BEFORE THE NEW MEXICO PUBLIC REGULATION COMMISSION

IN THE MATTER OF PUBLIC SERVICE	)	
COMPANY OF NEW MEXICO'S	)	
CONSOLIDATED APPLICATION FOR	)	
APPROVALS FOR THE ABANDONMENT,	)	**19-______-UT**
FINANCING, AND RESOURCE REPLACEMENT	)	
FOR SAN JUAN GENERATING STATION	)	
PURSUANT TO THE ENERGY TRANSITION ACT	)	

DIRECT TESTIMONY

OF

GARY W. DORRIS

July 1, 2019

NMPRC CASE NO. 19-_____-UT
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GARY W. DORRIS

WITNESS FOR
PUBLIC SERVICE COMPANY OF NEW MEXICO

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NMPRC CASE NO. 19-_____-UT

I. SUMMARY

Q. PLEASE STATE YOUR NAME, POSITION AND BUSINESS ADDRESS.

A. My name is Gary W. Dorris. I am the Chief Executive Officer (CEO) of Ascend Analytics, LLC ("Ascend"). Our headquarters is located at 1877 Broadway Street, Suite 706, Boulder, CO 80302.

Q. ON WHOSE BEHALF ARE YOU TESTIFYING IN THIS PROCEEDING?

A. I am testifying on behalf of Public Service New Mexico ("PNM" or "the Company").

Q. PLEASE SUMMARIZE YOUR TESTIMONY

A. My testimony supports the prudency and cost-effectiveness of PNM's preferred portfolio of resources for the replacement of San Juan coal plant. PNM is replacing a single large inflexible resource with a clean and diverse mix of resources. This portfolio will provide PNM system operators improved flexibility to integrate the increasing amount of renewable energy envisaged by the Energy Transition Act (ETA). The preferred portfolio of 280[1] MW of aeroderivative natural gas turbines, 350 MW of solar, 140 MW of wind, and 130 MW of 2- and 4-hour lithium-ion batteries, represents the most economic and rational transition toward a 100% renewable plan. The thermal investments can operate on

[1] Net summer capacity of 269 MW.

hydrogen or biofuel, and thus offer the option of carbon-free backup capacity, to meet the 2045 ETA goal.

The selected *Scenario 1* portfolio utilizes wind and solar projects to provide low-cost energy to PNM customers with physical firming of these renewable resources through a diverse and distributed battery capacity. The two and four-hour duration batteries will provide several important services for PNM, including maximizing the use of renewable resources, managing resource intermittency by providing frequency regulation services, grid-hardening benefits for the transmission and distribution system, and providing a physical hedge to protect the rate payer from real-time price spikes associated with operations in the highly volatile Western Energy Imbalance Market (EIM). Ascend's modeling of sub-hourly market dynamics clearly indicates that batteries will provide a valuable service to PNM rate payers in the EIM. I endorse PNM's strategy to contract with several battery vendors on smaller projects versus one or two vendors on large projects to manage the risk that accompanies adoption of new technologies. Utility ownership of Sandia and Zamora 2-hour batteries will provide PNM with the maximum operational flexibility to serve multiple power products of regulation services and incremental energy related to the EIM. The level of control through ownership not only enhances the expected value across multiple power products, but also provides PNM the opportunity to gain experience in maximizing the value of batteries.

In this proceeding, PNM is taking appropriate and cost-effective steps to transition from a coal and gas-based energy supply to a renewable and clean supply supported by the proposed bank of LM 6000 aeroderivative engines located at San Juan. These aeroderivative engines are completely congruent with the objectives of New Mexico's 100% clean energy goals because:

1) they serve as a critical flexible capacity resource to integrate renewables and costs less than half of energy storage
2) they are the least-cost capacity resource
3) they can be utilized as zero carbon back-up capacity beyond their expected life burning either hydrogen or biofuel
4) they will serve as a necessary back-up capacity resources in a 100% carbon-free future when unfavorable meteorologies, such as extreme load conditions combined with a short-term wind-drought, depress renewable generation, and leave the batteries drained.

Ascend independently evaluated PNM's four core *Scenarios 1-4.* All four reasonably represent the range of available options. Ascend also constructed two additional no-gas portfolios to further examine, with more advanced storage modeling, that PNM's selected storage and renewable resources were the least cost and best fit.

We find that *Scenario 1*, the preferred portfolio, is the most cost-effective supply portfolio to transition to a carbon free energy supply and meet reliability requirements. *Scenario 2*, while reliable, is significantly more costly. *Scenario 3* is both more costly and less reliable than *Scenario 1. Scenario 4* is simply not reliable and would put PNM customers at risk of supply interruptions and thus the potential for blackouts. One of our no gas scenarios satisfied the loss of load reliability criteria and the other failed this criteria, but both were more costly than *Scenario 1* (Preferred) and *Scenario 3* (no gas).

II. QUALIFICATIONS INTRODUCTION

Q. PLEASE SUMMARIZE YOUR EDUCATIONAL AND PROFESSIONAL BACKGROUND.

A. I am founder and CEO of Ascend. Ascend is an energy analytics software and consulting company that provides economic, financial, and technology solutions for the electric power industry, particularly in the area of long-term resource planning, energy supply procurement, asset valuation, portfolio risk management, quantitative modeling, and complex litigation.

I have been involved in the energy industry for over 25 years and have extensive experience in advising corporations in complex decision analysis, energy asset valuation, and risk management. I have also provided independent expert reports to support the valuation and financing of over $10 billion in electric generating assets. I have written and delivered expert testimony regarding risk management, energy procurement, trading practices, asset valuation, market power, and emissions trading. I have also led the analytic architecture of over ten analytic software products used by 30 of the top 100 energy companies.

Before founding Ascend, I served as CEO and Chief Model Architect for e-Acumen, a 60-person energy consultancy and software analytics firm, which was sold to Ventyx, an ABB subsidiary. I have also directed the development of the analytic infrastructure and risk management policies for the launching of the trading floors of Entergy Solutions, Duke Solutions, The Energy Authority, and Consolidated Edison, and led the development of the analytic infrastructure solutions for portfolio and risk management solutions at over a dozen other utilities.

I was also a faculty member at Cornell University in 1996, where I taught a doctoral-level course in modeling competitive energy markets and have been adjunct faculty at University of Colorado's Leeds Business School from 1997 to 2007. I have published papers on energy trading and risk management in peer-reviewed scholarly journals and have spoken at over 100 conferences on resource planning, battery storage economics, portfolio management, risk analysis, and modeling of competitive energy markets. I hold a PhD in applied economics and finance from Cornell University and both a BS in mechanical engineering and a BA in economics with Magna Cum Laude distinction from Cornell University. My Curriculum Vitae is attached as PNM Exhibit GWD-1.

I reserve the right to update and supplement my expert testimony as may be necessary.

Q. PLEASE SUMMARIZE ASCEND ANALYTIC'S EXPERIENCE IN RESOURCE PLANNING AND SELECTION.

A. Ascend actively works with utilities across the United States supporting resource planning activities with our advanced analytical tools including: Ameren, Austin Energy, Burbank Water & Power, City of San Francisco, Dayton Power & Light, Duke, Glendale Water and Power, Hawaiian Electric Utilities, Indianapolis Power and Light, Los Angeles Department of Water and Power, Monterey Bay Clean Energy, New York Power Authority, NorthWestern Energy, Peninsula Clean Energy, Puget Sound Energy, Redding Utilities, Riverside Public Utilities, Salt River Project, Silicon Valley Clean Energy, and Turlock Irrigation District.

We specialize in resource planning for high renewables systems and have recently developed integrated resource plans for Hawaiian Electric (100% renewable by 2045), Burbank Water and Power, Glendale Water and Power, and Reading (all 60% renewable by 2030 and 100% carbon free by 2045), and NorthWestern Energy. We excel in planning for high renewables systems because of our ability to accurately model the energy system conditions that emerge from adding large amounts of weather-driven intermittent power resources and the hourly/sub-hourly market and system dynamics relevant to balancing high renewable systems. We find that prudent decisions regarding the resources of the future can only be made when modeling captures the increasingly volatile system dynamics we expect to see as we transition towards a renewables-based energy system. This new approach to resource planning with a strong focus on weather driving the volatility of supply and inclusion of sub-hourly operations is what we call Resource Planning 2.0.[2]

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. My testimony is intended to provide my view on the economics and reliability of the portfolios developed to replace San Juan coal plant. PNM provided Ascend with a set of portfolios and resource bids for independent evaluation. Ascend developed fundamental forecasts regarding market conditions and evaluated the recommended and other potential portfolios using Ascend's resource planning model PowerSimm. PowerSimm adds a powerful new element to the analysis of resource value by capturing:

1) sub-hourly nodal interactions (5 and 15-minute market conditions) with the EIM,
2) new system and power market dynamics of a more volatile energy landscape with weather as a fundamental driver of renewable energy production, load, and market prices, and
3) battery storage economics including detailed value stacking and physical state-of-charge controls.

[2] Additional details of select project activities are contained in PNM Exhibit GWD-2.

By adding these critical analytic elements, Ascend evaluated the relative benefits of candidate portfolios and I will communicate our view of what is the best portfolio for PNM rate payers given a rapidly changing energy environment in the Western Energy Coordinating Council (WECC) grid.

Q. HOW IS YOUR TESTIMONY ORGANIZED?

A. Section II describes the credentials of myself and my firm Ascend Analytics in resource planning for high renewables systems. Section III describes the impact of WECC transitioning to near carbon free energy and its bearing on resource selection. In Section IV, I present the valuation and reliability analysis of the final four PNM selected energy supply portfolios plus two additional thermal free portfolios. The valuation uniquely includes a sub-hourly credit for operations to the EIM real-time prices and examines the utilization of the aeroderivative turbines as back-up capacity in 2045 with a no-carbon fuel. PNM Exhibit GWD-1 contains my Curriculum Vitae. PNM Exhibit GWD-2 describes Ascend's recent experience performing resource planning. PNM Exhibit GWD-3 provides a more detailed discussion of the evolving power market dynamics in the WECC and fundamental modeling performed in support of the analysis.

III. CHANGING MARKET DYNAMICS AND IMPLICATIONS FOR PNM RESOURCE DECISION MAKING

Q. WHAT CHANGES ARE OCCURRING IN THE WESTERN GRID WITH REGARDS TO RENEWABLE EXPANSION AND HOW SHOULD THAT AFFECT PNM'S RESOURCE DECISION MAKING WITH RESPECT TO SAN JUAN COAL PLANT REPLACEMENT?

A. To summarize, we believe that the WECC in 2045 will include a diversified mix of renewables, storage, and flexible thermal generation, powered by a mixture of hydrogen, bio-gas, and natural gas.[3] These thermal resources will serve as critical back up when meteorological regimes conspire to provide low renewable energy production in conjunction with high loads that drain energy storage. As I explain later, PNM's replacement portfolio for San Juan coal plant perfectly fits this blueprint of a supply portfolio to transition to a carbon free future. The portfolio physically and economically combines to provide a pathway toward a least cost future of carbon free energy.

Q. HOW DO CHANGES IN WESTERN ENERGY MARKET STRUCTURES AFFECT PNM'S RESOURCE DECISION MAKING WITH RESPECT TO SAN JUAN COAL PLANT REPLACEMENT?

A. The Western Energy Imbalance Market (EIM) is a rapidly expanding program that allows vertically integrated balancing authorities like PNM to purchase and

[3] Please see PNM Exhibit GWD-3 for a detailed discussion of changes in the western energy landscape.

sell energy in 15 and 5-minute (aka "real-time") energy markets. PNM has indicated that it will join the EIM in April 2021. The EIM is a computerized dispatch of participating resources and loads run by the California Independent System Operator (CAISO). The purpose of the real-time markets is to efficiently solve imbalances between generation and load between the day-ahead forecast and the realized system conditions. PNM can benefit from the EIM by allowing the CAISO to pay PNM's resources to ramp up or down. PNM can also benefit by purchasing energy to make up a short position between day-ahead and real-time instead of ramping up a more costly PNM resource.

Participants in the EIM settle load and resources to nodal specific real-time market prices. The EIM construct adds a critical dimension to resource planning for PNM by providing a transparent market price for the calculation of the cost to serve load on a 5-minute basis and an opportunity cost to realize revenue in response to the 5-minute prices. EIM stakeholders are actively discussing broadening the EIM to include the day-ahead market, where about 95 percent of California's energy is scheduled and traded. The extension of EIM to a day-ahead market provides gains in economic efficiency for the day-ahead market transactions relative to the current "over-the-counter" system. These efficiency gains in economic power transactions will help integrate increasing penetrations of renewable energy across a large geographic footprint. Our expectation is that within the next five years, this opening up of EIM to the day-ahead will be enacted. We may even see the adoption of a west-wide Regional Transmission

Organization (RTO), which would completely centralize the optimization of all western loads and resources under a single organization.

Because of the new market dynamic imposed through the EIM, PNM's decision-making with respect to replacement resources for the San Juan coal plant should move to reflect two critical aspects:

1) Resource Economics: Participation in the EIM means PNM's resources should include economic valuation in terms of the 15 and 5 minute market prices of power. For a replacement portfolio to be successful, it should account for EIM price levels and volatility, today and forecast into the foreseeable future.
2) Reliability: Participation in the EIM still requires PNM to control enough capacity that it can maintain its resource self-sufficiency in the absence of the market. In other words, the EIM does not relieve PNM from its responsibility to control enough variable and dispatchable generation to supply its own native load.

Evaluation of these two aspects, (1) resource economics and (2) reliability, along with PNM's goal for 100% clean energy production should also subsume the November 16, 2018 National Association of Regulatory Commissioners (NARUC) resolution for "Resolution on Modeling Energy Storage and Other Flexible Resources".[4] This resolution states the need for models to incorporate sub-hourly

[4] https://pubs.naruc.org/pub/2BC7B6ED-C11C-31C9-21FC-EAF8B38A6EBF

dynamics for evaluation of resource economics and renewable integration by stating:

"*Planning frameworks and modeling tools that are publicly and commercially available should model the full spectrum of services that energy storage and flexible resources are capable of providing, including subhourly services. Utilities should analyze a range of flexible resource options, such as energy storage, and current cost assumptions in their modelling, due to the diverse characteristics and resource lives of different technologies, with the goal of identifying and pursuing the most cost-effective opportunities that best meet the needs of the utilities' systems*".

Q. HOW DOES THE COMBINATION OF CHANGING MARKET DYNAMICS IN THE WECC AND THE INCORPORATION OF PNM IN ENERGY MARKETS AFFECT RESOURCE SELECTION FOR SAN JUAN COAL PLANT REPLACEMENT?

