specializing in regulatory and planning matters related to emerging energy technologies.

Mr. Hledik has consulted for more than 50 clients across 30 states and 8 countries. He has supported his clients in matters related to energy storage, load flexibility, distributed generation, electrification, retail tariff design, energy efficiency, and grid modernization.

Mr. Hledik's work has been cited in regulatory decisions establishing procurement targets for distributed energy resources, authorizing billions of dollars in smart metering investments, and approving the introduction of innovative rate designs. He is a recognized voice in debates on how to price electricity for customers with distributed generation. He co-authored Saudi Arabia's first Demand Side Management (DSM) plan, and the Federal Energy Regulatory Commission's landmark study, *A National Assessment of Demand Response Potential*.

Mr. Hledik has published more than 25 articles on electricity matters and has presented at industry events throughout the United States as well as in Brazil, Belgium, Canada, Germany, Poland, South Korea, Saudi Arabia, the United Kingdom, and Vietnam. His research on the "grid edge" has been cited in *The New York Times* and *The Washington Post*, and in trade press such as *GreenTech Media*, *Utility Dive*, and *Vox*. He was named to *Public Utilities Fortnightly's* "Under Forty 2019" list of rising stars in the utility industry.

Mr. Hledik received his M.S. in Management Science and Engineering from Stanford University, where he concentrated in Energy Economics and Policy. He received his B.S. in Applied Science from the University of Pennsylvania, with minors in Economics and Mathematics. Prior to joining Brattle, Mr. Hledik was a research assistant with Stanford's Energy Modeling Forum and a research analyst with Charles River Associates.Stanford University's Energy Modeling Forum and a research analyst at Charles River Associates.

AREAS OF EXPERTISE

- Energy Storage
- Grid Modernization
- Innovative Retail Electricity Pricing
- Demand Response and Energy Efficiency
- Electrification
- Wholesale Electricity Markets
- Model Development
- Energy Asset Valuation
- Mergers & Acquisitions

EXPERIENCE

Energy Storage

- Currently serving on the Energy Storage Association's Technical Advisory Council. Responsibilities include technical advice, providing input to the organization's research agenda, and developing whitepapers on emerging issues in the storage industry.
- For the ESA, currently organizing two workshops on emerging industry practices for incorporating energy storage into utility resource planning.
- For Public Service Company of New Mexico (PNM), led analysis of the value that new energy storage developments could provide to the utility's system. The analysis focused specifically on the benefits of standalone, utility-scale battery storage deployments. Results were summarized in a report titled, "The Value of Energy Storage to the PNM System," which was attached to a regulatory filing by PNM in June 2019.
- For the Public Utilities Commission of Nevada and the Nevada Governor's Office of Energy, led a study to estimate the statewide potential for cost-effective energy storage deployment. The analysis involved detailed modeling of the Western U.S. power system and included an assessment of both utility scale and behind-the-meter storage. Results were published in a report titled, "The Economic Potential for Energy Storage in Nevada." The study has contributed to a regulatory proceeding to establish an energy storage procurement target for the state.
- For a large Southeastern utility in PJM, provided and assessment of the opportunities available for deploying energy storage pilots. The analysis began with a screening analysis to identify most attractive pilot options based on net economic benefits as well as other practical considerations such as implementation time, technical feasibility, consistency with state policies, and repeatability. Based on the findings of the screening analysis, a detailed assessment of specific solar-plus-storage and standalone storage projects estimated the benefits and costs of each project under a range of market price scenarios, technology configurations, and operational strategies.
- For a large solar and storage developer, provided due diligence support for a potential investment in a solar-plus-storage facility in California. The analysis estimated revenue potential for the project under a range of price forecasts, technology configurations, and battery dispatch scenarios.
- For an international investor in power assets, analyzed the revenue opportunities and risks for standalone storage projects in California, Ontario (Canada), and New York. In addition to detailed revenue forecasts, the analysis included a review of wholesale market participation opportunities, state policies and incentives, and trends in market fundamentals.

- For an energy storage developer, provided an outlook of revenue opportunities in Ontario, Canada. The analysis included an assessment of near-term revenue potential and commentary on the likely impact of regulatory and market developments on that potential.
- For a large Midwestern utility, contributed to the development of a model that forecasts behind-the-meter storage adoption and its impact on utility revenues and costs, electricity rates, system peak demand, and other key metrics.
- For a battery technology manufacturer, reviewed the impacts that PJM rule changes for participation in the frequency regulation market had on the battery's performance.
- For EOS, a battery storage developer, assessed the "stacked value" of a battery in the California market. The valuation included a detailed assessment of market prices and was based on realistic modeling of the battery's ability to simultaneously capture multiple value streams. The study also included an assessment of barriers to capturing this value, and recommendations regarding retail tariff design features that could address the barriers.
- For an environmental advocacy group (NRDC) and consortium of utilities (NRECA), estimated the costs and benefits of using controllable hot water heaters as "thermal batteries." Evaluated several control strategies, including daily energy arbitrage, peak shaving, and fast-response controllers capable of providing ancillary services. The study was covered by the *Washington Post* and in industry trade press.
- For a battery manufacturer, assessed the potential benefits that could be realized by deploying their technology in PJM and NYISO. Developed a dispatch model to simulate the technology's optimal operation in wholesale energy and ancillary services markets. Also quantified the value of avoided generation capacity and transmission and distribution capacity costs, as well as the reliability value if deploying the battery behind the meter. Assessed the ability of various stakeholders (ratepayers, utilities, third parties) to capture the value.

Grid Modernization

- For Entergy, provided regulatory support for the company's proposal to roll out smart meters. Support included analysis of the energy efficiency and demand response benefits that would be enabled by the rollout.
- For a large British energy supplier, conducted an assessment of the national smart metering program. Identified risks that have emerged since the program's inception. Developed recommendations for plausible paths forward to mitigate the risks and increase the likelihood of the program's success. Research involved a detailed review of the BEIS smart metering

Impact Assessment (IA), including modifications to the IA based on alternative future smart metering adoption and TOU uptake scenarios.