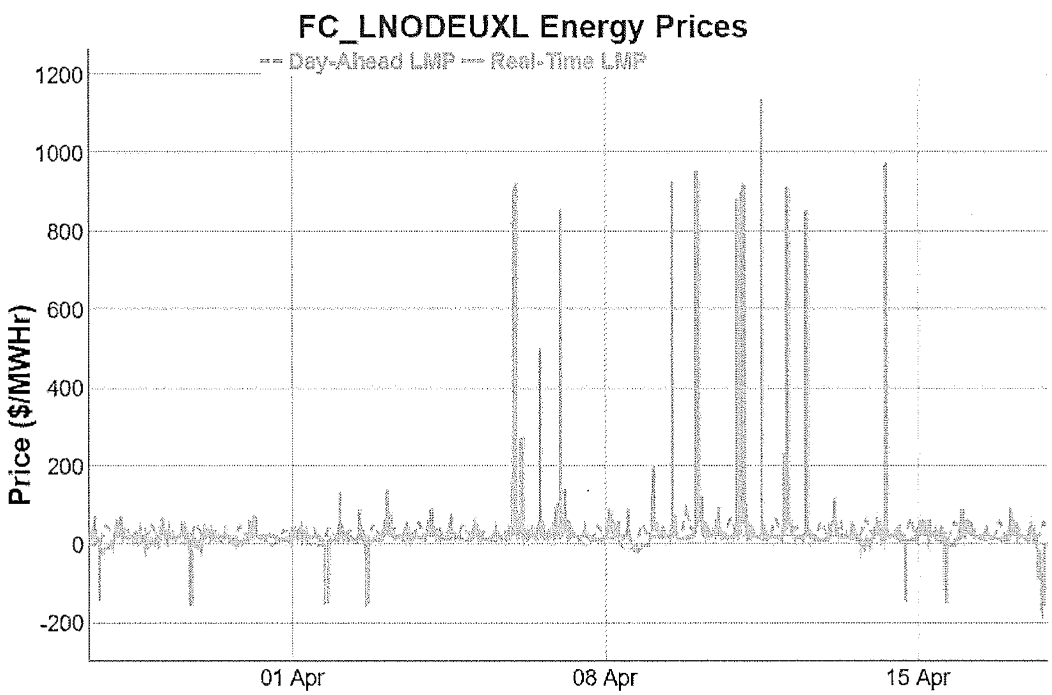
A. Renewables are rapidly becoming the principal energy supply resource of the west. The structural change in power supply realized through increasing renewables impacts the dynamics of power market prices, which in turn, impacts market prices. Regional power market prices exhibit a precipitous and continuous rise in volatility as a direct function of increasing renewables. We have observed a consistent annual increase in price volatility, with grid connected renewable penetration increasing from 8% in 2014 to 19% in 2018 and volatility in prices nearly tripling in the day-ahead market and a one and a half fold increase in the real-time market as shown in PNM Table GWD-1.[5] This increase in volatility is a direct result of increasing amounts of intermittent renewable generation.

PNM Table GWD-1: Renewable Penetration vs Price Volatility

Year	Renewable Penetration	Standard Deviation in DA Prices ($/MWh)	Standard Deviation in RT Prices ($/MWh)
2014	8%	12	53
2018	19%	38	72

PNM Figure GWD-1 shows a typical time series of real-time and day-ahead prices for the Four Corners node in northwestern New Mexico.

PNM Figure GWD-1: Typical Price Spike Behavior in the EIM



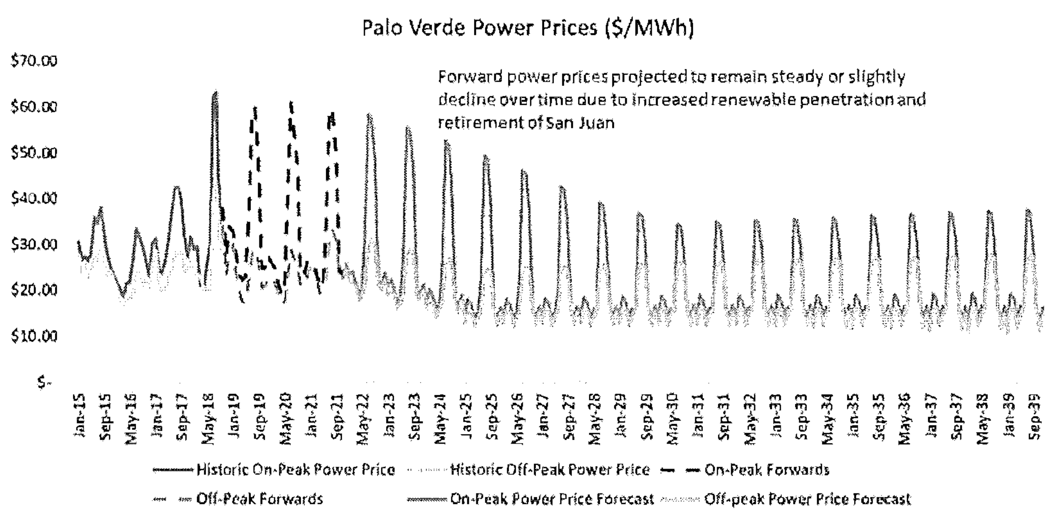
[5]Volatility is measured in terms of standard deviation of prices in $/MWh.

As more renewables are added to the system over time, we expect the frequency of positive and negative price spikes to increase concomitantly. Within this context of increased volatility, the resources best suited to dispatch and provide value for PNM ratepayers are highly flexible and dispatchable. Flexible generation can be called to capture the full value of price spikes by turning on and off quickly and economically and ramping up to full power quickly and efficiently. These resources include batteries, reciprocating engines, and aeroderivative engines. Resources that fare poorly in terms of flexibility include large frame style turbines, combined cycles and coal plants. PNM Exhibit GWD-3 includes further discussion of Ascend's outlook on hourly and sub-hourly price dynamics for the EIM.

Q. WHAT WERE YOUR INPUTS REGARDING POWER PRICES AND IMPLIED HEAT RATES IN THE FUTURE?

A. Ascend's forward price forecast is shown in PNM Figure GWD-2:

PNM Figure GWD-2: Palo Verde Power Price Forecast



Ascend forecasts power prices through a blending of forward market prices through the end of 2021 and a fundamentals-based forecast from 2022 through 2040. As described above and in PNM Exhibit GWD-3, prices remain relatively flat in real dollar terms as low-cost renewables flood the system. We forecast gas prices to increase at inflation after the forward curve for gas ends in 2023, which results in a market declining implied market heat rates.[6]

Ascend forecasts declining implied heat rates from an average of 11 to 7.5 MMBTU/MWh between today and 2030. On the other hand, we assume increased price volatility driven by renewable intermittency, until the time batteries become substantially deployed onto the grid.

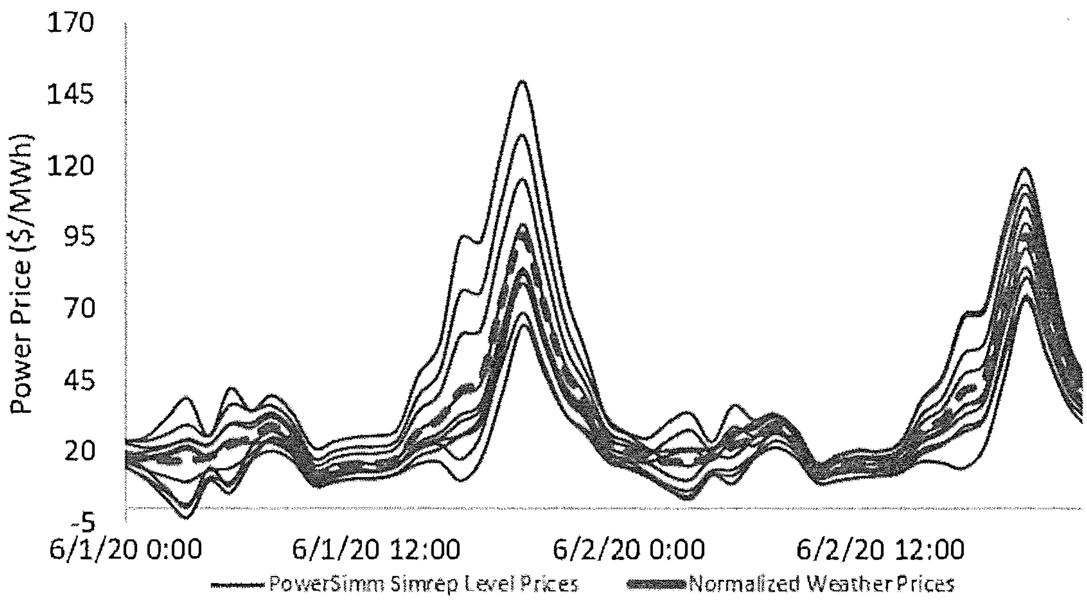
Q. HOW DOES POWERSIMM DIFFER FROM TRADITIONAL RESOURCE PLANNING MODELS AND WHY IS THAT IMPORTANT GIVEN THE CHANGES IN ENERGY MARKET DYNAMICS DESCRIBED ABOVE?

A. PowerSimm is a power system optimization/production cost modeling tool with deep roots in quantifying uncertainty and risk, making it a perfect fit for evaluation of high renewable energy portfolios. PowerSimm addresses this inherent uncertainty in supply and market conditions by creating a coherent and validated construct that generates renewable output, load, and energy prices as a function of simulated weather, the shared core driver. Instead of a single

[6] Implied heat rates are determined by dividing the price of power in $/MWh by the price of natural gas $/MBtu, realizing an average system conversion efficiency of gas to power in units of MBtu/MWh.

deterministic and weather-normalized run, PowerSimm simulates hundreds of hourly and sub-hourly system conditions rigorously benchmarked to current and evolving system fundamentals. Dispatch and market interactions are optimized to respond to the increasingly volatile simulated price conditions, thereby revealing the true value of flexible generation.

PNM Figure GWD-3: PowerSimm Simulated Prices vs Weather Normalized Prices



We are also able to run PowerSimm at a sub-hourly time increment and therefore simulate the behavior and economics of resources in the EIM and specifically reveal the value of flexible resources to benefit from volatility.

By creating conditions favorable to energy storage reflected through the highly volatile EIM market, PowerSimm provides a solid framework to remove traditional biases in resource selection. PowerSimm realizes the full economic value of battery storage through co-optimization between system ancillary services and the 5-minute energy market. The optimization engine of PowerSimm provides realistic values for storage by limiting foresight of future system conditions and actively managing the state of charge inclusive of degradation and depth of discharge constraints. The physical and economic modeling constructs have traditionally proven to select battery storage as a supply resource in the WECC, when other modeling frameworks realize less economic and reliability value.

IV. EVALUATION OF REPLACEMENT RESOURCES FOR SAN JUAN COAL PLANT

Q. HOW DID YOU EVALUATE THE REPLACEMENT OPTIONS FOR SAN JUAN COAL PLANT?

A. Ascend modeled PNM's power system in PowerSimm, including the transmission system, access to regional markets, and EIM market value through sub-hourly analysis. All assumptions were independently developed by Ascend, including PNM's renewable portfolio[7] needed over time to meet the requirements of the Energy Transition Act.

For the replacement portfolio analysis, PNM provided Ascend with its top four portfolios as shown in PNM Table GWD-2 below.

[7] See Figure C-7 in PNM Exhibit GWD-3

PNM Table GWD-2: Portfolios Analyzed for San Juan Coal Plant Replacement

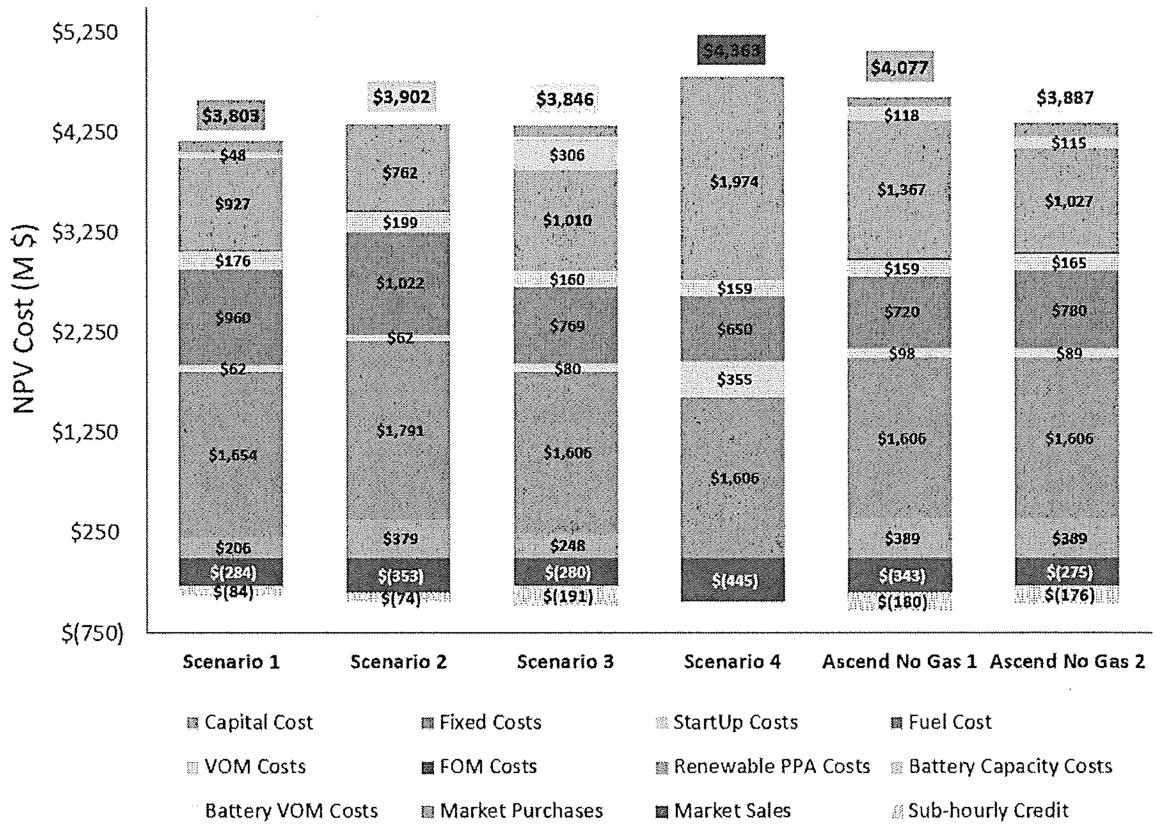
Portfolio Name	Thermal (MW)	Batteries (MW-Duration)	Solar (MW)	Wind (MW)
Scenario 1	7 aeroderivatives (268 MW)	60 MW – 4 hr 70 MW– 2 hr	350	140
Scenario 2	1 Frame (196 MW) 7 aeroderivatives (268 MW)	None	-	140
Scenario 3	None	260 MW – 4 hr 160 MW – 2 hr	500	140
Scenario 4	None	None	975	1199
Ascend No Gas 1	-	100 – 4 hour 300 – 2 hour	500	540
Ascend No Gas 2	-	150 – 4 hour 300 – 2 hour	200	140

Ascend modeled these portfolios for cost and reliability impacts. Ascend also developed two additional no gas portfolios to determine whether a completely carbon free portfolio would be economic and reliable.

Q. WHAT IS YOUR ECONOMIC ASSESSMENT OF THE SAN JUAN COAL PLANT PORTFOLIOS?

A. PNM Figure GWD-4 below shows Ascend's assessment of the four PNM scenarios and Ascend's additional sensitivities with additional details presented in PNM Table GWD-3.

PNM Figure GWD-4: Comparison of Net Present Value Portfolio Costs



PNM Table GWD-3: Economic Analysis with PowerSimm

Portfolio Name	Capital Cost	Production Cost	PPA Cost	Hourly Market Value	EIM Benefit	Total NPV
Scenario 1	206	2,911	927	-157	-84	3,803
Scenario 2	379	3,091	762	-256	-74	3,902
Scenario 3	248	2,939	1,010	-160	-191	3,846
Scenario 4	0	2,773	1,974	-383	0	4,363
Ascend No Gas 1	389	2,752	1,367	-251	-180	4,077
Ascend No Gas 2	389	2,790	1,027	-143	-176	3,887

The bar charts show the breakdown of system costs[8] to serve load plus the market benefits from interactions with hourly markets and the Energy Imbalance Market (shown as "EIM benefit" in gray cross hatch pattern).

Q. IS PNM'S PREFERRED PORTFOLIO RELIABLE WITH RESPECT TO PEAK CAPACITY?

A. Yes, Ascend's LOLH (Loss of Load Hours) analysis shows that PNM's preferred portfolio can reliably serve demand. LOLH determines the number of hours that PNM's capacity is insufficient to serve load and a shortfall will be observed. Ascend's model considers hourly dispatch results and determines whether PNM had enough capacity to serve load during each hour. The accepted criterion for this metric is 2.4 hours per year.[9] PNM Table GWD-4 shows the LOLH results for different portfolios.

PNM Table GWD-4: LOLH for Candidate Portfolios

Portfolio Name	LOLH 2023	LOLH 2030	LOLH 2038	Pass/Fail
Scenario 1	0	2.1	0.8	Pass
Scenario 2	0	1.1	0.5	Pass
Scenario 3	1.3	3.3	2.3	Fail
Scenario 4	181	255	205	Fail
Ascend No Gas 1	.4	2.3	1.9	Pass
Ascend No Gas 2	1.3	5.5	6.7	Fail

[8] These include fuel costs, variable operations and maintenance costs, startup costs, fixed operations and maintenance costs, other fixed costs, and PPA costs for energy (in green) and battery capacity (in yellow).
[9] Loss of load expectation (LOLE) is a similar metric to loss of load hours (LOLH). The comparable LOLE is 0.2, which is used by Astrape in its reliability analysis.

We find that *Scenario 1*, the preferred portfolio, is the most cost-effective supply portfolio to transition to a carbon free energy supply and meet reliability requirements. *Scenario 2*, while reliable, is significantly more costly. Scenario 3 is both more costly and less reliable than *Scenario 1. Scenario 4* is simply not reliable and would put PNM customers at risk of supply interruptions and thus the potential for blackouts. Our no gas scenarios were reliable but were more costly than *Scenario 1*.

Q. IS PNM'S PREFERRED PORTFOLIO RELIABLE WITH RESPECT TO FLEXIBLE CAPACITY FOR RENEWABLE INTEGRATION?

A. Yes, PNM's preferred portfolio adds 130 MW of highly flexible batteries and 280 MW of flexible aeroderivative gas turbines. According to an analysis Ascend has performed on PNM's system assuming 50 percent renewable by 2030 and 100% clean by 2045, PNM requires the amounts of flexible generation shown in PNM Table GWD-5.

PNM Table GWD-5: Estimated Flexible Capacity Need to Meet ETA Goals

Year	Regulation Reserves (MW)	15-minute Ramping Capability (INC/DEC)	Total Requirement
2020	66	246	430
2025	104	374	604
2030	117	427	678
2035	149	508	803

We separate flexible capacity requirements into two primary categories: regulation and 15-minute "INC". Regulation is the ability for a generator to move up or down at a 1-minute time scale. This is best used to smooth out short duration perturbations in generation and load. Batteries do an excellent job of providing this service economically and the 130 MW of batteries proposed in this plan cover this need through 2030. INC (or its opposite "DEC") are 15-minute ramps that smooth out renewables that have their production reduced by sudden drops in wind or transient cloudiness. These fast ramps are needed to maintain WECC standards for energy load balance across a 30-minute rolling time horizon. Batteries and the aeroderivatives can provide this service along with purchases or sales in the EIM. Between the batteries, aeroderivatives, and the EIM, PNM should not have a shortage of resources to cover INC/DEC requirements in the foreseeable future.

Q. HOW DOES PARTICIPATION IN THE EIM AFFECT THE VALUE OF PNM'S PREFERRED PORTFOLIO?

A. Ascend assumed new batteries and the aeroderivative turbines would be nominated as EIM participating resources. In Ascend's modeling construct, these resources provide both ancillary services such as regulating reserves and respond to price signals in the 15- and 5-minute energy markets. Ascend based its sub-hourly modeling on the prices at the nearby EIM node: DGAP-PNM-APND. To avoid overvaluing the resources through the use of "perfect foresight" into the prices, Ascend set fixed hours for resources to either perform ancillary services for PNM's system or bid into the EIM based on historical price patterns. Typically, real time price spikes that are advantaged for energy bids occur in the mid-day to late afternoon, therefore we schedule the resources to bid into energy markets during these times and provide regulation and spin at night.

Accordingly, the model calculates a reasonable value estimate for the additional value that can be generated from flexible resources in the EIM. This value is called the "EIM benefit" which is appended onto the results of the hourly production cost runs for final decision analysis. The forecast of the sub-hourly benefit related to the volatility forecast shown above, since price volatility is a direct driver of sub-hourly resource value. PNM Table GWD-6 shows Ascend's estimate for EIM benefit by resource type including power purchase agreement (PPA) and utility-owned generation (UOG):

PNM Table GWD-6: EIM Benefit in $/kw-year

Year	PPA – 4 hour battery	UOG – 4 hour battery	UOG – 2 hour battery	UOG – 1 hour battery	LM 6000
2022	100	105	101	92	44
2023	117	123	118	107	51
2024	100	105	101	92	44
2025	83	88	85	77	37
2026	67	70	68	61	29
2027	67	70	68	61	29

The EIM benefit reflects increases from 2022 to 2023 and then declines thereafter until an equilibrium is reached in 2026. The first-year increase in benefit reflects a perpetuation of current market dynamics of increasing volatility and value of flexible generation with increasing storage. However, new unit entry forecasts have these conditions of "super-normal" returns for flexible generation migrating to toward "normal returns" by 2026.[10]

Q. PNM PROPOSES A PORTFOLIO OF FOUR-HOUR DURATION BATTERIES TIED TO SOLAR FACILITIES UNDER POWER PURCHASE AGREEMENTS AND TWO-HOUR DURATION UTILITY OWNED STAND-ALONE BATTERIES. IS THIS A PRUDENT STRATEGY GIVEN THE STATE OF THE BATTERY MARKET TODAY?

A. Yes. Batteries are a critical technology to enable the transition to a reliable clean energy electricity system, but as with any new technology in the power sector, there are some technology risks as discussed in William Kemp's testimony. PNM has decided to limit any one storage project to 40 MW or less and contract with several vendors instead of just one or two. This diverse risk-managed portfolio approach is reasonable given PNM's growing reliance on battery technology to meet peak demand.

I also recommend PNM's strategy to purchase two two-hour battery projects under utility ownership because of the greater economic value and operational flexibility. There is only a 14% gain in energy value going from a one-hour to a four-hour battery system, but the cost increases by 300%. PNM Table GWD-5

[10] Normal returns reflect an 8% expected return.

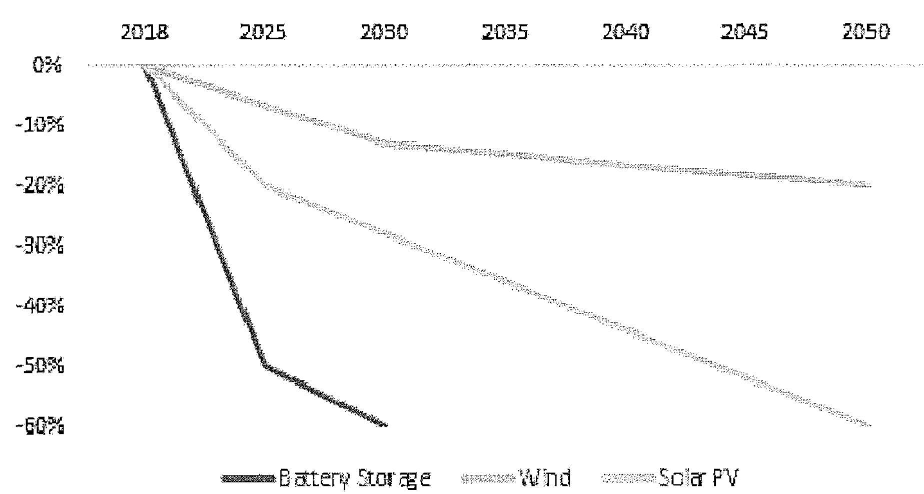
shows that the value of the battery in the EIM lies in the maximum power, not the duration, thus a 4-hour battery can earn $105/kw-year while a 1-hour battery can earn $92/kw-year. The corresponding capital costs are approximately $1,350/kW for the 4-hour and $450/kW for a 1-hour battery, making clear the concept that without the benefit of the ITC, shorter duration batteries are more cost-effective today for utility ownership. The choice of two-hour duration battery is also prudent because the majority of cost declines will be in the cost of the battery packs (i.e. the storage part) rather than the balance of plant (including inverters, racks, cooling equipment, etc.). As the cost of battery packs decline, PNM can add storage capacity later when it is more cost-effective.

PNM system operators will have complete flexibility to maximize battery storage across several value streams, including ancillary services, minimizing renewable curtailment, and capturing the value of price volatility in the EIM. Ownership will also allow the important benefit of providing PNM system operators with the organizational learning needed to take on increasing amounts of battery capacity onto the system over time. We also evaluated several PPA solar and storage projects that capture the full value of the Investment Tax Credit (ITC). These projects tend to have more physical restrictions such as cycle and state of charge limits, since the operator maximizes the value of the ITC by only charging from the solar during the first five years of operation. A standalone battery cannot take advantage of the ITC, but it provides more operational flexibility and capacity contribution with full grid charging and no stranded state of charge limitations during events where the battery would be needed for reliability to provide energy.

Q. IF PNM HAS AN OBLIGATION TO ACHIEVE 80 PERCENT RENEWABLE ENERGY AND 100 PERCENT CARBON FREE ELECTRICITY BY 2045, DOES IT MAKE SENSE TO ADD NEW GAS NOW?

A. Yes. At first this seems counter intuitive, but it makes perfect sense from an economic and reliability perspective. To track towards 100 percent clean energy, PNM must retire legacy coal and gas units and replace the capacity with flexible and ultimately non-emitting capacity resources. Batteries today can serve as capacity resources primarily charged by renewables, but from an economic perspective, it benefits PNM rate payers to wait until the industry matures and prices drop dramatically between now and the mid-2020s as shown in PNM Figure GWD-5 below.

PNM Figure GWD-5: NREL cumulative projected declines in technology cost



The National Renewable Energy Lab[11], Bloomberg New Energy Finance,[12] among others are projecting steep declines in battery storage costs through 2025 and continued moderate declines through 2030. In this environment, limiting battery procurement to 60 MW of 4-hour duration battery and 70 MW of 2-hour duration batteries strikes a reasonable balance between the desire to avoid out-of-the-money investments in a declining cost technology while still taking a substantial step towards building the clean energy system of the future.

If it pays to wait until storage technology matures, it follows that PNM should secure low cost flexible capacity today as part of the solution to replace San Juan coal plant's retiring capacity. Aero derivative turbines are a mature technology and these units are grey market and thus extremely attractive from a cost standpoint. These units will play an important role for PNM's clean energy transition.

The role of the aeroderivatives is to enable the retirement of less flexible coal and gas resources by providing *critical back-up power* when meteorological conditions are unfavorable for reliable self-supply of electricity. Critical back up power means the units capacity factors will be low and decline over time. Their role is not to provide energy; the renewables fulfill that purpose, but only to start

[11] Values taken from the NREL Annual Technology Baseline: https://atb.nrel.gov/electricity/data.html
[12] https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/

up and deliver capacity when the system needs short bursts of energy. According to our modeling, the capacity factor of the aeroderivatives would be as follows:

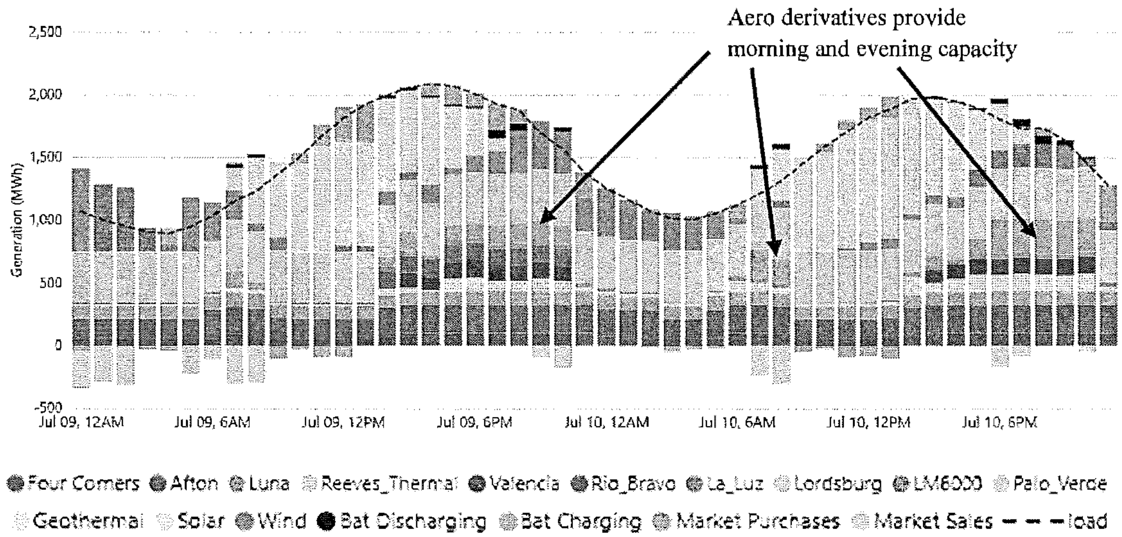
PNM Table GWD-7: Simulated Average Annual Capacity Factors for Aero Derivatives

	2022	2025	2030	2035	2040
Capacity Factor	18%	9%	7%	6%	5%

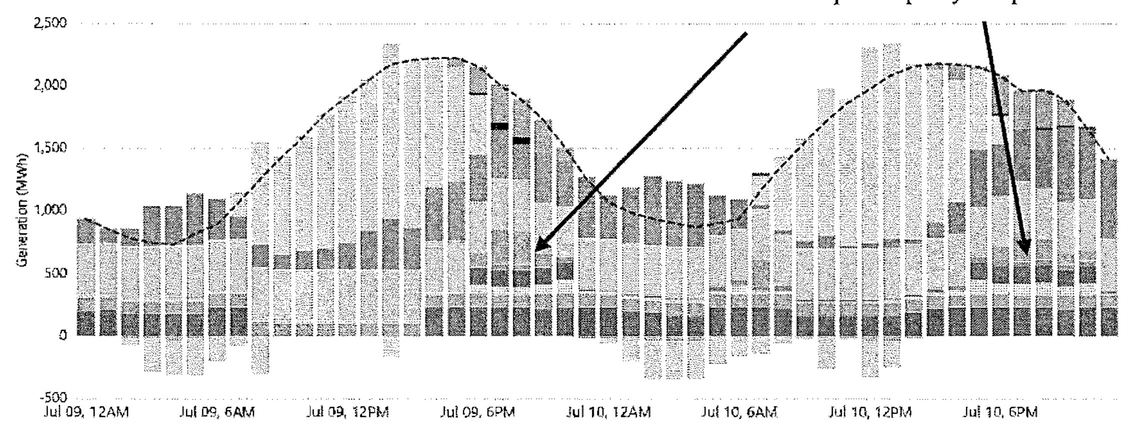
From the traditional Resource Planning 1.0 perspective, these units could be considered underutilized. However, in the new energy paradigm under Resource Planning 2.0, we find these units performing exactly the job we want and expect: to provide peaking capacity with a high level of flexibility while letting renewables provide the vast amount of system energy. PNM Figure GWD-6a-d shows this concept graphically.