- For the U.S. Department of Energy, served as a member of a Technical Advisory Group to review the activities of recipients of federal stimulus funding for consumer behavior studies. Reviewed smart grid pilot designs and provided guidance to improve their likelihood of success. Participated in regular meetings with the utilities on behalf of the U.S. DOE to monitor progress.
- Lead architect of Brattle's *iGrid* model for assessing the costs and benefits of smart grid deployment strategies over a long-term (*e.g.,* 50-year) forecast horizon. The model was used to evaluate seven distinct smart grid programs and technologies (*e.g.,* dynamic pricing, energy storage, plug-in hybrid electric vehicles) against seven key metrics of value (*e.g.,* avoided resource costs, improved reliability).
- Supported an expert witness in litigation regarding a contractual dispute between two smart grid companies. Assessed the likely market size for a new smart grid product using top-down and bottom-up modeling approaches. Drafted expert testimony.
- For the five Vietnamese distribution utilities, developed a 10-year roadmap for smart grid deployment across the country. The project began with a series of in-country stakeholder interviews and an initial assessment of the state of the Vietnamese grid. This information was used to develop preliminary recommendations for smart grid investment, which was presented and discussed during a one-day workshop with industry stakeholders. Feedback was incorporated into a final report titled *Vietnam's 10-year Smart Grid Roadmap*. The project was funded by the World Bank.
- For a firm investing in emerging energy technologies, developed an overview of key smart grid market developments. Topics included new non-traditional entrants to the utilities space, factors driving the decline in utility sales growth, and emerging regulatory constructs that could lead to new investment opportunities.
- For Pepco Holdings, established a universal list of metrics through which to track the impact of their smart grid rollout. Reviewed existing metric reporting requirements and proposed additional metrics that would be useful to report in future regulatory proceedings.
- For a smart grid technology startup, provided strategic advice on how to design a smart grid pilot that would best demonstrate the value of their products. Authored a whitepaper summarizing key recommendations and assisted the company in effectively articulating the full value proposition of their integrated approach to home energy management.

- For Oak Ridge National Lab (ORNL) and the Electric Power Research Institute (EPRI), contributed to a report for evaluating the cost-effectiveness of smart grid investments. The report was published under the title *Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects.*
- For the Connecticut Department of Energy and Environmental Protection (DEEP), contributed to the state's annual Integrated Resource Plan (IRP). Developed a chapter on emerging technologies (such as AMI, energy storage, and advanced waste-to-energy) and their potential future role in the state's mix of energy resources.

Innovative Retail Electricity Pricing

- For Abradee, the trade association for the Brazilian distribution utilities, developed two whitepapers. The first paper addressed international stakeholder perspectives on emerging distribution tariff designs. The second paper summarized opportunities and risks associated with new utility services.
- For Vector, a distribution utility in New Zealand, evaluated the relative advantages and disadvantages of a variety of new distribution tariff designs that the utility was considering. Conducted analysis of customer bill impacts and estimated likely demand response from the new tariff offerings, in addition to establishing other rate evaluation metrics.
- For NorthWestern Energy, provided regulatory support for the utility's proposal to create a new rate class for customers with distributed generation and to introduce three-part rates for those customers.
- For Arizona Public Service, provided regulatory support and analysis in a proceeding to determine if the utility's commission-approved rate increase had been appropriately implemented.
- For Westar Energy, supported the utility's proposal to create a separate rate class for residential customers with distributed generation, and to introduce a three-part rate for those customers
- For Idaho Power supported the utility's proposal to create a separate rate class for residential customers with distributed generation. Included an analysis of the extent to which behind-the-meter storage would impact the load shapes of customers with rooftop solar and reduce their energy exports to the grid.
- For Commonwealth Edison, contributed to the development of a pilot that would test customer acceptance of a prepayment metering program. Work involved identifying pilot objectives, developing experimental design, and establishing appropriate sample size.

- For Citizens Advice, the largest consumer organization in Great Britain, led a study on the value of time-varying rates. The study included detailed power system modeling to quantify the monetary value time-varying rates in terms of avoided system costs. The study also included primary and secondary market research to identify the features of time-varying rate offerings that are most appealing to customers. The final report has informed ongoing dialogue in Great Britain around how to best capture value from the nation's ongoing smart metering rollout.
- For the U.S. Department of Energy (DOE), co-authored a whitepaper on methods for unbundling and pricing distribution services in an environment of high distributed energy resource (DER) market penetration. The report identified the various services that are provided by the utility to DER customers, the discrete services provided by DER customers to the utility, and various frameworks for packaging and pricing these services. The report included an assessment of the advantages and disadvantages of each pricing framework from the perspective of both the utility and its customers.
- For a clean energy organization, developed a whitepaper on residential demand charges, their impact on low income customers, and the potential opportunities that they would create for behind-the-meter energy storage.
- For the Edison Electric Institute (EEI), researched stakeholder perspectives on residential demand charges. Conducted interviews with nine consumer advocates to better understand their views on the advantages and disadvantages of demand charges relative to other rate design options. Findings were summarized in a *Public Utilities Fortnightly* article.
- For Georgia Power, developed a model to simulate likely customer response to demand charges (i.e. load shifting and/or changes in overall consumption). The model assumptions are based on a review of price elasticity studies as well as three pricing pilots involving residential demand charges. Also surveyed recent utility experience with residential demand charges and established a list of "lessons learned" from this experience.
- For Westar Energy, assessed the extent to which a new three-part rate (with a fixed charge, a demand charge, and a variable charge) would impact customer bills. Simulated the impact on owners of distributed generation (DG) and assessed the extent to which rate increases associated with sales reductions due to DG adoption would be reduced by introducing the new rate. Estimated likely customer rate switching behavior that would result from the introduction of the new options and the impact that this would have on utility revenue.
- Assisted a large Southwestern U.S. utility in establishing its vision for the ideal residential rate. Established key principles for ratemaking and evaluated a comprehensive range of rate designs against these principles, particularly as they relate to fairness and equity in an environment of

rapidly growing solar PV adoption. Provided strategic recommendations for transitioning to the ideal rate design.

- For a large Midwestern utility, assessed the bill impacts of a rollout of mandatory residential demand charges. The assessment included a particular focus on the impacts on low income customers using estimates of household-level income data obtained through a market data firm and validated with public data from the U.S. Census.
- For Citizens Advice, led a study on distribution network tariff design. The report includes insights from interviews with industry stakeholders, a survey of tariff reform activity in other countries, and detailed modeling of the distribution of bill impacts from the new tariff designs for more than 14,000 British customers. The simulations account for likely consumer response to the tariffs.
- For Xcel Energy, contributed to rebuttal testimony in support of the utility's proposal to eventually introduce three-part rates for residential customers. Addressed points in intervenor testimony regarding the efficacy of residential demand charges.
- For a large Midwestern utility, simulated likely customer response to a three-part rate. Developed three different approaches to estimating the impacts. Results were provided in context of the utility's rates proceeding.
- For Salt River Project (SRP), conducted an assessment of the utility's rate proposal for residential DG customers. The proposal was a mandatory, revenue neutral three-part rate with a tiered demand charge. Analysis culminated in the development of a whitepaper that was presented to SRP's Board. The rate proposal was approved by the Board.
- Assisted PGE in the design of a dynamic pricing pilot. Providing pilot design and evaluation assistance to test a number of under-researched issues, such as the impact of behavioral DR and differences in customer response when rates are offered on an opt-in versus an opt-out basis.
- For more than 15 utilities and other organizations across North America, designed dynamic pricing rates such as time-of-use (TOU), critical-peak pricing (CPP), peak-time rebates (PTR), and real-time pricing (RTP). Simulated the likely impact of the rates on utility load shapes and customer bills. Conducted cost-effectiveness analysis of offering these rates to the mass market. Recently, these studies have been conducted in Arizona, California, Connecticut, the District of Columbia, Delaware, Florida, Hawaii, Idaho, Illinois, Kansas, Maryland, Michigan, Missouri, New Jersey, North Carolina, Oregon, and Pennsylvania. Several of the analyses served as input to AMI business cases. The analyses also included a review of other demand-side options such as direct load control and energy efficiency.