PNM Figure GWD-6a-d: Hourly Dispatch of PNM System: Scenario 1

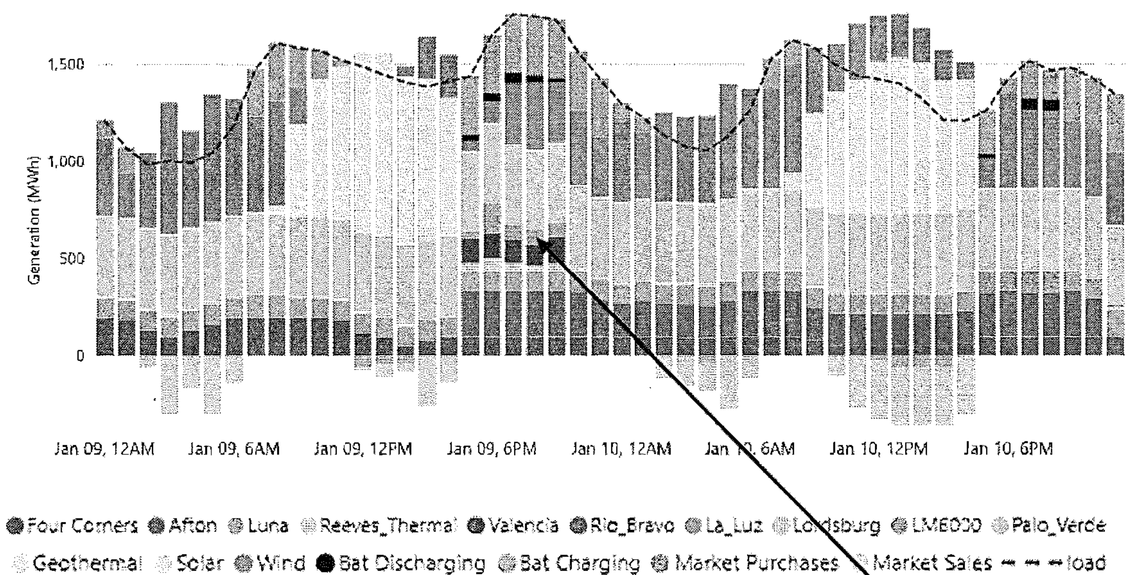
Figure 6a: Summer 2025



PNM Figure GWD 6b: Summer



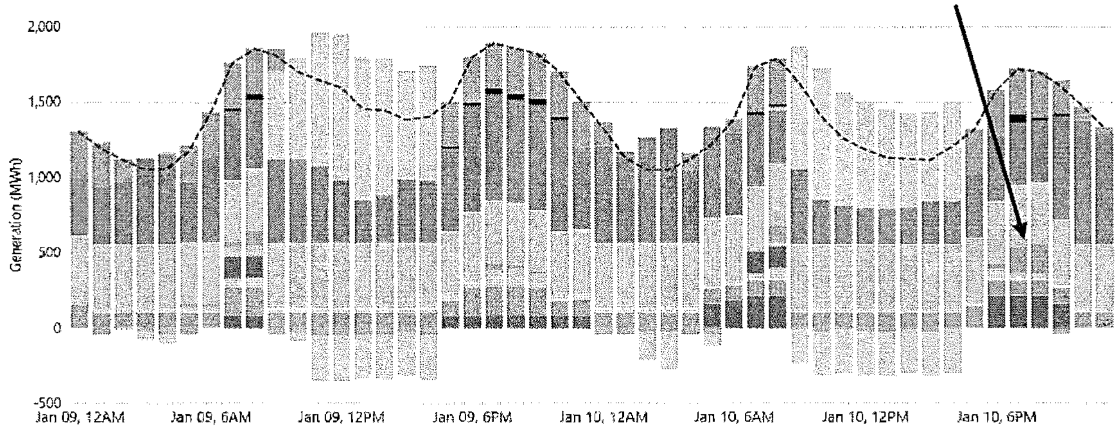
PNM Figure GWD-6c: Winter 2025



PNM Figure GWD-6d: Winter 2(

In winter, aeros only needed occasionally for peak capacity and reliability

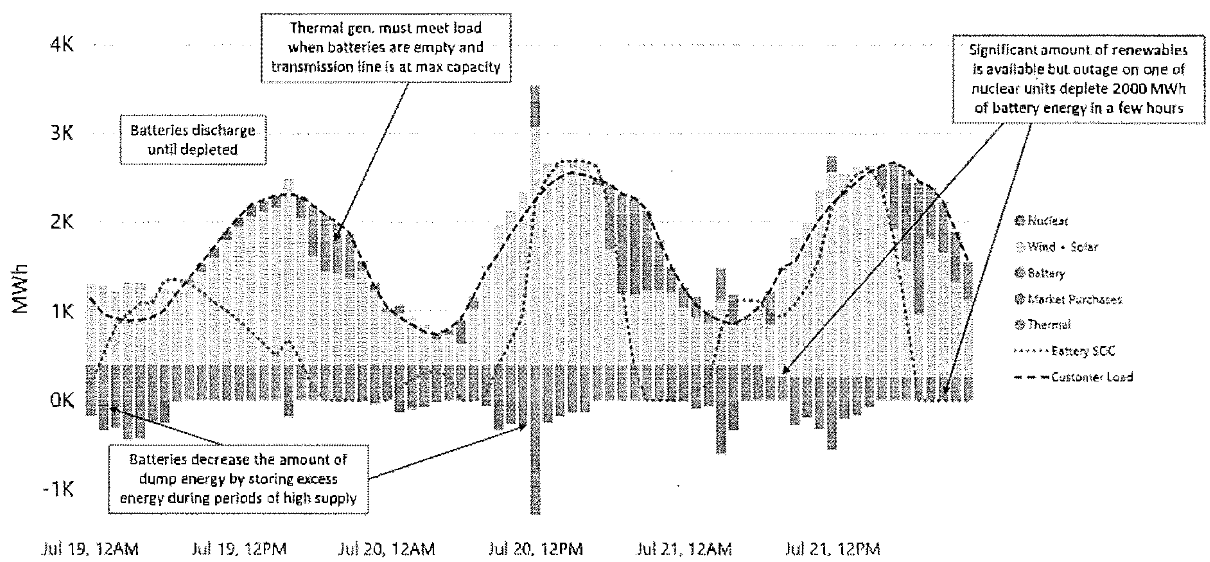
System is almost always renewable and clean in winter 2035.



Q. COULD PNM UTILIZE THE AERODERIVATIVE TURBINES AS PART OF A 100% CARBON FREE PORTFOLIO?

A. Yes. To test our hypothesis that these gas plants provide material benefit to PNM in a carbon free portfolio, we ran a simulation of 2045, assuming that these seven aero-derivatives become the sole thermal plants left on PNM's system. We added a balanced portfolio of renewables to cover 80% of PNM's energy needs, maintained Palo Verde providing of carbon free energy of 402 MW, and the addition of 2,560 MW of 4-hour duration batteries (10,240 MWh of storage) to cover the expected peak demand four hours.

PNM Figure GWD-7: Role of thermal in high-renewables system



PNM Figure GWD-7 shows that even with enough battery capacity to meet peak demand and enough renewables to provide 80% of system energy, there are still adverse meteorologies where thermal generation provides critical backup power. In the simulation above, the batteries charge as renewables generate and discharge to serve load when the renewable generation is inadequate. The afternoon of July 19th had an unusual decline in solar, perhaps due to a thunderstorm. The batteries are drained in the evening hours and the thermal generation must come online to augment the system. On the 20th, you see a sudden spike in renewable output, probably a short-lived high wind pattern, and the batteries quickly charge to absorb the excess generation and avoid renewable curtailment. Again, there is insufficient renewable generation to meet the evening load and thermal kicks on to supply the difference. Finally, on the 21st we simulate a partial outage at Palo Verde[13]. In this scenario, the batteries drain again and thermal turns on to provide system energy.

While the aeroderivative turbines are forecast to operate relatively infrequently, with a capacity factor in the low single digits, they provide a critical and cost-effective component to a 100% carbon free portfolio. The sustained value contribution of the aeroderivative turbines beyond their projected book life of 18 years adds to the economic rationale include flexible thermal generation as the most economic investment today to realize a carbon free portfolio in the future. To summarize, the role of thermal in a high-renewables system:

1) they serve as a critical flexible capacity resource to integrate renewables and costs less than half of energy storage
2) they are the least-cost capacity resource
3) they can be utilized as zero carbon back-up capacity beyond their expected life burning either hydrogen or biofuel
4) they serve as a necessary back-up capacity resources in a 100% carbon-free future when unfavorable meteorologies, such as extreme

[13] Each unit (of three) has a 5% forced outage rate, so the likelihood of this occurrence is not insignificant.

load conditions combined with a short-term wind-drought, depress renewable generation, and leave the batteries drained.

Q. IN YOUR PROFESSIONAL OPINION, IS PNM'S PREFERRED PORTFOLIO REASONABLE, DURABLE, AND IN THE INTEREST OF PNM'S RATE PAYERS?

A. Yes, PNM has developed a diverse, cost-effective, flexible, and reliable portfolio that will benefit PNM's rate payers for many years to come. The portfolio is well balanced, gaining most of its energy from low-cost solar and wind while also assuring enough flexible capacity to integrate the renewables and provide operators with the resources to assure continued supply during the peak load hours of the year. The seven aeroderivative engines at San Juan will allow PNM to modernize its generation fleet and retire older inflexible thermal generation without sacrificing reliability. This portfolio puts PNM on a path towards a clean energy future with that aligns with the targets of the Energy Transition Act.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes it does.

GCG#525663

Gary Dorris PhD Curriculum Vitae

PNM Exhibit GWD-1

Is contained in the following 19 pages.

Curriculum Vitae of Gary W. Dorris

EMPLOYMENT HISTORY

President & Founder	*Ascend Analytics*	Boulder, CO (2002-present)
CEO and Chief Model Architect	*e-Acumen (Acquired from Stratus)*	Boulder, CO (2000-2001)
Director of Energy Practice	*Stratus (Hagler Bailly spinoff)*	Boulder, CO (1998-1999)
Manager and Senior Associate	*Hagler Bailly*	Boulder, CO (1997-1998)
Faculty	*Cornell University*	Ithaca, NY (1996)
Power Marketing Manager	*Citizens Power & Light*	Boston, MA (1990-1991)
Power Supply Supervisor	*UNITIL Power Corp*	Exeter, NH (1988-1990)
Project Engineer: CO-OP	*Electric Power Research Inst.*	Barker, NY (1987)

SUMMARY

- Developed an industry-leading consulting and software company that supports resource planning, portfolio management and risk. Has grown Ascend to a 50 person company with a reputation as an industry leader for renewable integration, resource planning, and portfolio management analytics. Previously, lead e-Acumen to be an industry star with 60 people before sale of company to ABB.
- Chief model architect and engagement director to implement solutions for resource planning and portfolio management analytics at AES, ACES Power Marketing, American Electric Power, BC Hydro, Dayton Power and Light, Duke, Hawaii Electric Companies, Indianapolis Power and Light, Entergy Solutions, Essent, Exelon, InterGen, LADWP, PG&E, Puget Sound Energy, Pennsylvania Power & Light, Riverside Public Utilities, The Energy Authority, Tri-State G&T, NRG, Tennessee Valley Authority, and Turlock Irrigation District.
    - Developed and deployed resource planning software solutions and supported resource plans that systematically integrated uncertainty into capacity expansion planning and resource selection.
    - Developed and deployed solutions to capture the financial and physical dynamics of energy markets and operations including: 1) derivative instrument valuation, 2) asset valuation, 3) risk management and portfolio optimization, 3) forward and spot prices, 4) transmission/transportation, 5) load, 6) gas storage, and 7) credit risk.
- Performed numerous independent market assessments for valuation of electric generating assets:
    - Assessments for financing of over $5 billion in generating and gas storage assets.
    - Valuations performed for leading energy developers, banks, and S&P and Moody's.
- Presented to boards of directors and provided expert testimony.

EDUCATION

Cornell University, Ph.D., Applied Economics and Finance, 1996

Cornell University, B.S., Mechanical Engineering, B.A., Economics, Magna cum Laude 1988

PROFESSIONAL EXPERIENCE

Gary Dorris has pioneered innovative solutions for energy portfolio planning, risk management, and asset valuation for over two decades. His expertise with large-scale physical and financial risk modeling has proved his company, Ascend Analytics, and its resource planning and portfolio management solution to be indispensable to over 50 energy companies throughout the US and Europe. Industry leaders have appealed to Dr. Dorris for his delivery of expert testimony regarding resource planning, risk management, energy procurement, trading practices, asset valuation, market power, rate design, and emissions trading. He has also provided independent expert reports to support utility acquisition of rate based generation assets and the financing of merchant generation of over $5 billion in electric generating assets. He was chosen by the National Academy of Sciences to participate in a study on renewable integration. Prior to founding Ascend, he served as CEO and Chief Model Architect for e-Acumen, a 60 person energy consultancy and software analytics firm that he successfully grew and has been sold. He directed the development of the analytical and risk infrastructure for the launching of the trading floors of Entergy Solutions, Duke Solutions, The Energy Authority, and ConEdison. Before e-Acumen, he founded and directed the energy practice at Stratus Consulting and was a manager at Hagler Bailly.

Before joining Hagler Bailly in 1997, he was a faculty member at Cornell University, where he taught a doctoral-level course in modeling competitive energy markets. Dr. Dorris actively publishes research articles and speaks on resource planning, portfolio management, risk analysis, and modeling of competitive energy markets. He has been honored in 2001 by the International Petroleum Exchange for his innovations and contributions to the field of energy risk management.

Dr. Dorris holds a PhD in applied economics and finance from Cornell University and both a BS in mechanical engineering and a BA in economics with Magna Cum Laude distinction from Cornell University.

EXPERT TESTIMONY

Renewable Integration

NorthWestern Energy v. Montana Consumer Advocate. Regulatory Proceeding, Montana, Case Nos. D2014.4.43.

NorthWestern Energy v. Caithness Beaver Creek, LLC. Regulatory Proceeding, Montana, Case Nos. D2018.8.52.

NorthWestern Energy v. Grizzly Wind, LLC. Regulatory Proceeding, Montana, Case Nos. D2019.2.8.

NorthWestern Energy v. Black Bear Wind, LLC. Regulatory Proceeding, Montana, Case Nos. D2019.2.9.

Resource Planning

NorthWestern Energy v. Montana Consumer Advocate. Regulatory Proceeding in State Supreme Court Chambers, Montana, Case Nos. D2013.12.85.

Risk Management and Trading
Merrill Lynch v. Enron Shareholder. Federal District Court of Texas, Case Nos. H-01-3624.

Asset Valuation and Hydro Production
Montrose Energy Partners (Sithe Energy) v. Trout Unlimited. Colorado Water Court, Case Nos. 4-2002CW204 and 4-2002CW205.