- For the three California investor-owned utilities (IOUs), assessed the likely impact of residential rate reform on consumption. Analyzed the extent to which rate design changes (e.g., a reduction in the price differential between tiers of the inclining block rate, the introduction of a monthly customer charge, a reduction in the low income discount) would affect conservation. Drafted expert testimony that was submitted to the California Public Utilities Commission.
- For a large southwestern utility, benchmarked the utility's projected retail rate against those of other utilities. Reviewed utility resource plans to estimate each utility's retail rate trajectory. Compared the utilities across a variety of rate drivers, such as reserve margin, fuel mix, load growth, load factor, renewables investment requirements, and demand-side activities. Provided strategic recommendations for addressing these drivers of future rate growth.
- For PacifiCorp, assessed the likely impacts of new rate designs on customer behavior. Projected likely adoption of the new rate offerings based on a survey of enrollment rates in other jurisdictions. Extrapolated the customer-level impacts to system-level impacts. Analysis was a key element of the utility's DSM potential study.
- For a large Western utility, evaluated the degree to which the introductions of new optional residential rate options would affect the utility's revenue. Developed a model to simulate customer switching behavior between the rate options. Provide strategic advice for transitioning from the current rate offering to a new paradigm of rate choice.
- For the Regulatory Assistance Project (RAP), co-authored a whitepaper on issues and emerging best practices in dynamic pricing rate design and deployment. The paper's audience was international regulators and rate analysts in regions that are exploring the potential benefits of AMI and innovative retail pricing.
- For multiple U.S. utilities, helped design pilot programs for testing the impact of dynamic pricing rates and enabling technologies such as smart thermostats and in-home energy information displays. Contributions to pilot design included designing and selecting the appropriate treatments and providing general recommendations for ensuring the statistical validity of the results.
- For China Light & Power, provided guidance on dynamic pricing pilot design. Also evaluated the utility's methodology for calculating customer baseline consumption when determining rebate payments for a Peak Time Rebate program.
- For the Ontario Energy Board (OEB), developed recommendations for improving the effectiveness of the province's mandatory residential TOU rate. Co-authored a whitepaper benchmarking the rate's design and deployment against best practices, and provided

suggestions for improving certain elements. Co-presented the findings at a stakeholder workshop in Ontario.

- For Commonwealth Edison, contributed to the design of the first opt-out residential dynamic pricing pilot. Reviewed rate designs and simulated expected bill impacts across a representative sample of customers. Developed estimates of the potential value of an opt-out deployment of peak time rebates.
- For the Demand Response Research Center (DRRC), co-authored a whitepaper on leading issues in rate design. Developed a set of dynamic rates that were used in a workshop to guide California decision makers through the process of designing dynamic rates. Results were cited in a landmark ruling making dynamic pricing the default rate offering in California.
- For Xcel Energy, contributed to expert testimony supporting a filing proposing new inclining block rate (IBR) designs. The rates were designed to provide incentives for Xcel's customers to conserve energy. Developed a model for simulating customer response to the new rate designs and the resulting impact on Xcel's sales.
- For a large North American utility, developed estimates of the likely impact of moving from an inclining block rate structure to a time-of-use rate structure. Simulated the impact on overall energy consumption and peak demand under a range of rate design and price elasticity scenarios.
- For a large Southeastern utility, assessed the costs of the utility's green pricing program. Benchmarked the costs against those of similar programs offered by other utilities. Analyzed differences across programs and provided an assessment of the utility's costs, which was presented to the regulatory commission.

Load Flexibility, Demand Response, and Energy Efficiency

- For Xcel Energy, led a study to assess opportunities for load flexibility in its Northern States Power service territory. The study looked beyond conventional DR options to evaluate the potential for emerging programs (e.g., EV charging control, behavioral DR) while considering new value streams (e.g. ancillary services, off-peak load building, around-the-clock load flexibility). The study utilized Brattle's LoadFlex model and is based on a detailed survey of DR programs and pilot projects deployed around the U.S. The study was filed with the Minnesota PUC and results were be used as inputs to Xcel Energy's integrated resource plan in the Upper Midwest

- For EPRI, conducted a study to explore methods for incorporating DERs into integrated resource planning. A unique feature of this study was the use of Brattle's capacity expansion model, Grid

SIM, to quantitatively illustrate the implications of various DER modeling techniques. As a first phase, we assessed the implications of different approaches to modeling energy efficiency. We analyzed the advantages and disadvantages of modeling EE on the supply side versus the demand side, explored techniques for bundling EE measures, and addressed questions about planning around uncertain EE impacts. The second phase of the project includes other forms of DERs, such as DR and distributed storage.

- For Xcel Energy, conducted a first-of-its-kind study to assess the extent to which "organic conservation" (also known as naturally occurring energy efficiency) was affecting electricity sales. Surveyed industry contacts about trends in organic conservation. Conducted a quantitative assessment of the impact of organic conservation for three end-use case studies using data from the U.S. Energy Information Administration and Xcel Energy.
- Contributed to a study for the Texas Clean Energy Coalition to determine role of demand response, energy efficiency, and combined heat and power in future energy scenarios in Texas. Developed a feasible portfolio of EE and DR measures, including costs and performance characteristics. The programs were then fed into a suite of resource planning models to determine the impacts of EE and DR on ERCOT prices and system operations. The final report was highly publicized and presented to stakeholders and policymakers throughout the state.
- For EnerNOC, developed a whitepaper on valuing DR in international markets. Provided guidelines for quantifying the value of DR and presented three international case studies to illustrate how those calculations vary across markets.
- For a large power developer, assessed the energy efficiency aspects of the U.S. Environmental Protection Agency's (EPA's) Clean Air Act, section 111(d). Specifically, analyzed the extent to which the energy efficiency targets that were established in the proposed policy were reasonable and achievable, and whether the EPA had represented energy efficiency correctly in its modeling scenarios.
- For the Kingdom of Saudi Arabia's energy regulator (ECRA), worked with a team of consultants to develop the nation's first demand-side management (DSM) plan. Participated in an introductory workshop with key stakeholders and conducted a series of in-country interviews to gather more detailed information. Co-authored an extensive study on the potential impacts and cost-effectiveness of a full range of DSM measures in Saudi Arabia. Worked with the team to develop policy recommendations and a ten-year plan for rolling out DSM measures across the country.