Commodity Hedging, Risk Management and Derivative Accounting
Owens Corning v. Dennis Mangan. Federal Bankruptcy Court, District of Delaware, 2004. Case Nos. 00-3837 (JKF), Claim No. 6923.

Energy Risk Management and Trading Practices
Nevada Power v. MGM Grand. Nevada Regulatory Proceeding, 2002. PUCN Docket No. 01-11029.

Asset Valuation and Emissions Trading
AES Corp. v. Allegheny Power. Pennsylvania Arbitration Proceeding, 2000. Arbitration No. 71 198 00004 00.

Environmental Damages
US EPA v. Mid-west Ozone Group, Washington D.C. Federal Court, 1998 (expert report used in proceedings).

RESOURCE PLANNING AND SUPPLY PROCUREMENT 1988-2013

- ***Resource Planning:***
  - Developed renewable integration studies for Hawaii Electric, Duke Energy, and NorthWestern Energy that examined the amount of regulation and flexible reserves required as function of renewable generation types and location. Selected by National Academy of Sciences to participate in a study on renewable integration.
  - Developed optimal expansion planning with uncertainty for numerous utilities pursing high renewable portfolio standards including highly prominent and contested proceedings Hawaii, Northwestern Energy, and California utilities
  - Developed one of the nation's first integrated "risk based" energy supply resource plans for Xcel Energy in Colorado (2004) and PG&E (2003). Analysis included portfolio assessment of multiple resource options with respect to the expected costs and costs at risk.
  - Currently leading the resource planning analysis, report development, and providing facilitation support for the stakeholder process and expert testimony.
  - Provided thought leadership to the development of Ascend's PowerSimm software applied at over a dozen electric utilities for portfolio management, resource planning and asset valuation.

- Provided supply portfolio analysis for North Carolina Electric Membership Cooperative, Southern Maryland Electric Cooperative, and Old Dominion Electric Cooperative Oglethorpe Power Corporation

- ***Energy Costing and Supply Procurement***:
  - Developed methodology and software system for cost of supply analysis for competitive retail offerings of Duke Solutions and Entergy Solutions.
  - Executed energy supply procurement for UNITIL Power Corp.

- ***Power Trading***:
  - Executed of over 100 short-term and long-term power sale agreements for both utilities and IPPs.
  - Performed one of (if not) the first above cost electricity transaction in the US in 1988.
  - Marketed and structured complex long-term tolling contracts.

- ***Trading Floor Launches:***
  - Launched the trading floors of Entergy Solutions, Duke Solutions, The Energy Authority, and ConEdison including top to bottom analytics and trading/supply procurement practices.
  - Supplied major risk management and deal analysis infrastructure for Entergy, TXU, PZ Oil, ACES Power Marketing, PG&E, Arizona Public Service, and BC Hydro.

ELECTRIC MARKET ANALYSIS 1998-2004

- ***Asset Valuation:***

  Developed independent expert reports on the value and acceptable financial structure for valuing power generation and gas storage assets for the following clients:

Developers	**Financial Institutions**
AES Corporation	*Investment Banks*
Columbia Electric	- CS First Boston
Mosbacher Power	- Lehman Brothers
PP&L Global	*Commercial Banks*
Edison International	- GE Capital
Enron	- Bank of Tokyo
Xcel Energy	- Citibank
Sempra Energy	*Credit Rating Agencies*
Tampa Electric Co.	- S&P
Select Energy	- Moody's
El Paso	
Energetix	

- ***Risk Management***: Developed and implemented risk management policy and procedures for four trading floors.

Ascend Analytics
Better models. Better decisions.

- ***Sarbanes Oxley***: Performed internal audits, implemented policies and procedures, defined corporate structure governance, and implemented software solutions
- ***Supply Procurement***:
  - Developed least cost resource plan filing with risk analysis for PG&E.
  - Executed energy supply procurement for UNITIL Power Corp.
- ***Trading from Fundamental***: Trained power traders on short-term trading strategies and identification of hedging strategies based on real-time market fundamentals. Clients included: Duke, TXU, PP&L, ConEd, Coral, El Paso, Reliant, CMS, and BP.
- ***Market Power:***
  - Estimated HHI and Lerner index for PJM deregulation initiatives. Filed results as part of market design report to state commission.
- ***Capacity Market Design***: Drafted design of a capacity market for the CAISO.

ENERGY RISK AND POWER TRADING 1988-2004

- ***Resource Planning***: Developed one of the nation's first integrated "risk based" energy supply resource plans for Xcel Energy in Colorado (2004). Analysis included portfolio assessment of multiple resource options with respect to the expected costs and costs at risk.
- ***Energy Costing and Supply Procurement***:
  - Developed methodology and software system for cost of supply analysis for competitive retail offerings of Duke Solutions and Entergy Solutions.
  - Developed least cost resource plan filing with risk analysis for PG&E.
  - Executed energy supply procurement for UNITIL Power Corp.
- ***Power Trading***:
  - Executed of over 100 short-term and long-term power sale agreements for both utilities and IPPs.
  - Performed one of (if not) the first above cost electricity transaction in the US in 1988.
  - Marketed and structured complex long-term tolling contracts.
- ***Trading Floor Launches:***
  - Launched the trading floors of Entergy Solutions, Duke Solutions, The Energy Authority, and ConEdison including top to bottom analytics and trading/supply procurement practices.
  - Supplied major risk management and deal analysis infrastructure for .
- ***Trading from Fundamental***: Trained power traders on short-term trading strategies and identification of hedging strategies based on real-time market fundamentals. Clients included: Duke, TXU, PP&L, ConEd, Coral, El Paso, Reliant, CMS, and BP.

- ***Market Power:***
  - Estimated HHI and Lerner index for PJM deregulation initiatives. Filed results as part of market design report to state commission.

RETAIL PROGRAMS 1990-2004

- ***Retail Offerings:*** Developed a suite of retail product offerings for open market competition in Texas, PJM, and California.
- ***Retail Time Pricing:*** Developed retail time price offerings in competitive offerings and for regulated companies.
- ***Risk Based Pricing:*** Developed and implemented a system of risk based pricing for competitive retail offerings.

PROJECT FINANCE ANALYSIS 1998-2002

- ***Asset Valuation:***

Developed independent expert reports on the value and acceptable financial structure for power generation and gas storage assets for the following clients:

Developers	**Financial Institutions**
AES Corporation	*Investment Banks*
Columbia Electric	- CS First Boston
Mosbacher Power	- Lehman Brothers
PP&L Global	*Commercial Banks*
Edison International	- GE Capital
Enron	- Bank of Tokyo
Xcel Energy	- Citibank
Sempra Energy	*Credit Rating Agencies*
Tampa Electric Co.	- S&P
Select Energy	- Moody's
El Paso	
Energetix	

OIL AND GAS MARKET ANALYSIS 2002-2005

- ***Portfolio Analysis*:** Developed corporate strategy for portfolio risk analysis and capital investment allocation for a large oil field service company.
- ***Market Assessment and Gas Storage Valuation:***
  Dr. Dorris developed *GasVal* to capture the full value of storage assets for project analysis, mark to market energy accounting, and deal structuring. With the use of state-space modeling to capture the underlying dynamics of gas market behavior, his market analysis and asset valuations have been performed for industry leaders in gas storage including:

  - TXU
  - Pinnacle West
  - TECO Energy

- ***Energy Cycle Forecasting:***
  - Forecasting of rig counts for Halliburton and Baker Hughes Christensen
  - Development of Pasche price index and index forecast for energy services

DISTRESSED UTILITIES 1990-2004

- ***PG&E:*** Developed energy supply portfolio analysis for commission filings and credit risk mitigation for the bankrupt utility. Implemented energy risk management policies and software solutions.
- ***Cajun Electric COOP:*** Economic support for bankruptcy trustee including workout scenarios, power purchasing strategy, and preparation of expert testimony.
- ***Colorado Utah:*** Sold excess generation to mitigate losses and maintain operations.
- ***PSNH:*** Developed counter party protective measures to continue supply trading.

ANALYTIC SOFTWARE DEVELOPMENT 1997-2013

Developed a suite of analytic software products for energy risk management, asset decision analysis, and energy trading that were sold to 30 of the 100 energy companies. After merging his business activities and software from Stratus with e-Acumen, he served as CEO and Chief Model Architect. Since founding Ascend, he has developed a second generation suite of analytic products which include:

- ***PowerSimm:*** Monte Carlo simulation of physical assets and financial instrument for energy costing, portfolio management, risk measurement, and deal analysis.
- ***PowerSimm Planner:*** Performs resource planning with the inclusion of uncertainty. Automatic resource selection based on market dynamics and planning constraints.
- ***HydroOps:*** Optimization of hydro generation assets.
- ***CurveDeveloper:*** Provides complete monthly forward curves using no-arbitrage strip reduction along with volatilities and correlations.
- ***WeatherSimm:*** Simulates climatic variables temporally and spatially to integrate with HydroSimm, LoadSimm, and PriceSimm.
- ***LoadSimm:*** Simulates system load, industrial customer load, or load profile demand.
- ***GasVal:*** Values gas storage assets that address the new dynamics of gas market spot and forward prices combined with the physical operating dynamics of storage assets.
- ***DataScrubber:*** An automated data cleaning system that analyzes analytic data, reviews it for accuracy, and identifies and remedies errors or omissions in the data.
- ***OptionModeler:*** A series of option models from complex regime switching and jump diffusion with mean reversion to Black's standard model.

INTELLECTUAL PROPERTY/BUSINESS VALUATION 2000-2001

- Conducted a number of business transactions as CEO of e-Acumen involving the valuation of a business and acquisition of intellectual property.
- Provided expert support concerning intellectual property ownership.

ENVIRONMENTAL ANALYSIS/DAMAGES 1994-1999

Dr. Dorris developed the Regional Economic Model for Air Quality (REMAQ), an integrated framework to assess the costs and air quality implications of different emission trading strategies. He has also applied REMAQ to assess the joint benefits of air quality regulations and been used to evaluate regulations of NO_x emissions from power plants and address critical environmental policy question about electric utility restructuring. He was the principal investigator for the expert report to evaluate the air quality impacts and cost effectiveness of EPA's SIP Call for NO_x point sources, the most expensive environmental legislation for the state of New York, Illinois, North Carolina, the province of Ontario Canada, wide emission standards, and has been central to the development of transboundary emission policy between the US and Canada. In addition, his environmental analysis of emission markets and regulations has been used by numerous electric generators for development of compliance strategy and the financing of over $15 billion in generation.

INSTRUCTION 1996-2004

- ***Academic***:
  - Taught a course in Risk Management at the Leeds Business School of University of Colorado
  - Taught a course at Cornell University on Modeling Competitive Energy Markets in Spring of 1996.
  - Teaching assistant for advanced doctoral course in econometrics at Cornell University.
- ***Industry:***
  - Lead instructional seminars regarding:
    - Financial Risk Management
    - Portfolio Optimization
    - Techniques for Forward Curve Development
    - Energy Supply Planning
    - Trading Electricity from Fundamental
    - Option Pricing and Stochastic Process

RELATED WORK EXPERIENCE 1986-1991

At Citizens Power & Light, Dr. Dorris conducted electric power transactions and developed strategies for power sales; managed international project feasibility studies in Poland, Czechoslovakia, the Dominican Republic, and India. He directed project development for a $700 million power plant in Poland. He negotiated conditions for a joint venture with the national oil refinery and a power sales agreement with Polish National Power grid, and pursued project financing with the World Bank and EBRD.

At UNITIL, he negotiated power purchase contracts with independent power developers and utilities, and was responsible for the technical and economic analysis of new power projects. Conducted short-term power procurement and sales and was responsible for production costing and NEPOOL regulatory affairs.

At EPRI, Dr. Dorris performed pilot testing of spray dryer scrubbers for coal power plants. He also developed and coordinated a pH negative corrosion test program.

HONORS AND PROFESSIONAL AFFILIATIONS

- International Petroleum Exchange (IPE) recognition for developments of "Earnings at Risk", a conceptual framework for measuring financial and physical risk (2001).
- Second person in history of Department of Applied Economics and Management to receive special exemption from Master thesis requirement, Cornell University (1992).
- Who's Who
- Graduated *Magna cum Laude,* Cornell University, 1988
- Nation Association of Business Economists
- American Economic Association
- International Association of Energy Economists
- General Association of Risk Professionals

SELECTED PUBLICATIONS

1) "A New Evaluation Paradigm for Flexible Resources" with Mike Mendelsohn, *Greentech Media*, February 2019

2) "Navigating the New Energy Market Dynamics" with Carlos Blanco, *risk.net,* March 2018

3) "Application of Backwardation to Natural Gas Futures" with Sean Burrows and Vena Kostroun, *Energy Risk,* August 2006.

4) "Risk Based Retail Pricing" with Sean Burrows, *Public Utilities Fortnightly,* March 2004.

5) "Energy Risk Management, Making Risk Management an Affirmative Tool to Provide Stable Returns on Investment," with Andy Dunn, *Energy & Power Risk Management* and the *New Frontiers* supplement, December, 2001.

6) "Using Modern Risk Measurement Techniques to Understand the Risk Exposure of an Energy Company," *Energy & Power Risk Management*, February 2001.

7) "Making the Shift to Earnings at Risk," with Andy Dunn, *Electric Light & Power*, October, 2001.

8) "Evaluating Generation Using Modern Energy Risk Management," with Andy Dunn, *Power Industry Development,* August 2001.

9) "Portfolio Optimization Technology and Techniques: Making Risk Management an Affirmative Tool for Adding Value to the Bottom Line," with Andy Dunn, *Energy & Power Risk Management*, July, 2001.

10) "Using Modern Energy Risk Management," with Andy Dunn, *Global Energy Business,* May/June 2001.

11) "Electricity Pricing: How to Make Electricity Pricing Models More Accurate by Incorporating Price Spike," with R. Ethier, *Energy & Power Risk Management*, July/August 1999.

12) "Behavioral Transportation Controls Impact on Air Quality," with John Kim, *Transportation,* October, 1999.

13) "Power Purchase Contracts and the Cost of Debt," *The Fortnightly,* May, 1996.

14) "Rethinking Power Contracting: Implications of Dispatchable Power Purchase Contracts," with Timothy Mount, *Energy Journal, 15(4): 167-187.*

15) "Cogeneration Implication for Pollutant Reduction and Energy Conservation," with Timothy Mount, Cornell University, Department of Agricultural, Resource and Managerial Economics, Working Paper, December, 1991.

SELECTED CONFERENCE PROCEEDING/WORKING PAPERS/PRESENTATIONS

1) "How Will a Hybrid PV-Battery Plants Bid into the Market?", *ESIG,* Denver, CO, June 5, 2019

2) "Is Energy Storage a Cost-Effective Part of the Solution?", *SCPPA,* Burbank, CA, May 16, 2019

3) "Due Diligence and Hedging Your Bets," *ESA Con*, Phoenix, AZ, April 17, 2019

4) "Determining the Value of Storage and Flexible Generation with Increasing Renewable Generation," *CEATI- SOING,* Birmingham, AL April 9, 2019

5) "Planning for Accelerating Renewable Energy Conditions," *InfoCast Community Choice Energy Summit*, La Jolla, CA, April 25, 2018

6) "Energy Portfolio Risk Management," *InfoCast Community Choice Energy Summit*, La Jolla, CA, April 24, 2018

7) "Capturing New Energy Market Dynamics with High Renewable Generation," *Committee on Regional Electric Power Corporation*, Boise, ID, June 19, 2017

8) "Planning for Accelerating Renewable Energy Conditions," *EUCI, IRP Conference*, Portland, OR, April 16, 2017

9) "Impact of Renewables on Market Prices," *EUCI,* Denver, CO, April 11, 2017

10) "Innovations in Stochastic Modelling: Weather Conditions and the Impact on Modelling Integrated Physical and Financial Energy Portfolios," *Energy Risk USA*, Houston, TX, May 20-22, 2014. (pre-conference workshop)

11) "Utility Resource Planning: Integrated Decision Analysis for Resource Selection, Conversion and Retirement," *Electric Utilities Consultants*, Chicago, IL, May 13-14, 2014. (pre-conference workshop)

12) "Portfolio and Risk Management: California Carbon Policy Impacts on Western Power Markets," *Electric Utilities Consultants,* San Francisco, CA, January 27-28, 2014.

13) "Fast Ramp and Intra-hour Market Incentives," *Electric Utilities Consultants*, San Francisco, CA, January 29-30, 2014.

14) "California Power Markets and the West: Implications for Electricity Trade between California and the NW Panel Discussion," *Symposium of Northwest Power Coordinating and Conservation Council,* Portland, OR, September 12, 2013.

15) "Hydro Optimization: Realizing Maximum Value from Generation," *HydroVision International*, Denver, CO, July 24, 2013.

16) "Review of Resource Planning Model" *Northwest Power and Conservation Council*, June 2013.

17) "Resource Planning: IRP, Asset Valuation and Power Modeling," *Electric Utilities Consultants*, Westminster, CO, May 20-21, 2013.

18) "Resource Planning Under Uncertainty," *Electric Utilities Consultants,* Boulder, CO, March 21, 2013.

19) "Improving Settlement Processes for Organization Markets," *Electric Utilities Consultants*, Dallas, TX, February 20-21, 2013.

20) "Portfolio Management: Operational & Intermediate Term Best Practices," *Electric Utility Consultants*, Houston, TX, December 10-11, 2012.

21) "Decision Analysis for Converting Coal to Gas," *Electric Utilities Consultants*, Charlotte, NC, October 22-23, 2012.

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23) "Best in Breed and Best in Show Resource Planning," *Proceedings: Electric Utilities Consultants,* Portland, OR, March 8, 2012.

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30) "Electricity Storage: Business and Policy Drivers," *Electric Utilities Consultants,* Houston, TX, January 24, 2011.

31) "What Techniques Work in a High Renewables and Demand-Side Resources Environment," *Electric Utilities Consultants,* San Francisco, CA, November 1-3, 2010.

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33) "Optimization Strategies to Increase Cash Flow and Minimize Risk," *Energy Risk USA*, Houston, TX, May 25, 2010.

34) "Making Your Scenario Analyses More Robust: Meaningful Uncertainty in Price Simulations," *Electric Utilities Consultants,* Denver, CO, May 6, 2010.

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36) "Forward Curve Generation and Data Management," *Electric Utilities Consultants Webinar*, April 20, 2010.

37) "Selection of Optimal Resource Plan in an Uncertain World," *Electric Utilities Consultants,* San Francisco, CA, April 12, 2010.

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50) "Developing a No Regrets Energy Supply Portfolio," San Diego, CA, January 31, 2006.

51) "Building a Hedge Portfolio to Mitigate Earnings Volatility,"*Proceedings: Electric Utilities Consultants,* Boston, MA, August 10, 2005. (conference co-chair)

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53) "Techniques for Portfolio Optimization," *Proceedings: Electric Utilities Consultants, Denver, CO,* September 29, 2004. (conference co-chair)

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68) "Design and Operation of Combined Cycle Turbo Expanders for Gas Distribution Companies," *Proceedings of the New England Gas Association,* March, 1990.

69) "Developing Dispatchable Cogeneration Facilities: A Case Study," *Proceedings of the Joint Power Conference*, ASME Publication, October, 1990.

70) "Clean Power Supply through Cogeneration," Cornell University, Undergraduate Honors Thesis, June 1988.

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73) "An Application of the Regional Economic Model for Ozone Compliance for the Northeast," *Federal Advisory Committee Act. July 27, 1997.*

74) "Utility Capital Structure and Non-Utility Power Purchase Agreements," *Proceedings of the Cornell Utility Workshop*, August, 1992.

SELECTED TECHNICAL REPORTS AS PRINCIPAL INVESTIGATOR

1) "Comparative Market Design Analysis," Prepared for California Independent System Operator, April, 2002.

2) "Evaluation of US EPA SIP Call for NO_x Point sources," Prepared for US EPA, September, 1999.

3) "Environmental Analysis of Arizona Public Service Generating Assets," Prepared for Sempra Energy Resources, September, 1999.

4) "Economic and Air Quality Analysis of Episodic Controls to Reduce Ozone Concentrations in the State of Illinois," Prepared for Illinois department of Commerce and Community Affairs, October, 1998.

5) "Development of a Multivariate Ozone Response Surface," Prepared of Electric Power Research Institute, February, 1999.

6) "Least Cost Steps to Reduce Ozone in the Northeast Urban Corridor," Prepared for New York State Energy Research Development Authority, with Timothy Mount and S.T. Rao, November, 1998.

7) "Exploratory Analysis of Power Plant Retirements and Auctions," Prepared of US EPA, May 1998.

8) "Application of Option Models for Electricity," Prepared for The Energy Authority, July, 1997.

9) "Estimating Emission Weights for the Greater Chicago Metropolitan Area," Prepared for Illinois EPA, July 1997.

10) "Measuring Value at Risk," Prepared for the Energy Authority, August, 1997.

11) "Development of a Forward Price Curve for Electricity," Prepared for The Energy Authority, Jun 1997.

12) "Least Cost Solutions for Ozone Attainment in the Greater New York Metropolitan Area," Prepared for Niagra Mohawk Power Corp., with Timothy Mount and S.T. Rao, August, 1997.

13) "Capital Investment and risk of Private Sector Energy development in Egypt," Prepared for the Egyptian Electricity Authority by Arthor Anderson, August, 1996.

14) "Least Cost Strategies for Ozone Attainment," Prepared for New York Department of Environmental Conservation, with Timothy Mount, S.T. Rao, G. Sisla, P. Brandford, and Kurvila John, March, 1995.

Selected Ascend Experience

PNM Exhibit GWD-2

Is contained in the following 1 page.

PNM EXHIBIT GWD-2: ASCEND EXPERIENCE

Table B-1 summarizes select clients we have worked with on Resource Planning 2.0 activities.

Table B-1: Selected Experience in Resource Planning and Selection

Client	Project	Description
Silicon Valley Clean Energy	RFP valuation of Renewable Resources	Assisting SVCE to choose a portfolio of renewable resources and battery storage to meet RPS requirements and minimize risk to customers.
Salt River Project	Sub-hourly portfolio modeling	Modeling Salt River Project's supply portfolio as it interacts with the Energy Imbalance Market at a 5- and 15-minute granularity.
Burbank Water and Power	2019 Integrated Resource Plan	Provided the analytical backbone of Burbank's IRP. Evaluated supply options for achieving 60% RPS and storage options including batteries and compressed air energy storage.
Glendale Water and Power	2019 IRP and Clean Energy RFP Evaluation	Developed and evaluated a pioneering all-source RFP for clean energy resources, including local distributed energy resources and grid-scale renewable and battery resources. Helped Glendale develop a diverse portfolio of clean and fast-response thermal resources to maintain reliability and achieve GHG and RPS goals.
NorthWestern Energy	Acquisition of the Hydros	Provided the analytical support necessary for NorthWestern Energy to gain approval for purchase $3B worth of hydro assets from PPL.
Hawaii Electric	2016 Power Supply Improvement Plan	Provided critical analytical support for HECO to gain approval for their PSIP after several failed attempts. Developed a capacity expansion plan to get HECO to 100% renewable by 2045, including evaluating the optimal deployment of energy storage to maintain system reliability.

Additional experience and references available upon request.

Market Transformation in the WECC

PNM Exhibit GWD-3

Is contained in the following 16 pages.

Report on Market Transformation in the WECC

Ascend Analytics, LLC

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The western electricity grid, known by the acronym WECC, is undergoing a remarkable and unprecedented transformation from a system primarily fueled by coal and natural gas resources to one dominated by renewable energy. This is driven by two primary factors: policy and economics. First, concern about human caused climate change has led state policy makers to pass laws mandating increasing amounts of carbon-free and renewable energy[1]. New Mexico has recently joined California, Nevada, Colorado, Washington, and Oregon in passing laws that in various ways chart a path towards phasing out coal and gas resources in favor of solar, wind, hydroelectric, existing nuclear, geothermal, and electricity storage. Additionally, several large western utilities such as Xcel Colorado and Idaho Power have stated their intention to voluntarily move towards a carbon free portfolio. Table 1 shows a summary of recently announced policy initiatives that will rapidly change the western resource mix.

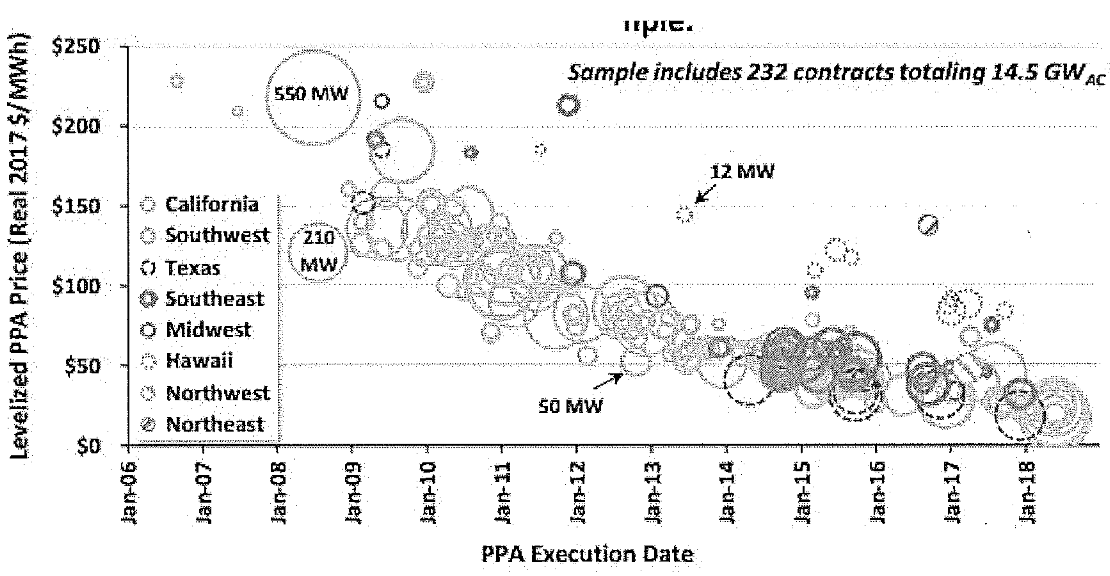
Table C-1: Clean Energy Legislation and Initiatives

Entity	Commitment
California	60% renewable energy and 100% clean energy by 2045
Nevada	50% renewable energy by 2030, and 100% carbon-free by 2050
Colorado	100% Carbon-free by 2040
Oregon	50% renewable energy by 2030
Washington	100% clean energy by 2045
New Mexico	100% carbon-free by 2045
Xcel Energy	100% carbon-free by 2050
Idaho Power	100% clean energy by 2045

[1] "Renewable energy" is defined as coming from wind, solar, run-of-river hydro, geothermal, and some types of biomass. "Clean Energy" or "Carbon Free" refers to these resources plus large ponded hydro and nuclear.

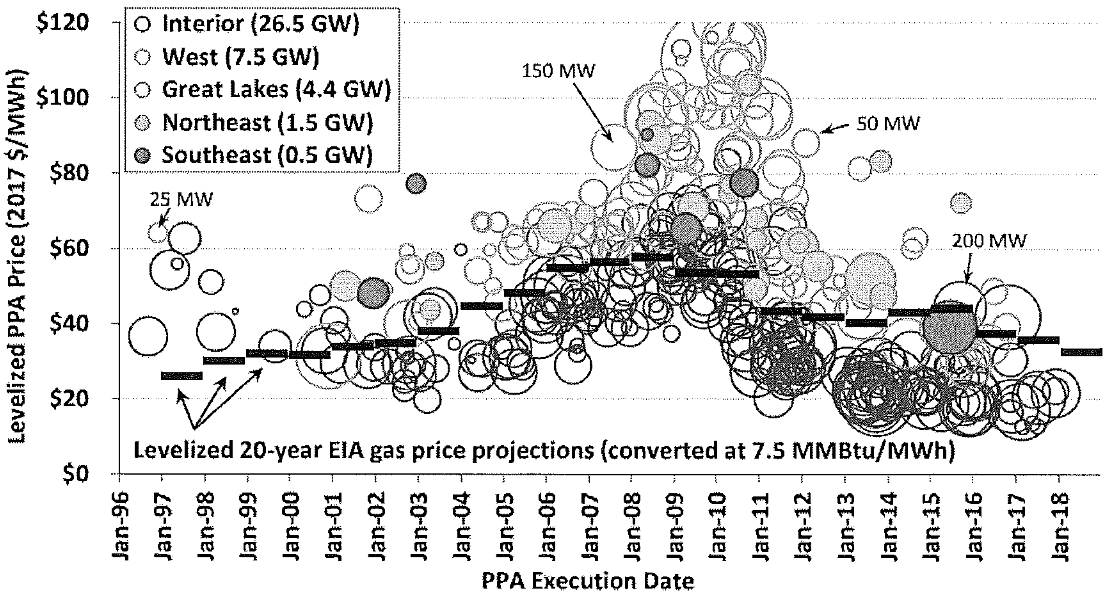
The second driving factor is increasingly favorable economics for renewable resources relative to coal and natural gas. According to the November 2018 Lazard study on levelized cost of energy resources,[2] since 2009 wind energy cost has declined 70 percent while solar has declined 88 percent. This means solar and wind resources are now economically favorable relative to conventional sources of energy such as natural gas, coal, and nuclear. The Investment Tax Credit for solar and Production Tax Credit for wind have further made renewables the economic choice for energy generation. Figure 1 shows the dramatic decline in power purchase agreement prices executed for solar and wind, as compiled by Lawrence Berkeley National Lab.