- For a national team of energy stakeholders in the Kingdom of Saudi Arabia, assessed the potential for broader adoption of combined heat and power (CHP). Developed a model to predict CHP potential by industry and technology type for a range of policy scenarios. Assessed barriers to adoption.
- For the Federal Energy Regulatory Commission (FERC), managed a team of contractors that developed the National Action Plan for Demand Response. The report defined a blueprint for maximizing the amount of cost-effective demand response (DR) that can be achieved in the United States. Led the development of a model that can be used to quantify the potential impacts and benefits of a variety of demand response and smart grid portfolios. Results were filed with U.S. Congress in June 2010.
- For FERC, developed a state-by-state assessment of the potential for DR. The analysis used a bottom-up approach to quantify economic and achievable potentials individually for each of the 50 states, and to characterize the existing level of DR in each state. Additionally, the work involved a comprehensive survey and analysis of existing literature on DR barriers at the wholesale and retail levels, as well as policy options for addressing these barriers. Results were filed with U.S. Congress in June 2009 in a report titled A National Assessment of Demand Response Potential. Co-authored the document and managed its development across a team of subcontractors.
- For the California Energy Commission (CEC), co-authored two whitepapers on demand response and the potential for the CEC to exercise its load management authority to further increase demand response efforts in the state. The whitepapers were the impetus for two CEC-sponsored workshops involving the California utilities, regulators, consumer advocates, and other stakeholders. The whitepapers contributed to the CEC's 2007 Integrated Energy Policy Report and have resulted in a formal proceeding on the CEC's load management authority.
- For one of California's investor-owned utilities, developed recommendations for a forward-looking demand response strategy. Conducted a series of interviews with internal stakeholders and helped to lead two workshops to create a common understanding across the company regarding the value proposition of demand response, and ways in which it can be used to address key challenges facing the utility.
- Lead architect of the Demand Response Impact and Value Estimation (DRIVE) model for assessing the hourly system impacts of portfolios of smart grid programs over a 20-year forecast horizon. The model simulates hourly system dispatch for 13 regions of the United States, both before and after a user-specified deployment of smart grid programs. The model is available on the FERC website.

- For Lawrence Berkeley National Laboratory (LBNL), updated the assumptions in FERC's 2009 A National Assessment of Demand Response Potential to reflect more recent industry developments. The results of that update were used as inputs to the Western Electricity Coordinating Council's (WECC's) transmission planning activities.
- For Portland General Electric, developed a bottom-up assessment of the peak demand reductions that could be achieved through and expanded offering of DR programs. Tailored the analysis to the specific market conditions that are unique to the Pacific Northwest and PGE's service territory. Reviewed studies on the ability of DR to integrate renewable energy resources into the grid. The study was first conducted in 2009 and then updated in 2012 and again in 2015. The 2015 update included a number of emerging DR options, such as bring-your-own-thermostat, behavioral DR, electric vehicle load control, and smart water heating programs.
- For Xcel Energy's Colorado and Minnesota service territories, conducted a bottom-up assessment of the potential impacts of DR programs. In Colorado, the study included an assessment of the cost-effectiveness of the DR options and results were filed with the Colorado PUC. In Minnesota, the study included the development of DR supply curves, which are inputs to Xcel Energy's integrated resource planning process.
- For the Midwest Independent System Operator (MISO), Bonneville Power Administration (BPA), and one of the largest power generation companies in the U.S., developed regional forecasts of the potential impacts of demand response and energy efficiency programs. Forecasts included a bottom-up assessment of existing demand response programs and a detailed projection of the achievable potential peak savings for each of these programs. The studies also included an assessment of the costs associated with the peak savings. The forecasts were used as inputs to the ISO's full-scale transmission expansion modeling effort and to enhance the market modeling efforts of BPA and the power generation company.
- For a large southern utility, assessed policies, standards, and rules/regulations addressing the development and implementation of energy efficiency programs and renewable energy resources by utilities. Analysis included an assessment of the pros and cons of various energy efficiency incentive mechanisms such as the Save-a-Watt model and California's shared savings model. Assessed the political influence and collaboration potential of the utility's stakeholders as part of the strategy formulation process.
- For a large Independent System Operator (ISO), co-authored a whitepaper assessing the status of the region's achievement of its demand response potential. The paper included an assessment of the barriers to achieving the demand response potential, followed by policy and

market design recommendations for addressing the barriers. The results were presented at the ISO's annual board meeting.

- For a large ISO, co-authored a whitepaper summarizing the current state of third party access to smart meter data. The paper reviewed existing policies in states that have already explored this issue, and drew parallels to other industries that have dealt with similar problems.
- For Comverge, developed an estimate of the potential benefits of offering an expanded residential direct load control program in the ComEd service territory. The assessment included quantification of avoided resource costs and a qualitative description of additional potential benefits, such as improved reliability and emissions reductions.

Electrification

- With the Smart Electric Power Alliance (SEPA), currently developing a paper on time-varying rates for home electric vehicle (EV) charging. The report is based on a survey of current utility rate offerings and identifies practices that are related to high enrollment in the rates.
- For the Electric Power Research Institute (EPRI), developed a survey and associated discrete choice modeling experiment to better understand drivers of EV adoption. The survey results were used to develop EV adoption models and resulting forecasts for several electric utilities.
- For EEI, developed a whitepaper to assess options and experience with rate design for fast-charging infrastructure to support adoption of electric vehicles. The whitepaper, titled, "Facilitating Electric Vehicle Fast Charging Deployment," was published in October 2018.
- For EPRI, currently developed a framework for evaluating the cost-effectiveness of new electrification initiatives. The framework, referred to as the Total Value Test, built upon cost-effectiveness tests used to evaluate demand-side management (DSM) programs. The report was published in August 2019.

Wholesale Electricity Markets

- For a large Canadian utility, developed long-run projections of marginal energy and capacity prices under a variety of scenarios (which were defined by different assumptions about fuel prices, demand, carbon prices, etc.). To help explain trends in the prices, these forecasts were accompanied by scenario-specific detail about capacity additions and retirements, emissions, unit dispatch, and other outputs.
- Developed energy and capacity price forecasts under a range of market conditions to assist a large investor-owned utility in developing a strategy related to the decision to potentially retire a nuclear generating facility.