Figure C-1a: Cost Declines in Solar Power Purchase Agreements



[2]Lazard's Levelized Cost of Energy Analysis – Version 12.0. 2018.
https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf

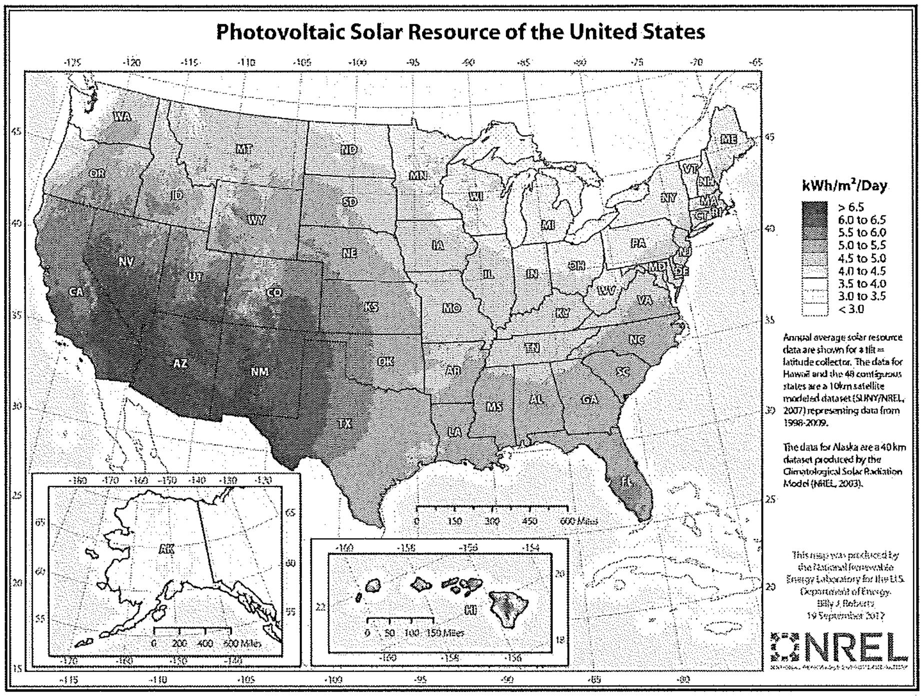
Figure C-1b: Cost Declines in Wind Power Purchase Agreements



Source: Lawrence Berkeley National Lab

Ten years ago, solar energy cost ratepayers up to $0.22/kWh but today that has dropped to as little as $0.02/kWh. Similarly, wind projects ranged from $0.06 - $0.12/kWh in 2009 but today cost as little at $0.015 - $0.025/kWh. Customers in PNM territory are in an optimal location to receive the best prices for solar energy given the strength of the solar resource in New Mexico, as shown by Figure 2 below. Eastern New Mexico also enjoys a strong wind-resource.

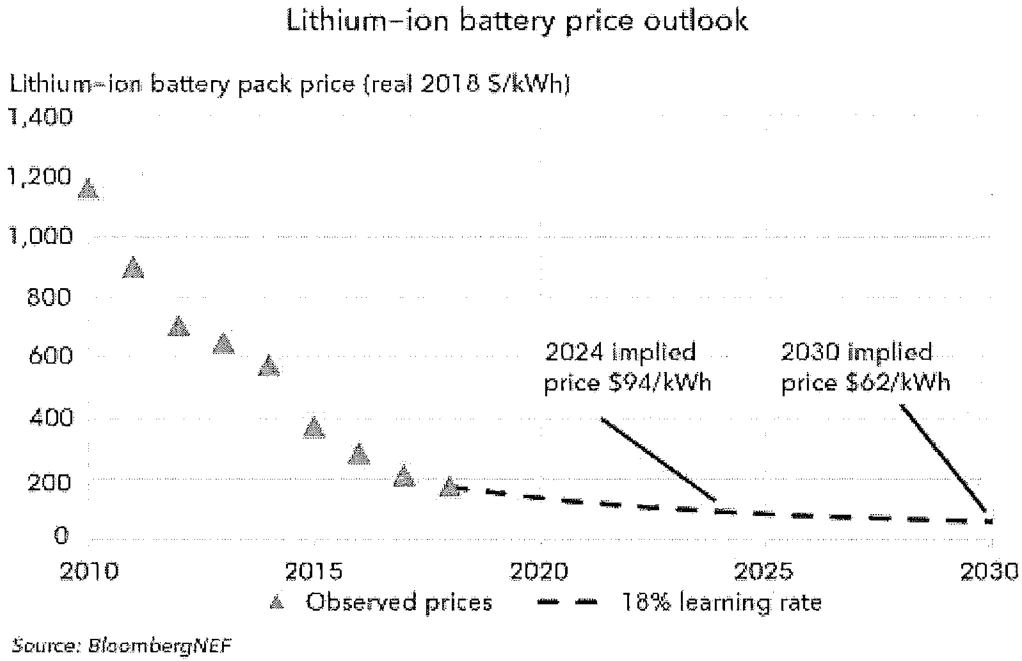
Figure C-2: New Mexico enjoys some of the highest solar irradiance in the US



Source: National Renewable Energy Laboratory

Renewables impose a challenge to grid operators due to the intermittency of the generation meaning that the output cannot be easily controlled to match the demand for electricity. Solar presents an additional challenge in that it only produces electricity during daylight hours. For power systems to work with renewable energy, energy storage must be part of the equation. Energy storage smooths fluctuations in the output from wind and solar and stores excess energy from wind and solar for use when it is needed. Fortunately, battery storage technology costs have declined significantly over the past decade. Figure 3 shows Bloomberg New Energy Finance's 2018 Outlook on the cost of battery packs[3]. The trend of declining costs is projected to continue through 2025.

Figure C-3: Bloomberg New Energy Finance 2018 Outlook on Cost of Battery Packs

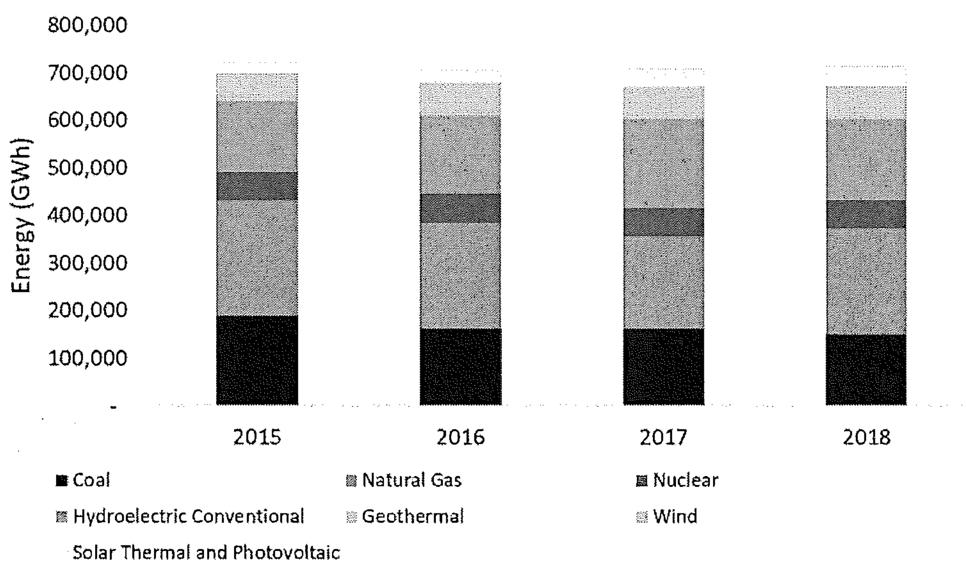


Given the legislative and economic drivers discussed above, we estimate that clean energy (wind, solar, geothermal, nuclear, and hydro) will account for nearly 90% of all generation in the WECC by 2045. While the road towards a decarbonized electricity grid is uncertain, we believe that the WECC in 2045 will include a diversified mix of renewables, storage, and flexible natural gas generation to act as critical back up when the meteorology is not suitable for consistent power generation.

[3] Battery packs are about 70% of the total cost of a battery and the rest is known as "balance of plant." While balance of plant costs are not dropping as dramatically, Bloomberg expects approximately an 8% per year decline in costs over the next 5 years.

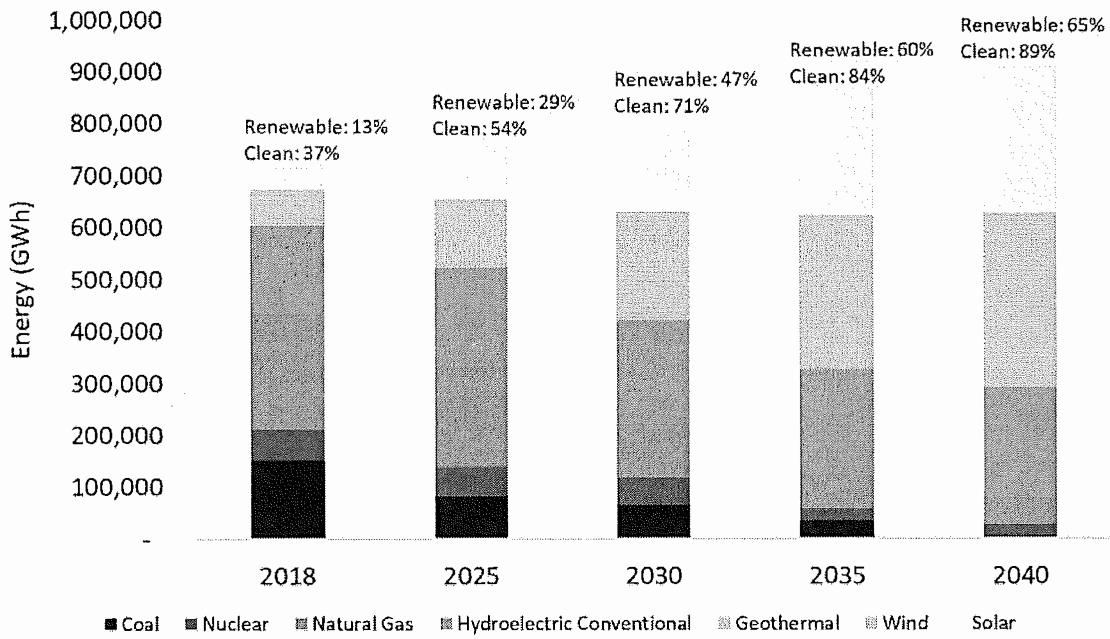
Historically, the Western US has depended on coal and gas generation to produce energy. Figure C-3 shows the historical breakdown of energy by fuel source in the WECC over the last four years. While total generation has remained relatively constant, the portion of energy coming from gas and coal has been declining. Replacing the retiring thermal generation has been wind, solar, and flexible thermal generation. This evolution toward a high renewable environment will continue over the foreseeable future.

Figure C-3: WECC Electricity Supply Composition



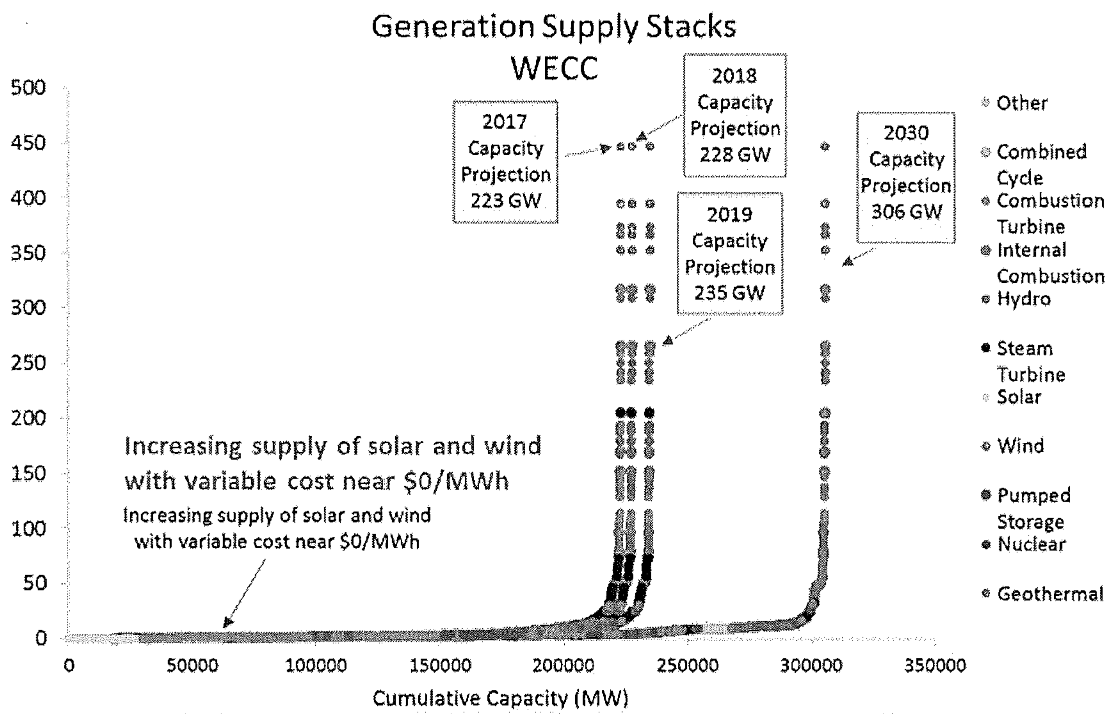
Based on current policy requirements and economic forces, Figure C-4 shows Ascend's energy supply forecast in the WECC through 2040.

Figure C-4: WECC Generation Mix Forecast



Optimal generation dispatch dictates that the lowest cost resources get selected before higher cost resources. Wind and solar have variable costs at or near zero, and since they are non-dispatchable (generates as the wind blows and sun shines), the coal or natural gas generation must follow the renewable generation. A supply stack shows the order of generators based on their variable cost to supply energy. Figure 4 shows the supply stack of generation for the WECC in 2017 - 2019 and 2030. The bottom of the supply stack curve consists of wind, solar, and hydro resources. As resources are added to the stack, the cost moves up modestly until the peaking resources are added where the curve moves up sharply. Although the average load increases over time, it will be served more often by low-cost renewables as opposed to higher cost thermal generation.

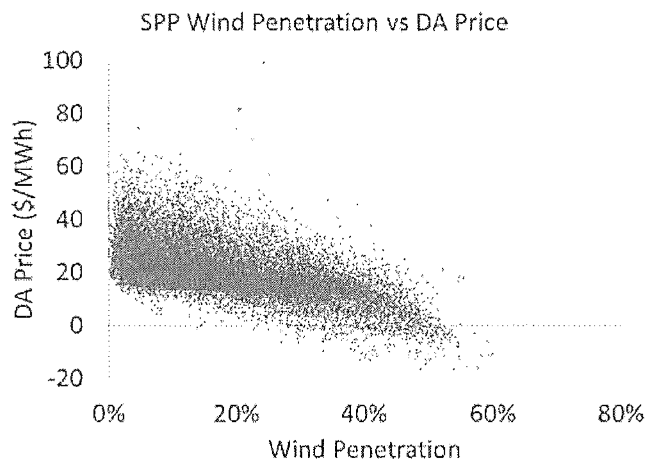
Figure C-5: Changing supply curve due to renewable generation growth



Data the Southwest Power Pool ("SPP")[4] shows the clear link between increased wind generation and lower prices. The SPP shows a much stronger trend due to higher levels of wind. For example, when wind penetration reaches around 50% of system load, the average price approaches zero and goes negative from there.