- Worked with an ISO to integrate demand response into its resource adequacy requirements. Reviewed existing utility demand response programs to identify those that would meet resource adequacy criteria. Developed a forecast of the potential for new demand response for the ISO's planning purposes.
- For a large transmission company, contributed to analysis using Brattle's Regional Capacity Model (RECAP) model to assess the value that new transmission lines would have from the perspective of bringing more renewables into the power market. The model quantified the impact of an increased market penetration of wind generation on system costs.
- For projects with multiple utilities, developed wholesale electricity price forecasts for regions across the United States using commercially licensed linear optimization models. Model forecasts were driven by assumptions about the outlook of fossil fuel prices and regional electricity demand levels, among other variables. Forecasts were developed using multiple data sources to create a range of price forecasts encompassing the varying assumptions established in the industry. Researched the inputs, set up and calibrated the model, and analyzed the resulting forecasts.
- For power marketers in California during the Western Energy Crisis, analyzed historical hourly California electricity bid data to quantify the potential economic impacts of the bidding strategies on regional electricity markets. Analysis included bids into the ISO's day ahead and real-time energy markets and ancillary services markets, as well as the California PX markets.

Model Development

- For the New York Department of Public Service (DPS), contributed to a model that will illustrate the impact of the state's Renewing the Energy Vision (REV) policy on utility financials. The analysis includes pricing structures for customers with distributed energy resources (DERs) as key inputs. The model can be used to assess the impacts of a range of DER market penetration scenarios on utilities, rates, and bills.
- Lead developer of the Regional Capacity Model (RECAP), an optimization model for forecasting the mix of generating capacity necessary to meet U.S. electricity demand. The model closely calibrates to Annual Energy Outlook forecasts and was used in a whitepaper for the Edison Electric Institute to quantify the amount of generation and transmission capital investment that could be avoided through demand-side management.
- Worked with a team to develop a linear optimization model for forecasting the economic impact of various emission control policies. The model has been used to provide strategic emissions compliance advice to large electric utilities and for forecasting generator-specific environmental decisions.

- Created a tool for determining the optimal dispatch of energy storage technologies against given price series (energy and ancillary service markets), subject to the device's specific operating constraints. The tool was used to develop an economic valuation of a pumped storage plant in New England and to assess the potential value of a large scale battery for a technology manufacturer.
- Developed a general equilibrium model for forecasting trends in international natural gas markets. The model was used in a study on the potential impacts of liquefied natural gas (LNG) adoption in the United States.
- Participated as a Research Assistant with Stanford University's Energy Modeling Forum (EMF). Presented an overview of participating models for an EMF study on issues in international natural gas markets.

Energy Asset Valuation

- For an infrastructure investment fund, provided due diligence support on potential fuel cell project investments in New York. Analysis included a forecast of potential project revenues and an assessment of regulatory risks facing the project.
- For NRECA and NRDC, assessed the costs and benefits of rooftop versus community solar in the context of zero net energy building policy. The study considered different solar PV configurations and market scenarios.
- For a foreign investor, assessed the likely future value of an investment in a new gas-fired combined cycle power plant in Western Pennsylvania. Projected gas, energy, and capacity prices under a range of plausible scenarios. Simulated the dispatch of the unit against these hourly price series to estimate potential earnings. Benchmarked the results against the performance of comparable units in the region.
- For one of the largest electricity consumers in the United States, conducted due diligence on the potential purchase of a large gas-fired combined cycle plan. Determined how a purchase of the plant would affect the firm's energy portfolio. Used EPRI's Energy Book System (EBS) to estimate the plant's energy value given uncertainty in future electricity and fuel prices. Researched capacity and ancillary services markets to assess the plant's potential for providing additional value in those areas. Investigated California LMP studies to determine whether the plant would have a price advantage or disadvantage due to transmission constraints when California transitioned to the MRTU market structure. Supplemented the LMP analysis with independent forecasts of nodal market prices in California using a large scale production cost model. Analyzed the plant's historical operations using publicly available data to determine

how it was dispatched against market prices and to identify any additional synergistic benefits that might be achieved if the firm were to own the plant.

Mergers and Acquisitions

- Conducted a detailed audit of the FERC merger filing between Duke Energy and Progress Energy, which created the largest regulated utility in the United States. Updated data in the market power assessment and estimated new Herfindahl-Hirschman Indices (HHI). Explored new mitigation strategies that would alleviate screen failures that arose from the update.
- For several large electric utility mergers, aided electric utilities and their counsel in FERC regulatory filings. Performed analyses to measure the impacts on market concentration of proposed mergers between large electric utilities in the United States. Utilized a proprietary linear optimization model to calculate market shares before and after the mergers and suggested divestitures that would minimize the potential impacts of the mergers.

PUBLICATIONS

Articles

"Emerging Landscape of Residential Rates for EVs: Creative Design Ahead," with John Higham and Ahmad Faruqui, *Public Utilities Fortnightly*, May 2019.

"Two Paths for Advancing the Smart Metering Programme," *Utility Week*, December 2018.

"Status of Residential Time-of-Use Rates in the U.S.: Progress Comes Slowly," with Cody Warner and Ahmad Faruqui, *Public Utilities Fortnightly*, November 2018.

"Storage-Oriented Rate Design: Stacked Benefits or the Next Death Spiral?" with Jake Zahniser-Word and Jesse Cohen, *The Electricity Journal*, October 2018.

"Nothing Worth Having Comes Easy: Capturing the Stacked Benefits of Energy Storage," RTO Insider, December 19, 2017.

"The Electrification Accelerator: Understanding the Implications of Autonomous Vehicles for Electric Utilities," with Jurgen Weiss, Roger Lueken, Tony Lee, and Will Gorman, *The Electricity Journal*, December 2017.

"The Distributional Impacts of Demand Charges," with Gus Greenstein, *The Electricity Journal*, July 2016.

"Competing Perspectives on Demand Charges," with Ahmad Faruqui, *Public Utilities Fortnightly*, September 2016.

"Trends and Emerging Opportunities in Demand Response," with Lucas Bressan and Ahmad Faruqui, *Recursos Energeticos Distribuidos*, May 2016.

"Understanding the UK's Potential for Demand Response," with Jurgen Weiss and Serena Hesmondhalgh, *Utility Week*, December 12, 2015.

"The Emergence of Organic Conservation," with Ahmad Faruqui and Wade Davis, *The Electricity Journal*, June 2015.

"The Paradox of Inclining Block Rates," with Ahmad Faruqui and Wade Davis, *Public Utilities Fortnightly*, April 2015.

"Rediscovering Residential Demand Charges," *The Electricity Journal*, August/September 2014.

"Smart by Default," with Ahmad Faruqui and Neil Lessem, *Public Utilities Fortnightly*, August 2014.

"Analytical Frameworks to Incorporate Demand Response in Long-Term Resource Planning," with Andy Satchwell, *Utilities Policy*, March 2014.

"Benchmarking Your Rate Case," with Ahmad Faruqui, *Public Utilities Fortnightly*, July 2013.

"Drivers of Demand Response Adoption: Past, Present, and Future," with Kelly Smith, *Public Utilities Fortnightly*, January 2012.

"Smart Pricing, Smart Charging," with Ahmad Faruqui, Armando Levy, and Alan Madian, *Public Utilities Fortnightly*, October 2011.

"The Energy Efficiency Imperative," with Ahmad Faruqui, *Middle East Economic Survey*, September 2011.

"Unlocking the €53 Billion Savings from Smart Meters in the EU: how increasing the adoption of dynamic tariffs could make or break the EU's smart grid investment," with Ahmad Faruqui and Dan Harris, *Energy Policy*, October 2010.

"Rethinking Prices," with Ahmad Faruqui and Sanem Sergici, *Public Utilities Fortnightly*, January 2010.

"Fostering Economic Demand Response in the Midwest ISO," with Ahmad Faruqui, Attila Hajos, and Sam Newell, *Energy Journal,* Special Issue on Demand Response Resources, October 2009.

"Piloting the Smart Grid," with Ahmad Faruqui and Sanem Sergici, *The Electricity Journal*, August 2009.

"Smart Grid Strategy: Quantifying Benefits," with Ahmad Faruqui and Peter Fox-Penner, *Public Utilities Fortnightly*, July 2009.

"How Green is the Smart Grid?" *The Electricity Journal*, April 2009.

"The Power of Dynamic Pricing," with Ahmad Faruqui and John Tsoukalis, *The Electricity Journal*, April 2009.

"Transitioning to Dynamic Pricing," with Ahmad Faruqui, *Public Utilities Fortnightly*, March 2009.

"The Power of Five Percent," with Ahmad Faruqui, Samuel A. Newell, and Johannes P. Pfeifenberger. *The Electricity Journal*, October 2007.

Conference Presentations

Participant, "Demand Flexibility and Control," panel at North America Smart Energy Week, Salt Lake City, Utah, September 24, 2019.

Participant, "Load Flexibility Potential in U.S. by 2030," PLMA Dialogue with Rich Barone, September 5, 2019.

Participant, "Transportation Electrification: Smart Strategies to Manage New Electric Vehicle Loads," panel at the SEPA Grid Evolution Summit, Washington, DC, July 29, 2019.

"The Potential for Load Flexibility in Northern States Power's Service Territory," Peak Load Management Alliance (PLMA) 2019 Spring Conference, Minneapolis, MN, May 14, 2019.

"Incorporating DERs into Resource Planning: Energy Efficiency," with Sanem Sergici and DL Oates, EPRI Winter 2019 Advisors Meeting, Tucson, Arizona, February 26, 2019.

"Determining Optimal Storage Deployment Levels: Insights from Nevada," with Roger Lueken, Energy Storage Association Webinar, December 11, 2018.

"Behind-the-Meter Storage: Stacked Benefits or the Next Death Spiral?" EEI Strategic Issues Roundtable, Pittsburgh, PA, October 12, 2018.

"The Value of TOU Tariffs in Great Britain," Citizens Advice Public Workshop, London, UK, July 10, 2017.

"The Hidden Battery," 3rd Annual Ancillary Services and DR Management Forum, Frankfurt, Germany, May 11, 2017.

"The Hidden Battery," Smart Energy Summit, Brussels, Belgium, April 6, 2017.

"Distribution System Pricing With Distributed Energy Resources," LBNL Future Electric Utility Regulation Series Webinar, May 31, 2016.

"The Emergence of Residential Demand Charges," 2016 EEI Rate Analysts Meeting, Baltimore, MD, May 23, 2016.

"Electricity Pricing for the Consumer of the Future," International Congress of Energy Science and Industry, Energi@21, Poznan, Poland, May 11, 2016.

Participant, "Community Storage Initiative and Hidden Battery Report," PLMA Dialogue with Keith Dennis, March 24, 2016.

"A Path Forward for Residential Demand Charges," 2015 NASUCA Annual Meeting, Austin, TX, November 10, 2015.

"The National Landscape of Residential Rate Reform," 2015 SNL Utility Regulation Conference, Washington, DC, December 10, 2015.

"The Top 10 Questions about Residential Demand Charges," EUCI Residential Demand Charges Symposium, Los Angeles, CA, August 31, 2015.

"Residential Rate Design: Emerging Issues," EEI WebTalks webinar, August 27, 2015.

"The Top 10 Questions about Residential Demand Charges," EUCI Residential Demand Charges Symposium, Denver, CO, May 14, 2015.

"Rolling out Residential Demand Charges," EUCI Residential Demand Charges Symposium Pre-Conference Workshop, Denver, CO, May 13, 2015.

"Residential Demand Charges: An Emerging Opportunity in Rate Design," EUCI webcast, December 16, 2014.

"Residential Demand Charges: A Rate Design Revolution?" Center for Research in Regulated Industries 27th Annual Western Conference, Monterey, CA, June 26, 2014.

"Rediscovering Residential Demand Charges," 2014 EEI Rate and Regulatory Analysts Meeting, San Francisco, CA, May 20, 2014.

"The New Direction of Home Energy Management," 2014 Comverge Utility Conference, New Orleans, LA, May 7, 2014.

"Surviving Sub-One Percent Growth," 2014 Institute for Regulatory Policy Studies Conference, Springfield, IL, April 16, 2014.

Panelist, Wharton Energy Conference, Smart Grid Panel, Philadelphia, PA, November 8, 2013

"The Smart Grid and the Future of Demand Response," presented at Energy Central webinar titled "Integrated Demand Response - How Utilities Leverage Data for Intelligent Decisions," September 18, 2013.

"Analytical Frameworks to Incorporate Demand Response in Long-term Resource Planning," with Andy Satchwell, CRRI Western Conference, June 21, 2013.

"The Future of Rate Design." 2013 EEI Rate Analysts Meeting, May 21, 2013. Orlando, Florida.

"Demand Response: Lessons Learned from Across the Border," presented at the CAMPUT Energy Regulation Course, Kingston, Ontario, August 1, 2012.

"The Current State of U.S. Demand Response," presented as moderator at Energy Bar Association Annual Event, Washington, DC, April 26, 2012.

"Vietnam's 10-year Smart Grid Roadmap," presented at World Bank stakeholder workshop in Hanoi, December 8, 2011.

"Bringing DSM to the Kingdom of Saudi Arabia," presented at AESP webinar, October 13, 2011.

"Dynamic Pricing Pilots: Past, Present, and Future," presented at EEI Rate Analysts Meeting, May 17, 2011.

"Inclining Block Rates – Are They a Good or Bad Thing?" presented at an EEI webinar, August 5, 2010.