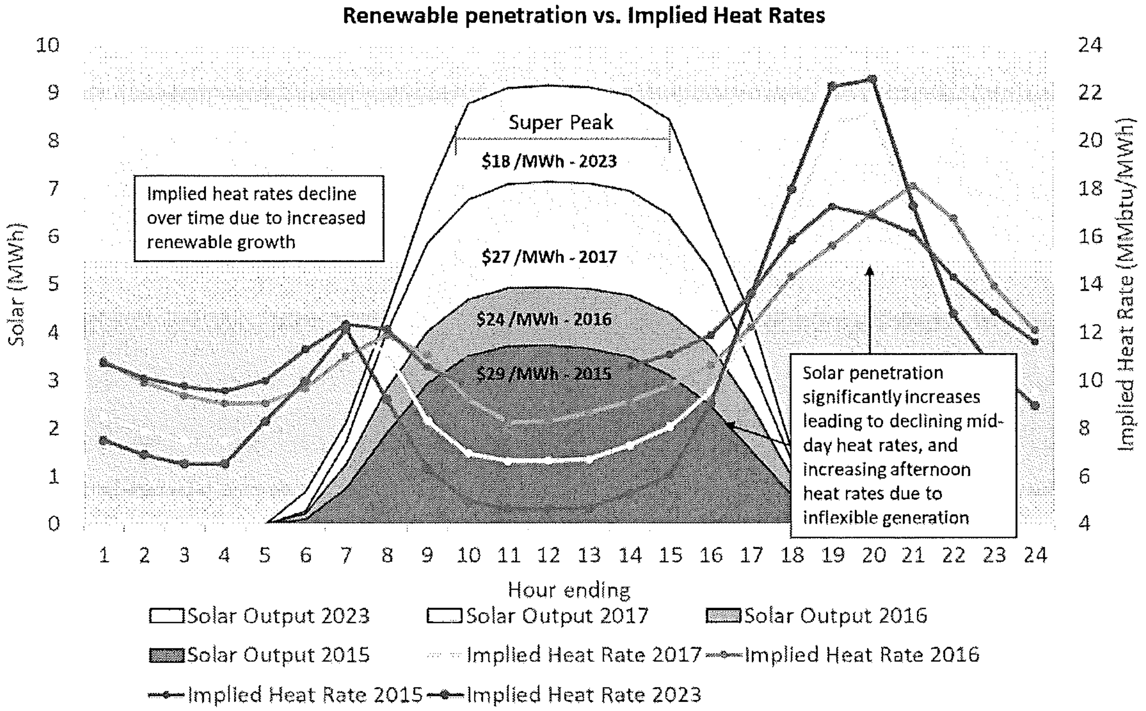
[4] Data pulled from https://www.spp.org/

Figure C-6: Market prices vs wind penetration for SPP



Implied heat rates are calculated as the price of power divided by the price of gas. It normalizes power prices relative to gas prices and indicates the type of resources that are in the money for dispatch. Increased renewables put downward pressure on market prices by reducing the number of hours where natural gas or coal is the marginal unit and sets the market price. As wind, solar, and hydro become the marginal generator more often in the supply stack, the implied heat rate must decline assuming constant gas prices. The implied heat rate will decline more drastically during hours of high wind and solar generation. Mid-day and nighttime prices will be suppressed due to solar and wind/hydro, respectively. However, in solar heavy markets, prices and implied heat rates should "pop" in the late afternoon hours, when solar generation ramps down and thermal generation radically ramps up to compensate. This is the so called "duck curve" phenomenon as data from CAISO illustrates clearly from 2016 to 2018 in Figure 6.

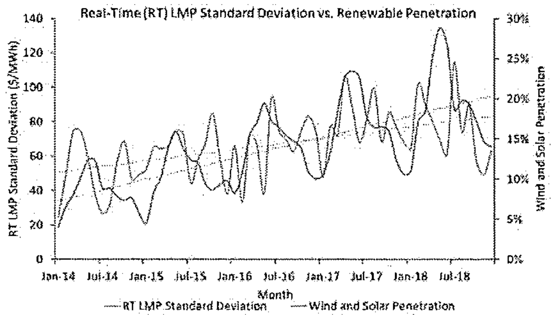
Figure C-7: Implied heat rate and renewable generation in CAISO



Daytime implied heat rates dropped significantly during solar peak from 9 AM until 5 PM, but pop during the morning and evening ramp events.

While prices are expected to decline on average, market price volatility will increase due to the variable and intermittent nature of solar and wind resources. Increased volatility means larger price spikes and more frequent negative prices. This trend has been observed in recent years in places where renewables have grown the fastest. Figure C-7 shows the relationship between renewable penetration and real-time price volatility.

Figure C – 8: Renewable penetration and price volatility

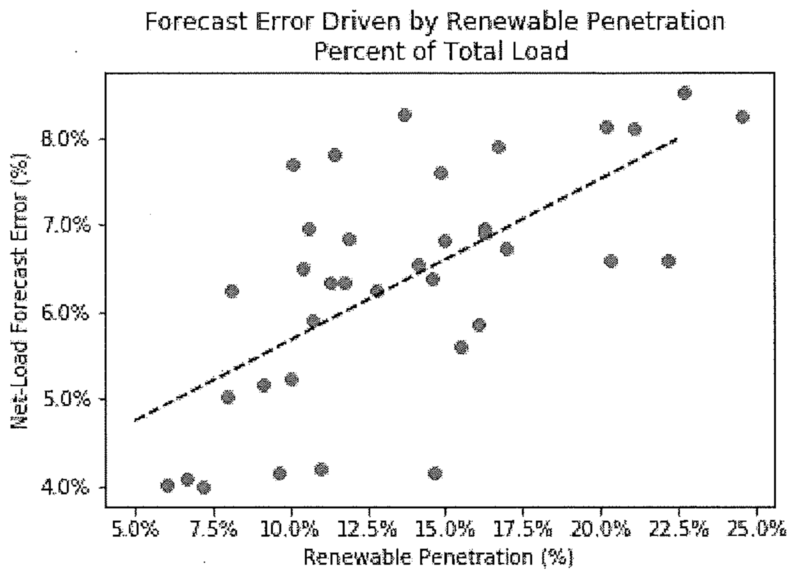


Year	Wind and Solar Penetration (%)	DA LMP Volatility*	RT LMP Volatility*
2014	8%	12.3	52.9
2015	11%	9.1	63.7
2016	14%	11.7	69.7
2017	17%	26.4	80.2
2018	19%	40.4	79.2

The increase in price volatility is not unique to CAISO, but is sustained cross-sectionally and attributable to renewable production in the Electric Reliability Council of Texas ("ERCOT"), and the SPP. In 2014, wind and solar generation served about 8% of CAISO's load and the standard deviation of prices was $12/MWh in the DA market and $53/MWh in the RT markets. Fast forward to 2018, 19% of generation was from wind and solar and the standard deviation of prices jumps to $40 in the DA and about $79 in the RT.

The rise in volatility is directly connected with increasing forecast error. With renewable generation, weather is the fuel, and it is difficult to accurately forecast renewable generation based on a weather forecast. The more renewables on a system, the more forecast error we see between day-ahead forecast and realized generation, as shown for the CAISO system in Figure C - 8.

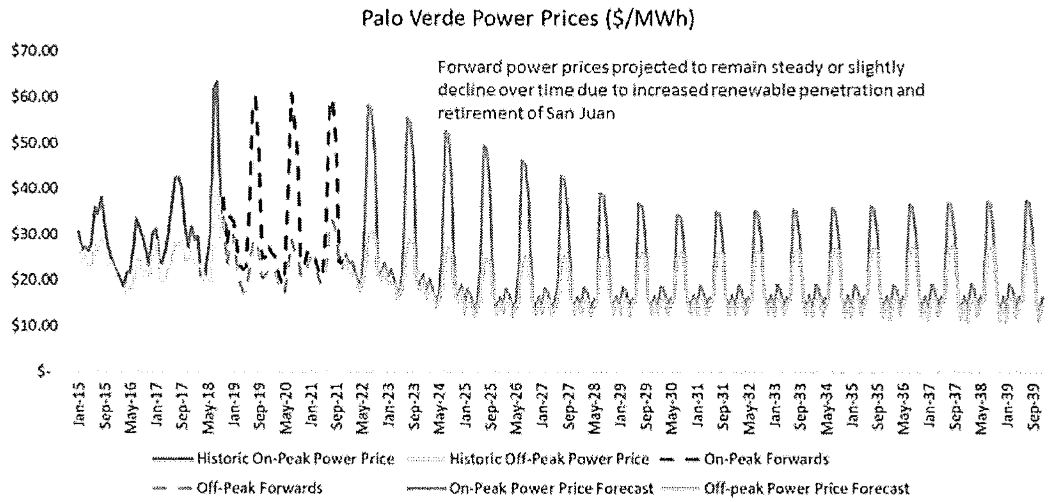
Figure C - 8: Renewables lead to more forecast error

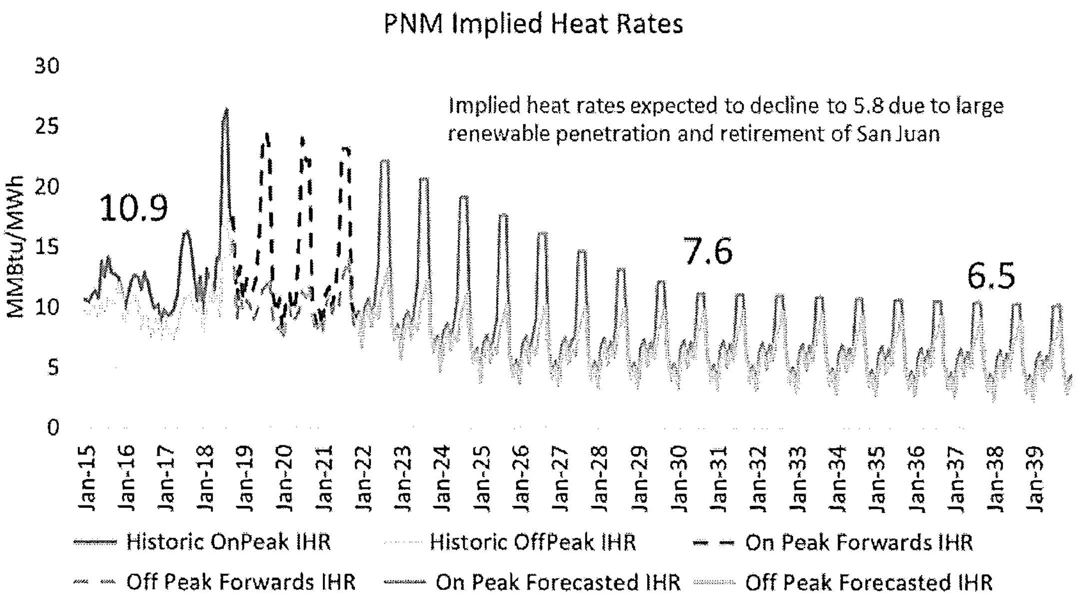


The increase in forecast error drives the increased volatility of prices in the EIM. The volatility manifests as clusters of price spikes that can range up to $1,000/MWh as well as negative prices.

In sum, these trends result in declining average heat rates and increasing price volatility. Renewable generation is negatively correlated with average power prices, and therefore the addition of large quantities of renewable generation will depress average power prices. We capture this dynamic in our forecast of Palo Verde prices and implied heat rates shown in Figure C – 9.

Figure C-9: Declining power prices and implied heat rates at Palo Verde node

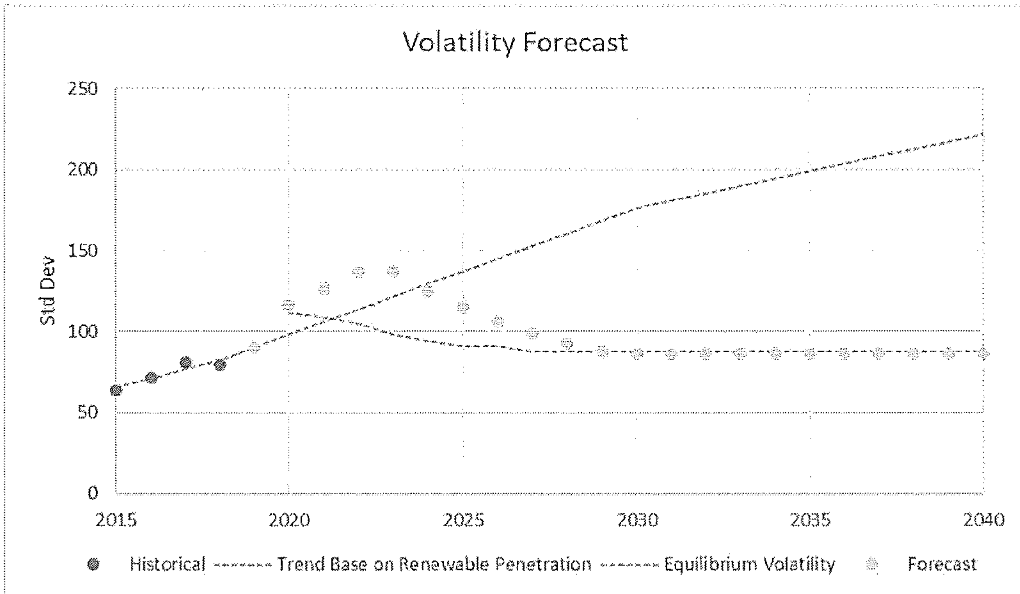




As renewables move to dominate the market, the marginal unit will no longer be older, inefficient, gas and coal generation, but rather newer gas generation or renewables For example, a natural gas combined cycle unit with a heat rate of 8.5 MMBTU/MWh would be uneconomic most of the time in a market has an implied heat rate of 7 MMBTU/MWh.

We've established that the intermittent nature of renewable generation increases the likelihood of forecast error, therefore causing increasing volatility in prices. On the other hand, increasing flexible generation capacity (batteries, ICEs), which can react to short term price signals, absorbs volatility. Flexible generation assets dispatch to short term price signals in order to take advantage of extreme prices (prices below $0/MWh, or above $100/MWh). Increased flexible generation capacity will dampen price volatility until an equilibrium point is reached where price spikes are able to sustain flexible generation by providing normal returns. As competition to dispatch to price spikes increases, the effect on the market of each price spike will be diminished. Ascend's forecast of price volatility is shown in Figure C-10. Volatility increases as renewables are added through the next 8 years, and then declines as fast-ramping batteries and ICEs are added to the grid reducing volatility. Eventually, volatility settles to the long run equilibrium level. With declining average prices, inflexible thermal generation, which cannot react to short term price signals will become uneconomic to run, while renewables and flexible generation will remain economic.

Figure C-10: Price Volatility Forecast



Increasing price volatility is a market signal demonstrating the value of flexible resources that can ramp quickly and economically. As volatility increases, the economic value of batteries, ICEs, aeros improves while baseload resources like coal, combined cycles, and frames become uneconomic.

BEFORE THE NEW MEXICO PUBLIC REGULATION COMMISSION

IN THE MATTER OF PUBLIC SERVICE COMPANY OF NEW MEXICO'S CONSOLIDATED APPLICATION FOR APPROVALS FOR THE ABANDONMENT, FINANCING, AND RESOURCE REPLACEMENT FOR SAN JUAN GENERATING STATION PURSUANT TO THE ENERGY TRANSITION ACT	)	**19-______-UT**

AFFIDAVIT

STATE OF COLORADO)
) ss
COUNTY OF BOULDER)

GARY W. DORRIS, Chief Executive Officer, Ascend Analytics, LLC, upon being duly sworn according to law, under oath, deposes and states: I have read the foregoing **Direct Testimony of Gary W. Dorris** and it is true and accurate based on my own personal knowledge and belief.

GCG # 525597

SIGNED this 26 day of June, 2019.

GARY W. DORRIS

SUBSCRIBED AND SWORN to before me this 26 day of June, 2019.

NOTARY PUBLIC IN AND FOR
THE STATE OF COLORADO

My Commission Expires:

3-20-23

ELIZABETH JUNE CRISLER
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 20194011066
MY COMMISSION EXPIRES MARCH 20, 2023