"Do Customers Respond to Dynamic Pricing?" presented at the Brookings Institution Behavior Insights for Smart Grid Policy Workshop, Washington, DC, July 28, 2010.

"Innovative Pricing for a Smarter Grid," presented at TechConnect 2010, June 24, 2010.

"The Geography of Demand Response," presented at the 2010 Southern California Edison Demand Response Forum, June 3, 2010.

"Fairness and Equity in Dynamic Pricing," presented at the 2010 EEI Rate Analysts Meeting, May 18, 2010.

"A National Assessment of Demand Response Potential," presented at an AESP webinar, October 15, 2009.

"A National Assessment of Demand Response Potential," presented at the ALCA 2009 Fall Meeting, Los Angeles, CA, October 8, 2009.

"How Green is the Smart Grid?" presented at an EUCI webinar, July 23, 2009.

"Sizing up the Smart Grid," presented at the ConnectivityWeek GridWise Expo, San Jose, CA, June 11, 2009.

"Integrating Dynamic Pricing and Inclining Block Rates," presented at the Stanford Energy & Feedback Workshop, Palo Alto, CA, September 5, 2008.

"Evaluating Alternative Dynamic Pricing Designs," presented at the CRRI 21st Annual Western Conference, Monterey, CA, June 19, 2008.

"The Coming Wave of Price-Based Demand Response," presented at the ConnectivityWeek DR Expo, San Jose, CA, May 22, 2008.

Selected Whitepapers and Reports

"The Total Value Test: A Framework for Evaluating the Cost-Effectiveness of Efficient Electrification," with Ahmad Faruqui, Michael Hagerty, and John Higham, prepared for the Electric Power Research Institute, August 2019.

"The National Potential for Load Flexibility: Value and Market Potential Through 2030," with Ahmad Faruqui, Tony Lee, and John Higham, The Brattle Group Report, June 2019.

"The Value of Energy Storage to the PNM System," with Johannes Pfeifenberger, Judy Chang, Pablo Ruiz, and Jesse Cohen, prepared for PNM, June 6, 2019.

"Two Paths for Advancing Great Britain's Smart Metering Programme," with Pinar Bagci and Saurab Chhachhi," The Brattle Group Whitepaper, December 2018.

"Facilitating Electric Vehicle Fast Charging Deployment," with Jurgen Weiss, prepared for the Edison Electric Institute, October 2018.

"The Economic Potential for Energy Storage in Nevada," with Judy Chang, Roger Lueken, Johannes P. Pfeifenberger, John Imon Pedtke, and Jeremy Vollen, prepared for the Public Utilities Commission of Nevada and the Nevada Governor's Office of Energy, October 1, 2018.

"The Value of TOU Tariffs in Great Britain: Insights for Decision-makers," with Will Gorman and Nicole Irwin, prepared for Citizens Advice, July 2017.

"Beyond Zero Net Energy? Alternative Approaches to Enhance Consumer and Environmental Outcomes," prepared for the National Rural Electric Cooperative Association (NRECA) and the Natural Resources Defense Council (NRDC), June 2018.

"Electrification: Emerging Opportunities for Utility Growth," with Jurgen Weiss, Michael Hagerty, and Will Gorman, The Brattle Group Whitepaper, January 2017.

"Distribution System Pricing with Distributed Energy Resources," with Jim Lazar, prepared for Lawrence Berkeley National Laboratory's Future Electric Utility Regulation series, May 2016.

"The Tariff Transition: Considerations for Domestic Distribution Tariff Redesign in Great Britain," with Ahmad Faruqui, Jürgen Weiss, Toby Brown, and Nicole Irwin, prepared for Citizens Advice, April 2016.

"The Hidden Battery: Opportunities in Electric Water Heating," with Judy Chang and Roger Lueken, prepared for the National Rural Electric Cooperative Association (NRECA), the Natural Resources Defense Council (NRDC), and the Peak Load Management Alliance (PLMA), January 2016.

"Demand Response Market Research: Portland General Electric, 2016 to 2035," with Ahmad Faruqui and Lucas Bressan, prepared for Portland General Electric, January 2016.

"An Evaluation of SRP's Electric Rate Proposal for Residential Customers with Distributed Generation," with Ahmad Faruqui, prepared for Salt River Project, January 5, 2015.

"Valuing Demand Response: International Best Practices, Case Studies, and Applications," prepared for EnerNOC, January 2015.

"Exploring Natural Gas and Renewables in ERCOT, Part III: The Role of Demand Response, Energy Efficiency, and Combined Heat & Power," prepared for The Texas Clean Energy Coalition, May 29, 2014.

"Demand Response Market Potential in Xcel Energy's Northern States Power Service Territory," with YouGov America, prepared for Xcel Energy, April 2014.

"Incorporating Demand Response Into Western Interconnection Transmission Planning," with Andy Satchwell, Glen Barbose, Ahmad Faruqui, and Charles Goldman, LBNL Report, July 2013.

"Estimating Xcel Energy's Public Service Company of Colorado Territory Demand Response Market Potential," with YouGov America, prepared for Xcel Energy, June 2013.

"An Assessment of Portland General Electric's Demand Response Potential," with Ahmad Faruqui, prepared for Portland General Electric, November 2012.

"Time-Varying and Dynamic Rate Design," with Ahmad Faruqui and Jenny Palmer, prepared for the Regulatory Assistance Project, July 2012.

"Vietnam's 10-year Smart Grid Roadmap," prepared for Northern Power Corporation and The World Bank, December 2011.

"Bringing Demand Side Management to the Kingdom of Saudi Arabia," with Global Energy Partners and PacWest Consulting Partners, prepared for ECRA, May 2011.

"National Action Plan on Demand Response," with GMMB, Customer Performance Group, and Definitive Insights, prepared for the Federal Energy Regulatory Commission, June 2010.

"A National Assessment of Demand Response Potential," with Freeman, Sullivan & Co. and Global Energy Partners, prepared for the Federal Energy Regulatory Commission, June 2009.

"Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S.," with Global Energy Partners, prepared for the Electric Power Research Institute, January 2009.

"Transforming America's Power Industry: The Investment Challenge," prepared for the Edison Electric Institute, November 2008.

"Rethinking Rate Design: A Survey of Leading Issues Facing California's Utilities and Regulators," prepared for the Demand Response Research Center, Lawrence Berkeley National Laboratory, August 2007.

"California's Next Generation of Load Management Standards," prepared for the California Energy Commission, May 2007.

"The State of Demand Response in California," prepared for the California Energy Commission, April 2007.

PRESS MENTIONS

"A Utah Housing Development is Just the Start of Sonnen's US Solar Ambitions." Wolfgang Kerler. Quoted in *The Verge*, August 28, 2019.

"Renewables' Variability Sends Wary Utilities from Traditional DR to DER and Load Flexibility." Herman K. Trabish. Quoted in *Utility Dive*, August 14, 2019.

"Using Electricity at Different Times of Day Could Save Us Millions of Dollars." David Roberts. Quoted in *Vox*, August 7, 2019.

"Rise of Net Zero Energy Homes Could Boost Utility-Led Community Solar." Herman K. Trabish. Quoted in *Utility Dive*, July 19, 2018.

"Stacking Energy Storage Values to Make Batteries More Profitable: Brattle Report." Quoted in *MicroGrid Knowledge*, September 18, 2017.

"Brattle: Regulatory Barriers Prevent Stacking of Battery Benefits." Peter Maloney. Quoted in *Utility Dive*, September 13, 2017.

"Batteries Hold Value in Various Applications: Study." Quoted in MW Daily, September 12, 2017.

"Utilities in hot water: Realizing the benefits of grid-integrated water heaters," Herman K. Trabish. Quoted in *Utility Dive*, June 20, 2017.

"ComEd jumps on the demand charge train with new Illinois proposal," Peter Maloney. Quoted in *Utility Dive,* May 9, 2016.

"Your home water heater may soon double as a battery," Chris Mooney. Quoted in the *Washington Post,* February 24, 2016.

"Move over, fixed fees—utilities see demand charges as revenue cure," Kari Lydersen. Quoted in *Midwest Energy News,* December 2, 2015.

"Using Telecom Tech, eCurv Looks to Lower Energy Bills, Raise Money," Thomas Miller. Quoted in *Xconomy,* May 4, 2015.

"Questions swirl around possible rates under a Boulder utility," Erica Meltzer. Quoted in *Daily Camera,* January 31, 2015.

"After SONGS: Forecasting the fate of demand response in California," Lisa Weinzimer. Quoted in *Utility Dive,* March 21, 2014.

"A National 'Smart Grid' Remains a Vision with Many Gaps," Peter Behr. Quoted in the *New York Times,* October 22, 2009.

AFFIRMATION

STATE OF CALIFORNIA

COUNTY OF SAN FRANCISO

I, Ryan Hledik do hereby swear under penalty of perjury the following:

That I am the person identified in the foregoing Direct Testimony and that such testimony was prepared by me or under my direct supervision; that the answers and information set forth therein are true to the best of my knowledge and belief as of the date of this affirmation; that I have reviewed and approved any modifications after the date of this affirmation; and that if asked the questions set forth therein, my answers thereto would, under oath, be the same.

Ryan Hledik

Subscribed and sworn to before me

this __ day of September, 2019.

____

NOTARY PUBLIC

See document attached.

CALIFORNIA JURAT WITH AFFIANT STATEMENT **GOVERNMENT CODE § 8202**

☒ See Attached Document (Notary to cross out lines 1–6 below)
☐ See Statement Below (Lines 1–6 to be completed only by document signer[s], *not* Notary)

1 ______________________________
2 ______________________________
3 ______________________________
4 ______________________________
5 ______________________________
6 ______________________________

Signature of Document Signer No. 1 *Signature of Document Signer No. 2 (if any)*

A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document.

State of California
County of San Francisco

Subscribed and sworn to (or affirmed) before me on this 26 day of September, 2019, by
(1) Ryan Hledik
(and (2) ______________________),
Name(s) of Signer(s)

proved to me on the basis of satisfactory evidence to be the person(s) who appeared before me.

TONI ENRIGHT
Notary Public – California
San Francisco County
Commission # 2204701
My Comm. Expires Jul 13, 2021

Place Notary Seal Above

Signature Toni Enright
Signature of Notary Public

OPTIONAL

Though this section is optional, completing this information can deter alteration of the document or fraudulent reattachment of this form to an unintended document.

Description of Attached Document

Title or Type of Document: ______________ **Document Date:** ______

Number of Pages: _____ **Signer(s) Other Than Named Above:** ______________

CERTIFICATE OF SERVICE

I HEREBY CERTIFY that I have this day served the foregoing **Prepared Direct Testimony of Ryan M. Hledik on behalf of Solar Partners XI, LLC** upon each of the parties on the attached service list in this proceeding via electronic mail.

DATED this 26th day of September, 2019.

/s/ Jesse O. Gorsuch
Jesse O. Gorsuch
Paralegal

Staff Counsel
Public Utilities Commission of Nevada
1150 E. William St.
Carson City, NV 89701
pucn.sc@puc.nv.gov

Michael Greene
Timothy Clausen
Lorelei Reid
NV Energy
6100 Neil Rd.
Reno, NV 89511
mgreene@nvenergy.com
tclausen@nvenergy.com
lreid@nvenergy.com

NV Energy Regulatory Department
NV Energy
PO Box 10100
Reno, NV 89520
regulatory@nvenergy.com

Jennifer Fedinec
NV Energy
6226 W. Sahara Ave.
Las Vegas, NV 89146
jfedinec@nvenergy.com

Tammy Cordova
Public Utilities Commission of Nevada
1150 E. William St.
Carson City, NV 89701
tcordova@puc.nv.gov

Michelle Newman
Whitney Digesti
Bureau of Consumer Protection
100 N. Carson Street
Carson City, NV 89701
mnewman@ag.nv.gov
wdigesti@ag.nv.gov

Attorney General
Bureau of Consumer Protection
8945 W. Russell Rd., Suite 204
Las Vegas, NV 89148
bcpserv@ag.nv.gov

Carolyn Tanner
Tanner Law and Strategy Group LT
216 E. Liberty St.
Reno, NV 89501
lina@tanner1nv.com

Lisa Tormoen Hickey
Tormoen Hickey LLC
14 N. Sierra Madre
Colorado Springs, CO 80903
lisahickey@newlawgroup.com

Cameron Dyer
Western Resources Advocates
550 W. Musser St., Suite I
Carson City, NV 89703-4997
cameron.dyer@westernresources.org

Matt Rubin
Western Resources Advocates
550 W. Musser St., Suite E
Carson City, NV 89703-4997
matt.rubin@westernresources.org

Regina Nichols
Western Resources Advocates
550 W. Musser St., Suite G
Carson City, NV 89703-4997
rnichols@westernresources.org

Geoffrey Inge
Kinect Energy
777 29th St., Suite 200
Boulder, CO 800027
ginge@kinectenergy.com

Justin Townsend
Karen Peterson
Allison MacKenzie Ltd.
402 N. Division St.
Carson City, NV 89703
jtownsend@allisonmackenzie.com
kpeterson@allisonmackenzie.com

Mark Boyadjian
Arevia Power
1044 10th Ave.
Redwood City, CA 94063
mark@areviapower.com